

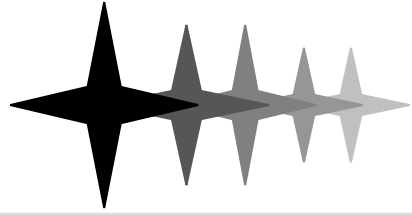
8th | INTERNATIONAL
SYMPOSIUM

RAQORS VIII

RECENT
ADVANCES
IN QUANTITATIVE REMOTE
SENSING

PROGRAMME
AND ABSTRACT BOOK





8th INTERNATIONAL SYMPOSIUM



RECENT ADVANCES IN
QUANTITATIVE
REMOTE SENSING

PROGRAMME AND ABSTRACT BOOK

21 – 25 SEPTEMBER 2026
TORRENT (VALENCIA) SPAIN

Copyright 2026 by the Authors

All rights reserved

No parts of this publication may be reproduced or transmitted in any form by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the authors.

GLOBAL CHANGE UNIT
Image Processing Laboratory
Universitat de València
C/ Catedrático José Beltrán, 2
E-46980 Paterna – Valencia
SPAIN

E-mail: sobrino@uv.es

© Cover: GLOBAL CHANGE UNIT

Deposito Legal: V-4038-2026

WELCOME MESSAGE

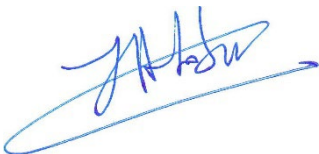
We are pleased to welcome you to the **Eighth International Symposium on Recent Advances in Quantitative Remote Sensing (RAQRS VIII)**, to be held in Torrent (Valencia), Spain, from 21 to 25 September 2026.

The Symposium will address recent scientific advances and their practical applications, with the main objective of assessing the state of the art in both the theory and application of remote sensing data analysis. We hope that the Symposium will also contribute to identifying common research priorities and future directions.

RAQRS VIII will provide a unique forum for scientific exchange and interaction among members of the international remote sensing community, while also offering participants the opportunity to enjoy their stay in Torrent and València.

Presentations by scientists from around the world will provide an in-depth overview of current advances in remote sensing and stimulate discussion on emerging scientific and technological challenges.

See you in Torrent!



José A. Sobrino
RAQRS VIII Chair
University of Valencia, Spain
sobrino@uv.es

SCIENTIFIC COMMITTEE

Presidente / Chair:

J. A. Sobrino University of Valencia, Spain

Miembros / Members:

K. Adeline	ONERA, France
G. Asrar	iCREST Foundation, USA
I. Barat	ESA/ESTEC, The Netherlands
G. Chehbouni	IRD, France
C. Corbari	Politecnico di Milano, Italy
F. Gamet	CNES, France
F. Gascon	ESA/ESRIN, Italy
D. Ghent	University of Leicester, UK
R. O. Green	NASA, JPL, Pasadena, USA
G. Gutman	NASA, Washington, D. C., USA
O. Hagolle	CNES, France
S. Hook	NASA, JPL, USA
A. Huete	University of Technology, Sydney Australia
G. Hulley	NASA, JPL, USA
Y. Kerr	CESBIO, Toulouse, France
B. Koetz	European Space Agency, Italy
M. Langsdale	DTU Space, Denmark
Z.-L. Li	University of Strasbourg, France
S. Liang	University of Hong Kong, Hong Kong SAR, China
Y. Ma	CAS, China
P. Maisongrande	CNES, France
K. Mallick	CESBIO, Toulouse, France
M. Menenti	Delft University of Technology, The Netherlands
J. Moreno	University of Valencia, Spain
F. Nerry	University of Strasbourg, France
A. Oliso	INRAE, Avignon, France
J. Privette	NOAA, USA
M. Rast	ISSI, Switzerland
H. Ren	Peking University, China
J.-L. Roujean	CESBIO, Toulouse, France
L. Roupioz	ONERA, France
Z. Su	University of Twente, The Netherlands
B.-H. Tang	IGSNRR/CAS, Beijing, China
W. Timmermans	University of Twente, The Netherlands
C. J. Tucker	NASA, USA
E. Vermote	NASA, USA
Y. Wang	CESBIO, Toulouse, France
J. P. Wigneron	INRAE, Bordeaux, France
H. Wu	LREIS, IGSNRR, Beijing, China
P.J. Zarco-Tejada	IAS-CSIC, Spain

ORGANIZING COMMITTEE

Presidente /Chair: Recent Advances, Torrent, Spain

P. Gómez González

Miembros/ Members: University of Valencia, Spain

J. C. Jiménez

G. Sòria

B. Franch

D. Skoković

Y. Julien

R. Llorens

D. Salinas

S. Gimeno

L. Wei

A. Sobrino-Gómez

I. Moletto-Lobos

F. Della Bellver

K. Cyran

J. Tarín-Mestre

A. Guillem-Valls

C. J. Guerrero Benavent

V. Betti

RAQRS 2026 – TIMETABLE

Time	Monday 21 Sep 2026	Tuesday 22 Sep 2026	Wednesday 23 Sep 2026	Thursday 24 Sep 2026	Friday 25 Sep 2026
8:30 - 9:30	REGISTRATION				
9:30 - 10:10	OPENING SESSION	ORAL SESSION 4	ORAL SESSION 8	ORAL SESSION 12	SESSION REPORT BY SESSIONS CHAIRPERSONS (10:00-11:30)
10:10-10:40	CONFERENCE				
10:40 - 11:10	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
11:10 - 12:30	ORAL SESSION 1	ORAL SESSION 5	ORAL SESSION 9	ORAL SESSION 13	CLOSING CEREMONY
12:30 – 13:30	POSTER SESSION 1	POSTER SESSION 2	POSTER SESSION 3	POSTER SESSION 4	Refreshment & Snacks
13:30 - 15:30	Lunch Break	Lunch Break	Lunch Break	Lunch Break	
15:30 - 17:10	ORAL SESSION 2	ORAL SESSION 6	ORAL SESSION 10	ORAL SESSION 14	
17:10 - 17:40	Coffee Break	Coffee Break	Coffee Break		
17:40 - 19:00	ORAL SESSION 3	ORAL SESSION 7	ORAL SESSION 11		
19:30 - 22:00	WELCOME RECEPTION	DINNER		GALA DINNER (20:00-24:00)	
22:00 - 24:00					

PROGRAMME OVERVIEW

MONDAY 21 SEPTEMBER 2026

Auditori de Torrent · C/ Vicent Pallardó, 25 · 46900 Torrent (Valencia)

8:30 – 9:30 Registration

9:30 – 10:10 Opening Session

10:10 – 10:40 Opening Conference

10:40 – 11:10 Coffee Break

11:10 – 12:30 ORAL SESSION 1

Land Surface Radiation and Inversion Modelling

Chair: J. Moreno

12:30 – 13:30 POSTER SESSION 1

Land Surface Radiation and Inversion Modelling

Thermal Infrared Remote Sensing

Multispectral and Hyperspectral Remote Sensing and Imaging Spectroscopy

13:30 – 15:30 Lunch Break

15:30 – 17:10 ORAL SESSION 2

Land Surface Radiation and Inversion Modelling

Thermal infrared remote sensing

Multispectral and Hyperspectral Remote Sensing and Imaging Spectroscopy

Chairs: O. Hagolle, E. Vermote

17:10 – 17:40 Coffee Break

17:40 – 19:00 ORAL SESSION 3

Earth Observation Missions & Services

Chair: J. L. Roujean, P. Gamet

19:30 – 22:00 Welcome Reception

TUESDAY 22 SEPTEMBER 2026

9:00 – 10:40 ORAL SESSION 4

Land Surface Radiation and Inversion Modelling
Thermal infrared remote sensing

Chairs: I. Barat, F. Nerry

10:40 – 11:10 Coffee Break

11:10 – 12:30 ORAL SESSION 5

Earth Observation Missions & Services
Evapotranspiration inversion techniques

Chairs: C. Tucker, Y. Kerr

12:30 – 13:30 POSTER SESSION 2

Machine Learning in Remote Sensing
Carbon and Water Cycle Observation and Modelling
Global Change and sustainable development
Evapotranspiration inversion techniques

13:30 – 15:30 Lunch Break

15:30 – 17:10 ORAL SESSION 6

Carbon and Water Cycle Observation and Modelling
Evapotranspiration inversion techniques

Chairs: A. Olioso, K. Mallick

17:10 – 17:40 Coffee Break

17:40 – 19:00 ORAL SESSION 7

Multispectral and Hyperspectral
Evapotranspiration Inversion Techniques
Machine Learning in Remote Sensing

Chairs: C. Corbari, K. Adeline

19:00 – 22:00 Dinner

WEDNESDAY 23 SEPTEMBER 2026

9:00 – 10:40 ORAL SESSION 8

From R&D to Operational Agriculture Monitoring
Land Cover/Use and Change

Chair: S. Gillians, B. Franch

10:40 – 11:10 Coffee Break

11:10 – 12:30 ORAL SESSION 9

Land Cover/Use and Change
Earth Observation Misions & Services

Chairs: R. O. Green, G. Gutman

12:30 – 13:30 POSTER SESSION 3

Land Cover/Use and Change
From R&D to Operational Agriculture Monitoring
Urban Heat Island Mapping and Mitigation
Inversion of Evapotranspiration

13:30 – 15:30 Lunch Break

15:30 – 17:00 ORAL SESSION 10

Urban Heat Island Mapping and Mitigation
Remote Sensing of Forest

Chairs: J.P. Wigneron, W. Timmermans

17:10 – 17:40 Coffee Break

17:40 – 19:00 ORAL SESSION 11

Calibration, Atmospheric Correction and Product Validation

Chairs: L. Roupioz, J. Blommaert

THURSDAY 24 SEPTEMBER 2026

9:00 – 10:40 ORAL SESSION 12

Sensor Calibration, Atmospheric Correction and Product Validation

Chairs: F. Camacho, J. Wagner

10:40 – 11:10 Coffee Break

11:10 – 12:30 ORAL SESSION 13

Passive and active fluorescence

Chairs: P. Zarco-Tejada, C. van der Tol

12:30 – 13:30 POSTER SESSION 4

Global Change and sustainable development

Remote Sensing of snow and ice

Sensor Calibration, Atmospheric Correction and Product Validation

Passive & active Microwaves Data Processing Applications

Passive and active Fluorescence

Earth Observation Missions & Services

13:30 – 15:30 Lunch Break

15:30 – 17:10 ORAL SESSION 14

Earth Observation Missions & Services

Chairs: M. J. Bonilla, R. Diaz-Delgado

20:00 Gala Dinner

FRIDAY 25 SEPTEMBER 2026

10:00 – 11:30 Session report by session chairpersons

Chair: J. A. Sobrino

11:30 – 12:00 Closing Ceremony

12:00 – 13:15 Refreshments & Snacks

CONTENTS

MONDAY 21 SEPTEMBER 2026

8:30 – 9:30 REGISTRATION

9:30 – 10:10 OPENING SESSION

10:10 – 10:40 **Progress in ESA's Earth Observation Programmes and Observing Systems**
T. Fehr, Head of Earth Science Division, ESA.

10:40 – 11:10 Coffee Break

11:10 – 12:30 **ORAL SESSION 1**

Land Surface Radiation and Inversion Modelling

Chair: J. MORENO

S1.1 47 years of Vegetation Indices

C. Tucker, NASA Goddard Space Flight Center, USA

J. Pinzon, J. Joiner

S1.2 Advances in the automated ground based validation of remotely sensed surface reflectance

E. Vermote, NASA Goddard Space Flight Center, USA

J. McCorkel, W. H. Rountree, A. Santamaria-Artigas, S. Skakun, B. Franch

12:30 – 13:30 **POSTER SESSION 1**

Land Surface Radiation and Inversion Modelling

Thermal Infrared remote sensing

Multispectral and Hyperspectral Remote Sensing and Imaging Spectroscopy

P1.01 Urban Albedo Estimation at Sub-Meter Scale: Integrating Airborne Observations with 3D Radiative Transfer Modeling

H. Joshi, University of Twente, The Netherlands

S. Gadde, W. Timmermans

P1.02 Towards a harmonized long-term surface albedo data record in the Copernicus Climate Change Service

J. Sánchez-Zapero, EOLAB, Spain

F. Camacho, E. Martínez-Sánchez, C. Toté, E. Swinnen, S. Gebruers, F. Perfetto

P1.03 Analyzing BRDF effects in Sentinel-2: global characterization and case study demonstration of the HABA algorithm

C. J. Guerrero Benavent, University of Valencia, Spain

B. Franch, I. Moletto Lobos, R. De Los Reyes, V. M. Betti, E. Vermote, S. Saunier

P1.04 Gap-filled operational land surface albedo at high spatial resolution from Sentinel-2 imagery: method presentation and validation

J. L. Roujean, CESBIO, France

B. Saulquin, J. Auclair, E. Ceschia, O. Hagolle

- P1.05 [Characterization of the Antarctic atmosphere, in the vicinity of the Antarctic Circle during austral summer, using atmospheric radiosoundings](#)
A. Calle, University of Valladolid, Spain
A.M. Burgos, J. Gatón, R. González, D. Mateos, R. Román, C. Toledano, C. Herrero, S. Herrero, D. González, V. Cachorro, A. de Frutos
- P1.06 [Synergistic Solar and Thermal Infrared Retrievals for Simultaneous Enhanced Dust Mineralogy and Trace Gas Characterization](#)
M. Herreras-Giralda, GRASP SAS, France
O. Dubovik, S. Victori, M. Momoi, Y. Zhang, J. Cuesta, M. Eremenko, W. Lin, D. Crozel, D. Fuertes
- P1.07 [Evaluating the impact of detailed LiDAR-based 3D tree reconstruction on centimetre-scale UAV hyperspectral simulations: an orchard case study](#)
K. Dia, ONERA/DOTA, France
N. Sikora, Y. Wang, N. Lauret, J.-P. Gastellu-Etchegorry, S. Fabre, K. Adeline
- P1.08 [Estimating nitrogen status across two major European rice systems using Sentinel-2 and EnMAP](#)
K. Cyran, University of Valencia, Spain
B. Franch, F. Della Bellver, I. Moletto-Lobos, C. Guerrero Benavent, C. Domingo, P. Piera, F. Nutini, M. Boschetti, I. Becker-Reshef
- P1.09 [Modeling time series of 3D vegetation energy balance and thermal infrared Earth observation with BALENO-DART](#)
A. Gourrat, CESBIO, France
Y. Wang, L. Lesage, N. Lauret, J. Guilleux, E. Chavanon, A. Kallel, Z. Malenovsky, T. Nguyen, O. Regaieg, M. Le Clec'h, J.-L. Roujean
- P1.10 [Joint Estimation of Surface Radiation Budget Components from MODIS Observations Using Multi-Task Learning Models](#)
J. Xu, University of Hong Kong, Hong Kong Special Administrative Region, China
S. Liang, H. Ma, W. Li
- P1.11 [Thermal characterization of two validation test sites over Peru: implications for Land Surface Temperature validation](#)
J. C. Jimenez, University of Valencia, Spain
C. Mattar, A. Santamaría-Artigas, J. Jesús Pasapera, J. A. Sobrino, R. Cruz, N. Salinas, E. Cosio, C. Eche, L. Fachin, J. Rengifo
- P1.12 [DART-EB: A large-scale Model of 3D Vegetation Energy Budget Simulating Thermal Infrared and Solar-Induced Fluorescence Remote Sensing Images](#)
L. Lesage, CESBIO, France
A. Gourrat, A. Kallel, T. Nguyen, N. Lauret, O. Regaieg, Y. Wang, Z. Malenovský, J. P. Gastellu-Etchegorry
- P1.13 [GloSVeT: A Global Monthly Soil–Vegetation Component Temperature Dataset Generated using a Multi-source Fusion Framework](#)
X. Liu, Chinese Academy of Agricultural Sciences, China
Z.-L. Li, S.-B. Duan, P. Leng
- P1.14 [Thermal Emissivity Estimation from VNIR-SWIR Reflectance: Evaluation of a Neural Network Approach in the TRISHNA context](#)
R. Nedelec, CESBIO, France
V. Rivalland, A. Olioso
- P1.15 [Assessment of LST retrieval algorithms for LSTM using simulated data under variable atmospheric conditions](#)
D. Skokovic, University of Valencia, Spain
J. A. Sobrino, J. C. Jiménez-Muñoz, R. Llorens, D. Salinas and S. Gimeno
- P1.16 [Multi-Nutrient Diagnosis in Winter Rapeseed Based on UAV Hyperspectral Imagery](#)
Q. Song, Chinese Academy of Agricultural Sciences, China

B. Xu

- P1.17** Adaptive Nonlinear-Enhanced Attention Network Based on Dense Nested U-Net for Infrared Small Target Detection
X. Zhang, Hebei GEO University, China
Y. Liu, X. Hou, G. Shang
- P1.18** Quantification of Urban Thermal Infrared Anisotropy at 60 m Scale from Airborne Measurements over Toulouse
Q. Dehaene, ONERA/DOTA, France
L. Roupioz, M. Irvine, F. Nerry, X. Briottet
- P1.19** Thermal anisotropy study in an urban canyon using the Discrete Anisotropic Radiative Transfer (DART) model
L. Wei, University of Valencia, Spain
J. A. Sobrino
- P1.20** Multiscale Land Surface Temperature (LST) Retrieval over Andean Mine Tailings Using Satellite Data Integration
C. Mattar, University of Chile, Chile
I. Moletto-Lobos, T. Acuña-Ruz, S. Castillo, T. Mir Bori

13:30 – 15:30 Lunch Break

15:30 – 17:10 **ORAL SESSION 2**

Land Surface Radiation and Inversion Modelling
Thermal Infrared remote sensing
Multispectral and Hyperspectral Remote Sensing and Imaging Spectroscopy

Chairs: O. HAGOLLE, E. VERMOTE

- S2.1** A new model for adjacency effect correction for optical earth observation imagers
K. Walcarus, CESBIO, France
J. Colin, M. Moulana, D. Ramon, O. Hagolle
- S2.2** Joint retrieval of atmospheric species and biosphere parameters
R. Giering, FastOpt, Germany
S. Blessing, C. von der Tol
- S2.3** Advances in DART Radiation Budget, Atmospheric Radiative Transfer, Thermal Emission and Error Propagation
Y. Wang, CESBIO, France
A. Gourrat, A. Benteyn, L. Lesage, Y. Karray, O. Regaieg, R. Demoulin, F. Ayari, Y. Liao, T. Nguyen, Z. Wang, Z. Zhen, T. Yin, N. Lauret, J. Guilleux, E. Chavanon, A. Kallel, F. André, Z. Malenovsky, J.-L. Roujean, J.-P. Gastellu-Etchegorry
- S2.4** LESS3: Interactive 3D radiative transfer simulation over heterogeneous vegetation canopies
J. Qi, Beijing Normal University, China
- S2.5** Surface albedo and emissivity for Belgian cities (SuaBe)
J. León-Tavares, VITO, Belgium
Z. Zhen, N. Kauret, J.-P. Gastellu-Etchegorry

17:10 – 17:40 Coffee Break

17:40 – 19:00 **ORAL SESSION 3**

Earth Observation Missions & Services

Chair: J. L. ROUJEAN, P. GAMET

S3.1 Land Surface Temperature Monitoring (LSTM) Mission Status and Data Processing

I. Barat, European Space Agency, ESTEC, The Netherlands

I. Fernandez, A. Garcia, S. Dransfeld, A. Novelli, A. Bolea, I. Manolis, F. Bernard, A. Chalew, K. Alonso, F. Gascon, B. Koetz, S. Proud, B. Tsonevska, M. Such, P. Mingorance

S3.2 TRISHNA mission: Scientific and algorithmic challenges in high-resolution thermal infrared processing and product generation

P. Gamet, CESBIO, France

E. Sarrazin, B. K. Bhattacharya, J.-L. Roujean, G. Boulet, A. Olioso, M. Weiss, N. Farhani, J. Etchanchu, S. Mbugu, V. Rivalland, M. Irvine, K. Mallick, O. Hagolle

S3.3 Measuring and modelling directional effects in the thermal infrared in the preparation of the TRISHNA mission: the TIRAMISU initiative in support of CalVal activities

J. L. Roujean, CESBIO, France

C. Pinnepalli, S. P. Thejaswini, M. Irvine, E. Rajasekaran

20:00-22:00 Welcome Reception

TUESDAY 22 SEPTEMBER 2026

9:00 – 10:40 ORAL SESSION 4

Land Surface Radiation and Inversion Modelling
Thermal Infrared remote sensing

Chairs: I. BARAT, F. NERRY

- S4.1** [The Land Surface Temperature Retrieval Algorithm for LSTM: An Overview and Results](#)
B. Courtier, Leicester University, UK
M. Perry, D. Ghent
- S4.2** [From Images to Numbers: Expanding Uncertainty frameworks for quantitative Earth Observation in the LSTM mission](#)
I. Fernández, European Space Agency, The Netherlands
F. Bernard, A. Garcia, I. Barat, I. Manolis, S. Dransfeld, A. Novelli, A. Bolea, A. Chalew, K. Alonso, F. Gascon, B. Koetz, S. Proud, B. Tsonevska, M. Such, P. Mingorance, C. Cox, M. Perry
- S4.3** [Enhancing the credibility of in-situ LST for satellite-derived land surface temperature validation](#)
J. Ma, University of Electronic Science and Technology of China, China
J. Zhou, F.-M. Göttsche, Z. Xiao, Z. Wang, T. Zhang, H. Wu, W. Tang, M. Li, X. Zhang, S. Wang, Y. Wang, S. Liu
- S4.4** [Component-Resolved Thermal Radiance Directionality in Structured Vineyard Canopies: A Single-Sensor Framework and Initial Evidence](#)
SP. Thejaswini, Indian Institute of Technology Bombay, India.
E. Rajasekaran, J.L. Roujean, M. Irvine, C. Pinnepalli
- S4.5** [Prevalence and drivers of abrupt land surface temperature shifts in natural vegetation lands](#)
J. Li, Chinese Academy of Agricultural Sciences, China.
Z.-L. Li, N. You

10:40 – 11:10 Coffee Break

11:10 – 12:30 ORAL SESSION 5

**Earth Observation Missions & Service
Evapotranspiration Inversion Techniques**

Chairs: C. TUCKER, Y. KERR

- S5.1** [NASA's EAGLE-VSWIR: Global Imaging Spectroscopy Measurements for Next Generation Objectives Spanning Mineral Exploration, Wildland Fire, Agriculture, Water Resources, Water Quality, and Scientific Research Across the Earth System.](#)
R. O. Green, Jet Propulsion Laboratory, California Institute of Technology, USA
D. Thompson, P. Brodick, D. Chadwick and the EAGLE-VSWIR Team
- S5.2** [The Fluorescence Explorer \(FLEX\) Mission: global scale quantification of the variability in the photosynthetic activity of terrestrial vegetation](#)
J. Moreno, IPL University of Valencia, Spain

S5.3 OpenET: Supporting Sustainable Water Management with Satellite-based Evapotranspiration Data

F. Melton, NASA Ames Research Center, USA

A. Ruhoff, S. Larsen, A. Purdy, C. Doherty, J. Volk, R. Allen, M. Anderson, L. Bleifuss, M. Bromley, B. Daudert, J. Eggleston, J. Fisher, M. Friedrichs, A. Guzman, C. Hain, J. Harding, T. Holmes, J. Huntington, K. Knipper, L. Johnson, A. Kilic, L. Laipelt, H. Liu, B. Minor, C. Morton, C. Pearson, P. ReVelle, G. Senay, Y. Yang

12:30 – 13:30 POSTER SESSION 2

Machine Learning in Remote Sensing

Global Change and Sustainable development

Carbon and Water Cycle Observation and Modelling

Evapotranspiration Inversion Techniques

P2.01 Kernel-Driven Model Correction of Thermal Directionality: Pixel-Level Analysis Using Airborne Multi-Angular Observations

L. Snyders, VITO, Belgium

M. Langsdale, J. Blommaert, J. León-Tavares

P2.02 Dry Biomass Estimation in Sahelian Pastoral Ecosystems: A Multi-Source Remote Sensing and Machine Learning Approach with Robust Spatial–Temporal Validation

H. Abdelmoula, VITO, Belgium

A. Vannoppen, A. Zakari, J. Degerickx

P2.03 Agentic AI for Environmental Impact Assessment of Construction Projects using Satellite Data

D. Skakun, Urbana High School, Maryland, USA

A. Shelestov, S. Drozd, A. Skakun

P2.04 Temperature Effects of Cropping Structure Adjustment in the Huang-Huai-Hai Plain

G. Shang, Hebei GEO University, China

Y. Hou, X. Zhang, Y. Liu, X. Liu

P2.05 Integrating Remote Sensing and Geospatial Analysis to Assess Environmental and Climatic Vulnerability and the Role of Peri-Urban Areas in Mediterranean Cities: The Cases of Valencia and Milan

C. Rivero Moro, University of Valencia, Spain

M. A. Gilabert, A. Pérez-Hoyos, E. López Baeza

P2.06 Integration of Multidimensional Data Cubes and Machine Learning for the Operational Monitoring of Aquaculture in the Spanish Mediterranean

A. Martín Olivo, Quasar Science Resources, Spain

A. B. Ruescas, M. Chowdhury, I. de la Calle

P2.07 Retrieval OF Gap-Free 20m 5-Day Vegetation Variables From Integrated Landsat And Sentinel-2 Analysis Ready Data

H. Ma, The University of Hong Kong, Hong Kong Special Administrative Region, China

S. Liang, Q. Wang

P2.08 Monitoring ecosystems through two decades of satellite-derived carbon and water use efficiencies

M. Campos-Taberner, University of Valencia, Spain

M. Vallés-Iborra, B. Martínez, S. Sánchez-Ruiz, A. Jiménez-Guisado, F.J. García-Haro, M.A. Gilabert

P2.09 Mapping Soil Organic Matter of the Black Soil Region in Northeast China based on Limited Samples Using TabPFN

K. Yang, Chinese Academy of Agricultural Sciences, China

M. Liu, X. Sang, X. Min, S.-B. Duan, L. Huang, R. Tang, Z.-L. Li

- P2.10 Artificial Intelligence for water and carbon fluxes estimation (AI4Fluxes) using in-situ and satellite data**
E. Martínez-Sánchez, EOLAB, Spain
F. Camacho, J. Sánchez-Zapero, J.B. Guillén
- P2.11 Long-Term Evapotranspiration Dynamics in River-basins of Contrasting Climate Region**
K. V. Athira, Luxembourg Institute of Science and Technology, Luxembourg
M. Machwitz, M. Sulis, K. Mallick
- P2.12 Estimation of net carbon fluxes of shrublands through the combination of remote sensing and the ecosystem process model Biome-BGC**
S. Sánchez-Ruiz, University of Valencia, Spain
M. Chiesi, L. Fibbi, F. Maselli, Campos-Taberner, M.A. Gilabert
- P2.13 Ensemble evapotranspiration and drought stress modelling at high spatial resolution for Denmark.**
E. Boegh, Climate Data Agency, Denmark
K. H. Kamper, G. B. Larsen, J. Vejby, T. Friborg, R. Schneider, S. Stisen
- P2.14 Mapping Evapotranspiration of Forest Watersheds from Remote Sensed Vegetation Fraction Cover and Water Balance Modelling**
A. Olioso, INRAE, France
C. Ollivier, G. Boulet, S. Mwangi, O. Marloie, N. Martin-StPaul, G. Simioni, A. Druel, A. Crespín-Boucaud, V. Léonardi, B. Loiseau, S. Carrière, R. Berthelin, J. Etchanchu, J. Demarty, V. Rivalland, P. Bérion, J.-B. Charlier, V. Hakoun, N. Mazzilli, V. Mercier, M. Weiss, Q. Chaffaut
- P2.15 Benefits of high-resolution satellite imagery for evapotranspiration estimation in Sahelian agro-silvo-pastoral Systems**
N. Farhani, Univ Montpellier, France
J. Etchanchu, S. Vauclaire, B. Goffin, T. Wijmer, G. Boulet, N. Chahinian, P. Gamet, A. Olioso, S. Mwangi, E. Sarrazin, K. Mallick, S. Mansour Diene, D. Mouhamadou Lamine Diongue, I. Maïnassara, O. Rouspard, J. Demarty
- P2.16 On the potential of constellr imagery for evapotranspiration: first analysis using several land surface energy balance algorithms**
S. Mwangi, INRAE, France
A. Olioso, O. Hagolle, E. Sarrazin, N. Farhani, B. Goffin, J. Etchanchu, J. Demarty, K. Mallick, V. Rivalland, P. Gamet, J.-L. Roujean, G. Triquet, D. Spengler, G. Boulet
- P2.17 All-Weather Crop Evapotranspiration at Plot Scale: Benchmarking Trishna L2 and L3 Algorithms Over Berambadi, India**
P. Kumar Amgoth, CESBIO, France
G. Boulet, M. Sekhar, A. Olioso, E. Sarrazin, J. Auclair, K. Mallick, P. Gamet, P. Fanise, C. Costaouec, L. Schmitt, B. K Bhattacharya, A. Das
- P2.18 Global Controls on Transpiration from 2000 to 2025**
P. Nandagopal, IIT, INDIA
E. Rajasekaran
- P2.19 Robustness of TRISHNA evapotranspiration algorithms (SWEAT): benchmarking STIC and EVASPA over diverse ecosystems**
S. Mwangi, INRAE, France
E. Sarrazin, G. Boulet, K. Mallick, A. Jia, J. Etchandu, N. Farhani, B. Goffin, J. Demarty, V. Rivalland, J. Auclair, B. Mateo-Herrera, O. Merlin, P. Gamet, O. Hagolle, J.-L. Roujean, A. Olioso
- P2.20 INMESAT project**
J. A. Sobrino, University of Valencia, Spain
S. Gimeno, Y. Julien, R. Llorens, A. Calle, J. C. Jiménez, D. Skokovic, G. Soria, B. Franch, D. Salinas, A. J. Sobrino-Gómez, L. Wei

13:30 – 15:30 Lunch Break

15:30 – 17:10 **ORAL SESSION 6**

Carbon and Water Cycle Observation and Modelling
Evapotranspiration Inversion Techniques

Chairs: A. OLIOSO, K. MALLICK

- S6.1** [Beyond Thermal: Stomatal Stress and Ecosystem Functioning in the TRISHNA Era Through Synergistic LST, SWIR, and VNIR Signals of Opportunity](#)
K. Mallick, CESBIO, France
G. Boulet, E. Sarrazin, Z. Pierrat, Z. Szantoi, C. Corbari, S. Mwangi, N. Farhani, J. Etchanchu, J. Demarty, A. Olios, P. Gamet, O. Hagolle, J.-L. Roujean
- S6.2** [Daily Evapotranspiration and Water Stress L2 products from the TRISHNA mission](#)
A. Olios, INRAE, France
G. Boulet, K. Mallick, E. Sarrazin, S. Mwangi, N. Farhani, A. Jia, B. Goffin, J. Etchanchu, C. Ollivier, V. Rivalland, O. Merlin, E. Rajasekaran, B. Matteo Herrera, J. Auclair, M. Weiss, S. Buis, J. Demarty, J.-L. Roujean, P. Gamet
- S6.3** [Towards the continuous L3 TRISHNA daily evapotranspiration product : some strategies under evaluation](#)
G. Boulet, CESBIO, France
A. Olios, E. Sarrazin, N. Farhani, K. Mallick, P. Gamet, V. Rivalland, P. Kumar Amgoth, M. Sekkar, B. K. Bhattacharya, A. Das
- S6.4** [Multi-scale monitoring of irrigation volumes and evapotranspiration by assimilating satellite land surface temperature and soil moisture into an energy-water balance model](#)
C. Corbari, Politecnico di Milano, Italy
N. Paciolla, C. Angeloni, S. Berendsen, J. Sheffield
- S6.5** [OpenET-Brazil: Advances in Field-Scale Evapotranspiration Estimation Using Landsat and Thermal Data Fusion for Water Security](#)
A. Ruhoff, Universidade Federal do Rio Grande do Sul, Brasil
L. Laipelt, G. Matte, J. Rossi, F. Linck, N. Viegas, W. Alves, F. Melton, S. Larsen, A. Purdy, J. Volk, R. Allen, M. Anderson, L. Bleifuss, M. Friedrichs, J. Fisher, A. Kilic, C. Morton, G. Senay, Y. Yang

17:10 – 17:40 Coffee Break

17:40 – 19:00 **ORAL SESSION 7**

Multispectral and Hyperspectral
Evapotranspiration Inversion Techniques
Machine Learning in Remote Sensing

Chair: C. CORBARI, K. ADELIN

- S7.1** [Challenges on monitoring the dynamics and evolution of evapotranspiration in Sahel from space](#)
J. Etchanchu, IRD, France
N. Farhani, S. Vauclaire, B. Goffin, T. Wijmer, G. Boulet, N. Chahinian, P. Gamet, A. Olios, S. Mwangi, E. Sarrazin, K. Mallick, S. Mansour Diene, D. M. L. Diongue, I. Maïnassara, O. Rounsard, J. Demarty

- S7.2 Intra-crown leaf chlorophyll content mapping in orchards from UAV imaging spectroscopy: improving laboratory model transfer with illumination correction
N. Sikora, ONERA/DOTA, France
S. Jay, K. Adeline
- S7.3 Resolving Canopy Thermal Extremes in Fragmented Amazonian Rainforests Using Thermal Infrared Downscaling
A. Kozhevnikova, University of Edinburgh, United Kingdom
S. King, D. Galbraith, E. Gloor, A. Lenzi, P. Meir, E. Mitchard
- S7.4 DART-AI Emulator of Bottom of Atmosphere Irradiance for VIS/TIR Remote Sensing Applications
Y. Karray, CESBIO, France
J.-P. Gastellu-Etchegorry, F. Ayari, J.-L. Roujean, A. Kallel

19:00 – 22:00 Dinner

WEDNESDAY 23 SEPTEMBER 2026

9:00 – 10:40 ORAL SESSION 8

From R&D to Operational Agriculture Monitoring
Land Cover/Use and Change

Chairs: S. GILLIAMS, B. FRANCH

- S8.1** [GEOGLAM: 15 years of Global Agricultural Monitoring](#)
S. Gilliams, GEOGLAM, Switzerland
- S8.2** [ARYA: Implementing an EO-based crop yield forecasting model across different countries and crops](#)
B. Franch, University of Valencia, Spain
I. Moletto-Lobos, J. Tarín-Mestre, V. Betti, E. Vermote, N. Kalecinski, S. Skakun, I. Becker-Reshef, L. de Simone
- S8.3** [ANN-PROSAIL model to estimate quality and digestibility of alfalfa forage from Sentinel-2 imagery](#)
G. Panza, University of Siena, Italy
J. L. Pancorbo, A. Dal Prà, L. Brilli, C. Camino, L. Genesio, S. Maccherini, B. Gioli
- S8.4** [Next-Generation Global Land Cover and Consistent Change Mapping at 10 m Resolution in The Copernicus LCFM Service](#)
Georgia Milli, VITO, Belgium
D. Zanaga, R. Van De Kerchove, W. De Keersmaecker, J. Coddé, Y. Kalfas, M. De Vroey, C. Toté, V. Verhaert, L. Bertels, A. Verhegghen, M. Goudar, F. Perfetto, M. Lesiv, S. Fritz, A. Lupi, R. Colditz, F. Achard, A. Brink

10:40 – 11:10 Coffee Break

11:10 – 12:30 ORAL SESSION 9

Land Cover/Use and Change
Earth Observation Missions & Services

Chairs: R. O. GREEN, G. GUTMAN

- S9.1** [SMOS after 16 years in operation: Results, Lessons Learnt and Remaining Challenges](#)
Y. H. Kerr, CESBIO, France
The SMOS team
- S9.2** [Impact of Selection Bias in Training Data on Model and Map Accuracy Assessment and Area Estimation](#)
S. Skakun, University of Maryland, USA
- S9.3** [Revisiting Land Remote Sensing Issues: Lessons Learned 30 years ago](#)
G. Gutman, NASA LCLUC Program Manager, Retired, USA

12:30 – 13:30 POSTER SESSION 3

Inversion of Evapotranspiration
Land Cover/Use and Change
From R&D to Operational Agricultural Monitoring
Urban Heat Island Mapping and Mitigation

- P3.01 [Towards a digital twin for physical and socio-economic analysis of coastal systems using artificial intelligence: the TWINPEACS-HUMAN project.](#)
A. B. Ruescas, University of Valencia, Spain
M. Sapena, C. Zornoza, F. Goerlich, F. Fajardo
- P3.02 [Early Prediction of *Delottococcus aberiae* outbreaks in Valencian Citrus using Sentinel-2 and machine learning](#)
A. Guillem Valls, University of Valencia, Spain
B. Franch, F. Della-Bellver, C. J. Guerrero-Benavent, S. Vacas
- P3.03 [Characterizing Late Frost Impacts on Winter Wheat Yield Using Remote Sensing, Climatic Indicators, and Cluster-Based Analysis](#)
S. Cogollos Soler, University of Valencia, Spain
I. Moletto-Lobos, B. Franch, J. Tarín-Mestre, V. Betti, E. Vermote
- P3.04 [Influence of Rice Variety on Nitrogen Level Classification and Yield Modeling Using UAV-Based imagery](#)
F. Della-Bellver, University of Valencia, Spain
B. Franch, J. Tarin-Mestre, C. J. Guerrero-Benavent, C. Domingo, M. Català Forner, K. Martí, L. Marqués
- P3.05 [Beyond Oblast: Improving Wheat Yield Forecasts in Russia with the ARYA Algorithm](#)
I. Moletto-Lobos, University of Valencia, Spain
B. Franch, N. Kalecinski, W. Anderson, J. Tarín-Mester, V. Betti, E. Vermote, I. Becker-Reshef, S. Ehrmann, C. Meyer
- P3.06 [Yield Forecasting in Data-Sparse Regions: Applying the ARYA Model and Evaluating Autonomous Crop Mapping in Zimbabwe](#)
J. Tarín-Mestre, University of Valencia, Spain
B. Franch, I. Moletto-Lobos, V. Betti, L. de Simeone, C. Justice, R. Sahajpal
- P3.07 [Millions of Artillery Craters in Agricultural Fields Impact Crop Production in Ukraine Due to the Ongoing War](#)
S. Skakum, University of Maryland, USA
E. Duncan, L. Shumilo, N. Kussul, J. Wagner, I. Becker-Reshef
- P3.08 [Reference Area Selection in Surface Urban Heat Island analysis over the Iberian Peninsula](#)
S. Arribas, University of Valencia, Spain
L. Pérez-Planells, R. Niclòs, E. Valor
- P3.09 [Air or Surface temperatures in urban environment : confusion and synergy](#)
A. Michel, ONERA-DOTA, France
Y. El Khanoussi, V. Masson, G. Dumas, J. Hidalgo, V. Lonjou
- P3.10 [Downscaling MODIS land surface temperature to 70 m resolution for surface urban heat island analysis using XGBoost](#)
L. Pérez-Planells, Mediterranean Center for Environmental Studies (CEAM), Spain
S. Khodayar
- P3.11 [A diagnostic methodology to assess urban districts' overheating](#)
A. Rodler, CEREMA BPE/IRSTV, France
M. Musy, F. André, N. Beaugendre, X. Briottet, R. Cifuentes La Mura, T. Gresse, J-C. Krapez, L. Merlier, F. Nerry, J. Pierro, L. Roupioz, D. Yao
- P3.12 [Analysis of the Impact of Climate Change in the World's Large Agglomerations: Modelling, Determinants and Multiscale Characterisation of SUHI](#)
D. Salinas-González. University of Valencia, Spain
J. A. Sobrino, D. Skokovic
- P3.13 [Large-Scale Tree Species Mapping from PRISMA Data: Comparison of two methods for Hyperspectral Dimensionality Reduction](#)
M. Chesneau, Aix Marseille University, France
A. Ahmad, T. Olive, G. Dubrasquet-Duval, S. Bourennane, M. Adel

- P3.14 **High-density thermo-hygrometric observations for urban heat and thermal exposure assessment in Valencia (Spain)**
S. Gavila-Lloret, CEAM, Spain
J. A. Valiente-Pardo, S. Khodayar
- P3.15 **A Radiometric Correction Framework for High-Resolution Surface Urban Heat Island Characterization Using HyTES**
S. Vega Parra, University School for Advanced Studies IUSS Pavia, Italy
S. J. Hook, G. Hulley, F. Rabuffi, J. A. Sobrino, F. Despini, S. Costanzini, S. Teggi
- P3.16 **UCG-FireDetection: An Open-Access Remote Sensing Platform for Burned Area Mapping and Wildfire Severity Assessment in Spain**
R. Llorens, University of Valencia, Spain
J. A. Sobrino, B. Franch
- P3.17 **SIDENCA: An EO-based framework for climate risk and emergency management using multi-source data**
A. Pérez-Hoyos, Albavaler, Spain
G. Tárrega, J. Belenguer, R. Díaz, J. C. García González, J. J. Cubillos Esteve, P. Juan Verdoy, S. Chaudhuri, J. J. Samper, D. García-Rodríguez, J. F. García Calderaro
- P3.18 **Development of an operational enhanced product for the detection of Burnt Area and Fire Severity by combining high resolution optical and thermal imagery**
S. Arioli, University of Strasbourg, France
M. Mauger-Vauglin, S. Battiston, V. Bouvier, P. Ferrage, R. Rodriguez-Suquet
- P3.19 **A Multi-Temporal Satellite Framework for Quantitative Monitoring of Seagrass Degradation and Restoration**
Y. Zou, National Satellite Ocean Application Service, Ministry of Natural Resources, China
J. Tang, Z. Ouyang, Y. Lu

13:30 – 15:30 Lunch Break

15:30– 17:10 **ORAL SESSION 10**

Remote Sensing of Forest
Urban Heat Island Mapping and Mitigation Strategies

Chairs: J.-P. WIGNERON, W. TIMMERMAN

- S10.1 **Satellite-based monitoring of the carbon budget of forests in tropical and boreal regions from VOD and IA-based high-resolution methods**
J.-P. Wigneron, INRAE, France
P. Ciais, X. Li, L. Fan, Y. Liu, X. Liu, F. Frappart
- S10.2 **Unveiling Amazon Forest Vertical Dynamics through Multifrequency Microwave Radiometry**
M. El-Khayati-Ramouz, Technical University of Catalonia, Spain
C. López-Martínez, M. Vall-Ilossera, A. Camps, A. Turiel, A. Alonso-González, G. Portal, A. Mustofa Irawan, M. Herrera, P. Villalvilla, J. Li
- S10.3 **Human accessibility shapes global forest greening and browning**
S. A. Schauman, CREAM, Spain
A. Verger
- S10.4 **Geospatial Identification of Wildfire Risk Areas in the Urban-Wildland Interface using Remote Sensing and Gis Techniques**
A. Novo, Misión Biológica de Galicia- CSIC, Spain
I. Martínez-Fernández, C. Fernández

- S10.5** [Incorporating airborne observations for realistic urban heat stress modelling: First results](#)
W. Timmermans, University of Twente, The Netherlands
S. Gadde, H. Joshi, L. Roupioz

17:10 – 17:40 Coffee Break

17:40 – 19:00 **ORAL SESSION 11**

Sensor Calibration, Atmospheric Correction and Product Validation

Chair: L. ROUPIOZ, J. BLOMMAERT

- S11.1** [Lunar Radiometric Calibration for Earth Observation in the Mid-Wave and Thermal IR using Thermo-Physical Models](#)
C. Mollière, OroraTech, Germany
K. Wohlfarth, T. Müller, [J. Blommaert](#), D. Nuyts, M. Seifert, J. Gottfriedsen
- S11.2** [Uncertainty-Aware Validation of Sentinel-3 OLCI GI-FAPAR: The Role of Spatial Representativeness and Matchup Strategy](#)
A. Pérez-Hoyos, Albavador, Spain
Z. Ma, B. Wu
- S11.3** [Current Status of Sentinel-3 SLSTR LST Validation and Exploratory NDVI-Based Analysis of Matchup Representativeness](#)
V. Taurino, ACRI-ST, France
S. Clerc, C. Henocq, D. Ghent, E. de Luca, P. Paolino, S. Dransfeld
- S11.4** [Evolution, validation and new application of Land Surface Temperature product on FY-3 Meteorological Satellite](#)
L. Dong, Key Laboratory of Radiometric Calibration and Validation for Environmental Satellites, China.
L. Fan, N. Kang, L. Chen, N. Xu

THURSDAY 24 SEPTEMBER 2026

9:00 – 10:40 ORAL SESSION 12

Sensor Calibration, Atmospheric Correction and Product Validation

Chair: F. CAMACHO, J. WAGNER

- S12.1** [Towards a Consistent Multi-sensor Vegetation Product: Validation of the ESA CCI+ VP CDRP-2 Dataset](#)
F. Camacho, EOLAB, Spain.
J. Sánchez-Zapero, E. Martínez-Sánchez, S. Blessing, R. Giering, C. Van der Tol, K. Vanhoof, E. Swinnen
- S12.2** [Open Crop LAI DB: harmonized in-situ Leaf Area Index data for decametric satellite product validation and applications](#)
J. Wagner, University of Strasbourg, France
M. Boschetti, Y. Sadeh, N. Sasi Rajan, F. Nutini, X. Bailleau, M. Gupta, I. Becker-Reshef
- S12.3** [Validation of CLMS NDVI and GPP products using independent in-situ data](#)
S. Gebruers, VITO, Belgium
E. Swinnen, C. Toté
- S12.4** [Validation of Sentinel-2 surface reflectance products with RadCalNet and HYPERNETS data](#)
R. de los Reyes, German Aerospace Center, Germany
E. Padilla, D. Marshall-Ingram, J. Louis, C. Guerrero, B. Pflug, F. C. Pignatale, F. Poustomis, A. Bialek, P. De Vis, M. Sinclair, A. Zimmermann, S. Clerc, S. Enache, V. Boccia, F. Gascon

10:40 – 11:10 Coffee Break

11:10 – 12:30 ORAL SESSION 13

Passive and active Fluorescence

Chair: P. J. ZARCO-TEJADA, C. VAN DER TOL

- S13.1** [Comprehensive assessment of SIF and photosynthetic pigment dynamics under a/biotic stress using sub-nanometer and narrow-band hyperspectral imagery](#)
P. J. Zarco-Tejada, IAS, Spain
V. Gonzalez Dugo, N. Wang, T. Vishwanath Harish, T. Poblete, P. Peña, A. Belwalkar, P. Yang, W., Choi, A. Hornero, R. Calderon1, C. Camino, B. B. Landa, J. A. Navas Cortes, Y. Ryu
- S13.2** [Joint retrieval of fluorescence quantum efficiency and fAPAR from SIF and multi-mission reflectance](#)
C. Van der Tol, University of Twente, The Netherlands
S. Blessing, R. Giering, K. Vanhoof, E. Swinnen
- S13.3** [An integrated framework coupling geometric-optical and spectral invariants for canopy fluorescence anisotropy modeling](#)
Y. He, China Agricultural University, China
Y. Zeng

12:30 – 13:30 **POSTER SESSION 4**

Global Change and sustainable development
Remote Sensing of snow and ice
Sensor Calibration, Atmospheric Correction and Product Validation
Passive & active Microwaves Data Processing Applications
Passive and active Fluorescence
Earth Observation Missions & Services

- P4.01** [Deployment of a calibration station for satellite-based observations of greenhouse gases and aerosols](#)
A. Calle, University of Valladolid, Spain.
R. González, O. García, R. Carracedo, D. Mateos, R. Román, C. Toledano, V. Cachorro, A. de Frutos, R. Ramos, C. Torres
- P4.02** [RemoTrees: A Novel In-situ Monitoring Technology for Hard-to-Reach Forests Supporting EO Land Product Validation](#)
F. Camacho, EOLAB, Spain
E. Martínez-Sánchez, J. Sánchez-Zapero, D. Andreatta, L. Beileli Marchesini, L. Salvino, Loris Vescovo, C. Mestre Runge, L. Opgenoorth, B. Brede, C. Lotz, R. Valentini
- P4.03** [Assesment of Google Earth Engine Applications to Generate Land Surface Temperature Maps at high spatio-temporal resolutions](#)
V. García-Santos, University of Valencia, Spain
A. Buil, J. M. Sánchez, C. Coll, R. Niclòs, J. Puchades, M. Perelló, L. Pérez-Planells, J. M. Galve, E. Valor
- P4.04** [High-resolution modelling of land surface temperature dynamics using multi-annual ECOSTRESS and Landsat data](#)
L. Pérez-Planells, CEAM, Spain
F.-M. Götsche, J. Cermak
- P4.05** [Validation of the KP Labs Multi-Class Cloud Segmentation Processor and Its Comparison to the Sentinel-2 L2A Scene Classification Map](#)
E. Padilla, German Aerospace Center (DLR), Germany
B. Grabowski, K. Kotowski, J. Nalepa, R. de los Reyes, D. Marshall-Ingram, S. Clerc, S. Enache, J. Louis, F. C. Pignatale, L. De Laurentiis, V. Boccia, F. Gascon
- P4.06** [Validation of the global 300m Land Surface Phenology V2 products of the Copernicus Land Monitoring Service](#)
J. Sánchez-Zapero, EOLAB, Spain
F. Camacho, E. Martínez-Sánchez, L. Eklundh, H. Jin, R. Lacaze, D. de Munck, D. Bekaert
- P4.07** [CLMS Global 300 m LAI, FAPAR and FCOVER from PROBA-V to Sentinel-3: Reprocessed 2014–2024 Time Series and Near-Real-Time Monitoring](#)
A. Verger, CIDE, CSIC-UV-GVA, Spain
J. Sánchez-Zapero, M. Weiss, E. Martínez-Sánchez, F. Camacho, A. Descals, S. Schauman, F. Baret, R. Lacaze
- P4.08** [EarthCARE observations of the extreme wildfire aerosols over the Iberian Peninsula during summer 2025](#)
S. Cogollos, University of Valencia, Spain
C. Dameto de España, P. D. Villarroya, W. Moná, P. C. Valdelomar, M. P. Utrillas
- P4.09** [Spatiotemporal Trends of Soil Moisture over the Iberian Peninsula from ESA CCI Satellite Data \(1988–2024\)](#)
G. Tomás-Portalés, University of Valencia, Spain
R. Niclòs, E. Valor

- P4.10 Decoupling structural and physiological controls on SIF–GPP relationships using 3D radiative transfer and in situ multi-sensor observations
S. Desguets, CESBIO, France
P. Fanise, T. Tallec, J.-P. Gastellu-Etchegorry, V. Le Dantec
- P4.11 Development of a High-Sensitivity, Fast-Acquisition LWIR Radiometer for Airborne Surface Temperature Mapping
N. Buis, ZeFrog, France
J. A. Sobrino
- P4.12 Methodology for SAR Image Resolution Enhancement through the Combination of Multi-Satellite Acquisitions
J. M. Cuerda Muñoz, INTA, Spain
M. García Rodríguez, M. J. González Bonilla
- P4.13 Satellite-based bioclimatic classification and evolution over peninsular Spain
A. García-Ten, University of Valencia, Spain
R. Niclòs, E. Valor, J. Vedri, M. J. Estrela
- P4.14 Standardized validation of global Data Record LAI, FAPAR and FVC products derived from AVHRR onboard the EUMETSAT Polar System
E. Martínez-Sánchez, EOLAB, Spain
F. Camacho, J. Sánchez-Zapero, F.J. García-Haro, M. Campos-Taberner, A. Jiménez-Guisado
- P4.15 Near real time monitoring through remote sensing within the framework of the INMESAT project
Y. Julien, University of Valencia, Spain
J. A. Sobrino, R. Llorens, S. Gimeno
- P4.16 EarthWatch: Bridging Earth Observation Science and Decision Support
A. Verger, CIDE, CSIC-UV-GVA, Spain.
E. Olmedo, 100+ EarthWatch members
- P4.17 SIRIUS: A Small-Satellite Thermal Infrared Mission Concept for Urban Heat Island Monitoring
J. A. Sobrino, University of Valencia, Spain
SIRIUS Team
- P4.18 Performance assessment of Landsat 8/9 and ECOSTRESS LST products over snow in mountain terrain
S. Arioli, University of Strasbourg, France
G. Picard, S. Gascoin, L. Arnaud
- P4.19 Multi-Polarimetric Power Features for PolSAR Land Cover Classification via Convolutional Neural Networks
S. Zhang, National University of Defense Technology, China
Z. Dong, Z. Zhang, Y. Zou, W. An

13:30 – 15:30 Lunch Break

15:30 – 17:10 **ORAL SESSION 14**

Earth Observation Missions & Services

Chairs: M. J. GONZALEZ BONILLA, R. DIAZ-DELGADO

S14.1 [ALIANZA OBSERVA: Strategic Network for Satellite Earth Observation](#)

M. J. González Bonilla, INTA, Spain

A. Turiel, D. de la Mata, I. Caballero, T. Lamelas, F. Aguilar, M. Béjar, J.A. Sobrino, E. Vega, N. Alfaro

S14.2 [The development of Real Time BNU Satellite and its Applications](#)

J. Fan, Beijing Normal University, China

S14.3 [The Programme of Earth Observation of the Spanish Space Agency \(AEE\)](#)

R. Díaz-Delgado, AEE, Spain

20:00 Gala Dinner

FRIDAY 25 SEPTEMBER 2026

10:00 – 11:30 Session report by session's chairpersons

Chair: J. A. SOBRINO

11:30 – 12:00 Closing ceremony

12:00 – 13:15 Refreshments & Snacks

47 YEARS OF VEGETATION INDICES

Compton Tucker, Jorge Pinzon, and Joanna Joiner

*NASA/Goddard Space Flight Center
Greenbelt, MD 20771 USA*

Vegetation indices are widely used in remote sensing with > 67,000 articles and >8000 symposium proceedings to date according to the Web of Science as of August 11, 2025. We review vegetation indices by updating the work of Tucker (1979), the first journal article on vegetation indices, and the first-principals work of Sellers et al. (1993) on the function of red and near-infrared spectral vegetation indices. We show many of the vegetation indices use the NDVI as their kernel and not all vegetation indices are equal. Normalizations of satellite data to a sun-target-sensor, atmospheric correction, and incorporation of solar-induced fluorescence all establish a direct link to photosynthetic capacity and stomatal conductance.

Sellers, P. J., J. A. Berry, G. J. Collatz, C. B. Field, and F. G. Hall 1992. Canopy reflectance, photosynthesis, and transpiration. III. A reanalysis using improved leaf models and a new canopy integration scheme. *Remote Sensing of Environment* 42(3):187-216. [https://doi.org/10.1016/0034-4257\(92\)90102-P](https://doi.org/10.1016/0034-4257(92)90102-P).

Tucker, C. J. 1979. Red and photographic infrared linear combinations for monitoring vegetation. *Remote Sensing of Environment* 8(2):127-150. [https://doi.org/10.1016/0034-4257\(79\)90013-0](https://doi.org/10.1016/0034-4257(79)90013-0)

ADVANCES IN THE AUTOMATED GROUND BASED VALIDATION OF REMOTELY SENSED SURFACE REFLECTANCE

E. Vermote¹, J. McCorkel², W.H. Rountree^{1,3}, A. Santamaria-Artigas^{1,3}, S. Skakun^{1,3} & B. Franch^{3,4}

¹NASA/GSFC Code 619, eric.f.vermote@nasa.gov Phone: +1 240 521 7791

²NASA/GSFC Code 618

³University of Maryland, College Park

⁴Universitat de València, Valencia

The directional surface reflectance product is a critical input for generating downstream products such as Vegetation Indices (VI), Leaf Area Index (LAI), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Bidirectional Reflectance Distribution Function (BRDF), Albedo, and Land Cover. The Surface Reflectance Fundamental Climate Data Record needs to be of the highest possible quality, so that minimal uncertainties propagate in the dependent/downstream products. One challenge is obviously the validation of the surface reflectance. It implies gathering enough surface observations through time and space. Unfortunately, the direct validation is limited to episodic field campaigns, or is continuous in time but is extremely limited in space (around 10m x 10m area) over homogeneous site (e.g. RADCALNET). Although, some indirect validation has been used to enable continuous and globally representative validation by using very detailed atmospheric characterization from AERONET data and accurate radiative code, these efforts have inherent limitations to what can be achieved. Here we describe an automated camera system (CAMSIS) mounted at a height of 123 meters on a TV tower (WLEF) near Park Falls, WI at the Chequamegon National Forest and at the El Palmar location (~20km from Valencia, Spain) at a height of 96 meters. This system provides data for the continuous validation of surface reflectance over a 200m x 200m area at the pixel level for high spatial resolution sensors (better than 30m).

CAMSIS consists of four monochrome cameras fitted with 470, 550, 650, and 850 nm filters. A 50% reflectance target mounted on a motorized arm provides a reference for calibration of the raw imagery. The system is installed on a tower with a view zenith angle of 45°. Data capture and transfer is automated at satellite overpass. Several processing steps are applied before CAMSIS data are used for validation. The Raw Data are corrected for dark current and flat fielded. The images pairs are then absolutely calibrated using a 50% calibration reference target. The Calibrated pairs are checked for possible changes in capture conditions

(e.g. cloud shadows) and composited together to remove the target from view. The calibrated and composited images are then georeferenced with ground control points selected from very high spatial resolution aerial imagery (USDA). Georeferenced images are resampled to the corresponding satellite grid with a mean filter. In addition, BDRF correction are applied to the CAMSIS data which spawn through a large range of view zenith (~up to 70deg) and azimuth angle to put them as the same observation geometry as the satellite data they are compared to. This system is associated with two sky cameras for cloud mask validation (SKYCAM) and is completed by a AERONET Sun Photometer. We present initial results that show good agreement with Sentinel-2A,B and Landsat 8,9 surface reflectance derived from our generic Land Surface Reflectance Code (LaSRC).

URBAN ALBEDO ESTIMATION AT SUB-METER SCALE: INTEGRATING AIRBORNE OBSERVATIONS WITH 3D RADIATIVE TRANSFER MODELING

Heet Joshi*, Srinidhi Gadde, and Wim Timmermans

Department of Geosciences, Faculty of Geo-Information Science and Earth Observation, University of Twente, Enschede, The Netherlands

** heet.joshi@utwente.nl, Tel: +31 53 489 5923*

Quantifying the surface energy balance is fundamental to understanding urban heat dynamics, with radiative fluxes acting as the primary driver of energy exchange within the urban system. Accurate estimation of radiative fluxes requires reliable estimation of radiative properties such as surface albedo and emissivity. However, satellite-based observations are often constrained by coarse spatial resolution, limiting their ability to resolve the spatial complexity of urban environments. The presence of heterogeneous materials, intricate urban morphology, and directional reflectance effects associated with three-dimensional (3D) structures introduces substantial uncertainty in conventional retrieval approaches.

To characterize urban material properties, an airborne measurement campaign was conducted over the city of Enschede, the Netherlands, acquiring hyperspectral imagery at sub-meter spatial resolution. The campaign utilized state of the art sensors, including CASI-1500 (380-1050 nm), SASI-600 (950-2450 nm), and TASI-600 (8000-11500 nm), enabling comprehensive spectral coverage from the visible to the thermal infrared domain. These data provide detailed insight into the spectral and spatial variability of urban surfaces.

In this study, we obtain an estimation of roof and facade albedo using the airborne hyperspectral imagery of spatial resolution 0.4 m employing the optical properties inversion module of the DART 3D radiative transfer model. The modeling framework explicitly represents urban geometry, allowing for improved treatment of directional reflectance and shadowing effects. The retrieved albedo values are evaluated against the ground measurements collected using an albedometer, demonstrating good agreement and the capability to capture fine-scale spatial variability. Furthermore, the study investigates the influence of urban morphological parameters and sub-pixel heterogeneity on albedo estimation. The findings highlight the importance of incorporating 3D structural information and high-resolution observations to reduce uncertainties in urban radiative flux assessments.

This work contributes to shows the importance of coupling 3D radiative transfer modeling with airborne hyperspectral data to better represent urban surface properties which improves the representation of urban surfaces in energy balance studies and supports more accurate modeling of urban heat dynamics.

TOWARDS A HARMONIZED LONG-TERM SURFACE ALBEDO DATA RECORD IN THE COPERNICUS CLIMATE CHANGE SERVICE

J. Sánchez-Zapero¹, F. Camacho¹, E. Martínez-Sánchez¹, C. Toté², E. Swinnen², S. Gebruers², F. Perfetto²

¹ EOLAB, Spain; ² VITO, Belgium

* Corresponding author: jorge.sanchez@eolab.es; Tel.: +34 963769448.

The Copernicus Climate Change Service (C3S) provides long-term Climate Data Records (CDRs) of Essential Climate Variables derived from satellite observations, including surface albedo (SA). The current C3S SA record, freely accessible through the C3S Climate Data Store (<https://cds.climate.copernicus.eu/>), spans from 1981 to present, combining multiple sensors: NOAA-AVHRR (1981–2005), SPOT-VGT (1999–2014), PROBA-V (2014–2020), and Sentinel-3 OLCI&SLSTR (2018–present). However, differences in retrieval approaches across missions still limit the consistency and homogeneity of the long-term record.

This contribution focuses on the development of the new C3S SA version 4.0 (v4.0), aimed at generating a harmonized 1 km albedo CDR from SPOT-VGT, PROBA-V and Sentinel-3 (1999–present). The approach builds upon the most advanced current Sentinel-3 retrieval scheme (v3.1), which is taken as baseline for cross-sensor harmonization.

This version introduces key algorithmic improvements. BRDF model coefficients are retrieved using a temporally regularised inversion approach (ReBels), combined with prior information from MODIS MCD43 climatology. Spectral albedo is derived for selected OLCI and SLSTR channels, and subsequently converted into broadband albedo (visible, NIR and total shortwave). The narrow-to-broadband conversion coefficients are obtained from a globally representative training dataset, accounting for a wide range of atmospheric and surface conditions. Additionally, separate coefficients are derived for black-sky and white-sky albedo, representing a novelty with respect to existing products (e.g., MODIS/VIIRS, LSA SAF).

Sentinel-3-derived albedo products play a central role in this framework, providing the most accurate and physically consistent estimates for snow-free land surfaces and serving as a reference for multi-mission harmonization. This approach supports the generation of a consistent long-term albedo CDR exceeding 25 years, suitable for climate applications.

The validation process is supported by the Committee on Earth Observation Satellites (CEOS) Land Product Validation (LPV) -endorsed Surface ALbedo VALidation (SALVAL) system, which ensures transparency, consistency, and traceability. The SALVAL online platform integrates the core components of an operational validation framework: long-term satellite albedo datasets, an in situ database of spatially representative sites, standardized validation protocols (CEOS-LPV guidelines), and an online evaluation environment. This framework enables the achievement of the highest CEOS LPV validation stage (level 4), while supporting continuous updates of validation results.

ANALYZING BRDF EFFECTS IN SENTINEL-2: GLOBAL CHARACTERIZATION AND CASE STUDY DEMONSTRATION OF THE HABA ALGORITHM

C. J. Guerrero Benavent¹, B. Franch^{1,2}, I. Moletto Lobos¹, R. De Los Reyes³, V. M. Betti¹, E. Vermote⁴, S. Saunier⁵

¹ Global Change Unit, Parc Científic, University of València (Paterna), 4498, Spain,
cesar.guerrero@uv.es, belen.franch@uv.es, italo.moletto@uv.es,

² Dept of Geographical Sciences, University of Maryland, College Park MD 20742, United States.

³ Remote Sensing Technology Institute, German Aerospace Center (DLR), Oberpfaffenhofen, Germany;
Raquel.delosReyes@dlr.de

⁴ NASA Goddard Space Flight Center Code 619, 8800 Greenbelt Road, Greenbelt, MD 20771, USA;
eric.f.vermote@nasa.gov

⁵ Telespazio France, Satellite System and Operation, ²⁶ Avenue JF Champollion, BP 52309, CEDEX ¹,

31023 Toulouse, France; Sebastien.Saunier@telespazio.com

Sentinel-2 acquisitions are characterized by near-nadir viewing geometries, which partially mitigate angular effects. Nevertheless, these effects persist due to seasonal variations in Solar Zenith Angle (SZA), the relative illumination–observation geometry expressed by the Relative Azimuth Angle (RAA), and the intrinsic anisotropy of surface targets. This study is structured in two complementary components. First, a global quantification and assessment of angular effects is conducted through the construction of a five-year Sentinel-2 L2A surface reflectance database (bands B4 and B8), considering 5000 tiles and up to 800 samples per tile with known land cover, all located within overlap regions of different relative orbits. Paired observations acquired under contrasting angular configurations are used to compute reflectance differences over short temporal intervals, revealing discrepancies that frequently exceed L2A surface reflectance uncertainty requirements under the assumption of reflectance invariance. This statistical framework enables the estimation of a probability of Bidirectional Reflectance Distribution Functions (BRDF)-affected observation pairs as a function of typical Sentinel-2 angular configurations, parameterized by the scattering angles of forward and backward orbits (Θ_{for} , Θ_{back}). These probabilities are subsequently organized into a lookup table (LUT) and mapped spatially to generate a grid-based product describing the annual evolution of BRDF effects for different land cover types. Second, site-specific case studies and mitigation assessment are performed over two tiles in Namibia and central Spain. These analyses demonstrate that angular effects introduce an important seasonal signal, with orbit-dependent magnitudes that lead to systematic biases between consecutive acquisitions from different relative orbits. The magnitude of these biases reaches absolute values between 0.03 and 0.07 during periods of minimum SZA. The strongest effects are associated with backscattering configurations approaching near hot-spot conditions. To address these limitations, the High Resolution Adjusted BRDF Algorithm (HABA) is applied as an operational normalization approach. By converting surface reflectance to Nadir BRDF-Adjusted Reflectance (NBAR) under standardized illumination conditions, HABA effectively removes angular-induced seasonality over bare soils and reduces orbit-dependent biases by approximately 50% over tree canopies. This normalization further results in a substantial reduction in time series noise (23%–60%) and significantly reduces correlation between reflectance and angular variables across all samples.

GAP-FILLED OPERATIONAL LAND SURFACE ALBEDO AT HIGH SPATIAL RESOLUTION FROM SENTINEL-2 IMAGERY: METHOD PRESENTATION AND VALIDATION

Jean-Louis Roujean, Bertrand Saulquin, Jérémy Auclair, Eric Ceschia, Olivier Hagolle
 CESBIO, Université de Toulouse, CNES/CNRS/INRAE/IRD, ¹⁸ avenue E. Belin, Toulouse, France
 Contact: jean-louis.roujean@utoulouse.fr, saulquin.bertrand@gmail.com, jeremy.auclair@ird.fr,
eric.ceschia@inrae.fr, olivier.hagolle@cnes.fr

Surface albedo is an Essential Climate Variable (ECV) that requires a routine and coherent update at global scale in order to ensure reliable estimates of the water and carbon fluxes. An operational method is implemented to map surface albedo at high resolution, which is based on an approach previously developed for PROBA-V satellite in the framework of the Copernicus Global Land Service. The method considers Level 2A Sentinel-2 (S2) issued from MAJA (MACCS-ATCOR Joint Algorithm) processing chain aimed at removing atmospheric components (cloud, water, aerosol) on the signal. A semi-empirical BRDF (Bidirectional Reflectance Distribution Function) kernel-driven model of reflectance is applied to Level 2A S2 to retrieve BRDF parameters.

Then, a weighed angular integration of the directional kernels allows deriving both directional-hemispherical (DHR) and bi-hemispherical reflectance (BHR) reflectance, namely surface albedo products. Finally, a narrow to broadband albedo conversion is achieved based on coefficients issued from a huge number of PROSAIL model simulations. In fine albedo products are at 10 meters spatial resolution and blue-sky albedo (BSA) derived as a combination of DHR and BHR weighed by diffuse sky fraction. Time series

are gap-filled of BSA in using a Kalman filter approach in giving appropriate weights to the a priori information and the innovative information.

The validation is carried on prairies sites permanently equipped from 2020 of pyranometers over experimental farms. This ground reference network is supported by CASDAR and maintained by IDELE (the French grazing and livestock company) under the banner of the ALBEDO-prairies and then ALBAATRE projects. The cross-comparison is a null bias and a rmse of 0.02.

It will be shown how this precision translates in quantitative estimates of the radiation forcing (RF) and besides in equivalent CO₂ as surface albedo can exert a significant cooling effect to mitigate global warming and compensate for carbon emissions, about an order of magnitude that remains comparable to the greenhouse effect and the soil carbon storage.

CHARACTERIZATION OF THE ANTARCTIC ATMOSPHERE, IN THE VICINITY OF THE ANTARCTIC CIRCLE DURING AUSTRAL SUMMER, USING ATMOSPHERIC RADIOSOUNDINGS

A. Calle, A.M. Burgos, J. Gatón, R. González, D. Mateos, R. Román, C. Toledano, C. Herrero, S. Herrero, D. González, V. Cachorro and A. de Frutos

Atmospheric Optics Group of University of Valladolid. abel.calle@uva.es; telf.: +34983423758

Marambio is an Argentine Antarctic base located on Marambio–Seymour Island at the northeastern tip of the Antarctic Peninsula, adjacent to the Ross Island region. The terrain is characterized by permafrost conditions, and the station is situated at geographic coordinates 64.240° S, 56.625° W. The base lies on a plateau approximately 200 m above sea level along the northeastern coast, facing the Weddell Sea.

This site is particularly well suited for the deployment of atmospheric instrumentation, as it operates year-round, hosting a population of approximately 50 personnel during winter and more than 100 during summer, including both military staff and scientists. The Atmospheric Optics Group of the University of Valladolid (GOA-UVa) has installed a range of atmospheric instruments, including an all-sky camera for cloud cover determination, a CIMEL sun photometer for aerosol property retrieval, and infrared radiometers for land surface temperature and sky radiance measurements.

During the 2024 austral summer Antarctic campaign, the Colombian Air Force conducted atmospheric soundings throughout February and part of March at two different times of day, with scientific collaboration from GOA personnel. In all cases, the soundings exceeded the tropopause, located at approximately 9 km altitude during this season. This study presents a characterization of the Antarctic atmosphere in the vicinity of the Antarctic Circle, including the determination of vorticity parameters (based on horizontal wind components) and the Richardson number for the assessment of atmospheric turbulence.

In addition, the ERA5 reanalysis dataset, produced by the European Centre for Medium-Range Weather Forecasts (ECMWF), provides a global atmospheric reanalysis that combines observations (including radiosondes, satellites, and surface stations) with a numerical weather prediction model. ERA5 is part of the Copernicus Climate Change Service within the European Union's Copernicus Programme. It delivers reconstructed atmospheric profiles with global, continuous, and homogeneous coverage, available on standard pressure levels (e.g., 1000, 850, 500 hPa), enabling direct comparison with conventional radiosonde observations.

In this work, we present a comparison between atmospheric soundings performed at the Antarctic base and ERA5 reanalysis products, including the prior computation of vorticity parameters from the reanalysis fields. The results aim to assess the suitability and performance of the ERA5 dataset in regions near the Antarctic Circle. The study's findings have practical applications for the atmospheric correction of satellite products using reanalysis data at Antarctic latitudes.

SYNERGISTIC SOLAR AND THERMAL INFRARED RETRIEVALS FOR SIMULTANEOUS ENHANCED DUST MINERALOGY AND TRACE GAS CHARACTERIZATION

Marcos Herreras-Giralda¹, Oleg Dubovik^{1,2}, S. Victori³, Masahiro Momoi¹, Yuheng Zhang¹, Juan Cuesta², Maxim Eremenko², Wushao Lin¹, D. Croze³, D. Fuertes¹

¹GRASP SAS, Lille, 59000, France

²Laboratoire d'Optique Atmosphérique, UMR 8518, Villeneuve-d'Ascq, 59650, France

³CIMEL Electronique, Paris, France

⁴Laboratoire Interuniversitaire des Systèmes Atmosphériques, UMR CNRS 7583, Université Paris Est Créteil, Université Paris Diderot, Créteil, France

Corresponding author: marcos.herreras@grasp-earth.com, tel: +34 657463253

This study presents a novel synergistic framework for the simultaneous retrieval of atmospheric gases, aerosol properties, and dust mineralogical composition by integrating remote sensing measurements across the visible–near-infrared (Vis-NIR) and thermal infrared (TIR) spectral ranges. Leveraging the Generalized Retrieval of Atmosphere and Surface Properties (GRASP; Dubovik et al., 2021) algorithm, the approach jointly retrieves essential aerosol parameters and key mineralogical indicators—specifically iron oxide fraction and quartz–clay–calcite contrast—alongside trace gases such as ozone and water vapor. To exploit the complementary strengths of diverse platforms, the retrieval scheme combines ground based CIMEL sensors as the CE318-T sunphotometer and the CLIMAT TIR radiometer, and spaceborne sensors as IASI-NG (TIR) and 3MI (Solar). The robustness of this integrated scheme was evaluated through synthetic retrieval tests under realistic noise and uncertainty conditions. Results demonstrate high consistency across both ground-based and spaceborne configurations. By reducing reliance on a priori assumptions and improving the accuracy of retrieved products, this synergistic approach offers a significant advancement for characterizing complex dust-gas interactions in the atmosphere.

Dubovik, O., Fuertes, D., Litvinov, P., Lopatin, A., Lapyonok, T., Dubovik, I., ... & Federspiel, C. (2021). A comprehensive description of multi-term LSM for applying multiple a priori constraints in problems of atmospheric remote sensing: GRASP algorithm, concept, and applications. *Frontiers in Remote Sensing*, 2, 706851. <https://doi.org/10.3389/frsen.2021.706851>, 2021

EVALUATING THE IMPACT OF DETAILED LIDAR-BASED 3D TREE RECONSTRUCTION ON CENTIMETRE-SCALE UAV HYPERSPECTRAL SIMULATIONS: AN ORCHARD CASE STUDY

Kassem Dia¹, Nathan Sikora¹, Yingjie Wang², Nicolas Lauret², Jean-Philippe Gastellu-Etchegorry², Sophie Fabre¹, Karine Adeline¹

¹DOTA, ONERA, Université de Toulouse, 31000, Toulouse, France ; kassem.dia@onera.fr, sophie.fabre@onera.fr, karine.adeline@onera.fr

²CESBIO, Université de Toulouse, CNES/CNRS/INRAE/IRD/UT3, ¹⁸, Avenue Edouard Belin, Toulouse, 31401, France ; yingjie.wang@iut-tlse3.fr, nicolas.lauret@univ-tlse3.fr, jean-philippe.gastellu@iut-tlse3.fr

Precision monitoring of orchard trees is increasingly needed to address challenges in sustainable agriculture, including optimized input management and the selection of resilient cultivars. UAV imaging spectroscopy offers strong potential for mapping leaf biochemical traits, which are useful for characterizing plant functional status at the individual tree scale. Hybrid inversion methods that integrate radiative transfer models with machine/deep learning to estimate these vegetation traits are widely used, but remain poorly explored for ultra-high spatial resolution data. At the centimetric scale, accurate retrieval of these traits from canopy reflectance remains challenging due to directional effects induced by both the optical anisotropy of

leaf surfaces and the complex 3D geometry of tree crowns, which generate self- and cast shadows, foliage gaps, and within-canopy multiple scattering. Therefore, the precision of 3D scene modelling (both optical and geometric) and illumination parameterization plays a major role in the success of vegetation trait retrieval.

This study evaluates the accuracy of centimetric UAV image simulations generated with the DART 3D radiative transfer model, using an approach that combines hyperspectral and LiDAR datasets and incorporates both radiometric and geometric directional components. To the best of our knowledge, the exact reconstruction of trees from LiDAR data and its impact on remote sensing simulations at centimetric scales have received little attention in the literature.

An orchard managed by INRAE (Bellegarde, France), composed of various peach and apricot genotypes and managed under conventional but optimized input practices, was studied. This orchard is part of the DIVAE orchard observatory network. A UAV and in situ campaign was conducted in September 2024. Using two rotary-wing hexacopter drones flying at an altitude of 50 m, the first flights consisted of LiDAR acquisitions with a RIEGL VUX-1LR instrument, resulting in an average point cloud density of 1200 pts/m². A second set of flights consisted of hyperspectral acquisitions using HySpex Mjölnir VS-620 cameras, yielding spatial resolutions of 1.35 cm and 2.7 cm for the Visible to Near Infrared (VNIR) and Shortwave Infrared (SWIR) ranges, respectively. Three flights were conducted in a single day (morning, solar noon, and afternoon) under clear-sky conditions. The following day, terrestrial LiDAR measurements were performed using a RIEGL VZ-2000i instrument on a selection of trees, with two scans acquired from opposite sides of each tree, each capturing a different face of the canopy. Preprocessing steps included orthorectification of the hyperspectral images onto a Digital Surface Model (DSM) derived from UAV LiDAR data, reflectance conversion using the empirical line correction method with known reference targets, and LiDAR scan registration.

The first methodological step consists of the explicit 3D reconstruction of tree models from the LiDAR acquisitions, including local scan registration, separation of photosynthetic (leaves) and non-photosynthetic (wood) components, and volumetric and surface reconstruction of both woody structures and foliage. The resulting 3D tree models were then used in the DART model to simulate top-of-canopy UAV hyperspectral images. The simulated images were compared with the acquired ones over tree foliage across a range of solar illumination geometries and tree morphologies, resulting in diverse leaf light conditions.

The findings highlight the advantages of combining hyperspectral and LiDAR datasets and provide a physically grounded interpretation of radiometric variability within tree crowns at centimetric resolution (ANR CANOP, ANR-22-CE04-0002).

ESTIMATING NITROGEN STATUS ACROSS TWO MAJOR EUROPEAN RICE SYSTEMS USING SENTINEL-2 AND ENMAP

Katarzyna Cyran^{1*}, Belen Franch^{1,2}, Fatima Della Bellver¹, Italo Moletto-Lobos¹, Cesar Guerrero Benavent¹, Concha Domingo³, Pancraccio Piera⁴, Francesco Nutini⁵, Mirco Boschetti⁵, Inbal Becker-Reshef^{2,6}

¹ Image Processing Laboratory, University of Valencia, Spain

² Department of Geographical Sciences, University of Maryland, College Park, USA

³ Centre de Genòmica, Institut Valencià d'Investigacions Agràries (IVIA), Spain

⁴ Cooperativa Valenciana del Camp Unió Cristiana (UNIANA), Spain

⁵ Istituto per il Rilevamento Elettromagnetico dell'Ambiente, Consiglio Nazionale delle Ricerche (CNR), Italy

⁶ ICube, University of Strasbourg, Illkirch-Graffenstaden, France

*katarzyna.cyran@uv.es ; +34684785345

Accurate monitoring of rice nitrogen (N) status using satellite remote sensing remains challenging under real agronomic conditions and across diverse environments. This study evaluates Sentinel-2 capability to estimate plant nitrogen concentration (PNC, %) and canopy nitrogen content (CNC, gm⁻²) over multiple seasons in Spain, assesses model transferability to an independent area in Italy, and investigates the added

value of Environmental Mapping and Analysis Program (EnMAP) hyperspectral data.

A five-year dataset (2021-2025) collected in Valencia (Spain) under contrasting fertilisation treatments was used to develop retrieval models using stratified k-fold cross-validation. Spectral observations were normalised with the accumulated growing degree days (GDD) to ensure phenological consistency. Among several algorithms, Ridge regression provided the most stable results.

At 600 GDD (end of tillering), PNC retrieval achieved $R^2=0.67$ and $RMSE=0.70\%$, while CNC predictions showed lower accuracy due to biomass error propagation. Feature importance analysis identified the blue (B2), red-edge (B5), and SWIR (B12) bands as key predictors, and a three-band model showed comparable performance ($R^2=0.64$, $RMSE=0.72\%$). Model transferability achieved $R^2=0.69$ and $RMSE=1.36\%$ with a systematic bias due to differences in N measurements and rice cultivars.

EnMAP analysis over the Spanish site showed that the Bidirectional Reflectance Distribution Function (BRDF) correction allows reliable retrieval for acquisitions with varying viewing geometries. Sentinel-2 and EnMAP results provided similar performance ($R^2=0.61$), confirming that N retrieval is driven by chlorophyll-sensitive regions and protein absorption features.

In conclusion, Sentinel-2 imagery allows operational monitoring of rice N status, while hyperspectral data improve the characterisation of N-related signals despite coarser spatial resolution. This research has been submitted to Science of Remote Sensing for publication.

MODELING TIME SERIES OF 3D VEGETATION ENERGY BALANCE AND THERMAL INFRARED EARTH OBSERVATION WITH BALENO-DART

Aldric Gourrat¹, Yingjie Wang¹, Luka Lesage¹, Nicolas Lauret¹, Jordan Guilleux¹, Eric Chavanon¹, Abdelaziz Kallel², Zbynek Malenovsky³, Thang Nguyen³, Omar Regaieg³, Maxence Le Clec'h¹, Jean-Louis Roujean¹

¹CESBIO, Université de Toulouse, CNES/CNRS/INRAE/IRD/Toulouse University, 18 avenue Édouard Belin, 31401 Toulouse, France, ²Digital Research Center of Sfax, SMARTS, Tunisia, ³RSRG, Department of Geography, Bonn University

E-mail: aldrick.gourrat@utoulouse.fr Tel : +33 6 52 07 09 23

Thermal infrared (TIR) Earth observations provide estimates of land surface temperature, which is a key parameter to study vegetation energy balance and water cycle processes. Several TIR satellite mission will soon be launched, e.g. TRISHNA (CNES-ISRO), LSTM (ESA) and SBG-TIR (NASA). They will offer a higher temporal and spatial resolutions, when compared to past and recent TIR satellite missions, which should allow us to monitor local dynamic evolution of vegetation temperature and the associated water stress. However, temperature at such finer scales depends significantly on a local microclimate. For example, local turbulence can lead to temperature change up to 5K at 5m, and 3K at 95m spatial resolution respectively, in several minutes. Consequently, an accurate modeling of turbulence leads to accurate retrieval of vegetation temperature and water stress from TIR satellite data. Soil Vegetation Atmosphere Transfer (SVAT) models, simulating the energy balance (EB), including the thermal dynamic temperature, turbulence and also the TIR remote sensing observations, can fulfill this goal. Nevertheless, most of the operational EB models, e.g. SCOPE, approximate vegetation canopy as a homogeneous turbid layer, which is less valid at finer scales (i.e., pixel-size < 100m) where the impact of surface heterogeneity and 3D canopy structure on turbulence become increasingly important. To overcome this challenge and to prepare the exploitation of future TIR satellite data, we are currently developing a high-resolution 3D EB model called BALENO, coupled with the 3D radiative transfer model DART. It aims to simulate high resolution TIR images of vegetation surfaces, while accounting for impacts of 3D topography and atmosphere. In addition to the 3D radiation budget simulated by DART, BALENO simulates major non-radiative processes influencing the vegetation energy balance, such as: vegetation functions (i.e. photosynthesis and stomata resistance), aerodynamics (i.e. turbulence and mass fluxes) and soil functioning (i.e. ground heat flux and soil thermal storage).

In this RAQRS symposium, we will present:

- 1) Recent developments of BALENO-DART, theory, algorithm, major functional features, products and the coupling with other models.

- 2) First results, specifically time series of 1D/3D canopy temperature and latent heat flux with corresponding TIR observations.
- 3) A model validation against in-situ measurements acquired at the CESBIO's experimental field.
- 4) Future perspectives of further development and potential deployment in new applications.

JOINT ESTIMATION OF SURFACE RADIATION BUDGET COMPONENTS FROM MODIS OBSERVATIONS USING MULTI-TASK LEARNING MODELS

Jianglei Xu¹, Shunlin Liang¹, Han Ma¹, Wenyuan Li¹

¹Jockey Club Laboratory of Quantitative Remote Sensing, Department of Geography, University of Hong Kong, Hong Kong Special Administrative Region, China

Emails: jlxurs@hku.hk, shunlin@hku.hk

Telephone: (+852) 5519 1736 (J.L. Xu)

Surface radiation budget (SRB) represents the balance between the surface heating through incoming solar radiation and cooling through the emission of thermal radiation. Changes in the SRB lead to climatological responses at different scales. Accurate estimation of SRB components at regional and global scales is critical for understanding climate change. However, previous satellite-based SRB products retrieved from multiple separate algorithms have large uncertainty and poor physical consistency. We proposed the SRB-constraint multi-task learning deep neural networks to jointly estimate all of the global daily mean SRB components at 1 km resolution from the Moderate Resolution Imaging Spectroradiometer (MODIS) observations. A combination of MODIS top-of-atmosphere reflectance from bands 1–5, 7, and 19; thermal radiance from bands 27–29 and 31–34; sun-sensor observing geometry and elevation; and Global Land Surface Satellite (GLASS)-MODIS surface longwave radiation was used as the predictors to jointly retrieve all of the SRB components. Using globally distributed measurements, the validation results showed that our SRB estimates have small uncertainties. The root-mean-square errors for downward, upward, and net shortwave radiation were 28.95, 14.65, and 25.11 Wm⁻², respectively; for downward, upward, and net longwave radiation, 20.52, 14.83, and 17.44 Wm⁻²; and for all-wave net radiation, 24.15 Wm⁻². The underestimations of downward and net shortwave radiation as well as downward longwave radiation in the existing SRB products are well improved; the averaging uncertainty of shortwave radiation decreased by 3.63% and that of longwave radiation decreased by 1.5% in the MODIS-derived estimates compared to other SRB products. Because of the SRB balance constraint, our SRB components presented an improved SRB conservation in comparison with GLASS-MODIS products, decreasing by 25.37% in magnitude. Our SRB estimates showed good spatial consistency with SYN1deg and ERA5 products. We also found the thermal radiances from MODIS bands 32 and 34 have a significant contribution to the shortwave radiation estimation due to stratocumulus's shortwave radiation effect, while TOA reflectance from MODIS bands 1, 4, 5, and 19 facilitates the estimation of longwave radiation because of the presence of stratus. Extensive validations have proved that the proposed method is a great scheme to retrieve the SRB components with high accuracy and great consistency. We have successfully generated this new set of MODIS-based SRB component products to be released to the public soon (<https://glass.hku.hk/download.html>). These products will provide better observational constraints for the variability of the SRB components over the recent two decades.

THERMAL CHARACTERIZATION OF TWO VALIDATION TEST SITES OVER PERU: IMPLICATIONS FOR LAND SURFACE TEMPERATURE VALIDATION

Juan Carlos Jimenez¹, Cristian Mattar², Andrés Santamaría-Artigas^{3,4}, José Jesús Pasapera⁵, José Antonio Sobrino¹, Rudi Cruz⁶, Norma Salinas⁶, Eric Cosío⁶, Carlos Eche⁵, Lizardo Fachin⁷, Jhon Rengifo⁷

¹GCU/IPL, Universitat de València, Spain

²Universidad de Chile, Chile

³Department of Geographical Sciences, University of Maryland, USA

⁴NASA Goddard Space Flight Center, USA

⁵CONIDA, Peru

⁶Pontificia Universidad Católica del Perú (PUCP), Peru

⁷Instituto de Investigaciones de la Amazonía Peruana (IIAP), Peru

Corresponding author e-mail: jcjm@uv.es

Ensuring that Earth Observation (EO) products are quantitatively reliable is essential to provide accurate global measurements of Essential Climate Variables (ECVs), such as Land Surface Temperature (LST). Calibration and Validation (Cal/Val) activities provide the reference measurements and the relevant methods to ensure the quality and uncertainty of EO products. An important factor for this purpose is the selection of an appropriate validation test site. In this work we present to candidate LST validation test sites located in the Peruvian Amazon. These sites are equipped with infrared radiometers that continuously collect radiometric temperature measurements from the top of towers above the canopy. The thermal heterogeneity of the test sites has been analysed using Landsat-8/9 thermal infrared data, and Landsat LST level-2 product was validated against the in situ canopy temperature measurements. Validation sites exhibited thermal heterogeneity below 0.2 K, and the Root Mean Square Error (RMSE) for the Landsat LST product validation was around 2 K. We also discuss the potential of these test site for the validation of LST products at lower spatial resolutions.

DART-EB: A LARGE-SCALE MODEL OF 3D VEGETATION ENERGY BUDGET SIMULATING THERMAL INFRARED AND SOLAR-INDUCED FLUORESCENCE REMOTE SENSING IMAGES

Lesage L.¹, Gourrat A.¹, Kallel A.², Nguyen T.³, Lauret N.¹, Regaieg O.³, Wang Y.¹, Malenovsky Z.³, Gastellu-Etchegorry J.P.¹

¹CESBIO, Université de Toulouse, CNES/CNRS/INRAE/IRD, Toulouse, France, ²Digital Research of Sfax, SMARTS, Tunisia, ³RSRG, Department of Geography, Bonn University, Germany

E-mail: luka.lesage@utoulouse.fr Tel: 05.61.55.63.63

Thermal infrared (TIR) image observation is an essential tool for quantifying key vegetation processes, such as evapotranspiration. Nevertheless, both vegetation processes and TIR observations (i.e., brightness temperature $T_{B,veg}^{2D}(\Omega)$ in direction Ω) strongly depend on vegetation emissivity $\epsilon_{B,veg}^{2D}(\Omega)$ and 3D temperature T_{veg}^{3D} , with $\epsilon_{B,veg}^{2D}(\Omega)$ and $T_{B,veg}^{2D}(\Omega)$ being angularly anisotropic mainly due to the vegetation canopy structure. This anisotropy highlights the need for models capable to simulate vegetation processes and TIR observations, while explicitly accounting for the canopy 3D structure. DART-EB is a new 3D energy budget (EB) model for spatially heterogeneous kilometre-scale landscapes based on the radiative transfer model DART. It simulates T_{veg}^{3D} and $T_{B,veg}^{2D}(\Omega)$ in the following three steps:

1) DART simulation of three vegetation 3D radiative budgets (RB): RB_1^{3D} covering the entire electromagnetic spectrum, RB_{APAR}^{3D} covering the photosynthetically active radiation domain, both due to the sun radiation and atmosphere thermal emission, and RB_2^{3D} due to only a vegetation thermal emission. Additionally, DART computes $\epsilon_{B,veg}^{2D}(\Omega)$ using the Kirchoff law.

2) EB simulation of a 1D scheme with the same 1D profiles (i.e., leaf and wood density, orientation and optical properties) as the 3D vegetation canopy. Non-radiative processes (e.g., photosynthesis) are simulated using the equations of the 1D EB model SCOPE, with two essential changes: i) leaves are classified as sunlit or shaded using RB_1^{3D} and not through the exponential approximation, leading to 4 classes of leaves with a distinct leaf area per a canopy height (i.e., high and low “ $RB_1^{3D}+RB_2^{3D}$ ” and RB_{APAR}^{3D}), and ii) the ground thermal radiation escaping the canopy through its openings is specifically computed. The EB simulation is

iterative, when RB_1^{3D} and RB_{APAR}^{3D} are constant, and RB_2^{3D} is iteratively up-dated per time-step. It provides 1D temperature T_{class}^{1D} per leaf, wood and ground class.

3) DART simulation of directional images of vegetation brightness temperature $T_{B,veg}^{2D}(\Omega)$ and solar-induced chlorophyll fluorescence (SIF) $T_{SIF,veg}^{2D}(\Omega)$ is conducted after computing the 3D temperature T_x^{3D} per scene element x (i.e., leaf, wood, ground) using its T_{class}^{1D} and environment conditions including RB_1^{3D} , RB_{APAR}^{3D} , RB_2^{3D} , and wind/air temperature profiles.

We applied DART-EB to three schematic 100x100 m tree scenes (i.e., row planted, homogeneous, and fragmented) and eight structurally distinct 3D forest stands of RAMI-V (Radiation transfer Model Intercomparison). The Planck's law applied to ratio “DART radiance $L_{B,forest}(\Omega) / \epsilon_{forest}(\Omega)$ ” provided $T_{forest}(\Omega)$. Resulting $\epsilon_{forest}(\Omega)$, $T_{B,forest}(\Omega)$ and $T_{forest}(\Omega)$ exhibited a strong, forest structure dependent, zenithal and azimuthal anisotropy. $T_{B,forest}(\Omega)$ and $T_{forest}(\Omega)$ varied by several Kelvins and $\epsilon_{forest}(\Omega)$ was from 0.972 to 0.996. These variabilities can potentially introduce more than 1K errors in the remote sensing estimation of $T_{forest}(\Omega)$. The TIR hot spot appeared in $T_{B,forest}(\Omega)$ and $T_{forest}(\Omega)$ conversely to $\epsilon_{forest}(\Omega)$.

This study underscores the complex dependence of $\epsilon_{forest}^{2D}(\Omega)$, $T_{B,forest}^{2D}(\Omega)$, and $T_{forest}^{2D}(\Omega)$ on forest structure, which can be critical for remote sensing applications and climate modelling. It also illustrates the potential of coupled DART and EB modelling for their assessment.

GLOSVET: A GLOBAL MONTHLY SOIL–VEGETATION COMPONENT TEMPERATURE DATASET GENERATED USING A MULTI-SOURCE FUSION FRAMEWORK

Xiangyang Liu, Zhao-Liang Li, Si-Bo Duan, Pei Leng*

State Key Laboratory of Efficient Utilization of Arid and Semi-arid Arable Land in Northern China, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China – liuxiangyang@caas.cn, lizhaoliang@caas.cn, duansibo@caas.cn, lengpei@caas.cn

* Authors to whom correspondence should be addressed: lizhaoliang@caas.cn;

Tel.: +86-10-82105077

Satellite-derived land surface temperature (LST) is widely used to characterize land–atmosphere interactions, but conventional LST products represent a radiative mixture of soil and vegetation signals and therefore cannot directly describe the thermal states of these two surface components. To address this issue, we developed GloSveT, the first global monthly dataset of soil and vegetation component temperatures covering 2003–2023 at a spatial resolution of 0.05°. The dataset was generated using an improved multi-source fusion framework that combines MODIS monthly LST products, ERA5-Land skin temperature, GLASS fractional vegetation cover, and MODIS land cover information. The retrieval strategy is based on a physically constrained parameterization of the monthly diurnal temperature cycle. In this framework, reanalysis data are used to constrain temperature-independent parameters, while satellite observations are used to optimize temperature-sensitive terms, allowing soil and vegetation temperatures to be estimated in a more robust and physically meaningful way. After optimization and spatial harmonization, monthly mean component temperatures were produced globally through forward simulation and temporal averaging. To evaluate the dataset, we compiled observations from multiple flux-tower networks and converted tower longwave radiation measurements into reference surface temperatures. Results show that the retrieved soil temperatures agree well with tower-based estimates, with correlations generally above 0.85 and root mean square errors mostly between 1.6 and 2.2 K. Vegetation temperatures also show strong performance, with R^2 values commonly between 0.90 and 0.96 and RMSEs ranging from 1.7 to 3.0 K. Seasonal analyses indicate that the retrievals remain stable across different biomes and climate regimes, although winter vegetation conditions and densely vegetated summer surfaces introduce slightly larger uncertainties. In summary, GloSveT provides offers a new observational basis for investigating land surface energy exchanges,

vegetation functioning, hydrothermal stress, and climate–biosphere interactions.

THERMAL EMISSIVITY ESTIMATION FROM VNIR-SWIR REFLECTANCE: EVALUATION OF A NEURAL NETWORK APPROACH IN THE TRISHNA CONTEXT

Renaud Nedelec¹, Vincent Rivalland¹, Albert Oliso²

¹CESBIO, Université de Toulouse, CNES, CNRS, IRD, INRAE, Toulouse, France

*²Unité de Recherche écologie des Forêts Méditerranéennes, INRAE, Avignon, France
renaud.nedelec@cnrs.fr*

The accurate separation and retrieval of the land surface temperature (LST) and land surface emissivity (LSE) from thermal infrared (TIR) data has been a long-standing challenge. Historically, this problem has been addressed with different strategies, e.g. based on the relationship between emissivity and vegetation indices or with the Temperature Emissivity Separation (TES) algorithm which uses the empirical relationship between the emissivity amplitudes in different TIR bands and their minimal value. However, these methods cannot be used both on natural and artificial surfaces and their accuracy remains limited for global applications. In the context of the future launch of new TIR missions such as TRISHNA and LSTM, we tested a new approach to retrieving LSE from VIS-NIR and SWIR channel reflectance, based on simulation and machine learning. The objective of this work is to retrieve the LST with sufficient accuracy for all types of surfaces using a single and efficient emissivity retrieval method.

To train our model, we generated a synthetic database of pixel-scale spectra for the whole VIS to TIR range for a wide variety of surface types. This was achieved by running radiative transfer models, using as input a comprehensive set of laboratory spectral libraries. For natural surfaces, we made a significant effort to inventory and compile all available soil and vegetation spectra covering the full VIS-TIR spectral range. We then trained various machine learning models on this database to learn the relationship between the VIS-NIR-SWIR and TIR spectral domains.

A major challenge of this approach lies in its reliable validation. To address this, we took advantage of the well-validated and benchmarked DART radiative transfer model to simulate a wide variety of satellite acquisitions from realistic 3D scenes with fully known physical properties. These simulations served as ground truth to cross-compare the proposed method with existing approaches. Both the accuracy and robustness of the methods were objectively evaluated.

ASSESSMENT OF LST RETRIEVAL ALGORITHMS FOR LSTM USING SIMULATED DATA UNDER VARIABLE ATMOSPHERIC CONDITIONS

Drazen Skokovic, José A. Sobrino, Juan Carlos Jiménez-Muñoz, Rafael Llorens, Daniel Salinas and Sergio Gimeno

*Global Change Unit, Image Processing Laboratory (IPL), University of Valencia, E-46980 Paterna, Spain
Corresponding Authors Email: drazen.skokovic@uv.es, sobrino@uv.es*

As a key parameter governing land surface processes at regional and global scales, Land Surface Temperature (LST) has long been a central focus of fundamental scientific research. The European Space Agency (ESA) future Land Surface Temperature Mission (LSTM) aims to provide high spatial resolution thermal data, with a particular emphasis on evapotranspiration, which is directly linked to LST variations. In this context, achieving accurate LST retrievals is essential, and the evaluation of algorithms capable of delivering reliable LST estimates should be a primary focus of the mission.

In this study, a combination of Split-Window (SW) and Temperature and Emissivity Separation (TES) algorithms is applied to simulated LSTM imagery generated through forward modelling based on the thermal Radiative Transfer Equation. The main inputs for these simulations are LST and emissivity data

acquired during ESA field campaigns conducted in Grosseto (Italy) within the framework of LSTM related thermal studies. The algorithms are tested under different atmospheric profiles in order to quantify the uncertainties associated with imperfect atmospheric characterization. The results provide valuable insights for improving LST retrieval algorithms and for better understanding the impact of atmospheric conditions on LST accuracy.

MULTI-NUTRIENT DIAGNOSIS IN WINTER RAPESEED BASED ON UAV HYPERSPECTRAL IMAGERY

Qian Song, Bincan Xu

Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences (CAAS), Beijing, China

The synchronous estimation of multiple nutrient elements and the diagnosis of nutrient balance are critical for supporting precision fertilization and variable-rate management in the field. However, multi-element nutrient diagnosis is currently limited by its reliance on labor-intensive and time-consuming chemical analyses. UAV-based hyperspectral imaging combined with machine learning offers a rapid, non-destructive approach for monitoring multiple crop nutrients. Nevertheless, existing studies have primarily focused on single-element estimation, with limited research on joint multi-element estimation and nutrient diagnosis. In this study, field experiments were conducted at the eight-leaf, ten-leaf, overwintering, bolting, and flowering stages of winter rapeseed using UAV imaging hyperspectral data (400–1000 nm). Estimation models for leaf nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), and boron (B) were developed, followed by compositional nutrient diagnosis (CND) based on the estimation results. The main findings are as follows: (1) The optimal model combinations varied among nutrients, but overall stable estimation was achieved. Relatively high accuracy was obtained for N (RFR, $R^2 = 0.72$, nRMSE = 14%) and K (GPR, $R^2 = 0.70$, nRMSE = 11%), while the optimal model for P also achieved $R^2 = 0.65$ and nRMSE = 12%. (2) Significant antagonistic or synergistic relationships existed among multiple elements and varied across phenological stages. N and B showed a consistently significant negative correlation (up to -0.76); P and K maintained a strong positive correlation across multiple stages (up to 0.75); and the relationship between N and K shifted from antagonism during the vegetative stage to synergy during the reproductive stage. (3) At the plot scale, nutrient problems in winter rapeseed were characterized by structural imbalances with coexisting deficiencies and excesses of multiple elements: K and S were mainly deficient; Ca, B, and P were mainly excessive; and N exhibited both deficiency and excess. Furthermore, the overall nutrient imbalance index (CND r^2) was significantly negatively correlated with yield at the overwintering and flowering stages. In summary, this study validates a research framework for hyperspectral-based multi-element estimation and nutrient diagnosis, providing a quantifiable and mappable reference for zone-specific management and variable-rate fertilization.

ADAPTIVE NONLINEAR-ENHANCED ATTENTION NETWORK BASED ON DENSE NESTED U-NET FOR INFRARED SMALL TARGET DETECTION

Xia Zhang*, Yue Liu, Xiaoxia Hou, Guofei Shang

Hebei International Joint Research Center for Remote Sensing of Agricultural Drought Monitoring, Hebei GEO University, Shijiazhuang, 052161, China

**Corresponding author: Xia Zhang Tel./Fax: 0311-87207648*

E-mail: zhangxia396@hgu.edu.cn

Infrared small target detection (IRSTD) plays a vital role in safety-critical applications under low-visibility conditions, but remains challenged by minuscule target sizes ($< 0.12\%$ image area), low signal-to-clutter ratio (SCR), and dynamic background clutter. While deep learning has advanced the field, conventional CNNs often suppress weak target signals through aggressive down-sampling and rely on linear

attention mechanisms incapable of modeling complex feature dependencies. To address these limitations, we propose ANEU-Net, an adaptive nonlinear-enhanced attention network based on a dense nested U-Net architecture. To overcome the inflexibility of linear attention mechanisms in modeling feature dependencies, we design the KAN-based attention module (KBAM), which employs Kolmogorov-Arnold network linear (KANLinear) layers with B-spline basis functions to enable nonlinear, adaptive channel recalibration and spatial saliency enhancement; To tackle the issue of target signal loss due to down-sampling, we introduce the KAN feature enhancement module (KFEM), which injects nonlinear residual excitation to amplify faint target responses without increasing network depth. Additionally, to expand the informational richness inherent in infrared imagery, a channel-based data augmentation strategy is developed, which expands the original single-channel infrared image into a three-channel RGB representation with different channel information. This augmentation enriches spectral diversity, improves target-background contrast, and effectively reduces background interference, enabling the network to learn more discriminative representations. Evaluated on three benchmark datasets, ANEU-Net achieves state-of-the-art performance, outperforming existing methods in intersection over union (IoU), probability of detection (Pd), and false alarm rate (Fa).

QUANTIFICATION OF URBAN THERMAL INFRARED ANISOTROPY AT 60 M SCALE FROM AIRBORNE MEASUREMENTS OVER TOULOUSE

Quentin Dehaene^{1,2}, Laure Roupioz¹, Mark Irvine³, Françoise Nerry², Xavier Briottet¹

¹ONERA / DOTA, Université de Toulouse, F-31055 Toulouse, France; ²ICube Laboratory, UMR 7357, CNRS-University of Strasbourg, 300 bd Sébastien Brant, CS 10413, F-67412 Illkirch Cedex, France; ³INRAE, UMR 1391 ISPA, 33140 Villenave d'Ornon, France; Main author contact information: quentin.dehaene@nyu.edu; (+1) 347-350-0488

Upcoming thermal infrared (TIR) satellite missions will deliver data with unprecedented spatial (60 m or less) and temporal (1 to 3 days) resolutions, opening new opportunities for in depth urban climate research. However, the wide scan angle of these future sensors introduces methodological challenges related to directional anisotropy in TIR measurements, particularly within complex 3D urban environments. While previous studies have demonstrated the significant impact of directional effects on TIR brightness temperatures in urban areas at city and canyon scales, none have investigated these effects specifically at the spatial resolution and angular configuration of the future satellite missions.

This research leverages airborne TIR data to quantify directional effects in urban environments for the TRISHNA mission (CNES/ISRO) configuration, which has a spatial resolution of 60 m and a scan angle of 34 degrees. The study is based on the directional TIR data acquired over Toulouse (France) during the CAPITOUL airborne campaign (Lagouarde et al., 2008, 2010, 2012). The flights are composed of several crossing flight lines allowing the measurement of the city surface temperature under different viewing and illumination geometries. CAPITOUL data are used to analyze the directional effects across three distinct urban morphologies: a central open square, a dense urban zone, and a residential neighborhood. The analysis also covers various times of day and seasons. The objective is to benefit from this extensive dataset to get a first evaluation of the directional effects at 60 m and to start exploring their spatial and temporal variability. Results indicate significant brightness temperature anisotropy within 34° viewing angle range for all three urban landscapes during daytime. The most significant effects, reaching up to 4.4 K, occurred during summer mornings along the solar plane. These effects diminish as the observation angle deviates from the principal solar plane and as the day progresses. Additionally, this anisotropy is strongly influenced by surface geometry and 3D structure.

Despite limitations due to airborne data availability, findings suggest that dense urban areas show consistent directional behavior irrespective of street orientation, whereas vegetation cover seems to reduce anisotropy in residential areas. Although no directional effects were observed during autumn and winter acquisitions at night, further analysis is needed to strengthen the conclusions for night-time conditions. As a preliminary assessment, this study highlights the necessity of accounting for angular dependencies in future high-resolution TIR satellite mission land surface temperature products to ensure accuracy, particularly for

high-frequency revisits with multi-angle observations. This work should be pursued using radiative transfer models to validate and expand on these findings.

THERMAL ANISOTROPY STUDY IN AN URBAN CANYON USING THE DISCRETE ANISOTROPIC RADIATIVE TRANSFER (DART) MODEL

Letian Wei, José A. Sobrino

*Global Change Unit, Image Processing Laboratory, University of València, 46980 Paterna, Spain
weile@alumni.uv.es, +34625957496, sobrino@uv.es*

Current temperature retrieval algorithms are developed under the assumption of natural surfaces. Coupled with three-dimensional (3D) structure of urban geometry and thermal radiation anisotropy, these factors all make it more challenging to obtain accurate 3D urban surface temperature. This work fully integrates multi-angle aerial observations and ground measurements, iteratively constraining at-sensor radiance to obtain the optimal surface temperature estimates by DART model. Oriented toward the next generation of multi-angle thermal infrared (TIR) satellites (e.g., TRISHNA, SIRIUS), it holds enormous research value.

An airborne campaign was conducted in València, Spain, from September 10 to 11, 2024. Meanwhile, field measurements were carried out using iButton data loggers to measure wall temperatures, with stable records covering the period from June 14 to mid-September. Four iButtons were installed within a downtown canyon.

DART can simulate directional radiance and brightness temperature (T_b) at any height and from any viewing angle, which allows us to investigate the urban thermal anisotropy (UTA) effect within an urban canyon located in downtown València. Furthermore, based on pixel-level component fractions and T_b derived from DART model, this work aims to develop an integrated temperature to characterize 3D urban surface.

MULTISCALE LAND SURFACE TEMPERATURE (LST) RETRIEVAL OVER ANDEAN MINE TAILINGS USING SATELLITE DATA INTEGRATION

Cristian Mattar^{1,2}, Italo Moletto-Lobos¹, Tomás Acuña-Ruz¹, Sebastián Castillo¹, Trinidad Mir Bori²

¹Agrospace SpA, Santiago, Chile

²Biosfera LAB, University of Chile, Lo Pintana, Chile

Corresponding author: cristian@agrospace.cl

Land Surface Temperature (LST) is a key parameter for estimating evapotranspiration in mine tailings located in the Andes mountains. Seasonal variations (dry and wet) and complex terrain present a major challenge for improving temperature estimation to accurately assess evapotranspiration and water loss. With over 100 mine tailings in Chile, quantifying water loss is critical to optimizing water balances and reducing the water footprint of mining processes. To address this gap, this work proposes a novel multiscale approach to estimate LST based on different satellite multispectral data across three main surface categories in mine tailings: lagoon, wet sand, and dry sand. A multiscale temporal framework integrating Sentinel-2, Landsat 8/9, and MODIS was applied to generate LST time series. Land Surface Emissivity (LSE) was derived from water and moisture indices calculated via Sen2Like multispectral data. Atmospheric corrections for Landsat LST were implemented using the Jiménez-Muñoz (JM-2014) single-channel method. A scaling factor was established from the spatio-temporal relationship between Landsat and MODIS LST. Additionally, a Random Forest algorithm was tested to downscale MODIS LST to a 10 × 10 m spatial resolution. Model outputs were validated against field measurements from an Apogee SI-411 broadband (8–14 μm) thermal radiometer and an NR01 Hukseflux net radiometer, recording at 5-minute intervals across two contrasting seasons: the wet season (January–March) and the dry season (July–August). Results demonstrated a strong

linear correlation between Landsat and Sentinel spatial scales ($SR^2 > 0.80$), whereas downscaled MODIS data displayed systematic bias (~ 4 K). These findings enhance the detection of thermal anomalies in tailings deposits, providing a more robust understanding of evaporative water loss.

A NEW MODEL FOR ADJACENCY EFFECT CORRECTION FOR OPTICAL EARTH OBSERVATION IMAGERS

Kevin Walcarius¹, Jerome Colin¹, Mustapha Moulana², Didier Ramon², Olivier Hagolle¹

¹CESBIO, Univ Toulouse, CNES, CNRS, INRAE, IRD, Toulouse, France

²HYGEOS, Euratechnologies, Lille, France

The scattering of light by molecules and aerosols in the atmosphere results in several effects: scattering adds some haze to the images (atmospheric reflectance), reduces the signal from the surface (atmospheric attenuation), and blurs the images (adjacency effects). For instance, in the case of a black lake in a bright environment, a significant fraction of the photons collected by the sensor over that lake actually originates from adjacent pixels, scattered towards the sensor by the atmosphere (“atmospheric adjacency effect”). Moreover, multiple reflections between the atmosphere and the surface can also bring extra light to the sensor (“coupling adjacency effect”). The resulting effects are modeled as a convolution of the true image with a point spread function (PSF).

Even if this phenomenon has been known for a long time, its modeling was not very accurate. For instance, the Sentinel-2 atmospheric correction processors MAJA (Hagolle et al., 2015) and Sen2cor (Louis et al., 2019) use a PSF with a range of about 1 km, while LaSRC (Claverie et al., 2018) does not apply adjacency effect corrections. But some studies (Bulgarelli et al, 2017) have shown an influence from the coast to observations at sea at a distance greater than 30 km. These observations and the availability of a fast radiative transfer code (SMART-G) that implements a Monte Carlo approach on GPU processors (Ramon et al., 2019), motivated us to work on a complete modeling of this effect. Indeed, SMART-G is one of the rare monte carlo codes able to launch billions of photons in a few seconds, which allows to accurately model adjacency effects.

If the atmospheric adjacency PSF can be computed quite easily in a Monte Carlo code (Wu et al 2023), the coupling adjacency PSF requires to consider a surface reflectance landscape. The separation between the landscape and the PSF is an ill-posed problem that was solved by assuming a parametric PSF shape. The two best models were two-parameter models: a generalized Gaussian and the King model, which yielded slightly better results. The resulting PSF often extends above 30 km, with only about 90 % of the adjacency effect included in a 10 km range, confirming the observations of Bulgarelli et al. In a sensitivity study, the aerosol type, the aerosol optical depth, and the altitude of the aerosol level were found to have a significant influence on the PSF.

Against numerical simulations, the King model performs two orders of magnitude better than the 1 km classical PSF, and also better than the Wu et al model that is restricted to the atmospheric adjacency effect. Compared to a data set of coastal and inland water surface reflectance measurements named GLORIA, our King model also brings a 50% improvement in the red and near infrared. The improvement is less obvious in the blue where the adjacency effects are weaker, and the atmospheric correction less accurate.

Using a long range PSF has significant implications for adjacency effect correction: it requires to handle well the limits of the remote sensing images, because the landscape outside these limits is not known. It is one more reason to have a 10 km overlap between scenes, as in the current Sentinel-2 grid. Long range adjacency effects also raise questions for sensors with a field of view under 10 km. Adjacency effect correction also has performance implications, requiring the use of convolutions in the frequency domain. Future work will study the adjacency effects in the presence of clouds, trying to determine the necessary buffer length around clouds to avoid a large degradation of surface reflectance accuracy.

- Bulgarelli, B., Kiselev, V., & Zibordi, G. (2017). Adjacency effects in satellite radiometric products from coastal waters: a theoretical analysis for the northern Adriatic Sea. *Applied optics*, 56(4), 854-869.

- Claverie, M., Ju, J., Masek, J. G., Dungan, J. L., Vermote, E. F., Roger, J. C., ... & Justice, C. (2018). The Harmonized Landsat and Sentinel-2 surface reflectance data set. *Remote sensing of environment*, 219, 145-161.
- Hagolle, O., Huc, M., Pascual, D. V., & Dedieu, G. (2015). A multi-temporal and multi-spectral method to estimate aerosol optical thickness over land, for the atmospheric correction of FormoSat-2, LandSat, VENμS and Sentinel-2 images. *Remote Sensing*, 7(3), 2668-2691.
- Louis, J., Pflug, B., Main-Knorn, M., Debaecker, V., Mueller-Wilm, U., Iannone, R. Q., ... & Gascon, F. (2019, July). Sentinel-2 global surface reflectance level-2A product generated with Sen2Cor. In *IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium* (pp. 8522-8525). IEEE.
- Ramon, D., Steinmetz, F., Jolivet, D., Compiègne, M., & Frouin, R. (2019). Modeling polarized radiative transfer in the ocean-atmosphere system with the GPU-accelerated SMART-G Monte Carlo code. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 222, 89-107.
- Wu, Y., Knudby, A., & Lapen, D. (2023). Topography-adjusted Monte Carlo simulation of the adjacency effect in remote sensing of coastal and inland waters. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 303, 108589.

JOINT RETRIEVAL OF ATMOSPHERIS SPECIES AND BIOSPHERE PARAMETERS

Ralf Giering^{1}, Simon Blessing¹, Christiaan von der Tol²*

¹*FastOpt*

²*Uni Twente*

**Correspondence: Ralf.Giering@FastOpt.com (Tel.: +49-40-48096347)*

Land surface and vegetation variables are typically retrieved from satellite data of reflectance that have been corrected for atmospheric effects, termed bottom-of-atmosphere (BOA) or top-of-canopy (TOC) reflectance. The separation of atmospheric correction (AC) from the retrieval of vegetation has the disadvantages that uncertainty propagation (let alone covariance propagation) is complicated, and that assumptions about the surface, such as Lambertian reflectance, are needed in the AC. To overcome these limitations, we propose retrieval in a single step in which both atmospheric and land surface variables are estimated jointly.

The required ancillary information of the atmospheric state and composition (surface pressure, aerosols, ozone, water vapour) usually comes from MERRA or CAMS reanalysis data sets and carries uncertainties related to the method and the resolution which is usually coarser than the sensor footprint. These uncertainties have a high influence on the TOC reflectances and are correlated across bands. By joining the AC and the retrieval step into a Bayesian framework joint retrieval system, information in the data can be used to consistently correct the atmospheric state in the retrieval, and, where this information is ambiguous, quantify the correlated uncertainties of the retrieved quantities. This framework has the additional strength that temporal autocorrelations can be used as prior information to reduce the ambiguity of the retrieval.

We adopted the Simplified Method for Atmospheric Correction (SMAC), a rapid, semiempirical radiative transfer model, to correct satellite measurements for atmospheric effects in the solar spectrum. It uses pre-computed coefficients for the specific sensor, and integrated it into OptiSail, a retrieval system for canopy and sub-canopy parameters including Leaf Area Index – LAI –, Fraction of absorbed Photosynthetic Active Radiation – fAPAR –, chlorophyll a+b, surface BRDF, and leaf composition. It is based on a coupled modelling framework including SAIL (canopy reflectance), PROSPECT-D (leaf properties), TARTES (snow properties), a soil model (soil reflectance anisotropy and moisture effects), and a cloud contamination module. OptiSAIL is generic in terms of observation geometry and angles and can process combinations of multi- to hyper-spectral data in the range from 400 nm to 2500 nm from multiple sensors together. It is used in the CCI+ Vegetation Parameters (VP) part of the ESA Climate Change Initiative and is the algorithm for

the next C3S LAI datasets.

We present first results from the prototype of the joint atmosphere-land retrieval system using OptiSAIL and SMAC with data from Sentinel-3 OLCI.

ADVANCES IN DART RADIATION BUDGET, ATMOSPHERIC RADIATIVE TRANSFER, THERMAL EMISSION AND ERROR PROPAGATION

Yingjie Wang^{1*}, Aldric Gourrat¹, Audrey Benteyn², Luka Lesage¹, Yasmine Karray¹, Omar Regaieg³, Romain Demoulin¹, Firas Ayari¹, Yao Liao^{1,4}, Thang Nguyen³, Ziyang Wang⁵, Zhijun Zhen^{1,7}, Tiangang Yin⁸, Nicolas Lauret¹, Jordan Guilleux¹, Eric Chavanon¹, Abdelaziz Kallel⁴, Frédéric André², Zbyněk Malenovsky³, Jean-Louis Roujean¹, Jean-Philippe Gastellu-Etchegorry¹

¹University of Toulouse, CNES/IRD/CNRS/INRAe, CESBIO, Toulouse, France

²Laboratoire d'Optique Atmosphérique, Lille, France

³University of Bonn, Department of Geography, Bonn, Germany

⁴Digital Research Center of Sfax, SMARTS, Sfax, Tunisia

⁵Guizhou Meteorological Bureau, Guizhou, China

⁶Nanjing Normal University, Nanjing, China

⁷Jilin University, Jilin, China

⁸The Hong Kong Polytechnic University, Hong Kong, China

*Correspondence: yingjie.wang@iut-tlse3.fr (Tel: +33782418803)

New satellite instruments and methodologies for their data processing and Cal/Val activities are continuously evolving. To interpret correctly a broad suite of various Earth observations, one requires increasingly accurate radiometric measurements and models. In this context, sophisticated physical models that simulate the radiative transfer in the Earth-Atmosphere system are essential. More accurate and simultaneously more efficient modelling is becoming increasingly feasible thanks to recent advances in numerical solutions of radiative transfer equations, 3D reconstructions of land surfaces and clouds, and advanced computer technology. Discrete Anisotropic Radiative Transfer (DART, <https://dart.omp.eu/#/>) is one of the most comprehensive 3D radiative transfer models used by the remote sensing community. Developed at CESBIO since 1992, it simulates remote sensing observations and radiation budget for any 3D natural and urban land surfaces with topography and atmosphere, from visible to thermal infrared domains. DART is used by various space agencies (e.g., CNES, ESA, and NASA) to support the preparation of future satellite missions, such as Sentinel-2 NG, LSTM, and TRISHNA. A number of research institutes use DART for a wide range of remote sensing applications, including leaf traits' retrievals, surface variables' inversions, and sensitivity analysis. In this contribution, we present recent DART advances introduced by the DART team (CESBIO, France) and collaborating institutes, with a focus on applications in quantitative remote sensing, specifically:

- (1) General principles of the DART model, including its physical basis, algorithms, products, and simulations' accuracy.
- (2) Recent developments, e.g., Jacobian matrices (error propagation), machine-learning emulation of atmospheric radiative transfer, spherical-shell atmosphere, Monte Carlo radiation budget, mobile LiDAR, night-time imaging, large-scale thermal imaging, etc.
- (3) Applications of the DART model in quantitative remote sensing, including sensitivity analysis, inversion of land surface variables, training of machine learning models, correction of directional effects, and preparation of future satellite missions.

LESS3: INTERACTIVE 3D RADIATIVE TRANSFER SIMULATION OVER HETEROGENEOUS VEGETATION CANOPIES

Jianbo Qi¹

¹Advanced Interdisciplinary Institute of Satellite Applications, Faculty of Geographical Science, Beijing Normal University, Beijing 100875, China

**Correspondence: jianboqi@bnu.edu.cn (Tel.: +86 15120096298)*

Three-dimensional (3D) radiative transfer (RT) modelling is fundamental to quantitative remote sensing of vegetation. Real-world canopies exhibit strong structural heterogeneity — varying crown shapes, gaps, and shadows — that violates the plane-parallel assumption underlying widely used one-dimensional models such as PROSAIL. While 3D RT models can explicitly resolve these effects, their high computational cost has long restricted their role to small-scale, offline case studies rather than routine components in inversion and sensitivity analysis workflows.

We present LESS3, a new-generation 3D radiative transfer simulation framework designed to make interactive radiation modelling over heterogeneous vegetation canopies practical. Built upon hardware-accelerated ray tracing, LESS3 reduces the computation time of full path-tracing simulations by two orders of magnitude compared to its CPU-based predecessor. The framework provides a complete vegetation radiation modelling chain: physically-based leaf optical models (Lambertian, PROSPECT), multiple canopy representations (explicit facet geometry and turbid medium), configurable illumination (direct sun and sky diffuse), and diverse sensor configurations (orthographic, perspective, fisheye, and multi-angular BRDF). A persistent “digital twin” design allows the same scene to be reused across simulations with varying illumination and observation geometries, naturally fitting the forward-model role required in inversion workflows.

LESS3 has been rigorously validated against analytical solutions and the established LESS model (Mitsuba-based CPU implementation). Cross-comparisons across 15 test scenarios — including Lambertian flat plates at multiple reflectances (0.1, 0.3, 0.5) and solar zenith angles (0°, 30°, 60°), explicit leaf canopies (LAI = 1, 3, 5), and heterogeneous forest scenes with PROSPECT leaves — demonstrate a relative root-mean-square error (RRSE) below 2% and negligible bias. Computation time is reduced from 51–73 seconds to 0.5–0.6 seconds per scene, enabling the generation of large look-up tables (LUTs) comprising tens of thousands of entries within minutes rather than days.

The removal of the computational bottleneck fundamentally changes how 3D RT can be employed in land surface radiation studies. LESS3 makes it feasible to construct LUTs that account for 3D structural effects, perform interactive sensitivity analyses exploring the influence of LAI, leaf angle distribution, and canopy density on bidirectional reflectance, and generate massive physically-consistent training datasets for machine-learning-based inversion. By providing an open-source Python API with a low entry barrier, LESS3 aims to bring the accuracy advantage of 3D radiative transfer into routine vegetation parameter retrieval, bridging the longstanding gap between 1D operational convenience and 3D physical realism.

SURFACE ALBEDO AND EMISSIVITY FOR BELGIAN CITIES (SUABE)

Jonathan León-Tavares^{1*}, Zhijun Zhen², Nicolas Lauret³, Jean Philippe Gastellu-Etchegorry³

¹VITO, Mol, Belgium

²Jilin University, China

³CESBIO, Toulouse, France

**Correspondence: jonathan.leontavares@vito.be*

Urban areas, with their abundance of materials that absorb solar radiation and high population density, are particularly vulnerable to the heat island effect. Mitigating this phenomenon requires accurate estimates of surface albedo and emissivity, yet such measurements are often unavailable at a citywide scale. High-resolution optical and thermal-infrared satellite sensors offer a solution, overcoming the spatial and

temporal limitations of in-situ observations. However, satellite measurements are constrained by limited acquisition geometries and spectral bands, which prevents the accurate computation of needed quantities such as urban albedo maps.

This contribution describes the SuaBe project (<https://stereoiv-suabe.eu/en>), which focuses on designing and implementing a fast, and robust algorithm, that uses the 3D radiative transfer code DART (<https://dart.omp.eu/#/>) to invert remote sensing images of cities as a 3D distribution of optical properties and temperature, using a geometric urban database. This approach enables us to obtain a 3D model of a city to simulate urban surface albedo, emissivity, and net radiation maps at any date as long as the optical properties of urban elements remain constant. These optical properties can be up-dated with the inversion of recently acquired satellite imagery.

As a case study, we will apply it to Brussels to retrieve surface albedo and emissivity maps at a neighbourhood scale. We show how this calibrated radiative digital of Brussels support the simulation of time series of net radiation estimates, which are compared against insitu measurements. These results can be considered an asset to be used by urban planners and decision-makers to identify what urban areas should be considered priority candidates for an intervention to mitigate heat pollution, which in turn, shall allow authorities or civil organisations to maximise benefits from limited financial resources. Since the SuaBe's methodology is based on a robust and rigorous physical model, it can be seamlessly implemented in any other city worldwide, provided that a geometric urban database is available.

LAND SURFACE TEMPERATURE MONITORING (LSTM) MISSION STATUS AND DATA PROCESSING

I. Barat¹, I. Fernandez¹, A. Garcia¹, S. Dransfeld¹, A. Novelli¹, A. Bolea¹, I. Manolis¹, F. Bernard¹, A. Chalew¹, K. Alonso¹, F. Gascon¹, B. Koetz¹, S. Proud¹, B. Tsonevska¹, M. Such¹, P. Mingorance¹

European Space Agency

**Correspondence: ltziar.Barat@esa.int*

The High Spatio-Temporal Resolution Land Surface Temperature Monitoring (LSTM) Mission is one of the Copernicus Sentinel Expansion Missions. The mission responds to priority requirements of the agricultural user community for improving sustainable agricultural productivity at field-scale in a world of increasing water scarcity and variability.

Its primary objective is to enable accurate monitoring of evapotranspiration (ET) at the European field scale by capturing the spatial and temporal variability of surface temperature (ST). This capability will support more robust assessments of water productivity, particularly in agricultural systems.

In addition to this core objective, LSTM will contribute to a range of complementary applications that benefit from thermal infrared (TIR) observations. These include soil composition analysis, urban heat island assessment, coastal zone management, and the detection and monitoring of high-temperature events. Together, these applications highlight the mission's relevance across environmental, agricultural, and climate-related domains.

The mission targets an LST measurement accuracy better than 1–1.5 K at a 300 K reference temperature.

To meet its objectives, LSTM is designed to provide systematic global acquisitions at a spatial resolution of 50 meters with a revisit time of less than two days. This will be achieved by means of a constellation of two satellites, each with a four-day revisit cycle, resulting in a combined two-day revisit frequency. The satellites will operate in a sun-synchronous orbit, crossing 45° north latitude at approximately 13:00 mean local solar time during the descending node.

Each satellite carries a whiskbroom scanner capable of measuring top-of-atmosphere spectral radiance across five TIR bands (8–12.5 µm) and six VNIR/SWIR bands. These spectral configurations are optimized to support agricultural monitoring and related services.

The mission design includes a nominal operational lifetime of seven years per satellite, following a six-month commissioning phase, with onboard consumables sized to support up to twelve years of operation.

LSTM will deliver Level-1 products consisting of radiometrically and geometrically calibrated top-of-atmosphere reflectance (for VNIR bands) and brightness temperature (for TIR bands), resampled to 50-meter resolution and aligned with the Sentinel-2 Global Reference Image. Level-2 product will consist of land surface temperature, land surface emissivity per TIR band, and bottom-of-atmosphere surface reflectance per visible band. Level-1 & 2 products are aimed to be delivered within six to twelve hours of acquisition with highest priority over Europe and Africa.

The LSTM mission entered Phase B2 in late 2020, successfully completed its System Preliminary Design Review in autumn 2022, and passed the Critical Design Review in March 2025. It is currently in Phase D, focusing on integration, testing, and calibration/validation (Cal/Val) activities.

This presentation provides an overview of the mission, its current status, selected retrieval algorithms, and initial plans for Cal/Val activities in orbit.

TRISHNA MISSION: SCIENTIFIC AND ALGORITHMIC CHALLENGES IN HIGH-RESOLUTION THERMAL INFRARED PROCESSING AND PRODUCT GENERATION

Philippe Gamet^{2,}, Emmanuelle Sarrazin¹, Bimal K. Bhattacharya³, Jean-Louis Roujean², Gilles Boulet², Albert Olioso⁴, Marie Weiss⁴, Nesrine Farhani⁵, Jordi Etchanchu⁵, Samuel Mbugu⁴, Vincent Rivalland², Mark Irvine⁴, Kanishka Mallick², Olivier Hagolle¹*

¹CNES, Paris, France

²CESBIO, Toulouse, France

³SAC/ISRO, India

⁴INRAE, Paris, France

⁵Université de Montpellier, Montpellier, France

*Correspondence: philippe.gamet@cnes.fr (Tel.: +33 561283223)

The TRISHNA (Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment) mission is a collaborative effort between CNES and ISRO, aimed at delivering high-resolution observations of the Earth's surface-atmosphere system in the thermal infrared domain. Over its planned five-year lifetime, the mission will provide global coverage approximately twice per week, with a spatial resolution of 60 m over land and coastal regions. By combining measurements in the visible, near-infrared, and thermal infrared spectral ranges, TRISHNA meets stringent spatial, temporal, and radiometric requirements, enabling monitoring at the scale of individual agricultural fields with revisit intervals of a few days.

The primary objective of TRISHNA is to estimate evapotranspiration, a key variable governing water exchanges between land and atmosphere, supporting the detection of vegetation water stress, irrigation management, and improved assessments of agricultural water use. Beyond agriculture, the mission addresses major scientific and societal challenges related to ecosystem functioning, inland and coastal waters, urban environments, the cryosphere, and atmospheric processes, with the demonstration of low-latency data delivery, enabling near-real-time applications such as drought early warning.

The mission provides a suite of Level 2 and Level 3 products derived from multi-spectral observations and auxiliary data, including key surface and atmospheric variables (e.g., reflectance, temperature, emissivity, aerosols, and water vapor), as well as higher-level biophysical parameters such as vegetation properties, albedo, and evapotranspiration, and temporally continuous time series of daily evapotranspiration.

This presentation will focus on the remaining scientific challenges, including the representation of directional anisotropy effects, the calibration and validation of contextual evapotranspiration approaches, and the robust quantification of uncertainties. It will also address key technical challenges related to the implementation of these algorithms within an operational near-real-time processing chain, including the integration of exogenous inputs such as meteorological data, as well as issues of data volume management and user access.

MEASURING AND MODELLING DIRECTIONAL EFFECTS IN THE THERMAL INFRARED IN THE PREPARATION OF THE TRISHNA MISSION: THE TIRAMISU INITIATIVE IN SUPPORT OF CALVAL ACTIVITIES

Jean-Louis Roujean (jean-louis.roujean@utoulouse.fr)¹, Chandrika Pinnepalli (chandrika.pinnepalli@gmail.com)¹, Thejaswini S P (taswini274@gmail.com)², Mark Irvine (mark.irvine@inrae.fr)³, Eswar Rajasekaran (mark.irvine@inrae.fr)²

¹ CESBIO, Université de Toulouse, CNES/CNRS/INRAE/IRD, ¹⁸ avenue E. Belin, Toulouse, France

² Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai-400076, India

³ INRAE, ISPA, ⁷¹ avenue E. Bourlaux, 33140 Villenave d'Ornon, France

Owing to a wide FOV around 35 degrees, global coverage will be ensured by TRISHNA mission at the frequency of three times during eight days at low latitudes and more revisit at mid-latitudes and above. The short-time revisit will, however, infer angular effects on the time series of measurements. Moreover, TRISHNA's overpass time will be around 12:30 at local solar time. In the tropics, such acquisition will be impacted by the hot spot effect from March to September. The error in LST measurements could go up to 10K in the presence of a hotspot based on in situ measurements. Otherwise, the impact of anisotropy properties of the surface on both optical and thermal reflectance could be less but still significant. This presentation will focus on the TIRAMISU (Thermal InfraRed Anisotropy Measurements In situ & Uav) which aims at establishing an in situ measurement protocol to serve as a baseline to explore the full characteristics of the visible and near-infrared (VNIR) plus Thermal InfraRed (TIR) radiometric signals at plot scale. It concerns continuous acquisition of temporal, directional, spectral and spatial dimensions of the radiometric signal along daytime and season owing to the implementation of a optical & thermal camera (MicaSense ALTUM-PT) equipped of a wide FOV.

The objectives are manyfold:

- To enhance R&D activities in the domain of thermal directionality and turbulence.
- To calibrate SCOPE and DART models with camera slots for further extension at patch scale based on drone flights to reach TRISHNA footprint.
- To propose timely and spatially matched (with TRISHNA) LST, albedo and ET products in a coherent manner with possibly fast delivery.
- To invert TEKDM (Time Evolving Kernel Driven Models)

Measuring DRC (Diurnal Reflectance Cycle) and DTC (Diurnal Temperature Cycle) for pixels (or group of pixels) contaminated by the hot spot (HS) or not (NHS) is at the core of TIRAMISU. Also, DRC and DTC are extracted for different proportions of the four components : sunlit/shaded vs soil/vegetation as it is the main directional driver with directional emissivity. The role of thermal inertia is also explored in the case of TIRAMISU initiative. Some illustrations will be given for the pilote site of vineyard at Malegaon (India).

THE LAND SURFACE TEMPERATURE RETRIEVAL ALGORITHM FOR LSTM: AN OVERVIEW AND RESULTS

Benjamin Courtier, Michael Perry, Darren Ghent*

University of Leicester, Leicester, UK

**Correspondence: bmc19@leicester.ac.uk*

Wide scale observations of Land Surface Temperature (LST) are vital to improve our understanding of climate change, monitor the rate of global warming and understand the impacts of a warming climate.

Land surface temperature information is also important in aiding the best use of agricultural land and has can help advise on the health implications of heat; especially for the large proportion of the world's population living in cities and given extreme heat events are becoming more common.

The Land Surface Temperature Monitoring (LSTM) mission, together with TRISHNA, will produce high resolution, highly accurate LST data, in order to improve the global surface temperature data stream. Here an overview of the operational retrieval algorithm for the LSTM mission is presented together with results from real-world and simulated test cases.

The LSTM retrieval algorithm is based on an Optimal Estimation (OE) framework, in particular the work of Perry et al. (in review). This framework retrieves the LST, the Land Surface Emissivity (LSE) and the absorption due to the atmospheric column (all gases absorptions are retrieved in a single catch all term); each of these variables are retrieved with an uncertainty term. The method works using a fast radiative transfer model (RTTOV) to propagate initial best estimates of the state vector (LST, LSE and the atmospheric column) to the observation space (i.e. Top of Atmosphere (ToA) radiances). Novelty, this algorithm is constructed over the tie-point grid (i.e. the grid that the atmosphere is specified on), rather than the usual observation grid. This allows a faster calculation of the jacobian matrix at each observation pixel, as the radiative transfer model does not need to be run at every pixel, just for the entire tie-point grid point. These jacobian matrices are used to make improvements to the initial best guess of the state vector by informing a search direction for the algorithm. The OE converges if it reaches a set tolerance for the

The results of the Optimal Estimation are shown in a two test scenarios: a scene generated using airborne observations of agricultural land in Grosseto, Italy and a simulated scene of an orange grove with ordered crop rows. The real-world observations of the Grosseto scene allow for the direct comparison between the OE retrieval and measurements of ground truth over a number of different surface types. Testing with the simulated scene allows for a wide variety of surface types, solar angles and atmospheric compositions to be included in the testing process.

FROM IMAGES TO NUMBERS: EXPANDING UNCERTAINTY FRAMEWORKS FOR QUANTITATIVE EARTH OBSERVATION IN THE LSTM MISSION

*I. Fernandez¹, F. Bernard¹, A. Garcia¹, I. Barat¹, I. Manolis¹, S. Dransfeld¹, A. Novelli¹, A. Bolea¹,
A. Chalew¹, K. Alonso¹, F. Gascon¹, B. Koetz¹, S. Proud¹, B. Tsonevska¹, M. Such¹, P. Mingorance¹,
C. Cox², M. Perry³*

¹European Space Agency

²RAL, UK

³University of Leicester, Leicester, UK

*Correspondence: Ignacio.fernandez@esa.int

In the last decade Earth Observation data has experienced a revolutionary uptake and its information is being integrated in multiple data pipelines ranging from precision farming, mineralogy, atmospheric research or climate monitoring. A key aspect allowing the increase of the data usability is the provision of propagated per pixel uncertainty across the different processing levels.

First generation Copernicus missions such as Sentinel-2 and Sentinel-3 have successfully introduced uncertainty products to users, either as dedicated tools or embedded within standard Level-1 outputs. Building on lessons learnt from these first-generation examples, we have identified two key aspects required to improve in the future Copernicus Expansion missions.

- The first is that scene induced uncertainty induced from geolocation, near-field Point Spread Function, spatial misregistration and/or resampling can be one of the main drivers for real scenes. This newly identified source of uncertainty needs to be tackled, modelled and implemented to provide reliable uncertainty information.
- The second aspect is that the Level 1 uncertainty propagation needs to be co-designed since the

beginning in combination with the Level 2 algorithm development in an end-to-end fashion. This does not only facilitate the integration but can even lead to an improvement in the algorithm retrieval performance.

We will present our most recent efforts in tackling these two aspects in the context of Land Surface Temperature Monitoring Mission (LSTM). LSTM makes use of an Optimal Estimator algorithm retrieval technique to recover Land Surface Temperature (LST) and Land Surface Emissivity (LSE) at Level 2. The algorithm performance is sensitive to how the Level 1 uncertainties are defined and hence having commensurate uncertainty definition has been a priority in the algorithm development. We will present our most recent and novel algorithms to estimate scene induced uncertainty at Level 1 and their propagation to Level 2. We will also explain how we have established an uncertainty architecture that includes both Level 1 and Level 2 teams and show the latest validated results and retrieval algorithm performance.

ENHANCING THE CREDIBILITY OF IN-SITU LST FOR SATELLITE-DERIVED LAND SURFACE TEMPERATURE VALIDATION

Jin Ma^{1*}, Ji Zhou¹, Frank-Michael Götsche², Ziliang Xiao¹, Ziwei Wang¹, Tao Zhang¹, Hua Wu¹, Wenbin Tang¹, Mingsong Li¹, Xiaodong Zhang¹, Shaofei Wang¹, Yongjie Wang¹, Shaomin Liu³

¹*School of Resources and Environment, University of Electronic Science and Technology of China, Chengdu 611731, China*

²*IMK-ASF, Karlsruhe Institute of Technology, Karlsruhe 76344, Germany*

³*State Key Laboratory of Earth Surface Processes and Resource Ecology, Faculty of Geographical Science, Beijing Normal University, Beijing 100875, China*

*Correspondence: jin.ma@uestc.edu.cn (Tel.: +86-18200116695), No. 2006, Xiyuan Ave, West Hi-Tech Zone, Chengdu 611731, Sichuan, China

A reliable quantification of uncertainty is essential for the application of Land Surface Temperature (LST) products. Currently, the temperature-based (T-based) method is the most widely utilized approach in satellite-derived LST validation. It allows to obtain uncertainty metrics from direct comparisons between satellite-derived LST and in-situ LST. However, estimating in-situ LST and its uncertainty on the – usually spatially heterogeneous – satellite pixel scale also brings some challenges to this approach. Therefore, most T-based validation studies rely on in-situ LST obtained over homogeneous surfaces. Furthermore, depending on the radiometer's spectral range, meteorological conditions can significantly impact the obtained in-situ LST. Consequently, enhancing the credibility of in-situ LST estimates on the satellite pixel scale is an urgent issue for T-based LST validation.

This presentation briefly introduces our previous analyses and the developed solution strategies. For narrow-band radiometers, e.g., the Heitronics KT15.85 IIP and the widely used Apogee SI-111/411 series, atmospheric effects between ground and instrument height can usually be neglected. However, for more commonly used net radiometers, e.g., the Kipp & Zonen CNR4, which typically include two pyrgeometers with a spectral range of 3~50 μm encompassing multiple atmospheric absorption bands, these effects cannot be neglected. We quantified these atmospheric effects and proposed a correction method that significantly improved the accuracy of radiation-based in-situ LST (Ma et al., 2023). Furthermore, to address the scale mismatch caused by surface heterogeneity, we defined a spatial representativeness index (SRI). Then, by integrating high-resolution data (e.g., Landsat LST) with the temporal dynamics of LST, the site-specific temporal variation of SRI was quantified on the pixel scale. Subsequently, ground-based LST observations were successfully converted—or upscaled—to pixel scale (Ma et al., 2021). Integrating these two aspects, we developed a comprehensive scheme to enhance the selection of in-situ LST and, consequently, satellite-derived LST validation (Ma et al., 2024).

Currently, we are conducting a multi-scale field experiment combining a UAV, a measurement tower with a height of 15 meters, and a ground platform to obtain a high-spatiotemporal resolution LST dataset. This dataset will be used to further explore methodologies for obtaining ‘ground truth’ LST on pixel

scale in complex environments and to improve satellite LST product validation on a global scale.

- Ma, J., Zhou, J., Gottsche, F.-M., Wang, Z., Wu, H., Tang, W., Li, M., Liu, S., 2023. An atmospheric influence correction method for longwave radiation-based in-situ land surface temperature. *Remote Sens. Environ.* 293, 113611. <https://doi.org/10.1016/j.rse.2023.113611>
- Ma, J., Zhou, J., Liu, S., Gottsche, F.-M., Zhang, X., Wang, S., Li, M., 2021. Continuous evaluation of the spatial representativeness of land surface temperature validation sites. *Remote Sens. Environ.* 265, 112669. <https://doi.org/10.1016/j.rse.2021.112669>
- Ma, J., Zhou, J., Zhang, T., Tang, W., Wang, Y., 2024. A Comprehensive Validation Scheme for Satellite-Derived Land Surface Temperature Dataset. *IEEE Trans. Geosci. Remote Sensing* 62, 5007812. <https://doi.org/10.1109/TGRS.2024.3488083>

COMPONENT-RESOLVED THERMAL RADIANCE DIRECTIONALITY IN STRUCTURED VINEYARD CANOPIES: A SINGLE-SENSOR FRAMEWORK AND INITIAL EVIDENCE

Thejaswini S P¹*, Eswar Rajasekaran¹, Jean-Louis Roujean², Mark Irvine³, Chandrika Pinnepalli²

¹Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India 400076

²Centre d'Etudes Spatiales de la Biosphère (CESBIO), 13 avenue du Colonel Roche, 31400 Toulouse, France

³INRAE, ISPA, 71 avenue E. Bourlaux, 33140 Villenave d'Ornon, France

*Correspondende: 23d0300@iitb.ac.in (Tel.: +91-9108972236)

Thermal infrared remote sensing of land surface temperature (LST) is inherently affected by thermal radiance directionality (TRD), yet its physical drivers remain insufficiently resolved, particularly in structurally complex agricultural systems. This study presents a novel experimental framework specifically designed to isolate and quantify TRD effects at the ground level using a single-sensor, multi-zone field-of-view (FOV) approach. By partitioning the instantaneous FOV into spatial zones representing distinct effective viewing geometries, the method enables simultaneous angular sampling under identical illumination conditions, thereby eliminating inter-sensor biases and temporal inconsistencies.

The framework integrates a component-resolved decomposition based on a swap formulation to separate geometric (fractional) and thermodynamic (temperature) contributions to directional variability. Sub-pixel structure is resolved into four radiatively distinct components: sunlit vegetation, shaded vegetation, sunlit soil, and shaded soil, using a hierarchical combination of optical and thermal clustering techniques.

Initial results, derived from multi-day observations over a North–South oriented vineyard in India, indicate that TRD is strongly governed by directional redistribution of sub-pixel component fractions. High viewing zenith angle configurations exhibit substantial increases in visible sunlit soil fraction (up to ~40–50% relative to a hotspot-aligned reference), while low-angle views show reduced visibility of sunlit vegetation due to canopy occlusion. These fractional shifts are associated with directional LST differences on the order of ~1–2 K, highlighting the sensitivity of bulk thermal signals to viewing geometry.

A consistent thermodynamic enhancement of approximately ~1 K is observed under near-hotspot conditions (cosine scattering angle, CSA > 0.99), suggesting an additional radiative contribution linked to shadow suppression. Furthermore, preliminary analysis indicates a temporal offset between peak geometric alignment and maximum thermal response, reflecting interactions between solar geometry and canopy structure.

These findings provide initial empirical evidence that TRD in row-structured canopies is a structurally driven and a scale-dependent phenomenon, rather than a purely transient effect. The proposed framework establishes a physically consistent basis for future investigations aimed at quantifying directional biases in satellite-derived LST and improving diurnal temperature cycle (DTC) characterization.

PREVALENCE AND DRIVERS OF ABRUPT LAND SURFACE TEMPERATURE SHIFTS IN NATURAL VEGETATION LANDS

Jing Li¹, Zhao-Liang Li^{1*}, Nanshan You²

¹State Key Laboratory of Efficient Utilization of Arable Land in China, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China

²Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

**Correspondence: lizhaoliang@caas.cn*

Land surface temperature (LST) represents the radiative skin temperature of the Earth's surface. It responds sensitively to variations in surface energy fluxes driven by climate forcing and changes in land surface properties thus serves as a key indicator for monitoring global climate change and land disturbances. Despite extensive research on global LST patterns, the prevalence of abrupt LST changes remains understudied, particularly those induced by extreme climate events or alterations in surface properties associated with human activities or natural disturbances, such as land use change, fire, and flooding. A better understanding of abrupt LST shifts is essential for uncovering the mechanisms underlying these transitions and for informing strategies to mitigate their impacts.

This study focuses on natural vegetation areas where abrupt LST changes have led to substantial and persistent shifts in thermal dynamics. We compiled a 20-year satellite-derived LST time series from MODIS observations. Using an improved Bayesian Estimator of Abrupt change, Seasonality, and Trend, we extracted LST trend trajectories and quantified the proportion of ecosystems exhibiting linear versus abrupt change patterns. We further applied machine learning methods to assess the associations between abrupt LST changes and multiple environmental drivers, including climate variability, surface properties, and human disturbances.

Our results show that approximately 30% of natural vegetation areas exhibit abrupt LST dynamics, with positive changes occurring more frequently than negative ones (61% vs. 39%). Case analysis in the Brazilian Amazon demonstrates that both LST and Normalized Difference Vegetation Index (NDVI) respond strongly to deforestation, although with temporal differences (Figure 1). Overall, climate variability plays a dominant role in triggering abrupt LST shifts, while human activities increase their frequency. These findings reveal global hotspots of abrupt thermal transitions and provide insights into their underlying drivers, offering a basis for improving ecosystem resilience under climate change.

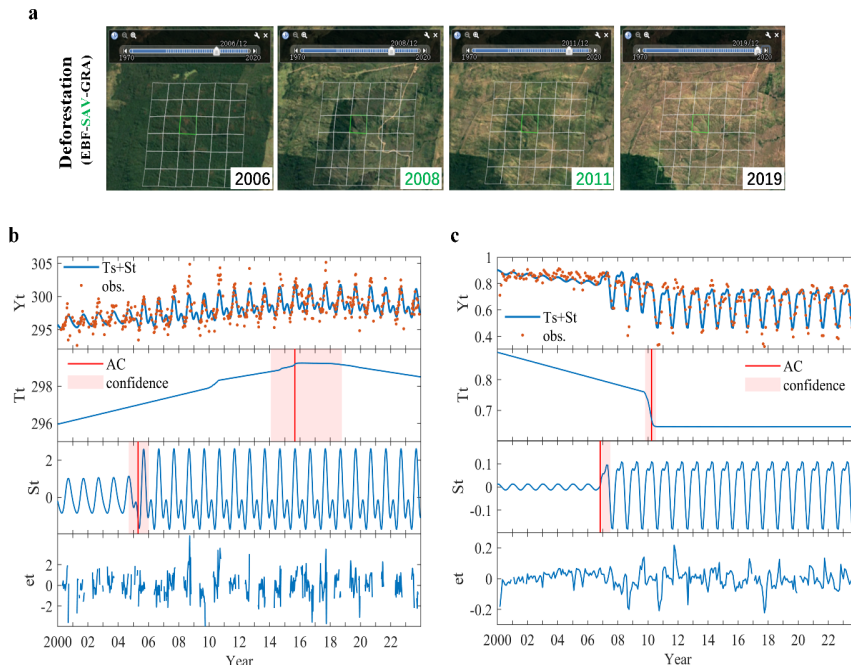


Fig. 1 Illustration of the abrupt response of LST and NDVI to deforestation in the Brazilian Amazon. a, High spatial resolution image sequences from Google Earth highlight crop expansion following deforestation after 2008, resulting in a land cover transition from the Ever-broadleaf Forest (EBF) to Savana (SAV) and Grass (GAR). White and red boxes represent MODIS pixels with a spatial resolution of 1 km. The sampled forest loss pixels are centered at 51.68° W, and 8.92° S. b and c are corresponding change detection results in the LST and NDVI time series, respectively. The red dotted points represent the LST and NDVI time-series observations (obs.). The change detection method used here decomposes the LST or NDVI dynamics into trend (Tt), seasonal (St), and remainder (et) components and detects abrupt changes (AC), marked as vertical red lines. The light red filled areas represent the confidence intervals of the detected abrupt changes.

NASA'S EAGLE-VSWIR: GLOBAL IMAGING SPECTROSCOPY MEASUREMENTS FOR NEXT GENERATION OBJECTIVES SPANNING MINERAL EXPLORATION, WILDLAND FIRE, AGRICULTURE, WATER RESOURCES, WATER QUALITY, AND SCIENTIFIC RESEARCH ACROSS THE EARTH SYSTEM.

*Robert O. Green, David R. Thompson, Phil Brodrick, Dana Chadwick, and the EAGLE-VSWIR Team
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA*

The Earth system is rich with opportunities for new and important applications and science objectives using imaging spectroscopy measurements of the visible to short-wavelength infrared (VSWIR) region of the electromagnetic spectrum from 380 to 2500 nm. Within this spectral range, diagnostic spectral signatures arise from fundamental physical processes, including atomic and molecular electron transitions, molecular bond vibrations, emission, and scattering effects. Quantitative analysis of the absorption, emission, and scattering features, often leveraging radiative transfer modeling, enables detection, identification, and quantification of constituents of the observable geosphere, biosphere, hydrosphere, cryosphere, atmosphere,

and anthroposphere. Repeat observation allows monitoring of constituents and physical process changes through time. To capture these signatures and deliver rigorously calibrated parameters with traceable units and uncertainties, advanced imaging spectrometers have been developed capable of measuring a continuous VSWIR spectrum for every spatial point in an image.

Today NASA is developing the next generation EAGLE-VSWIR global imaging spectroscopy mission. The EAGLE-VSWIR imaging spectrometer will deliver a 190-km swath with 30-m spatial sampling and continuous spectral coverage across the VSWIR range. The mission's orbit provides complete land and coastal coverage with a 16-day revisit, while deep oceans and ice sheets will be returned generally at a coarser 300-m sampling. This combination of sub-monthly revisit times, high spatial resolution, and global coverage will yield data volumes anticipated to be ≥ 29 times greater than those of EMIT. This expansion extends VSWIR imaging spectroscopy observations into the future, ensuring critical data continuity following the planned retirement of the International Space Station. The EAGLE-VSWIR mission directly addresses urgent challenges with an increased focus on stakeholder needs. Specific high-priority applications aim to strengthen national, regional, and local preparedness and resilience by characterizing wildland fire fuels, ensuring water and food security, optimizing agricultural measurement, and assisting exploration for mineral resources. We report the core objectives, status, and plans for EAGLE-VSWIR, which was announced in April 2026 at the U.S. National Academy Committee on Earth Science and Applications from Space.

THE FLUORESCENCE EXPLORER (FLEX) MISSION: GLOBAL SCALE QUANTIFICATION OF THE VARIABILITY IN THE PHOTOSYNTHETIC ACTIVITY OF TERRESTRIAL VEGETATION

Jose Moreno

IPL-Scientific Park / Faculty of Physics, University of Valencia, 46100 Burjassot, Valencia, Spain

Jose.Moreno@uv.es

After more than 25 years of developments, the ESA FLuorescence EXplorer (FLEX) mission is set for launch on 1 September 2026 from French Guiana, with a Vega rocket, in a dual launch together with Sentinel-3C, taking advantage of the fact that FLEX and Sentinel-3 will follow the same orbit (tandem flight). This presentation will highlight the latest developments towards the launch, and the preparations for scientific data exploitation and Cal/Val activities.

The FLEX mission was selected in 2015, by the European Space Agency (ESA), as the 8th Earth Explorer within the ESA Living Planet Programme. The key scientific objective of the mission is the quantitative mapping of actual photosynthetic activity of terrestrial ecosystems, and its variability, as a function of vegetation health status and environmental stress conditions, at a global scale and with a spatial resolution adequate to resolve land surface processes associated to vegetation dynamics. To accomplish such objective, the FLEX satellite carries the FLORIS spectrometer, specially optimized to derive the vegetation fluorescence emission, and is designed to fly in tandem with Copernicus Sentinel-3. Together with FLORIS, the OLCI and SLSTR instruments on Sentinel-3 provide all the necessary information to retrieve the emitted fluorescence by vegetation, and to allow proper derivation of the spatial and temporal dynamics of vegetation photosynthesis from such global measurements, including the compensation for atmospheric effects and the derivation of the additional biophysical information needed to interpret the variability in fluorescence measurements.

FLEX will provide science products which are not restricted to chlorophyll fluorescence measurements, but include also estimates of regulated heat dissipation, needed to quantify actual photosynthesis. Together with canopy temperature and other biophysical variables characterizing vegetation status, Level-2 products include chlorophyll fluorescence emission spectrum, decomposition of light absorption by elementary pigments, dynamical changes in leaf pigments with stress adaptations and energy dissipation cycles (xanthophylls), and high-level products such as actual photosynthetic (electron transport) rates and vegetation stress indicators (potential versus actual photosynthesis, photoprotection adaptations, non-photochemical energy dissipation and variable PSI/PSII contributions tracking photosynthesis

dynamics). Level-3 products are derived by means of spatial mosaics and temporal composites, giving also as a temporal product the activation / deactivation of photosynthesis, growing season length and related vegetation phenology indicators. Finally, combining such products by means of data assimilation into advanced dynamical vegetation models of FLEX time series, Level-4 products are also derived, including improved estimates of carbon assimilation (Gross Primary Productivity) and evapotranspiration rates, with an explicit coupling of dynamical effects in the combined energy-water-carbon cycles, and more advanced dynamical vegetation stress indicators. Usage of multi-resolution spatial grids for L2/L3/L4 products maximizes the inter-operability of FLEX products in global data assimilation approaches and applications.

Many of the new advanced products are very innovative and still in an early state of validation. In preparation for the FLEX launch, particular efforts are in place to provide each product with realistic and properly estimated uncertainties, with explicit confidence intervals, using the corresponding statistical distribution for each product, propagating the uncertainties from the original satellite data until the final high-level products, and with explicit separation of systematic and random uncertainties. This strategy is relevant for all users and applications, but results of special interest for those applications exploiting data assimilation into dynamical models of land processes, which is one of the key targets for FLEX products. Efforts are also in place to guarantee proper Cal/Val activities and dedicated validation networks for FLEX, where the associated uncertainties in satellite products and field data are consistently considered.

The availability of validated ready-to-use high level science products will allow an extensive scientific usage of FLEX data in vegetation dynamical models, and global carbon and climate models, with also a high potential for derived applications, such as agriculture, food security or biodiversity.

OpenET: SUPPORTING SUSTAINABLE WATER MANAGEMENT WITH SATELLITE-BASED EVAPOTRANSPIRATION DATA PRESENTING AUTHOR:

Forrest Melton^{1}, Anderson Ruhoff², Sara Larsen³, Adam Purdy^{1,4}, Conor Doherty^{1,4}, John Volk⁵, Richard Allen^{6,7}, Martha Anderson⁸, Lydia Bleifuss³, Matt Bromley³, Britta Daudert⁵, Jack Eggleston⁹, Joshua Fisher¹⁰, Mackenzie Friedrichs⁹, Alberto Guzman^{1,4}, Christopher Hain¹¹, Jordan Harding¹², Thomas Holmes¹³, Justin Huntington⁵, Kyle Knipper⁸, Lee Johnson^{1,4}, Ayse Kilic¹⁴, Leonardo Laipelt², Hui Liu¹⁵, Blake Minor⁵, Charles Morton⁵, Chris Pearson⁵, Peter ReVelle⁵, Gabriel Senay⁹, Yun Yang¹⁵*

¹NASA Ames Research Center, USA

²Universidade Federal do Rio Grande do Sul, Brazil

³OpenET, Inc., USA

⁴California State University Monterey Bay, USA

⁵Desert Research Institute, USA

⁶ETPlus, Inc.,

⁷University of Idaho, USA

⁸USDA Agricultural Research Service, USA

⁹United States Geological Survey, USA

¹⁰Chapman University, USA

¹¹NASA Marshall Space Flight Center, USA

¹²Habitat Seven, Inc., USA

¹³NASA Goddard Space Flight Center, USA

¹⁴University of Nebraska Lincoln, USA

¹⁵Cornell University, USA

**Correspondence: forrest.s.melton@nasa.gov (Mail Stop 245-5, NASA Ames Research Center, Moffett Field, CA USA)*

Sustainable management of water resources is one of the most pressing global challenges of our time, and avoiding further water bankruptcy in key agricultural regions around the world requires innovative, science-based approaches to balance water supply and demand. Evapotranspiration (ET) data computed from

satellite-driven models can play a key role in supporting the advancement of data-driven decision making and sustainable water management strategies by water managers at all scales, from individual farms and irrigation districts to major river basins.

OpenET is a fully automated system for field-scale (30 m), satellite-based mapping of ET at daily, monthly and annual timesteps. OpenET currently provides data for the contiguous United States (US) and includes low latency, near real-time information and multi-year timeseries of ET data from 1999 to present. The OpenET team has implemented an ensemble of six satellite-based ET models on Google Earth Engine, which provides a shared computing platform for collaboration on processing of data from Landsat and other satellites, land cover and meteorological inputs, leading to increased consistency and accuracy across the ensemble of models.

We present the development of the OpenET framework and discuss how the use of an open science approach and robust accuracy assessments have facilitated successful applications of OpenET data for a wide range of water resource management activities in the US. We highlight applications including support for sustainable groundwater management programs in the western US, incentive-based water conservation programs, data-driven irrigation management for a range of crops, water use reporting in the San Francisco Bay-Delta region, quantification of consumptive use across the Colorado River Basin, and water accounting at national scales. Collectively, these applications demonstrate that broad acceptance and ease of access to ET data contribute to the rapid adoption in support of innovative water management practices at scale, and facilitate meaningful progress towards more sustainable management of water supplies in the US. We conclude with a discussion of how the use of an open science, community-based approach is facilitating geographic expansion led by regional science teams and water resource management experts, such as the recently launched OpenET Brazil.

KERNEL-DRIVEN MODEL CORRECTION OF THERMAL DIRECTIONALITY: PIXEL-LEVEL ANALYSIS USING AIRBORNE MULTI-ANGULAR OBSERVATIONS PRINCIPAL

Louis Snijders¹, Mary Langsdale², Joris Blommaert¹, Jonathan León-Tavares¹

¹VITO/VUB, Mol / Brussels, Belgium

²KCL, London, United Kingdom

*Louis.snijders@vito.be, mary.langsdale@kcl.ac.uk, joris.blommaert@vito.be,
jonathan.leontavares@vito.be*

Remote sensing retrieved land surface temperatures (LST) depend not only on the time of acquisition but also on the position of the thermal sensor and the Sun. Upcoming high spatial resolution thermal infrared (TIR) satellite missions, such as LSTM, TRISHNA, and SBG, will acquire LST under large viewing zenith angles, up to 34°. Under these conditions, directional effects, influenced by sun-sensor geometry, will affect LST retrieval by several Kelvins. To achieve the target accuracy of 1 K, necessary for precision agriculture applications, it is essential to characterise and correct for directional effects.

Parametric models offer a desirable trade-off between applicability and accuracy for operational corrections of directional effects. However, due to the scarcity of multi-angular high-resolution datasets, little research has been done on applying parametric models to high-resolution LST and understanding the factors that affect the model coefficients. Our research utilises airborne data to (1) evaluate and compare six kernel-driven parametric models, demonstrating their ability to correct directional effects in high-resolution TIR data, (2) understand how model coefficients vary with land cover, biophysical parameters, and spatial resolution, and (3) introduce simplified model formulations that reduce parameter complexity while maintaining correction accuracy.

During the NETSense 2023 airborne campaign, multi-angular measurements were acquired by the Specim AisaOWL sensor over an agricultural area near Grosseto, Italy. The sensor was mounted on a tilting platform allowing view zenith angles up to 48°, exceeding the field of view of upcoming TIR satellite missions. A parallel flight line strategy with zenithal variability provided nadir and off-nadir observations in

rapid succession, minimising temporal drift. LST was retrieved using the OISAC atmospheric correction method and the TES algorithm.

The inversion of six kernel-driven models at pixel level provides the directional coefficients that determine the modelled temperature for any sun-sensor geometry. To assess the generalisability of these models, the analysis evaluates how coefficients and correction performance vary across spatial resolutions from 5 m up to 100 m, across different crop types, and across biophysical parameters.

A key finding is a consistent inverse relationship between hotspot magnitude and width, which was exploited to develop two simplified kernel formulations that reduce the number of free parameters via a power-law linking hotspot width to magnitude. Validation using an independent flight day confirmed the robustness of the simplified models, with the two-parameter Vinnikov–RLa outperforming all models including those with more parameters. Biophysical parameters such as NDVI, LAI, and FCOVER showed limited utility for direct coefficient estimation, indicating that multi-angular thermal observations remain essential for reliable parameter retrieval. These findings support the integration of directional correction into operational pipelines for future high-resolution thermal missions.

DRY BIOMASS ESTIMATION IN SAHELIAN PASTORAL ECOSYSTEMS: A MULTI-SOURCE REMOTE SENSING AND MACHINE LEARNING APPROACH WITH ROBUST SPATIAL–TEMPORAL VALIDATION

Hana Abdelmoula¹, Astrid Vannoppen¹, Abdourahamane Zakari², Jeroen Degerickx¹

¹VITO – Flemish Institute for Technological Research, Remote Sensing Unit, Boeretang 200, 2400 Mol, Belgium

²AGRHYMET Regional Centre – CILSS, BP 11011, Niamey, Niger

Corresponding author: Hana Abdelmoula

Tel: +32 469 73 19 42 hana.abdelmoula@vito.be, A. Vannoppen: astrid.vannoppen@vito.be, A. Zakari: abdourahamane.zakari@cilss.int, J. Degerickx: jeroen.degerickx@vito.be

Accurate estimation of aboveground dry biomass in semi-arid ecosystems remains a critical challenge due to high spatial heterogeneity, pronounced interannual climate variability, and the scarcity of ground observations. In the Sahel, dry biomass directly determines livestock grazing resources and guides transhumance decisions, making reliable monitoring essential for pastoral management and food security. Most existing remote sensing approaches rely on conventional random cross-validation, which inflates performance estimates through implicit spatial and temporal data leakage. This study addresses this gap within the ESA EOAfrica Explorers ARIES project (<https://eoafrika-aries.org/en>), with AGRHYMET coordinating multi-site field data collection across Niger.

An ExtraTrees machine learning model was developed using 503 in situ measurements collected across 19 pastoral sites in Niger between 2023 and 2025, spanning four dry-season campaigns. Input features were derived from multi-source Earth observation data, including Sentinel-2 optical imagery with additional shortwave infrared (SWIR)-based spectral indices, Sentinel-1 SAR data, and biophysical variables such as the fraction of absorbed photosynthetically active radiation (fAPAR), gross primary productivity (GPP; derived from Copernicus Global Land Service products at 300 m spatial resolution), and seasonal precipitation totals from the AgERA5 agrometeorological reanalysis dataset. The target variable was log-transformed to account for skewness in biomass distribution.

Five validation strategies were applied: random K-fold, site-and-year stratified K-fold, repeated stratified shuffle splits (30 iterations), leave-one-site-out, and leave-one-campaign-out. A pronounced gap was observed between random cross-validation ($R^2 = 0.76$) and site-and-year stratified validation ($R^2 = 0.27\text{--}0.38$), confirming that conventional approaches substantially overestimate operational performance. Spatial generalisation was moderate ($R^2 = 0.42 \pm 0.14$), demonstrating meaningful cross-site transfer. Temporal generalisation was partially achieved for typical dry-season campaigns ($R^2 = 0.07\text{--}0.31$), while an anomalous high-rainfall year produced negative R^2 , exposing the structural limits of training-set coverage under extreme interannual climate variability.

Feature importance analysis shows that SWIR-based features, sensitive to cellulose and lignin in senescent plant material, account for 41% of total model importance, substantially outweighing greenness-based features (18%) and fAPAR (7%). This result challenges the widespread reliance on greenness-based indicators for dry biomass estimation in pastoral savannas, where standing dead matter dominates the canopy spectral signal during the dry season.

These findings highlight that interannual climate anomalies are the primary limiting factor for model transferability in the Sahel, while strict grouped cross-validation performance ($R^2 = 0.27\text{--}0.42$) is competitive with previously reported results in comparable semi-arid ecosystems. Robust spatiotemporal validation is essential for unbiased performance reporting and for guiding field campaign design, supporting operational dry biomass monitoring for pastoral management and food security.

AGENTIC AI FOR ENVIRONMENTAL IMPACT ASSESSMENT OF CONSTRUCTION PROJECTS USING SATELLITE DATA

Daryna Skakun¹, Artem Shelestov², Sofiia Drozd^{3,4,5}, Anastasiya Skakun¹

¹Urbana High School, 21754 Ijamsville, Maryland, USA;

²College of Computing, Georgia Institute of Technology, 30332 Atlanta, Georgia, USA

³NTU “Igor Sikorsky Kyiv Polytechnic Institute”, 03056 Kyiv, Ukraine

⁴Space Research Institute NASU-SSAU, 03187 Kyiv, Ukraine

⁵Anhalt University of Applied Science, 06366 Köthen (Anhalt), Germany

Email: darynasskakun@gmail.com

The rapid expansion of large-scale construction projects, particularly data centers and other energy-intensive infrastructure, is increasingly pressuring local ecosystems through atmospheric emissions, land-use change, and rising water demand. These impacts can cause severe consequences, such as groundwater table drawdown and long-term landscape degradation. While Earth observation (EO) data provide unique capabilities for monitoring these environmental impacts consistently across large spatiotemporal extents, current environmental impact assessment (EIA) workflows remain largely manual, fragmented, and dependent on expert-driven analysis. This dependency limits their scalability and accessibility for planners and decision-makers. To overcome these limitations, this paper proposes an agentic artificial intelligence (AI) framework designed for the automated preliminary assessment of the environmental impact of construction projects. This framework is based on the concept of a Digital Twin (DT) for land cover and land use change monitoring, achieved by implementing autonomous EO-based workflows. The system is implemented on the n8n platform for workflow automation and employs a dual-agent architecture. A primary manager agent, based on the GPT-5.2 model, interprets user-defined construction scenarios and autonomously plans and runs the analysis. It dynamically generates and runs executable Python code for Google Earth Engine (GEE) to acquire, integrate, and analyze critical data. Key metrics include air quality data from Sentinel-5P, groundwater depth from the GLOBGM model, and soil moisture from the NASA Global Land Data Assimilation System (GLDAS). Subsequently, an assistant agent based on the GPT-4o model interprets the analytical results to produce user-readable environmental assessment scenarios. The proposed framework was evaluated using representative construction scenarios across the United States, automatically processing up to 10 years of satellite data. It successfully generated qualitative environmental viability assessments, classifying projects into VIABLE, RISKY, or CRITICAL categories. The average execution time was highly efficient at approximately 1.5 minutes per scenario, coupled with a minimal mean operational cost of USD 0.06. Ultimately, the results demonstrate that agentic EO workflows provide a rapid and cost-efficient preliminary assessment of construction-related environmental risks, representing a highly promising direction for the development of automated DT systems.

TEMPERATURE EFFECTS OF CROPPING STRUCTURE ADJUSTMENT IN THE HUANG-HUAI-HAI PLAIN

Guofei Shang, Xiaoxia Hou, Xia Zhang*, Yue Liu, Xiangyang Liu

Hebei International Joint Research Center for Remote Sensing of Agricultural Drought Monitoring, Hebei GEO University, Shijiazhuang, 052161, China

**Correspondence: zhangxia396@hgu.edu.cn (Tel./Fax: 0311-87207648)*

The Huang-Huai-Hai Plain, a core grain-producing region in China, faces chronic challenges including water scarcity and shifts in the regional thermal environment. While land use changes are known to influence land surface temperature (LST) via surface energy balance adjustments, existing research predominantly focuses on LST variations between distinct land cover types, overlooking the impacts of management practices within cultivated land. To address this gap, this study quantifies the LST effects of cropping structure adjustments in the Huang-Huai-Hai Plain from 2003 to 2020. Employing a "Space-for-time" substitution approach, the study analyzes impacts from three perspectives: initial crop type, cropping system, and land use intensity, with attribution analysis conducted using the Direct Temperature Decomposition Model (DTM). Results indicate that from 2003 to 2020, the total cropped area in the Huang-Huai-Hai Plain increased, with a clear transition from single-cropping systems toward double-cropping rotations, a shift most pronounced in the central-southern region. This transformation was primarily driven by urbanization, while climate warming exerted a significant negative constraint. Overall, cropping structure adjustments produced a net regional cooling effect. Specifically, winter wheat exhibited a strengthening cooling trend (-0.011 K/a), whereas maize showed a weakening cooling trend (0.010 K/a). Analyses from three complementary perspectives: initial crop type, cropping system, and land use intensity, consistently revealed that planting winter wheat in the subsequent year enhanced cooling, whereas shifting to maize consistently weakened it. DTM attribution revealed that enhanced cooling in winter wheat was primarily driven by increased latent heat flux (ΔLE), whereas weakened cooling in maize resulted from decreased ΔLE combined with reduced surface albedo. Based on thermal carrying capacity, differentiated optimization paths are proposed: the southern high-temperature zone should moderate disordered rotation expansion, while the northern transition zone should prioritize ordered maize-winter wheat rotation. Integrating cropping adjustments with water-saving technologies and albedo regulation is essential for achieving the dual goals of food and ecological security, thereby advancing the sustainable development of agricultural production systems

INTEGRATING REMOTE SENSING AND GEOSPATIAL ANALYSIS TO ASSESS ENVIRONMENTAL AND CLIMATIC VULNERABILITY AND THE ROLE OF PERI-URBAN AREAS IN MEDITERRANEAN CITIES: THE CASES OF VALENCIA AND MILAN

Rivero Moro C.¹, Gilabert M.A.¹, Pérez-Hoyos A.², López Baeza E.¹

¹Environmental Remote Sensing group (UV-ERS). Universitat de València, 46100 Burjassot, València (Spain),

²Albavallor. Parc Científic. Universitat de València, 46980 Paterna, València (Spain).

Urban areas are increasingly vulnerable to the impacts of climate change, particularly in Mediterranean regions, where compounded pressures from overbuilding, traffic, air pollution, and intensifying heat waves and extreme precipitation events are driving vulnerability. This study presents an integrated framework to assess environmental and climatic vulnerability in two Mediterranean cities, Valencia (Spain) and Milan (Italy), with a particular focus on the role of peri-urban agricultural landscapes in modulating urban climate risk.

Utilizing multi-source Earth Observation data (Landsat 8/9, ECOSTRESS, Sentinel-2) and geospatial analysis, vulnerability is characterized through three key dimensions: exposure, sensitivity, and

adaptive capacity. The exposure component integrates Land Surface Temperature, NO₂ air pollution, extreme temperature and precipitation events, and flood susceptibility layers. Sensitivity is quantified through NDVI, Leaf Area Index (LAI), and imperviousness, capturing the thermal regulatory role of vegetation and the amplifying effect of surface sealing. The adaptive capacity component incorporates green areas accessibility and ecological connectivity metrics. A composite spatial indicator of vulnerability was developed by integrating these variables through Geographically Weighted Principal Component Analysis (GWPCA), enabling the identification of vulnerability hotspots across both cities.

Results reveal that a substantial proportion of the population in both cities resides in areas of high or very high vulnerability, concentrated in dense urban cores where thermal stress, pollution exposure, and surface sealing converge, emphasizing disparities between the urban core and peri-urban areas, with more than half of the population (>50%) located within these high-vulnerability zones. Preliminary quantitative analysis indicates that peri-urban areas exhibit lower vulnerability levels, with differences of approximately 2–4 units on a normalized 1–10 scale compared to dense urban cores, and are associated with lower land surface temperatures, typically exceeding 2–3°C of cooling relative to highly urbanized zones. These areas also show consistently higher vegetation activity, with NDVI values increasing by approximately 20–40% compared to urban cores. Despite their contrasting urban morphologies and climate sub regimes, both cities show analogous patterns of peri-urban agricultural areas, including the Horta de València and the Po Plain fringe around Milan, acting as zones of low vulnerability and, particularly, high adaptive capacity that can actively moderate climatic risk for adjacent urban populations, highlighting their strategic value for climate resilience planning.

The proposed framework provides a consistent and transferable approach for assessing urban climate vulnerability across Mediterranean contexts. Beyond identifying hotspots, the results demonstrate the importance of peri-urban agricultural systems as functional components of climate adaptation strategies, offering valuable insights for spatial planning and policy design aimed at enhancing urban resilience.

INTEGRATION OF MULTIDIMENSIONAL DATA CUBES AND MACHINE LEARNING FOR THE OPERATIONAL MONITORING OF AQUACULTURE IN THE SPANISH MEDITERRANEAN

Arena Martín Olivo^{1,2}, Ana B. Ruescas², Masuma Chowdhury¹, Ignacio de la Calle¹

¹ Quasar Science Resources S.L. Calle Chile ⁸, 28290 Las Rozas de Madrid, Madrid, (Spain)

² Image Processing Laboratory, Parc Científic Universitat de València, C/ Cat. Agustín Escardino Benlloch 9, 46980 Paterna (València), Spain

Phone: +34963543229

amartin@quasarsr.com, ana.b.ruescas@uv.es

This study demonstrates the integration of satellite-derived data cubes (multidimensional, e.g. Sentinel-2 MSI time series) with machine learning (ML) algorithms for the systematic monitoring of water quality in aquaculture areas. The use of data cubes facilitates the calculation of spectral indices and the estimation of critical parameters, such as the concentration of suspended matter or phytoplankton, providing highly relevant inputs for determining water quality in aquaculture and adjacent areas.

The strategy employed is a ‘multi-model’ approach: ensemble models (like Gradient Boosting) are used to model complex non-linear relationships in the estimation of physical parameters such as turbidity or others; Long Short-Term Memory (LSTM) networks to predict trends and detect anomalous discharges; and Convolutional Neural Networks (CNN) to identify geometric patterns of marine cages and the morphology of organic plumes.

To ensure scalability, we are working in phases, using algorithms that are initially refined in specific areas (sub-cubes) of the Spanish Mediterranean. Following validation, the system will be scaled up to cover the entire coastline. For the initial phase, we are using the European DeepESDL (ESA) infrastructure, a cloud environment that enables the establishment of an operational processing pipeline using Python tools (xarray). The workflow will enable us to measure the computational efficiency and potential reproducibility

of the methodology employed, as the transition from localised pilot studies to a large-scale automated monitoring system should prove technically efficient and methodologically sound.

RETRIEVAL OF GAP-FREE 20M 5-DAY VEGETATION VARIABLES FROM INTEGRATED LANDSAT AND SENTINEL-2 ANALYSIS READY DATA

Han Ma¹, Shunlin Liang¹, Qian Wang²

¹Department of Geography, The University of Hong Kong

²Faculty of Geography, Beijing Normal University

Vegetation influences the climate and global carbon cycle by taking up atmospheric carbon dioxide through photosynthesis and cooling Earth's temperature (Knorr et al., 2010). The most widely used biophysical variables in climate and ecosystem models are Leaf Area Index (LAI) and the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), both recognized as Essential Climate Variables (ECVs) by the Global Climate Observing System (GCOS) [1].

Global LAI and FAPAR satellite products have been generated at coarse spatial resolutions (250m or coarser). However, many applications (e.g., regional environmental changes and sustainable development) urgently require the LAI and FAPAR time-series seamless products at fine scales (10-30m), which are not available worldwide. Landsat and Sentinel-2 are acquiring massive high-resolution Earth observations. Landsat series have provided the first 30m spatial resolution and longest data-record of Earth observation data since 1972, while Sentinel-2 MultiSpectral Instrument (MSI) has delivered multi-spectral observations at 10 to 60 m resolution over land surfaces since 2015. However, the optical Landsat and Sentinel-2 data is typically hampered by cloud contamination, and current vegetation variable estimation methods (physical, machine learning and hybrid based) from Landsat and Sentinel-2 are predominantly designed for clear-sky conditions [2-5], as a result, data gaps inevitably appear in the high-level products. Nevertheless, seamless vegetation products with fine spatial resolutions are essential for local-scale ecosystem, agriculture, and forest monitoring applications, as they offer more precise information [6], which will enable improved decision-making and planning processes in these critical areas.

AI deep learning models, such as Convolutional Neural Network (CNN), long short-term memory (LSTM) and Transformers, have become powerful tools in information extraction from satellite data due to their ability to automatically extract and analyze spatiotemporal features from large datasets [7-10]. However, deep learning for large area mapping at fine resolution requires both high-performance computing facilities and proper organization of multiple satellite data. Previous research adopts cloud computing platforms such as Google earth engine and Amazon Web Services are usually based on single phase or yearly-composited Landsat image [11, 12], to fully utilize the spatiotemporal information in Landsat observations, the satellite data should be organized in tiled grids-analysis ready data (ARD), which can facilitate time series analysis and generate composite results of large areas.

The objectives of this research are 1) to develop a deep learning based model to estimate vegetation variables from combined use of time series Landsat 8 and Sentinel-2 data; 2) to validate the estimation model at global distributed sites against field measurements and current products; and 3) to generate 20m resolution LAI/FAPAR products in China. To achieve these goals, we will leverage both cloud computing platform GEE and local high-performance computing facility (HKU-HPC) for handling large volumes of time-series imagery, creating combined Landsat and Sentinel-2 ARD, and building deep learning models for LAI/FAPAR estimation to better make use of the spatiotemporal information provided by both sensors.

We employed a temporal deep learning regression model to estimate gap-free, time-series 20m LAI/FAPAR from Landsat/Sentinel-2 surface reflectance data. The training sites were identified and created based on existing products including 30m Hi-GLASS land cover and 250m GLASS LAI/FAPAR. We divided the representative sites into heterogeneous and homogeneous groups, where LAI/FAPAR labels (Y) were assigned using two strategies. The training features (X) consisted of 5-day composited time series surface reflectance data from Landsat and Sentinel-2, which included data gaps and noise that we did not preprocess. We evaluated the two dominant temporal models—LSTM and Transformer—along with two combinations of these models to learn the relationships between X and Y.

The trained model was directly validated against 3,000 LAI/FAPAR in-situ measurements from 444 GBOV sites, and the root mean square error (RMSE) values are 1.1 for LAI and 0.16 for FAPAR, respectively (Fig.2). We also compared Hi-GLASS LS20 LAI/FAPAR products with SL2P 20m estimation, NASA official MODIS 500m, and GLASS 250m products, and demonstrated the over-performance of our model in terms of continuity, accuracy, and consistency. To implement the optimized model, we first constructed Landsat-8/9 and Sentinel-2 Analysis Ready Data (ARD) and then generated the 20m/5-day LAI/FAPAR product in China from 2022 to 2023 (Fig.3). Our model is suitable for global production, although we produced only the regional products simply because of the huge data volume.

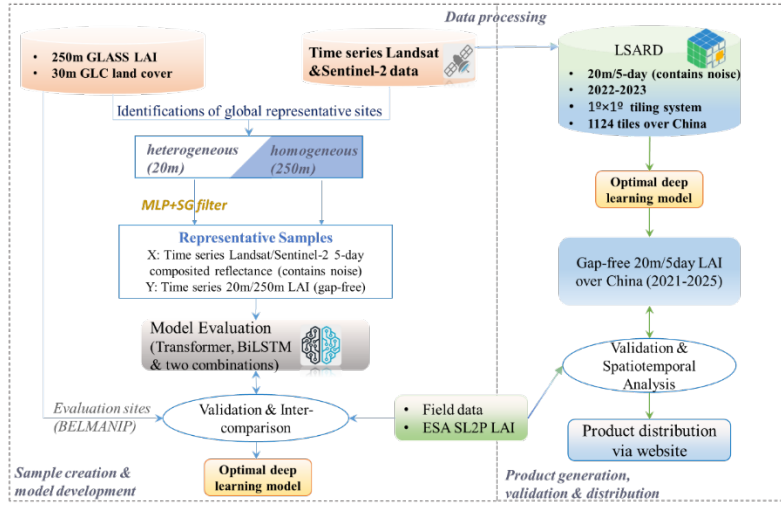


Fig. 1 Flowchart of the 20m seamless LAI/FAPAR product algorithm

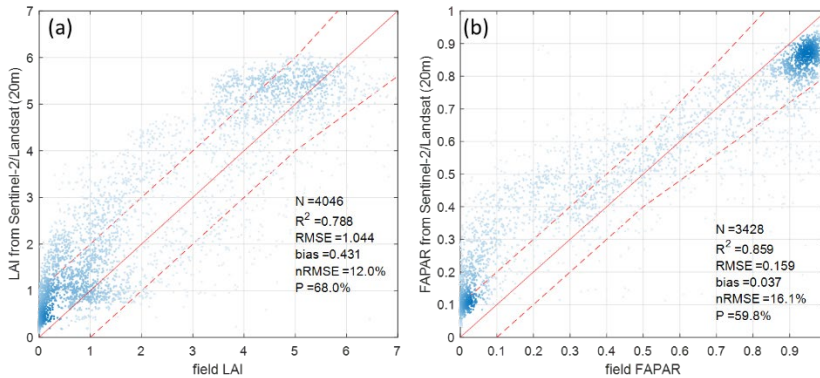


Fig. 2. Direct validation of the retrieved (a) LAI and (b) FAPAR at a 20-meter scale was performed using field plot data from 444 GBOV sites spanning 2019 to 2022. (Darker points indicate higher density, red dashed lines represent the accuracy requirement, and P denotes the percentage of pixels meeting this accuracy requirement).

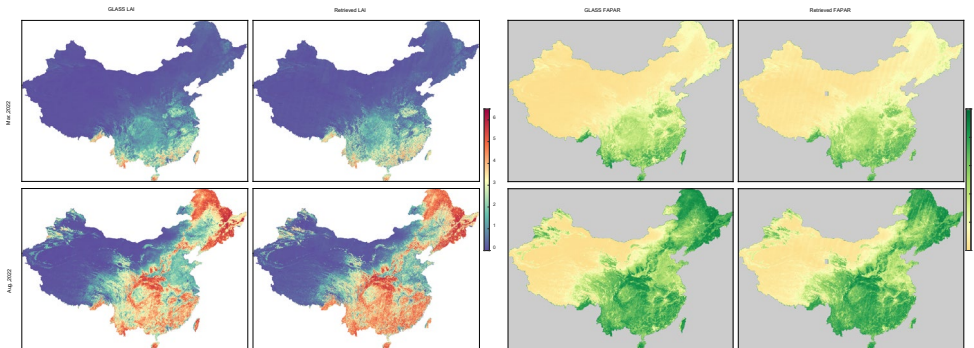


Fig. 3. Comparisons of GLASS and Retrieved LAI/FAPAR in China for March and August 2022. The spatial resolution has been adjusted to 0.05 for visualization (WGS-84 latitude/longitude projection (EPSG:4326)).

- [1] GCOS, "The Global Observing System for Climate: Implementation Needs, GCOS-200, GOOS-214," 2016.
- [2] Y. Kang et al., "A data-driven approach to estimate leaf area index for Landsat images over the contiguous US," *Remote Sensing of Environment*, vol. 258, p. 112383, 2021/06/01/ 2021, doi: <https://doi.org/10.1016/j.rse.2021.112383>.
- [3] H. Jin et al., "Generating high spatial resolution GLASS FAPAR product from Landsat images," *Science of Remote Sensing*, vol. 6, p. 100060, 2022/12/01/ 2022, doi: <https://doi.org/10.1016/j.srs.2022.100060>.
- [4] J. Estévez et al., "Gaussian processes retrieval of crop traits in Google Earth Engine based on Sentinel-2 top-of-atmosphere data," *Remote Sensing of Environment*, vol. 273, p. 112958, 2022/05/01/ 2022, doi: <https://doi.org/10.1016/j.rse.2022.112958>.
- [5] J. Verrelst et al., "Optical remote sensing and the retrieval of terrestrial vegetation bio-geophysical properties—A review," *ISPRS Journal of Photogrammetry and Remote Sensing*, vol. 108, pp. 273-290, 2015.
- [6] L. Martínez-Ferrer et al., "Quantifying uncertainty in high resolution biophysical variable retrieval with machine learning," *Remote Sensing of Environment*, vol. 280, p. 113199, 2022/10/01/ 2022, doi: <https://doi.org/10.1016/j.rse.2022.113199>.
- [7] R. Li, D. Wang, and S. Liang, "Comparison between deep learning architectures for the 1 km, 10/15-min estimation of downward shortwave radiation from AHI and ABI," *Remote Sensing of Environment*, vol. 295, p. 113697, 2023/09/01/ 2023, doi: <https://doi.org/10.1016/j.rse.2023.113697>.
- [8] J. Xu et al., "Towards interpreting multi-temporal deep learning models in crop mapping," *Remote Sensing of Environment*, vol. 264, p. 112599, 2021/10/01/ 2021, doi: <https://doi.org/10.1016/j.rse.2021.112599>.
- [9] L. Miller, C. Pelletier, and G. I. Webb, "Deep Learning for Satellite Image Time-Series Analysis: A review," *IEEE Geoscience and Remote Sensing Magazine*, 2024.
- [10] C. Persello et al., "Deep learning and earth observation to support the sustainable development goals: Current approaches, open challenges, and future opportunities," *IEEE Geoscience and Remote Sensing Magazine*, vol. 10, no. 2, pp. 172-200, 2022.
- [11] H. Liu, P. Gong, J. Wang, X. Wang, G. Ning, and B. Xu, "Production of global daily seamless data cubes and quantification of global land cover change from 1985 to 2020-iMap World 1.0," *Remote Sensing of Environment*, vol. 258, p. 112364, 2021.
- [12] X. Zhang, L. Liu, X. Chen, Y. Gao, S. Xie, and J. Mi, "GLC_FCS30: global land-cover product with fine classification system at 30&thinspm using time-series Landsat imagery," *Earth Syst. Sci. Data*, vol. 13, no. 6, pp. 2753-2776, 2021, doi: [10.5194/essd-13-2753-2021](https://doi.org/10.5194/essd-13-2753-2021).

MONITORING ECOSYSTEMS THROUGH TWO DECADES OF SATELLITE-DERIVED CARBON AND WATER USE EFFICIENCIES

M. Campos-Taberner*, M. Vallés-Iborra, B. Martínez, S. Sánchez-Ruiz, A. Jiménez-Guisado, F. J. García-Haro, M.A. Gilabert

Environmental Remote Sensing Group (UV-ERS), Departament de Física de la Terra i Termodinàmica, Facultat de Física, Universitat de València, 46100 Burjassot, Spain.

**Correspondence: manuel.campos@uv.es (Tel.: +34-963-543-256)*

Carbon use efficiency (CUE) and water use efficiency (WUE) are key ecological indicators for understanding the coupling of terrestrial carbon and water cycles. These indicators are essential for assessing the capacity of terrestrial ecosystems to act as carbon sinks and monitoring their responses to global climate change. This work presents a combined analysis of global CUE and WUE spatiotemporal distributions over the last two decades.

CUE was computed as the ratio of net ecosystem production (NEP) to gross primary production (GPP). In this work, an upscaled CUE product at a 1 km resolution is presented. It was generated using data-driven machine learning techniques, specifically Gaussian Process Regression (GPR). This algorithm spatializes in situ measurements from global eddy covariance towers by combining them with predictor variables derived from MODIS satellite products. Conversely, WUE, defined as the ratio between GPP and evapotranspiration (ET), was analyzed using the Penman-Monteith-Leuning version 2 (PML_V2) product hosted on the Google Earth Engine (GEE) platform. The PML_V2 model integrates meteorological forcings with MODIS surface parameters to solve the Penman-Monteith equation. Coupled with Leuning's canopy conductance theory, it provides a physically consistent and accurate estimation of both ET and GPP. The global-scale analysis shows a mean annual CUE of 0.43 ± 0.08 and a mean WUE of $2.01 \pm 0.26 \text{ g kg}^{-1}$ for the 2000–2020 period. In addition, CUE and WUE values were analyzed per biome type using the MODIS land cover product (IGBP labels) and across global climatic areas according to the Köppen–Geiger climate classification. The results reveal high spatial heterogeneity driven by latitudinal climate regimes and biome distribution. For instance, maximum WUE values are concentrated in temperate forests and agricultural zones of the Northern Hemisphere, while global CUE trends suggest a decline in the capacity of various ecosystems to sequester atmospheric CO₂. The distribution of CUE and WUE across diverse biomes and climatic areas highlights the specific carbon and water coupling capacities of different vegetation types. The findings of this study improve our understanding of global carbon and water cycles and provide key information for monitoring large-scale ecosystem functioning.

MAPPING SOIL ORGANIC MATTER OF THE BLACK SOIL REGION IN NORTHEAST CHINA BASED ON LIMITED SAMPLES USING TABPFN

Ke Yang¹, Meng Liu^{2*}, Xuejia Sang¹, Xiaoxiao Min², Si-Bo Duan², Lingxiao Huang³, Ronglin Tang³, Zhao-Liang Li²

¹School of Software Engineering, Chengdu University of Information Technology, Chengdu 610000, Sichuan, China;

²State Key Laboratory of Efficient Utilization of Arable Land in China, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China;

³State Key Laboratory of Resources and Environment Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China;

**Correspondence: liumeng01@caas.cn*

Soil organic matter (SOM) is a critical indicator of soil fertility, soil quality, and carbon cycling. Therefore, Accurate SOM mapping is essential for agricultural management in black soil regions. However, remote sensing technique, which is a potential way of SOM mapping is still constrained by several practical issues, including the sensitivity of bare-soil observations to acquisition time, redundancy in high-dimensional

predictors, limited training samples, and uncertain transferability across regions. In this study, a SOM prediction framework is developed for Black Soil Region in Northeast China by integrating Sentinel-2 multi-source covariates with temporal window optimization, recursive feature elimination (RFE), and the Tabular Prior-data Fitted Network (TabPFN). Five candidate temporal settings (10-day, 15-day, 20-day, 30-day, and the full bare-soil period) were first compared using TabPFN, random forest (RF), and XGBoost. Among them, the 20-day window at DOY 140–160 achieved consistently strong predictive performance while retaining substantially more valid samples, and was therefore selected for subsequent analysis. Based on this optimal window, a nested cross-validation RFE procedure reduced the initial 57 predictors to 31 key features. Using this optimized feature set, the TabPFN achieved the best overall performance ($R^2 = 0.69$, RMSE = 0.95, MAE = 0.65), outperforming both the RF and XGBoost. To further evaluate model robustness under limited training data, the training set size was progressively reduced from 100% to 10% by 10% steps. Across this process, the R^2 of TabPFN decreased from 0.68 to 0.59 (reduce by 12.7%), compared with substantially larger reductions in XGBoost from 0.620 to 0.418 (reduce by 32.58%) and RF from 0.644 to 0.532 (reduce by 17.4%), demonstrating the superior robustness of TabPFN under limited sample conditions. Furthermore, when evaluated on another independent dataset, TabPFN maintained the highest predictive accuracy, demonstrating its strong generalization ability. SHAP analysis further showed that SOM prediction was jointly influenced by spectral, climatic, topographic, soil, and spatial variables. Overall, these results suggest that combining an appropriate temporal window, feature-space optimization, and TabPFN provides a robust and reliable solution for SOM mapping using limited samples from regions with heterogeneous landcover.

ARTIFICIAL INTELLIGENCE FOR WATER AND CARBON FLUXES ESTIMATION (AI4FLUXES) USING IN-SITU AND SATELLITE DATA.

E. Martínez-Sánchez¹, F. Camacho¹, J. Sánchez-Zapero¹, J.B. Guillén¹

¹Earth Observation Laboratory (EOLAB), Carrer Savina, ⁸. Paterna, Valencia, Spain (46980). Phone: (34)963769448. Contact: enrique.martinez@eolab.es

The estimation of water fluxes (evapotranspiration, ET) and carbon fluxes (gross and net primary productivity, GPP and NPP) in terrestrial vegetation is essential for understanding and addressing a wide range of environmental challenges in the context of climate change. In recent years, artificial intelligence (AI) has emerged as a powerful tool for fully exploiting diverse data sources (in situ and satellite) to generate reliable estimates using machine learning techniques. Moreover, AI-based predictive models can outperform traditional physically based models, whose uncertainties often exceed user requirements.

Within the artificial intelligence for fluxes (AI4fluxes) project funded by the Spanish Industrial Technological Development Center (CDTI) several machine learning methods have been tested to estimate ET and GPP/NPP, including Sparse Variational Gaussian Processes (SVGP), Random Forests, and Neural Networks. These models use currently Copernicus Sentinel-2 (10–20 m spatial resolution and a revisit time of 5 days) data as input.

This work presents the preliminary results of the ET estimation at a decametric scale. Two different training approaches have been evaluated: purely in-situ based training and hybrid training approach that combines in situ and satellite data. The in-situ training data are obtained from well-established networks such as the Integrated Carbon Observation System (ICOS), Australia's Terrestrial Ecosystem Research Network (TERN) and the American Flux Network (AmeriFlux). Additional satellite training data are sourced from the ECOSystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) ET. The inclusion of ECOSTRESS Land Surface Temperature (LST), alongside Sentinel-2 reflectances, as input to the GPR model trained against in situ ET observations is further assessed.

The database was divided into 2/3 for training and 1/3 for validation. Preliminary results show good correlation (around 0.7) between the estimates and measurements, with best results for SVGP. Random Forests provides slightly lower correlation, and the worst results were obtained for Neural Networks, who is very sensitive to the bands used as input. The results for the different input band combination and training dataset (purely in-situ or hybrid training) will be presented and discussed.

LONG-TERM EVAPOTRANSPIRATION DYNAMICS IN RIVER-BASINS OF CONTRASTING CLIMATE REGIONS

Athira K V¹, Miriam Machwitz¹, Mauro Sulis¹, Kanishka Mallick²

Remote Sensing and Natural Resources Modelling Group, Luxembourg Institute of Science and Technology (LIST), Luxembourg

CESBIO, University of Toulouse, CNES, CNRS, IRD, INRAE, Toulouse, France

Evapotranspiration (ET) is a fundamental component of the hydrological cycle and land-atmosphere energy exchange, yet its long-term variability across climatically diverse regions remains insufficiently characterized. As the primary pathway of water vapor flux from the terrestrial surface to the atmosphere, ET integrates the coupled responses of vegetation physiology, soil moisture status, and atmospheric demand. Accurate quantification is therefore essential for water resource assessment, drought monitoring, and evaluation of land surface models.

This study analyzes ET dynamics over four river basins with contrasting hydroclimatic conditions: the Po Valley (Italy), the Oum Er-Rbia basin (Morocco), the Danube basin (Hungary), and the Guadalquivir basin (Spain). These basins span a wide gradient of environmental settings - from arid and semi-arid climates to humid and intensively irrigated agricultural systems - covering aridity indices ranging from approximately 0.2 in the Oum Er-Rbia basin to 0.75–1.0 in the Po Valley, with the Danube (0.50–0.75) and Guadalquivir (0.30–0.50) representing intermediate dry sub-humid and semi-arid conditions, respectively. This diversity provides a representative framework for examining interactions among atmospheric demand, soil moisture availability, and vegetation water use over multi-decadal timescales.

Actual ET is estimated using a remote sensing-based approach that replaces the static crop coefficients of the FAO-56 framework with dynamic water stress factors derived from satellite observations. The Thermal Response Water Stress Index (TRWSI), derived from time series of land surface temperature (LST) and radiative energy data, is used to quantify thermally driven vegetation and surface water stress by capturing crop thermal responses over time and reflecting variations in evaporative cooling across regions. In addition, the Shortwave Water Stress Index (SWSI), derived from shortwave reflectance data, captures water-related variations in canopy and surface optical properties. Together, TRWSI and SWSI provide complementary constraints on surface water status, enabling the conversion of potential ET into spatially and temporally explicit estimates of actual ET over a continuous 25-year record without reliance on site-specific calibration. The performance and consistency of the remote sensing-based ET product are evaluated through intercomparison with available benchmark datasets, including eddy covariance flux tower observations where available, as well as existing global ET products. Validation across four flux tower sites in the Po Valley yields RMSE values of 20.97–64.47 mm/month for TRWSI-based ET and 26.46–54.18 mm/month for SWSI-based ET, demonstrating generally satisfactory performance across contrasting land surface conditions.

Following ET estimation, a comprehensive analytical framework is applied to characterize long-term ET behavior across all four basins. Non-parametric trend tests are used to detect statistically significant monotonic changes in annual and seasonal ET, complemented by wavelet analysis to identify dominant periodicities and multi-scale temporal variability. Preliminary results reveal statistically significant annual trends in ET across all study sites, along with a semi-annual periodicity at agricultural sites, likely reflecting the seasonal cycle of crop growth and management. Trend signals will further be decomposed to assess the relative influence of atmospheric drivers and soil-related constraints on ET variability.

ESTIMATION OF NET CARBON FLUXES OF SHRUBLANDS THROUGH THE COMBINATION OF REMOTE SENSING AND THE ECOSYSTEM PROCESS MODEL BIOME-BGC

S. Sánchez-Ruiz*, M. Chiesi, L. Fibbi, F. Maselli, M. Campos-Taberner, M.A. Gilabert

Environmental Remote Sensing Group (UV-ERS), Departament de Física de la Terra i Termodinàmica, Facultat de Física, Universitat de València, 46100 Burjassot, Spain.

**Correspondence: sergio.sanchez@uv.es*

Identifying ecosystems as sources or sinks of carbon is especially relevant in the current context of global warming caused by the increase of CO₂ concentration in the atmosphere. Net ecosystem production (NEP) is the amount of carbon retained in vegetation after respiration processes. Particularly, it equals gross primary production (the amount of carbon absorbed by vegetation through photosynthesis, GPP) minus autotrophic respiration (plants convert products of photosynthesis into energy, AR) and heterotrophic respiration (decomposer organisms consume organic matter of dead plants, HR). Thus, an ecosystem with NEP > 0 is a carbon sink, while an ecosystem with NEP < 0 is a carbon source. The current study proposes a methodology for the estimation of NEP of a certain woody ecosystem: shrublands. GPP is calculated through a production efficiency model driven by visible and near infrared reflectance observations from MODIS sensor. Respirations are simulated by the ecosystem process model Biome-BGC. It uses long daily meteorological series together with site physical properties and ecophysiological parameters. Since results from Biome-BGC refer to climax conditions ($GPP \approx AR + HR$), respirations must be corrected to account for actual ecosystem conditions. For this purpose, three alternatives are tested: (1) the Percentage of Non-Tree Vegetation from MODIS MOD44B product, (2) the annual minimum of COPERNICUS fractional vegetation cover (FVC) product FCOVER300, and (3) the annual minimum of a FVC derived from MODIS NDVI (MOD13Q1). Results are compared against eddy covariance observations in a Mediterranean shrubland site. At daily scale, although explained variance is reduced by 5 percentage points, bias and uncertainty are respectively reduced to a 30 % and an 80 % of the non-corrected case. At annual scale, differences are reduced from 112 g m⁻² down to 34 g m⁻². Based on the obtained results and the spatio-temporal resolutions of the layers involved in the methodology, future research is oriented to the development of an operative product of shrublands annual NEP at 250-m spatial resolution.

ENSEMBLE EVAPOTRANSPIRATION AND DROUGHT STRESS MODELLING AT HIGH SPATIAL RESOLUTION FOR DENMARK

Eva Boegh¹, Karoline H. Kamper¹, Georg B. Larsen¹, Jacob Vejby¹, Thomas Friborg², Raphael Schneider³ & Simon Stisen³

¹ Climate Data Agency, Skt. Kjelds Plads 11, 2100 Copenhagen Ø, Denmark

² Geosciences and Natural Resource Management, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg C, Denmark

³ GEUS, Øster Voldgade 10, 1350 Copenhagen K, Denmark
+45 7254 5500, evboe@kds.dk

Drought is an increasing challenge in Denmark with significant economic impacts on agriculture and other sectors working with water supply, ecosystems and climate mitigation. To support water management during droughts, a national collaborative research initiative was launched.

The project is developing a Danish drought ensemble for monitoring (DEMON) system employing Earth Observation (EO) based evapotranspiration (ET) and drought stress simulations at 30 m resolution. Drought stress is calculated using the Crop Water Stress Index (CWSI). Similar to OpenET and ECOSTRESS, the system aims to support irrigation scheduling, increase water use efficiency and enhance water resource allocation based on evaporative demand.

EO-based ET and drought stress estimates are integrated with simulations from the National

Hydrological Model (DK-model) in the Hydrological information and Prediction portal (HIP Digital Twin) which includes near real-time hydrological observations, simulated hydrological indicators and 10-day hydrological forecasts. This study evaluates ET model performance in Denmark and examines integration with hydrological simulations in HIP.

The DEMON system uses three well-documented open-source EO-based ET-models (PT-JPL, STIC and TSEB) with a potential for including more ET-models in future. The models were selected for their validated performance and differing model structures enabling the production of independent ET-estimates. While PT-JPL is an empirical ET-model based on the Priestley-Taylor equation, STIC is a physically based one-source ET-model using an iterative surface energy balance closure derived from the Penman-Monteith equation, and TSEB is a two-source ET model simulating ET from soil and vegetation based on Shuttleworth-Wallace equations. The DK-model, based on MIKE SHE, applies a simple 2-layer ET model forced with Makkink reference ET and NDVI based crop coefficients (Kc).

The models are applied during Danish drought periods where cloud cover is limited, using Landsat 8/9 Level 2 data (30 m) for land surface temperature, NDVI, albedo and emissivity, combined with meteorological data from the Danish Meteorological Institute. Leaf area index is derived from NDVI, and surface albedo is estimated using a method suitable for the vegetated and urban areas typical for Denmark. The evaporative fraction is interpolated between satellite data acquisitions and multiplied by daily potential ET (FAO-PM equation) to estimate daily ET for Denmark.

Results are evaluated using ICOS eddy covariance latent heat fluxes for two agricultural and forest sites in Denmark. The study examines impacts of energy balance closure corrections and potential ET representation for drought stress mapping in Denmark, and the progression of EO-based drought stress signals is analyzed in relation to simulated hydrological indicators for soil, groundwater and river discharge.

MAPPING EVAPOTRANSPIRATION OF FOREST WATERSHEDS FROM REMOTE SENSED VEGETATION FRACTION COVER AND WATER BALANCE MODELLING

Oliosio A.¹, Ollivier C.², Boulet G.^{3,4}, Mwangi S.^{1,3}, Marloie O.¹, Martin-StPaul N.¹, Simioni G.¹, Druel A.¹, Crespin-Boucaud A.², Léonardi V.², Loiseau B.², Carrière S.², Berthelin R.², Etchanchu J.², Demarty J.², Rivalland V.³, Bérion P.⁵, Charlier J.-B.^{6,7}, Hakoun V.⁸, Mazzilli N.⁸, Mercier V.⁸, Weiss M.⁽⁸⁾, Chaffaut Q.⁽⁸⁾

¹Unité de Recherche 'Ecologie des Forêts Méditerranéenne', URFM, INRAE, Avignon, France

²HydroScience Montpellier (HSM, Univ. Montpellier, CNRS, IMT, IRD), France

³CESBIO, Université de Toulouse, CNES, CNRS, IRD, UT3, INRAE, Toulouse, France

⁴Indo-French Cell for Water Science, ICWaR, Indian Institute of Science, Bangalore, India

⁵Laboratoire Théma, Université Bourgogne Europe, UMR 6049, CNRS, Dijon, France

⁶G-eau, INRAE, CIRAD, IRD, AgroParisTech, Supagro, BRGM, Montpellier, France

⁷BRGM, Université Montpellier, Montpellier, France

⁸UMR Environnement Méditerranéen et Modélisation des Agro-Hydrosystèmes (EMMAH), INRAE-Avignon Université, Avignon, France;

⁹Sorbonne Université, UMR METIS, 4 place Jussieu, 75005 Paris.

correspondence: albert.oliosio@inrae.fr

Vegetation fraction cover (fCOVER) is an essential variable for monitoring forest canopy processes such as evapotranspiration (ET). ET plays a major role in the hydrological cycle and in the land surface energy balance and can be used for quantifying water stress. When regional information is required, e.g. for monitoring the extension of drought or water resources, ET can be monitored using water balance models driven by remote sensed fCOVER.

We implemented a simple soil water balance model, SimpKcET (Ollivier et al. 2021, doi: 10.1016/j.scitotenv.2021.146706), in order to map daily evapotranspiration and water stress over large territories and long periods of time. Evapotranspiration and water balance were calculated from potential evapotranspiration and precipitation provided by meteorological reanalysis such as SAFRAN (Meteo France)

or ERA5-Land (ECMWF) and precipitation products such as MSWEP or radar data. Transpiration and evaporation were considered. Transpiration depends on a canopy coefficient which accounts for vegetation fraction cover (fCOVER) and soil moisture. Evaporation depends on the fraction of soil surface and antecedent precipitation. Water stress is simply defined from the ratio of actual ET to potential ET. ET and water stress indices are presented as ensemble products combining several sets of inputs from various sources. The ensemble analysis provides a tool for inferring an uncertainty in the derivation of ET and water stress.

In this study we compared the results obtained using vegetation fraction cover derived from different sources of remote sensing data (MODIS, COPERNICUS), precipitations from different climate reanalysis (ERA5-Land, Safran, MSWEP, Comephore) and different soil maps (INRAE, Soil Grid). We derived fCOVER from the Enhanced Vegetation Index (EVI) available since 2000 as part of the MODIS vegetation index products (250 m spatial resolution). We developed relations between EVI and fCOVER over a synthetic dataset simulated by using the SAIL radiative transfer model. We also used the vegetation fraction cover products that are provided by the COPERNICUS Global Land Service. Products are available at the 1 km resolution from data of the VEGETATION sensor starting in 1999 and at 300 m resolution from the PROBA-V sensor starting in 2015 and Sentinel-3/OLCI starting in July 2020.

The model was applied at the 1 km and 300m/250m spatial resolutions over several watershed in France, in particular in karstic environment. Modeled daily evapotranspirations were evaluated over flux tower data when available (root mean square error between 0.4 mm d⁻¹ and 0.8 mm d⁻¹ depending on model inputs and locations were obtained). We also briefly present applications of the model in various studies that aimed at evaluate aquifer recharge and karstic spring flow or to qualify geophysical methodologies that are currently evaluated for estimating evapotranspiration through soil/ground water variation monitoring (gravimetry, electrical resistivity tomography...).

BENEFITS OF HIGH-RESOLUTION SATELLITE IMAGERY FOR EVAPOTRANSPIRATION ESTIMATION IN SAHELIAN AGRO-SILVO- PASTORAL SYSTEMS

Nesrine Farhani^{1,2}, Jordi Etchanchu¹, Simon Vauclare¹, Benjamin Goffin¹, Taeken Wijmer¹, Gilles Boulet^{3,4}, Nane Chahinian¹, Philippe Gamet³, Albert Oliso⁵, Samuel Mwangi⁵, Emmanuelle Sarrazin³, Kanishka Mallick³, Serigne Mansour Diene^{6,10}, Djim Mouhamadou Lamine Diongue⁷, Ibrahim Maïnassara^{1,11}, Olivier Roupsard^{8,9,10} and Jérôme Demarty¹*

¹ HSM, Univ Montpellier, CNRS, IRD, 15 Avenue Charles Flahault, 34093 Montpellier France; 2 Centre National d'Etude Spatiales (CNES),

² Place Maurice Quentin, 75039, Paris, France

³ Univ Toulouse, CNES, CNRS, INRAE, IRD, CESBIO, Toulouse, France

⁴ Indo-French Cell for Water Science ICWaR Indian Institute of Science Bangalore India

⁵ Unite de Recherche ecologie des Foret Mediterraneennes (URFM) INRAE 84000 Avignon, France

⁶ Mixed Research Laboratory, Polytechnic School of Thies, A10, Thies, Senegal

⁷ École Nationale Supérieure des Mines et de la Géologie, Université Cheikh Anta Diop, BP, Dakar, Fann 5396, Senegal

⁸ Eco Sols Univ Montpellier CIRAD INRAE IRD Montpellier SupAgro, Montpellier, France

⁹ CIRAD UMR Eco Sols BP1386 CP18524 Dakar, Senegal

¹⁰ LMI IESOL Centre IRD-ISRA de Bel Air BP1386 CP18524 Dakar, Senegal

¹¹ Institut de Recherche pour le Developpement (IRD) Representation, 276 avenue de Maradi, Niamey, Niger

*Corresponding author: nesrine.farhani@umontpellier.fr, +33766462151

Accurate spatial estimation of evapotranspiration (ET) is essential for effective water resource management, particularly in regions such as the Sahel, which is highly vulnerable to climate change and characterized by a sparse meteorological observation network. In this context, thermal infrared remote sensing (RS), combined with surface energy balance models, proves to be a valuable tool for deriving

spatially distributed ET across multiple scales. This study investigates the impact of spatial resolution in such a model in agro-silvo-pastoral system in the Sahel. The ensemble contextual model EVASPA is used. It relies on the identification of extreme surface conditions across an image in the Land Surface Temperature-Vegetation Index (LST-VI) variable space. These extreme conditions are referred as the “dry edge” (hottest pixels) and the “wet edge” (coldest pixels). The key objective is thus to assess how spatial resolution influences the delineation of these edges by improving the representation of actual surface heterogeneity. It is assessed through the use and comparison of medium-resolution (1 km, MODIS) and high-resolution (30 m, Landsat) thermal and visible/near infrared data. Then the ability of high-resolution data to capture small scale surface processes is investigated with a focus on an agro-silvo-pastoral area. Indeed, such area is characterized by high spatial heterogeneity with very localized interactions between crops and trees. The influence of tree density on ET has thus been investigated by combining EVASPA estimates derived from Landsat data with an individual tree map derived from Planetscope data. Our results demonstrate that higher spatial resolution significantly improves ET estimation when compared to eddy-covariance measurements. It also reduces the model’s structural uncertainties. Furthermore, the analysis reveals that improving the spatial resolution strongly improves the perception of the surface heterogeneity in different ecosystems and how their relative positions in the LST-VI space shapes the position of dry and wet edges. It confirms that contextual methods are particularly adapted when spatial resolution is improved, as they remain low-demanding on input data. The analysis across different tree densities in agro-silvo-pastoral ecosystems shows a positive effect on ET, regardless of the season. It highlights the ability to capture such fine scale surface processes with high-resolution satellite. Overall, high-resolution thermal remote sensing proves to be a powerful tool for improving our understanding of agroecosystem functioning, especially under water-limited conditions. This study thus highlights the potential for upcoming thermal Earth observation missions, such as TRISHNA (CNES/ISRO), LSTM (ESA), and SBG (NASA), in which this work is a contributing part.

ON THE POTENTIAL OF CONSTELLR IMAGERY FOR EVAPOTRANSPIRATION: FIRST ANALYSIS USING SEVERAL LAND SURFACE ENERGY BALANCE ALGORITHMS

Samuel Mwangi^{1,2*}, Albert Oliso^{1*}, Olivier Hagolle², Emmanuelle Sarrazin², Nesrine Farhani³, Benjamin Goffin³, Jordi Etchanchu³, Jérôme Demarty³, Kanishka Mallick², Vincent Rivalland², Philippe Gamet², Jean-Louis Roujean², Guillaume Triquet⁴, Daniel Spengler⁵, Gilles Boulet^{2,6}

¹Unité de Recherche Ecologie des Forêts Méditerranéennes, INRAE, Avignon, France

²CESBIO, Université de Toulouse (CNES/CNRS/IRD/INRAE) – UMR5126, ¹⁸ Av. Edouard Belin, 31401 Toulouse, France

³UMR HSM, IRD-CNRS-Université de Montpellier, Montpellier, France

⁴constellr France SASU, Toulouse, France

⁵constellr GmbH, Munich, Germany

⁶Indo-French Water Cell, IISc, Bangalore, India

*Correspondence (albert.oliso@inrae.fr; samuel.mwangi@inrae.fr).

High resolution (spatial, temporal and spectral) remote sensing data from sensors observing in the visible-near infrared (VNIR) and thermal infrared (TIR) spectrums allow enhanced monitoring of surface energy and water exchanges. Terrestrial TIR acquisitions, for example, enable evapotranspiration (ET) estimation and detection of water stress at finer scales for effective irrigation water management. Here, we present preliminary results on evapotranspiration analyses using data from the new constellr SkyBee microsatellites over a cropland and grassland in southern France. constellr operates the HiVE (High-precision Versatile Ecosphere) constellation (with two SkyBee satellites currently in orbit since 2025), providing global VNIR and TIR data products at high spatial resolution (e.g. LSTprecision at 30 m and LSTzoom at 10 m) every 1.5-3 days. Variables required for contextual and point-based ET modelling were calculated from the LSTprecision product, including: i) NDVI, ii) EVI, iii) surface broadband albedo, which was here fitted from the narrow VNIR bands while taking the Landsat-based albedo as the response/reference. These and Land

Surface Temperature (LST) were then assessed against those from Landsat8/9 OLI/TIRS. ET was herein calculated using the ensemble-based EVASPA algorithm (Gallego-Elvira et al., 2013), which will be used together with the STIC model (Mallick et al., 2014) to provide TRISHNA's ET products. Work is also ongoing to test the data on point-based source models such as STIC and SPARSE/SPARSE4 (Boulet et al., 2015; Mwangi et al., 2022). The LST and vegetation indices from the two platforms showed similar spatial distribution, though some disparity mainly arose due to the varying water/cloud masks. These differences manifested in EVASPA's contextual T-VI and SSEBI evaporative fraction (EF) spaces and thus in the calculated EFs and ETs, especially at the cropland. Further differences in the simulated contextual edges and thus EF were also introduced by the uncertainties in the fitted broadband albedos. Overall, the similarity of the sets of estimates based on data from the two satellites shows that new sensors with high spatial and temporal resolution like constellr's HiVE have great potential especially for local water use applications. Synergistically, constellr, which provides relatively higher spectral resolution in VNIR (particularly red-edge bands) but none in SWIR, can be used together with other high-resolution sensors (like Landsat OLI, ECOSTRESS ...) for more holistic vegetation monitoring.

ALL-WEATHER CROP EVAPOTRANSPIRATION AT PLOT SCALE: BENCHMARKING TRISHNA L2 AND L3 ALGORITHMS OVER BERAMBADI, INDIA

**Pavan Kumar Amgoth^{1,2}, Gilles Boulet^{1,2*}, Muddu Sekhar², Albert Olioso³, Emmanuelle Sarrazin¹,
Jérémy Auclair¹, Kanishka Mallick¹, Philippe Gamet¹, Pascal Fanise¹, Clémence Costaouec¹, Lise
Schmitt¹, Bimal K Bhattacharya⁴, Ayan Das⁴**

¹ Univ Toulouse, CNES, CNRS, INRAE, IRD, CESBIO, Toulouse, France

² Indo-French Cell for Water Science, Indian Institute of Science, Bangalore Karnataka, India

³ Unité de Recherche écologie des Forêts Méditerranéennes, INRAE, Avignon, France

⁴ Space Applications Centre, ISRO, Ahmedabad, India

*Corresponding author: Gilles Boulet E-mail : gilles.boulet@ird.fr

Monitoring crop water use in monsoon-dominated regions remains a persistent challenge. Thermal infrared (TIR) satellite observations, which underpin physically-based evapotranspiration (ET) retrieval, are systematically obscured by cloud cover during the wet season – the very period when accurate knowledge of crop water use matters most. The upcoming TRISHNA mission (CNES/ISRO), with 57-100 m spatial resolution and 2-3-day revisit, offers a meaningful operational capability for plot-scale agricultural monitoring. In preparation for TRISHNA Level-3 ecosystem stress product development, this study benchmarks four quantitative ET estimation approaches – SPARSE, STIC, EVASPA and SimpKcET – driven by TRISHNA-compatible inputs and evaluated against in-situ observations over constraining agricultural systems in the Berambadi catchment (Karnataka, India), a semi-arid landscape of smallholder rainfed and irrigated farms. Three energy balance models are evaluated alongside a crop-coefficient hydrological model. SPARSE (Simplified Two-Source Energy Balance) retrieves partitioned soil evaporation and transpiration from observed land surface temperature (LST) within a dual-source resistance network, using TRISHNA Level-2A LST products as the primary forcing. STIC (Surface Temperature Initiated Closure) achieves thermodynamic closure of the surface energy balance without requiring explicit aerodynamic resistance parameterisation, offering a robust single-pixel alternative where ancillary meteorological data are limited. EVASPA (EVApotranspiration from SPARce) employs a contextual modelling strategy characterizing scene-level dry/wet edges in LST-albedo space to derive daily ET; while explicitly accounting for the directional variability introduced by TRISHNA's acquisition geometry and off-nadir viewing angles. Finally, SimpKcET is a simplified crop-coefficient model driven by vegetation cover fraction, reference ET, and rainfall, operates independently of thermal observations and is therefore well suited for maintaining ET continuity through cloudy monsoon gaps.

The SPARSE and SimpKcET were applied over two instrumented field plots: a rainfed maize plot (Kharif season 2024) and an Irrigated beans plot. All meteorological forcing: air temperature, relative

humidity, wind speed, net radiation, and rainfall was sourced from on-site flux tower stations at Berambadi. Crop phenology was characterized through double-logistic LAI fitting applied to hemispherical canopy images and Sentinel-1 RVI time series. Model performance was assessed against flux tower observations using RMSE, Bias, and R², across all days and clear-sky conditions separately. SPARSE retrieval was strictly constrained to cloud-free days, producing only scattered estimates through the monsoon season and leaving extended periods with no ET retrieval at all; on the days it did retrieve, it consistently overestimated observed ET at both sites (clear-sky RMSE: 1.20 mm/day; bias: +0.84 mm/day for rainfed maize; 1.10 mm/day, bias: +0.79 mm/day for irrigated beans). SimpKcET, by contrast produced as continuously daily ET time series across the entire monitoring period including the cloudy monsoon core, but systematically underestimated ET at both sites (bias: -0.43 mm/day for maize, -0.55 mm/day for beans, RMSE: 0.93 and 0.92 mm/day respectively). Beyond flux tower-based evaluation, the models will also be applied to UAV thermal imagery 2024, and ConstellR high-resolution data 2025-2026 which are particularly essential for EVASPA. Building on the complementary between the energy balance and crop-coefficient approaches, ET retrieved from LST clear-sky observations will be assimilated into the SimpKcET trajectory.

GLOBAL CONTROLS ON TRANSPIRATION FROM 2000 TO 2025

Pooja Nandagopal^{1} and Eswar Rajasekaran^{1,2}*

**ryanpoojan3@gmail.com*

¹ Department of Civil Engineering, IIT Bombay INDIA

² Centre for Climate Studies, IIT Bombay INDIA

Transpiration connects plants to climate; it is considered one of the major indicators of plant productivity. It is a key regulator of land–atmosphere coupling, linking ecosystem physiology with boundary layer dynamics and hydroclimate feedback. Despite its importance, the relative dominance of environmental controls on transpiration across biomes remains insufficiently resolved. In this study, we quantify the influence of radiative, thermal, vegetative, and water-supply controls on transpiration using a machine learning framework trained on flux-tower-derived estimates and interpret these controls from 2000 to 2025 using SHAP-based attribution and partial dependence relationships. Across global vegetation types, thermal and radiative drivers emerge as the dominant controls on transpiration, consistent with theoretical expectations that atmospheric demand (temperature, vapor pressure deficit) and available energy govern evapotranspiration processes. Forest ecosystems show a pronounced thermal control, with PDP curves revealing strong nonlinear increases in transpiration beyond critical temperature thresholds, reflecting enhanced vapor pressure deficit and stomatal responses. This aligns with recent findings that transpiration is highly sensitive to atmospheric dryness, often more than to soil moisture in energy limited. In contrast, savannas and shrublands exhibit stronger radiative control, indicating tighter coupling to net radiation and canopy energy balance. Vegetation controls, represented by NDVI and LAI, consistently rank among the top predictors, underscoring the role of canopy structure and phenology in regulating stomatal conductance and surface–atmosphere exchange. Meanwhile, water-supply controls show a comparatively weaker direct influence in humid and energy-limited systems but become more significant in semi-arid regions, where soil moisture constraints impose limits on transpiration, particularly during dry-down periods. By synthesizing these controls into physically interpretable groups, our results demonstrate that global transpiration is governed by a shifting balance between atmospheric demand, energy availability, and biological regulation, with water limitation acting as a conditional constraint. As climate change intensifies thermal and atmospheric demand signals, these control regimes are likely to reorganize, with profound implications for future water and carbon cycle dynamics.

- Monteith, J. L. (1965). Evaporation and environment. Symposia of the Society for Experimental Biology, 19, 205–234.
- Penman, H. L. (1948). Natural evaporation from open water, bare soil and grass. Proceedings of the Royal Society A, 193(1032), 120–145. <https://doi.org/10.1098/rspa.1948.0037>

- Novick, K. A., Ficklin, D. L., Stoy, P. C., Williams, C. A., Bohrer, G., Oishi, A. C., Papuga, S. A., Blanken, P. D., Noormets, A., Sulman, B. N., Scott, R. L., Wang, L., & Phillips, R. P. (2016). The increasing importance of atmospheric demand for ecosystem water and carbon fluxes. *Nature Climate Change*, 6(11), 1023–1027. <https://doi.org/10.1038/nclimate3114>
- Grossiord, C., Buckley, T. N., Cernusak, L. A., Novick, K. A., Poulter, B., Siegwolf, R. T. W., Sperry, J. S., & McDowell, N. G. (2020). Plant responses to rising vapor pressure deficit. *New Phytologist*, 226(6), 1550–1566. <https://doi.org/10.1111/nph.16485>
- Running, S. W., & Coughlan, J. C. (1988). A general model of forest ecosystem processes for regional applications: I. Hydrologic balance, canopy gas exchange and primary production processes. *Ecological Modelling*, 42(2–3), 125–154. [https://doi.org/10.1016/0304-3800\(88\)90112-3](https://doi.org/10.1016/0304-3800(88)90112-3)
- Sellers, P. J., Randall, D. A., Collatz, G. J., Berry, J. A., Field, C. B., Dazlich, D. A., Zhang, C., Collelo, G. D., & Bounoua, L. (1996). A revised land surface parameterization (SiB2) for atmospheric GCMs: Part I—Model formulation. *Journal of Climate*, 9(4), 676–705. [https://doi.org/10.1175/1520-0442\(1996\)009<0676:ARLSPF>2.0.CO;2](https://doi.org/10.1175/1520-0442(1996)009<0676:ARLSPF>2.0.CO;2)
- Seneviratne, S. I., Corti, T., Davin, E. L., Hirschi, M., Jaeger, E. B., Lehner, I., Orlowsky, B., & Teuling, A. J. (2010). Investigating soil moisture–climate interactions in a changing climate: A review. *Earth-Science Reviews*, 99(3–4), 125–161. <https://doi.org/10.1016/j.earscirev.2010.02.004>
- Miralles, D. G., Gentile, P., Seneviratne, S. I., & Teuling, A. J. (2014). Land–atmospheric feedbacks during droughts and heatwaves: State of the science and current challenges. *Annals of the New York Academy of Sciences*, 1311(1), 19–35. <https://doi.org/10.1111/nyas.12385>

ROBUSTNESS OF TRISHNA EVAPOTRANSPIRATION ALGORITHMS (SWEAT): BENCHMARKING STIC AND EVASPA OVER DIVERSE ECOSYSTEMS

Samuel Mwangi^{1,2*}, Emmanuelle Sarrazin², Gilles Boulet^{2,3}, Kanishka Mallick², Aolin Jia^{4,(5)}, Jordi Etchanchu⁶, Nesrine Farhani⁶, Benjamin Goffin⁶, Jérôme Demarty⁶, Vincent Rivalland², Jeremy Auclair², Blanca Mateo-Herrera², Olivier Merlin², Philippe Gamet², Olivier Hagolle², Jean-Louis Roujean², Albert Oliso^{1*}

¹Unité de Recherche Ecologie des Forêts Méditerranéennes, INRAE, Avignon, France

²CESBIO, Université de Toulouse, CNES/CNRS/IRD/INRAE, Toulouse, France

³Indo-French Cell for Water Sciences (IFCWS), IISc, Bangalore, India

⁴Department of Environmental Research and Innovation (ERIN), LIST, Belvaux, Luxembourg

⁽⁵⁾Now at Department of Environmental Systems Science, ETH, Zurich, Switzerland

⁶UMR HSM, IRD-CNRS-Université de Montpellier, Montpellier, France

⁷EMMAH, INRAE/Avignon Université, Avignon, France

* samuel.mwangi@inrae.fr, *albert.oliso@inrae.fr

The TRISHNA satellite will carry sensors operating in both the optical and thermal infrared domains, offering enhanced capabilities for ecosystem monitoring. Upon launch, the acquired remote sensing data will be ingested into the EVASPA and STIC algorithms to generate high-resolution evapotranspiration products. The combined algorithm is named SWEAT for Spatial Water-stress and Evapotranspiration Assessment for TRISHNA. The EVASPA and STIC schemes differ in both their input data requirements and the physical principles they apply to estimate terrestrial energy and water fluxes, specifically latent heat flux and evapotranspiration. EVASPA applies an ensemble of contextual methods based on land surface temperature relationships with albedo and vegetation indices (e.g., NDVI or fractional vegetation cover). In contrast, STIC is a pixel-based surface energy balance model developed by finding ‘closed-form’ analytical expressions of biophysical conductances to estimate evapotranspiration using the Penman-Monteith equation. To ensure the robustness of the methods for global use, benchmarking activities are currently underway. These use representative remote sensing datasets from MODIS and Landsat, along with standardized

methodologies for validating model parameterizations. These efforts add to a body of prior validation studies performed on both methods.

Here we present an overview of evaluations that have been (and are currently being) carried out across diverse regions of interest globally, including the Sahel, southern France, northern Spain, India, among other focus areas, with the validation datasets drawn from FLUXNET, ICOS flux measurement sites. The evaluation approach also includes observed fluxes from other independent measurement sites. The validation against field data shows that the estimates are within expected accuracies, and are in general agreement with accuracies of other global / regional evapotranspiration products. However, most of these studies - particularly those on EVASPA - are based on the relatively high temporal but low spatial resolution MODIS products. Our focus is now on evaluating evapotranspiration estimates at finer spatial scale, i.e., from high resolution products (e.g. Landsat) - this should ensure better consistency with the anticipated TRISHNA product(s). The TRISHNA ET benchmarking activities are expected to continue well beyond the satellite's launch, providing a framework for ongoing refinement and enhancement of the evapotranspiration products over time.

INMESAT PROJECT

José Antonio Sobrino ^{1*}, Sergio Gimeno ¹, Yves Julien ¹, Rafael Llorens ¹

¹ Global Change Unit, Image Processing Laboratory, University of Valencia, 46980 Paterna, Spain

*Correspondence: sobrino@uv.es

Financed by the Generalitat Valenciana within the PROMETEO 2024 funding framework, the INMESAT project ("Indicadores Medioambientales y Fenómenos Adversos en la Comunidad Valenciana usando datos de satélite") focuses on the robust estimation of environmental indicators and the monitoring of adverse phenomena through the integration of satellite remote sensing and in-situ measurements. To achieve this, imagery from Landsat, Sentinel, VIIRS, MODIS, and METEOSAT is leveraged to generate operational products across a diverse range of applications. Key outputs include updated land cover mapping, as well as the assessment of wildfires, droughts, frost events, evapotranspiration, land and sea surface temperatures, urban heat island effects, NDVI anomalies, greenhouse gas concentrations, and overall air quality. Furthermore, by exploiting the computational capabilities of Google Earth Engine, dynamic and interactive products have been developed to enable stakeholders to customize the retrieval of specific variables on demand. These user-tailored geospatial outputs are fully downloadable and accompanied by practical use cases and relevant scientific literature. This framework provides accessible, near-real-time environmental intelligence, thereby facilitating evidence-based decision-making and enhancing the regional comprehension of environmental dynamics across the Valencian Community.

This research was funded by the European Union and the Government of the Valencian Community through the project "Indicadores medioambientales y fenómenos adversos en la Comunidad Valenciana usando datos de satélite," under the PROMETEO 2023 funding programme (CIPROM/2023/42).

BEYOND THERMAL: STOMATAL STRESS AND ECOSYSTEM FUNCTIONING IN THE TRISHNA ERA THROUGH SYNERGISTIC LST, SWIR, AND VNIR SIGNALS OF OPPORTUNITY

Kanishka Mallick¹, Gilles Boulet^{1,7}, Emmanuelle Sarrazin¹, Zoe Pierrat², Zoltan Szantoi³, Chiara Corbari⁴, Samuel Mwangi⁵, Nesrine Farhani⁶, Jordi Etchanchu⁶, Jerome Demarty⁶, Albert Olioso⁵, Philippe Gamet¹, Olivier Hagolle¹, Jean-Louis Roujean¹

¹CESBIO, University of Toulouse, CNES, CNRS, INRAE, IRD, Toulouse, France;

²University of California, Santa Barbara, United States;

³Science, Applications & Climate Department, European Space Agency, Frascati, Italy;

⁴*Dept. Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy;*

⁵*Unité de Recherche écologie des Forêts Méditerranéennes (URFM), INRAE, Avignon, France;*

⁶*HydroSciences Montpellier (HSM), Univ Montpellier, CNRS, IRD, Montpellier, France;*

⁷*Indo-French Cell for Water Sciences, ICWaR, Indian Institute of Science, Bangalore, India*

**Correspondence: kaniska.mallick@utoulouse.fr*

Monitoring ecosystem responses to water stress is fundamental for quantifying carbon uptake, evapotranspiration (ET), and ecosystem resilience under a changing climate. Land surface temperature (LST) from thermal infrared observations provides a direct signal of plant water stress through its tight coupling with stomatal regulation. However, complementary physiological information is contained in shortwave infrared (SWIR) reflectance, sensitive to canopy water content; and visible-near infrared (VNIR) reflectance, sensitive to photosynthetic activity and canopy structure. Exploiting all three signals together offers a more physically complete picture of vegetation water stress and complements thermal observations. Here we propose a synergistic framework integrating LST, SWIR, and VNIR to constrain stomatal conductance, water stress, and ecosystem functioning, making full use of the thermal and multi-spectral capabilities of the forthcoming TRISHNA mission.

The framework is implemented in the analytical surface energy balance model, STIC (Surface Temperature Initiated Closure), extended here as TRISHNA-STIC. An LST-based water stress index is combined with a SWIR multi-band water stress index and a VNIR physiological indicator to segregate surface and root-zone water availability controls on stomatal response and ET. These combined stress signals initialize the STIC energy balance equations, which are then iteratively solved to retrieve stomatal conductance and ET through physically consistent updates of canopy aerodynamic variables and surface energy fluxes.

TRISHNA-STIC is evaluated across arid and semi-arid ecosystems of Europe and the United States using multi-year time series of Landsat-8/9, ECOSTRESS LST, and harmonized Landsat/Sentinel-2 SWIR-VNIR products, validated against eddy covariance flux observations. Single-pixel comparisons at the EC footprint reveal a systematic improvement in stomatal response versus water stress coupling and ET estimation relative to LST-only retrievals, with differences becoming more pronounced with increasing aridity and vegetation sparseness. Stomatal coupling with water stress and ET improves by up to 50% in arid savanna, with a marked reduction in ET error at low ET magnitudes. RMSE and R2 of instantaneous ET improve by 25-40% across woody savanna, grassland, and alfalfa. However, an overly strong stomatal response is detected over row crops, attributable to false stress detection, pointing to a remaining challenge for structured canopies. Together, these results show that the synergistic use of LST, SWIR, and VNIR signals, as will be delivered by the forthcoming TRISHNA mission, substantially improves field-scale ET and ecosystem functioning retrievals, with direct implications for agricultural water management and ecohydrology.

DAILY EVAPOTRANSPIRATION AND WATER STRESS L2 PRODUCTS FROM THE TRISHNA MISSION

Oliosio A.¹, Boulet G.^{2,3}, Mallick K.³, Sarrazin E.³, Mwangi S.^{1,2}, Farhani N.⁴, Jia A.^{5,(6)}, Goffin B.⁴, Etchanchu J.⁴, Ollivier C.⁴, Rivalland V.³, Merlin O.³, Rajasekaran E.⁷, Matteo Herrera B.³, Auclair J.³, Weiss M.⁸, Buis S.⁸, Demarty J.⁴, Roujean J.-L.³, Gamet P.³

¹ Mediterranean Forest Ecology Lab, INRAE, Avignon, France

² Indo-French Cell for Water Science, ICWaR, Indian Institute of Science, Bangalore, India

³ CESBIO, Toulouse, France

⁴ HSM, Montpellier, France

⁵ Department of Environmental Research and Innovation, LIST, Belvaux, Luxembourg

⁶ Now at Department of Environmental Systems Science, ETH, Zurich, Switzerland

⁷ IITB, Mumbai, India

⁸ EMMAH, Avignon, France

The joint ISRO/CNES TRISHNA mission (Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment), to be launched in 2027, will provide thermal infrared data with high revisit (3 acquisitions every 8 days at equator) and high spatial resolution (60 m). Such data will make it possible unprecedented monitoring of evapotranspiration (ET) and water stress. Evapotranspiration and water stress products will be proposed at level 2 within less than one day after image acquisition.

Here, we present the various options for the operational algorithms that will be used for generating ET and water stress products. For evapotranspiration, two main models will be used:

1. EVASPA which provides ET maps by combining several models based on the evaporative fraction formulation of surface energy balance based on the S-SEBI and the triangle approaches (contextual approach). As EVASPA provides an ensemble estimation of ET, an estimation of uncertainty in the derivation of ET is also provided
2. STIC which is based on the integration of the surface temperature into the Penman-Monteith (PM) formulation at the pixel scale (single-pixel approach). The model was recently implemented within the European ECOSTRESS Hub

For water stress indicators, two main indices are foreseen: the evaporative fraction as provided by EVASPA and the ratio of daily ET to reference ET.

Calculation of evapotranspiration requires a large number of information that will be obtained from different sources: -i) surface temperature from TRISHNA thermal channels, -ii) albedo and vegetation fraction cover from vis/nir data, -iii) clear sky incident solar radiation (corrected for topography effect) and incident downward thermal radiation at the time of acquisition as derived from TRISHNA channel data, -iv) air temperature and air vapour pressure from ECMWF analysis, -v) daily solar radiation from geostationary satellites (e.g. the new MTG satellite over Europe and Africa) that will be used to upscale instantaneous estimates of ET to daily ET.

At level 2, daily evapotranspiration will be provided for clear sky TRISHNA acquisition (depending on satellite orbit and cloud cover). Reconstruction of a continuous serie of daily evapotranspiration will be provided as a level 3 product. We will use a simple upscaling method on the basis of the daily evapotranspiration / daily solar radiation ratio, that was shown as usually providing good performances.

TOWARDS THE CONTINUOUS L3 TRISHNA DAILY EVAPOTRANSPIRATION PRODUCT : SOME STRATEGIES UNDER EVALUATION

**Gilles Boulet ^{1,2*}, Albert Olioso ³, Emmanuelle Sarrazin ¹, Nesrine Farhani ⁴, Kanishka Mallick ¹,
Philippe Gamet ¹, Vincent Rivalland ¹, Pavan Kumar Amgoth ^{1,2}, Muddu Sekhar ², Bimal K
Bhattacharya ⁵, Ayan Das ⁵**

¹ Univ Toulouse, CNES, CNRS, INRAE, IRD, CESBIO, Toulouse, France

² Indo-French Cell for Water Science, Indian Institute of Science, Bangalore Karnataka, India

³ Unité de Recherche écologie des Forêts Méditerranéennes, INRAE, Avignon, France

⁴ HSM, Univ Montpellier, CNRS, IRD, Montpellier France

⁵ Space Applications Centre, ISRO, Ahmedabad, India

*Corresponding author: Gilles Boulet

Tel. +33673317843, E-mail : gilles.boulet@ird.fr

Most applications related to monitoring of the water budget in hydrology, agronomy or ecology require daily estimates of evapotranspiration (ET) or alert about the intensity of water stress (WS) factor every day, that is, a continuous time series updated daily. However, with the projected TRISHNA revisit frequency of 2-3 days and the added challenge of cloud or overcast-sky interference, it becomes necessary to fill the gaps between cloud-free acquisitions in order to generate continuous daily evapotranspiration and

water stress products. To address this, a range of interpolation methods has been proposed in the literature, spanning from simple approaches—based on easily accessible meteorological data—to more complex schemes that involve data assimilation of multi-sensor observations into distributed hydrological or energy balance models. Generation of daily all-sky ET or WS can be considered as a two-step process, encompassing predictions under cloudy sky first and interpolation thereafter at daily scale using clear and cloudy sky estimates.

In this study, we present and evaluate a range of such options for use in an operational TRISHNA algorithm over multiple crop types in France, Tunisia, Morocco and India. These solutions show an increasing complexity in accounting for the water status of the surface through water budget information (from a simple Antecedent Precipitation Index to a water budget model forced with optical visible/near infrared remote sensing data). Additionally, we explore the use of alternative sensors to fill observation gaps on cloudy days or to enhance temporal resolution. These include disaggregated daily ET products from platforms like Sentinel 3 or MODIS such (e.g., SEN_ET), SAR-based retrievals from Sentinel-1 and machine learning or deep learning assisted time-series predictions, which can provide valuable input under persistent cloud cover.

MULTI-SCALE MONITORING OF IRRIGATION VOLUMES AND EVAPOTRANSPIRATION BY ASSIMILATING SATELLITE LAND SURFACE TEMPERATURE AND SOIL MOISTURE INTO AN ENERGY-WATER BALANCE MODEL

Chiara Corbari ¹, Nicola Paciolla ¹, Carolina Angeloni ¹, Sven Berendsen ², Justin Sheffield ²

¹ Politecnico di Milano, Italy

*² University of Southampton, United Kingdom
chiara.corbari@polimi.it, +39-3498603864*

The agricultural sector is the biggest and least efficient water user, accounting for around 70% of total water use in the Mediterranean region, which is already strongly impacted by climate change with prolonged drought periods, imposing limitation to irrigation water availability. The objective of this study was to develop a procedure for the monitoring irrigation water use and evapotranspiration across different agricultural districts in the Po Valley at 30 m of spatial resolution from 2022 to 2024 and over the entire agricultural area of the basin at 250 m from 2015 to 2024.

The analysis is based on the FEST-EWB model, that computes continuously in time both soil moisture (SM) and evapotranspiration based on the coupling of the energy and water balances. A specific model procedure has been implemented to consider the presence of flooded paddies. The model has been calibrated and validated over non-irrigated areas, against land surface temperature (LST) from downscaled MODIS data at 250m and LANDSAT data at 100 m; Sentinel 1 soil moisture data and local eddy covariance evapotranspiration measurements.

The model has been run using as input the past meteorological forcings (ECMWF ERA5-Land or ground network) and vegetation data from Sentinel2 at 30 m and MODIS at 250 m. Groundwater dynamic was considered from the available groundwater wells from the regional networks.

The actual irrigation volumes have been estimated through the calibrated model implementing three different irrigation strategy: the FAO approach based on SM crop stress thresholds (Allen et al., 1998), the separate and jointly assimilation of satellite LST and SM data to update the modeled fluxes and estimate the irrigation volumes. The different irrigation efficiencies have been considered when modelling the irrigation volumes.

Overall, the results suggested that the yearly total irrigation volumes modeled with the FAO approach are generally underestimated in respect with the observed water allocations. Higher agreement was found when satellite LST or SM are assimilated, but with differences across the years.

OPENET-BRAZIL: ADVANCES IN FIELD-SCALE EVAPOTRANSPIRATION ESTIMATION USING LANDSAT AND THERMAL DATA FUSION FOR WATER SECURITY

Anderson Ruhoff¹, Leonardo Laipelt¹, Gabriel Matte¹, Julia Rossi¹, Felipe Linck¹, Nicole Viegas¹, Wilany Alves¹, Forrest Melton², Sara Larsen³, Adam Purdy^{1,4}, John Volk⁵, Richard Allen^{6, 7}, Martha Anderson⁸, Lydia Bleifuss³, Mackenzie Friedrichs⁹, Joshua Fishe¹⁰, Ayse Kili¹¹, Charles Morton⁵, Gabriel Senay⁹, Yun Yang¹²

¹ Universidade Federal do Rio Grande do Sul, ² NASA Ames Research Center,

³ OpenET, Inc., ⁴ California State University Monterey Bay, ⁵ Desert Research Institute, ⁶ ETPlus, Inc., ⁷ University of Idaho, ⁸ USDA Agricultural Research Service, ⁹ United States Geological Survey, ¹⁰ Chapman University, ¹¹ University of Nebraska Lincoln, ¹² Cornell University

Corresponding author: Anderson Ruhoff, +55 51 99720 6995, andersonruhoff@gmail.com

Accurate estimates of evapotranspiration (ET) over space and time are essential for water resources management, supporting decision-makers to improve water security and achieve better accounting of water use from agriculture. Multiple remote sensing methods are currently available, with different levels of complexity, input data, and uncertainties. Thermal-based models remain the most widely used approaches for agricultural applications, as land surface temperature is directly related to latent and sensible heat fluxes and serves as a strong proxy for relative soil moisture. OpenET, originally developed for the United States, combines high-resolution Landsat imagery with high resolution meteorological datasets to achieve accurate field-scale ET estimates. Given the increasing expansion of cropland and irrigation in South America and its associated impacts on water availability, we present OpenET-Brazil, an international expansion of the OpenET framework applied to Brazil. We use Landsat historical and current imagery combined with ERA5-Land meteorology to estimate ET at field scale, running five models (geeSEBAL, SSEBop, PT-JPL, SIMS, and eeMETRIC) and computing an ensemble output. Validation against eddy covariance measurements from approximately 48 flux tower sites spanning major Brazilian biomes demonstrates accurate ET estimates, with ensemble errors below 1.1 mm/day and bias below 5%. To address the inherent trade-off between spatial and temporal resolution of Landsat imagery, we also present advances in downscaling thermal infrared data by fusing Harmonized Landsat Sentinel-2 (HLS) with VIIRS land surface temperature through the DuST (Dual Source Thermal Sharpening) algorithm. This data fusion approach substantially increases the temporal frequency of field-scale ET retrievals beyond Landsat revisit constraints, enabling near-daily monitoring. Key applications for OpenET-Brazil include assessment of water consumption in agricultural irrigation systems, monitoring of drought impacts on water availability, tracking of cropland intensification and irrigation expansion, estimation of reservoir evaporation, and quantification of deforestation and land-use change impacts on the water cycle. Together, these advances highlight the critical need to actively monitor and improve water use efficiency throughout Brazilian territory, contributing to resilient agricultural systems and sustainable water management.

CHALLENGES ON MONITORING THE DYNAMICS AND EVOLUTION OF EVAPOTRANSPIRATION IN SAHEL FROM SPACE

Jordi Etchanchu^{1}, Nesrine Farhani^{1,2}, Simon Vauclaire¹, Benjamin Goffin¹, Taeken Wijmer¹, Gilles Boulet^{3,4}, Nanee Chahinian¹, Philippe Gamet³, Albert Oliso⁵, Samuel Mwangi⁵, Emmanuelle Sarrazin³, Kanishka Mallick³, Serigne Mansour Diene^{6,10}, Djim M. L. Diongue⁷, Ibrahim Maïnassara^{1,11}, Olivier Rounsard^{8,9,10} and Jérôme Demarty¹¹*

¹ HSM, Univ Montpellier, CNRS, IRD, ¹⁵ Avenue Charles Flahault, 34093 Montpellier, France

² Centre National d'Etude Spatiales (CNES), ² Place Maurice Quentin, 75039, Paris, France

³ Univ Toulouse, CNES, CNRS, INRAE, IRD, CESBIO, Toulouse, France

⁴ Indo-French Cell for Water Science ICWaR Indian Institute of Science Bangalore India

⁵ Unite de Recherche ecologie des Foret Mediterraneennes (URFM) INRAE 84000 Avignon, France

⁶ *Mixed Research Laboratory, Polytechnic School of Thies, A10, Thies, Senegal*

⁷ *École Nationale Supérieure des Mines et de la Géologie, Université Cheikh Anta Diop, BP, Dakar, Fann 5396, Senegal*

⁸ *Eco Sols Univ Montpellier CIRAD INRAE IRD Montpellier SupAgro, Montpellier, France*

⁹ *CIRAD UMR Eco Sols BP1386 CP18524 Dakar, Senegal*

¹⁰ *LMI IESOL Centre IRD-ISRA de Bel Air BP1386 CP18524 Dakar, Senegal*

¹¹ *Institut de Recherche pour le Développement (IRD) Representation, 276 avenue de Maradi, Niamey, Niger*

**Corresponding author: jordi.etchanchu@ird.fr, +33449338263*

Evapotranspiration (ET) is one of the main components of the water budget. As such, monitoring its dynamics and long-term evolution is crucial. It is particularly true in semi-arid regions where water scarcity may have severe repercussions on food security, as in Sahel. However, in such region, in-situ ET measurements remains rare. Earth Observation (EO) thus appears as a great opportunity to overcome this problem. Moreover, the time-depth of the current and past spatial missions now becomes interesting enough to analyze the long-term tendencies on ET, in line with the global changes. The present study highlights the challenges of monitoring ET from space in Sahel through the preparation of the future TRISHNA mission (CNES/ISRO). The landscape of existing global or continental ET products is first pictured through a multi-scale spatial and temporal comparison. It shows that no current product combines good local performances against in-situ measurements and good spatio-temporal characteristics. Moreover, the relative range between ET products, with respect to an annual mean around 400 mm.yr⁻¹, is between 50 and 100% depending on the ecosystems. The EVASPA algorithm, selected for the future TRISHNA ET products, is thus used to estimate ET from several EO missions (MODIS, Landsat, S2, Ecotress) on four meso-scale sites across Niger and Senegal. As an ensemble contextual model, this algorithm relies on sufficiently heterogeneous thermo-hydric conditions within the images. Such conditions can be challenging to obtain in Sahelian climate, characterized by a monsoon regime with a long dry season. The model has thus been improved to account for the lack of heterogeneity depending on the season. It is evaluated through comparison to in-situ measurements as well as spatial analysis. With these developments, results show that EVASPA has the potential to become a reference product over semi-arid regions. The monsoon regime is also challenging for thermal EO due to the cloud cover. It usually causes large temporal gaps in the cropping season, when monitoring ET is particularly crucial. Several data fusion techniques are thus compared to tackle this issue, as they allow for the interpolation of ET between clear-sky acquisitions. Such technique allows for the construction of long-term continuous timeseries of ET from EVASPA, by taking advantage of long-lasting missions such as MODIS. The analysis of these timeseries, along with climate variables and land surface evolution, provides new insights on the main drivers of ET in the different areas and ecosystems of Sahel. Indeed, it shows contrasted ET tendencies across sites and ecosystems, ranging from -2 to +4 mm.yr⁻¹ during the last 25 years. The long-term evolution of vegetation coverage appears to be the main driver of these tendencies on most ecosystems rather than the precipitations, even though ET on these ecosystems is mostly water limited.

INTRA-CROWN LEAF CHLOROPHYLL CONTENT MAPPING IN ORCHARDS FROM UAV IMAGING SPECTROSCOPY: IMPROVING LABORATORY MODEL TRANSFER WITH ILLUMINATION CORRECTION

Nathan Sikora¹, Sylvain Jay², Karine Adeline¹

¹ *ONERA / DOTA, Université de Toulouse, F-31055 Toulouse, France ; nathan.sikora@onera.fr, karine.adeline@onera.fr*

² *EMMAH, INRAE, Avignon Université, Avignon, France; sylvain.jay@inrae.fr*

Monitoring orchard health and nutritional status is a key challenge for the development of sustainable and agroecological practices. Leaf chlorophyll content (LCC) is a widely used proxy for photosynthetic activity and nitrogen status, making it a relevant indicator of biotic and abiotic stresses, plant

growth vigor and, indirectly, fruit production capacity. Centimetric-resolution UAV imagery enables precise leaf-scale analysis and aims toward tree-based management decision-making. However, the complex radiation regime observed at such scale complicates LCC estimation due to directional effects induced in general by leaf orientation, optical property anisotropy and multiple scattering within the canopy. Therefore, appropriate correction methods are necessary, but remain underexplored. This study investigates the potential of upscaling laboratory-calibrated models to UAV hyperspectral imagery using a physically-based illumination correction method for precise intra-crown LCC estimation.

Two orchards managed by INRAE (Bellegarde, France) composed of various peach and apricot genotypes and with different pesticide treatments were studied. Two UAV campaigns were carried out in June and September 2024 under varying illumination conditions, acquiring hyperspectral images in the visible to near-infrared range at 1.35 cm spatial resolution. A first database (DB1) was collected under controlled laboratory conditions from May to September 2024, including leaf-clip and destructive measurements of LCC, and reflectance spectra (400–2500 nm). A second database (DB2) was acquired in field conditions during UAV campaigns using the same measurement protocol, and a third database (DB3) was built to assess intra-crown variability using leaf-clip measurements on selected trees.

The first step was to calibrate LCC estimation models from DB1 and validate them using the independent DB2. Using spectroscopic measurements, both a model-driven and a data-driven approaches were evaluated: PROSPECT-D leaf radiative transfer model inversion and Partial Least Squares Regression (PLSR). An exhaustive exploration of spectral subdomains over 400–800 nm identified the 700–750 nm range as optimal, giving root mean square error (RMSE) values of $3.5 \mu\text{g}\cdot\text{cm}^{-2}$ and $2.8 \mu\text{g}\cdot\text{cm}^{-2}$, respectively. Using leaf-clip measurements, species-specific linear regressions showed RMSE values of $2.6 \mu\text{g}\cdot\text{cm}^{-2}$ and $3.6 \mu\text{g}\cdot\text{cm}^{-2}$ for apricot and peach trees, respectively.

The second step was to correct leaf reflectances of UAV image sunlit pixels using the physically-based illumination correction method of Ihalainen et al. (2023) based on spectral invariant theory. The method relies on a forward model using PROSPECT and the estimation of three spectrally invariant parameters: p (canopy multiple scattering), ρ (direct solar irradiance contribution sensitive to leaf orientation) and C (leaf specular reflection). This method was validated for close-range acquisitions but never for centimetric-scale UAV images. Corrected leaf reflectances were compared with those of DB2.

The third step was to apply the previous laboratory-calibrated models to these corrected reflectances and validate LCC estimations using DB3 and leaf-clip regressions. Results showed similar RMSE values of 4.2 and $4.8 \mu\text{g}\cdot\text{cm}^{-2}$ between LCC values averaged at the tree scale for the model-driven and data-driven approaches, respectively, close to laboratory performance. In contrast, they reached 14.3 and $40.5 \mu\text{g}\cdot\text{cm}^{-2}$, respectively, without correction. LCC distributions at tree scale were more consistent after correction.

In summary, this method proved efficient for deriving intra-crown LCC maps under varying illumination conditions (due to several UAV acquisitions) and diverse tree structures (due to the variety of species genotypes and two contrasted phenological stages). It could be extended to short-wave infrared data to estimate additional biochemical traits such as leaf water content. This work is part of the ANR CANOP project (grant: ANR-22-CE04-0002).

RESOLVING CANOPY THERMAL EXTREMES IN FRAGMENTED AMAZONIAN RAINFORESTS USING THERMAL INFRARED DOWNSCALING

Anastasia Kozhevnikova¹, Stuart King¹, David Galbraith², Emanuel Gloor², Amanda Lenzi¹, Patrick Meir³, Ed Mitchard⁴

¹School of Mathematics, University of Edinburgh, United Kingdom

²School of Geography, University of Leeds, United Kingdom

³School of GeoSciences, University of Edinburgh, United Kingdom

⁴Space Intelligence, United Kingdom

Corresponding author: Anastasia Kozhevnikova

Email: A.Kozhevnikova@sms.ed.ac.uk
Tel: +44 7910214301

Tropical rainforests play a crucial role in global carbon and water cycles, regulating climate and supporting biodiversity. However, these ecosystems face increasing threats from climate change, deforestation, and habitat fragmentation. Fragmented forests are particularly vulnerable to heat stress [1], which can disrupt ecosystem functioning and accelerate biodiversity loss. Capturing canopy thermal extremes at ecologically relevant spatial scales is therefore essential for understanding forest vulnerability. However, current thermal infrared remote sensing products are limited by trade-offs between spatial and temporal resolution [2], constraining their ability to resolve fine-scale temperature variability. MODIS Aqua provides daily afternoon land surface temperature (LST), capturing peak temperatures, but at coarse 1 km resolution, limiting the detection of localised hotspots. Landsat 8/9 offer higher spatial resolution (30 m) imagery every 8 days, but infrequent morning overpasses miss critical thermal extremes. These temporal and spatial trade-offs highlight the need for integrating complementary LST datasets [3].

To overcome these limitations, we develop a machine-learning downscaling model to enhance MODIS LST from 1 km to 30 m resolution using high-resolution satellite data and auxiliary biophysical information. The methodology is designed to reconstruct fine-scale land surface temperature while preserving the magnitude and spatial structure of thermal extremes. Training is performed using synthetically degraded datasets to enable robust learning of cross-scale thermal relationships. Preliminary results indicate a substantial improvement in the representation of canopy temperature variability, revealing localised heat stress hotspots that are not detectable in native resolution of MODIS LST product. Validation is conducted using UAV-based thermal imagery acquired during satellite overpasses, allowing direct multi-scale comparison. In addition, downscaled LST products are evaluated against in situ measurements from drought and control plots in different parts of the Amazon basin.

This methodology advances the monitoring of heat stress in the Amazon rainforest and provides a scalable framework for downscaling LST data in other complex ecosystems. The results provide insights, which are vital for informing targeted conservation strategies and supporting sustainable forest management practices.

[1] Tuff, K. T., Tuff, T., & Davies, K. F. (2016). A framework for integrating thermal biology into fragmentation research. *Ecology letters*, 19(4), 361-374.

[2] Zhan, W., Chen, Y., Zhou, J., Wang, J., Liu, W., Voogt, J. & Li, J. (2013). Disaggregation of remotely sensed land surface temperature: Literature survey, taxonomy, issues, and caveats. *Remote Sensing of Environment*, 131, 119-139.

[3] Wu, P., Shen, H., Zhang, L., & Göttsche, F. M. (2015). Integrated fusion of multi-scale polar-orbiting and geostationary satellite observations for the mapping of high spatial and temporal resolution land surface temperature. *Remote Sensing of Environment*, 156, 169-181.

DART-AI EMULATOR OF BOTTOM OF ATMOSPHERE IRRADIANCE FOR VIS/TIR REMOTE SENSING APPLICATIONS

Yasmine Karray^{1,2,3}, Jean-Philippe Gastellu-Etchegorry¹, Firas Ayari¹, Jean-Louis Roujean¹, Abdelaziz kallel²

¹CESBIO, Université de Toulouse, CNES/CNRS/INRAE/IRD/UT3, 18 avenue E. Belin, Toulouse, France

²Digital Research Center of Sfax, SMARTS, Sfax, Tunisia

³Ecole Nationale d'Electronique et des Télécommunications de Sfax, University of Sfax, Tunisia

Tel: +216 29 025 003 | Email: yasmine.karray@enetcom.u-sfax.tn

For remote sensing applications requiring the determination of land surface reflectance and brightness temperature, simulating bottom-of-atmosphere (BOA) irradiance is often computationally demanding. This challenge is particularly pronounced when modeling the VIS/NIR/TIR radiative budget and generating remote sensing images of three-dimensional (3D) landscapes using radiative transfer (RT) models

such as DART, especially when considering multiple spectral bands. As a result, the operational applicability of RT models can be significantly limited. To address this bottleneck, we propose two end-to-end AI-based emulation pipelines designed to predict BOA diffuse irradiance in the visible/near-infrared (VIS/NIR) and thermal infrared (TIR) spectra, respectively. We focus on partitioning VIS/NIR irradiance into its direct and diffuse components, as this distinction critically influences land surface reflectance. Indeed, accurate reflectance estimation is essential for deriving key remotely sensed parameters—such as Leaf Area Index—as well as for assessing the radiative budget of urban areas, croplands, and forests. These factors, in turn, impact urban temperatures, vegetation growth dynamics, and energy sector applications, including the optimal sizing and yield estimation of photovoltaic installations. The DART atmospheric RT model serves as the reference for our AI-based emulators. It integrates 12 key parameters, including:

- Sun direction,
- 1D profiles of density, spectral transmittance and temperature of aerosols and gases,
- Henyey-Greenstein coefficients of the aerosol scattering phase function, and
- Surface altitude and mean reflectance to account for its radiative coupling with the Atmosphere.

The two emulation pipelines are built upon two methodological pillars. The first is a Gaussian Process (GP)-guided adaptive sampling strategy designed to efficiently construct a representative training dataset from DART's high-dimensional parameter space (i.e., 12 parameters). A GP surrogate is iteratively trained to map predictive uncertainty across the input space; new simulation points are then drawn from stratified uncertainty intervals, concentrating computational effort where the surrogate is least confident. Convergence is monitored through the Coefficient of Variation of the GP predictive standard deviation, ensuring uniform and informative coverage. The second component involves the application of Neural Architecture Search (NAS) to identify the optimal deep neural network for each spectral domain. NAS systematically explores a search space by jointly optimizing architectural and training hyperparameters via Bayesian Optimization with Hyperband (BOHB). Results show that the VIS/NIR and TIR AI emulators closely agree with the reference while greatly reducing computation time. The VIS/NIR emulator is already implemented in the DART version, freely distributed by Toulouse University. Its mean relative accuracy is better than $0.5 \cdot 10^{-3}$, with larger inaccuracy in the gas absorption bands, and it is much faster (e.g., 30 times faster for simulating a reflectance spectra $[0.3\mu\text{m} \text{ } 4\mu\text{m}]$ of a vegetation cover in 650 bands). This is ideally suited to the level of accuracy required for remote sensing applications. It demonstrates that deep learning can faithfully accelerate physically-based RT modeling without sacrificing scientific rigor. A more advanced AI-based emulator of the DART atmosphere RT model is being designed for fast simulation of VIS/NIR/TIR remote sensing observations.

GEOGLAM: 15 YEARS OF GLOBAL AGRICULTURAL MONITORING

Sven Gilliams

GEOGLAM, 7 bis, avenue de la Paix, Geneva, Switzerland, sgilliams@geosec.org

Fifteen years after its endorsement by the G20 in 2011, the Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM) demonstrates that routine crop assessment is feasible at global scale—and that technical capability alone does not create sustained, decision-ready services.

This retrospective traces GEOGLAM's development from international coordination to an operational community producing consensus-based crop-condition assessments. Since 2013, the Crop Monitor has combined Earth-observation indicators, in situ evidence, agroclimatic information, and partner expertise. Monthly review and reconciliation produce an impartial assessment for market transparency and food-security early warning. Essential Agricultural Variables translate policy needs into observation requirements, the Joint Experiment for Crop Assessment and Monitoring tests methods across diverse sites, and regional networks help carry research into operations.

For its next phase, GEOGLAM will focus on further integration. Mandated national services will generate and own the evidence, regional centres will connect capabilities across countries, and an impartial global function would steward standards and convene consensus without centralising control. The proposed

framework has five dimensions: standards and trust; national capacity and ownership; shared resources; sustained policy and financing; and adaptive monitoring and synthesis.

Quantitative estimates of crop area, yield, and production should complement—not replace—operational condition monitoring. Their responsible use requires documented validation, quantified uncertainty, transparent provenance, open methods, governed data sharing, and human review.

GEOGLAM's central lesson is that scientific innovation creates public value when trusted institutions translate comparable evidence into action. Success is ultimately measured by whether decision-makers can act before a production shortfall becomes a crisis.

ARYA: IMPLEMENTING AN EO-BASED CROP YIELD FORECASTING MODEL ACROSS DIFFERENT COUNTRIES AND CROPS

Belen Franch^{1,2}, Italo Moletto-Lobos¹, Javier Tarín-Mestre¹, Victor Betti¹, Eric Vermote², Natacha Kalecinski³, Sergii Skakun³, Inbal Becker-Reshef³, Lorenzo de Simone⁴

¹ Global Change Unit, Image Processing Laboratory (UCG-IPL). Parque Científico, Universitat de Valencia, Spain; belen.franch@uv.es, italo.moletto@uv.es, javier.tarin@uv.es, victor.betti@uv.es,

² NASA Goddard Space Flight Center Code 619, 8800 Greenbelt Road, Greenbelt, MD, USA; eric.f.vermote@nasa.gov

³ Department of Geographical Sciences, University of Maryland, College Park MD, United States; nkalecin@umd.edu, ireshef@umd.edu, skakun@umd.edu

⁴ FAO-ESTELLA, Via de Terme di Caracalla, Rome, Italy Lorenzo.DeSimone@fao.org

The transferability and operational applicability of Earth Observation (EO)-based crop yield forecasting models across diverse agroecological contexts remain key challenges for large-scale agricultural monitoring systems. This study evaluates the performance and adaptability of the Agriculture Remotely-sensed Yield Algorithm (ARYA), an empirical EO-based yield forecasting approach, across multiple crops, regions, and production systems.

ARYA integrates satellite-derived vegetation dynamics from MODIS Difference Vegetation Index (DVI), thermal-based crop stress indicators derived from Land Surface Temperature (LST), and meteorological information in the form of Growing Degree Days (GDD) from MERRA-2 reanalysis. The model is calibrated at subnational level using historical yield statistics, allowing region-specific parameterization through statistically-driven selection of predictor combinations.

This work focuses on assessing ARYA's robustness across contrasting environments and cropping systems, including winter wheat in major exporting countries (United States, Ukraine, Russia), as well as maize in food-insecure regions such as Kenya and Zimbabwe under the framework of FAO Estella project. Additional applications to maize in Brazil and rice in Spain further support the evaluation of cross-crop transferability. The analysis explores the consistency of model performance, sensitivity to input data, and its ability to capture interannual yield variability under varying climatic and agronomic conditions.

Results demonstrate that ARYA maintains stable predictive skill across heterogeneous contexts, highlighting its capacity as a scalable and cost-effective tool for operational yield forecasting. Its reliance on globally available EO and reanalysis datasets makes it particularly suitable for deployment in data-sparse regions. The study underscores the potential of empirically calibrated EO models to support agricultural monitoring, early warning systems, and decision-making at multiple spatial scales.

ANN-PROSAIL MODEL TO ESTIMATE QUALITY AND DIGESTIBILITY OF ALFALFA FORAGE FROM SENTINEL-2 IMAGERY

Giacomo Panza^{1,2}, José Luis Pancorbo², Aldo Dal Prà², Lorenzo Brilli², Carlos Camino³, Lorenzo Genesio², Simona Maccherini¹, Beniamino Gioli²

¹ University of Siena - Department of Life Sciences, Via Aldo Moro 2, Siena, 53100, Italy

² National Research Council-Institute of BioEconomy (CNR-IBE), Via Caproni ⁸, 50145, Firenze, Italy

³ *Laboratory of Geo-Information Science and Remote Sensing, Wageningen University and Research, Wageningen, Netherlands. Corresponding author: Giacomo Panza (e-mail: giacomopanza@cnr.it, telephone: +39338 221 9891)*

Alfalfa (*Medicago sativa* L.) forage value largely depends on the balance between protein content and fiber digestibility. This balance, primarily regulated by growth stage since plant development influences both nitrogen assimilation and carbon allocation, is reflected in several vegetation biophysical parameters, including chlorophyll content (Cab); carbon-based constituents, (CBCs) and leaf area index (LAI). Cab is closely linked to nitrogen status and protein content, representing a key biochemical indicator of forage quality. Fiber accumulation is associated with the broader group of CBCs, including lignin, cellulose, hemicellulose, sugars, and starch. LAI describes canopy development and biomass accumulation, integrating the structural dimension that modulates light interception, photosynthetic activity, and carbon partitioning, resulting in a proxy for yield. Since CBCs, Cab, and LAI vary across growth stages in response to metabolic activity and climatic conditions, their continuous monitoring is essential to improve both modelling approaches and agronomic management.

In this study, a methodological framework combining Sentinel-2 satellite imagery with a hybrid Artificial Neural Network (ANN) – Radiative Transfer Model (PROSAIL) inversion approach, implemented through the ToolsRTM R package, was developed to estimate CBCs, Cab and LAI across different alfalfa growth stages and harvest cycles in two fields located in Northern Italy during the 2025 cutting period (May – October). The model outputs were validated using ground-based measurements collected during the same period. Cab was measured in situ using a Dualex sensor, while CBCs were determined through laboratory analyses. Dry matter yield measurements were used to validate the remotely sensed estimates of LAI.

Results indicate that PROSAIL-derived CBCs, Cab, and LAI estimates from Sentinel-2 reflectance spectra were consistent with ground-truth data collected. The estimated CBCs showed good performances ($R^2 = 0.56$), with lowest values occurring at the early vegetative stage ($\sim 2.46 \text{ mg cm}^{-2}$), followed by the late bud stage ($\sim 3.32 \text{ mg cm}^{-2}$). The highest concentrations were observed from mid-vegetative to early bud stages ($\sim 4.42 \text{ mg cm}^{-2}$), while early flowering (pre-cut) showed slightly lower but still elevated values ($\sim 3.57 \text{ mg cm}^{-2}$). The estimated Cab ($R^2 = 0.79$) showed lowest values occurring at the early vegetative stage ($\sim 12.4 \mu\text{g cm}^{-2}$), progressively increasing to its highest concentrations at early flowering stage ($\sim 29.6 \mu\text{g cm}^{-2}$), Kalu and Fick scale, 1981. The estimated LAI resulted in a robust proxy for yield ($R^2 = 0.68$), with highest values observed at the first cuts of the season (up to ~ 2.98) followed by a progressive decline toward late summer. These results suggested the robustness of the hybrid ANN-PROSAIL framework for retrieving CBCs, Cab, and LAI in alfalfa systems. Additional ground measurements will be collected in 2026 to further strengthen model validation and assess its transferability across different growing and climatic conditions.

NEXT-GENERATION GLOBAL LAND COVER AND CONSISTENT CHANGE MAPPING AT 10 M RESOLUTION IN THE COPERNICUS LCFM SERVICE

Giorgia Milli¹; Daniele Zanaga¹; Ruben Van De Kerchove¹; Wanda De Keersmaecker¹; Joris Coddé¹; Yannis Kalfas¹; Mathilde De Vroey¹; Carolien Toté¹; Victor Verhaert¹; Luc Bertels¹; Astrid Verhegghen¹; Manu Goudar¹; Francesco Perfetto¹; Myroslava Lesiv²; Steffen Fritz²; Andrea Lupi³; René Colditz³; Frédéric Achard³; Andreas Brink³

¹VITO - Flemish Institute for Technological Research, Belgium;

²IIASA - International Institute for Applied Systems Analysis, Austria;

³JRC - Joint Research Centre (European Commission), Italy

Contact: giorgia.milli@vito.be, +32 456356069

The Copernicus Land Cover and Forestry Monitoring (LCFM) service is a new operational component of the Copernicus Land Monitoring Service, designed to produce regularly updated annual land cover and tropical tree cover density products at 10 m resolution, based on Sentinel-1 and Sentinel-2 data. LCFM land cover products build on several methodological innovations, marking a significant evolution from its predecessor, ESA WorldCover. Key advances include a new global expert-annotated reference

dataset for land cover mapping, improved Sentinel-2 preprocessing through a deep learning-based cloud and artefact detection approach, and a hybrid model architecture (EvoNet) combining spatial context learning with pixel-level spectral prediction. Together, these components enable the generation of robust and temporally consistent land cover time series with enhanced spatial detail, reduced artefacts, and improved class discrimination. This talk focuses on the transition from single-year land cover mapping to temporally consistent land cover time series within LCFM. While global mapping at 10m resolution enables unprecedented spatial detail, it also amplifies temporal inconsistencies, as classification noise, residual cloud contamination, and input variability can introduce spurious year-to-year changes. Addressing these limitations requires moving beyond independent annual predictions towards approaches that explicitly account for temporal context and model uncertainty. To improve robustness, LCFM adopts a multi-annual learning strategy, where both training data and model design capture interannual variability. Data augmentation further enhances resilience to fluctuations in input observations, such as atmospheric effects or seasonal inconsistencies, reducing sensitivity to artefacts that would otherwise propagate into the time series. Building on this foundation, temporal consistency is enforced through a change-aware harmonization approach. A deep learning-based change detection model identifies pixels where genuine land cover transitions are likely between consecutive years, complementing land cover predictions. The outputs of the land cover and change models are combined through a voting-based mechanism that accounts for model uncertainty. Where both models agree, predictions are preserved or updated; where they disagree, information from multiple years is merged to avoid both oversmoothing real changes and propagating spurious ones. This approach reflects a practical compromise, acknowledging that model errors are unavoidable and may occur inconsistently over time. By combining complementary information and exploiting temporal redundancy, the methodology reduces uncertainty and stabilizes land cover trajectories. The resulting annual Land Cover Map at 10m resolution (LCM-10) for the 2020–2025 period provides both discrete classifications and continuous representations of land cover categories, enabling a more comprehensive characterization of landscape composition. These temporally consistent outputs form the basis for land cover change products, including annual loss and gain maps that quantify transitions between classes. Together, these products provide a coherent and spatially explicit representation of land cover dynamics, supporting a wide range of environmental monitoring and policy applications. The presentation will outline the methodology and showcase representative time series and change examples across diverse landscapes, highlighting improvements in temporal consistency and change reliability, as well as remaining challenges.

SMOS AFTER 16 YEARS IN OPERATION: RESULTS, LESSONS LEARNT AND REMAINING

Yann H. Kerr¹ and the SMOS team

¹ CESBIO, yann.kerr@cnes.fr +33 5 61 55 85 22 18 avenue Edouard Belin, 31401 Toulouse cedex 9, France

The ESA (European Space Agency) led SMOS (Soil Moisture and Ocean Salinity) mission, operating since November 2009, is the first satellite dedicated to measuring surface soil moisture and ocean salinity. It has been now in operation continuously for more than 16 years, delivering a wealth of new measurements including the first time ever global, frequent, quantitative and absolute measurements of soil moisture and ocean salinity. From these measurements a large number of science and applied products have emerged ranging from strong wind or thin sea ice thickness to root zone soil moisture or biomass but also fire or flood risks prediction, snow density or freeze thaw to name but a few. Operational users (such as numerical weather prediction) have also emerged. To obtain such results several challenges had to be addressed and overcome but results show the uniqueness of L band radiometry for some crucial water cycle measurements.

Recent advances have been made and notably root zone soil moisture fields and drought indices, giving way to first assessment of irrigation; biomass estimates and related carbon storage estimates; freeze thaw and related greenhouse gas emissions; snow properties and permafrost indicators or even rainfall estimates. In parallel high resolution fields are being produced and used operationally.

Currently, using the long term data set and developing approaches to extend it in time, climate trends can start to be considered as well as teleconnections and SMOS is contributing to a large number of ECV (Essential Climate Variables) / CCI (Climate Change Initiative). Moreover, synergisms with other missions either existing (SMAP, AMSR, S3 for instance) or planned (Biomass, FLEX, LSTM/ Trishna) are being studied or put into use, paving the way to even more outstanding science results.

At the time of writing SMOS is in very good condition and can last for a few more years, extending the length of the data sets but will not last forever. Consequently the team is both investing time in new or improved science and application products but also on potential follow on mission which would be very much similar to SMOS (or SMAP) but with a significantly improved spatial resolution.

The presentation will give an overview of the most striking new results as well as future plans and remaining challenges

IMPACT OF SELECTION BIAS IN TRAINING DATA ON MODEL AND MAP ACCURACY ASSESSMENT AND AREA ESTIMATION

Sergii Skakun¹

¹*University of Maryland, College Park, MD, US Phone: +1-301-405-2179, Email: skakun@umd.edu*

One of the core applications of satellite-based classification maps is land area estimation. The remote sensing research and application communities have developed a framework to derive land area estimates from unbiased estimators. One of the recommended approaches is a sample-based approach that incorporates probability sampling of reference data and a design-based inference framework within which estimation of the target variables, such as accuracy and area, is performed. Failing to do so, i.e., when estimates are not characterized in probabilistic terms and are subject to selection bias, will lead to situations when “the map cannot serve as a basis for scientific inference; from an inferential perspective, the map may be little more than just a pretty picture” (McRoberts, 2011). Satellite-based land cover land use (LCLU) maps can be used for stratification in the sampling design to improve the precision of the estimator. In this case, the quality of the map, i.e., how accurate it is, will not impact the bias of the estimator because the bias depends on the sampling design and the choice of estimator. The quality of the map, however, will impact the efficiency of stratification and, consequently, the precision of the estimator. This study aims to provide a quantitative assessment of the impact of selection bias in training data on model and map accuracy assessment and area estimation. The relative efficiency depends on class-specific producer’s (PA) and user’s accuracy (UA) and true area (f), and therefore, map producers should report those within the confusion matrix. Numerical simulations will demonstrate how relative efficiency depends on area estimation objectives, target area proportion, and the map’s performance metrics (PA and UA), and how selection bias in training data impacts efficiency assessment and the model selection process. The impact is non-linear, and contributions of the PA, UA, and f are not equal. When the target class is minor or rare, a stratified random sampling approach with an inaccurate map ($PA/UA \sim 0.6$) is more efficient than simple random sampling. PA has a larger impact on the relative efficiency than UA in the sense that larger gains in PA will lead to larger gains in the relative efficiency. An increase in UA, at the expense of PA reduction, could lead to a decrease in relative efficiency. As the target class proportion increases and becomes a major class, the gains in relative efficiency compared to the simple random sampling approach decrease. For major classes, UA has a larger impact on the relative efficiency than PA. Overall, there are multiple values in the PA/UA space to reach the same relative efficiency. The proposed approach allows one to estimate the achievable range of PA and UA values to obtain the desired level of efficiency, depending on the requirements regarding sample size and target precision. F-score, which is the harmonic mean of PA and UA, is not an adequate measure for benchmarking algorithm performance when maps are used for stratification in support of area estimation, because the same efficiency can be achieved by a range of F-score values.

REVISITING LAND REMOTE SENSING ISSUES: LESSONS LEARNED 30 YEARS AGO

Garik Gutman¹

¹NASA LCLUC Program Manager, Retired, Washington, DC USA

There is a saying: "the new is well forgotten old". In this presentation, I revisit issues that, over the past 50 years, have posed obstacles to studying physical processes at the land surface from space. These issues have been addressed by scientists working with remote sensing data over land, and many have been resolved to some extent through advanced methods and improved datasets.

However, investigators working with observations of land-atmosphere system still face difficulties in identifying cloud contamination and correcting for atmospheric effects and surface anisotropy. When analyzing time series, investigators must also distinguish between true physical trends and data artifacts caused by instrument-related issues, such as sensor degradation and orbital drift. In addition, the use of multiple land-imaging sources requires careful intercalibration among sensors.

I will provide a brief overview of the data processing chain used to derive land surface variables, highlight persistent and often treacherous residual errors in compositing procedures and applying smoothing filters, and draw attention to key challenges that scientists continue to encounter when working with land remote sensing data. The examples are based on the lessons learned from my own research in 1990s.

A review of recent publications, along with insights gained from presentations at the recent RAQRS symposium, suggests that some longstanding issues I encountered in my earlier work remain formidable challenges today – despite the availability of advanced methods and significant improvements made in the radiometric, temporal and spatial resolution of the observations.

TOWARDS A DIGITAL TWIN FOR PHYSICAL AND SOCIO-ECONOMIC ANALYSIS OF COASTAL SYSTEMS USING ARTIFICIAL INTELLIGENCE: THE TWINPEACS-HUMAN PROJECT.

**Ana B. Ruescas (ana.b.ruescas@uv.es)^{1,2}, Marta Sapena (marta.sapena@uv.es)¹, Carmen Zornoza²,
Francisco Goerlich³, Felix Fajardo²**

*¹ Image Processing Laboratory, Parc Científic Universitat de València
C/ Cat. Agustín Escardino Benlloch,⁹
46980 Paterna (València), Spain
Phone: +34 963543229*

² Departament of Geography. Univesitat de València, Avda. Blasco Ibañez²⁸, 46010, València, Spain

³ Department of Economic Analysis. Univesitat de València, Avda. Tarongers, s/n. 46022 València, Spain

Coastal urban areas are increasingly threatened by the convergence of climate change, rapid urbanization, and high population densities. Rising sea levels, intensified storm surges and changing coastal dynamics are increasing exposure to natural hazards, particularly in areas of intense human activity. Addressing these challenges requires advanced tools for risk assessment and land-use planning. Against this background, the TWINPEACS project introduces an interoperable framework centered on artificial intelligence (AI)-enhanced Digital Twins (DT) designed for integrated coastal risk assessment. Specifically, the project addresses the challenges posed by compound erosion-flooding hazards by merging hydrodynamic and morpho dynamic modeling with dynamic exposure and vulnerability analysis. This integration enables a robust suite of capabilities, including real-time forecasting, medium-to-long-term predictive modeling and adaptive planning, while quantifying inherent uncertainties. TWINPEACS consists of several sub-projects. The TWINPEACS-HUMAN sub-project aims to develop AI models to estimate population distribution at fine spatial and temporal scales, thereby advancing current capabilities in exposure and vulnerability mapping. This is achieved by integrating diverse geospatial and socioeconomic datasets to assess local

vulnerability and simulate urban expansion under alternative development strategies using advanced AI architectures. Data sources will include census and mobility records, remote sensing products, historical urban growth maps, land cover datasets, and coastal hazard layers from other sub-projects. Deep learning architectures, ensemble techniques, and explainable AI will be key tools used to produce detailed, uncertainty-aware maps of exposure and vulnerability. These outputs will improve risk communication and support informed decision-making in land use planning and disaster preparedness. Spanish coastal cities, representing a diverse mix of urban typologies ranging from dense tourist hubs to dispersed settlements, will serve as test sites. These locations will serve as archetypes for training and validating models, ensuring generalizability to other coastal contexts. The sub-project results are designed in interoperable formats for integration into the DT platform. This will enable the simulation and visualization of evolving risk conditions and support planning, emergency response and climate adaptation strategies.

EARLY PREDICTION OF DELOTTOCOCCUS ABERIAE OUTBREAKS IN VALENCIAN CITRUS USING SENTINEL-2 AND MACHINE LEARNING.

Andreu Guillem Valls¹, Belen Franch^{1,2}, Fàtima Della-Bellver¹, Cesar José Guerrero-Benavent¹, Sandra Vacas³

¹Global Change Unit, Parc Científic, University of València (Paterna), 46980, Spain, andreu.guillem@uv.es

² Dept of Geographical Sciences, University of Maryland, College Park MD 20742, United States

³ Centre for Agricultural Chemical Ecology – Mediterranean Agroforestry Institute, Universitat Politècnica de València. València, Spain.

The production of citrus fruits and olive trees is a fundamental pillar in the agri-food economy of the Mediterranean region. According to data provided by the Ministry of Agriculture, Spain produced a total of 5.7 Mt of citrus fruits, which places it as the main producer in the European Union, and with a world export share of between 30% and 35%. However, the Valencian citrus sector is going through a critical transition phase, with its model threatened by global pests, which have become a structural risk factor. Among the most important pests are the *Delottococcus aberiae*, which causes direct damage to the fruit. Its management implies that production costs increase by up to 55% more and, in cases of high infestation, causes losses of more than 30% of global production. Estimations of recent years have exceeded 120 million euros. Given the enormous economic importance of these crops, it is appropriate to apply monitoring techniques using remote sensing to improve agricultural pest management.

This study evaluates the capabilities of Earth Observation to predict up to 3 months in advance the appearance of the plague on different orange and mandarin orange cultivars. To achieve this objective 75 parcels from all over the Valencian Region, with a total 167.12 ha, were monitored during 4 years (2020-2023) with on site traps, retrieving monthly quantitative measures of captured nymphs. The other input for the models are Remote Sensing images, in concrete, Sentinel-2 imagery. As previously stated by (F. Della et al., 2024) BRDF corrections are essential to accurately retrieve phenological information, so we explore further the effects of this correction on the predictability of the plague outbreak. The study tests the performance of different machine learning algorithms (XGBoost, Random Forest, SVM, etc.) to link multispectral and vegetation indices data and variations with pest infestation presence, and analyses the deterioration of accuracy and recall statistic as early prediction is executed one, two or three months prior to the month of interest. The classifiers had similar performance, obtaining all of them categorizations (low, medium, high) of risk of infestation with up to 88% recall accuracy over low risk of *Delettococcus aberiae* presence and 75% for high risk infestation.

CHARACTERIZING LATE FROST IMPACTS ON WINTER WHEAT YIELD USING REMOTE SENSING, CLIMATIC INDICATORS, AND CLUSTER-BASED ANALYSIS

Saül Cogollos Soler¹, Italo Moletto-Lobos¹, Belén Franch^{1,2}, Javier Tarín-Mestre¹, Victor Betti¹, Eric Vermote³

¹*Global Change Unit, Image Processing Laboratory, Universitat de València, Paterna, Spain*

²*University of Maryland, College Park, MD, USA*

³*NASA Goddard Space Flight Center, Greenbelt, MD, USA*

Corresponding author: saulcoso@alumni.uv.es

Wheat is a key crop for global food security and one of the most traded cereals worldwide. In recent decades, its production has been increasingly affected by extreme weather events, among which late spring frosts stand out due to their strong impact on yield. These events are particularly damaging when they occur around sensitive growth stages such as anthesis, where freezing temperatures can lead to sterility without necessarily causing visible canopy deterioration. This makes their detection using standard satellite-based indicators especially challenging.

This work explores the impact of frost events on winter wheat by combining climate data, remote sensing observations, and phenological information. Growing Degree Days (GDD) are used as a temporal reference to account for differences in crop development across regions and seasons. In addition, a clustering approach based on yield reduction time series is applied to group regions with similar responses, providing more representative units for analysis than administrative divisions.

The framework is applied to the 2007 spring frost in the United States, with a focus on Kansas. Early results suggest the existence of a phenological window in terms of accumulated GDD within which crops appear to be more sensitive to frost. In this context, MODIS NDVI time series are analyzed to describe vegetation dynamics and their relationship with yield reduction at the cluster level.

Finally, the approach is linked to the ARYA yield forecasting algorithm. The model is recalibrated using the defined clusters instead of administrative units, with the aim of improving the robustness and representativeness of yield predictions.

INFLUENCE OF RICE VARIETY ON NITROGEN LEVEL CLASSIFICATION AND YIELD MODELING USING UAV-BASED IMAGERY

Fàtima Della-Bellver¹, Belen Franch^{1,2}, Javier Tarin-Mestre¹, Cesar José Guerrero-Benavent¹, Concha Domingo³, Mar Català Forner⁴, Karen Martí⁴, Luis Marqués⁵

¹*Global Change Unit, Parc Científic, Universitat de València (Paterna), 46980, Spain, fatima.della@uv.es*

²*Dept of Geographical Sciences, University of Maryland, College Park MD 20742, United States*

³*Institut Valencià de Investigacions Agràries, Moncada, 46113 Valencia, Spain*

⁴*Institut de Recerca I Tenologia Agroalimentàries, Amposta, 43870 Tarragona, Spain*

⁵*COPSEMAR, Sueca, 46410 Valencia, Spain*

Rice (*Oryza sativa* L.) is a primary global crop, accounting for 8% of the global primary harvesting production (FAO, 2024), with Spain being the second-largest producer in Europe (European Commission, 2026). However, the sector faces significant environmental challenges stemming from climate change and increasing water demand. Although remote sensing (RS) offers tools to optimize inputs such as nitrogen (N), many current models are calibrated for specific varieties, which limits their applicability across different cultivars (Franch et al., 2021; Brinkhoff et al., 2019).

This study evaluates the transferability of RS models to monitor nitrogen fertilization status across a highly heterogeneous set of genotypes, locations, and seasons. Trials were conducted at six experimental sites located in Valencia and Tarragona during 2022 and 2023. The study includes over 170 commercial cultivars, encompassing both Japonica and Indica types, along with a selection of 170 non-commercialized

experimental lines under two N fertilization doses, low (100 kg N/ha) and high (200 kg N/ha). UAV multispectral imagery (MAIA S2) was used to train Random Forest (RF) classifiers to differentiate between N doses and Accumulated Growing Degree Days (GDD) were employed to align phenological stages across sites. The MS3+ yield regression model, previously calibrated for the JSendra variety, was subsequently subjected to performance evaluation against the diverse multi-variety dataset.

The classifiers achieved over 85% accuracy in several locations, showing that visible (VIS) bands are more relevant in early stages, while Near-Infrared (NIR) and Red-edge (RE) reflectance are key throughout the cycle. Furthermore, 82% of the varieties showed high compatibility with the global N model. In contrast, the yield model demonstrated restricted inter-variety transferability, although 48.8% of commercial varieties-maintained residuals between ± 1 t/ha specifically those sharing genetic traits with the training set. Consequently, the study suggests that while remote sensing (RS) classifiers provide robust N-status monitoring regardless of rice genetics, yield models remain highly genotype-dependent.

- Brinkhoff, J., Dunn, B. W., Robson, A. J., Dunn, T. S., & Dehaan, R. L. (2019). Modelling Mid-Season Rice Nitrogen Uptake Using Multispectral Satellite Data. *Remote Sensing*, 11(15), 1837. <https://doi.org/10.3390/rs11151837>
- European Commission. (2026). Rice production and trade statistics. Agri-food Data Portal. <https://agridata.ec.europa.eu/extensions/DashboardRice/RiceProduction.html>
- FAO. 2024. World Food and Agriculture – Statistical Yearbook 2024. Rome. <https://openknowledge.fao.org/items/43ef9f2c-a023-4130-81ce-dc5ac3f825ef>
- Franch, B., Bautista, A. S., Fita, D., Rubio, C., Tarrazó-Serrano, D., Sánchez, A., Skakun, S., Vermote, E., Becker-Reshef, I., & Uris, A. (2021). Within-Field Rice Yield Estimation Based on Sentinel-2 Satellite Data. *Remote Sensing*, 13(20), 4095. <https://doi.org/10.3390/rs13204095>

BEYOND OBLAST: IMPROVING WHEAT YIELD FORECASTS IN RUSSIA WITH THE ARYA ALGORITHM

Italo Moletto-Lobos¹, Belén Franch^{1,2}, Natacha Kalecinski², Weston Anderson², Javier Tarín-Mestre¹, Victor Betti¹, Eric Vermote³, Inbal Becker-Reshef^{2,4,5}, Steffen Ehrmann⁶, Carsten Meyer⁷

¹Global Change Unit, Image Processing Laboratory, Universitat de València, Paterna, Spain

²University of Maryland, College Park, MD, USA

³NASA Goddard Space Flight Center, Greenbelt, MD, USA

⁴ICube Laboratory, UMR 7357, CNRS-University of Strasbourg, 300 bd Sebastien Brant, CS 10413, Strasbourg, F-67412, Illkirch Cedex, France

⁵AI for Good Lab, Microsoft Research, Redmond, WA, United States of America

⁶resonantia research gUG (haftungsbeschränkt): Leipzig, DE

⁷German Centre for Integrative Biodiversity Research (iDiv) Halle Jena Leipzig, Leipzig 04103, Germany

Corresponding author: italo.moletto@uv.es

Accurate and timely wheat yield forecasting is critical for global food security. Russia is currently the world's largest wheat exporter, yet forecasting its production at fine spatial scales remains a significant challenge due to the vast agricultural extent of the country and the high interannual variability of yields driven by droughts, winterkill, and extreme temperatures. The Agriculture Remotely-sensed Yield Algorithm (ARYA) was previously validated for wheat yield forecasting at the national and first subnational (oblast) level across the main wheat exporting countries, achieving a national RMSE of 0.34 t/ha (~11.5%) for Russia from Day of Year (DOY) 130 onwards. ARYA combines MODIS-derived Difference Vegetation Index (DVI) at 1 km spatial resolution with Growing Degree Days (GDD) from ERA5 reanalysis data and Land Surface Temperature (LST) to forecast yield via a Gaussian-based regression model. In this work, we leverage a new district-level (level-2) crop statistics dataset for Russia that enables the implementation of ARYA at the second administrative level. Given Russia's vast agricultural extent, level-1 oblasts encompass highly heterogeneous agroclimatic conditions, masking significant within-oblast spatial variability in both DVI

signal and surface temperature. Working at the rayon scale the algorithm to better capture this variability, improving the spatial representativeness of yield estimates across diverse regions spanning from the North Caucasus to Western Siberia. Results demonstrate that ARYA's performance is allowed at the disaggregated level, with forecasts becoming skilful well ahead of harvest and improving production estimates when aggregated to the national level. This work contributes to closing key gaps in global agricultural monitoring by providing quantitative, spatially detailed, and timely wheat production forecasts with associated uncertainty estimates for one of the world's most critical wheat-producing nations.

YIELD FORECASTING IN DATA-SPARSE REGIONS: APPLYING THE ARYA MODEL AND EVALUATING AUTONOMOUS CROP MAPPING IN ZIMBABWE

Javier Tarín-Mestre¹, Belen Franch^{1,2}, Italo Moletto-Lobos¹, Victor Betti¹, Lorenzo de Simone³, Christina Justice², Ritvik Sahajpal²

¹Global Change Unit, Image Processing Laboratory (UCG-IPL). Parque Científico, Universitat de Valencia, Spain; javier.tarin@uv.es, belen.franch@uv.es, italo.moletto@uv.es, victor.betti@uv.es

²Department of Geographical Sciences, University of Maryland, College Park MD, United States; ritvik@umd.edu, justicec@umd.edu

³FAO-ESTELLA, Via de Terme di Caracalla, Rome, Italy lorenzo.desimone@fao.org

The transferability and operational applicability of Earth Observation (EO)-based crop yield forecasting models across diverse agroecological contexts remain key challenges for large-scale agricultural monitoring systems. The Agriculture Remotely-sensed Yield Algorithm (ARYA) is an empirical model that addresses this challenge by optimizing the use of moderate-resolution satellite data (such as 1-km MODIS). To achieve this, ARYA applies an unmixing process that isolates the pure vegetation dynamic signal of the target crop using crop type masks as a reference. Based on the unmixed Difference Vegetation Index (DVI) and its gaussian behaviour, the algorithm employs multiple linear regression models to relate yield with three key gaussian parameters: the maximum amplitude (peak) of the seasonal DVI evolution, the duration of this peak, and the stress conditions evaluated weeks after the peak estimated through Growing Degree Days.

This study expands the evaluation of ARYA's robustness by focusing on its application in Zimbabwe to assess its performance at the subnational level, a critical environment for food security but characterized by a scarcity of in situ data. To overcome the lack of field data, we evaluate the forecasting performance by integrating crop type maps generated without parcel-level training labels, following advanced remote sensing approaches. Results demonstrate that the integration of transfer learning techniques for crop identification allows ARYA to maintain stable predictive skill in Zimbabwe by successfully unmixing the signal in areas of fragmented agriculture. This synergy underscores the potential of combining autonomous crop type mapping with empirical yield models, consolidating ARYA as a scalable and cost-effective tool to support early warning systems, agricultural monitoring, and decision making in data-sparse regions.

MILLIONS OF ARTILLERY CRATERS IN AGRICULTURAL FIELDS IMPACT CROP PRODUCTION IN UKRAINE DUE TO THE ONGOING WAR

Sergii Skakun¹, Erik Duncan¹, Leonid Shumilo¹, Nataliia Kussul¹, Josef Wagner², Inbal Becker-Reshef^{1,2}

¹University of Maryland, College Park, MD, US

²University of Strasbourg, Strasbourg, France Phone: +1-301-405-2179, Email: skakun@umd.edu

Russia's full-scale invasion of Ukraine in February 2022 has profoundly affected all aspects of life in Ukraine, including agriculture. The war of aggression has caused extensive damage to agricultural infrastructure, reduced crop production and available resources, disrupted cropping patterns, and created

major uncertainty about the sector's future. Heavy artillery and associated fighting have left many fields burned, damaged, abandoned, and ultimately unplanted and/or unharvested. While the Ukrainian government has some information on agricultural activity in free (unoccupied) territories from limited farmer surveys, comparable information is not available for Russian-held areas. In this context, Earth observation from space is the only source of synoptic, regular, and objective data to assess the war's impacts at the national scale. In this study, we use very high spatial resolution (VHR) satellite imagery acquired by Maxar's WorldView (at 0.3-0.5 m) and Planet's SkySat (at 0.5 m), to identify and map shelled agricultural fields in 2022, and a sample-based approach to estimate the area of fields with the presence of artillery craters, burnings, and those that were abandoned and not cultivated. We estimated agricultural land use transitions in the study area from 2022 to the present time. Maxar imagery was acquired through the NASA Commercial Smallsat Data Acquisition (CSDA) Program, and Planet's SkySat imagery was acquired through a collaboration between the NASA Harvest Program and Planet Labs. The study area covers the frontline and adjacent areas totaling 31,034 km² (c. 5% of the total Ukraine area). The majority of the land (c. 66%) is used for agriculture. Sixty percent of the area is used to grow major commodity crops such as wheat, maize, soybean, and sunflower. Approximately 3% is used for smallholder farming (the so-called "family gardens"); another 3% has been abandoned since 2014, mainly in Donetsk and Luhansk oblasts. The region was divided into blocks of 1x1 km² and stratified into four strata based on the number of craters in the block detected with satellite imagery. Fifteen blocks were randomly sampled in each stratum (60 sample units in total). Each sampled block was photointerpreted with the help of VHR imagery to label craters in 2022 and multi-temporal Sentinel2 imagery to identify the type of crops (winter, potential summer), and whether the fields in the block were burned, harvested, or planted (2022-2025). We estimate over 3.8 million craters in the study region during 2022. The area of shelled agricultural fields was estimated at >1.1 million hectares (Mha). Our results show that ~0.25 Mha (the majority of which was winter crops, 60%) were burned because of shelling, and almost 1 Mha of fields in the region were abandoned, meaning that winter crops that were planted in 2021 before the full-scale invasion were not harvested, and spring/summer crops were not planted. Information generated within this study can be further used by demining operators for prioritizing and optimizing nontechnical surveys, and to assess the impact of the conflict on agricultural production and cropland abandonment in Ukraine.

REFERENCE AREA SELECTION IN SURFACE URBAN HEAT ISLAND ANALYSIS OVER THE IBERIAN PENINSULA

Sara Arribas¹, Lluís Pérez-Planells², Raquel Niclòs¹, Enric Valor¹

¹*Department of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Av. Vicent Andrés Estellés, 19, 46100 Burjassot, Spain; Tel. 96 354 43 50, Fax. 96 354 33 85; sara.arribas@uv.es (S.A.), raquel.niclos@uv.es (R.N.), enric.valor@uv.es (E.V.)*

²*Mediterranean Center for Environmental Studies (CEAM), Spain; lluis@ceam.es (L.P)*

Since 1950, the global urban population has grown from less than 20% to almost 50%. In Spain this proportion reaches 70% across 86 cities. In this context, it is essential to study the specific impacts of climate change on cities.

Cities show different Land Surface Temperature (LST) values compared to their surrounding non-urban areas, often leading to the Surface Urban Heat Island (SUHI) effect, which has been studied in numerous cities worldwide. To examine the SUHI effect, urban temperature is compared with the temperature of a given rural area (RA). However, the definition of this RA is not always justified and varies across studies, both in its spatial boundaries and land cover characteristics.

In this study, we investigate how different approaches to define the RA influence SUHI estimates, showing that the choice of the reference RA can substantially affect results and should therefore be clearly defined and justified. We focused on SUHI effects in 12 cities in the Iberian Peninsula (IP) over the past 20 years by using the MYD11A1v061 LST product derived from EOS-Aqua MODIS Aqua (1 km spatial resolution). We defined 5 different RAs and subdivided them using the Local Climate Zones (LCZ) and the CORINE Land Cover classifications.

Using a Digital Elevation Model, we found that, for most cities, forested areas are located at higher

elevations, making them unsuitable as reference RA. For SUHI estimates, the influence of the selected RA is greater during daytime, with standard deviations ranging from 0.23 K to 2.2 K, while at nighttime the maximum standard deviation reaches 0.62 K in Madrid. This effect becomes more pronounced when analyzing summer conditions only, with a mean daytime standard deviation of 1.14 K and differences exceeding 2 K among the reference RAs. In some cities, a Surface Urban Cooling Island (SUCI) is observed during daytime, whereas the SUHI reappears at night.

This work was carried out within the framework of the project UV-INV_AE_4226564 of the own program of the University of Valencia Research Vice-Rectorate, Special Actions call. It was also carried out within the previous projects Tool4Extreme (PID2020-118797RB-I00), funded by the Spanish Ministerio de Ciencia e Innovación and the Agencia Estatal de Investigación (MCIN/AEI/10.13039/501100011033), and PROMETEU/2021/016, funded by the Conselleria d'Educació, Cultura, Universitats i Ocupació of the Generalitat Valenciana. Sara Arribas' participation is supported by the Generalitat Valenciana (CIACIF/2023/525), co-funded by the European Social Fund Plus (ESF+).

AIR OR SURFACE TEMPERATURES IN URBAN ENVIRONMENT : CONFUSION AND SYNERGY

Aurélie Michel¹, Yassine El Khanoussi², Valéry Masson³, Guillaume Dumas³, Julia Hidalgo⁴, Vincent Lonjou^{2,1}

¹ONERA-DOTA, University of Toulouse, F-31055 Toulouse, France ; aurelie.michel@onera.fr

²CNES, 18 Avenue Edouard Belin, 31400 Toulouse France ; yassine.elkhanoussi@cnes.fr +33651304902
(Presenting);; vincent.lonjou@cnes.fr

³CNRM, Université de Toulouse, Météo-France, CNRS, 42, Avenue Gaspard Coriolis, 31057 Toulouse
Cedex 1, France ; guillaume.dumas@toulouse-metropole.fr ; valery.masson@meteo.fr

⁴Laboratoire Interdisciplinaire Solidarités Sociétés Territoires (LISST), Université de Toulouse, CNRS, 5
Allée Antonio Machado, 31058 Toulouse, France ; julia.hidalgo@univ-tlse2.fr

Extreme urban heat poses increasing risks to human health, driven by climate change and urban expansion, and amplified by the Urban Heat Island (UHI) effect. Effective adaptation strategies require identifying intra-urban thermal contrasts. However, near-surface air temperature, which is most relevant for health assessment, remains sparsely observed in cities. As a result, many studies rely on satellite-derived Land Surface Temperature (LST), although it represents a different physical component of the urban energy balance.

This study evaluates the relationship between air temperature and LST over Toulouse Métropole (France), a metropolitan area of approximately one million inhabitants. Air temperature is measured using a dense network of in situ stations distributed across Local Climate Zones (LCZs), while LST is derived from MODIS Terra and Aqua observations (MOD21 and MYD21 products) for the year 2022. These products are based on the Temperature Emissivity Separation (TES) algorithm, which retrieves LST and emissivity simultaneously, making them particularly suitable for heterogeneous urban surfaces. Only clear-sky conditions and low-wind situations are retained to limit atmospheric and advective effects. A combined analysis is performed at city-wide and LCZ scales, comparing seasonal (summer and winter) and diurnal (daytime and nighttime) variability, as well as associated Surface Urban Heat Island (SUHI) and air temperature UHI patterns. Results show that air temperature is comparatively homogeneous at urban scale, while LST exhibits stronger spatial variability, particularly during daytime under strong radiative forcing. During summer daytime conditions, LST and air temperature show weak correlation and large absolute differences, exceeding 10–15°C in certain LCZs, especially in industrial and open low-rise areas. These discrepancies reflect surface energy storage and radiative processes that are not directly captured by air temperature measurements. In contrast, winter conditions reduce radiative contrasts and lead to more coherent spatial patterns between both variables. At night, although LST and air temperature remain physically distinct

variables, their spatial patterns become significantly more consistent. Correlation improves compared to daytime, and LCZ-dependent structures are well captured by both datasets. A systematic offset of approximately 2°C is observed in summer, consistent with the slow release of heat stored in urban materials through longwave radiation exchange. Importantly, nighttime LST is effective in reproducing the spatial structure of the air temperature field, even if it does not reproduce its absolute magnitude. These results demonstrate that LST should not be interpreted as a direct proxy for air temperature or thermal exposure. However, it remains a valuable and operationally relevant indicator of urban thermal patterns. In particular, nighttime LST provides robust information for identifying spatial structures of the Urban Heat Island and for preliminary diagnosis of thermal vulnerability when in situ networks are not available. The study highlights the complementary nature of LST and air temperature and provides guidance for their appropriate joint use in urban climate and heat mitigation applications.

DOWNSCALING MODIS LAND SURFACE TEMPERATURE TO 70 M RESOLUTION FOR SURFACE URBAN HEAT ISLAND ANALYSIS USING XGBOOST

Lluís Pérez-Planells¹, Samira Khodayar¹

¹*Mediterranean Center for Environmental Studies (CEAM), Meteorology and Climatology Area, Paterna, Spain.*

Corresponding author: lluis@ceam.es; Phone: +34 660 252 865

The urban heat island (UHI) effect intensifies thermal conditions in cities worldwide, and its interaction with heatwave events can compound and amplify their impacts, with direct consequences for human health, thermal comfort, and quality of life. A better understanding of its spatial variability is therefore essential for climate-sensitive urban planning and the design of heat mitigation strategies. In this context, thermal infrared (TIR) remote sensing offers a valuable framework for assessing the Surface Urban Heat Island (SUHI), although current applications remain strongly constrained by the trade-off between spatial and temporal resolution. Within the SUHIST project, this work represents a first step towards the generation of high spatio-temporal resolution land surface temperature (LST) data for urban environments.

An XGBoost-based statistical downscaling framework was developed to derive LST at 70 m spatial resolution from one year (2025) of MODIS MOD11A1 observations. Predictor variables with different native spatial resolutions were reprojected and resampled to a common 70 m grid consistent with ECOSTRESS. They were then aggregated to the MODIS resolution for model training and subsequently used to reconstruct high-resolution LSTs. The complete dataset was divided into training (70%) and testing (30%) subsets. The predictor set included annual static variables describing the thermal behaviour of the surface, namely five annual-diurnal cycle parameters (ADCPs), built-up index, impervious surface index, and elevation. In addition, a temporally varying 16-day NDVI product (MOD13Q1) was incorporated by assigning to each MODIS acquisition date the corresponding NDVI observation, thus accounting for seasonal vegetation changes throughout the year.

Three predictor configurations were evaluated: (i) annual predictors only, excluding NDVI; (ii) all predictors except ADCPs; and (iii) the complete predictor set. The best performance was obtained with the full configuration, yielding R²/RMSE values of 0.80/0.69 K for nighttime and 0.77/1.14 K for daytime conditions. Excluding NDVI led to only a slight reduction in performance, with R²/RMSE values of 0.78/0.73 K at night and 0.76/1.17 K during daytime. In contrast, removing ADCPs caused a more substantial degradation, with R²/RMSE values of 0.71/0.85 K for nighttime and 0.70/1.27 K for daytime.

These results highlight the strong contribution of thermally meaningful annual-diurnal descriptors to high-resolution LST reconstruction, while temporally varying vegetation information provides an additional, though more moderate, improvement. Overall, this framework provides a robust basis for the next stages of SUHIST, including the generation of urban thermal datasets suitable for SUHI assessment across different local climate zones and cities.

A DIAGNOSTIC METHODOLOGY TO ASSESS URBAN DISTRICTS' OVERHEATING

A. Rodler¹, M. Musy¹, F. André², N. Beaugendre³, X. Briottet⁴, R. Cifuentes La Mura⁵, T. Gresse⁶, J.-C. Krapez⁷, L. Merlier⁶, F. Nerry⁵, J. Pierro⁴, L. Roupioz⁴, D. Yao¹

¹ CEREMA BPE/IRSTV, Nantes F-44262, France

² Univ Lyon, CNRS, UCBL, INSA Lyon, CETHIL, UMR5008, Villeurbanne F-69621, France

³ Kermap, Cesson-Sévigné, France

⁴ ONERA, DOTA, Université de Toulouse, Toulouse, France (laure.roupioz@onera.fr; +33 5 62 25 28 83)

⁵ ICube Laboratory, UMR 7357, CNRS-University of Strasbourg, F-67412 Illkirch Cedex, France

⁶ Univ Lyon, UCBL, INSA Lyon, CNRS, CETHIL, UMR5008, Villeurbanne F-69621, France

⁷ ONERA / DOTA, F-13661 Salon cedex, France

As heat waves become more frequent, local authorities are seeking to adapt urban public spaces to limit the impact of urban heat island on the population. However, they are facing methodological challenges in identifying at-risk areas, designing effective solutions, and managing crises, due to a lack of appropriate tools and accurate data. Upcoming satellite missions will soon deliver TIR data with unprecedented spatial (60 m or less) and temporal (up to daily) resolution, opening new opportunities for urban climate studies. While promising, the use of this data in urban environments remains limited by the scale differences with the radiative and thermal processing taking place in the urban canopy, which makes it difficult to derive local air temperatures. The ANR DIAMS project aims to support the use of TIR satellite data to refine the diagnosis and management of heat waves at the neighborhood level, in anticipation of future space missions such as TRISHNA. To this end, the project developed a fast diagnostic tool to assess urban districts vulnerable to heatwaves, using thermal infrared (TIR) satellite data and microclimate modeling.

This presentation outlines the main scientific challenges of the project, the key steps undertaken to address them and the outcomes achieved through a multidisciplinary consortium and approach. First, a benchmark of urban microclimate tools is established to describe the features, capabilities, and accuracy levels of the consortium's research tools. An academic benchmark is proposed, and the AI4GEO/CAMCATT dataset is used to compare these tools. This step supports the selection of the most suitable model for the subsequent project stages. Second, analyses are conducted to evaluate the accuracy of land surface temperature (LST) derived from TRISHNA-like TIR satellite data over urban areas, focusing on the impact of the spatial variability of atmospheric water vapor and of the 3D surface geometry. Approaches are also developed to facilitate the integration of these images into microclimate tools. Third, the Solene-microclimat tool is selected to develop a fast predictive meta-model capable of forecasting district-scale surface and air temperatures over the next three days using TIR satellite data. The meta-model integrates both spatial and temporal indicators and is based on seven urban archetypes defined by their morphological and thermal properties. Among the spatial indicators, thermal conductivity is a crucial in-situ parameter, but it is difficult to obtain. Therefore, an innovative methodology is proposed to identify urban thermal properties by combining microclimate modeling with thermal infrared satellite data. Fourth, the meta-model is evaluated on a real district in the city of Nantes and tested under several climatic conditions. Finally, the DIAMS diagnostic approach is applied to a district in Toulouse and compared with real-world data weather data. The limitations of the approach are discussed, along with its validity and applicability.

ANALYSIS OF THE IMPACT OF CLIMATE CHANGE IN THE WORLD'S LARGE AGGLOMERATIONS: MODELLING, DETERMINANTS AND MULTISCALE CHARACTERISATION OF SUHI

Daniel Salinas-González, José A. Sobrino, Drazen Skokovic

*Global Change Unit (GCU), Imaging Processing Laboratory (IPL), University of Valencia, Carrer del Catedratic José Beltrán Martínez, ², 46980 Paterna, Valencia,
daniel.salinas@uv.es, jose.sobrino@uv.es, drazen.skokovic@uv.es.*

Climate change is one of today's greatest challenges, with particularly severe impacts on urban environments, where more than 55% of the global population lives. Cities can further intensify warming by altering the surface energy balance and accumulating heat. In this context, the Surface Urban Heat Island (SUHI) is a key indicator of the thermal impact associated with urban development. The relevance of studying SUHI has increased with the growing frequency and intensity of extreme heatwaves, which can severely affect thermal comfort and public health, particularly among vulnerable populations.

Thermal remote sensing provides systematic observations at the global scale to investigate these effects. This study is based on the extensive exploitation of the UVEG-TES global thermal database, derived from historical observations acquired by the MODIS sensor. The spatiotemporal behaviour of SUHI was analysed for 56 large urban agglomerations worldwide over a 21-year period (2003–2023). The study focuses on the characterisation and identification of extreme summer thermal events and on the quantification of bioclimatic and ecological risk through Level 3 biophysical products. These include SUHI intensity, the Urban Thermal Field Variance Index (UTFVI), the Discomfort Index (DI), and the detection of intra-urban thermal hotspots. The DI analysis revealed that 69.6% of the cities reach hot or very hot nocturnal thermal stress levels.

To ensure the robustness of the results and identify the main drivers of urban warming, a multivariate statistical analysis was performed using Ordinary Least Squares (OLS) multiple linear regression and Principal Component Analysis (PCA). The results show that regional macroclimate and topography, which explain 52.6% of the thermal variance, are the main factors modulating the thermal behaviour of metropolitan areas, clearly outweighing the influence of demographic size.

These findings provide a comprehensive assessment of urban thermal vulnerability and demonstrate the potential of spatial and statistical analyses as operational tools for climate-change mitigation planning and the development of more effective public-health policies. Finally, the methodology could be applied to future high-resolution thermal infrared satellite missions.

LARGE-SCALE TREE SPECIES MAPPING FROM PRISMA DATA: COMPARISON OF TWO METHODS FOR HYPERSPECTRAL DIMENSIONALITY REDUCTION

**Mathieu Chesneau^{1,2}, Ali Ahmd, Thomas Olive², Guillaume Dubrasquet-Duva², Salah Bourennane¹,
Mouloud Adeli³**

¹ Aix Marseille Univ, CNRS, Centrale Med, Institut Fresnel, Marseille, France

² Diginove SAS, ⁴ Rue Mahatma Gandhi, Espace Beauvalle Bat. B, 13090 Aix-en-Provence, France

³ Computer engineering department, Galatasaray University, Istanbul, Türkiye

*Corresponding author: mchesneau@diginove.com

Climate change is seriously impacting forest ecosystems, affecting species distribution, health, and resilience. In this context, accurate tree species mapping is critical for many forestry applications, including ecosystem monitoring, biodiversity assessment, and wildfire risk management [1, 2, 3]. Remote sensing has become a primary data source for this task, leveraging Unmanned Aerial Vehicles (UAV), airborne, and multimodal satellite imagery [1, 3], enabling large-scale spatial coverage. Multispectral data such as Sentinel-2 are widely used due to their accessibility and high revisit frequency [3]. In contrast, hyperspectral (HS) sensors such as PRISMA (PRecursore IperSpettrale della Missione Applicativa) and EnMAP (Environmental Mapping and Analysis Program), provide richer spectral information, enabling finer discrimination of vegetation species [2], albeit at the cost of increased data dimensionality and computational complexity. This makes dimensionality reduction a critical step for efficient hyperspectral analysis.

Our study investigates the impact of two dimensionality reduction techniques for tree species

classification: Principal Component Analysis (PCA) and Minimum Noise Fraction (MNF). Both are compared to a baseline without dimensionality reduction. Experiments are conducted over Mediterranean forests in the south-east of France using 21 PRISMA L2D tiles. A 2D Convolutional Neural Network (CNN) is designed with a Receptive Field (RF) equal to the input patch size before the output layer. Preprocessing steps include Bad Band Removal (BBR) as defined in [2], percentile clipping (2–98%) and per-band min–max normalization. The hyperspectral cube initially contains 239 spectral bands, reduced to 204 after BBR, and further reduced to 20 components using PCA or MNF. Ground-truth labels are derived from the IGN BD Forêt V2 database [4].

The baseline model achieves an overall accuracy (OA) of 86.2% and a weighted-average F1-score of 0.867. PCA improves performance to 89.5% OA and 0.897 Weighted-average F1 Score. MNF achieves the best results, with an OA of 91.9% and a weighted-average F1-score of 0.922. These results demonstrate that MNF outperforms PCA for hyperspectral dimensionality reduction and provides significant performance gains for large-scale tree species classification using PRISMA satellite data.

- [1] L. Zhong, Z. Dai, P. Fang, Y. Cao, and L. Wang, “A Review: Tree Species Classification Based on Remote Sensing Data and Classic Deep Learning-Based Methods,” *Forests*, 2024.
- [2] G. Delogu, M. Perretta, E. Caputi, A. Patriarca, C. C. Funsten, F. Recanatesi, M. N. Ripa, and L. Boccia, “Leveraging the Potential of PRISMA Hyperspectral Data for Forest Tree Species Classification: A Case Study in Southern Italy,” *Remote Sensing*, vol. 16, no. 24, p. 4788, Jan. 2024.
- [3] S. G. Yel and E. Tunc Gormus, “Exploiting hyperspectral and multispectral images in the detection of Frontiers in Remote Sensing, tree species: A review,” vol. 4, p. 1136289, 2023. [Online]. Available: <https://www.frontiersin.org/journals/remote-sensing/articles/10.3389/frsen.2023.1136289/full>
- [4] Institut national de l’information géographique et forestière (IGN), “Bd forêt® version 2.0,” 2018. [Online]. Available: <https://geoservices.ign.fr/bdforet>

HIGH-DENSITY THERMO-HYGROMETRIC OBSERVATIONS FOR URBAN HEAT AND THERMAL EXPOSURE ASSESSMENT IN VALENCIA (SPAIN)

Sara Gavila-Lloret¹, Jose Antonio Valiente-Pardo¹, Samira Khodayar¹

Mediterranean Center for Environmental Studies (CEAM), Paterna (Valencia)

Correspondence: gavila@ceam.es (638826068); josean@ceam.es (638847900); khodayar@ceam.es (638759833)

Urban heat is a major climate-related hazard in cities, with direct impacts on public health, energy demand, and social vulnerability. A robust and spatially detailed observational basis is essential to characterize the spatio-temporal variability of urban thermal environments and to support climate services for heat risk management and urban adaptation. In this contribution, we present a newly deployed high-density thermo-hygrometric monitoring network designed to observe urban heat and thermal exposure at high spatial and temporal resolution in Valencia (eastern Spain), a Mediterranean metropolitan area identified as a climate change hotspot.

The network comprises more than 70 fixed monitoring stations distributed across the metropolitan area at an average density of approximately one station per 2 km². Near-surface air temperature and relative humidity are measured at 3 m above ground level across a wide range of urban morphologies, including compact city centers, residential neighbourhoods, industrial areas, urban green spaces, and peri-urban zones. Sensors are installed following standardized exposure criteria to ensure data quality and inter-site comparability, with hourly sampling that allows the characterization of diurnal cycles, heatwave conditions, and intra-urban thermal heterogeneity. The system includes centralized data acquisition, quality control, and long-term data storage, enabling both operational applications and climatological analyses.

This observational framework is conceived as a multi-purpose tool for urban climate science and services. It enables a detailed assessment of urban heat patterns, including urban heat island (UHI) intensity, nocturnal heat retention, and thermal contrasts associated with different urban fabrics and land uses.

Furthermore, the dataset provides an empirical basis for the evaluation and calibration of urban climate models and downscaled reanalysis products, improving the representation of local-scale thermal processes. The network also supports the development of climate services focused on heat exposure and risk assessment, contributing to the identification of priority areas for targeted adaptation measures.

Preliminary analyses reveal pronounced intra-urban thermal contrasts, with daytime near-surface air temperature differences of several kelvin between densely built or industrial areas and nearby vegetated or less urbanized locations. Results further indicate that industrial areas tend to cool more rapidly during nighttime compared to compact urban fabrics, leading to sustained nocturnal heat exposure in specific neighbourhoods. These patterns are particularly evident under clear-sky and heatwave conditions. A comparison with satellite-derived land surface temperature (LST) shows amplified spatial contrasts during daytime, linked to surface radiative heterogeneity, while nighttime LST provides a closer proxy for near-surface thermal patterns. Overall, the network provides a robust observational foundation to advance urban heat research and to inform evidence-based strategies for climate-resilient cities.

A RADIOMETRIC CORRECTION FRAMEWORK FOR HIGH-RESOLUTION SURFACE URBAN HEAT ISLAND CHARACTERIZATION USING HYTES

Stephanie Vega Parra^{1,2}, Simon J. Hook³, Glynn Hulley³, Federico Rabuffi^{3,4}, José Antonio Sobrino⁵, Francesca Despini⁶, Sofia Costanzini⁶, Sergio Teggi⁶

¹ PhD in Sustainable Development and Climate Change, University School for Advanced Studies IUSS Pavia, Italy

² Department of Engineering “Enzo Ferrari”, University of Modena and Reggio Emilia, Modena, Italy

³ NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

⁴ National Institute of Geophysics and Volcanology, Rome, Italy

⁵ Global Change Unit (GCU), Image Processing Laboratory (IPL), University of Valencia, Spain

High-spatial-resolution thermal infrared observations are a valuable resource for characterizing small-scale Surface Urban Heat Islands (SUHI). The Hyperspectral Thermal Emission Spectrometer (HyTES) acquires hyperspectral thermal imagery with 256 spectral bands spanning 7.5–12 μm and a ground sampling distance of approximately 3.4 m. However, the 2023 European HyTES campaign was affected by systematic cross-track radiometric biases that introduced striping artifacts and reduced the accuracy of Land Surface Temperature (LST) retrievals.

This work presents a processing framework that enables reliable SUHI characterization from HyTES observations. First, a cross-track radiometric correction methodology is developed and applied to the 2023 European HyTES campaign, using different correction strategies for land and water surfaces. Validation against in situ radiometer measurements acquired in Grosseto (Italy) demonstrates a substantial improvement in LST accuracy, reducing the Mean Absolute Deviation (MAD) from 2.72 K to 0.98 K and the bias from 2.44 K to 0.86 K.

The corrected LST mosaic of a medium-sized city in the Po Valley is then used to classify urban surfaces into Non-SUHI, SUHI, and Surface Urban Hot Spot categories using statistical thresholds based on the mean temperature (μ) and standard deviation (σ).

The proposed framework demonstrates that accurate radiometric correction is a prerequisite for quantitative urban thermal analysis, enabling reliable SUHI characterization from airborne hyperspectral thermal data. The methodology also enhances the value of HyTES observations for urban climate studies and provides a benchmark for future thermal infrared missions such as EAGLE-TIR, TRISHNA, and LSTM.

UCG-FIREDETECTION: AN OPEN-ACCESS REMOTE SENSING PLATFORM FOR BURNED AREA MAPPING AND WILDFIRE SEVERITY ASSESSMENT IN SPAIN

Rafael Llorens, José Antonio Sobrino*, Belen Franch

*Global Change Unit, Image Processing Laboratory, University of Valencia, Spain;
sobrino@uv.es; Tel.: +34 963 543 115.*

Wildfires represent one of the most significant environmental threats in Spain, further exacerbated by climate change, which is intensifying both the frequency and impact of these events. Rising temperatures, prolonged drought periods, and the accumulation of combustible biomass have substantially increased the total burned area, resulting in considerable environmental and economic losses, as well as a marked rise in CO₂ emissions and their consequent feedback on global warming. In this context, remote sensing has established itself as the most effective tool for the monitoring and mapping of burned areas at regional and global scales, largely outperforming traditional methodologies in terms of cost-efficiency and reliability. Building on these capabilities, the UCG-FireDetection project (funded by the BBVA Leonardo Grant 2024) proposes a comprehensive methodology for the assessment of burned areas and the characterization of wildfire severity across Spain.

The developed methodology integrates freely available satellite imagery, LiDAR data, and in situ measurements — including field plots and radiometric measurements — to produce high-accuracy cartographic outputs. The generated products include burned area maps, fire severity indices for both vegetation and soil, post-fire erosion risk assessments, vegetation regeneration analyses, and monitoring of peak carbon monoxide (CO) concentrations associated with each fire event.

As the central outcome of this project, the UCG-FireDetection Geoportal (<https://ucg-firedetection.github.io/>) is presented — an open-access web platform designed to facilitate the retrieval and analysis of wildfire-derived information. Through this tool, any user can define a polygon of interest and access: burned area maps, fire severity indices for vegetation and soil, maximum post-fire CO values, burned area statistics disaggregated by severity class expressed in hectares, and the option to download the final severity maps in GeoTIFF format, compatible with any Geographic Information System (GIS). The geoportal represents a significant contribution to proactive forest management, providing researchers, land managers, and public authorities with an operational, reproducible, and readily integrable tool within existing GIS workflows. Its accessibility- and interoperability-oriented design makes it a valuable resource for both post-fire restoration planning and the long-term monitoring of post-fire dynamics in Mediterranean ecosystems.

SIDENCA: AN EO-BASED FRAMEWORK FOR CLIMATE RISK AND EMERGENCY MANAGEMENT USING MULTI-SOURCE DATA

Pérez-Hoyos, A.^{1*}, Tárrega, G.², Belenguer, J. ², Díaz, R. ², García González, J.C³, Cubillos Esteve, J.J.⁴, Juan Verdoy, P. ⁵, Chaudhuri, S.⁵, Samper, J.J. ⁶, García-Rodríguez, D.⁶, García Calderaro, J.F. ⁶

¹ Albavalor, Catedrático Agustín Escardino Benloch, ⁹, 46980, Paterna, Valencia Spain.

² AINIA, Calle Benjamín Franklin, 5-11¹, 46980 Paterna, Valencia, Spain

³ Innovageo, Plaza Vicente Andrés Estellés, ², 46950, Xirivella, Spain

⁴ Laberit, Avenida Cataluña, ⁹, 46010, Valencia, Spain

⁵ Department of Mathematics, Universitat Jaume I, Av. Sos Baynat S/N, Castell'on 12071, Spain

⁶ IRTIC-LISITT, University of Valencia, Carrer del Catedrático José Beltrán Martínez, ², 46980, Paterna, Valencia, Spain

Correspondence: ana.perezhoyos@albavalor.es, +34 645 213 689

The increasing frequency and severity of climate-driven extreme events, such as floods, wildfires, heatwaves, and severe storms, require a paradigm shift in how risk and emergency management are addressed. In response to this challenge, the SIDENCA project (Sistema Inteligente para la DEtección de

riesgos y toma de decisiones ante Catástrofes) develops an integrated and interoperable platform to support multi-hazard risk detection and decision-making in emergency contexts.

SIDENCA is designed as a scalable and modular system that integrates multi-source data, including Earth Observation (EO) imagery, in situ sensors, meteorological data, and socio-economic information, to provide a comprehensive understanding of risk conditions. The platform combines optical, thermal, and radar satellite data (e.g. Sentinel missions), drone observations, IoT sensor networks, and geospatial datasets to generate dynamic information products across all phases of the emergency management cycle: prevention, preparedness, response, and recovery.

A key component of SIDENCA is the development of advanced modelling and data integration strategies to analyse complex environmental processes and support real-time decision-making. In particular, the platform incorporates spatial-temporal modelling approaches based on INLA-SPDE, enabling the representation of environmental dynamics and risk propagation across heterogeneous landscapes. These capabilities, combined with machine learning, detect patterns, identify affected areas, and generate dynamic risk and severity maps. The system integrates data from EO sensors, in situ monitoring networks, and high-resolution drone observations, including dedicated sensor deployments, enhancing the spatial and temporal characterisation of extreme events.

In parallel, SIDENCA implements a semantic data architecture to ensure interoperability and efficient integration of heterogeneous data sources. This approach enables standardised access, visualisation, and exploitation of critical information across the platform, facilitating communication between systems and users. The resulting products are delivered via an interactive geoportal designed for multiple end users, including emergency services, civil protection agencies, public authorities, and territorial planners.

In addition, SIDENCA includes edge computing capabilities, enabling autonomous data processing and alert generation directly in the field, even under limited connectivity conditions. The system is co-designed and validated with end users in operational environments, ensuring its applicability and usability in real-world emergency scenarios. Building upon an existing pilot implementation, SIDENCA aims to advance towards a more robust and flexible solution capable of addressing multiple hazards simultaneously. SIDENCA helps bridge the gap between Earth Observation technologies and operational emergency management services by providing an integrated platform that enhances situational awareness, supports timely decision-making, and improves resilience to climate-related risks.

DEVELOPMENT OF AN OPERATIONAL ENHANCED PRODUCT FOR THE DETECTION OF BURNT AREA AND FIRE SEVERITY BY COMBINING HIGH RESOLUTION OPTICAL AND THERMAL IMAGERY

***Sara Arioli¹, Mathilde Mauger-Vauglin¹, Stéphanie Battiston¹, Victor Bouvier²
Pascale Ferrage³, Raquel Rodriguez-Suquet³***

¹ Université de Strasbourg, SERTIT-ICube-UMR, Illkirch, France

² Descartes Underwriting, Paris, France

³ Centre National d'Études Spatiales, Toulouse, France

The increasing scale and frequency of wildfires across the globe is a public safety hazard that threatens both human communities and natural ecosystems. During and after a wildfire, monitoring the Burnt Area (BA) helps identifying affected communities and infrastructures, calculating Fire Severity (FS), environmental and economical damages. Such information is fundamental to parametric insurance companies like Descartes Underwriting, that offer payout based on the data-driven detection of measurable events such as wildfires. The BA is usually retrieved using Earth observation satellite acquisitions in the optical domain (VNIR-SWIR). They are used to compute a series of indexes – such as the Normalized Difference Vegetation Index (NDVI), the Burnt Area Index (BAI) and the Normalized Burn Ratio (NBR) – indicative of vegetation health, canopy moisture and burn scar presence, and their difference between before and after a wildfire occurs – dNDVI and dNBR –. Although well established, this approach presents some limitations, such as the low sensitivity of the indexes where vegetation is sparse or under major hydric-stress

before the wildfire, as well as the missed detection of belowcanopy burnt areas and vegetation affected by strong heat or smoke. Few studies showed the potential of High-Resolution Thermal InfraRed (HR-TIR) satellite acquisitions to address these issues in the past, but did not develop operational products because of the low temporal availability of HR-TIR imagery. This is no longer an issue thanks to the advent of the TRISHNA mission (CNES/ISRO), the LSTM mission (ESA) and numerous private constellations providing HR-TIR imagery with high revisit. In the context of the CNES Ambition Aval program (SEVERIT3D project) and through a partnership between ICubeSERTIT and Descartes Underwriting, an innovative BA and FS product was developed exploiting HR-TIR imagery. The product is based on the Normalized Burnt Ratio – Thermal 3 (NBRT3, Holden et al. 2005) and has been tested using NASA/USGS Landsat-8/9 L2 LST products and ConstellLR LST30 and HiVE products (LST type). The detected BA using the NBRT3 index over 5 case studies was 3 % to 8 % higher than the BA estimated with the sole dNBR index extracted from Sentinel-2 images, and showed an improved overlap with validation BA maps issued from in-situ observations and user reports. Current work is focusing on the refinement of the thresholding of the NBRT3 index, in order to account for phenomena other than wildfires that impact LST patterns, such as the presence of complex topography or varied meteorological conditions. Further work will focus on the development of an operational version of this innovative, enhanced BA and FS product, combining the potential of both optical and thermal acquisitions.

A MULTI-TEMPORAL SATELLITE FRAMEWORK FOR QUANTITATIVE MONITORING OF SEAGRASS DEGRADATION AND RESTORATION

Yarong Zou ¹, Jun Tangb, Zhiyuan Ouyang ², Yingcheng Lu ²

*¹ National Satellite Ocean Application Service, Ministry of Natural Resources, Beijing 100081, China
zyr@mail.nsoas.org.cn 18600589667*

*² International Institute for Earth System Science, Nanjing University, Nanjing 210046, China
luyc@nju.edu.cn 18136657211*

Seagrass meadows are critical coastal ecosystems but are increasingly threatened by coastal development and human disturbance. Quantitative monitoring of their long-term dynamics remains challenging due to tidal variability, seasonal phenology, complex underwater topography, and frequent data gaps in optical satellite observations. In this study, a multi-temporal satellite remote sensing framework is developed to quantify long-term changes in the Caoheidian (CFD) seagrass meadow in the northern Bohai Sea, China, the largest continuous seagrass habitat in the country. Sentinel-2 Multispectral Instrument (MSI) imagery acquired between 2016 and 2024 was processed to generate Rayleigh-corrected reflectance products and to characterize the spectral signatures of both exposed and submerged seagrass. A zonal threshold classification scheme combined with multi-scene image compositing was implemented to mitigate uncertainties caused by tidal stage, phenological variation, and cloud contamination. Pixel-level weighted regression was further applied to identify spatially explicit trends of degradation and recovery. The results reveal a clear long-term decline of the CFD seagrass meadow over the past decade, although temporary recoveries occurred following two restoration programs after 2019. Spatial trend analysis identifies five change classes, including significant degradation (5.2%), slight degradation (15.5%), stable areas (55.8%), slight recovery (22.9%), and significant recovery (0.6%). Severe degradation is mainly associated with coastal construction and sediment disturbance, whereas recovery is primarily concentrated in restoration zones. The proposed framework demonstrates the capability of multi-temporal satellite observations to provide robust quantitative assessments of coastal ecosystem dynamics under complex environmental conditions. The methodology is readily transferable to other data-limited coastal environments and offers valuable support for large-scale ecological monitoring and restoration evaluation.

SATELLITE-BASED MONITORING OF THE CARBON BUDGET OF FORESTS IN TROPICAL AND BOREAL REGIONS FROM VOD AND IA-BASED HIGH-RESOLUTION METHODS

Jean-Pierre Wigneron¹, Philippe Ciais², Xiaojun Li³, Lei Fan⁴, Yuqing Liu¹, Xiangzhuo Liu¹, Frederic Frappart¹

¹ ISPA, UMR 1391, INRAE Nouvelle-Aquitaine, Bordeaux Villenave d'Ornon, France

² Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSIL, CEA-CNRS-UVSQ, Université Paris-Saclay, 91191 Gif-sur-Yvette, France

³ Faculty of Geosciences and Engineering, Southwest Jiaotong University Chengdu 611756, China

⁴ Chongqing Jinpo Mountain Karst, Ecosystem National Observation and Research Station, School of Geographical Sciences, Southwest University, Chongqing, China

Correspondence: jean-pierre.wigneron@inrae.fr; Tel: +33 557 122 424

Monitoring forest carbon (C) stocks is essential for a better understanding of the global carbon balance, as well as for predicting long-term trends and inter-annual variability in atmospheric CO₂ concentrations. In this context, remote sensing offers many advantages for monitoring above-ground biomass (AGB) on a global scale, overcoming the time and spatial limitations of national forest inventories (NFIs): remote sensing provides continuous, homogeneous yearly mapping on a global scale. However, traditional methods of monitoring AGB are affected by saturation effects when AGB exceeds approximately 100 t/ha for optical and synthetic aperture radar (SAR) systems.

Over the last decade, two methods that are less susceptible to saturation effects have emerged. Firstly, passive microwave remote sensing at the L-band has been shown to be a key technique for monitoring forest carbon stocks via the L-band vegetation optical depth (L-VOD) microwave vegetation index. Despite its coarse spatial resolution of around 25 km x 25 km, L-VOD enables the monitoring of forests up to aboveground biomass (AGB) levels of approximately 400 tonnes per hectare at the global scale, based on observations from the Soil Moisture and Ocean Salinity (SMOS) mission (2010–present) and the Soil Moisture Active Passive (SMAP) mission (2015–present). More recently, IA-based methods applied to high-resolution optical and SAR images have also emerged as a key approach for monitoring forest carbon stocks.

In this communication, we review the main applications of L-VOD and IA-based methods for tracking the carbon balance of vegetation. We present the most recent results from tropical regions (South America, Africa and Asia), as well as from boreal regions (Siberia and Canada), which together contain the largest forest carbon stocks on the planet. Using the two methods in parallel allows for more robust results and a better evaluation of the uncertainties associated with remote sensing estimates.

UNVEILING AMAZON FOREST VERTICAL DYNAMICS THROUGH MULTIFREQUENCY MICROWAVE RADIOMETRY

Mohamed El-Khayati-Ramouz^{1*}, Carlos López-Martínez^{1,2}, Mercè Vall-llossera^{1,2}, Adriano Camps^{1,2,3}, Antonio Turiel⁴, Alberto Alonso-González¹, Gerard Portal², Amir Mustofa Irawan^{1,5}, Marc Herrera², Pol Villalvilla¹, and Jiachen Li¹

¹ Signal Theory and Communications Department, Technical University of Catalonia (UPC), 08034 Barcelona, Spain

² Institute for Space Studies of Catalonia, IEEC, 08034 Barcelona, Spain

³ ASPIRE Visiting International Professor, UAE University CoE, PO Box 15551, Al Ain, United Arab Emirates

⁴ Institute of Marine Sciences (ICM-CSIC), Barcelona 08034, Spain

⁵ Department of Climatology, Indonesia State College of Meteorology, Climatology, and Geophysics (STMKG), Tangerang Selatan 15221, Indonesia

Correspondence: mohamed.el.khayati@upc.edu / +34 612 580 821

Monitoring the early stages of critical transitions in forest ecosystems is essential for improving our capacity to anticipate, adapt to, and mitigate their impacts. Such transitions may originate in the lower strata of forests, where structural and physiological changes can precede observable alterations in the upper canopy. Conventional satellite-based observations, largely reliant on optical vegetation indices and upper-frequency microwave bands (e.g., Ku-band), often fail to capture these early signals due to their limited penetration depth. In contrast, microwave remote sensing at low frequencies offers a unique capability to penetrate the canopy, providing valuable information on deeper forest layers. In this context, vegetation biomarkers derived from L- and C-band microwave observations (1.4–7 GHz), such as vegetation optical depth (VOD), which serves as a proxy for vegetation water content (VWC), offer new opportunities for assessing forest condition. Despite their potential, such datasets remain underutilized compared to optical records, which are more commonly employed due to their longer temporal coverage. In our study, we use L- and C-band VOD to investigate and quantify the mean spatiotemporal patterns, the resilience, and stability of undisturbed regions of the Amazon Rainforest over the period 2010–2023. Our analysis reveals persistent interannual declines in VWC across several regions, with pronounced signals emerging around the 2015–2016 El Niño event onwards. These changes are particularly evident in the northeastern Amazon, a region characterized by the highest biomass across the basin. Further, quantitative estimates of resilience and stability indicate that this region exhibits the lowest stability within the Amazon Rainforests, with localized clusters showing declining resilience over the period analyzed. Notably, these emerging patterns remain largely undetectable using conventional optical vegetation indices but become apparent through the analysis of low-frequency microwave signals capable of penetrating the forest canopy. These findings highlight the critical role of multifrequency microwave satellite observations in understanding the dynamics of different forest layers and detecting early-warning signals of ecosystem stress. Integrating such approaches into forest monitoring frameworks could significantly enhance our ability to anticipate critical transitions and better inform conservation and management strategies aimed at mitigating large-scale forest dieback.

HUMAN ACCESSIBILITY SHAPES GLOBAL FOREST GREENING AND BROWNING

Santiago A. Schauman^{1,2*}, Alexandre Verger²

¹ CREAM, 08193 Cerdanyola del Vallès, Catalonia, Spain

² CIDE, CSIC-UV-GVA, 46113 València, Spain

Correspondence: santischauman@gmail.com; Telephone: 614 050 074

Forests store 80–90% of terrestrial plant biomass and represent the planet’s largest terrestrial carbon sink, playing a central role in climate regulation, biodiversity conservation, and ecosystem functioning. However, forest integrity is under increasing pressure: nearly half of Earth’s original forests have been lost, and ~70% of remaining forests occur within 1 km of an edge, where exposure to human and environmental stressors is most intense. Understanding long-term changes in forest canopy structure and productivity is therefore essential for assessing the stability of global carbon sinks. Leaf Area Index (LAI), a key structural and functional indicator of vegetation, provides a robust proxy for canopy density and photosynthetic capacity, capturing both greening linked to carbon uptake and regeneration, and browning associated with degradation, disturbance, or deforestation. Although global greening and browning have been widely reported, their spatial organization in forests and relationship with human accessibility remain poorly understood. Here, we present a global analysis of forest LAI trends (2000–2024) using the High-Quality Reprocessed MODIS LAI product (HiQ-LAI; 8-day, 500 m), restricted to pure forest pixels from Hansen’s global forest cover dataset (30 m). Trends were estimated using Sen’s slope and significance assessed with the Mann–Kendall test. We examine how human accessibility, expressed as distance-to-road gradients, structures greening and browning patterns across global forests and whether these relationships differ between the Global North and Global South. We further assess biome consistency and link observed patterns to disturbance drivers, including logging, fire, shifting cultivation, and agricultural expansion. Accessibility gradients reveal fundamentally contrasting global patterns. In the Global South, forests near roads exhibit strong net browning, transitioning to greening beyond ~3 km from infrastructure, with greening increasing

up to ~15 km before stabilizing (LAI greening trend of $\sim 0.015 \text{ m}^2 \text{ m}^{-2} \text{ yr}^{-1}$). This pattern is consistent across all major biomes, indicating accessibility as a pervasive constraint on vegetation dynamics. In contrast, the Global North shows a distinct pattern: greening is slightly strongest near roads ($\sim 0.008 \text{ m}^2 \text{ m}^{-2} \text{ yr}^{-1}$) and declines with distance (up to ~10 km), stabilizing at lower positive values ($\sim 0.005 \text{ m}^2 \text{ m}^{-2} \text{ yr}^{-1}$). This trend is largely driven by boreal forests, while other forest types exhibit increasing greening with distance from roads. These patterns are strongly linked to disturbance regimes. In the Global South, negative trends near roads are primarily associated with agricultural expansion, particularly in South America and Southeast Asia, while shifting cultivation and selective logging generate more heterogeneous responses. In the Global North, logging dominates negative trends near roads, whereas fire-related disturbances prevail in more remote forests, especially in boreal regions of Canada and Eastern Europe. Overall, these findings highlight infrastructure-driven accessibility as a fundamental organizing force shaping LAI dynamics in global forests, with important implications for the functioning and potential stability of terrestrial carbon sinks under ongoing environmental change.

GEOSPATIAL IDENTIFICATION OF WILDFIRE RISK AREAS IN THE URBANWILDLAND INTERFACE USING REMOTE SENSING AND GIS TECHNIQUES

Ana Novo¹, Isabel Martínez-Fernández, Cristina Fernández
Misión Biológica de Galicia- CSIC, P.P Box ²⁸, Pontevedra 36080, Spain
E-mail: anovo@mbg.csic.es; Phone: +34 986 596136

The 2025 wildfire season in Spain was marked by numerous large fire events, with 401,266 ha burned under extreme climatic conditions. The increasing proximity between settlements and forested areas, together with the recurrence of wildfires in these zones, has made their management a priority within spatial planning frameworks. This situation highlights the need to assess wildfire risk using geospatial tools capable of anticipating fire occurrence and minimizing its social, economic, and environmental impacts. In this context, identifying predicted risk areas around settlements is essential for establishing safety zones to protect people and property, while also supporting decision-making related to vegetation management.

This study focuses on settlements in the province of Ourense, developing an applied analysis that generates cartographic information useful for territorial management and wildfire prevention. The research integrates spectral indices derived from Sentinel-2 images with GISbased approaches and Machine Learning techniques to identify high-risk areas around settlements and to determine the main drivers influencing wildfire risk.

A total of more than 50 wildfire events were selected over the past decade were selected, each with a burned area exceeding 500 ha to analyzed in this study. Nine key variables were considered as indicators of wildfire occurrence: elevation, slope, aspect, distance to roads, distance to settlements, vegetation type, Normalized Difference Vegetation Index (NDVI), Fire Weather Index (FWI), and historical fire regimes. The study evaluates the interaction between bottom-up factors (fuel characteristics and topography) and top-down factors (fire weather conditions) using a Random Forest classifier at the regional scale in Galicia (NW Spain).

The model achieved high classification accuracy (>80%) in predicting fire size and severity. These results demonstrate the potential of integrating remote sensing and machine learning techniques into wildfire risk assessment frameworks. Furthermore, this approach provides a basis for incorporating additional variables into post-fire risk models, as well as supporting studies on watercourse contamination and the planning of measures to mitigate flood risk.

INCORPORATING AIRBORNE OBSERVATIONS FOR REALISTIC URBAN HEAT STRESS MODELLING: FIRST RESULTS

Wim Timmermans¹, Srinidhi Gadde¹, Heet Joshi¹, Laure Roupioz²

¹ University of Twente, Faculty of Geo-information Science and Earth Observation, The Netherlands

² French Aerospace Lab, Optics and Associated Technologies Dept. (ONERA-DOTA), Toulouse, France

Email: w.j.timmermans@utwente.nl, Tel: +31 534 874 488

Objective determination of urban heat stress, which we confine here to heat stress experienced by humans in urban environments, basically comes down to the determination of energy budgets. Humans experience heat stress when deviating from “the condition that expresses satisfaction with the thermal environment”. Heat stress results in a rise of body temperature, regulated by biophysiological processes such as vasodilation, shivering and sweating, which are all described in terms of human body energy budgets. These experiences are, next to internally consumed energy due to physical activity, governed by externally exposed thermal stresses on the human body by radiative, conductive and turbulent energy fluxes. Since in an urban environment these external loads are highly variable in space and time and manifest themselves in a 3D fashion, monitoring is required at high resolution, both in terms of observations as well as in (3D) modelling.

In the city of Enschede, The Netherlands, an observational network for urban climate is installed to facilitate this. It consists of an eddy-covariance tower and a set of scintillometers that measure the turbulent flux exchanges of heat and water-vapor between the city and the overlying atmosphere. In addition a spatially distributed network is measuring basic meteorological parameters (air temperature, air humidity, solar radiation, air pressure) at 11 outdoor and 13 indoor locations to gain insight in local climatic conditions and its typical behavior in different neighborhoods, streets and homes.

High resolution (sub-meter) hyperspectral airborne observations spanning the full range of the optical-thermal spectrum (380 – 11500 nm) are employed to provide relevant thermo-radiative material properties required in the urban climate model PALM4U, which is validated versus the in-situ observational network. The PALM4U Large Eddy Simulation (LES) model is a robust and versatile model for simulating urban climate in complex 3D geometries. It is used here to simulate both turbulent and radiative fluxes for a diurnal cycle at high spatial and temporal resolution (meter and second) for the city center of Enschede in order to derive the so-called Physiological Equivalent Temperature (PET), an indicator of the aforementioned thermal heat stress experienced by the human body.

In this contribution first results are presented on the effect of incorporating high resolution optical-thermal observations on the external thermal stresses humans experience in a realistic 3D urban setting.

LUNAR RADIOMETRIC CALIBRATION FOR EARTH OBSERVATION IN THE MID-WAVE AND THERMAL IR USING THERMO-PHYSICAL MODELS

Christian Mollière¹, Kay Wohlfarth², Thomas Müller³, Joris Blommaert⁴, Dirk Nuyts⁵, Marc Seifert¹, Julia Gottfriedsen¹

¹ OroraTech – München – Germany

² TUD – Dortmund – Germany

³ MPE – Garching bei München – Germany

⁴ VITO/VUB – Mol / Brussels – Belgium

⁵ VITO – Mol – Belgium

Correspondence: Christian.molliere@ororatech.com

Accurate in-orbit radiometric calibration is needed to provide precise Land Surface temperature products. Such calibration is often based on onboard calibration sources. However, with the upcoming small satellites such devices can often not be included, and one is restricted to vicarious calibration. In-flight validation can be retrieved from observing dedicated sites on Earth using field campaigns in dedicated land

areas with homogenous surface temperatures or water sites (e.g. Tonooka et al. 2005). Here we present an alternative with lunar measurements calibrated with Thermo-Physical Models (TPM) which are developed to study airless bodies like asteroids and planetary moons. TPM predictions of the lunar disk integrated radiances can reach accuracies down to 5% (Müller et al. 2021, Wohlfarth et al. 2023).

The present study was performed with observations by the new space company OroraTech that has launched a constellation of cost-effective mid-wave and thermal infrared (MWIR/TIR) imagers to provide high-quality Earth observation data for mitigating the effects of climate change, as for example by providing timely wildfire detections. OroraTech regularly observes the Moon with the SAFIRE instruments to calibrate their Mid- and Thermal IR imagers and monitor their stability. A special campaign was set up with frequent monitoring of the Moon, covering a wide range of lunar phase angles (0° - ±120°). We will present the outcome of a comparison of Lunar acquisitions of the SAFIRE imagers to two thermo-physical models of the Moon. The results show that the calibration residuals are approximately 3% in both MWIR and LWIR bands, demonstrating their suitability for the automated in-flight calibration of a constellation of MWIR/TIR imagers. Our results provide a methodology for the inter-calibration and homogenization of different TIR missions, including upcoming large missions like LSTM and TRISHNA.

UNCERTAINTY-AWARE VALIDATION OF SENTINEL-3 OLCI GI-FAPAR: THE ROLE OF SPATIAL REPRESENTATIVENESS AND MATCHUP STRATEGY

Pérez-Hoyos, A. ¹, García-Rodríguez, D. ², Gobron, N. ³, Henocq, C. ⁴, Rommelaere, S. ⁴, Clerc, S. ⁴, Dransfeld, S. ⁵

¹ Albavalor, Catedrático Agustín Escardino Benlloch, ⁹, 46980, Paterna, Valencia, Spain. Corresponding

² IRTIC-LISITT, University of Valencia, Polígono de la Coma s/n, 46980, Paterna, Valencia, Spain

³ European Commission Joint Research Centre, Ispra, Italy

⁴ ACRI-ST, 260 Route du Pin Montard, BP 234, 06410, Sophia-Antipolis, France

⁵ European Space Agency (ESA), European Space Research Institute (ESRIN), 00044 Frascati, Rome, Italy

Author: ana.perezhoyos@albavalor.es, +34 645 213 689

The Copernicus Sentinel-3 mission provides global, high-frequency observations of terrestrial biophysical variables through the Ocean and Land Colour Instrument (OLCI). Among these, the Green Instantaneous Fraction of Absorbed Photosynthetically Active Radiation (GI-FAPAR) is a key indicator of vegetation productivity and an essential component of the FAPAR Essential Climate Variable (ECV) (Gobron et al., 2024). Ensuring the long-term consistency and reliability of these products requires validation frameworks that go beyond conventional statistical metrics and explicitly address scale mismatch, spatial representativeness, and uncertainty.

This research presents a comprehensive validation of OLCI GI-FAPAR using in situ reference measurements from the Copernicus Ground-Based Observations for Validation (GBOV) network, as part of the operational validation activities of the Sentinel-3 Optical Mission Performance Cluster (OPT-MPC). The validation is formulated as a measurement-comparison problem, consistent with the Guide to the Expression of Uncertainty in Measurement (GUM) (JCGM 100:2008), in which differences between satellite and ground observations are interpreted in terms of their combined uncertainties and spatial support.

A central objective of this work is to assess the sensitivity of validation outcomes to the spatial matchup strategy. Four protocols are systematically evaluated, ranging from point-to-pixel comparisons to aggregation approaches based on neighbourhood windows and Elementary Sampling Units (ESUs). Results suggest that validation metrics, such as R^2 , RMSD, and bias, are sensitive to the selected protocol but do not point to a single strategy that is consistently preferable across contexts. Instead, the different protocols capture spatial heterogeneity in different ways, which affects the resulting agreement statistics.

The analysis also confirms strong temporal consistency between Sentinel-3A and Sentinel-3B products, indicating excellent inter-platform agreement. Nevertheless, systematic discrepancies persist across ecosystems. OLCI GI-FAPAR tends to underestimate values in dense forest canopies, while more variable

behaviour is observed in heterogeneous landscapes such as croplands and shrublands, where sub-pixel variability plays a dominant role.

By introducing a preliminary uncertainty budget that accounts for reference upscaling, temporal mismatch, and spatial representativeness, we show that a substantial fraction of the observed differences lies within the combined uncertainty of the comparison. These results indicate that validation outcomes are shaped not only by product performance but also by spatial heterogeneity and the matchup definition. Overall, this work demonstrates that validation is protocol-dependent and that representativeness effects cannot be fully resolved by a single optimal-matching strategy. The proposed framework contributes to the ongoing evolution of operational validation practices within the Sentinel-3 OPT-MPC, supporting a transition from purely statistical assessment toward uncertainty-aware, physically consistent validation of OLCI vegetation products for climate and ecosystem applications.

CURRENT STATUS OF SENTINEL-3 SLSTR LST VALIDATION AND EXPLORATORY NDVI-BASED ANALYSIS OF MATCHUP REPRESENTATIVENESS (TOPIC 18: SENSOR CALIBRATION, ATMOSPHERIC CORRECTION, AND PRODUCT VALIDATION)

V. Taurino ¹, S. Clerc ¹, C. Henocq ¹, D. Ghent ², E. de Luca ³, P. Paolino ³, S. Dransfeld ⁴

¹ACRI-ST

²University of Leicester

³LEONARDO

⁴ESA

Correspondence: veronica.taurino@acri-st.fr

The Copernicus Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR) provides global Land Surface Temperature (LST) retrievals at 1 km resolution. Within the Optical Mission Performance Cluster (OPT-MPC) framework supporting ESA activities, Category-A validation is routinely carried out through comparisons with LST derived from ground-based radiometric measurements, using stations from the SURFRAD and USCRN networks in the United States, complemented in 2025 by selected sites from the LAW network in Europe, thus covering a range of biomes and climatic conditions.

This contribution summarizes the status of SLSTR LST validation based on the 2025 matchup dataset, with complementary analyses of seasonal behaviour and temporal drift over the 2021-2025 period. In addition, an exploratory NDVI-based analysis is introduced to better interpret the impact of the site heterogeneity and of the representativeness of the sampling point within the satellite footprint.

Clear-sky matchups are evaluated in terms of accuracy, expressed as median bias, and precision, expressed as robust standard deviation, separately for daytime and nighttime overpasses. The results reveal a recurring seasonal pattern across most stations, with larger daytime satellite-in situ differences during summer and comparatively stable nighttime performance. A drift analysis over the 2021-2025 period identifies persistent trends at a subset of station-platform combinations; the broad consistency between Sentinel-3A and Sentinel-3B at affected sites suggests that site-dependent factors and evolving matchup conditions may contribute to the observed variability.

The representativeness of the sampling point within the satellite footprint is assessed using the difference between a satellite-derived NDVI estimate at 1 km and the average Sentinel-2 NDVI within a local patch around the station (Δ NDVI); large values indicate that the station environment differs from the pixel mean. The site heterogeneity is characterized by the interquartile range of Sentinel-2 NDVI within the Sentinel-3 pixel (IQR_NDVI); high values flag conditions where the spatial heterogeneity within the pixel may undermine the representativeness of a single ground measurement, even when Δ NDVI is small. The study is currently focused on Bondville (Illinois), an agricultural site characterized by pronounced seasonal crop dynamics. Preliminary results show that daytime residuals are substantially linked to Δ NDVI, which captures the directional bias associated with the mismatch between the station environment and the pixel mean, while nighttime residuals show little sensitivity to the same descriptor. IQR_NDVI provides additional

information, suggesting that point representativeness and site heterogeneity capture distinct but related aspects of the point-topixel comparison. Both metrics peak during the crop transition period, when the 1 km pixel integrates mixed surfaces that diverge from the local station environment.

Work is in progress to extend the approach to additional stations and land-cover types, and to tighten the temporal alignment between LST matchups and Sentinel-2 acquisitions. These analyses are expected to contribute to a more physically informed interpretation of LST validation residuals, to support the design of representativeness-aware quality criteria for operational satellite validation, and ultimately to improve the quantification of matchup uncertainty.

EVOLUTION, VALIDATION AND NEW APPLICATION OF LAND SURFACE TEMPERATURE PRODUCT ON FY-3 METEOROLOGICAL SATELLITE

Lixin Dong^{1,2*}, Liangyu Fan, Ning Kang, Lin Chen, Na Xu

¹ Key Laboratory of Radiometric Calibration and Validation for Environmental Satellites,

² National Satellite Meteorological Center (National Center for Space Weather), China Meteorological Administration

Correspondence: dlx_water@163.com, Tel:13683318956

Land surface temperature (LST) is a very important physical variables characterizing land surface change process and the driving factors of land - atmosphere energy exchange. It is widely used in the fields of surface energy balance, climate change, resource and environment monitoring. In this paper, the development and evolution of Fengyun 3 (FY-3) LST algorithm are firstly introduced. Some candidates split window LST algorithms are compared to evaluate their applicability for the Medium Resolution Spectral Imager (MERSI) onboard the FY-3 satellite using simulated data by the MODTRAN radiative transfer model. And then the enterprise algorithm of FY-3 LST is determined and the operational products are produced in clear sky condition. Secondly, the MERSI LST products is validated by using the in-situ data and Moderate Resolution Imaging Spectroradiometer (MODIS) LST product. The validation results indicate that the preferred LST algorithm meets the required accuracy (2.5 K) of the FY-3 mission. Finally, some application of LST products in the field of high-temperature process monitoring, inversion of LST on the artificial and nature snow surface and the study of island LST change before and after volcanic eruption is introduced. The results shows that the temporary and spatial resolution of FY-3 250 meters the need for monitoring in many fields.

TOWARDS A CONSISTENT MULTI-SENSOR VEGETATION PRODUCT: VALIDATION OF THE ESA CCI+ VP CDRP-2 DATASET

F. Camacho^{1*}, J. Sánchez-Zapero¹, E. Martínez-Sánchez¹, S. Blessing², R. Giering², C. Van der Tol³, Kris Vanhooff⁴, E. Swinnen⁴

¹EOLAB, Spain;

²FastOpt, Germany;

³University of Twente, The Netherlands;

⁴VITO, Belgium

*Correspondence: fernando.camacho@eolab.es

The CCI+ Vegetation Parameters (VP) project is part of the ESA Climate Change Initiative and aims at developing long data records of the essential climate variables (ECV) of leaf area index (LAI) and the fraction of absorbed photosynthetically active radiation (fAPAR) from multi-platform and multi-sensor satellite data. The project includes three cycles, in which different data sources are progressively integrated, the scientific and operational maturity of the algorithms is enhanced, and user feedback is incorporated. Products are derived from a retrieval system for canopy and sub-canopy parameters (OptiSAIL), based on a coupled modelling framework including SAIL (canopy reflectance), PROSPECT-D (leaf properties),

TARTES (snow properties), a soil model (soil reflectance anisotropy and moisture effects), and a cloud contamination module. OptiSAIL also computes correlated uncertainties of the data products.

This work presents the CCI+ VP with focus on the validation and intercomparison results of the climate research data package from the second cycle (CRDP-2) retrieved from multi-sensor data. The CRDP-2 integrates data from SPOT/VGT, PROBA-V, Metop/AVHRR-3, VIIRS/Suomi-NPP, and Sentinel-3/OLCI sensors to generate a consistent multi-sensor dataset at 1 km spatial resolution covering the 2000–2020 period over a subset of global sites and a latitudinal transect. The global production is currently ongoing as part of the CRDP-3 dataset following several refinements in the algorithm and band configuration. The added value of increased spectral, spatial, temporal, and angular diversity is further assessed through the exploitation of complementary sensors (e.g., MERIS, MODIS) at 300 m resolution, as part of the CRDP-4 currently under development.

The validation approach, fully compliant with the CEOS LPV good practices, evaluates the product accuracy, precision, uncertainty and stability among other quality criteria. Validation against ground-based measurements (CEOS DIRECT V2.1, GBOV, AMMA) and intercomparison with satellite products including Copernicus Land Monitoring Service (CLMS) V2, MODIS C6.1 and VIIRS C1 demonstrate the overall good quality of the CRDP-2 dataset. LAI and fAPAR show consistent spatial patterns and well-captured temporal dynamics across most regions. Comparisons with ground-based observations indicate good agreement, particularly for fAPAR, while LAI (effective) tends to be underestimated despite strong correlations. Overall, CRDP-2 provides robust multi-sensor estimates, showing good consistency and agreement with existing global products. The main validation outcomes will be discussed, together with the way forward in the context of the Copernicus Climate Change Service (C3S), where CRDP-3 will be extended to the present, including true LAI and green fAPAR.

OPEN CROP LAI DB: HARMONIZED IN-SITU LEAF AREA INDEX DATA FOR DECAMETRIC SATELLITE PRODUCT VALIDATION AND APPLICATIONS

Josef Wagner^{1*}, Mirco Boschetti², Yuval Sadeh³, Nikhil Sasi Rajan¹, Francesco Nutini³, Xavier Bailleau⁴, Manav Gupta¹, Inbal Becker-Reshef^{1,5,6} all authors contribute equally to this work

¹ ICube Laboratory, University of Strasbourg – France

² Institute for Electromagnetic Sensing of the Environment (IREA), National Research Council of Italy (CNR) – Italy

³ School of Earth, Atmosphere and Environment, Monash University -Australia

⁴ SatFarming – France

⁵ Department of Geographical Sciences, University of Maryland-College Park, USA

Correspondence: jwagner@unistra.fr; Tel: +336 12 80 58 75

Leaf Area Index (LAI), defined as the one-sided leaf area per unit ground area, is a key biophysical variable for monitoring cropland dynamics. It is routinely inferred from decametric resolution satellite data (e.g. Sentinels, Landsats) for downstream agricultural applications such as yield monitoring, carbon accounting, fertilization management, evapotranspiration or water balance assessments, and many more. Despite its importance for agricultural monitoring, in situ crop LAI data remains scarce and is rarely made openly available, limiting progress towards more reliable LAI estimation, validation and downstream applications. To address this gap, we introduce Open Crop LAI DB, an initiative to compile and openly share a harmonized, carefully curated database of in-situ LAI measurements over broadacre crops. The dataset focuses on observations collected using standardized protocols (e.g. CEOS LPV) and instruments (Li-Cor LAI-2000, Decagon Accu-Par LP80), suitable for satellite validation over croplands. The initial release includes 3063 samples spanning three countries (Italy, France, and Australia), covering 11 crop types and 10 years, provided by researchers from CNR-IREA, University of Strasbourg / SatFarming and University of Monash. We take the opportunity of this conference to invite researchers and institutions to contribute their LAI datasets to this collaborative effort. By fostering data sharing, this initiative aims to

support the validation of decametric remote sensing products over croplands and to accelerate advances in agricultural and environmental monitoring. The presentation will detail the database structure, data curation workflow, and currently available datasets accessible to the community

VALIDATION OF CLMS NDVI AND GPP PRODUCTS USING INDEPENDENT IN-SITU DATA

Sarah Gebruers^{1*}, Else Swinnen¹, Carolien Toté¹
¹ VITO

Correspondence: sarah.gebruers@vito.be; Tel: +32 497 65 12 86

The Copernicus Land Monitoring Service (CLMS) provides long-term, consistent, and operational land surface products supporting environmental monitoring, climate services, and policy implementation at European and global scales. Given the wide range of scientific and operational applications, rigorous and transparent product validation is essential to ensure that CLMS products meet user requirements and are fit for purpose.

This contribution presents the CLMS product validation strategy for the latest Normalised Difference Vegetation Index (NDVI) and Gross Primary Production (GPP) products, and its alignment with the Committee on Earth Observation Satellites (CEOS) Land Product Validation (LPV) good practice guidelines that are being prepared. The methodology is designed to ensure traceability of validation procedures, standardise accuracy metrics, and to characterise uncertainties. Validation procedures and datasets are fully documented to ensure reproducibility. Key elements of the quality assessment approach include determination of product completeness, temporal and spatial consistency, and inter-annual stability.

For the NDVI 300m V3 product, the validation currently focuses on satellite intercomparisons and temporal consistency analyses to evaluate stability and phenological behaviour across space and time. The future integration of in-situ observations from PhenoCam networks is foreseen to provide an independent, ground-based reference to validate vegetation seasonal dynamics and phenological metrics. The GPP 300m V2 validation is, apart from spatial and temporal intercomparison with satellite reference data, also focussed on comparison with in-situ eddy covariance-based measurements from the FLUXNET network. This allows the evaluation of productivity magnitude and dynamics across a wide range of biomes and climatic conditions.

The use of well-established in-situ networks such as FLUXNET, and the planned inclusion of PhenoCam data, is essential for strengthening the independence and robustness of CLMS product validation and for meeting CEOS LPV requirements. But it also presents some challenges since in-situ and satellite data have different spatial footprints and measure slightly different quantities that should be matched together. This contribution will describe certain methods to tackle these challenges.

VALIDATION OF SENTINEL-2 SURFACE REFLECTANCE PRODUCTS WITH RADCALNET AND HYPERNETS DATA

***R. de los Reyes^{1*}, E. Padilla¹, D. Marshall-Ingram¹, J. Louis², C. J. Guerrero-Benvanet⁷, B. Pflug¹, F. C. Pignatale³, F. Poustomis⁵, A. Bialek⁶, P. De Vis⁶, M. Sinclair⁶, A. Zimmermann⁶, S. Clerc⁵, S. Enache⁴,
V. Boccia⁸, F. Gascon⁸***

¹German Aerospace Center (DLR), Earth Observation Center (EOC), Germany

²Telespazio France, France

³Telespazio Germany GmbH, Germany

⁴CS Group, France

⁵ACRI-ST, France

⁶National Physical Laboratory (NPL), UK

⁷Universitat de València, Spain

⁸European Space Agency (ESA), European Space Research Institute (ESRIN), Italy

*Correspondence: raquel.delosreyes@dlr.de (Tel.: +49 81532283144)

Since 2015, the Sentinel-2 mission of the Copernicus program has delivered continuous global Earth observation in the spectral range of 400 – 2200 nm. With the launch of Sentinel-2B in 2017, the mission reached full operational capacity, achieving a global revisit time of five days. The third unit, Sentinel-2C, launched in September 2024, was initially intended to replace Sentinel-2A in 2025; Sentinel-2A has since been retained under an extended mission scenario to increase overall revisit frequency. This three-unit configuration ensures consistent observation over Europe and improves revisit over cloud-prone tropical regions in Africa and South America.

The quality of Level-2A (L2A) surface reflectance products remains a priority, maintained through a comprehensive validation framework. This study presents the radiometric validation results for Sentinel-2 L2A products from all three satellites during 2025 over shared in-situ reference sites to assess accuracy and consistency of the surface reflectance products.

Validation is performed using high-quality in-situ radiometric measurements from the Radiometric Calibration Network (RadCalNet)(<https://www.radcalnet.org/>) and LANDHYPERNETS (<https://www.landhypernet.org.uk/>). These in-situ measurements provide an independent robust baseline against which the remote sensing derived reflectance values are compared. Both data networks together cover a broad spectrum of land cover types and atmospheric conditions encountered during the year, ensuring that the validation results are representative of global operational scenarios. Additionally, intermediate atmospheric parameters derived from atmospheric correction—including Aerosol Optical Thickness (AOT) and Water Vapor (WV)—are cross-referenced with ground-based observations from the AEROSOL RObotic NEtwork (AERONET) (https://aeronet.gsfc.nasa.gov/new_web/aerosols.html).

The results contribute to ongoing efforts in maintaining and improving the quality assurance of Copernicus Sentinel-2 data for downstream applications. This work demonstrates the continued radiometric stability and inter-mission consistency of Sentinel-2 L2A surface reflectance products as the constellation expands with the addition of Sentinel-2C. The radiometric stability of the surface reflectance has an impact on the derived remote sensing products and therefore are essential for maintaining the continuity of long-term Earth observation records.

COMPREHENSIVE ASSESSMENT OF SIF AND PHOTOSYNTHETIC PIGMENT DYNAMICS UNDER A/BIOTIC STRESS USING SUB-NANOMETER AND NARROW-BAND HYPERSPECTRAL IMAGERY

Zarco-Tejada ¹, P.J., Gonzalez-Dugo ¹, V., Wang ^{1,2}, N., Vishwanath Harish ², T., Poblete ², T., Peña ¹, P., Belwalkar ³, A., Yang ^{4,5}, P., Choi ^{6,7}, W., Hornero ¹, A., Calderon ¹, R., Camino ⁸, C., Landa ¹, B.B., Navas-Cortes ¹, J.A., Ryu Y. ^{6,7,9}.

¹ Institute for Sustainable Agriculture (IAS), Spanish Council for Scientific Research (CSIC), Cordoba, 14004, Spain

² School of Agriculture, Food and Ecosystem Sciences (SAFES), Faculty of Science, University of Melbourne, Melbourne, VIC, Australia

³ Precision Agriculture Lab, School of Life Sciences, Technical University of Munich, Germany

⁴ Key Laboratory of Virtual Geographic Environment, Ministry of Education, Nanjing Normal University, Nanjing, China

⁵ Jiangsu Center for Collaborative Innovation in Geographical Information Resource Development and Application, Nanjing, China

⁶ Interdisciplinary Program in Landscape Architecture, Seoul National University, Seoul, South Korea

⁷ Integrated Major in Smart City Global Convergence, Seoul National University, Seoul, South Korea

⁸ Laboratory of Geo-information Science and Remote Sensing, Wageningen University, The Netherlands

⁹ Department of Landscape Architecture and Rural Systems Eng., Seoul National University, South Korea

Solar-induced chlorophyll fluorescence (SIF), photosynthetic pigments and thermal traits provide complementary indicators of stress dynamics in tree crops. In almond and olive, water limitation and vascular pathogens alter photosynthesis, transpiration, photoprotection and pigment composition before advanced visual symptoms become evident. This contribution presents airborne sub-nanometer and narrow-band hyperspectral results showing that SIF retrievals, fluorescence in-filling in O₂-A and O₂-B absorption features, Fraunhofer lines, photosynthetic pigments, and canopy temperature respond to stress as a function of time, season, and stress intensity. In almond, red and far-red fluorescence in-filling showed divergent responses to water-stress levels and recovery, providing physiological evidence of reduced photosynthetic activity that, when sustained, constrains carbon assimilation and affects yield. In parallel, thermal indicators provided the transpiration-related context needed to interpret water-deficit dynamics and distinguish stomatal regulation from photochemical responses. Importantly, hyperspectral retrievals of photosynthetic pigment traits, including chlorophyll, and xanthophyll-related indicators, also capture stress-induced biochemical dynamics, with sensitivity varying across mild, high, and recovery stages of water stress. In olive, sub-nanometer hyperspectral imagery revealed early biotic-stress symptoms through O₂-A and Fraunhofer-line features, and multi-trait analyses combining hyperspectral and thermal information helped disentangle disease-induced stress from abiotic water-stress pathways. The presentation will show that combining SIF, pigment-sensitive hyperspectral traits and thermal indicators provides complementary physiological information on photosynthesis, photoprotection, transpiration and canopy energy balance. This multi-trait approach improves early stress detection and helps discriminate water-deficit responses from biotic-stress pathways, while highlighting the value of sub-nanometer imagery and the operational potential of broader-band hyperspectral data.

JOINT RETRIEVAL OF FLUORESCENCE QUANTUM EFFICIENCY AND FAPAR FROM SIF AND MULTI-MISSION REFLECTANCE

C. van der Tol^{1*}, *S. Blessing*², *R. Giering*², *K. Vanhoof*³, *E. Swinnen*³

¹ University of Twente, The Netherlands;

² FastOpt, Germany;

³ VITO, Belgium

Correspondence: c.vandertol@utwente.nl

The combination of solar induced fluorescence (SIF) and multi-spectral surface reflectance (R) can provide insight into the photosynthetic activity of vegetation. From observations of R, vegetation variables such as Leaf Area Index (LAI), pigment composition, and the leaf orientation can be estimated. In addition to these variables, SIF also depends on the quenching of fluorescence in the light harvesting complexes associated with photosynthesis. From R and SIF combined, the quantum efficiency of the fluorescence emission (FQE) can be retrieved, a key state variable in the light harvest and energy dissipation in the vegetation.

We present results of joint retrievals from SIF and R in the context of the Vegetation-CCI+ project as part of the ESA-CCI program. For selected sites globally, we retrieve FQE jointly with the fraction of absorbed photochemically active radiation (fAPAR) and other vegetation variables, using a SIF product based on TROPOMI on Sentinel-5p and top-of-canopy (TOC) reflectance data of a suite of multi-spectral satellite missions. For the retrieval at 1/1120 spatial resolution, we used OptiSAIL, an efficient system for Bayesian retrieval, which includes code from automatic differentiation for the efficient computation of gradient, Jacobian and Hessian. It combines the canopy model SAIL, with the leaf models PROSPECT and FLUSPECT, the snow model TARTES, a bi-directional soil reflectance model, and a (residual) cloud contamination model. OptiSAIL-SIF is set up in dual resolution mode. We minimize a cost function that includes the difference between modelled and measured reflectance and SIF on the coarser TROPOMI pixels, and deviations of the posterior estimates of vegetation variables from their prior. We use a moving window of 10-days to select from clear sky reflectance observations, and daily inputs of SIF. The algorithm also provides a SIF product corrected for variations across-track variations in viewing angle on the fine grid. We show the evolution of the algorithm development, and results of FQE and fAPAR for different

ecosystems. We analyse the seasonal cycle and present ways forward toward estimating photosynthesis rates from these data products.

AN INTEGRATED FRAMEWORK COUPLING GEOMETRIC-OPTICAL AND SPECTRAL INVARIANTS FOR CANOPY FLUORESCENCE ANISOTROPY MODELING

Yachang He^{1,2}, Yelu Zeng^{1,2,*}

¹College of Land Science and Technology, China Agricultural University, Beijing 100083, China

²Key Laboratory of Remote Sensing for Agri-Hazards, Ministry of Agriculture and Rural Affairs, Beijing 100083, China

*Correspondence: zengvelu@163.com

The spectral invariants theory (-theory) has received much attention in the field of quantitative remote sensing over the past few decades and has been adopted for modeling of canopy solar-induced chlorophyll fluorescence (SIF). However, the spectral invariant properties (SIP) in simple analytical formulae have not been applied for modeling canopy fluorescence anisotropy primarily because they are parameterized in terms of leaf total scattering, which precludes the differentiation between forward and backward leaf SIF emissions. We have developed the canopy-SIP SIF model by combining geometric-optical (GO) theory to account for asymmetric leaf SIF forward and backward emissions at the first-order scattering and by modeling multiple scattering based on the -theory. The applicability of the model simulations especially over 3D heterogeneous canopies was improved by incorporating canopy structure through multi-angular clumping index, and by modeling single scattering from the four components of the scene in view according to the GO approach. The results show good consistency with both the state-of-the-art SIF models and multi-angular field SIF observations over grass and chickpea canopies. The coefficient of determination (R^2) between the simulated SIF and field measurements was 0.75 (red) and 0.74 (far-red) for chickpea, and 0.65 (both red and far-red) for grass. The average relative error was approximately 3% for 1D homogeneous scenes when comparing the canopy-SIP SIF model simulations to the SCOPE model simulations, and around 4% for the 3D heterogeneous scene when comparing to the LESS model simulations. The results indicate that the proposed approach for separating asymmetric leaf SIF emissions is a robust way to keep a balance between satisfactory simulation accuracy and efficiency. This study presents a simple but efficient analytical approach for canopy fluorescence modeling, with potential for large-scale canopy fluorescence simulations.

DEPLOYMENT OF A CALIBRATION STATION FOR SATELLITE-BASED OBSERVATIONS OF GREENHOUSE GASES AND AEROSOLS

A. Calle^{1,2,*}, R. González^{1,2}, O. García³, R. Carracedo^{1,2}, D. Mateos^{1,2}, R. Román^{1,2}, C. Toledano^{1,2}, V. Cachorro^{1,2}, A. de Frutos^{1,2}, R. Ramos³ and C. Torres³

¹Atmospheric Optics Group of University of Valladolid.

²Laboratory of Disruptive Interdisciplinary Science (LADIS).

³Izaña atmosphere observatory, AEMET.

*Correspondence: abel.calle@uva.es (Tel.: +34 983423758)

The current international strategy to mitigate the effects of climate change requires precise knowledge of greenhouse gas (GHG) concentrations, a goal toward which the development of satellite-based sensors is directed. These sensors, in turn, require robust in situ data to validate their products. Among the sensors focused on GHG monitoring are IASI (Infrared Atmospheric Sounding Interferometer), TROPOMI (TROPOspheric Monitoring Instrument), OCO-2 and OCO-3 (Orbiting Carbon Observatory), and GOSAT (Greenhouse Gases Observing Satellite). Regarding aerosol products that can be validated, MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS (Visible Infrared Imaging Radiometer Suite)

are particularly noteworthy.

The Low Atmosphere Research Centre of the University of Valladolid (CIBA-UVa) has joined the international greenhouse gas measurement networks ICOS (Integrated Carbon Observation System) and COCCON (Collaborative Carbon Column Observing Network). Within ICOS, CIBA has been designated as the third Class 2 atmospheric station, following the Izaña Observatory on the island of Tenerife, operated by the Spanish State Meteorological Agency (AEMET), and the El Arenosillo Experimental Station in Huelva, managed by the National Institute for Aerospace Technology (INTA). CIBA is the first continental-type station in Spain located in a rural environment isolated from urban and 100 m for measuring CO₂, CH₄ and CO, as well as meteorological variables such as temperature, areas, and it is equipped with a 100 m tower. The station features a gas analyzer with air inlets at 10, 50, relative humidity, and wind parameters.

In addition, CIBA is equipped with further instrumentation, including a 15 km ceilometer, an all-sky camera for real-time cloud cover analysis, a CIMEL sun photometer integrated into the AERONET network, an FTIR spectrometer for the quantification of trace gas total column amounts, and several infrared radiometers (8–14 µm) for the validation of satellite-derived land surface temperature products.

Therefore, CIBA integrates the two key factors identified by the Intergovernmental Panel on Climate Change (IPCC) for climate change studies—greenhouse gases and aerosols (including both their properties and their interactions with clouds)—and will serve as a validation site for satellite products related to major greenhouse gases and aerosols.

REMOTREES: A NOVEL IN-SITU MONITORING TECHNOLOGY FOR HARD-TO-REACH FORESTS SUPPORTING EO LAND PRODUCT VALIDATION

F. Camacho¹, E. Martínez-Sánchez¹, J. Sánchez-Zapero¹, Davide Andreatta², Luca Belelli Marchesini², Luca Salvino², Loris Vescovo², Cristian Mestre Runge³, Lars Opgenoorth³, Benjamin Brede⁴, Christoph Lotz⁴, Riccardo Valentini⁵

¹ EOLAB, Spain;

² Fondazioni Edmund Mach (FEM), Italy;

³ Philipps-Universität Marburg, Germany;

⁴ GFZ Helmholtz Centre for Geosciences, Germany;

⁵ Nature 4.0, Italy

* Correspondence: fernando.camacho@eolab.es (Tel.: +34 - 963769448).

Forests play a key role in the Earth climate system. However, the extent and severity of climate change impacts remain uncertain due to the lack of in-situ data, particularly in hard-to-reach areas characterized by strong logistical limitations. Recent advances in Internet of Things (IoT) technologies, satellite connectivity, and energy harvesting systems are opening new opportunities for the deployment of autonomous in-situ monitoring devices in standalone configurations.

The aim of the Horizon Europe RemoTrees project is to design and develop an innovative, autonomous in-situ monitoring system tailored for remote forest environments, capable of transmitting data via satellite communication to a dedicated platform. Within this framework, RemoTrees enables the in-situ measurement of up to four Essential Climate Variables (ECVs), including the fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Leaf Area Index (LAI), soil moisture, and above-ground biomass change. Additional variables such as stem growth, stem moisture, sap flow, canopy transmittance, and meteorological parameters are also acquired. RemoTrees, thus, aims to strengthen the Copernicus in-situ component, supporting the calibration and validation of Earth Observation (EO) products.

This work presents preliminary results based on RemoTrees (RT) data collected at Level 1 (L1) sites, where the system is currently being tested prior to deployment at Level 2 (L2) sites worldwide. The analysis focuses on spectral measurements acquired above and below the canopy using the cyberRadiation, cyberTrunk and cyberSoil devices. Canopy multispectral transmittance is derived from relative measurements

between above- and below-canopy sensors. Based on these measurements, photosynthetically active radiation (PAR) and canopy transmittance are estimated. fAPAR is derived using a two-flux approach based on incident and transmitted radiation. LAI is retrieved either assuming a Beer–Lambert extinction law or, alternatively, by using hemispherical photography to calibrate LAI–fAPAR relationships.

RT-derived LAI and fAPAR estimates are compared against hemispherical digital photography (as a reference approach) and Sentinel-2/MSI LAI and fAPAR products. At this stage, the analysis is limited to preliminary assessments of data quality, consistency, and feasibility.

ASSESSMENT OF GOOGLE EARTH ENGINE APPLICATIONS TO GENERATE LAND SURFACE TEMPERATURE MAPS AT HIGH SPATIO-TEMPORAL RESOLUTIONS.

Vicente Garcia-Santos, Alejandro Buil, Juan Manuel Sánchez, César Coll, Raquel Niclòs, Jesús Puchades, Martí Perelló, Lluís Pérez-Planells, Joan Miquel Galve and Enric Valor

Department of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Av. Vicent Andrés Estellés, 19, 46100 Burjassot, Spain

Current satellite-derived Land Surface Temperature (LST) products exhibit a persistent trade-off between spatial and temporal resolutions. High-resolution data (approx. 100 m) are typically available only bi-weekly, while daily products are limited to a 1 km resolution. Such constraints hinder applications in high-precision agriculture and urban climate mitigation, where LST maps at 50–100 m every few days are required. To address this, various disaggregation techniques have been developed; however, their complexity and reliance on extensive external inputs often limit practical implementation. To date, only two operative 10 m downscaled LST systems are available to end-users via Google Earth Engine (GEE): Daily Ten-ST-GEE and LST-downscaling-GEE. This study presents a critical benchmark by performing the first direct intercomparison and rigorous in situ validation of these two systems using field campaign data from contrasting agricultural sites in Spain. While both methods showed strong correlations, with R² values of 0.74 for Daily Ten-ST-GEE and 0.94 for LST-downscaling-GEE, the former performed poorly in highly heterogeneous landscapes (RMSE of 5.8 K). Consequently, LST-downscaling-GEE emerged as the more robust solution (RMSE of 3.6 K) for generating high-spatiotemporal-resolution LST products.

HIGH-RESOLUTION MODELLING OF LAND SURFACE TEMPERATURE DYNAMICS USING MULTI-ANNUAL ECOSTRESS AND LANDSAT DATA

Lluís Pérez-Planells^{1}, Frank-M. Göttsche², Jan Cermak²*

¹Mediterranean Center for Environmental Studies (CEAM), Meteorology and Climatology Area, Paterna, Spain.

²IMKASF, Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz ¹, 76344 Eggenstein-Leopoldshafen, Germany

**Correspondence: lluis@ceam.es (Tel.: +34 660 252 865)*

Land surface temperature (LST) is a key variable for describing surface thermal behavior and surface–atmosphere exchanges across a wide range of environments. However, capturing LST variability consistently across both seasonal and diurnal timescales at high spatial resolution remains challenging, particularly when observations are irregular in time or acquired by sensors with different orbital characteristics. In this context, approaches that summarize LST dynamics using a compact set of physically meaningful parameters offer an efficient way to characterize average thermal behavior from multi-sensor observations.

In this study, a combined annual-diurnal temperature cycle (ADTC) model was applied to a merged high-resolution dataset of ECOSTRESS and Landsat 8/9 LST observations acquired between 2018 and 2023.

The analysis was conducted over four European study areas with contrasting environmental conditions: Karlsruhe (Germany), Paris (Paris), Madrid (Spain), and Valencia (Spain). The model represents typical annual and diurnal LST variability using five parameters describing annual minimum temperature, annual amplitude, maximum daily amplitude, mean thermal noon, and phase lag with respect to the summer solstice. Because acquisition time is explicitly included as an independent variable, the model can be fitted to irregularly sampled observations, making it suitable for the joint use of ECOSTRESS and Landsat data. The obtained high-resolution parameters were spatially upscaled and evaluated against corresponding MODIS-derived LSTs.

Results show that the merged ECOSTRESS–Landsat dataset supports ADTC modelling at 70 m spatial resolution with an overall root mean square error (RMSE) of 3.8 ± 0.7 K between model LST and satellite LST. Comparison with model parameters obtained for MODIS showed good agreement for annual minimum temperature, annual amplitude, mean thermal noon and fit RMSE, with robust RMSE values of 1.6 K, 2.0 K, 0.2 h, and 0.4 K, respectively. Larger discrepancies were obtained for maximum daily amplitude and annual phase lag, with robust RMSE values of 6.5 K and 6.8 days. These differences are mainly attributed to the limited number of high-resolution observations around thermal noon, which reduces the accuracy of parameters linked to maximum temperature.

Beyond the quantitative evaluation, the ADTC parameters clearly captured differences between water bodies, forests, croplands, and artificial surfaces, and also reflected topographic effects on LST dynamics. The results demonstrate that merged high-resolution thermal infrared observations can provide a concise and physically interpretable description of average LST behavior, which holds significant potential for surface thermal characterization and monitoring next-generation thermal satellite missions.

VALIDATION OF THE KP LABS MULTI-CLASS CLOUD SEGMENTATION PROCESSOR AND ITS COMPARISON TO THE SENTINEL-2 L2A SCENE CLASSIFICATION MAP

E. Padilla^{1,}, B. Grabowski², K. Kotowski², J. Nalepa^{2,3}, R. de los Reyes¹, D. Marshall-Ingram¹, S. Clerc⁴, S. Enache⁵, J. Louis⁶, F. C. Pignatale⁷, L. De Laurentiis⁸, V. Boccia⁸, F. Gascon⁸*

¹German Aerospace Center (DLR), Earth Observation Center (EOC), Germany

²KP Labs, Poland

³Silesian University of Technology, Poland

⁴ACRI-ST, France

⁵CS Group, France

⁶Telespazio France, France

⁷Telespazio Germany GmbH, Germany

⁸European Space Agency (ESA), European Space Research Institute (ESRI), Italy

*Correspondence: Efrain.Padilla@dlr.de. (Tel.: +49 1525 7832618)

New classifiers developed using machine-learning techniques, designed for global-monitoring applications face the challenge of generalizing across a wide variety of biomes and across seasonal changes. Satellite images offer large, potentially global spatial scalability, but they might be contaminated by clouds – such cloudy images can be removed from further downstream processing and downlinking. Therefore, building accurate cloud segmentation algorithms are of practical importance, and may be used as smart onboard/on-the-ground data selection/compression steps. In this context, and as part of the Artificial Intelligence for Quality Control (AI4QC) activity supported by the European Space Agency (ESA), KP Labs recently developed a deep learning classifier built upon the Automated Machine Learning (AutoML) paradigms. Operating on all spectral bands of Sentinel-2 imagery, the classifier produces multi-class cloud-classification products at 10-meter spatial resolution, providing the following classes: clear-sky, thick cloud, thin cloud, and cloud shadow.

Validation is performed using two reference datasets: fixed-sites, comprising 12 scenes from five fixed locations that represent five different biomes, and random-sites, comprising 13 randomly selected

scenes from around the globe. Both datasets cover a wide variety of biomes captured across multiple seasons in 2024 by the Sentinel-2 mission. These datasets were manually annotated by an expert through photointerpretation, comprehending ~677.000 reference pixels. They test the classifier's performance under diverse land-surface conditions (bare soil, vegetation, water, snow) and atmospheric conditions. Validation results are compared with the Scene Classification Layer (SCL) of the baseline Sen2Cor processor, which is distributed in the L2A products of the Sentinel-2 mission. Robust performance metrics for imbalanced classification, such as the Normalized Matthews Correlation Coefficient (nMCC), are used, ranging from 0 (total misclassification) to 1 (perfect prediction), with 0.5 indicating no better performance than random guessing. In addition, misclassification patterns are analyzed with confusion matrices, spider plots, and a qualitative assessment through visual inspection.

The results show an overall improvement over Sen2Cor of +1 percentage point (p.p.) (from 0.89 to 0.90 in nMCC) for the fixed-sites dataset. In the other hand, a significant improvement of +5 p.p. (from 0.86 to 0.91 in nMCC) was observed for the random-sites dataset, with the greatest gain for the cloud-shadow class (+9 p.p., from 0.87 to 0.96). The qualitative assessment indicates a general reduction in noise within the classification maps, likely due to the ability of the classifier to appropriately capture spatial-spectral features of the Sentinel-2 image data, and suggests specific improvements such as better cloud-shadow detection over snow. These results translate to better filtering for downstream analysis applications and improved decision making.

VALIDATION OF THE GLOBAL 300M LAND SURFACE PHENOLOGY V2 PRODUCTS OF THE COPERNICUS LAND MONITORING SERVICE

J. Sánchez-Zapero¹, F. Camacho¹, E. Martínez-Sánchez¹, L. Eklundh², H. Jin², R. Lacaze³, D. de Munck⁴, D. Bekaert⁴

¹ EOLAB, Spain;

² Lund University, Sweden;

³ HYGEOS, France;

⁴ VITO, Belgium

* Correspondence: jorge.sanchez@eolab.es (Tel.: +34 963769448)

The Copernicus Land Monitoring Service (CLMS) provides a series of qualified bio-geophysical products on the status and evolution of land surface. The products are used to monitor vegetation, crops, water cycle, energy budget and terrestrial cryosphere. Production and delivery take place in a timely manner and are complemented by the constitution of long-term time series. The CLMS portfolio has recently included an annual global Land Surface Phenology (LSP) V2 product at 300 m resolution, based on PROBA-V (2014-2018) and Sentinel-3 OLCI acquisitions from 2019 to the present. CLMS LSP V2 provide a total of 13 vegetation phenology and productivity (VPP) parameters, derived for up to two growing seasons annually. The parameters are calculated from smooth seasonal trajectories of the plant phenology index (PPI), which is obtained from Bidirectional Reflectance Distribution Function (BRDF)-adjusted nadir surface reflectance data at 5-day frequency.

This study presents the validation results of CLMS LSP V2, with focus on the Start (SOSD) and the End (EOSD) Of the Season Dates. A robust validation approach is applied, combining phenology observations, near-ground-based estimates, and satellite-derived products. The evaluation includes in situ datasets from the Pan-European Phenology Project (PEP725), TEMPO over France, and the U.S. National Ecological Observatory Network (NEON), as well as the Ecosystem Phenology Camera (PhenoCam) V3 phenometric estimates. In addition, CLMS LSP V2 is intercompared against NASA MODIS V6.1 and VIIRS V2 LSP at global scale.

CLMS LSP V2 shows strong spatial and temporal consistency between PROBA-V and OLCI, with no significant discontinuities across the sensor transition. CLMS LSP V2 parameters are also spatially consistent with MODIS V6.1 and VIIRS V2 over large areas. Inter-annual precision shows mean absolute deviation (MAD) values of 6–9 days for SOSD, and 7–9 days for EOSD. Precision is comparable to, or better than, MODIS V6.1 and VIIRS V2, ensuring robust multi-year consistency.

Validation against PEP725, TEMPO, NEON, and PhenoCam V3 confirms that CLMS LSP V2 reliably captures the timing of phenological transitions. SOSD is typically slightly later than observations, with biases mainly ranging from -3 to +9 days, while EOSD is slightly earlier, with biases between -18 and +5 days, resulting in marginally shorter growing seasons. These differences are partially expected due to satellite phenophase definitions compared to diverse in-situ phenophase observations.

Overall, CLMS LSP V2 is a consistent, accurate, and robust global vegetation phenology and productivity dataset, suitable for environmental monitoring.

CLMS GLOBAL 300 M LAI, FAPAR AND FCOVER FROM PROBA-V TO SENTINEL-3: REPROCESSED 2014–2024 TIME SERIES AND NEAR-REAL-TIME MONITORING

A. Verger^{1,2}, J. Sánchez-Zapero³, M. Weiss⁴, E. Martínez-Sánchez³, F. Camacho³, A. Descals², S. Schauman^{2,1}, F. Barer¹, R. Lacaze⁵*

¹CIDE, CSIC-UV-GVA, 46113 València, Spain

²CREAF, 08193 Cerdanyola del Vallès, Catalonia, Spain

³EOLAB, Savina ⁸ A4, 46980 Paterna, València, Spain

⁴INRAE UMR114 EMMAH, Domaine Saint-Paul, Site Agroparc, 84914 Avignon, France

⁵HYGEOS, Euratechnologies, 165 Avenue de Bretagne, 59000 Lille, France

*Correspondence: verger@csic.es

The Copernicus Land Monitoring Service (CLMS) delivers operational global vegetation biophysical products at 300 m resolution, including leaf area index (LAI), fraction of absorbed photosynthetically active radiation (FAPAR), and fractional vegetation cover (FCOVER). A fully reprocessed version (V2) of the LAI, FAPAR and FCOVER Collection 300 m products has recently been generated. The dataset covers the 2014–2024 period using observations from PROBA-V and Sentinel-3/OLCI, and is complemented by an operational near-real-time production updated every 10 days.

This new collection benefits from improved input data, including enhanced cloud and snow screening for PROBA-V and corrections of geolocation issues in Sentinel-3 surface reflectance, as well as algorithm refinements. These updates result in improved spatial consistency and temporal stability. The retrieval approach relies on machine learning techniques applied to surface reflectance, followed by temporal filtering, smoothing and compositing to ensure robust, continuous and near-real-time estimates.

A comprehensive validation exercise was conducted following standardized protocols, including comparisons with satellite-based reference datasets, direct evaluation against ground measurements, and analysis of temporal consistency across sensors. Results indicate overall good agreement with independent products, with typical RMSD values of ~0.76–0.96 for LAI, ~0.10 for FAPAR, and ~0.12 for FCOVER, particularly against NASA VIIRS and LSA SAF products. Validation against ground-based datasets confirms strong correlations, moderate bias, and low uncertainties (e.g., RMSD ~0.7–0.9 for LAI; ~0.06–0.07 for FAPAR; ~0.07–0.1 for FCOVER, based on upscaled reference maps from DIRECT2.1 and GBOV v3.5). The products show high intra-annual precision and competitive inter-annual stability, generally matching or exceeding the performance of existing global datasets.

The transition between PROBA-V and OLCI shows high consistency during the overlap period, although a systematic positive shift in magnitude is observed, particularly for high LAI values over Evergreen Broadleaf Forest (EBF). In these regions, PROBA-V retrievals tend to exhibit higher noise and slight underestimation, while the more stringent cloud screening in Sentinel-3 leads to more stable high LAI values.

The near-real-time production is delivered every 10 days and progressively consolidated over a 60-day period through successive updates (RT0, RT1, RT2, RT6). The initial estimates (RT0) may exhibit higher noise and occasional artefacts, especially in persistently cloudy regions, while subsequent consolidation steps significantly improve temporal consistency, reduce noise, and enhance spatial completeness. Product values rapidly converge towards the fully consolidated RT6 estimates, with the largest improvements typically observed after the first update.

Overall, the CLMS 300 m V2 products offer a consistent and reliable global record of vegetation dynamics, supporting a wide range of environmental and climate applications and informed decision-making.

EARTHCARE OBSERVATIONS OF THE EXTREME WILDFIRE AEROSOLS OVER THE IBERIAN PENINSULA DURING SUMMER 2025

Saül Cogollos¹, José Luis Gómez-Amo^{1,}, Carmen Dameto de España¹, Pedro D. Villarroya¹, Waira Moná¹, Pedro C. Valdelomar¹, María Pilar Utrillas¹*

¹Solar Radiation Group, Dpt. de Física de la Terra i Termodinàmica, Universitat de València, Burjassot, Spain.

*Correspondence: jose.l.gomez-amo@uv.es (Tel.: +34 963543313)

The year 2025 recorded the largest burned area due to wildfires in the historical series of the Iberian Peninsula, despite exhibiting a lower number of fire events compared to other years. Carbon emissions during spring and early summer 2025 remained well below the historical average; however, they increased dramatically during the short period 10–22 August 2025, nearly doubling the historical maximum. This sharp increase coincided with the near-simultaneous ignition of numerous wildfires across northwestern Spain and northern Portugal. The resulting emissions were transported across the entire Iberian Peninsula following a close-wise circulation pattern, initially affecting the northeastern regions, then the Mediterranean basin, and finally reaching the southern and southwestern areas. During this episode, daily surface concentrations of particulate matter (PM_{2.5}) exceeded $500 \mu\text{g m}^{-3}$, far surpassing the European air quality limit of $50 \mu\text{g m}^{-3}$. Furthermore, outputs from the European Centre for Medium-Range Weather Forecasts (ECMWF) model suggest that these emissions may have been coupled with long-range transported aerosols originating from large wildfire events in Canada. This transcontinental transport produced extreme aerosol optical depth (AOD) values at several AERONET stations across the Iberian Peninsula, with values reaching up to AOD = 3 over the Mediterranean region.

This study presents the first quantitative wildfire observations based on data from the EarthCARE space mission, launched in 2024 and specifically designed to observe atmospheric aerosols and clouds in order to address key uncertainties regarding their effects on the climate system. The main objectives are: a) to characterize the vertical distribution and temporal evolution of the optical properties of wildfire smoke over the Iberian Peninsula, and b) to disentangle the relative contributions of long-range transported versus local wildfire emissions. To achieve these goals, we analyze measurements from the ATmospheric LIDar (ATLID) instrument, including vertical profiles of backscatter and extinction coefficients, lidar ratio (LR), and particle volume depolarization ratio (PVDR). These observations are complemented by backward trajectory analyses at multiple altitudes corresponding to six EarthCARE overpasses over the Iberian Peninsula during the study period (15, 17, and 19 August 2025).

The results reveal a clear vertical separation between aerosol sources. Long-range transported emissions are predominantly detected above 6 km altitude, particularly over northern Iberian Peninsula and the Mediterranean region, whereas locally generated smoke remains confined below 6 km. The presence of long-range transported aerosols coincides spatially with the regions experiencing the highest AOD values. Retrieved LR values for smoke range between 63 and 73 sr, consistent with previous studies, and show no significant dependence on altitude. In contrast, PVDR exhibits a strong vertical variability: values below 6 km remain under 0.11, in agreement with typical biomass-burning aerosol characteristics, while higher PVDR values above 6 km suggest possible interactions between transported smoke and ice clouds. These findings highlight the added value of EarthCARE observations for understanding the vertical structure and origin of extreme wildfire aerosol events.

SPATIOTEMPORAL TRENDS OF SOIL MOISTURE OVER THE IBERIAN PENINSULA FROM ESA CCI SATELLITE DATA (1988–2024)

Gala Tomás-Portalés^{1,*}, Raquel Nicolòs¹, Enric Valor¹

¹*Thermal Remote Sensing Group, Department of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia (UV), 19, Av. Vicent Andrés Estellés, 46100 Burjassot, Spain.*

**Correspondence: gala.tomas@uv.es (Tel.: +34 963 543 249)*

Soil moisture (SM) is a key climate variable regulating water and energy exchanges between the land surface and the atmosphere and plays a central role in ecosystem dynamics, hydrological processes, and climate feedbacks. Mediterranean regions such as the Iberian Peninsula are particularly vulnerable to climate variability and global change, making long-term monitoring of SM essential. This study analyses the spatiotemporal evolution of near-surface SM across the Iberian Peninsula over the 1988–2024 period using satellite remote sensing data.

The analysis relies on the ESA Climate Change Initiative (CCI) combined SM product, which merges multiple active and passive microwave sensors to provide a consistent long-term record at 25 km spatial resolution. After applying a rigorous quality control based on retrieval uncertainty thresholds and data availability, SM trends were assessed at the pixel scale using robust non-parametric statistical methods. Trend detection was performed with the Mann–Kendall test, while trend magnitude was quantified using the Theil–Sen slope estimator. To ensure reliable results, additional methodological refinements were implemented, including minimum data coverage thresholds, accounting for seasonal dependence, and correction for serial correlation.

Results reveal an overall moderate but persistent decline in SM across the Iberian Peninsula. Although spatially dispersed, negative trends exhibit a higher density in the southeastern regions and along the Ebro Basin, areas already characterized, respectively, by semi-arid conditions and high vulnerability to water stress. Seasonal analyses reveal that SM decreases are most pronounced during spring and summer, coinciding with enhanced evapotranspiration and increasing temperatures. In contrast, winter exhibits a slight increase in SM, while autumn shows a weakening of its traditional role as a recharge season. An assessment of extreme values highlights a progressive compression of the SM range, with decreasing maxima and stable or slightly increasing minima, suggesting a reduction in infiltration efficiency and altered recharge dynamics.

Possible relationships between SM trends and other environmental variables, including vegetation and precipitation-related indicators, were also explored. In general, these associations are weak and partly inconclusive, likely reflecting differences in spatial resolution, temporal coverage, and surface heterogeneity.

Overall, this study provides consistent observational evidence of a long-term decline in SM over the Iberian Peninsula, in line with projected Mediterranean climate change signals. The findings underline the importance of satellite-based climate data records for regional-scale assessments and support the need for adaptation strategies focused on sustainable water and land management.

This work was carried out within the framework of the project reference UV-INV_AE_4226564 of the own program of the University of Valencia Research Vice-Rectorate, Special Actions call. It was also carried out within the previous projects Tool4Extreme (PID2020-118797RB-I00), funded by the Spanish Ministerio de Ciencia e Innovación and the Agencia Estatal de Investigación (MCIN/AEI/10.13039/501100011033), and PROMETEU/2021/016, funded by the Conselleria d'Educació, Cultura, Universitats i Ocupació of the Generalitat Valenciana. The corresponding author is supported by a predoctoral researcher contract fellowship (CIACIF/2024/071) under the European Social Fund Plus (ESF+) Programme of the Generalitat Valenciana.

DECOUPLING STRUCTURAL AND PHYSIOLOGICAL CONTROLS ON SIF–GPP RELATIONSHIPS USING 3D RADIATIVE TRANSFER AND IN SITU MULTI-SENSOR OBSERVATIONS

Sami Desguets¹, Pascal Fanise¹, Tiphaine Tallec¹, Jean-Philippe Gastellu-Etchegorry¹, Valerie Le Dantec¹

¹CESBIO - UPS, CNES, CNRS, IRD, Université de Toulouse, 31401 Toulouse Cedex 9, France

As drought events increase in frequency and severity, precise monitoring of agroecosystem health is essential. Solar-induced chlorophyll fluorescence (SIF) has emerged as a powerful proxy for gross primary productivity (GPP), providing a direct link to the energy available for carbon fixation. Unlike traditional vegetation indices, SIF responds rapidly to moderate abiotic stress, making it a key indicator of actual photosynthetic activity. However, a major challenge in the SIF–GPP relationship is that the signal measured at the top of the canopy is heavily influenced by 3D architecture, shading, and reabsorption, which can mask purely physiological changes.

The study is conducted at the Auradé agricultural site (43°32'59"N, 1°06'22"E), integrated within the ICOS and Regional Space Observatory networks. This site enables the monitoring of sunflower in 2026. The experimental setup relies on proximal remote sensing using field sensors and prototypes developed at CESBIO to capture optical signals in the 500–800 nm range (Balde, 2023), including the SIF3 instrument, an automated in situ system equipped with dual spectrometers that continuously measures incident radiation, canopy reflectance, and sun-induced chlorophyll fluorescence. These measurements are complemented by a comprehensive suite of in situ instruments to track plant functional status: sap flow sensors to monitor transpiration, and devices to measure Relative Water Content (RWC), Leaf Area Index (LAI), and chlorophyll parameters ([Chla], Fm, Ft). At the ecosystem scale, eddy covariance towers are used to provide ground-truth observations of carbon fluxes derived from eddy covariance to ground-truth GPP estimates, water, and energy fluxes.

To address these uncertainties in the SIF–GPP conversion, this research utilizes a physical scaling approach through 3D radiative transfer (Gastellu-Etchegorry et al., 2017). By decoupling structural effects from the radiometric signal, we isolate the fluorescence quantum efficiency (FQE) at the photosystem level (Regaieg et al., 2025). This allows for a more robust characterization of photosynthetic variations compared to leaf-scale measurements. In addition, this approach was compared with a reflectance-based index (FCVI) to account for PAR absorption and SIF scattering effects (Yang et al., 2020).

DEVELOPMENT OF A HIGH-SENSITIVITY, FAST-ACQUISITION LWIR RADIOMETER FOR AIRBORNE SURFACE TEMPERATURE MAPPING

Nicolas Buis¹, José A. Sobrino²

¹ZeFrog, France.

*²Global Change Unit, Image Processing Laboratory, University of València, 46980 Paterna, Spain
sobrino@uv.es*

A new compact six-band LWIR radiometer is being developed to provide high-sensitivity surface temperature measurements with a significantly reduced integration time. The primary objective is to enable rapid airborne thermal mapping while preserving the radiometric performance required for environmental and climate applications.

The instrument combines high-performance thermopile detectors, optimized Köhler optics and a very low-noise readout architecture based on independent 24-bit analog-to-digital converters for each spectral channel. This design provides a substantial improvement in sensitivity over conventional thermopile radiometers, allowing acquisition rates exceeding six measurement cycles per second without increasing integration time.

The resulting acquisition speed is compatible with airborne surveys at typical UAV or low-altitude

aircraft velocities while maintaining a high longitudinal overlap between successive ground footprints. Such capability is particularly attractive for land surface temperature mapping, as well as inland and coastal water bodies, where both high spatial sampling and radiometric accuracy are essential.

The work presents the instrument concept, the optical and electronic architecture, the expected radiometric performance, and the current status of the prototype, which is presently undergoing laboratory validation.

METHODOLOGY FOR SAR IMAGE RESOLUTION ENHANCEMENT THROUGH THE COMBINATION OF MULTI-SATELLITE ACQUISITIONS

Juan Manuel Cuerda Muñoz*, Marcos García Rodríguez, María José González Bonilla

Instituto Nacional de Técnica Aeroespacial (INTA)

*Correspondence: cuerdamjm@inta.es, (Tel.: 915201703)

The state of the art of spaceborne SAR systems in the scientific field is characterized by a rapid evolution toward more flexible and accurate architectures with enhanced global observation capabilities. From the first single-frequency and single-polarization systems to current multi-band, polarimetric, and interferometric missions, SAR has established itself as a key remote sensing technology due to its all-weather acquisition capability and high spatial resolution.

At present, the field is experiencing a “golden age” marked by the proliferation of low-Earth-orbit constellations and increased temporal revisit capabilities. From a technological perspective, notable advances include the use of digital beamforming techniques, advanced imaging modes, and configurations aimed at simultaneously improving resolution and coverage, as well as interferometric and multistatic configurations, which enable the extraction of increasingly rich geophysical information.

These trends point toward two divergent but complementary development philosophies: high-capability and high-performance systems, characterized by high reliability and long development times, and distributed and cooperative system constellations, offering moderate performance but high replacement capacity and exploiting cooperation among simpler units.

This paper addresses the challenge of achieving high-resolution and wide-coverage systems in low-cost, rapid-development environments by proposing an image formation methodology based on the co-operation of simple instruments, such as those already in operation.

The methodology uses the combination of multiple distributed acquisitions to increase the spatial resolution of a scene by exploiting observations from different sensors under different geometric conditions.

For validation of the methodology, a point-target simulator was developed, the proposed processing scheme was applied, and the impulse response functions of the native acquisitions were compared with that obtained from their combination.

SATELLITE-BASED BIOCLIMATIC CLASSIFICATION AND EVOLUTION OVER PENINSULAR SPAIN

Alejandro García-Ten¹*, Raquel Niclòs¹, Enric Valor¹, Joan Vedri¹, and María José Estrela²

¹*Department of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia*

²*Department of Geography, Faculty of Geography and History, University of Valencia*

*Correspondence: gartena@uv.es (Tel.: +34 644 364 308)

Climate change has reportedly increased stress over mediterranean ecosystems and species. Bioclimatology studies the relationship between climate and the distribution of living beings and their communities on Earth. The bioclimatic classification from Rivas-Martínez et al. (2011) relies uniquely on temperature and precipitation data. Ground weather gauges constitute the most reliable source, but might show uneven geographical distribution and incomplete records. Satellite data can provide continuous, global coverage with good revisit frequency, but their indirect measurement inevitably introduces bias.

Here we have analysed the suitability of satellite data for extracting an appropriate bioclimatic classification over peninsular Spain along the 2002-2020 period and for studying the changes on bioclimatic units between the 2002-2010 and the 2011-2020 periods. Satellite data is constituted by MSWEP V2.8 precipitation product and surface air temperature maps derived mainly from MODIS LST, while reference data are the gauge-based ROCIO_IBEB daily precipitation and temperature grids.

Concordance between satellite and reference bioclimatic classification was always higher than 80% (with missassignment always between consecutive units), and the observed evolution was always towards warmer and more arid conditions. Furthermore, diverse crop yields in some provinces show relation with the local annual ombrothermic index. This is the first study to use satellite data for bioclimatic classification over peninsular Spain.

This work was carried out within the framework of the project UV-INV_AE_4226564 of the own program of the University of Valencia Research Vice-Rectorate, Special Actions call. It was also carried out within the previous projects Tool4Extreme (PID2020-118797RB-I00), funded by the Spanish Ministerio de Ciencia e Innovación and the Agencia Estatal de Investigación (MCIN/AEI/10.13039/501100011033), and PROMETEU/2021/016, funded by the Conselleria d'Educació, Cultura, Universitats i Ocupació of the Generalitat Valenciana. Alejandro García-Ten was hired through a FPU grant funded by Ministerio de Universidades (FPU/22/02807).

STANDARDIZED VALIDATION OF GLOBAL DATA RECORD LAI, FAPAR AND FVC PRODUCTS DERIVED FROM AVHRR ONBOARD THE EUMETSAT POLAR SYSTEM

E. Martínez-Sánchez¹, F. Camacho¹, J. Sánchez-Zapero¹, F.J. García-Haro², M. Campos-Taberner², A. Jiménez-Guisado²

¹Earth Observation Laboratory (EOLAB), Carrer Savina, 8. Paterna, Valencia, Spain (46980).

²Environmental Remote Sensing Group (UV-ERS), Departament de Física de la Terra i Termodinàmica, Facultat de Física, Universitat de València, 46100 Burjassot, Spain.

**Correspondence: enrique.martinez@eolab.es (Tel.: +34 963769448)*

The Satellite Application Facility for Land Surface Analysis (LSA SAF), part of the EUMETSAT SAF Network, provides global land surface products from the EUMETSAT Polar System (EPS) based primarily on AVHRR-3 observations from Meteorological Operational (MetOp) satellites. The University of Valencia has developed an algorithm to retrieve key vegetation variables: the leaf area index (LAI), the fractional vegetation cover (FVC), and the fraction of absorbed photosynthetically active radiation (FAPAR). The algorithm relies on a hybrid approach based on multi-output Gaussian process regression, combining the generalization capabilities of physical radiative transfer models with the accuracy and computational efficiency of machine learning methods. This approach also provides a unified framework applicable to both polar-orbiting and geostationary platforms.

This work presents the main results of the standardized validation of LSA SAF EPS global vegetation data record (EPS VEGA-R) combining data from MetOp-A (2007-2014) and MetOp-B (2015-mid 2021), at 10-day frequency and 1.1 km spatial resolution. EPS VEGA-R is derived from the latest version of the EPS algorithm, operational in near real time since 2015. The standardized validation, compliant with CEOS LPV good practices, evaluates several criteria including completeness, spatial and temporal consistency, accuracy, precision, uncertainty, stability and conformity testing. Several ground-based and satellite-based references were used in this exercise, including Copernicus Land Monitoring Service (CLMS) 1 km V1, Copernicus Climate Change (C3S) V3, and NASA MODIS V6.1, CEOS DIRECT 2.1 and Copernicus GBOV upscaled land products V2.0. A particular attention was put in the transition between MetOpA and MetOp-B, the stability of the time serie and the consistency with the operational estimates.

The results show high consistency between MetOp-A and MetOp-B retrievals, good agreement

with both satellite and ground references, and high temporal stability comparable to NASA products. This temporal stability outperforms that of the Copernicus data records, where the impact of sensor transitions (from SPOT to PROBA-V) is clearly visible. EPS VEGA-R meets the threshold requirement for up to 80% of the GBOV ground-based data and up to 92% of the CLMS V1 satellite-based reference, demonstrating strong overall performance. Moreover, the strong consistency between VEGA-R and the operational production enable the extension of the EPS VEGA time series up to the present (2007–2026), making it highly suitable for long-term studies.

NEAR REAL TIME MONITORING THROUGH REMOTE SENSING WITHIN THE FRAMEWORK OF THE INMESAT PROJECT

Yves Julien, José A. Sobrino, Rafael Llorens and Sergio Gimeno*

*¹Image Processing Laboratory, Scientific Park, University of Valencia,
C/ Catedrático José Beltrán 2, E-46980 Paterna, España.*

**Correspondence: yves.julien@uv.es*

Within the framework of the INMESAT (Indicadores Medioambientales y Fenómenos Adversos en la Comunidad Valenciana usando datos de satélite) project, the Global Change Unit of the University of Valencia has developed several capacities for near real time monitoring of our planet. In 2007, receiving stations for Meteosat Second Generation and MODIS (Moderate Resolution Imaging Spectroradiometer) data were installed in our premises for these purposes, and have been updated for the reception of VIIRS (Visible Infrared Imaging Radiometer Suite) data in 2013. Recently, with the launch of Meteosat Third Generation (MTG) first satellite, we updated our reception system so as to be able to receive these data. Additionally, we recently implemented an automatic processing chain for change detection from Sentinel-2 MSI (Multispectral Instrument) data. In this work, we will focus on these two novel implementations.

In a first step, we describe the receiving station for MTG-FCI (Flexible Combined Imager) data and its processing chain, which provides in near real time different biophysical parameters. Since this instrument provides data every 10 minutes for half the globe at 1 to 2 km spatial resolution (at nadir), this processing has to be highly efficient to provide validated results within 5 minutes of image completion. This automatic processing chain provides a fire detection mask, as well as NDVI (Normalized Difference Vegetation Index) and surface temperature for both land and sea based on the split-window approach. All these parameters need a previous correction from atmospheric effects, carried out with the RTTOV software. The correct functioning of this processing chain is continuously monitored, and its results are automatically uploaded to a dedicated webpage: <https://www.uv.es/iplsat/index.html>.

As for the Sentinel-2 MSI automatic processing chain, it focuses on change detection, with the aim of providing rapid post-disaster assessment data in the Valencian Region. In this case, changes between latest data and a previous reference are identified in the 10 S2-MSI tiles covering the area, and mapped so that a dedicated operator can provide a rapid refined analysis for relevant disasters. The main changes detected regard floods and forest fires, although any change in vegetation (through NDVI) and color are mapped. For floods, the extent of the disaster can be assessed by mapping the resulting mud extent, and its severity in the case of forest fires. Both automated and operator produced results are uploaded to a dedicated webpage: <https://www.uv.es/777Dxw6NiQtJw=/desastres.html>.

In both cases, quantitative validation is to be carried out as more data are processed. The resulting products are intended for educational purposes, as well as for decision making and public information after disasters, when rapid data are most highly needed.

This research was funded by the European Union and the Government of the Valencian Community through the project “Indicadores medioambientales y fenómenos adversos en la Comunidad Valenciana usando datos de satélite,” under the PROMETEO 2023 funding programme (CIPROM/2023/42), and by Project PID2023-150737OB-I00, funded by MICIU/AEI/10.13039/501100011033 and by FEDER, EU.

EARTHWATCH: BRIDGING EARTH OBSERVATION SCIENCE AND DECISION SUPPORT

*Alexandre Verger^{*1}, Estrella Olmedo², on behalf of the 100+ EarthWatch members*

¹ CIDE, CSIC-UV-GVA, 46113 València, Spain

² ICM, CSIC, 08003 Barcelona, Spain

** Corresponding author; E-Mail: verger@csic.es*

Earth Observation (EO) is entering a new era driven by the unprecedented availability of satellite data, advances in artificial intelligence (AI), cloud and high-performance computing, and the growing demand for evidence-based decision making. EarthWatch has been established as a new research network under the Conexión programme of the Spanish National Research Council (CSIC) to help address these challenges by bringing together the Earth Observation community within a coordinated scientific framework that connects researchers, research infrastructures, operational services and public stakeholders. Building upon previous collaborative initiatives in remote sensing, EarthWatch extends its scope beyond environmental applications by integrating expertise from Earth sciences, marine sciences, archaeology, social sciences, artificial intelligence and data science. The initiative currently brings together more than 100 researchers from CSIC institutes, universities and strategic partners, fostering interdisciplinary collaboration and increasing the societal impact of EO.

Beyond traditional environmental monitoring, EO is increasingly expected to provide operational information supporting public policies, climate adaptation, natural hazard management, territorial planning and socioeconomic analysis. Realizing this potential requires moving from isolated thematic applications towards integrated, interoperable and multidisciplinary ecosystems capable of combining physical, biological and social information.

The scientific strategy of EarthWatch is organized around four complementary pillars: (i) establishing a national scientific node capable of coordinating EO activities and strengthening interactions with national and international space agencies; (ii) developing a shared AI-enabled computational ecosystem supporting FAIR data management, cloud processing and scalable analysis of multi-source EO datasets; (iii) promoting advanced applications addressing major societal challenges, including water resources, natural hazards, infrastructure resilience, cultural heritage, ecosystem monitoring and territorial planning; and (iv) fostering international collaboration, training and technology transfer to accelerate innovation and operational deployment. These activities aim to support the development of Digital Twins and next-generation EO services integrating satellite observations with numerical models and socioeconomic information.

This contribution presents the scientific vision underpinning EarthWatch and its organizational framework for transforming fragmented EO capabilities into an integrated research and innovation ecosystem. Particular emphasis is placed on interoperability, open science, AI-driven analytics and cross-disciplinary collaboration as key enablers for maximizing the societal value of Earth Observation. EarthWatch provides a blueprint for strengthening coordination across the EO community and for bridging Earth Observation science, operational services and evidence-based decision making.

SIRIUS: A Small-Satellite Thermal Infrared Mission Concept for Urban Heat Island Monitoring

José Antonio Sobrino¹ on behalf of the SIRIUS Team

*¹ Global Change Unit, Image Processing Laboratory, University of València, 46980 Paterna, Spain
sobrino@uv.es*

SIRIUS was proposed as a candidate ESA Scout mission to advance the understanding of Urban Heat Island (UHI) processes through repeatable night-time thermal infrared observations over selected cities and multi-angle acquisitions with controlled viewing geometry. The mission concept was based on a small agile satellite carrying a compact uncooled thermal infrared imager (Smart-TIRI) with three longwave

infrared (LWIR) bands centred at approximately 8.85, 10.6, and 12.0 μm . This spectral configuration was designed to enable the joint retrieval of land surface temperature and emissivity (LST/LSE) using a temperature–emissivity separation (TES) approach. With a spatial sampling of 64 m and an approximately 64 km swath, SIRIUS was designed to provide a dedicated suite of products for urban thermal analysis, from Level 1 observations to Level 2 LST/LSE and Level 3 products, including surface urban heat island (SUHI) intensity, Urban Thermal Field Variance Index (UTFVI), hot-spot detection, and discomfort indices. The combination of night-time observations, multi-angle capabilities, and dedicated urban thermal products was conceived to provide complementary information to forthcoming and planned thermal missions such as LSTM, TRISHNA, and SBG. The SIRIUS concept demonstrates the potential contribution of agile small-satellite thermal missions to the characterization and monitoring of urban thermal environments.

PERFORMANCE ASSESSMENT OF LANDSAT 8/9 AND ECOSTRESS LST PRODUCTS OVER SNOW IN MOUNTAIN TERRAIN

Sara Arioli¹, Ghislain Picard², Simon Gascoin³, Laurent Arnaud²

¹Université de Strasbourg, SERTIT-ICube-UMR, Illkirch, France

²Université Grenoble Alpes, CNRS, IGE, 38000 Grenoble, France

³Université de Toulouse, CNRS, CNES, IRD, INRAE, Centre d'Études Spatiales de la Biosphère, Toulouse, France

Thermal InfraRed (TIR) satellite observations of the surface temperature of snow provide fundamental information about changes in mountain ecosystems and can unlock the estimation of water resources stored in mountain snowpacks. Still, their use in cryospheric science has been limited, mainly because of the low availability of high-resolution TIR acquisitions. The upcoming launch of the CNES/ISRO mission TRISHNA, the ESA mission LSTM and the advent of multiple private constellations of satellites, all acquiring images in the TIR domain, will potentially solve the availability issue. Yet, the limited evaluation of TIR satellite products over snow covered areas still compromises the quantitative exploitation of these acquisitions, especially over complex topography, where the presence of altitudinal changes and slopes complexifies the radiative transfer and atmospheric composition. To address this issue, we aim to assess the accuracy of high-resolution Land Surface Temperature (LST) products from Landsat 8, Landsat 9, and ECOSTRESS in a snow-covered Alpine site. The validation dataset consists of maps of the snow surface temperature acquired with a TIR camera over two winter seasons, and was thoroughly and continuously validated against high-accuracy TIR radiometers in different points of the camera's field of view. The results of the assessment show a general warm bias (mean absolute error) across all LST products compared to in-situ validation measurements. For Landsat Collection 2 LST products, a +1.06 K bias was found, which is in line with previous studies performed on warmer surfaces and well within the 2% expected accuracy. Results for ECOSTRESS Version 1 LST show a slightly higher bias of +1.24 K that exceeds the declared accuracy goals of the ECOSTRESS LST product, but marks an overall satisfactory performance for an instrument designed to operate over warm surfaces. In addition to previously known calibration issues for temperatures below 295 K, we identified a potential additional source of error in the low emissivity values used for the LST retrieval, likely due to the limited representation of snow emissivity in the ECOSTRESS spectral library. Finally, results for ECOSTRESS Version 2 LST shows a significantly higher bias of +3.91 K, indicating a performance degradation with respect to Version 1. A potentially contributing cause for this accuracy loss is the correction of a cold bias observed in ECOSTRESS Version 1 LST for temperatures above 270 K. Still, the correction of this bias for cold temperatures in upcoming ECOSTRESS LST collections would contribute to extend the use and application of ECOSTRESS LST over snow and other cold surfaces of several years.

MULTI-POLARIMETRIC POWER FEATURES FOR POLSAR LAND COVER CLASSIFICATION VIA CONVOLUTIONAL NEURAL NETWORKS

Shuaiying Zhang¹, Zhen Dong¹, Zhendong Zhang², Yarong Zou³, Wentao An^{3*}

¹College of Electronic Science and Technology, National University of Defense Technology, 410073 Changsha, China. - zhangshuaiying@nudt.edu.cn, -zhendong@163.com. Tel.: +⁸⁶-1881-0991-992

²School of Surveying and Urban Spatial Information, Henan University of Urban Construction, 467036 Pingdingshan, China. -zhendongzhang0625@163.com

³National Satellite Ocean Application Service, 100081 Beijing, China

*Correspondence: zouyarong@nsoas.edu.cn, -wentaoan@163.com

Features extracted from PolSAR images using polarimetric decomposition methods contain scattering information of objects in both horizontal and vertical directions. The application of these polarimetric features has important implications. Although plenty of scholars have conducted researches on this method, there is still a problem of insufficient utilization of polarimetric scattering information. This paper proposes a method for PolSAR image classification based on polarimetric channel features. Unlike traditional methods, this method uses the power values of the polarimetric channels as input to the deep learning network. These power values are equivalent to the original polarimetric matrix and contain complete polarimetric information. By comparing with three other input schemes designed in this study, the superiority of the proposed method is verified, and the classification accuracy of PolSAR images is improved to a certain extent, validating the effectiveness of the method for large-scale area classification.

ALIANZA OBSERVA: RED ESTRATÉGICA DE OBSERVACIÓN DE LA TIERRA POR SATELITE

M.J. González Bonilla^{1*}, A. Turiel², D. de la Mata³, I. Caballero⁴, T. Lamelas⁵, F. Aguilar⁶, M. Béjar⁷, J.A. Sobrino⁸ E. Vega¹, N. Alfaro¹

¹Instituto Nacional de Técnica Aeroespacial (INTA)

²Instituto de Ciencias del Mar (CSIC)

³Universidad de Alcalá

⁴Instituto de Ciencias Marinas de Andalucía (CSIC)

⁵Departamento de Geografía y O.T. Universidad de Zaragoza

⁶Instituto de Física de Cantabria (CSIC)

⁷Instituto Geológico y Minero (IGME)

⁸Universitat de València

*Correspondence: glezbmj@inta.es (Tel.: 915201704)

La observación de la Tierra mediante satélite se ha consolidado en los últimos años como una herramienta esencial para abordar desafíos globales como el cambio climático, la sostenibilidad ambiental o la gestión eficiente de recursos. En este contexto, surge ALIANZA OBSERVA, una Red Estratégica orientada a fortalecer la coordinación nacional en el ámbito de la teledetección, promoviendo sinergias entre actores del sistema de I+D+i y facilitando la transferencia de conocimiento hacia la sociedad y los responsables de la toma de decisiones.

Esta iniciativa se enmarca en la convocatoria de Redes Estratégicas impulsada en 2024 por la Agencia Estatal de Investigación, cuyo objetivo es fomentar estructuras colaborativas capaces de articular capacidades científicas y tecnológicas en áreas clave. A diferencia de otras redes temáticas, estas plataformas están específicamente diseñadas para generar orientación estratégica, hojas de ruta y recomendaciones dirigidas a las políticas públicas. La propuesta ALIANZA OBSERVA fue concebida bajo este enfoque y ha sido financiada como una de estas redes de coordinación nacional.

La misión principal de la red es establecer un entorno estable de cooperación que potencie las capacidades existentes en teledetección en España, proporcionando además asesoramiento independiente en

la definición de programas estratégicos. Asimismo, busca alinear las iniciativas nacionales con los desarrollos internacionales, en particular en el ámbito europeo, donde la observación de la Tierra desempeña un papel creciente. La red también persigue mejorar la visibilidad y accesibilidad de los productos y servicios generados en el ámbito académico, muchos de los cuales permanecen infrautilizados a pesar de su alto valor potencial para administraciones públicas e industria.

ALIANZA OBSERVA está formada por un grupo multidisciplinar de expertos procedentes de organismos de referencia, incluyendo centros de investigación, universidades y entidades públicas, lo que le confiere una base sólida de conocimiento y experiencia. Entre sus objetivos destacan el apoyo al diseño de políticas públicas basadas en evidencia, la promoción de la cultura científica en teledetección, el impulso de la cooperación internacional y la defensa de modelos de acceso abierto a datos y productos.

En definitiva, la red aspira a actuar como elemento integrador dentro del ecosistema nacional, reduciendo la fragmentación existente y favoreciendo un enfoque más coordinado y eficiente. Su papel como interfaz entre comunidad científica, administraciones y sector productivo resulta clave para maximizar el impacto de la observación de la Tierra y acelerar su incorporación en procesos de toma de decisiones estratégicas.

THE DEVELOPMENT OF REAL TIME BNU SATELLITE AND ITS APPLICATIONS

Jinlong Fan^{1,2}

¹*State Key Laboratory of Earth Surface Processes and Resource Ecology, Faculty of Geographical Science, Beijing Normal University, China*

²*Advanced Interdisciplinary Institute of Satellite Applications, Faculty of Geographical Science, Beijing Normal University, Beijing 100875, China*

Earth observation satellite development supports and promotes the remote sensing application in various sections. For the major applications at present, the logic of retrieving information from satellite image is that user has to access to the satellite image before one can start to work on the image. The latency of accessing to the satellite image is days or hours for most satellites in the world. However, for emergency applications and operational business, the latency of days or hours is not tolerated or affects the quick response measures taken. At present, the latency of satellite data access to users via traditional ground station is almost reaching the limit. Therefore, the concept of real time remote sensing was proposed to develop a new solution of circulating the information from satellite direct to the users instead of transmitting the satellite image in the case of emergency application. The concept of real time remote sensing was to seek another approach to accelerate the procedure of information to users, like minute latency of information to users in near future. The main concern of this concept is about to address the SPEED issue of remote sensing applications. It believes that the timely information to the user hands through the concept of real time remote sensing should be a very importance subdirection of remote sensing development.

Fortunately, the concept will be testified by the coming twin small BNU satellites of lighter than 100 kg. These twin satellites are expected to be put in the orbit in summer 2026 and one is equipped with a 8-channel Imaging spectrometer in optical and near infrared spectrum with a GSD of 20 meters while another is equipped with a 26-channel Imaging Hyperspectrometer in optical, near infrared and middle infrared spectrum with the GSD of 10 and 30 meters. The work mode is that the multispectral one is flying a few minutes earlier than the Hyperspectral one. The multispectral one will be flying and searching abnormal earth surface and sending the AOI identified to the Hyperspectral one following just a few minutes later. The on-board computation chips will immediately process the images captured by twin satellites and retrieve the information about abnormal condition on the earth surface and compile them into a text message that will be sent back to the end user equipment on the earth via Chinese Navigation satellite series. These considerations will be fulfilled by the BNU Satellites. Feed backs and experiences from community will be heard and used to improve the design for BNU Satellites. The user community is also warm welcome to improve and engage the implementation of this kind of observing and using application for real time remote sensing.

THE PROGRAMME OF EARTH OBSERVATION OF THE SPANISH SPACE AGENCY

Ricardo Díaz-Delgado

*Head of the Earth Observation Department. Spanish Space Agency (Agencia Espacial Española-AEE). c/
José Galán Merino, 6, Sevilla, 41015, Spain.
ricardo.diaz@aee.gob.es*

The recently created Spanish Space Agency has initiated different activities under the responsibility of the Earth Observation Department. These activities include downstream applications as well as the definition of requirements for the new Spanish Earth Observation missions. The Spanish component of Atlantic Constellation (ESCA) has successfully completed the critical design key checkpoint, and its first satellite is expected to be launched in Q2 2027. Up to 8 satellites will be launched and operational in Q3 2028, each one equipped with a VHR multispectral camera in the optical domain. The mission will acquire a systematic coverage of Spain and Portugal at @2.1 m with spectral bands in the VNIR suitable for the monitoring of land use and cover changes. A full coverage of both countries is expected to be provided every 40 days. Data access will be made available through a dedicated marketplace for governmental users, including API services and 3d party applications for elaborated products. Additionally, programmed acquisitions by tasking will focus on national emergencies enabling the rapid mapping of natural or anthropogenic disasters (latency < 1 h). ESCA mission is proposed as a Copernicus Contributing Mission, what will enable other countries to benefit from their products.

ESCA+, an expansion mission of ESCA, has recently been approved and seeks to continue ESCA mission with larger space platforms onboarding radio-frequency receivers, VHR thermal infrared and optical cameras to address dual services for governmental users. ESCA+ has been included in the ESA's European Resilience from Space (ERS) as ESA contribution to the European Commission programme Earth Observation Governmental Services. A systems architect has been assigned by an ESA ITT to manage and supervise the implementation of a multi-mission approach. The ESCA+ Governmental Board has designated the ESCA+ User Forum incorporating all declared governmental users. The enhanced capacities of ESCA+ will certainly be critical not only for Spain but also for European countries as a federated mission.

Finally, the AEE and ESA have recently signed the agreement for the Spanish Copernicus Sentinel Collaborative Ground Segment, including the following 4 initiatives: i) the Copernicus Portal for Spain led by IGN, in charge of CLMS Spain; ii) the X-band Collaborative Acquisition Station (CAS) led by INTA and Junta de Extremadura for rapid download of Sentinel-1 data; iii) the Spanish Sentinel Data Center (SSEDAT) providing elaborated products led by CSIC; and iv) the Spanish Ground-Based Observation Network, which provides a network of sites in Spain for cal/val activities, also led by CSIC and other academic institutions. In a near future, a hub on Earth Observation for Emergencies will be adopted to integrate the most innovative products and applications into decision making for emergency management.



VNIVERSITAT
DE VALÈNCIA