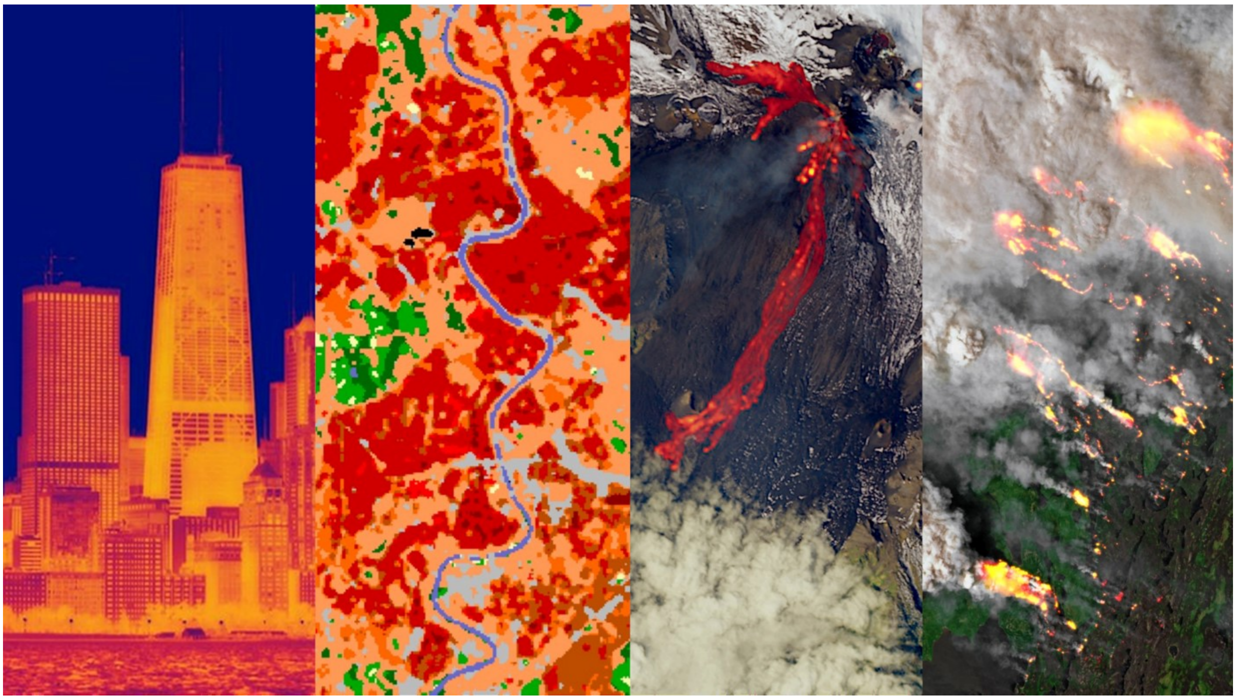
Workshop "Present & future of thermal applications based on Earth Observation data"



Organised by Agenzia Spaziale Italiana / Italian Space Agency (ASI)

ASI Headquarters in Via del Politecnico snc, Rome, Italy

13-14 May 2026

ASI Scientific and Organising Committee

Deodato Tapete

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Settore “Coordinamento Utenti, Data Policy e Downstreaming” / “User Coordination, Data Policy and Downstreaming” Sector

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Day 1 – 13 May 2026

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Participants registration		09:00 – 09:30	14:00 – 14:30
Welcome and Workshop objectives	Simona Zoffoli Italian Space Agency (ASI)	09:30 – 09:45	14:30 – 14:45
Session #1 "Italy-Vietnam LCZ-UHI-GEO project" Chair: Deodato Tapete ASI			
The executive programme for scientific and technological cooperation between Italy and Vietnam	Marco Abbiati, Science and Technology Counsellor, Embassy of Italy in Hanoi, Ministry of Foreign Affairs and International Cooperation (MAECI)	09:45 – 10:00	14:45 – 15:00
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Introduction to VNSC and collaboration between VNSC and Italian institutions	Lam Dao Nguyen Ho Chi Minh City Space Technology Application Center (STAC), Vietnam National Space Center (VNSC)	10:15 – 10:30	15:15 – 15:30
ASI's contribution to the LCZ-UHI-GEO project	Patrizia Sacco ASI	10:30 – 10:45	15:30 – 15:45
LCZ methodology and air temperature analysis in Rome and Milan	Matej Žgela POLIMI	10:45 – 11:00	15:45 – 16:00
The relationship of Local Climate Zone and Land Surface Temperature in the	Pham Thi Mai Thy VNSC-STAC, Ho Chi Minh City	11:00 – 11:15	16:00 – 16:15

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Session #2 "State of the art of research in Vietnam on urban heat islands and thermal comfort" Chairs: Pham Thi Mai Thy and Maria Antonia Brovelli VNSC-STAC, Ho Chi Minh City and POLIMI			
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Impact of Green Space Decline on Land Surface Temperature in Hanoi using MODIS data	Quang Truong Xuan, Vietnam National University	11:30 – 11:45	16:30 – 16:45
Urban Golf Courses in Hanoi: Land Cover Change and Surface Temperature Impacts from Remote Sensing	Anh Nguyen Kim VNSC-STAC, Hanoi	11:45 – 12:00	16:45 – 17:00
Leveraging Open Satellite Data for Low-Barrier Monitoring of Urban Green Space in Rapidly Urbanizing Cities	Leon Scheiber Leibniz University Hannover, Climate Service Center Germany (GERICS), Helmholtz-Zentrum Hereon	12:00 – 12:15	17:00 – 17:15
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Board number	**Poster session** Hall in front of ASI's canteen **<u>Both Day 1 and Day 2 posters are allowed to present</u>**	**CET** 12:30 – 13:30	**ICT** 17:30 – 18:30
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2	Mapping and Monitoring of Urban Heat Islands in Piedmont (M2UHIP)	Giorgio Roberto Pelassa & Enrico Suozzi Regione Piemonte Chiara Richiardi ENEA	
3	From satellite data to decision support: the MIRIFICUS Project and WebGIS platform for Surface Urban Heat Island monitoring	Marina Funaro ISPRA	
4	High-Resolution Surface Temperature Mapping for Urban Heat Risk. Assessment in African Cities	Anna Lisa Labaar S[&]T	
5	Improving Thermal Infrared LST Products Through NDVI-Based Downscaling for Earth Observation Applications	Malvina Silvestri INGV	

6	Thermal Analysis for Resilient Transport Infrastructure: A Downscaling Approach Using Satellite Data and UAV	Valerio Gagliardi Università Roma Tre
7	Sensitivity study of the 4.8 µm channel to CO2 emissions from high temperature sources	Vito Romaniello INGV
8	Combining optical and thermal data for cryosphere monitoring in the Alps	Biagio Di Mauro CNR-ISP
9	A Semi-Supervised Approach to Classifying Proxy Thermal-States Using Satellite-Derived Time Series at Vulcano (2016–2024)	Francesco Spina INGV
10	Enhancing National Capability in Earth Observation Based on Small Satellite Constellations in Vietnam	Pham Anh Tuan, Vu Anh Tuan, Le Xuan Huy VNSC
11	Land use/land cover (LULC) mapping with satellite images and field spectral libraries combined in linear mixture models	Emiliana Valentini CNR-ISP Pham Thy Mai Thy VNSC et al.
12	Using COSMO-SkyMed images to detect natural disasters & support emergency response in Vietnam	Thy Pham Thi Mai & Nguyen Lam Dao et al. VNSC Maria Virelli & Deodato Tapete ASI

Lunch	**CET**	**ICT**
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Session #3 "State of the art of research in Italy and beyond" Chairs: Deodato Tapete and Patrizia Sacco ASI			
Title	**Speaker**	**CEST**	**ICT**
HEATWISE Advanced Urban Materials and Climate Zone Products for Urban Resilience Exploiting Hyperspectral and Thermal Data	Paolo Gamba University of Pavia	14:30 – 14:45	19:30 – 19:45
Local Climate Zone Mapping by Integrating Hyperspectral and Multispectral Data with a Spectral–Spatial Fusion Network	Silvia Liberata Ullo University of Sannio	14:45 – 15:00	19:45 – 20:00
Urban Heat Island Spatialization in an Alpine Valley: A Heatwave Case Study in Grenoble, France	Paolo De Piano Latitudo 40	15:00 – 15:15	20:00 – 20:15
Urban Heat Island and thermal comfort assessment with geomatics techniques and Earth Observation data: the Space It Up! project	Maria Brovelli POLIMI	15:15 – 15:30	20:15 – 20:30
Urban Heat Island monitoring using multi-sensor high-resolution thermal infrared satellite imagery	Mattia Pecci National Institute of Geophysics and Volcanology (INGV)	15:30 – 15:45	20:30 – 20:45
Daily urban air temperature mapping from satellite LST for heat-related stress assessment	Daniele Settembre University of Rome "Tor Vergata"	15:45 – 16:00	20:45 – 21:00
High-resolution reconstruction of urban air temperature from geostationary satellite LST using machine learning: application to UHI analysis in Rome	Andrea Cecilia Institute of Atmospheric Sciences and Climate (ISAC), National Research Council (CNR) of Italy	16:00 – 16:15	21:00 – 21:15

Using Satellite Data to Identify "Unhealthy Islands" in the Rome Metropolitan Area	Davide De Santis University of Rome "Tor Vergata"	16:15 – 16:30	21:15 – 21:30
Scale Dependence of Tree Canopy Cooling and Imperviousness Effects in Rome from Mobile Air Temperature Observations (TRAMS)	Lorenzo Marinelli ISAC, CNR	16:30 – 16:45	21:30 – 21:45
A methodological approach for microclimatic analysis and assessment from the macroscale to proximity open spaces	Ilaria Montella Roma Tre University	16:45 – 17:00	21:45 – 22:00
Land Surface Temperature Downscaling for High-Resolution Urban Heat Monitoring	Simone Lolli Institute of Methodologies for Environmental Analysis (IMAA), CNR	17:00 – 17:15	22:00 – 22:15
From satellite data to decision support: the MIRIFICUS WebGIS platform for Surface Urban Heat Island monitoring	Marina Funaro Italian Institute for Environmental Protection and Research (ISPRA)	17:15 – 17:30	22:15 – 22:30
SMARTY – Integration of Satellite Data and Operational Information to Support the Resilience of Metropolitan Cities	Francesca Fratarcangeli & Edoardo Zoppi e-GEOS	17:30 – 17:45	22:30 – 22:45

	CET	**ICT**
Conclusive discussion & remarks	17:45 – 18:00	22:45 – 23:00

Day 2 – 14 May 2026

"Algorithms and applications for Earth Observation in the thermal infrared"

Title	Speaker	CEST
Participants registration		09:00 – 09:30
Welcome and Workshop objectives	Simona Zoffoli ASI	09:30 – 09:45
Overview of scientific activities using EO thermal data	Maria Fabrizia Buongiorno INGV	09:45 – 10:00
Session #1 "THERESA project" Chair: Sara Venafra ASI		
The THERESA Project: Advanced Algorithms for VNIR–TIR Data in the Context of the SBG-TIR Mission	Malvina Silvestri INGV	10:00 – 10:15
Analysis of methodologies for SBG-TIR L1 and L2 products retrievals (geometric and atmospheric correction, land surface temperature and emissivity estimation, cloud/shadow/snow/land-sea mask)	Giovanni Laneve SIA-SAPIENZA	10:15 – 10:30
Use of SBG-TIR data for applications related to vegetation	Roberto Colombo UNIMIB	10:30 – 10:45
Fire and volcanic applications	Vito Romaniello INGV	10:45 – 11:00
Thermal remote sensing for topsoil characterization and raw material analysis	Stefano Pignatti CNR-IMAA	11:00 – 11:15
COFFEE BREAK + **Continuation of the poster session** Hall in front of ASI's canteen **<u>Both Day 1 and Day 2 posters are allowed to present</u>**		11:15 – 11:45
Enhanced Detection of Volcanic Thermal Anomalies Using Normalized Thermal Indices	Gaetana Ganci INGV	11:45 – 12:00

Volcanic Ash and SO2 Retrievals	Lorenzo Guerrieri INGV	12:00 – 12:15
A cloud mask approach for thermal missions	Karthick Dharmarajan SIA-SAPIENZA	12:15 – 12:30
Estimation of Leaf Area Index and Vegetation Fractional Cover using SCOPE simulated data and Sentinel-2 images	Luca Tuzzi UNIMIB	12:30 – 12:45
Predicting Soil Organic Carbon with LWIR Spectral Data: From Laboratory and Airborne Imagery to Simulated Future Thermal Missions.	Francesco Rossi CNR-IMAA	12:45 – 13:00
Surface Mineral Mapping Using LWIR airborne data in view of the future thermal missions	Saham Mirzaei CNR-IMAA	13:00 – 13:15

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	13:15 – 13:30

Lunch	**CEST**
	13:30 – 14:30

Session #2 "EO Thermal Algorithms and Applications" Chairs: Sara Venafra and Giorgio Antonio Licciardi		
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Assessing the contribution of ECOSTRESS-derived TIR products to LCZ mapping in view of the future thermal missions	Alberto Vavassori POLIMI	14:30 – 14:45
MASTER Level-3 Products: Algorithms and Applications for Future TIR Satellite Missions	Federico Rabuffi INGV	14:45 – 15:00
Advanced Thermal Mapping Products in Urban and Periurban Areas	Paolo Gamba UNIPV	15:00 – 15:15
High-Resolution Thermal Infrared Imaging for Small Satellites and Small-Series Production in Benevento	Marco Esposito COSINE ITALIA	15:15 – 15:30

The smallsat VULCAIN mission for EO scientific products in VIS\TIR	Michèle Lavagna POLIMI	15:30 – 15:45
High Resolution Sea Surface Temperature monitoring in coastal areas: state of the art and proposed advances from the ASTRO research proposal	Daniele Ciani CNR-ISMAR	15:45 – 16:00
Thermal remote sensing for monitoring mountain environment	Paola Filippi NV5 Claudia Notarnicola EURAC	16:00 – 16:15
Leveraging the thermal missions for Advanced Crop Stress Monitoring: Indices based on Physical TIR Modeling	Guido Masiello UNIBAS	16:15 – 16:30
Exploiting σ radiative transfer capabilities for advanced thermal infrared products	Tiziano Maestri UNIBO	16:30 – 16:45
Towards a Geostationary Thermal System for Operational Support of the Italian National Fire Corps	Gianmarco Valletta CNVVF	16:45 – 17:00

	CET
Conclusive discussion & remarks	17:00 – 17:15

ABSTRACT BOOK

Oral presentations

"Earth Observation, urban heat islands and thermal comfort in cities: the experience of the Italy-Vietnam LCZ-UHI-GEO cooperation and beyond" (Day 1, 13 May 2026)

Session #1 "Italy-Vietnam LCZ-UHI-GEO project"

Session chaired by Deodato Tapete, Senior Researcher at the Italian Space Agency (ASI) and ASI Scientific Responsible of the Italy – Vietnam project LCZ-UHI-GEO.

The session is jointly organised with Politecnico di Milano (POLIMI) and the Vietnam National Space Center (VSNC).

The session aims to present the results achieved in the framework of the **Italy – Vietnam project "Analysis of Local Climate Zones and Urban Heat Island using geomatic techniques (GIS and Earth Observation) – LCZ-UHI-GEO**", funded by the Italian Ministry of Foreign Affairs and International Cooperation (MAECI) and Vietnam's Ministry of Science and Technology (MOST) for the period 2024-2026.

LCZ-UHI-GEO is a collaborative project between POLIMI, ASI and VSNC, and promotes the use of satellite hyperspectral data from ASI's PRISMA mission.

The project aimed at:

- generating Local Climate Zone (LCZ) maps from GIS data and Earth Observations (EO),
- generating air temperature maps from in situ and satellite observations,
- assigning accurate temperature ranges to each LCZ class in a number of selected case studies in the two countries.

The localized and elevated warming of temperatures in urban areas compared to their surrounding rural or natural environments is known as Urban Heat Island (UHI) phenomenon. It impacts our health and that of our ecosystems, implies an increase of energy consumption and produces many other economic effects. The spatial distribution of temperatures changes from place to place depending on many factors, such as the morphology of the built areas, the building materials, and the presence of vegetation. Local Climate Zones (LCZs) are a classification system used to categorize different urban and suburban areas based on their physical and thermal characteristics. This classification is meant to help urban planners, architects, researchers, and policymakers to define strategies for the mitigation of UHI and to monitor their effects on the urban microclimates.

LCZ-UHI-GEO explored how EO and geospatial data can be integrated for characterising urban thermal environments across different urban contexts. The experimental work focused on Italian and Vietnamese cities, i.e. Rome, Milan, Hanoi, and Ho Chi Minh City. It aimed to improve the understanding of UHI dynamics in both temperate and tropical regions. High-resolution LCZ maps were produced using a combined remote sensing and GIS method. It utilised hyperspectral PRISMA satellite data with detailed Urban Canopy Parameters (UCPs) derived from EO and GIS datasets. This fusion of hyperspectral information improved the classification accuracy compared to the standard multispectral approach. The resulting LCZ maps helped better understand how the shape and structure of cities, i.e. urban morphology, affect local temperatures. Furthermore, a detailed interpolation of air temperature was conducted for the city of Milan using machine learning and focusing on heat wave periods throughout the year 2022.

The project results demonstrate the importance of detailed LCZ and air temperature mapping in assessing the spatial variability of urban heat load. The fine spatial resolution urban climate information provided by this research is essential for effective urban environmental management and targeted mitigation of heat-related risks.

Over the past three years, the project achieved several impacts:

- Bilateral collaboration, i.e. country partnerships, stakeholder engagement and Italian satellite asset promotion;
- LCZ maps diffusion, to support mitigation strategies and prove monitoring effects;
- UHI awareness, through public awareness campaigns and research publications;
- Student and Researcher Training, through training programs, workshops and seminars.

This work was supported in part by the Italian Ministry of Foreign Affairs and International Cooperation, grant number VN24GR02.

The executive programme for scientific and technological cooperation between Italy and Vietnam

Marco Abbiati [(1)]

[(1)] Science and Technology Counsellor, Embassy of Italy in Hanoi, Ministry of Foreign Affairs and International Cooperation (MAECI)

The Science and Technology Counsellor, Embassy of Italy in Hanoi, Ministry of Foreign Affairs and International Cooperation (MAECI) will introduce the executive programme for scientific and technological cooperation between Italy and Vietnam for the years 2024-2026 (https://www.esteri.it/wp-content/uploads/2024/06/VIETNAM-PE-24-26.pdf), under which the Italy – Vietnam project "Analysis of Local Climate Zones and Urban Heat Island using geomatic techniques (GIS and Earth Observation) – LCZ-UHI-GEO" is funded by MAECI and Vietnam's Ministry of Science and Technology (MOST).

LCZ-UHI-GEO project from the Italian side

Maria Antonia Brovelli [(1)]

[(1)] Department of Civil and Environmental Engineering, Politecnico di Milano (POLIMI), Milan, Italy

The Italian Principal Investigator will present the Italy – Vietnam project "Analysis of Local Climate Zones and Urban Heat Island using geomatic techniques (GIS and Earth Observation) – LCZ-UHI-GEO", from the Italian side.

Introduction to VNSC and collaboration between VNSC and Italian institutions

Lam Dao Nguyen [(1)]

[(1)] Ho Chi Minh City Space Technology Application Center (STAC), Vietnam National Space Center (VNSC), Ho Chi Minh City, Vietnam

The Director of the Ho Chi Minh City Space Technology Application Center (STAC) will present the activities undertaken by the Vietnam National Space Center (VNSC) and illustrate the most recent and current research cooperation with Italian research organisations.

ASI's contribution to the LCZ-UHI-GEO project

Patrizia Sacco [1]

[1] Italian Space Agency (ASI), Matera, Italy

The ASI Project and PRISMA Data Manager will introduce the PRISMA mission and present the contribution that ASI has made to the Italy – Vietnam project "Analysis of Local Climate Zones and Urban Heat Island using geomatic techniques (GIS and Earth Observation) – LCZ-UHI-GEO".

LCZ methodology and air temperature analysis in Rome and Milan

Matej Žgela [1]

[1] Department of Civil and Environmental Engineering, Politecnico di Milano (POLIMI), Milan, Italy

The presentation will focus on the results achieved over Rome and Milan, Italy, in the framework of the Work Package 2 "Local Climate Zone mapping" and Work Package 3 "Air Temperature Mapping" of the Italy – Vietnam project "Analysis of Local Climate Zones and Urban Heat Island using geomatic techniques (GIS and Earth Observation) – LCZ-UHI-GEO".

The relationship of Local Climate Zone and Land Surface Temperature in the case of Vietnam

Pham Thi Mai Thy [1]

[1] Ho Chi Minh City Space Technology Application Center (STAC), Vietnam National Space Center (VNSC), Ho Chi Minh City, Vietnam

The Vietnamese Principal Investigator will present the Italy – Vietnam project "Analysis of Local Climate Zones and Urban Heat Island using geomatic techniques (GIS and Earth Observation) – LCZ-UHI-GEO", from the Vietnamese side. In particular, the presentation will focus on the relationship of Local Climate Zones (LCZs) and Land Surface Temperature (LST) in the Vietnamese cities.

Session #2 "State of the art of research in Vietnam on urban heat islands and thermal comfort"

Session chaired by Pham Thi Mai Thy and Maria Antonia Brovelli, Vietnamese and Italian Principal Investigators, respectively, of the Italy – Vietnam project LCZ-UHI-GEO.

The session aims to showcase the most recent and current research undertaken by Vietnamese and foreign institutions on urban heat islands and thermal comfort. The presentations will highlight the scientific and societal importance of these topics, and how Earth Observation and GIS data play a crucial role in providing evidence base and contributing to urban planning, design of mitigation measures and policy-making.

The session contributes to LCZ-UHI-GEO project objective of fostering technical-scientific knowledge exchange between Italy and Vietnam.

Impact of Green Space Decline on Land Surface Temperature in Hanoi using MODIS data

Quang Truong Xuan [1]

[1] Vietnam National University

This study investigates the impact of green space decline on land surface temperature (LST) in Hanoi during the period 2005–2024, in the context of rapid urbanization. Using multi-temporal MODIS data processed on the Google Earth Engine platform, the Normalized Difference Vegetation Index (NDVI) was used to represent vegetation cover, while LST was derived from thermal remote sensing data.

The results show a strong negative relationship between NDVI and LST, indicating that areas with higher vegetation density tend to have lower surface temperatures, whereas densely built-up areas experience significantly higher thermal conditions. A clear urban gradient is observed, with the urban core characterized by high thermal stress and low vegetation, while fringe areas exhibit more favourable environmental conditions. Hotspot analysis further shows the intensification and spatial expansion of the Urban Heat Island effect over time.

Overall, the findings highlight the critical role of urban green spaces in regulating the urban thermal environment and mitigating heat stress. This study provides important scientific evidence to support urban planning strategies that prioritize the preservation and expansion of green infrastructure for sustainable urban development under climate change.

Urban Golf Courses in Hanoi: Land Cover Change and Surface Temperature Impacts from Remote Sensing

Anh Nguyen Kim [(1)]

[(1)] Space Technology Application Center (STAC), Vietnam National Space Center (VNSC), Hanoi, Vietnam

Rapid urbanization in the Hanoi Metropolitan area in recent decades has driven the formation of golf courses, which raise concerns on their environmental and social impact. Regular on-site inspections are costly, resulting in the need for a more cost-effective monitoring tool filling the knowledge gap for inspectors and decision makers. This study develops a remote sensing methodology to map and assess golf course dynamics utilizing optical satellite imagery from Landsat and Sentinel-2A from 1989 to 2023 with two analytical frameworks: NDVI thresholding and spectral mixing analysis with spatial features classification. NDVI thresholding of 0.55-0.75 effectively captures the year-round maintained turfgrass, it proved susceptible to false positives in Vietnam's tropical climate due to spectral similarities with parks and agricultural fields. In contrast, feature-based classification leveraging Sentinel-2's 10-meter spatial resolution yielded vastly superior performance, achieving an overall accuracy of 98.41% for 2023 when classifying golf course features. This high precision is attributed to the sensor's capacity to resolve structural elements specifically small sand bunkers and to detect a unique spectral mixed signal consisting of combined sand and turf grass signatures. Comparatively, Landsat's coarser 30-meter resolution struggled with these micro-features, resulting in misclassifications and a lower overall detection accuracy (80.03% to 94.49% for the year 1989 to 2023) but is useful for temporal studies. The findings demonstrate that integrating high-resolution multispectral satellite data with machine learning provides a highly accurate framework for monitoring urban land use. This automated approach ultimately provides policymakers and urban planners with the critical data needed to monitor land use compliance, optimize resource management, and enforce sustainable environmental standards in rapidly expanding cities.

Leveraging Open Satellite Data for Low-Barrier Monitoring of Urban Green Space in Rapidly Urbanizing Cities

Leon Scheiber [1,2], Vera Zühlsdorff [1], Duong Huu Nong [3], Thanh Son Ngo [3], Nigel K. Downes [4], Felix Bachofer [5], Hong Quan Nguyen [6,7], Matthias Garschagen [8], Andrea Reimuth [8,9]

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[7] Center of Water Management and Climate Change, Institute for Environment and Resources, Vietnam National University Ho Chi Minh City, 50000, Ho Chi Minh City, Viet Nam

[8] Ludwig-Maximilians-Universitaet München (LMU), Department of Geography, Luisenstr. 37, 80333, Munich, Germany

[9] Technical University of Munich, School of Engineering and Design, Chair of Data Science in Earth Observation, Arcisstr. 21, 80333, Munich, Germany

Urban Green Space (UGS) plays a vital role in climate resilient urban development by mitigating heat exposure, supporting ecosystem services, and enabling equitable access to cooling. Yet, in rapidly urbanizing regions, green spaces are often lost faster than they can be documented, creating substantial gaps between planning reality, public expectations, and environmental justice. This contribution presents a deliberately simple, open-access Earth Observation (EO) workflow that enables independent monitoring of UGS dynamics using long-term Sentinel 2 NDVI data combined with census-based population indicators. Demonstrated for two rapidly urbanizing Vietnamese metropolises, Hanoi and Ho Chi Minh City, the approach

identifies UGS through a robust NDVI quartile thresholding method that requires minimal preprocessing and can be reproduced readily without specialized expertise or proprietary tools.

The results reveal strong spatial gradients between densely built urban cores and greener peripheries in both cities, while temporal trends diverge: while UGS areas in Hanoi are relatively stable overall but declining per capita due to ongoing urbanization, HCMC experiences a general decline in both UGS indicators. Beyond these findings, the study underscores a broader societal need that the EO community is uniquely positioned to address: accessible, transparent, and transferable monitoring methods that empower local researchers, civil society, and NGOs to independently track, for instance, land use changes and hold planning processes accountable. Such low barrier EO applications can help bridge the gap between technical remote sensing advances and their practical uptake in climate governance, especially in regions where data accessibility, institutional capacity, and public participation remain limited.

Session #3 “State of the art of research in Italy and beyond”

Session chaired by Deodato Tapete and Patrizia Sacco, Senior Researcher and Senior Technologist, respectively, in the “Earth Observation” Office at the Italian Space Agency (ASI).

The session aims to showcase the most recent and current research undertaken by the Italian scientific, institutional and industrial community on urban heat islands and thermal comfort. As such, it will provide a forum for discussion of the state of the art and most recent technological and algorithmic innovations in the field of scientific research and downstream applications for the study of urban heat islands, classification of Local Climate Zones and evaluation of thermal comfort. The presentations will also help to identify future lines for development.

The session contributes to LCZ-UHI-GEO project objective of fostering technical-scientific knowledge exchange between Italy and Vietnam.

HEATWISE Advanced Urban Materials and Climate Zone Products for Urban Resilience Exploiting Hyperspectral and Thermal Data

Leonel Garro Linck (1), Antonietta Sorriso (1), Paolo Gamba (1), Panagiotis Sismanidis (2), Iphigenia Keramitsoglou (2), Chris T. Kiranoudis (2,3), and Jürgen Fischer (4)

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(2) Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, 15236 Athens, Greece

(3) School of Chemical Engineering, National Technical University of Athens, 15780 Athens, Greece

(4) Spectral Earth GmbH, 12205 Berlin, Germany

The aim of this research is to investigate potential uses of the hyperspectral and thermal future missions by the European Space Agency (CHIME and LSTM, respectively) for urban climate research. To this aim, this presentation will first focus on methodologies to obtain synthetic images for these future ESA missions starting from existing airborne or spaceborne data sets, taking into account the latest information about the new sensors, and comparing a radiative transfer approach with a spectrospatial sampling approach. The synthetic CHIME data sets are used to characterize urban materials while LSTM measurements helps to discriminate among different thermal behaviours. Spectral unmixing using database spectra of urban materials or image-driven endmembers is applied to synthetic data for three cities, characterized by different climate settings: Athens (Greece), Berlin (Germany) and Helsinki (Finland). For each of these locations existing data sets are used to simulate CHIME and LSTM data, exploring aerial campaigns, such as ESA's THERMOPOLIS-2009 in Athens and GFZ's Berlin Urban Gradient in Berlin. Moreover, spaceborne hyperspectral sensors such as PRISMA and EnMap, together with thermal data sets from the ECOSTRESS sensor on board of the International Space Stations or from Landsat are considered to emulate LSTM products. Experimental results on two neighbourhoods of the city of Athens, the southern part of Berlin and the city centre in Helsinki show that these synthetic data have the potential to extract urban material maps and relate them to urban heat island effects.

Local Climate Zone Mapping by Integrating Hyperspectral and Multispectral Data with a Spectral–Spatial Fusion Network

Ximing Liu (1), Luigi Russo (1), Wenbo Li (1), Alim Samat (2, 3), Silvia Liberata Ullo (4), Paolo Gamba (1)

(1) Department of Electrical, Computer and Biomedical Engineering, University of Pavia, 27100 Pavia, Italy

(2) State Key Laboratory of Ecological Safety and Sustainable Development in Arid Lands, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China

(3) China-Kazakhstan Joint Laboratory for RS Technology and Application, Al-Farabi Kazakh National University, Almaty 050012, Kazakhstan

(4) Department of Engineering, University of Sannio, 82100 Benevento, Italy

Urbanization has profoundly transformed urban environments in recent decades. The replacement of natural pervious surfaces with artificial impervious cover has altered land cover and surface energy balance, reshaping urban structure and landscape patterns. These transformations contribute to urban climate effects, particularly the Urban Heat Island (UHI) phenomenon. The Local Climate Zone (LCZ) classification system proposed by Stewart and Oke [1] provides a standardized framework for describing urban surface structure and characteristics, linking urban morphology with thermal and climatic properties.

Most remote sensing-based LCZ mapping approaches rely on pixel-level classification using multispectral data, which limits their ability to capture urban scene heterogeneity and distinguish structurally similar LCZ classes. With the rapid development of deep learning (DL), scene-level LCZ classification has emerged as a promising alternative [2]. Instead of labeling individual pixels, this approach analyzes image patches as integrated units, better representing the heterogeneous composition of LCZs.

At this end, Sentinel-2 multispectral images (MSI), with 10 m spatial resolution, are widely used because they provide sufficient spatial context for scene-level LCZ classification [2]. However, hyperspectral images (HSI) offer richer spectral information that enables more detailed characterization of urban materials [3–8]. A key challenge is that hyperspectral data often have lower spatial resolution, limiting their ability to capture urban structures [9].

To address these limitations, we propose LCZ-HMSSNet (Hyperspectral–Multispectral Spectral–Spatial Network), a scene-level LCZ classification framework integrating PRISMA hyperspectral imagery with Sentinel-2 MSI [10], introducing a spatial–spectral feature separation (SSFS) strategy to enhance fused feature discriminability and improve recognition of morphologically similar LCZ classes. Experiments on multi-city European datasets show consistent improvements over CNN-based baselines and single-source inputs with notable gains for challenging and minority LCZ classes, demonstrating its robustness and potential for LCZ mapping in data-scarce scenarios.

References

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Urban Heat Island Spatialization in an Alpine Valley: A Heatwave Case Study in Grenoble, France

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The problem of urban heat islands (UHIs) in complex topographic settings, such as alpine valleys, poses a growing challenge for climate-adaptive city planning because terrain-driven airflow modulates nocturnal temperature patterns and intensifies spatial heterogeneity. We aim to present an end-to-end pipeline for high-resolution mapping of nocturnal UHI intensity in the Grenoble alpine valley (France), combining a dense IoT sensor network (~140 street-level stations), Local Climate Zone (LCZ)-derived land-cover fractions (built-up, vegetation, water) computed at multiple spatial scales, and XGBoost regression with automated feature selection and Bayesian hyper-parameter optimisation. Applied to the heatwave period of 18-24 August 2023, the pipeline shows that LCZ-based built-up and vegetation fractions, optimised at radii of 200-600 m, are the dominant and most consistent predictors of UHI intensity, while elevation acts as a secondary predictor during the earliest nocturnal hours (02:00-03:00) and water fraction plays a minor role due to limited urban water bodies. The resulting spatial UHI patterns are qualitatively consistent with an independent

reference map derived from the same sensor network, confirming the pipeline's operational viability for municipal climate-adaptation services without requiring physics-based model inputs. The approach highlights how recent technological advances, high-density IoT monitoring, LiDAR-derived elevation, standardized LCZ products, and algorithmic innovations (Spearman-based scale optimisation, hierarchical partitioning for feature importance, Bayesian optimisation via Optuna) advance UHI research, LCZ mapping, and thermal-comfort assessment. Future developments include integrating dynamic predictors such as real-time wind fields or soil moisture to improve generalisability across diverse synoptic conditions and extending the methodology to other alpine cities for scalable, operational climate services.

Urban Heat Island and thermal comfort assessment with geomatics techniques and Earth Observation data: the Space It Up! project

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Within the "Space It Up!" project, funded by the Italian Space Agency (ASI) and the Ministry of University and Research (MUR), Task 7.4.2 addresses the growing impacts of urban heat islands (UHI) under increasing heatwave frequency, duration, and intensity. The Task focuses on urban and suburban environments, with the goal of improving the understanding, monitoring, and modelling of urban thermal patterns and their drivers.

A first research line exploits very-high-resolution (2.2 km) climate reanalysis data (VHR-REA_IT dataset) together with authoritative long-term station-based observations to analyse spatial patterns and trends of heatwaves and thermal stress indices across Italy. The analysis spans the 1981-2024 period (44 years), allowing for a robust assessment of climatic variability and long-term changes affecting the Italian territory.

A second activity develops machine learning regression models to predict the spatial distribution of near-surface air temperature by integrating in situ measurements (from official and crowdsourced meteorological networks) with GIS and Earth Observation (EO) predictors. The resulting high-resolution air temperature maps are generated for different times of day to capture the diurnal evolution of the UHI effect.

The project also focuses on mapping Local Climate Zones (LCZs) using hyperspectral PRISMA imagery, urban canopy parameter (UCP) layers, and machine learning models.

Building on state-of-the-art methodologies, workflow improvements focus on automating and quality-checking the selection of training and testing samples, based on polygon geometry, class balance, and UCP statistics. Data acquisition and UCP computation are streamlined through Google Earth Engine and Python-based tools.

Finally, hyperspectral unmixing of PRISMA and DESIS imagery is applied to estimate the fractional abundance of urban surface materials and assess their relationship with land surface temperature from Landsat 8/9 TIR data. Results are being validated using hyperspectral and thermal data acquired during an aerial survey over Milan (15-16 August 2025).

This study was carried out within the Space It Up project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under contract n. 2024-5-E.0 – CUP n. I53D24000060005.

Urban Heat Island monitoring using multi-sensor high-resolution thermal infrared satellite imagery

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Climate change is driving a sustained increase in global temperatures and an intensification of extreme events, including heatwaves. Urban areas are typically warmer than the surrounding suburban and rural environments, a phenomenon known as the Urban Heat Island (UHI). This effect is primarily associated with the presence of buildings and inhomogeneous surfaces, which affects surface energy and water exchanges as well as the local meteorology. UHI strongly affect urban climate, ecosystems, air quality, and human thermal comfort, and its impact is exacerbated during heatwaves, with risks for human health.

Therefore, monitoring and characterizing UHI is crucial for climate mitigation and adaptation strategies.

The Surface Urban Heat Island (SUHI) can be effectively investigated through the study of the Land Surface Temperature (LST) derived from satellite observations, enabling comprehensive spatial and temporal analyses of urban thermal patterns, including the identification of hot- and cold-spots, and the assessment of mitigation measures such as high-albedo materials and urban green areas.

In this study, thermal infrared satellite observations of LST are used to characterize the SUHI and its dynamics over selected urban areas in Central and Southern Italy. A decadal dataset (>10 years) is built using Landsat 8 data (100 m spatial resolution, 16-day revisit time, available since 2013) to analyse long-term variations. For recent years, Landsat 8 and 9 observations (8-day revisit time when used in combination) are combined with ECOSTRESS data (70 m spatial resolution, variable overpass times, 1–2 day revisit), significantly enhancing temporal sampling. This multi-sensor approach enables an improved assessment of urban temperature evolution and its response to climate change.

This work was supported by the ASI "Space It Up!" contract N. 2024-5-E.0, CUP I53D24000060005., SPOKE 5 and SPOKE 7 activities.

Daily urban air temperature mapping from satellite LST for heat-related stress assessment

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Urban areas are increasingly affected by rising temperatures driven by climate change, with the Urban Heat Island (UHI) effect amplifying thermal stress, particularly during heatwaves. Assessing these impacts requires reliable information on near-surface air temperature, which is more directly linked to human thermal exposure and comfort than land surface temperature (LST).

However, in situ air temperature observations are often sparse and unevenly distributed, especially in urban environments. Satellite data provide continuous global LST measurements, but converting LST into accurate air temperature remains challenging due to physical differences and sensitivity to surface characteristics.

In this work, we develop a statistical approach to estimate daily air temperature (Tair) by combining daytime and nighttime MODIS LST, using ERA5-Land 2 m air temperature as reference over the period 2012–2023. The model is calibrated across 70 major cities worldwide, ensuring balanced geographic representation, and stratified by latitude and month. For each class, we fit the relationship:

T2m = a · LSTday + b · LSTnight + c

This yields coefficients (a, b, c) specific to each latitudinal band and month, enabling air temperature retrieval at 1 km resolution.

The method captures diurnal variability and spatial heterogeneity, making it suitable for urban applications. The derived air temperature fields reflect the thermal conditions experienced by urban populations and support the evaluation of thermal comfort in relation to urban structure and Local Climate Zones.

Validation against ERA5-Land daily data for 2024 shows strong agreement, with Pearson correlation coefficients ranging from 0.84 to 0.93 (daytime) and 0.77 to 0.93 (nighttime). Additional comparisons with VIIRS and in situ data confirm the robustness of the approach, supporting its use as a scalable framework for high-resolution urban climate analysis and heat-related risk assessment.

High-resolution reconstruction of urban air temperature from geostationary satellite LST using machine learning: application to UHI analysis in Rome

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Air temperature (Ta) is a key variable for assessing thermal conditions in urban environments, particularly in the context of urban heat island (UHI) studies. However, its spatial characterization is often limited by the sparse distribution of in situ measurements. In this work, we present a machine learning approach to reconstruct high-resolution air temperature fields by converting geostationary satellite land surface temperature (LST) into Ta, enabling a spatially continuous analysis of urban thermal patterns.

The methodology is based on a gradient boosting model trained using in situ observations from a dense urban meteorological network in Rome (Italy), combined with multi-temporal LST data from MSG-SEVIRI and ancillary geospatial predictors, including land cover, imperviousness, vegetation indices, and topographic variables.

The model exploits both instantaneous and time-lagged LST (up to 4 hours) to account for surface–atmosphere interactions. The resulting dataset provides hourly air temperature fields at 3 km spatial resolution under clear-sky and stable atmospheric conditions.

Model performance shows high accuracy, with an overall RMSE of 0.9 °C, demonstrating the capability of geostationary Earth Observation data, when integrated with machine learning, to reliably estimate near-surface air temperature. The reconstructed fields allow for a detailed investigation of UHI spatio-temporal dynamics, significantly improving spatial coverage compared to analyses based solely on in situ data. In particular, the approach reveals enhanced nocturnal UHI intensity due to a more accurate representation of rural reference conditions and highlights the role of mesoscale processes, such as sea breeze, in shaping daytime thermal gradients.

This study demonstrates the potential of combining geostationary thermal observations with data-driven approaches to bridge the gap between surface and atmospheric temperature measurements, providing a valuable tool for urban climate analysis, heat risk assessment, and downstream applications in environmental monitoring and urban planning.

Using Satellite Data to Identify "Unhealthy Islands" in the Rome Metropolitan Area

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This study examines the environmental and public health challenges faced by the Rome metropolitan area by analysing the spatial overlap between high Land Surface Temperature (LST) and elevated concentrations of tropospheric nitrogen dioxide (NO_2). Integrating these two parameters enables the identification of "unhealthy islands," defined as urban zones where extreme heat and air pollution converge, posing significant risks to public health.

The analysis covered the five-year period from 2019 to 2024, excluding 2020 due to anomalies in pollution levels caused by COVID-19 lockdowns. High-resolution satellite datasets were used. In particular, LST data were derived from the VIIRS sensor using the VNP21A1 algorithm, which provides adequate spatial resolution to capture the heterogeneity of urban environments. Nitrogen dioxide data were obtained from the TROPOMI instrument aboard the Sentinel-5P satellite and further processed to achieve a spatial resolution of 1 km × 1 km.

The methodology involved defining critical thresholds for both parameters as the mean plus one standard deviation, followed by identifying the months in which these thresholds were exceeded and mapping their spatial overlap. A severity classification was then applied based on the intensity of the overlap, dividing affected areas into three categories: Medium-High, High, and Very High. Overall, the results indicate that Rome exhibits widespread environmental vulnerability, with critical hotspots concentrated in suburban belts around the central core. The generated severity maps provide valuable tools for urban planners and policymakers, emphasizing the need for targeted mitigation strategies, such as expanding urban green areas and improving traffic management, to address the combined challenges of climate change and air pollution in densely populated environments.

Scale Dependence of Tree Canopy Cooling and Imperviousness Effects in Rome from Mobile Air Temperature Observations (TRAMS)

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This study investigates the relationship between Air Temperature (AT), tree canopy cover, and imperviousness in Rome, Italy, using a novel observational approach based on low-cost sensors mounted on public buses within the TRAMS (Temperature Rome ATAC Monitoring System) experiment. The network operates autonomously, requiring no on-site personnel, and provides continuous 24-hour measurements across the entire urban area.

Data were collected during two summer seasons under clear-sky and meteorologically stable conditions. Mobile observations were compared with measurements from a network of fixed rooftop stations to derive temperature anomalies with respect to an average citywide signal. This normalization allows the homogenization of measurements collected at different times and locations and enables a consistent comparison of spatial temperature patterns across the city.

The analysis focuses on the influence of urban vegetation and built surfaces on near-surface air temperature. Results reveal a clear cooling effect associated with tree canopy cover during daytime hours, characterized by a robust relationship between temperature anomalies and canopy fraction. The magnitude of this cooling depends on the spatial scale at which vegetation is evaluated. By analysing canopy cover across multiple spatial scales, stronger cooling signals emerge at larger spatial extents, suggesting that vegetation provides more effective thermal regulation at neighbourhood scales than at very fine resolutions.

During night-time, air temperature exhibits a strong linear increase with imperviousness, with differences up to 3.6°C between fully urbanized and non-urbanized areas. The resulting diurnal cycle of Urban Heat Island (UHI) intensity, derived from the imperviousness-based method, is consistent with theoretical expectations and previous studies, showing negligible values during daytime and peaks of 3–4°C at night.

Overall, these results highlight the scale-dependent role of urban vegetation in mitigating urban heat, supporting the development of targeted urban climate adaptation strategies.

A methodological approach for microclimatic analysis and assessment from the macroscale to proximity open spaces

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This paper outlines a research methodology within the field of architectural technology which, by combining the use of GIS and satellite imaging and interrelating map data at various levels, aims to analyse—from the regional to the neighbourhood scale—parameters relating to soil studies, the presence and health of vegetation, air and surface temperatures, with the aim of identifying critical areas in the city of Rome, characterised by prevalent risk factors linked to the broader issue of the Urban Heat Island.

Based on the results of the territorial analyses, within a needs-performance matrix, the methodological workflow involves correlating data for the territorialisation of interventions with the aim of proposing mitigation and adaptation strategies which,

through strategic solutions and technological guidelines, aim to support designers in making informed choices to mitigate the intensity of the Urban Heat Island Effect.

To support strategic decisions, for the critical areas identified in Rome, pre- and post-intervention microclimatic models were created using the multi-physics software ENVI-met to test, with measurable results, the effectiveness of the proposed intervention options and compare their effects in the neighbourhoods included in the study.

Further simulation, using climate data containing the IPCC's 2050 temperature projections, enabled the evaluation—through the simulation of the UTCI and PET thermal comfort indices—of possible design variants suited to the future climate.

The methodological approach highlighted how, through the implementation of synergistic and cross-cutting analysis and design strategies, it was possible to test the measurability of design actions and the replicability of the method, in support of designers and administrators at various levels of local government.

Furthermore, the future climate projection has made it possible to develop project scenarios that can, from today onwards, incorporate the future's requirements into design concepts.

Land Surface Temperature Downscaling for High-Resolution Urban Heat Monitoring

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The accurate characterization of the Urban Heat Island (UHI) effect is often hindered by the relatively low spatial resolution of satellite thermal infrared (TIR) sensors compared to visible and near-infrared (VNIR) instruments. While thermal data are essential for monitoring surface energy fluxes and heat extremes, the physical limitations of thermal detectors often result in poor spatial resolution to maintain an adequate signal-to-noise ratio. This study presents a two-stage hypersharpening protocol, developed within the framework of the Italian Space Agency's MUSTER project, here applied to enhance Landsat 8/9 Thermal Infrared Sensor (TIRS) data from its native 100 m resolution to a 15 m spatial sampling interval.

The core methodology focuses on a multimodal fusion approach that exploits the statistical correlation between thermal emission and reflected solar radiation. The first stage of the process, named assimilation, involves the synthesis of unique sharpening images tailored to each thermal band. This is achieved by performing a pixel-by-pixel multivariate linear regression of the higher-resolution optical bands—including eight 30 m VNIR/SWIR bands and the 15 m panchromatic (Pan) channel-towards the 100 m TIRS bands. The resulting regression coefficients are then used to synthesize "synthetic Pan" images at 15 m resolution that optimize the spatial details to be injected.

In the second stage, a projection-based fusion algorithm is employed to perform the actual hypersharpening. This algorithm injects high-pass spatial frequency components from the synthetic sharpening images into the interpolated TIRS bands. A projection-based injection gain, calculated from data covariance, ensures that the spatial detail enhancement is physically consistent and balanced according to the correlation between the reflective and thermal datasets. This multivariate regression framework makes the method robust and independent of the data format, whether utilizing top-of-atmosphere spectral radiance or level-two surface reflectance products.

The methodology is validated using a case study of Poznań, Poland, demonstrating that the 15 m sharpened Land Surface Temperature (LST) maps successfully capture fine-grained thermal variability within the urban landscape. Quality assessment using no-reference statistical indices confirms that the hypersharpened products maintain high physical consistency, with correlation coefficients significantly exceeding those of the original thermal bands when compared to individual reflective channels. These results facilitate more precise investigations into urban heat intensity measurements.

From satellite data to decision support: the MIRIFICUS WebGIS platform for Surface Urban Heat Island monitoring

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(3) INAIL

Earth Observation (EO) data are of paramount importance to address the challenges posed by climate change and extreme thermal events affecting the urban environment. In this context, sustainable urban planning increasingly requires continuous environmental monitoring and access to actionable spatial information to support Public Administrations (PAs) in implementing effective climate adaptation strategies. Remote sensing technologies provide multi-scale, spatially, and temporally consistent observations that enable the identification of vulnerable areas and the evaluation of mitigation actions.

Within this framework, the MIRIFICUS project, which investigates the potential of nature-based solutions and cool materials to mitigate the Surface Urban Heat Island (SUHI) effect in Italian cities, developed a GIS-based remote sensing platform aimed at supporting urban planning and environmental decision-making. The project was funded by the Italian Space Agency (ASI) and coordinated by the Institute of Bioeconomy of the National Research Council of Italy (IBE-CNR) in collaboration with the Institute for Environmental Protection and Research (ISPRA). Satellite-derived indicators and geospatial analyses produced during two years of project activities were integrated into an interactive WebGIS platform designed to provide accessible and operational information for PAs. The system leverages open EO data from NASA's Landsat-8/9 missions and the Copernicus Sentinel-1/2 programmes, with spatial resolutions ranging from 10 to 60 m.

A multi-scale approach was adopted: at the national level, seasonal land surface temperature and land cover analyses were developed for all Italian municipalities. SUHI intensity, surface albedo, and thermal anomalies were further investigated for the twenty regional capitals. In addition, Florence and Rome were selected as case studies, where microclimate simulations were performed in urban hot-spot areas to evaluate the potential of urban reforestation strategies to mitigate intra-urban temperature extremes.

The main goal of the MIRIFICUS project is to support urban planners and strategic decision-makers by granting them intuitive spatial layers for planning strategies.

SMARTY – Integration of Satellite Data and Operational Information to Support the Resilience of Metropolitan Cities

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(1) e-GEOS

SMARTY – Integration of Satellite Data and Operational Information to Support the Resilience of Metropolitan Cities is a joint ASI–e-GEOS project that develops advanced geo-information services for metropolitan governance and risk management. Within ASI's I4DP_MARKET program, the project exploits Earth Observation data in combination with in-situ and operational datasets from local authorities, environmental agencies to deliver decision-ready products for urban resilience, environmental monitoring, and public safety.

A key thematic focus of SMARTY is the characterization and monitoring of urban heat islands, addressed through dedicated thermal applications based on satellite observations. By integrating thermal EO products with ancillary data (e.g. land use, population exposure, critical infrastructures), SMARTY generates maps that support the analysis of heat-stress patterns, identification of vulnerable areas, and evaluation of mitigation measures at metropolitan scale. These outputs are designed to feed planning processes and emergency preparedness, enabling public authorities to better understand spatial and temporal dynamics of urban heat and to prioritize interventions.

The project implements an integrated service platform that orchestrates thermal and multispectral satellite data acquisition, processing chains, and data fusion workflows, and disseminates products through standardized service interfaces towards institutional users. A user-driven co-design process with metropolitan cities and public bodies ensures that service specifications, validation activities, and demonstration scenarios are aligned with real operational needs, particularly for climate adaptation and heat-related risk management. Beyond the technical development, SMARTY includes activities on service sustainability and business modelling, positioning thermal EO applications for urban heat island monitoring as a core pillar of future operational services for resilient metropolitan areas.

Oral presentations

"Algorithms and applications for Earth Observation in the thermal infrared" (Day 2, 14 May 2026)

Session #1 "THERESA project"

Session chaired by Sara Venafra, Technologist at the Italian Space Agency (ASI) and Project Manager of the "THERESA – THErmal infRarEd SBG Algorithms" project.

The session is jointly organised with Istituto Nazionale di Geofisica e Vulcanologia / National Institute of Geophysics and Volcanology (INGV).

The session aims to present the results achieved in the framework of **"THERESA – THErmal infRarEd SBG Algorithms"** project, funded by ASI to promote scientific activities in support to the SBG-TIR mission. The project is a collaboration between ASI and INGV.

The project supported the potential development of the SBG-TIR mission by advancing data processing algorithms and scientific applications in the visible and thermal infrared domain. Conducted between 24 July 2023 and 23 May 2026, the study focused on the development, testing, and validation of Level 1 and Level 2 algorithms, as well as higher-level application products related to vegetation, volcanoes activities, soil and atmosphere.

The project activities were carried out through a combination of physics-based approaches, including radiative transfer simulations, surface energy balance modelling, and airborne and satellite data analysis, as well as field measurements. Significant progress was achieved in geolocation, atmospheric correction, cloud masking, and retrieval of key geophysical and biophysical parameters. The integration of physically based models and machine learning approaches further improved algorithm performance.

The results demonstrate a substantial increase in the Scientific Readiness Level (SRL) of the developed methodologies, reaching pre-operational maturity. The project also supported the integration of algorithms into a mission-oriented processing framework, including contribution to the SBG-VIREO End-to-End simulator.

The THERESA Project: Advanced Algorithms for VNIR–TIR Data in the Context of the SBG-TIR Mission

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The THERESA (THErmal infRarEd SBG Algorithms) project was conceived to support SBG-TIR mission by developing and refining algorithms for the processing of VNIR–TIR data. Building upon state-of-the-art approaches, THERESA accounted for the specific technical characteristics of the SBG-TIR mission in order to design advanced methodologies capable of exploiting multiple spectral channels in a synergistic way. A key strength of the project was the simultaneous availability of visible and thermal imagery, which enabled the development of sharpening techniques and innovative approaches for the joint estimation of land surface temperature and emissivity. Within THERESA, several processing steps were investigated, including accurate image georeferencing, the generation of simplified classification maps (e.g., clouds, shadows, snow, and water bodies), and the retrieval of emissivity and surface temperature. The project addressed multiple application domains. These included vegetation analysis through the estimation of fractional cover and related parameters such as evapotranspiration; the monitoring of dynamic events such as volcanic eruptions and wildfires, providing estimates of key variables including SO and ash emissions, hotspots, and Fire Radiative Power (FRP); and the characterization of soil surface properties, including the estimation of organic matter and the detection of geologically relevant raw materials. Overall, THERESA contributed to advancing the exploitation of multi-spectral thermal data, providing a consistent framework for future applications in environmental monitoring and Earth system analysis.

Analysis of methodologies for SBG-TIR L1 and L2 products retrievals (geometric and atmospheric correction, land surface temperature and emissivity estimation, cloud/shadow/snow/land-sea mask)

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One of the 5 WPs of the THERESA project, namely the WP 2, has been devoted to developing procedures useful for the preprocessing of the images acquired by the 2 sensors (VIREO and OTTER), in order to support and facilitate the implementation of procedures for the generation of higher Level products. The 4 objectives of this WP can be synthetized as follows:

• OBJ 1. TOA Calibrated Radiance VNIR in cartographic geometry: analysis of methodologies necessary to obtain a georeferenced Level 1 product with the typical accuracies of sensors with comparable swath.

• OBJ 2. TOA and BOA Reflectance VNIR in cartographic geometry: analyze the methodologies necessary to obtain a georeferenced Level 1 product with the typical accuracies of sensors with comparable swath, as well as the atmospheric correction methodologies.

• OBJ 3. Cloud/Shadow/Snow/Land-Sea Mask L2 Global: define an optimal approach for masking pixels of no interest or which can constitute a source of error in the generation of value-added products.

• OBJ 4. Land Surface/Emissivity Temperature: implement procedures for extracting surface temperature and emissivity.

The paper aims to illustrate briefly the two-year project activity, whereas a specific presentation will be devoted to discussing one of the project achievements we consider more interesting. The activity of WP 2 covers the problem of correctly geolocating on the ground the area imaged by a pixel of the EO satellite image. This problem is particularly relevant given the large swath of the VIREO sensor (□ 1000 km). Then the problem of implementing an optimal cloud mask procedure was addressed and the advantage of combining the data collected by the two sensors has been shown. Further the possibility to reduce the image geolocation error to sub-pixel distance by using Sentinel-2 imagette (S2-GRI) and GCP (Ground Control Point) has been demonstrated and finally a study to use OTTER thermal data to extract water vapor maps has been carried out.

Use of SBG-TIR data for applications related to vegetation

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The SBG-TIR mission is a cooperation of ASI and NASA/JPL for the development of an earth observing satellite for the estimation of land surface temperature and emissivity, evapotranspiration, snow properties, soil moisture, minerals, wildfires and volcanoes parameters. The instrumental payload of the SBG-TIR satellite is composed of two instruments on the same rotating mirror. The thermal instrument, the Observing Thermal Emission Radiometer (OTTER) consists of a multispectral scanner with six spectral bands operating between 8 and 12.5 m and two mid-infrared bands at 4 m and 4.8 m, with a 60 m ground sample distance. The optical instrument, Visible InfraRed Earth Observation camera (VIREO) consists of a Visible and Near Infrared two bands scanner at 655 and 835 nm with a 60 m ground sample distance and a panchromatic band centered at 750 nm with a 30 m spatial resolution. Indeed, the combination between OTTER and VIREO cameras is very important in the context of SBG-TIR mission since allowing the retrieval of vegetation parameters co-registered with surface temperature and eliminates geolocation errors, which is critical for applications relying on accurate evapotranspiration and surface energy flux estimates. This combination also reduces reliance on external data sources, minimizing the impact of cloud cover associated with the assimilation of data coming from other space missions. Moreover, it enables consistent retrievals across the sensor's wide swath and facilitates synergistic use of VNIR and TIR observations throughout the mission. This contribution presents the methodological aspects and some of the results obtained within the THERESA project (THErmal infRarEd SBG Algorithms), concerning: (i) the possibility of estimating vegetation products, (ii) issues related to temperature anisotropy, and (iii) sensitivity analysis of evapotranspiration with respect to the directionality of surface temperature.

Fire and volcanic applications

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The WP4 of THERESA project is dedicated to fire and volcanic applications and is composed of six tasks: 4.1 - Fire Radiative Power, 4.2 - Hot Spot Detection, 4.3 - Volcanic ash and SO2 retrievals, 4.4 - Sensitivity to CO2, 4.5 - Land Surface Temperature/Emissivity sharpening (VNIR-NDVI-TIR), 4.6 - Activities for CAL/VAL. The Fire Radiative Power (FRP) of an active fire has been derived by using MASTER data acquired on a wildfire in California. The MIR single band approach was considered for the FRP retrieval. Concerning the Hot Spot Detection, the Normalized Thermal Index (NTI) has been considered. A lookup table was developed for NTI thresholds and employed for a MASTER image acquired in 2018 during the Kīlauea eruption. The purpose of Task 4.3 is to test the capability of SBG-TIR for volcanic ash and SO2 retrievals, using synthetic images obtained from MODTRAN. In particular, the SBG-TIR bands (8.3-8.6 m for SO2, 10.3-11.3-12.0 m for ash) were used. As test cases, Etna (Italy), Eyjafjallajökull (Iceland) and Krakatau (Indonesia) volcanoes were considered. Task 4.4 is dedicated to the study of MIR-2 channel. The objective is to evaluate the sensitivity of this channel to CO2 emissions from high-temperature sources, considering that the gas exhibits absorption bands around 4.8 m. The scope is to derive sensor characteristics, in terms of NEDT, needed to detect CO2 emissions. In the framework of Task 4.5, we investigated downscaling methodologies that exploit the relationship between LST and NDVI. Performance analyses of different algorithms have been conducted, with particular attention to the TsHARP algorithm that has been tested using Landsat 8–9 data over heterogeneous environments. Finally, the team conducted field campaigns during 2023 (at Stromboli, Vulcano, Sardegna, Biancane) and 2025 (at Vulcano and Mt. Etna) with the aim to collect data for algorithm validation purposes.

Thermal remote sensing for topsoil characterization and raw material analysis

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The activities carried out within WP5 of the THERESA project aimed to explore advanced Level 3 (L3) remote sensing products for mapping surface materials. The project also aimed to anticipate and leverage the capabilities and synergies of future

Italian and European Earth observation facilities (IRIDE, PRISMA-SG, CHIME and LSTM). WP5 considered thermal remote sensing for raw material analysis (qualitative and quantitative mineral mapping) and the characterization of topsoil components (texture, carbonates and soil organic carbon – SOC). Activities primarily exploited data from an airborne campaign to simulate the upcoming SBG-TIR (Surface Biology and Geology – Thermal InfraRed) mission. Algorithms will be designed, developed and tested based on existing literature and state of the art, and implemented in prototype processing chains using an input database of emulated/simulated TIR (aerial) data with characteristics similar to SBG-TIR L1/L2 data products. These will then be validated using in situ data. Several sites will be used for product validation: Jolanda di Savoia and Maccarese for topsoil and the serpentinitic outcrops in the northern Apennines for raw materials. This communication will present the results of the WP5 activities in terms of the products and validations performed on the considered L3 products, with a view to future applications of thermal EO resources. Moreover, a brief description of the SOCRATIR project, recently submitted to the ASI call “Prodotti prototipali evoluti per la missione SBG”, will be presented.

Enhanced Detection of Volcanic Thermal Anomalies Using Normalized Thermal Indices

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Efficient detection of volcanic thermal anomalies is essential for improving early warning systems and supporting continuous monitoring of active volcanoes at both regional and global scales. Satellite remote sensing, particularly in the Middle InfraRed (MIR) and Thermal InfraRed (TIR) spectral regions, provides a unique capability to identify high-temperature features even when they occur at subpixel scale. This study develops and validates a set of advanced algorithms within the THERESA (THErmal infRarEd SBG Algorithms) project, specifically designed for the SBG-TIR sensor. Building on existing approaches such as threshold-based, contextual, and Normalized Thermal Index (NTI) methods, new NTI formulations are introduced to enhance sensitivity to thermal anomalies. These indices exploit the different radiative behavior of surfaces in the MIR and TIR domains, while accounting for spectral response functions, atmospheric effects, and sensor saturation. A large simulation dataset, comprising approximately 2.8 million synthetic pixels with varying thermal compositions, was generated to evaluate algorithm performance under realistic volcanic conditions. The simulations include combinations of hot lava, cooler crust, and background temperatures, enabling robust

assessment of subpixel anomaly detectability. An optimal detection threshold of approximately -0.6 was identified, ensuring high sensitivity with minimal false positives. To further address uncertainties related to mixed pixels, a fuzzy logic approach was implemented, assigning confidence levels based on the agreement among multiple NTI estimators. Spatial coherence analysis was also applied to reinforce clustered detection and suppress isolated noise. The results demonstrate a significant improvement in the detection of both intense and subtle thermal anomalies, highlighting the potential of the proposed methodology for operational volcanic monitoring using next-generation satellite sensors.

Volcanic Ash and SO2 Retrievals

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In the sphere of THERESA (THErmal infRarEd SBG Algorithms) project, the capability of the SBG-TIR mission for volcanic ash and SO2 retrievals has been studied. Two different algorithms, both working in the TIR range, have been used for this purpose: Look-Up-Table procedure (LUTp, Corradini et al, 2009. https://doi.org/10.5194/amt-2-177-2009) and Volcanic Plume Retrieval (VPR, Pugnaghi et al, 2016. https://doi.org/10.5194/amt-9-3053-2016). Both procedures are able to retrieve the ash aerosol optical depth (AOD), the ash effective radius (Re) and the vertical column density of ash (VCDa) and SO2 (VCDs) inside a volcanic cloud. Both LUTp and VPR have so far been successfully applied to several TIR satellite sensors such as MODIS (on Terra & Aqua platform), SEVIRI (on Meteosat Second Generation), SLSTR (on Sentinel-3). Using MODTRAN 5.3 radiative transfer model, the behaviour of the six SBG-TIR channels (from 8.3 to 12.0 micron) has been simulated. As test case, Mt. Etna (Italy), Eyjafjallajökull (Iceland) and Krakatau (Indonesia) volcanoes were considered. For each volcano, 4 synthetic images have been produced, simulating summer/winter atmospheric conditions and pre/syn-eruptive scenarios. All the outputs of LUTp and VPR have been compared with true simulated values, obtaining the relative errors, by considering six different SBG-TIR bands triplets (channels 1-4-5, 2-4-5, 1-4-6, 2-4-6, 1-5-6, 2-5-6). The results are encouraging and confirm the possibility of obtaining reliable quantitative estimates of volcanic ash and SO2 from the SBG-TIR sensor. Finally, a sensitivity study regarding the detection limit of SBG-TIR on SO2 and ash columnar content was carried out too. An accuracy of 0.5 K for all the SBG-TIR bands was considered as indicated in the technical specifications from NASA JPL.

A cloud mask approach for thermal missions

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The development of cloud masking algorithms for the SBG-TIR mission highlights the importance of adding thermal infrared (TIR) bands to VNIR only cloud masking approach. VNIR-only approaches (e.g., Cloud Index, K-means, Sentinel band difference technique) suffer from low recall rate for cirrus clouds and high commission errors over bright desert soils and snow regions. A new Thermal Cloud Index algorithm is introduced, which combines VNIR bands with a single TIR band. This has resulted in substantial improvement in accuracy, especially in regions with bare soil and cirrus clouds. The algorithm was tested using Landsat data, with Landsat Fmask being used as a reference. High F1 scores exceeding 95% in challenging semi-arid regions (e.g., Tunisia) were achieved by exploiting the temperature contrast between hot soils and cool clouds, effectively eliminating false positives and improving cloud detection. The Dual Thermal Cloud Index algorithm further enhances performance by incorporating two TIR bands to compute the Cirrus Thermal Index (CTI = $BT_{10} - BT$). This helps us to achieve a reasonable separation of cirrus clouds from snow and ice, a scenario where VNIR-only and single-TIR methods struggle. The algorithm uses adaptive thresholds based on cloud brightness temperature and CTI values. In snow-covered regions, this approach improved F1 scores by up to 10% over the single-TIR version, with high precision for opaque clouds and thin cirrus while maintaining low omission errors. There are still issues in heavy snow regions, especially compared with algorithms that have access to SWIR. In summary, the addition of TIR bands to a VNIR-only algorithm improves cloud detection in most conditions (Arid, Tropical, high latitudes). The proposed algorithm is excellent in snow-free conditions (F1 score>90%) with reasonable results in regions with snow cover. Additionally, the work also includes probability-based cloud masks with 3 levels of cloud confidence for various operational use cases.

Estimation of Leaf Area Index and Vegetation Fractional Cover using SCOPE simulated data and Sentinel-2 images

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We present a study conducted within the framework of the joint NASA/ASI Surface Biology and Geology Thermal Infrared (SBG-TIR) mission, which will operate in a sun-synchronous polar orbit collecting data at global scale. The mission will acquire spectral data in the thermal infrared domains (3–5 m and 8–12 m) and in the Visible and Near-Infrared (VNIR) with two spectral bands centered at 655 nm (VNIR0) and 835 nm (VNIR1), along with a panchromatic channel spanning 580–920 nm. All spectral bands will be collected at 60 m spatial resolution. In this context, accurate retrieval of Fractional Vegetation Cover (FC) and Leaf Area Index (LAI) is of particular relevance, as it enables synergistic use of VNIR and TIR observations to support vegetation monitoring and surface energy flux estimation. To address this objective, several machine learning algorithms were evaluated under different configurations for the retrieval of FC and LAI. Model training was performed using synthetic datasets generated with the Soil-Canopy Observation, Photochemistry and Energy Fluxes (SCOPE) radiative transfer model, which simulates reflectance and radiance from soil, leaf, and canopy components across the optical spectrum [Van Der Tol et al., 2009, Yang et al., 2020]. Calibration and validation were conducted using independent synthetic datasets to ensure generalizability and robustness. Input features included VNIR spectral bands, the panchromatic channel, vegetation indices, and variables describing illumination and observation geometry. Model performance was assessed on independent test data, with uncertainty quantification included. The optimal configuration achieved RMSE values of 0.046 for FC and 0.053 m2/ m2 for LAI using a six-channel input set. These results are consistent with previous studies, [e.g. García-Haro et al., 2018; Weiss et al., "S2ToolBox Level 2 products"] supporting the validity of the proposed approach. The trained models were subsequently applied to Sentinel-2 imagery to evaluate performance under re-al-world conditions. Validation was performed using the GBOV (Ground-Based Observations for Validation) dataset [Bai et al., 2019] and standard Sentinel-2 biophysical retrievals. The results demonstrated strong statistical agreement with the Biophysical Processor implemented in the ESA Sentinel Application Platform (SNAP) toolbox, confirming the robustness of the proposed framework for operational estimation and mapping of FC and LAI in the context of SBG-TIR space mission.

Predicting Soil Organic Carbon with LWIR Spectral Data: From Laboratory and Airborne Imagery to Simulated Future Thermal Missions

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Soil Organic Carbon (SOC) and texture quantification are useful for precision agriculture to manage soil health. While Vis-NIR-SWIR (0.4-2.5 m) spectroscopy is a widespread technique for topsoil mapping, the Longwave Infrared (LWIR, 8.0–12.0 m) spectral range remains underexploited due to data lack and temperature/emissivity separation (TES) difficulties. Addressing this gap is relevant given the upcoming launch of high-resolution satellite thermal missions, such as LSTM, TRISHNA, and SBG-TIR. In this context, as part of the activities of the ASI-funded THERESA project, this study evaluates the potential of hyperspectral LWIR emissivity for estimating SOC and soil texture within our dedicated Work Package 5 Topsoil mapping. Focusing on Jolanda di Savoia, one of the largest Italian farms, airborne Hyperspectral Thermal Emission Spectrometer (HyTES) data were integrated with laboratory FTIR spectroscopy. A processing chain was applied, including spatial atmospheric compensation via ICCAAC, and the TES algorithm. A deep learning Autoencoder was implemented to simulate acquisitions from future orbital sensors. Several machine learning algorithms were trained on libraries built with laboratory, airborne and simulated satellite data. The analysis revealed that spectral features in the 7.5–8.3 m and 10.7–11.9 m ranges are correlated with SOC and clay content, while the 8.3–10.7 m range is strongly correlated with sand content. On HyTES data, the SVR model achieved the best performance for SOC (R = 0.53, RMSE = 0.74%). By simulating LWIR emissivities for future missions, SBG-TIR data processed with PLSR achieved an R of 0.41 and an RMSE of 1.13 % for SOC. These results demonstrate that LWIR thermal data allow for an accurate characterisation of soil properties, supporting the future operational use of satellite emissivity for soil health monitoring.

Surface Mineral Mapping Using LWIR airborne data in view of the future thermal missions

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Serpentine minerals exhibit spectral differences primarily due to structural variations. Among these, the Mg-serpentine polymorphs—lizardite, antigorite, and chrysotile—can be distinguished in the Mid-Infrared (MIR) and Long-Wave Infrared (LWIR) regions. While the most diagnostic infrared features lie between 2.7–2.74m and 15.5–16.2m, these ranges are not covered by current satellite missions. However, absorption features in the 9.7–10.5m range, attributed to Si-O stretching, also vary among serpentine polymorphs. Notably, this critical spectral window is encompassed by the Surface Biology and Geology (SBG) sensor's bands (e.g., TIR-4 at 10.30 m), presenting promising opportunities for future exploration. This study evaluates the capability of airborne TASI-600 hyperspectral data in the LWIR range for mineral mapping in a serpentine-rich area. Using reference spectra from established spectral libraries, the analysis focuses on identifying mineralogical variations associated with serpentinized rocks to support and guide the future application of the SBG mission. The study area consists of exposed serpentinite minerals in the Val di Taro region near Parma, Italy (44.577°N, 9.883°E). TASI-600 data, comprising 28 spectral bands from 8.27 to 11.23 m, were acquired on December 5, 2019, supported by a field sampling campaign on June 9, 2023. Mineralogy was validated using X-ray Diffraction (XRD), with additional MIR-LWIR emissivity measurements collected using a portable FTIR spectrometer. A total of 64 spectra representing 12 minerals (antigorite, lizardite, chrysotile, chlorite, vermiculite, quartz, olivine, calcite, hematite, goethite, albite, and talc) were selected from the ECOSTRESS Spectral Library and resampled to TASI spectral resolution. Multiple Endmember Spectral Mixture Analysis (MESMA) was then performed using two- and three-endmember mineral mixtures, including a shade component. The results demonstrate that LWIR data are highly effective for mineral mapping, particularly in distinguishing serpentine polymorphs. The SBG-TIR sensor is expected to deliver high-quality data with strategically positioned bands ideally suited for characterizing serpentine minerals.

Session #2 "EO Thermal Algorithms and Applications"

Session chaired by Sara Venafra and Giorgio Licciardi, Technologists in the "Earth Observation" Office at the Italian Space Agency (ASI).

The session aims to showcase the most recent and current research undertaken by the Italian scientific, institutional and industrial community on EO thermal algorithms and applications. In particular, it will provide a forum for discussion of the state of the art and most recent technological and algorithmic innovations in the field of scientific research and downstream applications for the study of sea surface temperature and marine heat waves, water resources, crop health status, surface temperature and heat island mapping, mapping of volcanic emissions and their composition, fire characterization, raw materials. The presentations will also help to identify future lines for development.

Assessing the contribution of ECOSTRESS-derived TIR products to LCZ mapping in view of the future thermal missions

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The Local Climate Zone (LCZ) system is a standardized framework for the analysis of urban thermal environments and the Urban Heat Island (UHI) effect assessment. Current LCZ mapping approaches primarily rely on optical remote sensing imagery and urban canopy parameters (UCPs), which effectively describe urban morphology but only partially capture urban thermal properties. As a result, surface materials and building types with similar spectral and structural properties often remain difficult to distinguish.

This work investigates the potential contribution of high-resolution thermal infrared (TIR) data, representative of the forthcoming SBG-TIR mission, to LCZ mapping. ECOSTRESS is used as a proxy dataset, as it currently provides the most comparable high-resolution TIR products in terms of spatial detail and multi-variable surface characterization.

Sentinel-2 multispectral imagery and UCPs are integrated with ECOSTRESS-derived land surface temperature (LST), emissivity, NDVI, and albedo within a Random Forest classification framework. The objective is to assess whether the inclusion of high-resolution TIR information improves classification accuracy, temporal robustness, and geographical transferability.

The analysis is structured in three stages. First, a case study over Milan evaluates the incremental contribution of ECOSTRESS features for a representative summer date. Including all ECOSTRESS products increases overall accuracy from 81.5% to 85.9% (+4.4%), improving both built-type and land cover classes. Thermal variables reduce material-related confusion and enhance building subtype discrimination, while ecological variables improve vegetation and natural land cover classification.

Second, a multi-temporal analysis confirms that improvements in built-type classes remain stable across summer dates. Third, a cross-city transferability assessment (Rome, Hanoi, and Ho Chi Minh City) shows consistent gains in land cover accuracy; however, improvements in built-up classes depend on urban complexity and data consistency.

Overall, the results demonstrate that high-resolution TIR data can substantially enhance LCZ mapping, supporting more physically informed urban climate analyses and future SBG-TIR applications.

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MASTER Level-3 Products: Algorithms and Applications for Future TIR Satellite Missions

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Thermal infrared (TIR) observations provide key information on surface composition, thermal anomalies, and land surface energy processes. These measurements enable the retrieval of multiple surface parameters, including mineral composition, active fire characteristics, and evapotranspiration. Although retrieval approaches have been proposed in the literature, they have not been systematically implemented and distributed as standard Level-3 products. The MODIS/ASTER (MASTER) Airborne Simulator offers multispectral measurements from the visible to the TIR (0.4–13 m) with high spatial resolution and provides a unique dataset for the development and validation of algorithms and the data simulation relevant to upcoming thermal infrared missions, such as SBG-TIR, TRISHNA, LSTM and Landsat Next. This contribution presents a new suite of Level-3 products derived from MASTER data, designed to support several applications. Four MASTER Level-3 products are presented: Surface Mineralogy (SM), Elevated Temperature Features (ETF), Fire Radiative Power (FRP), and Evapotranspiration (ET). The SM product uses spectral emissivity features in the TIR domain to unmix the surface mineralogy and map the abundances of the main rock forming minerals, including: silicates (feldspars, pyroxenes, olivines, amphiboles, micas, and quartz), carbonates (calcite), and sulfates (gypsum). The ETF product identifies high temperature features using indices derived from mid-wave and long-wave infrared channels, enabling detection and identification of active fires, volcanic activity, and other high-temperature sources. The resulting ETF mask is then used as input to the FRP algorithm, which provides quantitative characterization of fire intensity and energy release. In parallel, the ET product estimates the evapotranspiration by solving the surface energy balance equation, combining land surface temperature with atmospheric and meteorological inputs. These Level-3 products demonstrate the potential of TIR observations for environmental monitoring, hazard detection and ecosystem studies, while providing a robust framework for algorithm development and validation in preparation for next-generation thermal missions such as SBG-TIR.

Advanced Thermal Mapping Products in Urban and Periurban Areas

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The use of thermal information from spaceborne sensors in urban areas has been matter of research for many years, especially considering how to compute accurately the Land Surface Temperature (LST) as well as understand how it correlates with the urban spatial morphology, as well as the presence of vegetation and water. The PAMTAUP project, submitted to the ASI SBG product call, aims to go one step further, providing prototype products (information layers) that show the impact of LST on the quality of life of the urban population. The project introduces a set of novel and scientifically advanced products that extract from SBG-TIR and ancillary data information layers that could revolutionize urban heat-aware planning and foster rapid uptake by relevant stakeholders and end-users of the knowledge derived from thermal measurements in densely populated areas. By integrating thermal observations with multi/hyperspectral data sets, these products allow a novel and detailed characterization of climate change and/or heat island effects pertaining to the so-called grey (built-up), blue, (water) and green (vegetation) urban components. Accordingly, LST will be used in conjunction with hyperspectral data (from PRISMA or IRIDE) to extract in an operational scenario a better characterization of urban materials and help quantify their positive or negative effect on the local climate. Similarly, Local Climate Zones will be better characterized using LST, directly incorporating in the recognition of the local behavior of urban blocks according to their thermal response. Moreover, water quality and vegetation characterization using LST will provide the urban stakeholders and/or the urban citizens with further tools to interpret and possibly change the thermal behavior of a given neighborhood and reduce the thermal discomfort that affects already a relevant portion of the urban population. Finally, in all these real-world scenario products, the need for an adequate spatial resolution of the LST maps from space is recognizable, and this project will consider solid approaches to obtain finer resolution than the original SBG one.

High-Resolution Thermal Infrared Imaging for Small Satellites and Small-Series Production in Benevento

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As part of cosine's SCOUT product line, TScout® is the first high-resolution multispectral thermal infrared imager developed for small satellites. Designed for operation on nano-, micro-, and larger satellite platforms, it leverages recent advances in detector technology and calibration to deliver high-quality infrared measurements that have so far been difficult to achieve on cost-effective space systems. TScout® features an onboard data handling system capable of real-time processing, including direct onboard generation of Level-2 products. This significantly reduces the volume of data that must be transmitted to Earth and processed on the ground, enabling more efficient mission operations and faster delivery of actionable information. The instrument addresses a clear need within the remote sensing community for frequent, high-spatial-resolution thermal data. Relevant application domains include agriculture, fire monitoring, urban planning, and defence, with use cases such as plant water stress assessment, irrigation support, and soil moisture mapping. This contribution will present the TScout® instrument concept and discuss cosine Italia's plans for implementing small-series production in its laboratories in Benevento. An overview will also be provided of the target missions and application areas foreseen for this new capability.

The smallsat VULCAIN mission for EO scientific products in VIS\TIR

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Monitoring changes in volcanic activity is crucial to understand signs of impending eruptions. Satellite data can provide a very effective tool to study active volcanoes remotely to understand their evolution. The new planned space missions equipped with thermal sensors, such as ESA-LSTM and NASA/ASI-SBG, will provide a great contribution to the scope. The proposed twin satellites VULCAIN mission aims to complement such challenging goals. The study, funded by ASI under the ESA-GSTP program ended its phase B, sees 2x12U nanosatellites flying in formation to obtain volcanoes stereoscopic images and run IOD for autonomous relative navigation based on RF-ISL. Each satellite embarks two Commercial Off-The-Shelf (COTS) instruments on board: a visible camera and a multispectral thermal camera with four channels in the 8-12 m spectral range with a Ground Sampling Distance of about 30 m and 90 m respectively and a swath over 80 km, flying at low altitude with a low revisit time. The main scientific objectives are to measure the Land Surface Temperature (LST), as well as the SO2 content in degassing plumes and to detect ash emissions from active volcanoes. Furthermore, the combining of visible and thermal data allows to improve the observation on volcanic areas. The 2-spacecraft formation gets to a 3D thermal\visible image reconstruction of the targets and their morphological analysis, their edifice thermal structure and SO_2 and ash plumes 3D analyses. The mission will

target primarily 34 volcanic sites, not limited to. The scientific applications achievable with VULCAIN acquisitions, with examples, together with the distributed mission architecture, will be presented, considering VULCAIN as a potential precursor for an extended TIR-EO fleet.

High Resolution Sea Surface Temperature monitoring in coastal areas: state of the art and proposed advances from the ASTRO research proposal

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The demand for consistent and reliable monitoring of coastal Sea Surface Temperature (SST) is rapidly growing due to its importance in understanding environmental and socio-economic impacts. However, current Earth Observation (EO) satellite products lack the spatio-temporal resolution needed to capture fine-scale coastal dynamics. CNR-ISMAR has extensive expertise in SST remote sensing, contributing to the Copernicus Marine Service, participating in ESA-funded projects on Marine Heat Waves (MHW), and actively engaging in the GHRSST scientific community, particularly in discussions on future high-resolution thermal missions. Within this context, the ASTRO proposal (Analysis of ultra-high resolution Sea Surface Temperature via Remote Observations - currently under evaluation as part of a dedicated ASI initiative) aims to develop a prototype Level-2 (L2) SST product based on the characteristics of the future Surface Biology and Geology Thermal Infrared (SBG-TIR) mission, addressing key observational gaps in coastal and regional seas. ASTRO aims at combining physically-based radiative transfer simulations with observation-driven approaches using NASA-ECOSTRESS data as proxy, enabling the development of dedicated SST retrieval algorithms and their assessment with field data and satellite observations. A major focus will be the exploitation of prototype SBG-TIR SST products to demonstrate new applications in transitional, coastal, and marine environments, with potential synergies with other missions such as TRISHNA or LSTM. The ASTRO scientific activities aim to investigate: i) synergies between SBG-TIR and other EO missions (e.g. Sentinel-2, Landsat) to better characterise land-sea interactions and coastal physical processes at relatively fine spatial scale; (ii) the impact of ultra-high resolution SST on the detection of MHWs and their impacts on marine species and aquaculture; (iii) the integration of HR SST into operational frameworks as the Copernicus Marine Service, with the aim of maximising usage of the results. As a main outcome, the proposed activities will thus enhance monitoring capabilities and support decision-making in coastal management.

Thermal remote sensing for monitoring mountain environment

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Thermal remote sensing missions, such as the forthcoming SBG-Thermal Infrared (SBG TIR) mission, are designed to address the growing need for enhanced observation capabilities to study natural processes and human induced changes. Owing to their high spatial and temporal resolution and the ability to acquire measurements both day and night, thermal sensors offer unprecedented opportunities for continuous monitoring in heterogeneous and challenging environments, particularly mountainous regions. Within this framework, the T4M project seeks to develop a suite of advanced prototype products tailored to the SBG TIR mission, with a specific focus on the integrated monitoring of cryospheric and biospheric processes in these complex landscapes. T4M leverages synergistic use of optical and thermal data, in combination with innovative machine learning techniques and physically based models, to generate novel products that quantify key environmental variables. These include snow and ice properties, permafrost characteristics, and vegetation biophysical parameters such as Leaf Area Index (LAI) and Fractional Cover (Fc). The project further aims to enhance evapotranspiration (ET) modeling over orographically complex terrain, where current approaches often struggle due to lack of high resolution, physically consistent observations. The resulting products are expected to play a crucial role in strengthening digital twin models of the Earth's surface, which typically suffer from insufficiently detailed calibration and validation datasets. A comprehensive processing chain will be developed with a strong industrial perspective, emphasizing the quantification of product uncertainties and the execution of extensive field validation campaigns. By doing so, T4M will maximize both the operational relevance and scientific value of the SBG mission. Ultimately, the project will deliver prototype algorithms for cryosphere and biosphere monitoring, provide robust validation tools, and contribute to the industrialization of an L2 processor within the VIREO Ground Segment, supporting the broader ecosystem of SBG TIR data exploitation.

Leveraging the thermal missions for Advanced Crop Stress Monitoring: Indices based on Physical TIR Modeling

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Traditional satellite-based monitoring of crop health predominantly relies on vegetation indices like the NDVI, which are based on greenness in the VNIR spectrum. However, these indices often face limitations in distinguishing between senescent vegetation and bare soil, particularly during prolonged droughts or extreme heatwaves when thermodynamic stress precedes visible changes in chlorophyll content. The "Novel Indices for Crop Estimation using SBG" (NICE-SBG) project aims to overcome these constraints by exploiting the advanced Thermal Infrared (TIR) capabilities of the upcoming Surface Biology and Geology (SBG) mission. This contribution presents the development and validation of two innovative indices: the Emissivity Contrast Index (ECI) and the Water Deficit Index (WDI). The ECI utilizes multi-channel emissivity information in the TIR Reststrahlen bands of quartz to accurately differentiate vegetation states and soil backgrounds. The WDI integrates retrieved Land Surface Temperature (LST) and emissivity with atmospheric thermodynamic parameters (air temperature and water vapor near the surface) to provide a direct assessment of plant water stress and evapotranspiration. A key technical aspect of this work is the application of a physical forward model for the simulation and retrieval of SBG-TIR radiances. Our methodology is built upon the sigma radiative transfer modelling (also known as sigma-IASI and sigma-FORUM). This approach allows for a self-consistent physical retrieval of surface parameters, including LST and principal component scores for the emissivity spectrum, overcoming the limitations of standard split-window or statistical methods. The study focuses on a regional case study in Southern Italy (Basilicata, Campania, and Puglia), demonstrating how these TIR-derived products can provide earlier and more accurate detection of crop stress compared to conventional indices. These results underline the potential of the SBG mission to enhance value-added services within the Copernicus ecosystem for precision agriculture and environmental sustainability.

Exploiting σ radiative transfer capabilities for advanced thermal infrared products

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Thermal infrared (TIR) observations provide key information on both surface and atmospheric properties, making them highly relevant for future missions such as the future NASA-ASI Surface Biology and Geology (SBG). In this work, we present the potential of the -based radiative transfer framework for the retrieval of geophysical products from hyperspectral TIR measurements. The methodology combines machine learning scene classification (CIC) with a fast inversion scheme based on radiative transfer modelling, enabling the retrieval of surface properties, atmospheric temperature and water vapour profiles, as well as cloud and aerosol properties. These parameters provide the necessary constraints for an accurate characterization of surface radiative properties. The main focus of this study is on surface products, including land surface temperature and spectral emissivity, retrieved consistently across heterogeneous scenes. Building on these quantities, we derive higher-level indicators such as the Emissivity Contrast Index (ECI) and the Water Deficit Index (WDI), which are sensitive to surface composition, vegetation state, and soil moisture stress. We will also discuss the broader potential of the -based framework for the analysis of thermal infrared observations, highlighting its pseudo-monochromatic formulation and its capability to compute analytical Jacobians for both surface and atmospheric parameters, enabling efficient and flexible retrieval applications. Application to

Stratospheric balloon-based datasets demonstrates that the proposed approach captures spatial variability in emissivity and water stress conditions, highlighting the capability of TIR observations to link surface biophysical properties with near-surface atmospheric states. These results underline the potential of -based retrieval frameworks to support advanced surface product generation for SBG, including drought monitoring and ecosystem characterization.

Towards a Geostationary Thermal System for Operational Support of the Italian National Fire Corps

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The Italian National Fire Corps (CNVVF), within its technical emergency response activity and wildfire management, has progressively integrated Earth Observation (EO) data into its operational and decision-making processes. This evolution, further strengthened through collaboration with the Italian Space Agency (ASI), has enabled the development of advanced capabilities in processing and interpretation of multispectral, SAR, and hyperspectral data, including data from the PRISMA mission. These datasets support fuel characterization, burned area mapping, and damage assessment activities. Despite this progress, operational experience highlights a structural limitation in current polar-orbiting satellite systems (e.g. Sentinel-3, MODIS, VIIRS), whose revisit time and data latency are not fully aligned with the rapid dynamic of active wildfires and the need for near real-time decision support. In this context, next-generation geostationary systems (e.g. Meteosat Third Generation) represent a strategic opportunity for continuous Earth observation. However, for effective operational use in emergency response scenarios, a targeted enhancement of thermal sensing capabilities is required. From an operational perspective, the following key requirements are identified:

• high temporal resolution (sub-hourly, ideally on the order of minutes)

• enhanced spatial resolution in the thermal domain (≤100–250 m)

• high radiometric sensitivity

• near real-time data availability

• multi-sensor interoperability

Meeting these requirements would enable an advanced operational model based on early detection, rapid validation, and continuous monitoring of wildfire events, significantly enhancing the CNVVF's response capability and contributing to improved risk management at national scale. In light of these operational needs, the development of a geostationary platform equipped with high-resolution thermal sensors, specifically designed for emergency management applications, would be highly desirable. In this perspective, ASI could play a strategic role in promoting and leading the development of a dedicated mission, capable of addressing not only the needs of the CNVVF but also those of the broader civil protection system, public administrations, and potential dual-use and commercial applications. An investment would represent a significant paradigm shift: from the availability of data primarily for analysis purposes to the full integration of satellite data as a real-time operational tool supporting decision-making and territorial safety.

Abstracts of the poster session

Poster board #1

Bridging Surface Urban Heat Islands and Predictive Modelling of Land Surface Temperature

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Surface Urban Heat Islands (SUHIs) represent a critical challenge for urban resilience, with direct impacts on public health, energy consumption, and infrastructure stability. Thermal Infrared (TIR) sensors enable the measurement of Land Surface Temperature (LST); however, a significant gap remains in translating these observations into dynamic and predictive tools for operational use.

This work presents a downstream application developed within the CC-PLAN (Climate-change adaptation and planning of human activities) framework, an Advanced Application Service of the DestinE Platform.

Leveraging CGI's Insula platform and in collaboration with the Istituto Nazionale di Geofisica e Vulcanologia (INGV), we introduce the "Forward Urban Heat Island" methodology. This approach combines a decade of historical TIR satellite data with ERA5 reanalysis to characterize local urban thermal behavior. Statistical analysis reveals a strong relationship between near-surface air temperature and TIR-derived LST, with correlation coefficients reaching 0.95.

The methodology enables the generation of "what-if" scenarios and nowcasting products that capture urban thermal variability at high spatial resolution, supporting decision-making processes. By integrating simulations from the DestinE Climate Digital Twin as a baseline, the framework can also be extended to estimate future urban temperature distributions.

A case study over Caserta demonstrates the capability of the approach to detect localized thermal anomalies, including temperature increases of up to 10°C associated

with recent land-cover changes, and to monitor heat stress in high-exposure areas such as UNESCO heritage sites, including the Reggia di Caserta.

Destination Earth (DestinE) is a European Union funded initiative implemented by ESA, ECMWF and EUMETSAT. Access Destination Earth at destine.platform.eu.

Poster board #2

Mapping and Monitoring of Urban Heat Islands in Piedmont (M2UHIP)

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The Urban Heat Island (UHI) phenomenon describes the temperature difference between urban and surrounding rural areas. The main causes are high building density, which traps radiation, the prevalence of heat-absorbing pavements and materials, and the lack of vegetation and permeable surfaces — elements that constitute Green Infrastructure (GI) and promote air cooling. The WHO has highlighted heatwaves as one of the primary challenges for urban planning, as they intensify the UHI effect and increase mortality rates. While established tools already exist for other hazards — such as hydrogeological instability or seismic risk — those dedicated to managing urban heat remain insufficient or not fully operational.

The M2UHIP project aims to address these gaps through two main actions. First, it will produce thematic maps of heat islands across Piedmont's residential centres, analysing their evolution in relation to land-use changes and climatic conditions. Second, it will develop a design support tool for GI, enabling the monitoring of the effects — positive or negative — of specific urban planning interventions. The project will also assess the socioeconomic and health factors needed to estimate risk, integrating data on population exposure and vulnerability. The outputs will further allow the construction of future scenarios projecting health risks based on climate change forecasts and urban development policies.

To achieve these objectives, satellite, meteorological, morphological, and socioeconomic data will be integrated, with particular attention to the most vulnerable population groups. The data will be freely available across the entire regional territory, in compliance with applicable regulations. The key innovation lies in the integration of heterogeneous sources that, while already available today, remain fragmented — providing decision-makers and planners with a new diagnostic tool for interpreting the urban fabric and its vulnerabilities.

Poster board #3

From satellite data to decision support: the MIRIFICUS Project and WebGIS platform for Surface Urban Heat Island monitoring

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The poster presents the MIRIFICUS project, funded by the Italian Space Agency (ASI) in the framework of "Innovation for Downstream Preparation – Public Administration" (I4DP_PA). See also the abstract of the matching oral presentation.

Poster board #4

High-Resolution Surface Temperature Mapping for Urban Heat Risk. Assessment in African Cities

Anna Lisa Labaar [(1)], Marcella Veneziani [(1)]

[(1)] S[&]T

Urban heat poses a growing threat to city populations worldwide, driven by rising global temperatures and rapid urbanization. Compounding this challenge, urban areas consistently record higher temperatures than their rural surroundings, a phenomenon known as the Urban Heat Island (UHI) effect, caused by the heat-absorbing properties of built surfaces such as concrete and pavement.

Under the FAO Green Cities in Action for Africa initiative, ten cities across five African countries are being supported in developing evidence-based Green City Action Plans that address climate adaptation while generating co-benefits for urban communities, the environment, and local economies. As part of this initiative, we developed an hourly high-spatial-resolution surface temperature mapping tool that combines local land-use data with publicly available weather and satellite datasets, using machine learning to estimate surface temperatures across urban areas. This allowed us to map heat patterns for every hour of the day and in every city block, across different land cover types and varying geospatial contexts.

By overlaying these temperature maps with population density data, we identified the areas where heat exposure poses the greatest risk to urban residents. We also simulated the effect of land-use changes, such as converting bare soil to tree cover, to assess the cooling potential of green infrastructure interventions. In some areas, this analysis revealed temperature differences of up to 10°C, highlighting the significant impact that targeted greening can have on urban thermal comfort.

The methodology is designed to be scalable and transferable across diverse urban contexts, with potential for adoption by city planners and institutional users beyond the current pilot cities.

Poster board #5

Improving Thermal Infrared LST Products through NDVI-Based Downscaling for Earth Observation Applications

Malvina Silvestri [1], Vito Romaniello [1], Davide Migliarini [1], Federico Rabuffi [1]

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This work presents the development and preliminary validation of thermal sharpening algorithms in the framework of the THERESA (THErmal infRarEd SBG Algorithms) project, aimed at enhancing the spatial resolution of Land Surface Temperature (LST) products derived from thermal infrared (TIR) satellite data.

Due to instrumental constraints, TIR observations typically exhibit coarser spatial resolution compared to visible and near-infrared (VNIR) data, limiting their applicability in high-resolution environmental monitoring. To address this issue, we investigate and implement downscaling methodologies that exploit the relationship between LST and high-resolution auxiliary variables, particularly the Normalized Difference Vegetation Index (NDVI).

The proposed approach is based on a modified TsHARP (Thermal Sharpening) algorithm, which leverages the inverse correlation between NDVI and LST through a multiple linear regression framework. The method consists of three main steps: (i) co-registration and resampling of multi-resolution datasets, (ii) estimation of regression parameters at coarse resolution, and (iii) application of the model to fine-resolution predictors, followed by a residual correction to preserve spatial consistency.

The algorithm has been tested using Landsat 8–9 data over heterogeneous environments, including urban and coastal areas (Catania, Italy) and complex urban-river systems (Bratislava, Slovakia). Results demonstrate a significant improvement in spatial detail, particularly in boundary delineation and heterogeneous landscapes. Quantitative validation against reference LST products (USGS delivered) shows strong agreement.

A comparative analysis with alternative downscaling techniques confirms the robustness and reliability of the proposed method, with performance comparable to state-of-the-art approaches. Additionally, computational optimization strategies, including data type reduction and code refinement, enabled a reduction in processing time of up to 90% without degrading accuracy.

These results highlight the potential of NDVI-based thermal sharpening techniques for next-generation missions such as SBG-TIR, supporting high-resolution applications in urban climate studies, agriculture, and environmental monitoring.

Poster board #6

Thermal Analysis for Resilient Transport Infrastructure: A Downscaling Approach Using Satellite Data and UAV

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In the context of the ongoing climate crisis, the Urban Heat Island (UHI) phenomenon represents one of the most critical challenges for the sustainability of the built environment. Critical transport infrastructures, such as highways, railways, and airports, play a crucial role in this process. Due to their extension and to the thermophysical properties of the construction materials employed (e.g., asphalt, concrete), they act as significant thermal collectors. On the other hand, in urban areas large transport infrastructures, such as train stations, parking lots areas and airports, negatively affect the local microclimate.

In this context, satellite Earth Observation (EO) has emerged as a promising tool for monitoring temperature variations [1]. However, temperature measurement in the context of transport infrastructure remains challenging due to the limitations imposed by the spatial resolution of satellite sensors. The primary issue concerns the limited spatial resolution of currently available thermal satellite sensors (with a native resolution of 100 m, resampled to 30 m), such as the TIRS instrument on Landsat 8/9 [2]. While these sensors provide accurate radiometric data, they lack the geometric detail required to analyse specific transportation assets. To overcome this limitation, this research proposes an innovative methodology based on a multi-scale thermal downscaling procedure, implemented within the Google Earth Engine platform and applied on a real-scale wide parking area scenario. The adopted methodology relies on the synergistic integration of multi-scale satellite data, following the approach implemented by [3]. This study exploits the well-established relationship between Land Surface Temperature (LST) and land-cover metrics, including the Normalized Difference Vegetation Index (NDVI), the Normalized Difference Built-up Index (NDBI), and the Normalized Difference Water Index (NDWI). A multiple linear regression model was first defined using spectral indices and LST derived from Landsat 8 data; this model was then applied using the corresponding spectral indices extracted from Sentinel-2 imagery [4] to predict LST at a spatial resolution of 10 m. A second down-scaling step was carried out using a multivariate regression approach that integrated RGB bands from Sentinel-2 with UAV imagery derived from photogrammetric processing, enabling the estimation of surface-temperature related bands at sub-meter spatial resolution. Through this two-stage procedure, the resolution of LST maps was significantly enhanced, achieving a resolution appropriate with the scale of transport infrastructure. This approach was applied to a parking area in Rome, demonstrating the potential of a sequential thermal downscaling procedure that progressively refines satellite-derived temperatures using higher-resolution Sentinel-2 data and UAV imagery. The results confirm that thermal analysis based on satellite EO data and downscaling techniques is a promising, effective, and cost-efficient method for assessing infrastructure resilience.

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Poster board #7

Sensitivity study of the 4.8 μm channel to CO2 emissions from high temperature sources

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Task 4.4 of THERESA project is dedicated to the study of MIR-2 channel (centered at 4.8 μm) planned for the SBG-TIR mission. The objective is to evaluate the sensitivity of this channel to CO2 emissions from high-temperature sources, considering that the gas exhibits absorption bands around 4.8 μm. The study methodology is based on following research activities: 1) Model simulations to study the sensitivity of the MIR-2 channel to surface temperature and atmospheric CO2 concentration; 2) Evaluation of realistic scenarios to reproduce real-world cases in the model simulations; 3) Analysis of MASTER (Modis ASTER) acquisitions around 4.8 μm.

The model simulations were performed using the MODTRAN radiative transfer model to study the relationship between the TOA (Top Of Atmosphere) radiance and the gas concentration considering ground temperatures between 400 and 800 K, that are consistent with characteristics of the MIR-2 channel. The TOA radiation from the model simulations has been convolved using a realistic SRF (Sensor Response Function) with a FWHM (Full Width Half Maximum) of 0.15 µm. The objective is to evaluate the sensor's NEDT (Noise Equivalent Delta Temperature) and NedR (Noise equivalent delta Radiance) parameters, which are necessary to detect and estimate CO2 emissions.

Furthermore, several model simulations were performed considering a realistic scenario such as that of Mt. Etna volcano, also using an atmospheric dispersion model.

Finally, preliminary analyses of MASTER acquisitions at Kilauea volcano were performed.

Poster board #8

Combining optical and thermal data for cryosphere monitoring in the Alps

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Monitoring the Alpine cryosphere is essential for understanding regional water cycles and energy balance in the context of rapid climate change. While optical and radar remote sensing are well-established for assessing snow cover and glacier extent, the thermal infrared (TIR) domain remains significantly underexploited. This is largely due to the complexities of retrieving accurate surface temperatures over high-reflectance, low-temperature targets where spectral emissivity is often poorly constrained. Upcoming satellite missions (TRISHNA, SBG-TIR, LSTM) will provide novel measurements in the TIR domain, setting the stage for advancing our comprehension of cryospheric dynamics. However, these missions require preparatory research to fill existing gaps in data exploitation.

In this contribution, day-time and night-time thermal data from two automatic weather stations (AWS) were combined with optical data (broadband albedo) to calculate apparent thermal inertia (APs), aiming to determine the onset of snow melting phases at two Alpine sites in the Aosta valley (Torgnon and Cime Bianche). We estimated the start, end, and duration of the snow phases from all three datasets (APs, Sentinel-1, and SNOWPACK simulations) and compared them to assess their consistency.

Furthermore, we present preliminary results from two repeated aerial surveys conducted in the Eastern Alps under contrasting conditions (spring 2023 and summer 2025). The aircraft was equipped with optical hyperspectral sensors (CASI and SASI) covering the VNIR-SWIR range (400–2500 nm) and a thermal hyperspectral sensor (TASI) covering the long-wave infrared range (8.5–11.5 μm). The campaigns were conducted in the context of the PRISCAV (ASI-funded) and SNOWTRACK (Danubius-IP) projects. This allowed for a synergistic analysis of dry snow during accumulation in 2023, as well as melting snow, glacier ice, and rock glaciers during the 2025 ablation season.

By bridging the gap between ground-based observations and airborne hyperspectral imaging, this work set the stage in preparation for the next generation of thermal satellite missions.

Poster board #9

A Semi-Supervised Approach to Classifying Proxy Thermal-States Using Satellite-Derived Time Series at Vulcano (2016–2024)

Francesco Spina [1, 2], Sebastiano Battiato [2], Giuseppe Bilotta [1], Iole Serena Diliberto [3], Danilo Nastasi [4], Alessandro Ortis [2], Gaetana Ganci [1]

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The island of Vulcano (Italy) is characterized by persistent secondary volcanic activity, where fluctuations in hydrothermal fluid circulation periodically drive the system from background to unrest phases. Since 1990, a ground-based monitoring network has collected long-term fumarole temperature time series, which have been essential for reconstructing the temporal evolution of these phases. In parallel, satellite remote sensing has become an effective tool, offering the synoptic coverage and precision needed to monitor surface thermal variations in complex hydrothermal environments such as Vulcano.

This work proposes an automated methodology to classify thermal activity states (Background, Minor Crisis, and Unrest) using satellite-derived thermal and environmental indicators as proxies for the hydrothermal system. A Semi-supervised Generative Adversarial Network (SGAN) is applied to a set of satellite features, including the Normalized Thermal Index (NTI) and Volcanic Radiative Power (VRP) from VIIRS, as well as the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Moisture Index (NDMI) from Sentinel-2 MSI. Ground-based temperature measurements are used to label the different activity classes.

To evaluate the model's effectiveness, the SGAN was benchmarked against several fully supervised architectures (including 1D-CNN, Multi-Layer Perceptron (MLP), Random Forest (RF), k-Nearest Neighbors (kNN), and Support Vector Machines (SVM)) across different training set subsets (10%, 50%, and 100% of labeled data).

The experimental results, covering the period from April 2016 to December 2024, demonstrate that the SGAN significantly outperforms traditional supervised models, particularly in scenarios of labeled data scarcity. Achieving a Macro F1-Score of 97%, the proposed architecture proves to be a robust computational tool for long-term monitoring, highlighting the strategic value of semi-supervised learning in enhancing satellite-based detection of hydrothermal instabilities.

Poster board #10

Vietnam Academy of Science and Technology, Vietnam National Space Center. Enhancing National Capability in Earth Observation Based on Small Satellite Constellations in Vietnam

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The poster illustrates the needs, objectives, implementation roadmap, infrastructure and current activities at the Vietnam National Space Center (VNSC) to build Vietnam's capability in independently developing, operating, and utilizing small Earth observation satellites.

Poster board #11

Land use/land cover (LULC) mapping with satellite images and field spectral libraries combined in linear mixture models

Emiliana Valentini [1,2], Pham Thy Mai Thy [3], Serena Sapio [2], Sara Liburdi [2], Federico Mattei [2], Mariano Bresciani [4], Claudia Giardino [4], Mirco Boschetti [4], Francesco Nutini [4], Andrea Pellegrino [4], Chon Le Trung [5], Son V. Nghiem [6], Andrea Taramelli [2]

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This interdisciplinary synthesis study aims at capturing the dynamics of the landscape in terms of fragmentation and connectivity from natural to built-up units and characterizing the continuum of ecosystem structures and functions in the rapidly changing area of the Cần Giờ Mangrove Biosphere Reserve in Vietnam.

Poster board #12

Using COSMO-SkyMed images to detect natural disasters & support emergency response in Vietnam

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Since 2024, the Vietnam National Space Center (VNSC) and the Italian Space Agency (ASI) have started a cooperation on the use of SAR data for natural disasters and emergency response. High-resolution COSMO-SkyMed (CSK) data were provided by ASI to support Vietnam in monitoring natural hazards such as floods and subsidence. 15 scenes were used for flood analysis due to Typhoon Yagi in 2024, while 45 scenes for a series of Typhoons in 2025. To investigate land subsidence over a long period, the full archive of CSK imageries from 2014 to 2022 including 354 scenes for Ho Chi Minh City and 516 scenes for Ha Noi City was provided and analysed. This activity is undertaken in the framework of the CSK Project Card ID 1060 "CSK Vietnam SUBS". The poster illustrates the maps and analyses that have been produced so far.