AISAM
Associazione Italiana di Scienze dell'Atmosfera e Meteorologia

UNIVERSITÀ CATTOLICA del Sacro Cuore

6° Congresso Nazionale
Associazione Italiana di Scienze dell'Atmosfera e Meteorologia

10-12 febbraio 2026
Centro Paolo VI
BRESCIA

La sessione di apertura si terrà presso la Sala Polifunzionale
Università Cattolica del Sacro Cuore

www.aisam.eu congresso@aisam.eu

Sponsor:

CAE – innovation for a safer world.
SIAP+MICROS – Environmental Monitoring Solutions
GILL
LM – Lombard & Marozzini
ASNACODI Italia
CONDIFESA Lombardia Nord-Est
FuturAgri

CONFERENCE AGENDA
and
ABSTRACTS

Sponsor:

PRESENTAZIONE NUOVI STRUMENTI

6° CONGRESSO NAZIONALE AISAM

10-12 FEBBRAIO 2026

MAXIMET GMX522
LA PRIMA STAZIONE METEOROLOGICA COMPATTA CON MISURAZIONE DELLO STRESS TERMICO

Misurazioni efficaci per salvaguardare la forza lavoro e mantenere la produttività nei luoghi di lavoro con elevata esposizione al calore, come agricoltura, edilizia, infrastrutture, produzione, addestramento militare, smart city ed eventi e strutture sportive. La prima nel suo genere a integrare il monitoraggio dello stress termico, sviluppata in conformità alla norma ISO7243:2017. è dotata di un sistema integrato di calcolo della temperatura di bulbo umido e globo (WBGT - Wet-Bulb Globe Temperature).

MISURAZIONE DELLE PRECIPITAZIONI DI NUOVA GENERAZIONE

Un nuovo standard nel monitoraggio delle precipitazioni. il nostro prossimo pluviometro sarà disponibile sia come sensore autonomo (PW100) che integrato nella gamma MAXIMET (GMX603). Aumento dell'affidabilità e della precisione dei dati sulle precipitazioni, riducendo notevolmente gli oneri di manutenzione.

GILL CONNECT

NUOVA APP PER CONFIGURAZIONE WIRELESS

Connettività bluetooth progettata per rendere l'installazione e la risoluzione dei problemi più rapide e semplici.

GILL

LOMBARD & MAROZZINI

lombardemarozzini.com

Organizzazione:
Associazione Italiana di Scienze dell'Atmosfera e Meteorologia
Università Cattolica del Sacro Cuore

Comitato Scientifico:

Giacomo Gerosa (Chair)	Università Cattolica del Sacro Cuore
Francesco Barbano	Università di Trento / C3A
Laura Bignotti	ECOSYS-INRAE / AgroParisTech Université Paris-Saclay
Daniele Biron	Servizio Meteorologico dell'Aeronautica Militare
Paolo Cristofanelli	CNR-ISAC
Piero Di Carlo	Università «D'Annunzio» di Chieti-Pescara
Daniela Famulari	CNR-IBE
Patrizia Favaron	Servizi & Territorio srl
Angelo Finco	Università Cattolica del Sacro Cuore
Marco Gaetani	IUSS Pavia
Umberto Giostra	Università degli Studi di Urbino «Carlo Bo»
Veronica Manara	Università degli Studi di Milano
Arturo Pucillo	ARPA Friuli Venezia-Giulia
Angelo Riccio	Università Parthenope di Napoli
Stefano Serafin	Università di Vienna
Barbara Tomassetti	Università degli Studi dell'Aquila / CETEMPS
Nadia Vendrame	Fondazione E. Mach

Comitato Organizzatore – Università Cattolica del Sacro Cuore
Angelo Finco (Presidente)
Erica Cabrioli
Glauco Pentenero
Riccardo Marzuoli
Davide Plebani
Elisa Lahrech
Perluigi Renan Guaita
Giacomo A. Gerosa
Irene Maffezioli
Antonio Negri
Alessandro Marzo
Niccolò Cabrini

MARTEDI’ 10 febbraio 2026

8:30am - 9:30am	**REGISTRATION** Location: **Sala Polifunzionale - Università Cattolica - Via Trieste 17**
9:30am - 10:00am	**OPENING** Location: **Sala Polifunzionale - Università Cattolica - Via Trieste 17**
10:00am - 10:30am	**Invited speaker: Prof.ssa Elisa Palazzi** Location: **Sala Polifunzionale - Università Cattolica - Via Trieste 17**

Climate change in the mountains: From elevation-dependent warming to elevation-dependent climate change

Elisa Palazzi, **Enrico Arnone, Olivia Ferguglia**
Università di Torino, Italy

While elevation-dependent warming (EDW) has become a widely studied phenomenon referring to the systematic variation of warming rates with elevation (Pepin et al., 2015), recent research has highlighted the need to move beyond temperature alone toward the broader concept of elevation-dependent climate change (EDCC, Pepin at al., 2022, 2025). EDCC encompasses the diverse responses of multiple climate variables to climate change along elevational gradients, reflecting the complex interactions between atmospheric processes, surface conditions, and topography in mountain regions.

In addition to elevation-dependent temperature trends, EDCC includes changes in precipitation and climatic extremes, along with in the variables useful to disentangle the driving mechanisms of the observed change, such as in snow cover, cloudiness, radiation balance. These changes have profound implications for mountain hydrology, cryosphere dynamics, ecosystems, and downstream water resources, particularly in regions that depend strongly on meltwater and orographic precipitation.

This talk provides an overview of the state-of-the-art understanding of EDW and EDCC, drawing on observational evidence, reanalysis products, and climate model simulations (e.g. Palazzi et al., 2019; Ferguglia et al., 2024). Particular attention is given to major mountain systems, including the Alps, Himalayas, Andes, and Rocky Mountains, where elevation-dependent signals have been documented but also show regional variability.

The presentation further discusses the physical mechanisms proposed to explain elevation-dependent climate responses, as identified in the literature, including changes in snow–albedo feedbacks, cloud–radiation interactions, water vapor and lapse-rate effects, and land–atmosphere coupling. Emphasis is placed on how the relative importance of these mechanisms varies across regions and seasons, contributing to the uneven distribution of climate change impacts with elevation.

Overall, the talk highlights EDCC as a framework for understanding how climate change manifests in mountain environments, stressing the need for integrated observational strategies and high-resolution modeling approaches to better assess future risks and inform mitigation and adaptation in high-elevation regions.

References:

- Ferguglia, O., Palazzi, E. & Arnone, E. Elevation dependent change in ERA5 precipitation and its extremes. Clim Dyn 62, 8137–8153 (2024). https://doi.org/10.1007/s00382-024-07328-6

- Palazzi, E., Mortarini, L., Terzago, S. et al. Elevation-dependent warming in global climate model simulations at high spatial resolution. Clim Dyn 52, 2685–2702 (2019). https://doi.org/10.1007/s00382-018-4287-z

- Pepin, N; Bradley, RS; Diaz, HF; Baraer, M; Caceres, EB; Forsythe,; Fowler, H; Greenwood, G; Hashmi, MZ; Liu, XD; Miller, JR; Ning, L; Ohmura, A; Palazzi, E; Rangwala, I; Schoner, W; Severskiy, I; Shahgedanova, M; Wang, MB; Williamson, SN; Yang, DQ: “Elevation-dependent warming in mountain regions of the world”, Nature Climate Change, Volume 5, Issue 5, Pages 424-430, ISSN: 1758-678X, 2015

- Pepin, N. C., et al. (2022). Climate changes and their elevational patterns in the mountains of the world. Reviews of Geophysics, 60, e2020RG000730. https://doi.org/10.1029/2020RG000730

- Pepin, N., Apple, M., Knowles, J. et al. Elevation-dependent climate change in mountain environments. Nat Rev Earth Environ 6, 772–788 (2025). https://doi.org/10.1038/s43017-025-00740-4

10:30am - 11:00am	**CLIMA-I** Location: **Sala Polifunzionale - Università Cattolica - Via Trieste 17** Session Chair: **Michele Brunetti** Session Chair: **Paolo Cristofanelli**

Climatologia sinottica degli eventi di caldo estremo negli Appennini

Vincenzo Capozzi[1], **Annalisa Di Bernardino**[2], **Giorgio Budillon**[1]
[1]Università degli Studi di Napoli "Parthenope", Italy; [2]Sapienza Università di Roma, Italy

Questo studio analizza gli eventi di temperatura estrema verificatisi negli Appennini tra il 1961 e il 2022, utilizzando dati giornalieri in situ e rianalisi ERA5. Gli obiettivi principali sono: i) valutare, tramite il test stagionale di Kendall, le tendenze delle ondate di calore estive (heat waves) e degli episodi di caldo anomalo che si verificano nelle altre stagioni (warm spells), in termini di frequenza, durata e intensità; ii) descrivere ed analizzare, su base stagionale, la climatologia sinottica di tali eventi. L’analisi mostra un aumento significativo degli eventi di caldo estremo. In particolare, nel trentennio 1991-2020, rispetto al 1961-1990, il numero di eventi è cresciuto del 134% in estate e del 102% in primavera, mentre in autunno e inverno l'aumento risulta di portata inferiore e spesso non significativo. Attraverso un approccio metodologico basato sull'analisi in componenti principali e sul metodo di clustering k-means, sono stati individuati diversi schemi sinottici su larga scala associati alle heat waves e alle warm spells. In estate, sta aumentando l'incidenza di particolari configurazioni atmosferiche, caratterizzate da un'area ciclonica (spesso nello stadio di cut-off) sull'Atlantico nord-orientale, in corrispondenza delle Isole Britanniche o al largo dell'Irlanda, e da un promontorio esteso dal nord-Africa alla penisola Balcanica. Tale schema favorisce l'afflusso verso l'Appennino di masse d'aria molto calde di origine subtropicale, soprattutto ai livelli medi della troposfera. È stata inoltre osservata una connessione tra le ondate di calore appenniniche e le temperature superficiali dell'Atlantico nord-orientale: queste ultime sono generalmente al di sotto delle medie climatologiche durante gli eventi di caldo estremo e nei giorni immediatamente precedenti, contribuendo al prolungamento e all'intensificazione degli stessi. Queste evidenze offrono nuove chiavi di lettura sui rapporti tra caldo estremo e circolazione atmosferica su larga scala, e costituiscono strumenti utili per migliorare la previsione delle ondate di calore. Lo studio mette infine in luce l'importanza di disporre di serie climatologiche lunghe, affidabili e ben distribuite anche in aree montane, indispensabili per comprendere come il cambiamento climatico stia trasformando gli ecosistemi d'alta quota e incidendo sulle attività umane.

Systematic Heat Extreme Intensification at European Aviation Infrastructure Under Climate Change

Federica Guerrini[4], Paul Williams[1], Sara Dal Gesso[2], Marco Venturini[2], Marcello Petitta[3]

[1]Department of Meteorology, University of Reading, UK; [2]Amigo s.r.l., Italy; [3]Department of Mathematics and Physics, Università Roma Tre, Italy; [4]Personal Contribution

Aviation systems face unprecedented challenges from climate-driven temperature extremes, with critical infrastructure particularly vulnerable due to dependence on atmospheric conditions. We present the first continental-scale analysis of projected heat extreme evolution across 30 major European airports using bias-corrected CMIP6 ensemble projections spanning 2035-2064. Daily maximum temperatures from 10 General Circulation Models under three emission scenarios (SSP1-2.6, SSP3-7.0, SSP5-8.5) were processed using advanced Generalized Quantile Delta Mapping bias correction specifically designed for extreme events. Heatwaves were identified using percentile-based thresholds (99.7th percentile, minimum 3-day duration) with comprehensive analysis of frequency, duration, and intensity metrics.

Our analysis reveals systematic intensification of heat extremes across all studied locations, with southern European airports experiencing the most sistematic changes. Across the 30 airports, ensemble-median anomalies of daily Tmax rise by ~+4.1 °C (SSP1-2.6), +5.3 °C (SSP3-7.0), and +6.2 °C (SSP5-8.5), with a marked north–south gradient. Heatwave frequency, duration, and intensity all increase southern hubs approach 4–5 events yr^{-1} by SSP5-8.5 (e.g., Antalya 4.91 yr^{-1}), mean durations lengthen from ~4.1 to ~7.0 days, and a standardized heatwave intensity (SHI) typically exceeds 3.6, indicating sustained extremes relative to site climatology. Rare but recurring multi-month episodes (~100 days) appear as statistical outliers at several Mediterranean airports in SSP3-7.0/5-8.5, signaling potential regime shifts. The tail of the distribution expands such that ≥45 °C enters the regular range at multiple airports, while 25–29 of the 30 sites exhibit significant positive trends in heatwave frequency under SSP3-7.0/5-8.5.

These findings demonstrate systematic evolution toward "new climatologies" across European aviation infrastructure, with relevant implications for flight operations, airport engineering standards. The continental-scale coherence of changes suggests pervasive impacts requiring transformative rather than incremental adaptation strategies. Results underscore urgent need for infrastructure resilience planning addressing conditions that exceed historical design assumptions and operational experience.

11:00am - 11:30am **Coffee Break**

11:30am - 1:00pm **CLIMA-II**

Location: **Sala Polifunzionale - Università Cattolica - Via Trieste 17**
Session Chair: **Michele Brunetti**
Session Chair: **Paolo Cristofanelli**

Widespread Multi-Year Droughts in Italy: Identification and Causes of Development

Salvatore Pascale[1], Francesco Ragone[2]

[1]Università di Bologna, Italy; [2]University of Leicester, UK

Multi-year droughts pose a significant threat to the security of water resources, putting stress on the resilience of hydrological, ecological and socioeconomic systems. Motivated by the recent multi- year drought that affected Southwestern Europe and Italy from 2021 to 2023, here we utilise two indices—the Standardised Precipitation Evapotranspiration Index (SPEI) and the Standardised Precipitation Index (SPI)—to quantify the temporal evolution of the percentage of Italian territory experiencing drought conditions in the period 1901–2023 and to identify Widespread Multi-Year Drought (WMYD) events, defined as multi-year droughts affecting at least 30% of Italy. Seven WMYD events are identified using two different precipitation datasets: 1921–1922, 1942–1944, 1945–1946, 2006–2008, 2011–2013, 2017–2018 and 2021–2023. Correlation analysis between the time series of Italian drought areas and atmospheric circulation indicates that the onset and spread of droughts in Italy are related to specific phases of the winter North Atlantic Oscillation (NAO), the Scandinavian Pattern (SCAND), East Atlantic/Western Russia (EAWR) pattern and the summer East Atlantic (EA) and East Atlantic/Western Russia (EAWR) patterns. Event-based analysis of these drought episodes reveals a variety of atmospheric patterns and combinations of the four teleconnection modes that contribute to persistently dry conditions in Italy during both winter and summer. This study offers new insights into the identification and understanding of the meteorological drivers of Italian WMYD events and serves as a first step toward a better understanding of the impacts of anthropogenic climate change on them.

A Convolutional Neural Network for Downscaling Climate Projections: Temperature and Salinity Dynamics in the Venice Lagoon

Fabio Bozzeda[1], Marco Sigovini[2], Piero Lionello[3]

[1]DiSTeBA - University of Salento, Lecce, Itay and National Biodiversity Future Center, Palermo, Italy; [2]National Research Council, Institute of Marine Science, Venice, Italy; [3]DiSTeBA - University of Salento, Lecce, Itay

Coastal lagoons, such as the Venice Lagoon, are ecologically significant yet highly vulnerable ecosystems facing increasing pressure from climate change. Accurate projections of key hydrographic variables—such as water temperature and salinity—are crucial for developing effective adaptation and management strategies. However, traditional process-based hydrodynamic models, while physically robust, are often computationally prohibitive for performing the long-term, large-ensemble simulations required for comprehensive climate impact assessments. This study addresses this challenge by introducing a novel data-driven framework that leverages a Convolutional Neural Network (CNN) to efficiently simulate and project monthly temperature and salinity dynamics at key locations within the Venice Lagoon, representing distinct marine, riverine, and intermediate regimes. The core of the methodology is a CNN architecture specifically designed to capture the complex, non-linear relationships between large-scale environmental drivers and localized lagoon responses. A major methodological hurdle was the limited observational dataset, comprising only four years of irregular, approximately monthly measurements. To overcome this data scarcity, we implemented a non-standard training protocol based on a sequential optimization strategy, which enhanced the model's ability to learn robust dependencies and generalize effectively. The model was trained using a minimal yet physically meaningful set of predictors: 2 m air temperature, precipitation, offshore sea level, and offshore sea surface salinity. For future projections, the validated CNN was forced with a set of synthetic climate scenarios representing global warming levels (GWLs) of 1.5, 2.0, and 3.0 °C relative to pre-industrial conditions. These scenarios were constructed by perturbing the historical driver data according to established climate sensitivities for the Mediterranean region. The results demonstrate the framework's high predictive accuracy, with the CNN successfully reproducing historical observations (R-squared > 0.96 for temperature; R-squared> 0.85 for salinity). Sensitivity analyses confirmed that the model learned physically plausible dynamics, correctly identifying atmospheric forcing as the primary driver for temperature and recognizing the distinct roles of oceanic exchange and terrestrial freshwater input in controlling salinity across the lagoon's spatial gradient. Projections under the 3.0 °C GWL scenario reveal substantial future changes: lagoon water temperature is projected to increase by up to 6 °C in summer, while salinity is expected to rise by more than 4 psu at the riverine station. These changes are not uniform throughout the year, leading to a pronounced amplification of the annual cycle for both variables and, consequently, to increased seasonal stress on the ecosystem. In conclusion, this work highlights the potential of tailored CNNs as powerful and computationally efficient tools for downscaling climate information and generating actionable projections in complex coastal systems. The proposed framework provides a viable alternative to resource-intensive models and offers critical insights into the future hydrographic evolution of the Venice Lagoon, underscoring the urgent need for climate-resilient management.

Acknowledgments: FB was funded from NBFC – National Biodiversity Future Center, funded by European Union – NextGenerationEU, Project code CN_00000033, CUP F87G22000290

Reference: Bozzeda, F.; Sigovini, M.; Lionello, P. Neural Network Modelling of Temperature and Salinity in the Venice Lagoon. *Climate* **2025**, *13*, 189. https://doi.org/10.3390/cli13090189

Comparison of climate data from artificial intelligence models and physics-based models

Ludovica Perilli[1], Sandro Calmanti[2], Marcello Petitta[1]

[1]Roma Tre University, Italy; [2]ENEA, Roma, Italy

In recent decades, the frequency and intensity of extreme weather events have increased. Heavy precipitation is of major scientific and societal relevance, yet its analysis is especially challenging due to spatiotemporal variability and multiscale interactions among processes of different nature. In this work, precipitation and its extremes are investigated using data from heterogeneous sources, including weather-station observations, reanalysis products, and outputs from downscaling techniques based on Artificial Intelligence algorithms. In particular, the latter comprise results from new machine-learning methods that employ convolutional architectures for climate downscaling, developed through a collaboration between FBK and ENEA. Designed to provide high spatial resolution forecasts, these methods yielded four historical precipitation datasets that form the basis of the present analysis. This study examines seasonal mean precipitation by comparing these datasets with the ERA5 reanalysis after regridding to a common reference grid and assessing the reproduced spatial patterns. In doing so, it quantifies the differences between the reanalysis and the AI-generated datasets. Finally, return period estimates obtained via extreme-value methods highlight the strengths and limitations of the various datasets relative to the reference reanalysis.

Dataset operativo climatico ArCIS di temperature minime e massime giornaliere sul centro-nord Italia

Valentina Pavan[1], Gabriele Antolini[1], Caterina Tiscano[1], Antonio Volta[1], Giulio Contri[2], Christian Ronchi[3], Marta Salvati[4], Francesco Rech[5], Roberto Barbiero[6], Luca Maraldo[7], Andrea Cicogna[8], Stefano Sofia[9], Marco Stelluti[10], Tommaso Torrigiani Malaspina[11], Veronica Bonati[12], Francesco Boccanera[9], Luca Onorato[12], Elvio Panettieri[6], Valentina Gallina[8]

[1]Arpae, Italy; [2]Centro Funzionale della Regione Autonoma Valle d'Aosta; [3]Arpa Piemonte; [4]Arpa Lombardia; [5]Arpa Veneto; [6]Provincia Autonoma di Trento; [7]Provincia Autonoma di Bolzano; [8]Arpa Friuli Venezia Giulia; [9]Centro Funzionale della Regione Marche; [10]Regione Umbria; [11]Lamma; [12]Arpal

Viene presentato un nuovo dataset operativo climatico di temperature minime e massime giornaliere esteso all'Italia centro-settentrionale per il periodo dal 1991 ad oggi, creato dal Gruppo di lavoro ArCIS (Archivio Climatologico per l'Italia Centro-Settentrionale). Il dataset copre l'area di studio con una griglia regolare di circa 5 km di risoluzione ed è costruito a partire da dati osservativi raccolti e controllati per la qualità dai servizi meteorologici regionali locali. I dati sono stati controllati per qualità e omogeneità statistica. Ai fini dell'interpolazione, il ruolo delle stazioni è stato determinato in base alla loro rappresentatività dal punto di vista termico e in base alla loro appartenenza a serie climatiche storiche; inoltre, il territorio è stato diviso in 28 macroaree, con caratteristiche meteorologiche e geografiche specifiche e, partendo dalle mappe di uso del suolo rese disponibili dal Servizio Corine, sono state create mappe di frazione urbana e una mappa statica dei corpi idrici principali. In ogni macroarea l'interpolazione è stata quindi eseguita prima identificando la dipendenza della temperatura dalla quota, poi identificando la dipendenza lineare dei residui dalla frazione urbana e dalla distanza dai corpi idrici; il prodotto finale è stato completato interpolando i residui sull'intero territorio in base alla distanza tra le stazioni.

Il dataset è descritto mostrando mappe giornaliere per eventi meteorologici specifici, anomalie mensili, descrivendo le caratteristiche dei valori climatologici e delle tendenze annuali e stagionali sul periodo coperto dal dataset. Particolare attenzione sarà dedicata alla descrizione dei valori medi e delle tendenze di specifici indici climatici, costruiti a partire dai dati giornalieri di temperatura minima e massima, che descrivono la frequenza degli eventi estremi nell'area di studio.

Evaluating the changing risk of cyclones for Italian precipitation extremes

Giuseppe Zappa[1], Paolo Ghinassi[1], Federico Grazzini[1], Cristina Iacomino[2], Salvatore Pascale[2], Alice Portal[1], Claudia Simolo[1]

[1]CNR-ISAC, Italy; [2]University of Bologna, Italy

An increase in precipitation extremes is one of the most robust aspects of anthropogenic climate change, but the latest assessment of the IPCC still reported low confidence on projected changes in the Mediterranean region. Yet, a number of Mediterranean cyclones, i.e intense mid-latitude storms, have caused considerable precipitation extremes and economic damage in the most recent years, including in Italy. The role played by climate change in these events remain poorly quantified.

In this work we first show that the CERRA regional reanalyses show a significant upward trend (1985-2024) in the number of annual daily precipitation extremes within the Warning Areas of the Italian Civil Protection, and that the upward trend is largely robust to the driving large-scale weather type. To better understand these trends, we then take a storyline approach and by looking at circulation analogs we analyse the response to climate change of selected past high-impact Italian storms, such as storm Vaia and Cyclone Minerva, in large ensembles of regional and global climate model simulations. This enables us to cleanly separate the contribution of internal climate variability from the forced response to climate change. A probabilistic framework is introduced to isolate the role of changes in the large-scale atmospheric circulation, cyclone-development and precipitation intensity in the risk of precipitation extremes. Results show a clear increase in the risk of intense cyclone-associated Italian precipitation extremes, though internal variability is large, and it can mask the climate change signal at individual grid points in single climate realisations. We conclude suggesting new storyline-based and statistical approaches that might help to generalise the results to the different weather types that cause Italian precipitation extremes.

The atmospheric station at Plateau Rosa: analysis of the continuous carbon dioxide and methane mole fractions record and identification of source areas in Europe

Giulia Zazzeri[1], Francesco Apadula[1], Stephan Henne[2], Andrea Lanza[1]

[1]Ricerca sul Sistema Energetico - RSE S.p.A., Italy; [2]Empa, Swiss Federal Laboratories for Materials Testing and Research, Dübendorf, Switzerland

The atmospheric monitoring station at Plateau Rosa, situated in in the north-western Italian Alps near Mt. Cervino, is part of the WMO/GAW (World Meteorological Organisation/Global Atmospheric Watch, Identification Code: PRS) program since 1989 and part of the ICOS (Integrated Carbon Observation System) framework since 2021. At the station carbon dioxide (CO_2) and methane (CH_4) mole fractions have been measured since 2018 with a cavity ring down spectrometer (Picarro G2301). Concentration measurements at this site, 3480 m AMSL, are particularly valuable for tracking the atmospheric background and global trend of greenhouse gases but are also impacted by various source areas in Europe.

In this study, we analyzed the seven years (2018-2024) record of CO_2 and CH_4 mole fractions at the station. We focused on the past five years, since the station has been part of the ICOS network, to analyse periods of enhanced CO_2 and CH_4 levels over the background that are associated with pollution events at regional scale. We identified 30 pollution events, when air masses were coming mainly from the Po Valley and central Europe. We used the FLEXPART atmospheric transport model coupled to the high resolution (1 km x 1 km) output of the numerical weather prediction model COSMO to produce concentration footprints and simulate regional CO_2 and CH_4 contributions. We assessed how well this transport model, coupled with different surface fluxes (EDGAR, CAMS), captures the selected pollution events and reproduces the continuous CO_2 and CH_4 record at the station.

We finally demonstrate how CO_2 and CH_4 mole fraction data measured continuously at the station at Plateau Rosa can be used to attribute pollution events to specific regional source areas in Europe that might not be accounted by the inventories.

1:00pm - 2:00pm **LUNCH-BREAK**

Location: **Centro Paolo VI - Via Gezio Calini 30**

2:00pm - 3:30pm

POSTER SESSION 01
Location: **Centro Paolo VI - Via Gezio Calini 30**

The ReData Project: Scanning and Digitization of Historical Daily Weather Bulletins through Citizen Science activities

Veronica Manara[1], Alessandro Ceppi[2,3], Yuri Brugnara[4,5], Gabriele Buccheri[1], Goffredo Caruso[2], Luca Cerri[3], Maria Di Giovanni[1], Marco Giazzi[3], Ludovico Lapo Luperi[6,7], Luca Ronca[3], Elisa Sogno[1], Maurizio Maugeri[1]

[1]Università degli Studi di Milano – Department of Environmental Science and Policy, Milano, Italy; [2]Politecnico di Milano - Department of Civil and Environmental Engineering (DICA), Milano, Italy; [3]Associazione Meteonetwork OdV, Milano, Italy; [4]University of Bern - Institute of Geography, Switzerland; [5]University of Bern - Oeschger Centre for Climate Change Research, Switzerland; [6]CEA - Paris-Saclay, Paris, France; [7]INFN - Sezione di Milano, Milano, Italy

Long-term weather records are often stored in archives still in paper format. These data come from different sources, and they represent a key starting point to understand the climate of the past, a reference to validate climate models and an input data for reanalysis. This problem concerns both rich regions and data-sparse areas. In recent decades, numerous climate data rescue programs have begun in many countries worldwide. These projects aim to preserve data by digitizing, transcribing and analyzing them, in order to make them accessible to the scientific community. One of these projects is presented in this study, ReData (Recovery of Data), launched by the Meteonetwork Association in collaboration with the University of Milan in 2017. The aim of this project is to scan and digitize the daily weather bulletins available from 1879 to 1940 relative to the Italian country plus some colonies and surrounding territories edited by the Italian Royal Central Meteorological Office. The scanning process is finished, resulting in a collection of 99,518 pages (about 200GB) that will be soon available. The digitization is in progress through the Zooniverse platform (https://www.zooniverse.org/projects/meteonetwork/redata). Here, volunteers from all over the world can contribute to the digitization of a station with data for 12 variables in about 1 minute per day only. Since December 2024, when the project has been launched on Zooniverse, with a mean of about 5000 classification per week and a number of active participants per week stabilized between 50 and 100, we have digitized more than 10 years for 37 stations. Moreover, considering the good quality of the digitization (for about 99% of the data two of the three digitization are equal) it has been decided to move from three digitizations for each day to two digitizations to reduce the whole transcription.

A Classification of High- Risk Atmospheric Circulation Patterns for Italian Precipitation Extremes

Cristina Iacomino[1], Salvatore Pascale[1], Giuseppe Zappa[2], Marcello Iotti[3], Federico Grazzini[4], Paolo Ghinassi[2], Alice Portal[2]

[1]Università di Bologna, Italy; [2]ISAC-CNR, Bologna, Italy; [3]IMATI-CNR, Genova, Italy; [4]SIMC-ARPAE, Bologna, Italy

Precipitation extremes are a significant natural hazard that has caused considerable destruction in Italy over the past decade. However, our understanding of the effects of climate change on these extremes remains incomplete, with unclear trends in the intensity and frequency of precipitation extremes. Part of this uncertainty results from internal variability in atmospheric circulation, which is key in triggering high-impact precipitation events. To address this issue, here we develop a comprehensive classification of the Weather Types (WTs) associated with November 1984 to October 2024 Extreme Precipitation Events (EPEs) from CERRA in the 156 operational warning areas used by the Italian Department of Civil Protection, by applying Self-Organising Maps to sea level pressure and 500 hPa geopotential height. We identify six different WTs associated with Italian EPEs, corresponding to different large-scale dynamical drivers: Atlantic cyclone over France/northern Tyrrhenian Sea (WT1), Mediterranean cyclone over Central Italy (WT2), Western Mediterranean cyclone associated with upper level trough over Iberia (WT3), Westerly zonal flow (WT4), upper-level cut-off low (WT5), and Mediterranean cyclone centred over the Tyrrhenian Sea (WT6). The relevance of these WTs for different warning areas is evaluated through composites of moisture transport, the probability of EPEs given a specific WT and a seasonality analysis. The annual frequency of extreme precipitation events exhibits a statistically significant increasing trend (Mann-Kendall, $p < 0.05$), corresponding to an average rise of more than two additional events per year per decade. The positive trend in precipitation extremes occurs for five out of the six WTs, with the largest increase occurring for WT4. These results add to the existing knowledge of drivers of extreme precipitation events in Italy, providing an understanding of underlying large-scale atmospheric circulation and a database of weather types to investigate the role of anthropogenic climate change in climate model simulations.

Toward predictive indicators of compound drought extremes in Europe

Costanza Bartucca[1], Yassmin Mahmoud[2], Chunxue Yang[1]

[1]CNR - Institute of Marine Science (ISMAR), Italy; [2]Goethe-Universitaet - Institut für Atmosphäre und Umwelt (IAU), Germany

Understanding the interplay between meteorological and agricultural droughts is crucial for assessing the impacts of compound climate extremes. While the link between temperature, precipitation, and soil moisture has been largely investigated for drought assessment, their physical properties and role in drought type are region-dependent and influenced by different drivers that are still not fully understood. In this study, we combine satellite and reanalysis datasets to understand the atmospheric drivers for the transition from meteorological to agricultural drought, and address the physical characteristics of major drought events in Europe. Particular attention is given to the role of land-atmosphere interaction for compound drought events. Preliminary results highlight where and under what conditions the persistence indices can serve as robust

proxies for linking meteorological and agricultural droughts, analyze favourable weather conditions that contribute to drought amplification, and finally address knowledge gaps in this aspect.

Extreme Precipitation in a Warming Climate: A Storyline-Based Analysis over Italy Using High-Resolution Destination Earth Simulations

Marco Burderi[1], **Salvatore Pascale**[1], **Giuseppe Zappa**[2]

[1]University of Bologna, Italy; [2]CNR-ISAC Bologna, Italy

Anthropogenic climate change is profoundly altering the global water cycle, increasing both the frequency and severity of extreme precipitation events. This issue is particularly acute in the Mediterranean basin, a recognized climate-change hotspot where heavy rainfall and flooding already impose severe societal risks, as demonstrated by the May 2023 Emilia-Romagna and October 2024 Bologna floods.

This study validates and applies the newly produced *Destination Earth IFS–FESOM* dataset to investigate the thermodynamic contribution of anthropogenic warming to mean and extreme precipitation over Italy. First, it examines how climate change influences precipitation intensity, assessing whether heavy rainfall events are intensifying at rates consistent with thermodynamic expectations. Second, it explores how this intensification is modulated by large-scale circulation patterns, evaluating differences across Weather Types (WTs) associated with Italian extremes. Finally, it analyzes how anthropogenic warming affects the magnitude and spatial structure of recent flood events, using spectrally nudged storyline experiments to isolate the thermodynamic contribution of climate change in the Emilia-Romagna (May 2023) and Bologna (October 2024) floods.

Two background-climate simulations of the *Destination Earth IFS–FESOM* dataset were analyzed: Control, representing a 1950s climate, and Historical, representing present-day conditions. Both were produced using spectral nudging toward ERA5, ensuring consistent large-scale circulation while allowing small-scale processes to evolve freely. The simulations were validated against multiple benchmarks (ERA5, CERRA, and ArCIS), confirming their ability to realistically reproduce Mediterranean precipitation variability.

Analyses of precipitation changes employed complementary diagnostics, including quantile behaviour, weather-type composites, and storyline case studies. Results reveal a clear thermodynamic amplification of rainfall under warming, particularly in northern Italy and during autumn. The precipitation response depends on the quantile, with the strongest increases occurring in the most extreme events, and is modulated by atmospheric circulation patterns associated with different Weather Types.

Overall, this work confirms that extreme precipitation is intensifying under anthropogenic warming and demonstrates the explanatory power of the storyline framework in attributing observed flood magnitudes to climate change. These findings highlight the urgent societal need to anticipate and adapt to escalating hydrological risks in the Mediterranean region.

More Than Just Rain: Spatial and Temporal Variations in Precipitation Across the Verona-Tyrol Alpine Transect, 1923-2024

Sebastiano Carpentari[1], **Dino Zardi**[1,2]

[1]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy; [2]Center Agriculture Food Environment (C3A), University of Trento, San Michele all'Adige, Italy

Historical meteorological data are crucial for understanding a region's climate. This research analyzes spatial patterns and trends of daily precipitation in a transect between the Po Plain near Verona, Italy, and Tyrol.

A dataset of daily precipitation was created spanning 1923-2024. Many station's data were manually digitized from historical annual reports. The entire dataset was quality-checked with suitable procedures, and suspicious data were verified. The time series were homogenized using the R library Climatol.

Climatological precipitation indices were calculated on the homogenized dataset. Additionally, some indices were spatially interpolated for three normal reference periods (1931-1960, 1961-1990, and 1991-2020). Data normality was first verified. Then, an iterative procedure calculated experimental semivariograms to determine the best interpolation parameters. Finally, the kriging with external drift algorithm was executed.

Results confirm established climatic features of pre-alpine precipitation distribution. Notably, however, novel spatial patterns have emerged. The Precipitation Concentration Index suggests that, over the past century, locally the domain has seen an increase in highly irregular precipitation distribution. Furthermore, R95pTOT, R99pTOT, R95p, and R99p indices indicate spatial shifts and significant variations within the domain. The synoptic-scale weather regime variability is currently hypothesized to be the driving force behind this observed pattern.

In conclusion, the present study underlines the importance of reliable historical data from meteorological measurements and encourages the systematic digitization and publication of paper-based annual reports.

Temporal Consistency of Long-Term Seasonal Precipitation Trends in Italy from High-Resolution Regional Reanalyses

Francesco Cavalleri[1], **Paolo Stocchi**[2], **Michele Brunetti**[2], **Veronica Manara**[1], **Cristian Lussana**[3], **Maurizio Maugeri**[1], **Silvio Davolio**[4]

[1]Environmental Science and Policy Department (ESP), University of Milan, Italy; [2]Institute of Atmospheric Sciences and Climate, National Research Council (CNR-ISAC), Bologna, Italy; [3]Division for Climate Services, Norwegian Meteorological Institute, Oslo, Norway; [4]Earth Sciences Department, University of Milan, Italy

Reanalyses are widely used by the scientific community to assess precipitation trends across a broad range of disciplines. In particular, high-resolution regional reanalyses offer unique opportunities to monitor small-scale processes and evaluate the impacts of extreme precipitation events. Nevertheless, previous studies based on ERA5 and other global reanalyses have highlighted limitations in the temporal consistency of long-term annual precipitation estimates, calling for caution regarding their suitability for detecting robust climatological signals.

This study extends the analysis of temporal consistency to four state-of-the-art convection-permitting reanalyses specifically developed for the Italian domain (MORE, CHAPTER, MERIDA HRES, and VHR-REA_IT) by dynamically downscaling ERA5 using different numerical models (MOLOCH, WRF, and COSMO). Long-term seasonal precipitation trends are evaluated against a homogenized observational dataset (UniMi/ISAC-CNR), specifically designed for climate analysis and ensuring temporal consistency. This comparison allows for a detailed quantification of uncertainties in precipitation trends across regions and seasons, helping to disentangle the climate signal from potential artefacts. Such inhomogeneities may be inherited from ERA5 in some cases or further introduced during the assimilation of local observations through techniques such as observational nudging. Finally, similarities and differences among the various reanalyses are discussed in the context of the specific architecture and configuration of each product.

By providing an uncertainty assessment of seasonal precipitation trends, this work will deliver crucial information to reanalysis users on the extent to which trend results can be reliably employed in climate studies and impact assessments. At the same time, it will offer valuable feedback to reanalysis developers, supporting the design of reanalysis products that meet the highest standards of temporal consistency for Italy.

An assessment of ENSO variability in CMIP6 using spectral OLR observations

Martina Taddia[1], Federico Fabiano[1], Stefano Della Fera[2], Elisa Castelli[1], Bianca Maria Dinelli[1]
[1]CNR-ISAC, Italy; [2]CNR-IFAC, Italy

El-Niño Southern Oscillations (ENSO) is the most important variability mode of the climate system on the interannual time scale. In addition to its significant impact on the climate system, it has been suggested that ENSO will play a crucial role in shaping the effects of climate change on future weather and climate extremes. The ability of climate models to correctly reproduce ENSO variability is a strict test of the reliability of their future projections. Particularly, ENSO provides the context for the study of the climate system response to unforced radiative feedbacks, which in turn provides information on the long-term feedbacks related to climate change. This study evaluates the variability of outgoing longwave radiation (OLR) driven by El Niño-Southern Oscillation (ENSO), as simulated by a subset of climate models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6). This is achieved by using spectral OLR fluxes derived from satellites observations. The first part of the work uses two datasets of spectral fluxes derived from the Infrared Atmospheric Sounding Interferometer and the Atmospheric Infrared Sounder, to investigate the spectral ENSO feedback. Then, ENSO spectral signature is calculated for CMIP6 models using spectral radiative kernels and climate models outputs of water vapor, surface and air temperature fields. The results obtained are compared with those from observations to identify potential biases in the climate models reproduction of the time lag and peak of the radiative response to ENSO driven sea surface temperature anomalies that were not apparent from the broadband observations.

Intrinsic oceanic variability: from the North Atlantic Ocean to the Mediterranean Sea

Stefano Pierini
Università di Napoli Parthenope, Italy

In the climate system many components interact with each other in a nonlinear manner, producing variability over a wide range of spatial and temporal scales. These variabilities, called internal, cannot be traced back to direct responses to external forcings, and are generally chaotic in nature. However, despite the holistic nature of the climate, modeling some of its components separately from others can be fully justified by the immense complexity of the system. Of course, modeling studies of this kind must focus on phenomena and processes that are known not to interact through strong feedbacks with other climate components. Modeling the ocean system through a hierarchy of models (from low-dimensional ones up to high-resolution three-dimensional ones) is, in fact, of great interest in order to disentangle internal variability (here more commonly referred to as “intrinsic”) from that directly connected to atmospheric forcing.

In this context, this communication presents modeling results regarding the intrinsic variability of the Gulf Stream (GS) in the North Atlantic and the Mediterranean Sea (MS). In the first case, the focus is on the separation of the GS at Cape Hatteras due to inertial overshooting, on its dependence on the jet intensity, on the presence of a critical transition and on its possible effect on the AMOC in a scenario of global climate change. As regards the MS, preliminary results are presented based on ensemble simulations using the FESOM-C finite element model.

This research is carried out within the INVMED (“Investigation of the intrinsic variability of the Mediterranean Sea”) project funded by PRIN-2022.

Evaluation and Quality Control of Climate data under the Copernicus Climate Change Service

Costanza Bartucca[1], Federico Serva[1], Paolo Cristofanelli[2], Vincenzo De Toma[1], Daniele Ciani[1], Fabio Madonna[3], Andrea Pisano[1], Andrea Storto[1], Gianluigi Liberti[1], Rosalia Santoleri[1], Chunxue Yang[1]
[1]CNR- Institute of Marine Science (ISMAR), Italy; [2]CNR- Institute of Atmospheric Sciences and Climate (ISAC), Italy; [3]CNR - Institute of Methodologies for Environmental Analysis (IMAA), Italy

The C3S2_520_CNR project improves the evaluation and quality control (EQC) function of the Copernicus Climate Change Service (C3S) by providing efficient and transparent quality assurance of climate data sets in the Climate Data Store (CDS). The main objective is to answer the question “How, and how well, can I use these data for my purposes?” To this end, the EQC material is organised in a hierarchical structure so that users can find high-level information on fitness for purpose with application examples, detailed requirements that data, metadata and documentation must meet, and scientific assessments with explicit examples of data use. The approach is strongly user-oriented and combines interactive self-assessment tools, stakeholder consultation and continuous feedback to ensure the reliability, usability and long-term sustainability of quality information for climate datasets.

Data rescue nei percorsi per le competenze trasversali e l'orientamento (PCTO) come strumento per promuovere l'alfabetizzazione climatica negli studenti delle scuole superiori

Francesca Frasca[1], Annalisa Di Bernardino[1], Margherita Erriu[1], Serena Falasca[2], Luigi Iafrate[3], Anna Maria Siani[1]

[1]Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italia; [2]ENEA -Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Roma Italia; [3]Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria, Ufficio Affari Istituzionali e Relazioni Internazionali (CREA-UTS2), Roma Italia

Di fronte a eventi meteorologici intensi sempre più frequenti, determinati dal riscaldamento globale in atto, diventa indispensabile aumentare la consapevolezza collettiva sul sistema climatico. In questo contesto, la scuola e l'università assumono un ruolo chiave nel processo di educazione climatica, offrendo a studenti e insegnanti l'opportunità di comprendere il sistema climatico terrestre, le sue cause e le conseguenze dei cambiamenti che lo caratterizzano. Le attività di recupero e digitalizzazione dei dati meteorologici storici possono rappresentare un importante strumento educativo. A tale scopo, tra i Percorsi per le Competenze Trasversali e l'Orientamento (PCTO) di Sapienza Università di Roma, è stato avviato nel 2023 il progetto *Non perdiamo il “Tempo”: adotta una serie storica di dati meteorologici di Roma*.

L'attività proposta riguarda la trascrizione di un anno di dati del Registro Meteorologico dell'osservatorio centenario del Collegio Romano (fondato in Roma nel 1787, come Torre Calandrelli), e il successivo confronto dei dati di temperatura con quelli misurati a distanza di 100 anni. Tale percorso si propone di: (i) avvicinare gli studenti e studentesse alla riscoperta dei dati meteorologici di elevato interesse storico-scientifico conservati su supporti cartacei ormai dimenticati; (ii) contribuire al recupero del dato storico mediante la digitalizzazione e, quindi, rendere le persone coinvolte coscienti dell'importanza della raccolta delle osservazioni a lungo termine per studiare la tendenza evolutiva del clima. Ad oggi sono stati coinvolti circa 65 liceali provenienti da due scuole superiori di secondo grado di Roma e provincia.

Il presente contributo descriverà la struttura delle attività del PCTO, i risultati emersi nel biennio di realizzazione e una valutazione del loro impatto formativo.

AISAM's initiatives for rescuing historical data in Italy

Alessandro Ceppi[1,4], Michele Brunetti[2,4], Maurizio Maugeri[3,4], Sergio Pisani[4], Dino Zardi[4,5], Veronica Manara[3,4]

[1]Politecnico di Milano - Department of Civil and Environmental Engineering (DICA), Milan, Italy; [2]CNR - Institute of Atmospheric Sciences and Climate, Bologna, Italy; [3]Università degli Studi di Milano – Department of Environmental Science and Policy, Milan, Italy; [4]Italian Association of Atmospheric Sciences and Meteorology, Rovereto, Italy; [5]University of Trento – Department of Civil, Environmental and Mechanical Engineering (DICAM), Trento, Italy

Italy has long played a pivotal role in the development of meteorology, from inventing key instruments to establishing one of the earliest international observation networks. Over the past three centuries, this legacy has generated a vast and valuable archive of meteorological data preserved in Italian repositories. While numerous initiatives have helped to safeguard parts of this heritage, a large portion of the records still exists only in paper form. These collections are vulnerable to deterioration, placing at risk data of inestimable scientific value for meteorology, climate science, and climate change assessments.

This study highlights recent projects in which the Italian Association of Atmospheric Sciences and Meteorology (AISAM) has been central to national data rescue efforts.

The first is **Cli-DaRe@School**, a Citizen Science initiative launched in 2022 to digitize previously untapped Italian meteorological observations not yet available in digital format. The project focused on four monographs published by the Italian Hydrographic Service containing monthly temperature (1926–1955) and precipitation (pre-1950) data. Over two academic years, more than 500 students from 10+ high schools contributed to the digitization, producing around 7,931 station records.

The second, **Dieci e Lode** (2023–2025), targeted the recovery and digitization of meteorological records from former Italian colonies and territories. These included data collected in regions administered by Italy at various times between the late 19th and early 20th centuries, such as Eritrea, Somalia, Ethiopia, Libya, the Dodecanese Islands, Albania, Dalmatia, and Istria. The project carried out extensive archival searches to retrieve meteorological observations from these areas and periods.

The third initiative, **Cli-DaRe@Images**, launched in 2024 and still ongoing, combines education and awareness-raising on climate change with historical data recovery. It engages high school students in the Trentino region to digitize meteorological records preserved in the San Bernardino Library in Trento.

A comparison of modelled concentrations from sonic and cup-vane meteorological data at sites with different wind statistical distributions

Patrizia Favaron[1], Cristiana Morosini[2], Elisabetta Zanardini[2]

[1]Servizi Territorio srl, Italy; [2]University of Insubria, Department of Advanced Science and Technologies (DISAT)

In current practice, short-range atmospheric dispersion modelling is typically conducted using meteorological data obtained from local measurements, typically gathered using "conventional" electro-mechanical sensors, such as cup-vane anemometers and other similar devices.

Recently, wind sensors, such as three-dimensional ultrasonic anemometers, have become more widely available, allowing for higher-resolution measurements.

In a recent paper, the authors investigated the effect of using meteorological data from conventional or ultrasonic anemometers on modelled results in the case of a short Summer-time measurement campaign at Como and found significant ground concentration differences, especially evident in low-speed regimes.

This study extends this result by evaluating the modelled concentration differences over a longer time span at multiple sites in Lombardy equipped with both cup-vane and 3d sonic anemometers, the same used in the previous work.

The new test sites are characterized by different wind statistics and this allowed exploring the effect of different wind speed regimes. The new results confirm the former paper conclusions and reinforce them showing to what extent model outputs may change due to the use of wind sensors based on different technologies.

Influence of Atmospheric Conditions on Etna Volcanic Plumes: Insights from Observations and Numerical Modeling

Daniele Nigro[1,2], Mauro Coltelli[2], Massimo Cassiani[3], Franco Colombo[2], Giorgio Doglioni[1,3], Luigi Mereu[2], Simona Scollo[2], Dino Zardi[1,3]

[1]University of Trento, Center Agriculture, Food, Environment (C3A), Trento, Italy; [2]Istituto Nazionale di Geofisica e Vulcanologia – Osservatorio Etneo (INGV-OE), Catania, Italy; [3]University of Trento, Department of Civil, Environmental and Mechanical Engineering, Trento, Italy

Volcanic ash released during Etna's paroxysms poses a significant hazard to aviation at nearby airports, with Catania Airport being the most affected. This is because volcanic ash has a relatively low melting temperature compared to the operational temperature of jet engines, and its ingestion can cause engine failure. Consequently, accurate forecasting the volcanic cloud height, ash concentration, and atmospheric dispersion is crucial. To achieve this, plume-rise models are employed, with one-dimensional (1D) models commonly used for operational forecasting. Among these, FPLUME (Folch et al., 2016) is considered the most comprehensive, accounting for the effects of wind, moisture, latent heat, and variable entrainment coefficients. FPLUME requires several input parameters for the initial conditions, including the mass eruption rate (MER), exit ash velocity, exit ash temperature, exit water fraction, and meteorological variables.

Here we present the results from the analysis of 34 eruption events that occurred between 2011 and 2024. MER was retrieved using the Volcanic Ash Radar Retrieval (VARR) technique (Marzano et al., 2012; Mereu et al., 2015), based on data from an X-band weather radar located in Catania. Meteorological soundings were obtained from ERA5 reanalysis dataset. To account for uncertainties in the initial conditions, a Monte Carlo simulation was performed, running FPLUME 10,000 times for each event while perturbed input parameters. The results show that for events with MER $> 8 \times 10^5$ kg/s, FPLUME accurately predicts volcanic cloud heights. However, for weaker events, FPLUME consistently underestimates the cloud height. This discrepancy is more pronounced during eruptions occurring under unstable atmospheric conditions, characterized by high Convective Available Potential Energy (CAPE) and very low wind speeds.

These findings suggest that for weak paroxysms, atmospheric processes—particularly convection, which FPLUME does not currently represent—play a dominant role in plume evolution. To address this limitation, a modified version of FPLUME was developed, incorporating a parameterization of convective vertical velocity through CAPE, as well as a revised formulation of vortex entrainment that depends on wind speed rather than the Richardson number. This new model reduced the error between observed and simulated cloud heights, especially for weaker eruptions.

Climate Information as a Political Right: Breaking Private Control Over Public Knowledge

Marcello Petitta[1], Sandro Calmanti[2], Matteo De Felice[3]

[1]Department of Mathematics and Physics, Università Roma Tre, Italy; [2]ENEA, Italy; [3]Personal Contribution

Climate services connect atmospheric science to societal decision-making in the face of rapid climate change. Current provision reveals fundamental tension between commercial interests and equitable access, prompting our advocacy for transformation from market-only models toward a knowledge commons approach that balances innovation with universal accessibility.

Commercial trends in climate services create concerning information disparities. Our analysis across multiple countries demonstrates that profit-driven models frequently exclude vulnerable populations from essential climate data due to cost barriers, creating a paradox where those most exposed to climate risks have least access to adaptation knowledge. This commercialization of publicly-funded research fundamentally weakens the social contract between science and society. In several Western nations, data access restrictions deliberately create lucrative markets, enabling corporations to develop superior risk assessments while constraining public access, thereby reinforcing existing socioeconomic disparities.

However, our research recognizes the legitimate role of private sector innovation in climate services. Drawing on team members' business experience, we acknowledge that commercial applications can flourish alongside equitable data access principles, particularly when specialized tools and interfaces build upon freely accessible core datasets.

Empirical evidence illustrates these inequities' real-world consequences. Asymmetric forecast access undermines adaptation capacity (Lemos et al., 2007), while agricultural insurance applications can paradoxically disadvantage resource-poor farmers despite actuarial benefits (Carriquiry and Osgood, 2012). Developing nations face additional institutional barriers that further widen access gaps (Buontempo et al., 2018).

Promising solutions emerge from European models, particularly the Copernicus Climate Change Service (C3S), which successfully balances open data provision, rigorous quality control (Dee et al., 2024), and stakeholder engagement (Buontempo et al., 2022) while enabling commercial innovation.

Through examination of restriction ethics, successful governance frameworks, and differential adaptation outcomes, we propose a tiered system ensuring universal core service access complemented by specialized commercial offerings. This approach recognizes that publicly-funded scientists must serve broader public interests while accommodating private engagement through mechanisms like open data mandates.

Our institutional analysis, economic modeling, and comparative case studies provide guidance for funding agencies and policy frameworks, advancing both knowledge commons theory and climate justice implementation to ensure climate services enhance collective resilience, particularly for the most vulnerable populations.

Simulating a heat wave event in Rome (Italy) through WRF at high resolution and with Local Climate Zones

Serena Falasca[1,2], Margherita Erriu[2], Stefania Argentini[3], Erika Brattich[4], Giampietro Casasanta[3], Andrea Cecilia[3], Annalisa Di Bernardino[2], Anna Maria Siani[2]

[1]Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), Roma, Italia; [2]Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italia; [3]CNR, Istituto di Scienze dell'Atmosfera e del Clima (ISAC), Roma, Italia; [4]Dipartimento di Fisica e Astronomia “Augusto Righi”, Università di Bologna, Bologna, Italia

Cities are typically affected by the urban heat island (UHI) effect, that is the positive temperature difference between the urban area and the surrounding rural areas. Furthermore, in the context of a changing climate the increase in frequency and intensity of heat waves add up, exacerbating the overheating to which city dwellers are subjected, with severe consequences on health and society.

A full understanding of the distribution of meteorological variables within the perimeter of a metropolitan area is therefore essential to investigate the several issues affecting the urban population (e.g., outdoor thermal stress), so as to identify the neighbourhoods that suffer most from each of these issues, especially during heat waves. Numerical models such as the Weather Research and Forecasting (WRF) model are fundamental tools for this purpose as they guarantee thermodynamic fields with high spatial-temporal resolution and with continuous spatial coverage.

This work presents an innovative WRF configuration recently developed and tuned for the city of Rome (Italy), including a detailed characterization of the urban land use based on the Local Climate Zones at high resolution (grid horizontal size of 500 m in the innermost domain). Such configuration has been applied here to the simulation of a heat wave event that occurred in Rome during the exceptionally hot year 2022 testing different planetary boundary layer schemes and urban canopy models available in WRF.

Simulated values of temperature at 2 meters height and wind speed at 10 meters height were compared with the acquisitions of the 13 weather stations of the *ASTI-Network*, showing a good agreement for the different Local Climate Zones. Average bias is mostly less in module than 0.5°C, RMSE is about 1°C and the Pearson correlation coefficient is higher than 0.95 for temperature; average bias is mostly less in module than 1 m/s, RMSE is about 1m/s and the Pearson correlation coefficient is higher than 0.8 for wind speed.

These statistical parameters reveal that this tool is suitable for the exploration of UHI-related vulnerabilities in the city of Rome, even during heat waves.

From Shelter to Safeguard: are Massive Buildings our Allies in Heritage Conservation?

Giulia Boccacci[1], Francesca Frasca[2], Chiara Bertolin[3], Tonje Dahlin Saeter[4], Erlend Lund[4], Anna Maria Siani[2]

[1]Dipartimento di Scienze della Terra, Sapienza Università di Roma, Italia; [2]Dipartimento di Fisica, Sapienza Università di Roma, Italia; [3]Department of Mechanical and Industrial Engineering, Norwegian University of Science and Technology, Trondheim, Norway; [4]Library Section for Special Collections, NTNU University Library, Dora, Trondheim, Norway

The high thermal inertia of massive buildings (thick masonry, concrete, or stone walls with minimal openings) naturally attenuates and delays outdoor climate variability, offering a potential sustainable solution for the passive preservation of climate-vulnerable heritage collection. This research proposes an approach combining multiple statistical techniques for indoor climate (named also as microclimate) characterization, and for assessing existing buildings as passive or low-energy conservation spaces. The approach is applied to multi-years series of indoor temperature (T) and relative humidity (RH), including the mixing ratio (MR) of moist air, available at the Library Section for Special Collections (LSSC), located within the WWII massive bunker “Dora I” (Trondheim, Norway). Five years of microclimate data (2020-2024) are analyzed to investigate the intrinsic properties of the time series relevant for the microclimate characterization in conservation spaces housing climate vulnerable collections (paper-based objects housed within Dora I). It is found that indoor climate conditions remain stationary, with no discontinuities or trends over five years.

Indoor T and MR are delayed of 70 and 50 days and attenuated by a factor of 0.2 and 0.4 compared to outdoor values, demonstrating high thermal inertia and moisture buffer. Findings confirm the suitability of heavyweight, passively conditioned massive buildings in ensuring stable indoor conditions for heritage conservation, supporting sustainable reuse strategies as an energy-saving solution. Given the widespread availability of similar massive structures (often former industrial, military, or infrastructural buildings), their potential is particularly promising.

Long-term variation in exposure to NO2 concentrations in the city of Naples, Italy: results of a citizen science project

Angelo Riccio, Elena Chianese
Università Parthenope, Italy

In questo studio si indaga la variazione a lungo termine dell'esposizione della popolazione al biossido di azoto (NO2) nell'area urbana di Napoli, Italia, durante il periodo 2013–2022. La ricerca integra dati ad alta risoluzione temporale dalla rete regionale di monitoraggio di riferimento con misure ad alta risoluzione spaziale raccolte durante la campagna di citizen science "NO2, NO grazie!", condotta nel febbraio 2020 con campionatori passivi a basso costo. L'obiettivo principale è stato quello di generare stime ad alta risoluzione delle concentrazioni di NO2 per valutarne l'andamento temporale, l'esposizione della popolazione e l'impatto sanitario in un ambiente urbano densamente popolato.

E' stato utilizzato un modello Random Forest basato sull'uso del suolo (Land Use Random Forest, LURF) per estrapolare i dati sperimentali della campagna di citizen science e per calibrare e armonizzare questi dati con la rete di monitoraggio ufficiale. Questo approccio ha permesso di stimare la concentrazione media annuale di NO2 su una griglia spaziale fine per ciascun anno del periodo di studio. La metodologia ha tenuto conto delle incertezze delle stime di esposizione e ha permesso di valutare la conformità agli standard della Comunità Europea (EC) e alle linee guida sulla qualità dell'aria dell'Organizzazione Mondiale della Sanità (OMS).

I risultati evidenziano che, nonostante una lieve tendenza al ribasso delle concentrazioni di NO2 nel decennio, una larga parte della popolazione napoletana è esposta a livelli superiori sia al nuovo valore guida dell'OMS (10 ug/m3) sia agli obiettivi intermedi, sempre indicati dall'OMS. Nella maggior parte degli anni, circa due terzi della popolazione ha sperimentato valori medi annuali di NO2 superiori a 40 ug/m3, con una riduzione temporanea osservata solo nel 2020 durante il lockdown per l'epidemia da COVID, quando la percentuale di esposti sopra questa soglia è scesa al 6%. La valutazione dell'impatto sanitario, basata su funzioni di risposta concentrazione-effetto consolidate, ha stimato che circa 1.300 decessi all'anno a Napoli sarebbero attribuibili all'esposizione a NO2 sopra la soglia di 10 ug/m3, con una riduzione significativa osservata solo nell'anno del lockdown.

Lo studio dimostra che le campagne di citizen science co-progettate, se integrate con il monitoraggio ufficiale e la modellazione statistica avanzata, possono migliorare notevolmente la risoluzione spaziale e l'affidabilità delle valutazioni sull'esposizione all'inquinamento urbano da NO2. I risultati sottolineano la persistenza di un'elevata esposizione a NO2 a Napoli e l'importanza di politiche di riduzione delle emissioni più rigorose e continuative per raggiungere la conformità agli standard internazionali sulla qualità dell'aria e tutelare la salute pubblica.

Characterizing the interaction between Urban Heat Island and Urban Pollution Island in Rome (Italy) through ground-based measurements

Annalisa Di Bernardino[1], Stefania Argentini[2], Erika Brattich[3], Monica Campanelli[2], Giampietro Casasanta[2], Andrea Cecilia[2], Margherita Erriu[1], Andrea Faggi[3], Serena Falasca[1,4], Anna Maria Siani[1]
[1]Dipartimento di Fisica, Sapienza Università di Roma; [2]CNR, Istituto di Scienze dell'Atmosfera e del Clima; [3]Dipartimento di Fisica "Augusto Righi", Università di Bologna; [4]Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo sostenibile (ENEA)

Urban Heat Island (UHI) and Urban Pollution Island (UPI) are two interlinked phenomena that exacerbate the vulnerability of cities to climate change, extreme weather events, and deteriorating air quality. While UHI refers to the excess temperature in built-up areas compared to their rural surroundings, UPI describes the accumulation of atmospheric pollutants within the urban canopy. Understanding their interaction is crucial for improving thermal comfort, air quality, and urban sustainability.

This study investigates the UHI–UPI relationship in Rome (Italy) by combining in-situ measurements of meteorological variables and pollutant concentrations using an integrated approach that combined multiple statistical techniques. Data collected over the period 2018–2023 include air temperature, humidity, and wind speed from dense meteorological stations, together with PM_{10}, $PM_{2.5}$, NO, NO_2, and O_3 from the ARPA Lazio air quality network.

Results reveal marked temporal variability of UPI intensity, with aerosol and nitrogen oxides peaking in winter under stagnant conditions, and ozone reaching maxima in summer. Seasonal cycles are mirrored by UHII, which is strongest in summer and weakest in winter. Lag-correlation analysis reveals the most significant coupling when nocturnal UHII is shifted backward by one day, indicating that daytime emissions accumulate overnight. Regression analyses identify daily mean air temperature and wind speed as key drivers of UHI–UPI interaction. Spearman correlations indicate negative associations of UHII with NO, PM_{10}, NO_2, and $PM_{2.5}$, and a positive correlation with O_3. Case studies (atmospheric stagnation, calm wind days, cold-air pooling nights, and heatwaves) confirm that atmospheric dynamics strongly modulate the intensity and persistence of both phenomena.

These findings highlight the complexity of UHI–UPI feedback and stress the importance of integrated monitoring and modelling frameworks. Science-based insights from this analysis provide valuable guidance for urban planning and environmental management aimed at reducing combined thermal and pollution stress in Mediterranean cities.

Personal solar UV radiation exposure of rangers in an Alpine natural park

Annachiara Bellini[1], Henri Diémoz[1], Daniele Stellin[2], Giuseppe Casale[3], Anna Maria Siani[4]

[1]ARPA Valle d'Aosta; [2]Mont Avic Natural Park; [3]Independent scientist; [4]Sapienza University of Rome

Solar ultraviolet (UV) radiation is a major risk factor for a variety of short- and long-term health conditions affecting the skin, eyes and the immune system. At the same time, controlled UV exposure is essential for human health, as it is the primary source of vitamin D. Individual exposure levels are influenced not only by ambient UV irradiance, typically monitored by fixed broad band radiometers, but also by the orientation of exposed body parts, outdoor exposure duration, activity patterns and interactions with the surrounding environment. Reliable quantification of personal UV exposure therefore requires the use of dosimeters, portable UV-sensitive devices - based on radiation-sensitive materials or electronic sensors such as photodiodes - that can be worn by individuals. At high altitudes, where solar UV irradiance is enhanced by elevation, snow cover, and clean atmospheric conditions, both residents and visitors are at increased risk of overexposure. To investigate this issue, a field campaign was carried out from July to August 2025 in the Mont Avic Natural Park, an Alpine protected area in the Aosta Valley (northern Italy). Ten volunteers, including park rangers and seasonal outdoor workers, wore calibrated electronic dosimeters at the wrist to measure personal UV exposure during their daily activities in high-altitude (1500–2700 m a.s.l.) environments. The collected exposure data are analyzed in relation to ambient UV levels measured by a fixed broadband radiometer and classified by type of outdoor activities. The individual exposure was compared to the occupational threshold limit value of UV radiation of 1 SED (1 standard erythemal dose is equivalent to an erythemal effective radiant exposure of 100 Jm^{-2}) as recommended by the International Commission on Non Ionizing Radiation Protection (ICNIRP). To our knowledge, this study represents one of the first assessments of occupational UV exposure among park rangers, a group that can also serve as a representative proxy for other cohorts of population such as mountain hikers. The results are beneficial for developing targeted sun protection guidelines for both occupational groups and mountain visitors.

Weather, Climate and Health: the TRIGGER project

Silvana Di Sabatino

University of Bologna, Italy on behalf of the TRIGGER Consortium

TRIGGER (Solutions for mitigating climate-health induced risks) https://project-trigger.eu/ is an Horizon Europe project started in September 2022 dealing with the complex interlinkages between extreme weather and health effects. It involves 22 partners from several European countries working together to understand how to mitigate the incidence of several diseases such as cardio-vascular disorders in a warming climate. Specifically, the project focuses on achieving a better integration between personal health protection and the environment in which choices at personal level can be made to mitigate climate-related health risks. TRIGGER's engines are the Climate-Health Connections Labs (CHC Labs): five selected Labs built in European cities, strategically distributed from south to north Europe to capture the diversity in climate. The role of CHCL is to act as hub for the various TRIGGER activities. Each represents a specific environment and climate-related risks ranging from heat waves to air pollution. Each Lab co-design and implement clinical studies, namely the CrossCLAVIS (cross-sectional study), the LongCLAVIS (longitudinal study) and a retrospective study (RetroCLAVIS) to gather new information about climate-related health conditions and use refined climate and health indicators to understand criticalities and work on mitigation of those. TRIGGER is one of the 6 Horizon Europe projects, BlueAdapt, CATALYSE, CLIMOS, HIGH Horizons, IDAlert, and TRIGGER, form the climate change and health cluster. All cluster projects address climate change-induced health risks and help increase preparedness and adaptation by creating synergies, sharing experiences and knowledge, and developing aligned communication actions to maximise impact of climate change. In this presentation we focus on the findings of the first 3 years of projects with emphasis on the identifications of meteo-climate indicators used to infer health effects as well as the sensitivity to spatial and temporal scales. Starting from heat-waves cases, a methodology is presented to downscale relevant variables to formulate fine-grain novel indicators of heat exposure. The presentation will provide some insight on the relevance of data requirements to advance climate science in the health domain.

A near real-time alert service for extreme weather events using low-cost GNSS receivers

Wafi Mahdi Eldoud Mahdi, Ilaria Ferrando

Department of Civil, Chemical and Environmental Engineering, University of Genoa, Italy

The monitoring of atmospheric water vapor is crucial in understanding and predicting severe weather conditions such as heavy rainfalls. This work presents a cost-effective and near real-time approach to estimate Precipitable Water Vapor (PWV) using low-cost dual frequency Global Navigation Satellite System (GNSS) receivers and open-source software to create a near real-time monitoring and alerting service for extreme weather conditions. The positioning method is based on real-time Precise Point Positioning (PPP) with State Spatial Representation (SSR), a messaging standard provided by the International GNSS service (IGS) to disseminate corrections for orbits, clocks, phase-biases and ionospheric delays in real-time. In this process, the Zenith Total Delay (ZTD), i.e., the delay experienced by GNSS signals while crossing the atmosphere, is estimated and PWV can be computed, thanks to the availability of ZTD estimates, and surface pressure and temperature data that are estimated through Global Pressure and Temperature (GPT-3) models. The service allows users to receive warnings about potential extreme weather events based on the sharp increase of PWV in a short period of time, which often indicates an imminent severe weather event. The system structure integrates GNSS data processing, atmospheric data estimation and dissemination of timely and reliable outputs. It also uses cloud computing for data logging to enable further analysis, and supports the potential integration of additional data sources for scalability. This framework offers an

affordable and adaptable solution for enhancing weather monitoring, ensuring global applicability, thanks to the use of PPP technique.

The study was carried out within "PAIN AND GAIN - Positioning and INtelligent Alarms supported by a New Dense GNSS Affordable Infrastructure" Project n. 2022P8C7ZA, funded by European Union-Next Generation EU within the PRIN 2022 program (D.D. 104-02/02/2022 Ministero dell'Università e della Ricerca).

Impact of micro-climate conditions and urbanization on NTM infections: an Italian nationwide case-control study

Enrico Cesare Maggioni[1], Paola Faverio[2,3], Lorenzo Del Castello[4], Maura Spotti[5], Paola Rebora[4,6], Francesco Blasi[5,7], Alessandro Perotto[1], Raffaele Salerno[10], Stefano Aliberti[8,9]

[1]Ideam srl, Cinisello Balsamo, Italy; [2]School of Medicine and Surgery, University of Milano-Bicocca, Monza, Italy; [3]Respiratory Unit, Fondazione IRCCS San Gerardo dei Tintori, via Pergolesi 33, 20900, Monza; [4]Bicocca Bioinformatics Biostatistics and Bioimaging B4 Center, School of Medicine and Surgery, University of Milano-Bicocca, Monza, Italy; [5]Internal Medicine Department, Respiratory Unit and Cystic Fibrosis Center, Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico, Milano, Italy; [6]Biostatistics and Clinical Epidemiology, Fondazione IRCCS San Gerardo dei Tintori, Monza, Italy; [7]Department of Pathophysiology and Transplantation, Università degli Studi di Milano, Milan, Italy; [8]IRCCS Humanitas Research Hospital, Respiratory Unit, Via Manzoni 56, 20089, Rozzano, Milan, Italy; [9]Department of Biomedical Sciences, Humanitas University, Via Rita Levi Montalcini 4, 20072, Pieve Emanuele, Milan, Italy.; [10]Meteo Expert (Mopi srl), Cinisello Balsamo, Milan, Italy

Nontuberculous mycobacteria (NTM) are opportunistic agents, with main sources of infection being soil and water. Higher population densities and tropical/subtropical climates were associated with increased pulmonary NTM infection (pNTM). Aim of this study was to assess whether pNTM was associated with climate parameters (temperature, humidity, wind speed, and precipitation) and urbanization.

We conducted a case-control study evaluating meteorological conditions (in the 12 months before the first NTM isolate for every patient) and urbanization in the municipalities of residence of 1,061 adults with pNTM enrolled in an Italian multicenter observational study (2013-2022), compared with a random sample of 10,000 adults from the Italian population.

Climate conditions of the municipalities involved in the study for the period of interest (January 2013-December 2022) were reconstructed using an interpolation technique called MLRLI (Multi-linear regression with local improvement).

The input data comes from various networks of meteorological weather stations, spread all over the Italian territory, measuring temperature at 2-meter height, relative humidity, wind speed and direction, barometric pressure and precipitation. Among these networks it is notable to mention the MNW network (Meteonetwork). Other networks (regional, private and aerodrome networks) are also included in the present analysis. For the rain precipitation field, satellite data are also included, from the GPM (Global Precipitation Measurement) mission.

Results show that densely populated areas were at higher risk for pNTM, even after adjusting for age, sex and meteorological parameters in a multivariable mixed-effects logistic regression model. Hotter, poorly ventilated climates with less precipitation were at higher risk for NTM infection, with OR (Odds Ratio) 95%; CI (Confidence Interval) 0.90 for each km/h increase in mean annual windiness; CI 0.99 for each 10 mm increase in mean annual precipitation; CI 1.21 for each °C increase in mean annual temperature.

Implementation of a three-dimensional urban canopy parameterization in the mesoscale WRF model

Dario Di Santo[1], Giulia Ravizza Garibaldi[2], Elena Conigliaro[2], Giovanni Leuzzi[2], Paolo Monti[2], Lorenzo Giovannini[1]

[1]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy; [2]Department of Civil, Constructional and Environmental Engineering, University of Rome "La Sapienza", Rome, Italy

This contribution presents the Three-Dimensional Urban Canopy Model (3DUCM), a novel three-dimensional urban parameterization, and its implementation in the Weather Research and Forecasting (WRF) model (WRF/3DUCM). Traditional urban sub-grid scale parameterizations implemented into mesoscale meteorological models typically consider a simple two-dimensional canyon geometry representative of the average urban morphology of the mesoscale model grid cell. On the other hand, 3DUCM is a single-layer urban canopy model that takes into account every single building of the urban area, also considering canyon orientation and explicit crossroads modeling, i.e., three-dimensional effects. Model output incorporates not only average grid cell variables, but also predicted fields down to the building scale.

In this work, WRF/3DUCM is tested in the city of Rome during a summer heat wave. Simulations benefit from detailed information on the geometric characteristics of the city, whereas physical properties of urban materials are assigned based on the local climate zone (LCZ) framework. Simulation results obtained with WRF/3DUCM are compared with those from simulations performed with WRF coupled with the default single-layer and multi-layer urban canopy parameterizations and evaluated against an observational dataset. The results highlight the potential of incorporating single-building details to improve the representation of urban microclimates with mesoscale meteorological models.

A probabilistic approach to risk analysis for the effects of microclimatic conditions on cultural heritage

Mauro Giudici, Jacopo Melada, Natalia Boffelli, Alessandro Zanon, Alessandro Comunian
Università degli Studi di Milano, Italy

A rigorous definition for risk as the product of three factors (hazard, vulnerability and damage) is proposed. The application of this formalism requires: (1) the determination of the hazard as the probability density function (pdf) of a set of variables that correspond to the quantities that are potentially harmful for the conservation of cultural heritage; (2) the determination of the vulnerability as the conditional pdf of the damages produced by the potentially harmful conditions; (3) the damage, i.e., the value of the elements at risk or the costs to their restoration. Examples are given to test the application of this approach, through the processing of indoor and/or outdoor data and the use of dose-response (or loss, or damage) functions, to different study cases.

Climate Services for Supporting the Strategy for the Mitigation and Adaptation to Climate Change of the Autonomous Province of Trento

Anna Napoli[1,2], Michael Matiu[2], Lavinia Laiti[3], Roberto Barbiero[3], Alberto Bellin[2], Dino Zardi[1,2], Bruno Majone[2]
[1]C3A - Center Agriculture Food Environment, University of Trento; [2]DICAM - Department of Civil, Environmental and Mechanical Engineering, University of Trento; [3]APPA - Agency for Environmental Protection of the Autonomous Province of Trento

Recognizing the growing urgency of climate change, many regional administrations are developing tailored adaptation strategies based on the specific characteristics of their territories, including climate patterns, local atmospheric dynamics, topography, and, importantly, environmental and socio-economic factors. However, effectively leveraging this wealth of information to design robust climate strategies remains a challenge. This study presents the comprehensive approach used to establish the knowledge foundation for the mitigation and adaptation strategy of the Trentino region. We highlight three main steps in this process, emphasizing the collaborative effort of multiple stakeholders: 1) Preparing a scientific report reviewing current knowledge and identifying research gaps regarding climate change impacts in the region; 2) Disseminating a synthesis of this information to the general public; 3) Creating reference climate scenarios.
The literature review revealed substantial variation in both the scope and depth of analyses across different scientific sectors concerning climate change impacts in Trentino. This heterogeneity was reflected in the informative report, which employed a structured methodology to simplify and synthesize technical information without compromising scientific accuracy. For the climate scenarios, we considered multiple factors, including topography, data availability, and stakeholder needs. A layered approach was applied, incorporating spatially aggregated results, statistical downscaling, and high-resolution numerical simulations using a convection-permitting model. The study projects a general increase in temperatures, with more pronounced rises in winter minima and summer maxima. Extreme precipitation events are expected to become more frequent and intense, while seasonal patterns vary depending on the emissions scenario considered.

Understanding Microclimates in Preventive Conservation: Insights from 15 Years of Climate4Heritage Research

Francesca Frasca, Anna Maria Siani
Dipartimento di Fisica, Sapienza Università di Roma

Preventive conservation involves strategies and practices that aim to minimise the risk of damage and losses to cultural heritage before deterioration occurs. Within this framework, microclimate — the climate conditions surrounding an object — plays a key role as it directly influences preservation.

Therefore, investigating microclimates is not merely about collecting data; it requires a meticulous analysis of datasets rather than simply calculating statistical parameters or verifying compliance with thresholds. It demands a thorough understanding of the complex interactions between the environment and the materials, along with an awareness of the climate-induced mechanisms responsible for deterioration.

This integrated approach is essential for assessing past and present conditions that have led to the object's current conservation status, and for guiding the identification of the most appropriate preservation actions in view of future scenarios. In this context, it is crucial to consider the growing impact of climate change and the pressure of mass tourism, both of which pose new challenges to the cultural heritage protection.

The *Climate4Heritage* laboratory of the Physics Department at Sapienza University of Rome has investigated the microclimate in more than 20 case studies over the past 15 years. This contribution analyses the challenges addressed during this period, from instrumental issues to data analysis, and discusses how combining theory with experiences in microclimate studies can lead to effectively and scientifically support preventive conservation of cultural heritage.

Catwink: a rainfall-based tool for the insurance claim verification for floods and landslides in Italy

Gianbattista Bussi, Ines Cerenzia, Santiago De La Fuente, Viola Meroni
REDRISK - Risk Engineering + Development, Italy

Insurance claim verification is the process through which insurance companies assess and validate the legitimacy and accuracy of claims before approval. This often involves complex procedures aimed at identifying inconsistencies, errors, or potential fraud.

Catwink is a new tool developed for the Italian context, designed to improve the efficiency of claim verification related to natural hazards such as floods, landslides, and earthquakes.

In this work, we present the Catwink components focused on evaluating the plausibility of claims caused by floods and landslides. The methods leverage multiple rainfall datasets and have been calibrated using recent extreme weather events. System performance has been assessed both through selected case studies and statistical analyses.

Assimilazione di stime di precipitazione da satellite per il miglioramento delle simulazioni numeriche dei medicane

Lorenzo Silva[1], **Silvio Davolio**[1,2]
[1]Università degli Studi di Milano – Dipartimento di Scienze della Terra – Milano (Italia); [2]Consiglio Nazionale delle Ricerche – Istituto di Scienze dell'Atmosfera e del Clima (CNR-ISAC) – Bologna (Italia)

I medicane sono cicloni mediterranei che acquisiscono caratteristiche tipiche dei cicloni tropicali. Sebbene si verifichino mediamente pochi eventi ogni anno, i medicane hanno riscosso un crescente interesse poiché sono spesso associati a forti impatti (piogge intense, tempeste di vento, mareggiate) che colpiscono soprattutto le coste densamente popolate del bacino del Mediterraneo.

I prodotti satellitari non solo permettono di monitorare l'evoluzione e identificare le caratteristiche chiave dei medicane, ma forniscono anche preziose stime di precipitazione sopra il mare, dove questi cicloni si sviluppano e dove le osservazioni sono solitamente scarse. Nell'ambito del progetto "MEDICANES – Earth Observations as a cornerstone to the understanding and prediction of tropical-like cyclone risk in the Mediterranean" finanziato dall'Agenzia Spaziale Europea (https://medicanes.isac.cnr.it), vengono raccolti diversi prodotti di stime di pioggia da satellite. Lo scopo di questo studio è indagare le potenzialità dell'assimilazione di questi dati in un modello meteorologico ad alta risoluzione "convection-permitting", al fine di migliorare la simulazione numerica dei medicane. L'assimilazione sfrutta una tecnica di nudging che modifica progressivamente i profili di umidità specifica del modello a seguito del confronto tra pioggia osservata e simulata.

Utilizzando due intensi eventi recenti come casi di studio, i medicane Ianos e Apollo, l'assimilazione si è mostrata capace di migliorare le simulazioni della traiettoria e dell'intensità dei cicloni, inducendo una modifica nei processi diabatici, che può propagarsi e influenzare anche la dinamica a larga scala.

Confronto tra tecniche di nowcasting radar in Italia: definizione di un dataset di riferimento e criteri di benchmark

Clizia Annella[1,2], **Edoardo Raparelli**[3], **Gianfranco Vulpiani**[4], **Vincenzo Capozzi**[2], **Elisa Adirosi**[1], **Luca Baldini**[1], **Giorgio Budillon**[2], **Raffaele Lidori**[3], **Mario Montopoli**[1,3]
[1]ISAC-CNR, Italy; [2]Università Napoli Parthenope; [3]Centro di Eccellenza in Telerilevamento E Modellistica Previsionale di eventi Severi (CETEMPS) Università Dell'Aquila; [4]Presidenza del Consiglio dei Ministri, Dipartimento della Protezione Civile

Il radar meteorologico è uno degli strumenti che si presta maggiormente per supportare le tecniche per la previsione di eventi precipitativi con un'elevata risoluzione spaziale e temporale (ossia il nowcasting). Attualmente, esistono numerosi metodi di nowcasting che utilizzano in input serie temporali di echi radar, sfruttando anche tecniche di intelligenza artificiale. Le performance di tali metodi, tuttavia, sono influenzate da vari fattori e le loro capacità previsionali devono essere investigate localmente per applicazioni specifiche a livello nazionale. Questo lavoro si propone quindi di confrontare varie tecniche di nowcasting (tradizionali, basate sulla stima del campo di moto, e più recenti, considerando algoritmi di intelligenza artificiale) sul territorio italiano, al fine di stabilire una metodologia per fissare una soglia minima accettabile di performance (MAP) da utilizzare nell'analisi delle prestazioni di futuri metodi di nowcasting per quantificare il miglioramento rispetto allo "stato dell'arte".

I risultati presentati sono ovviamente validi per l'Italia, anche se l'approccio è generale e potrà essere riprodotto in altre aree geografiche. Più nel dettaglio, come dataset di test sono stati adoperati circa due anni di stime radar di precipitazione, da gennaio 2022 a febbraio 2024, rivelate dal mosaico radar nazionale ogni 5 minuti, con una risoluzione spaziale di 1 km. Il dataset è stato filtrato mediante l'introduzione di un nuovo processo di screening che consente di selezionare in modo automatico le immagini contenenti un numero minimo di punti griglia distribuiti in modo omogeneo e consistente con i pattern spaziali tipici della precipitazione. Il risultato più evidente è la grande variabilità nelle prestazioni di ogni metodo testato. Inoltre, è stata rilevata una dipendenza stagionale e geografica delle performance. Durante la stagione estiva, infatti, quando i temporali convettivi sono più frequenti, le capacità predittive di tutti i metodi risultano ridotte e ciò suggerisce la necessità per il futuro di implementare moduli di nowcasting specifici per la convezione, possibilmente ottimizzati localmente, per migliorare le capacità di previsione in caso di instabilità atmosferica.

DiToNA: Gemello Digitale ad Alta Risoluzione per la Previsione Meteomarina nell'Alto Adriatico

Angelo Riccio[1], **Giovanni Cinque**[2], **Rossella Ferretti**[3], **Matteo Nastasi**[3], **Antonio Ricchi**[3]
[1]Università Parthenope, Italy; [2]HIMET Srl; [3]CETEMPS, Center of Excellence Telesensing of Environment and Model Prediction of Severe events

Il progetto DiToNA (Digital Twin of North Adriatic) mira a implementare una piattaforma di gemello digitale per la regione dell'Alto Adriatico, integrando modelli numerici avanzati di previsione meteorologica, oceanografica e ondosa, in grado di assimilare dati osservativi, inclusi quelli satellitari ad alta risoluzione, e produrre simulazioni ad altissima fedeltà spazio-temporale. DiToNA è cruciale per un'area vulnerabile a eventi meteo-marini estremi, quali cicloni mediterranei, la Bora, mareggiate e fenomeni di acqua alta che colpiscono città costiere e infrastrutture dell'Adriatico settentrionale.

La piattaforma combina i modelli WRF (atmosfera), ROMS (oceano) e SWAN (onde) tramite il framework COAWST, consentendo simulazioni tridirezionali e processi multi-scala tra atmosfera, oceano e onde. Le griglie di simulazione prevedono risoluzioni fino a 1 km nelle aree costiere più sensibili e una dettagliata stratificazione verticale nei primi metri sopra e sotto la superficie, per una rappresentazione accurata di scambi termici e turbolenze. L'innovazione chiave di DiToNA risiede nell'uso di tecniche di data assimilation variazionale (3DVAR) e nell'integrazione di dati da radar satellitari SAR, che migliorano significativamente l'inizializzazione dei modelli in aree marine.

La validazione, effettuata tramite indicatori quantitativi (bias, MAE, RMSE, CSI, POD), evidenzia benefici dell'assimilazione soprattutto nelle fasi iniziali della simulazione e nei modelli accoppiati, pur rilevando persistenti criticità nelle previsioni di precipitazioni estreme e una tendenza alla sovrastima degli eventi più intensi. Le analisi condotte su casi di studio emblematici, come il ciclone Detlef (novembre 2019), confermano la capacità del sistema di riprodurre eventi eccezionali, sottolineando la necessità di ulteriori miglioramenti, in particolare tramite reti osservative più dense e strategie di calibrazione dinamica. DiToNA si propone dunque come riferimento nazionale ed europeo per la previsione e la mitigazione degli impatti meteomarini nelle coste mediterranee.

Modelling Localized Convective Events affecting Energy Infrastructures: The Verretto Case Study

Riccardo Bonanno, Elena Collino, Francesco Gambetta
RSE, Italy

As a result of greenhouse gases mitigation strategies to face climate change, renewable energy plants have greatly expanded during the last decades. Concurrently, extreme weather events are increasing in frequency and intensity, posing significant challenges for renewable energy generation and grid stability. Deep convection, capable of generating strong wind gusts, heavy rainfall and hailstorms, is often responsible for substantial damage to electrical infrastructure. As a result of the small temporal and spatial scales in which convection typically develops, its associated phenomena are difficult to predict accurately.

It follows that improving the ability of weather forecasting models to predict them is essential for making disaster prevention measures more effective.

This study used the regional model WRF-ARW to investigate the capabilities of forecasting a convective event that occurred in Northern Italy on August 28th, 2025. During the event, strong wind gusts uprooted several panels from a large PV plant in Verretto (PV). This event was analyzed using several high-resolution simulations conducted in both reanalysis and forecast mode, with three nested domains at resolutions of 12 km, 4 km and 1.3 km, respectively. As far as reanalysis mode is concerned, ERA5 was used, while two simulations using GFS and IFS drivers were carried out in forecast mode to assess the relative performance of the different boundary conditions in reconstructing this event.

Various meteorological variables were examined to evaluate the performance of each simulation. Convective parameters related to the genesis and development of thunderstorms, as well as surface wind speed and vertical velocity, were analyzed to assess the simulation's relative performance in accurately reconstructing this event in space and time.

This study has also deepened the ability of regional downscaling in the detection of this localized event at different spatial resolutions.

These preliminary results are useful for guiding the selection of the most appropriate model configuration, such as grid settings and parameterizations, and boundary conditions for describing destructive and localized convective phenomena, which pose an even greater threat to energy infrastructure.

Modelling the factors impacting urban cool islands using the TEB-Surfatm model

Laura Bignotti, Patrick Stella, Nomena Andrianarisoa, Benjamin Loubet, Erwan Personne
ECOSYS, INRAE, AgroParisTech, Université Paris-Saclay, Palaiseau, FR, France

Urbanisation is responsible for deep modifications to the environment, altering the energy balance and local microclimate. In particular, urban areas are known for the so-called heat island effect, associated with a reduction in thermal comfort and, more generally, a series of negative effects on human physical and mental health.

Vegetation (shading, evapotranspiration), soil (support for vegetation, interface between vegetation and water, water reserve), water (integrated management returned to the soil directly or indirectly) and surface cover (thermoradiative properties, evapotranspiration) are considered the main factors capable of counterbalancing the heat island effect, contributing to the creation of urban cool islands. However, the impact of these factors on the urban microclimate is variable and is affected by the mutual influence of the various factors.

In this study, we will examine the impact of the main factors contributing to the development of urban cool islands, using the TEB-Surfatm model on several case studies in France. Parameters such as the colour and thermal properties of coatings, the height and the rate of coverage of the vegetation, water requirements associated with the presence of vegetation will be taken into account in order quantify their impact on the microclimate. The results of this research, developed in collaboration with Vinci Constructions, will be used to create resilient urban environments, reducing the impact of the urban heat island effect.

The assimilation of surface observations on limited area forecasts over complex terrain

Giorgio Doglioni[1], Stefano Serafin[2], Martin Weissmann[2], Gianluca Ferrari[3], Dino Zardi[1]

[1]Department of Civil Environmental and Mechanical Engineering (DICAM), University of Trento, Trento, Italy; [2]Department of Meteorology and Geophysics, University of Vienna, Vienna, Austria; [3]Hypermeteo SRL, Padua, Italy

We present a computationally efficient regional weather prediction system based on the Weather Research and Forecasting (WRF) model and its data assimilation component, WRFDA. The system generates twice-daily 24-hour forecasts (00 and 12 UTC) over the European Alps and surrounding regions at 3.5 km resolution. Surface observations are assimilated using the 3D-Var algorithm, and forecast performance is evaluated against independent surface and radiosonde measurements. The assimilated observations are obtained from both conventional sources (SYNOP observations) and the dataset hosted by Hypermeteo S.r.l., which comprises observations from publicly and privately owned surface stations that are usually not included in assimilation routines. Assimilating these observations results in substantial improvements in near-surface temperature and humidity forecasts compared to control simulations without assimilation. In the first six forecast hours, mean temperature and humidity errors are reduced by up to 0.26 K and 0.18 g kg^{-1}, while the spread of errors decreases by 7–10%. The comparison of forecasts against radiosondes indicates, however, that these surface-based adjustments can increase forecast biases within the planetary boundary layer (PBL). At the same time, the assimilation of surface observations leads to an overestimation of the accumulated precipitation. We show that these side effects can be effectively mitigated by considering a different assimilation algorithm. The assimilation also exhibits different effects across terrain types, with greater benefits in lowlands than in mountainous regions, likely due to limitations in how static covariances spread observational information along terrain-following coordinates. Moreover, the forecast skill displays a clear diurnal pattern, with larger temperature errors occurring over mountains during the day and over plains at night.

Detection and tracking of Medicanes through VideoMAE selfsupervised vision transformer

Daniele D'Armiento, Stefano Sebastianelli, Leo Pio D'Adderio, Paolo Sanò, Daniele Casella, Giulia Panegrossi

National Research Council of Italy, Institute of Atmospheric Sciences and Climate, CNR-ISAC, Rome, Italy

Mediterranean Hurricanes (hereafter Medicanes) are high-impact, short-fused events whose rapid intensification and small spatial extent challenge conventional nowcasting systems. Reliable, automatic detection and tracking from geostationary satellite imagery could improve situational awareness and contribute to earlier warnings. Within the MEDICANES project funded by the European Space Agency (ESA), we apply a selfsupervised vision transformer called VideoMAE for learning high-level spatiotemporal features from geostationary satellite IR image sequences. Our aim is to both automatically detect Medicanes and track them from short video clips. The dataset consists of airmass RGB composites over the Mediterranean basin, built by means of the IR channels images collected by the Rapid Scan Service (RSS) of the Spinning Enhanced Visible InfraRed Imager SEVIRI on board the Meteosat Second Generation (MSG) geostationary satellite. We perform self-supervised pretraining of VideoMAE for representation learning, and fine-tune the pretrained model for downstream tasks: binary classification for cyclone presence, and regression for the cyclone-eye center localization. The pretrained-then-fine-tuned VideoMAE model yields robust detection task performance on the imbalanced test set, with overall accuracy exceeding 90% and POD above 95%. The model captures key cyclone dynamics, such as rotational cloud patterns and evolving airmass contrasts without manual feature engineering. The study shows that VideoMAE can provide a scalable and efficient approach to satellite video analysis, demonstrating robust transfer to cyclone detection despite severe class imbalance and delivering consistent center localization. These results suggest that transformer-based video models are well suited for operational use in rare-event detection, offering a practical path toward automated monitoring and early warning of Medicanes.

Selezione ottimale di membri da ensemble globali per downscaling probabilistico nel Mediterraneo

Matteo Nastasi[1], Antonio Ricchi[1], Rossella Ferretti[1], Francesco Barbariol[2]

[1]University of L'Aquila, Italy; [2]CNR-ISMAR, Italy

La previsione meteorologica probabilistica è una tecnica che utilizza ensemble forecasting, ovvero insiemi di simulazioni con condizioni iniziali e parametrizzazioni leggermente diverse per quantificare l'incertezza previsionale.

L'*Ensemble Prediction System* (EPS) dell'*European Centre for Medium-Range Weather Forecasts* (ECMWF) genera 50 membri ogni 6 ore. L'utilizzo operativo di questo ensemble per fornire condizioni iniziali e al contorno a modelli regionali ad alta risoluzione richiede una riduzione del numero di membri compatibile con le risorse computazionali disponibili. Si pone quindi il problema della selezione ottimale dei membri da utilizzare.

Questo studio presenta e valuta un metodo di riduzione dell'ensemble che preserva la consistenza statistica del campione originale. La metodologia si basa sulla riduzione dimensionale tramite *Principal Component Analysis* (PCA) delle variabili prognostiche del modello globale a livelli isobarici selezionati, seguita da *clustering* nello spazio latente. Da ogni raggruppamento viene estratto il membro più prossimo alla centroide. La numerosità dell'ensemble ridotto è stabilita priori con il numero di raggruppamenti prescritto. I membri selezionati vengono utilizzati come condizioni iniziali e al contorno per altrettante simulazioni con il modello ad area limitata WRF-ARW, mantenendo invariati i parametri del modello per ogni membro.

Il metodo è stato testato su cinque eventi meteorologici severi che hanno coinvolto il territorio italiano. Lo stesso dominio è stato usato per ogni evento. I risultati dimostrano che l'approccio proposto mantiene meglio

la dispersione statistica dell'ensemble originale rispetto a una selezione casuale, offrendo una soluzione computazionalmente efficiente e facilmente implementabile per sistemi di previsione probabilistica operativi con numero arbitrario di membri.

Can ensemble-based parameter estimation aid parameterization design?

Stefano Serafin, Martin Weissmann
University of Vienna, Austria

Ensemble-based data assimilation algorithms can be used for the objective estimation of the optimal values of uncertain empirical constants in parameterization schemes. This is accomplished by state augmentation: empirical parameters are appended to the model state vector and updated on the basis of flow-dependent ensemble covariances with observable quantities. The method has been used so far as a way of increasing ensemble spread and accounting for model errors in the assimilation process. In this study, we show that parameter estimation results can be useful also for parameterization design, but only under rather restrictive conditions. The error variance of the assimilated observations needs to be as low as that of the state perturbations induced by the estimated parameter, and parametric uncertainty must be the dominant contributor to the total forecast uncertainty. We illustrate the methodology with examples dealing with parameterizations of boundary-layer turbulence and gravity-wave drag.

A procedure for seasonal forecasting of water table elevation in shallow unconfined aquifers

Miriam Saraceni[1], Gregorio Gazzetta[2], Lorenzo Silvestri[3], Bruno Brunone[4], Silvia Meniconi[4], Paolina Bongioannini Cerlini[4]
[1]Norwegian University of Science and Technology (NTNU); [2]AceGasApsAgma SpA; [3]University of Modena and Reggio Emilia, Italy; [4]University of Perugia, Italy

Accurate seasonal forecasting of water table elevation is essential for the effective management of water resources in unconfined aquifers, especially in the context of climate variability and human-induced pressures. This study presents a novel methodology for predicting water table elevation on seasonal timescales. This approach couples reanalysis and seasonal forecast data of soil moisture with a calibrated non-linear transfer model. This approach uses ERA5 reanalysis and SEAS5 seasonal forecasts to estimate the flux towards the aquifer and predict the water table elevation. A case study in the Umbria region of central Italy demonstrates the model's ability to simulate and predict monthly water table fluctuations. Two modelling strategies were compared: a static calibration approach (OPT 1) and a dynamic calibration approach (OPT 2), in which model parameters were updated by considering different time periods. Both options yielded skilful forecasts across lead times of 1 to 6 months, with OPT_2 showing slightly improved stability in forecast performance metrics. The results confirm the feasibility of incorporating seasonal climate forecasts into operational groundwater prediction frameworks. As expected, the accuracy of the forecasts is limited by the accuracy of the precipitation predictions, particularly during autumn and winter. The proposed framework establishes the basis for anticipatory aquifer management and early warning systems in the context of changing hydroclimatic conditions.

Variogram analysis of intense convective events

Mauro Giudici[1], Alessandro Comunian[1], Francesco Ferrari[2]
[1]Università degli Studi di Milano, Italy; [2]Università degli Studi di Genova, Italy

The interpolation of sparse ground data for the initialization of numerical weather forecast, for model validation, and for data assimilation is sometimes performed with geostatistical interpolation. Standard theoretical variograms are often applied. The characteristics of some intense convective events have triggered the idea of a new formula for a theoretical variogram. Strengths and possible difficulties occurring in the application of this variogram model are analyzed.

3:30pm - 4:30pm

CLIMA-III

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**
Session Chair: **Michele Brunetti**
Session Chair: **Paolo Cristofanelli**

MORE, un nuovo dataset meteoclimatico convection-permitting per l'Italia e le Alpi: validazione e applicazioni in meteorologia, climatologia e idrologia

Paolo Stocchi[1], Francesco Cavalleri[2,3], Mohsin Tariq[4], Michele Brunetti[1], Stefania Camici[4], Daniele Mastrangelo[1], Fabio Di Sante[5], Silvio Davolio[1,6]
[1]ISAC-CNR, Italy; [2]Università degli Studi di Milano, Dipartimento di Scienze e Politiche Ambientali, Milano, Italia; [3]Dipartimento per lo Sviluppo Sostenibile e le Risorse Energetiche, Ricerca sui Sistemi Elettrici (RSE), Milano, Italia; [4]Istituto di Ricerca per la Protezione Idrogeologica, Consiglio Nazionale delle Ricerche (CNR-IRPI), Perugia, Italia; [5]CINECA, Casalecchio di Reno, Bologna, Italy; [6]Dipartimento di Scienze della Terra, Università degli Studi di Milano, Milano, Italia

Si presenta un nuovo dataset meteoclimatico ad alta risoluzione per l'Italia e la regione alpina, ottenuto tramite downscaling dinamico dei campi di rianalisi ERA5 con il modello meteorologico ad area limitata non idrostatico MOLOCH. Il prodotto, denominato MORE (MOloch-downscaled ERA5 REanalysis), ha una risoluzione spaziale di circa 1.7 km e copre in modo continuo il periodo 1990–presente, fornendo campi orari di numerose variabili sia al suolo che ai principali livelli isobarici.

La validazione di MORE è stata effettuata con un approccio multiscala per la precipitazione e la temperatura a 2 metri, utilizzando dataset osservativi densi e controllati. Il confronto con altre rianalisi convection-

permitting e con prodotti a più bassa risoluzione spaziale evidenzia che MORE riproduce in modo realistico la variabilità spazio-temporale delle osservazioni, migliora la simulazione della frequenza e dell'intensità delle precipitazioni, degli estremi sub-giornalieri (in particolare in condizioni convettive) e di indicatori climatici rilevanti come il numero di notti tropicali, pur mostrando un bias freddo sistematico nella temperatura.

Come caso di studio applicativo è stata analizzata l'alluvione che ha colpito l'Emilia-Romagna nel maggio 2023. MORE ricostruisce in maniera realistica l'evoluzione meteorologica dei due episodi di precipitazione estrema, offrendo un valore aggiunto nella rappresentazione delle strutture a mesoscala che hanno determinato gli accumuli precipitativi localizzati. Le simulazioni idrologiche forzate con i dati MORE mostrano inoltre un miglioramento nella rappresentazione delle portate a scala di bacino e della dinamica dell'umidità del suolo.

Nel complesso, MORE rappresenta la rianalisi a più alta risoluzione attualmente disponibile per l'Italia e la regione alpina. La ricchezza informativa del dataset, con numerose variabili a risoluzione oraria, ne fa una risorsa di riferimento per studi idrometeorologici, analisi di impatto e adattamento ai cambiamenti climatici, e per lo sviluppo di servizi climatici in aree a complessa orografia e ad elevata esposizione agli eventi estremi.

Classificazione degli schemi di circolazione atmosferica associati agli eventi di catabatico a Baia Terra Nova (Mare di Ross, Antartide)

Lauro D'Esposito[1,2], Vincenzo Capozzi[1], Pasquale Castagno[3,2], Giannetta Fusco[2], Giorgio Budillon[2]
[1]Dipartimento di Scienze Ambientali, Informatica e Statistica, Università degli Studi di Venezia «Ca' Foscari; [2]Dipartimento di Scienze e Tecnologie, Università degli Studi di Napoli "Parthenope"; [3]Dipartimento di Scienze Matematiche e Informatiche, Scienze Fisiche e Scienze della Terra, Università degli Studi di Messina

I venti catabatici svolgono un ruolo determinante nel sistema climatico antartico, influenzando le dinamiche di interazione tra oceano e atmosfera. Essi favoriscono la formazione delle polynye costiere, siti di produzione di acque dense che alimentano la circolazione oceanica globale. L'obiettivo dello studio è analizzare i pattern di circolazione atmosferica che favoriscono gli eventi catabatici nell'area di Baia Terra Nova durante l'autunno, l'inverno e la primavera australi (marzo-novembre). Per l'identificazione degli eventi, è stata utilizzata la serie storica dei dati orari di vento della stazione meteorologica automatica "Eneide" (afferente all'Osservatorio meteo-climatologico antartico dell'ENEA), relativa al periodo 1995-2024. È stato applicato un criterio di selezione oggettivo che combina due condizioni simultanee: velocità del vento superiore al 90° percentile della distribuzione e direzione di provenienza compresa in un intervallo specifico, definito tramite l'analisi della rosa dei venti.

La caratterizzazione delle configurazioni atmosferiche si è basata sui dati ERA5, analizzando sia il campo di pressione al suolo sia i campi di geopotenziale, temperatura e vento a diverse quote isobariche. La classificazione dei regimi sinottici favorevoli agli eventi catabatici è stata ottenuta tramite un approccio che integra l'Analisi in Componenti Principali con un algoritmo di clusterizzazione k-means. Le configurazioni sinottiche identificate sono state successivamente esaminate in termini di frequenza di occorrenza, variabilità interannuale e caratteristiche medie degli eventi associati. Infine, è stata analizzata la potenziale connessione tra la frequenza di questi regimi e la variabilità climatica su larga scala, attraverso la correlazione con i principali indici teleconnettivi dell'Emisfero Sud, quali il Southern Annular Mode, il Southern Oscillation Index e il Dipole Mode Index.

A flux-based global ozone risk assessment for vegetation under future climate change scenarios

Pierluigi Renan Guaita[1,2], Giacomo Gerosa[1], Riccardo Marzuoli[1], Paola Crippa[3]
[1]Dep. Mathematics and Physics, Catholic University of the Sacred Heart, Brescia, Italy; [2]Department of Applied Computational Mathematics and Statistics, University of Notre Dame, Notre Dame, IN, USA; [3]Department of Civil and Environmental Engineering and Earth Sciences, University of Notre Dame, Notre Dame, IN, USA

Tropospheric ozone (O_3) is a well-known phytotoxic pollutant and can lead to reduced photosynthesis, accelerated leaf senescence and to other negative effects, thus threatening food security and impairing biomass growth and carbon sequestration in forest ecosystems. Traditional global assessments often rely on exposure-based metrics, overlooking how environmental and physiological factors regulate O_3 uptake by plants.

This study presents a global flux-based assessment of O_3 risk to wheat and to forests across the 21st century, employing a dual-sink big-leaf dry deposition model to estimate the phytotoxic ozone dose (POD) and the associated effects on crop and forests productivity. Simulations were driven by meteorological and O_3 concentration data from the UKESM1 Earth System Model, under three contrasting Shared Socioeconomic Pathways (SSP1, SSP3, and SSP5). The study analyzed trends in POD from the early 2000s to the end of the century, with particular attention to the roles of soil water availability and rising atmospheric CO_2 concentrations, both of which are expected to influence stomatal conductance and thereby O_3 uptake.

Results indicate a general decline in global O_3 risk toward 2100, though regional and ecosystem differences persist. For wheat, strong O_3 precursors emission controls (SSP1-2.6) could reduce O_3-related global production losses to below 1.4%, while weaker controls (SSP3-7.0, SSP5-8.5) may exacerbate O_3 risks in key agricultural regions of Asia, South America, and Sub-Saharan Africa. For forests, reduced O_3 uptake is largely driven by notably lower stomatal conductance under elevated CO_2 and higher vapor pressure deficits, rather than decreases in ambient O_3 levels.

These findings highlight the value of flux-based frameworks to assess global O_3 risk under climate change, by providing a basis for prioritizing region-specific mitigation strategies to protect crop productivity and forest ecosystems from O_3 damage under future climate conditions.

Using satellite-based Other Long-Lived GHGs datasets for climate models applications and climate studies: The ESA LOLIPOP CCI project

Elisa Castelli[1], Gabriele Brizzi[2], Antonio Bruno[3], Martyn Chipperfield[3], Lieven Clarisse[4], Cathy Clerbaux[5], Pierre Coheur[4], Samuele Del Bianco[6], Stefano Della Fera[6], Martine De Mazière[7], Bart Dils[7], Bianca Maria Dinelli[1], Federico Fabiano[1], Marco Gai[6], Maya George[5], Jeremy Harrison[3], Michaela Hegglin[8], Giuliano Liuzzi[9], Claire Macintosh[10], Guido Masiello[9], Alessandro Montanarini[1], Simon Pinnock[10], Margherita Premuda[1], Felix Ploeger[8], Piera Raspollini[6], Laura Saunders[11], Reinhold Spang[8], Gabriele Stiller[12], Massimo Valeri[2], Sophie Vandenbussche[7], Corinne Vigouroux[7], Kaley Walker[11], Simon Withburn[4]

[1]CNR-ISAC, Italy; [2]Serco Italia S.p.a, Italy; [3]NCEO, UK; [4]ULB, Belgium; [5]LATMOS; [6]CNR-IFAC, Italy; [7]BIRA, Belgium; [8]FZJ, Germany; [9]University of Basilicata, Italy; [10]ESA; [11]University of Toronto, Canada; [12]KIT, Germany

To fully understand Earth's climate system, it is crucial to account for all atmospheric gases that have a high global warming potential or a significant impact on the ozone layer. Among these, nitrous oxide (N_2O) and halogenated carbon compounds—including CFCs, HFCs, HCFCs, and PFCs—stand out due to their long atmospheric lifetimes and considerable warming effects. Nitrous oxide and chlorine-containing compounds also play a key role in human-driven ozone depletion and are regulated globally under the 1989 UN Montreal Protocol.

Satellite-based instruments offer a powerful, multi-mission tool for tracking and analyzing the behavior of these so-called Other Long-Lived Greenhouse Gases (OLLGHGs) in the atmosphere. To support the use of these satellite datasets, the European Space Agency (ESA) launched the LOng-LIved greenhouse gas PrOducts Performances (LOLIPOP) CCI+ project in 2023 in the framework of the Climate Change Initiative (CCI) program.

The primary objective of LOLIPOP is to assess whether the current generation of satellite observations meets the quality requirements needed for climate research and related services, as well as to identify the needs of end users. To demonstrate their potential, the project includes five dedicated case studies. Results from these studies, user needs survey as well as datasets quality assessment will be presented.

4:30pm - 5:00pm — **Coffee Break**

5:00pm - 6:30pm

APPLICAZIONI-I

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**
Session Chair: **Anna Maria Siani**
Session Chair: **Marcello Petitta**

Strumenti avanzati per la qualità dell'aria: simulazione, intelligenza artificiale e osservazione satellitare a supporto delle strategie di tutela ambientale e salute

Angelo Riccio[1], Giorgio Budillon[1], Andrea Buono[1], Vincenzo Capozzi[1], Elena Chianese[1], Diana Di Luccio[1], Anna Imperato[1], Gennaro Mellone[1], Maurizio Migliaccio[1], Raffaele Montella[1], Anna Verlanti[1], Maria Rosaria Della Rocca[2]

[1]Università Parthenope, Italy; [2]Dirigente Settore Sviluppo sostenibile – Qualità dell'Aria – Gestione delle Risorse Naturali Protette, Tutela e Salvaguardia dell'Habitat Marino e Costiero

Il progetto SCINTILLA, promosso dalla Regione Campania in collaborazione con il MASE, mira a sviluppare strumenti innovativi per il monitoraggio e la previsione della qualità dell'aria, con un focus sul particolato atmosferico e i suoi impatti sulla salute umana. Le attività hanno integrato modelli numerici (CAMx) su scala nazionale e regionale, alimentati da inventari emissivi aggiornati (ISPRA, EMEP, HERMESv3) e forzati con simulazioni meteorologiche WRF, validando le simulazioni tramite confronti con dati osservativi ARPAC per il 2017. I risultati evidenziano una buona capacità dei modelli di riprodurre i pattern stagionali e diurni di NO2, PM10 e PM2.5, seppure con una sottostima dei picchi invernali.

Per superare le limitazioni dei modelli deterministici, sono state adottate tecniche di Intelligenza Artificiale basate su reti neurali (AFNO), in grado di correggere il bias delle simulazioni e migliorare la previsione temporale delle concentrazioni di inquinanti. Sul fronte sperimentale, sono state condotte campagne di campionamento del particolato in due siti urbani (Napoli e Avellino), integrando misure in-situ, sensori a basso costo e dati meteorologici ad alta frequenza, al fine di una caratterizzazione chimico-fisica dettagliata e dell'analisi sugli effetti sanitari.

Una componente innovativa riguarda l'uso integrato di osservazioni satellitari (MAIAC MODIS AOD550) e modelli numerici per estendere la copertura del monitoraggio e calibrare stime spaziali di PM10 laddove scarseggiano le stazioni di misura. I risultati preliminari supportano la validità dell'approccio di data fusion per generare mappe continue di esposizione, più rappresentative per la valutazione del rischio sanitario e ambientale. Il progetto si pone così come riferimento per strategie regionali di tutela ambientale, offrendo metodologie trasferibili in altri contesti territoriali.

The increasing occurrence of Hourly Precipitation Extremes in Italy: leveraging the Convection-Permitting reanalysis data

Francesco Cavalleri[1], Francesca Viterbo[2], Michele Brunetti[3], Riccardo Bonanno[2], Veronica Manara[1], Matteo Lacavalla[2], Maurizio Maugeri[1]

[1]Environmental Science and Policy Department (ESP), University of Milan, Italy; [2]Sustainable Development and Energy Resources Department, Research on Electric Systems (RSE), Milan, Italy; [3]Institute of Atmospheric Sciences and Climate, National Research Council (CNR-ISAC), Bologna, Italy

The latest generation of high-resolution, convection-permitting reanalyses, capable of representing atmospheric processes at small spatial scales (≤4 km), is crucial for studying the temporal and spatial evolution of phenomena such as convective storms and orographic precipitation. Leveraging long (>35 years) and continuous datasets over Italy, this study investigates the occurrence and characteristics of hourly precipitation extremes (HPE) and quantifies their potential increase over time. Previous studies have validated convection-permitting reanalyses against observations from climatological to daily scales, demonstrating their ability to capture fine-scale precipitation events, although spatial mismatches sometimes occur.

The work is based on the MERIDA HRES convection-permitting reanalysis (1986–2022). Spatially coherent hourly precipitation structures (~160,000 per year) are identified from hourly reanalysis fields through clustering techniques and percentile-based thresholds. Each of them is characterized by maximum spatial extent, timing, peak value, mean intensity. The resulting dataset allows calculation of seasonal climatological averages of their distribution, intensity, and spatial extent. HPE are then extracted using local annual maxima in hourly precipitation (RX1hour).

Results reveal a marked increase in HPE occurrences over Alpine and Prealpine regions during summer, and along some southern and insular coastlines in autumn. These spatial and seasonal patterns correspond to regions where convective processes dominate intense, localized precipitation, potentially amplified by climate change. This study provides detailed insights into hourly precipitation patterns over Italy and guidance for stakeholders to leverage reanalysis data for enhancing infrastructure resilience to extreme precipitation.

One-way coupling of WRF with the ADMS dispersion model to simulate heatwave impacts on air quality in a large Mediterranean city

Erika Brattich[1], Serena Falasca[2,3], Annalisa Di Bernardino[3], Margherita Erriu[3], Andrea Faggi[1], Stefania Argentini[4], Giampietro Casasanta[4], Andrea Cecilia[4], Tiziano Maestri[1], Anna Maria Siani[3], Silvana Di Sabatino[1]

[1]Dipartimento di Fisica e Astronomia "Augusto Righi", Università di Bologna, Bologna, Italia; [2]Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), Roma, Italia; [3]Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italia; [4]CNR, Istituto di Scienze dell'Atmosfera e del Clima (ISAC), Roma, Italia

Rapid urbanization, deteriorating air quality, and climate change are increasingly interacting in ways that amplify risks for urban populations. Cities are both major sources of greenhouse gas emissions and hotspots of vulnerability, where dense populations face the compounded effects of air pollution and climate extremes. In the context of more frequent and severe weather events, urban areas must urgently design and implement adaptation strategies informed by emerging scientific evidence.

This study introduces a novel multiscale modeling framework that couples the ADMS-Urban dispersion model with the Weather Research and Forecasting (WRF) mesoscale model to simulate the combined effects of extreme heat events on thermal comfort and pollutant dispersion. Developed within the PRIN2022 project "Urban hEat and pollution iSlands inTerAction in Rome and possible mitigation strategies" (RESTART), the approach assimilates high-resolution WRF meteorological fields (up to 500 m) into the ADMS-Urban system to capture interactions between climate and air quality at the city scale.

Using the July 2022 heatwave in Rome (Italy) as a case study, we demonstrate the capability of this modeling chain to assess how extreme heat conditions influence both thermal comfort and pollutant concentrations in densely populated urban environments. Following sensitivity analyses to identify the most robust model configuration and validation against ground-based observations of meteorological and air quality variables (13 weather stations and 16 air quality stations), the framework is applied to evaluate two greening scenarios and their potential to mitigate heat stress and improve air quality across the metropolitan area.

Results highlight the applicability of this integrated modeling chain as a decision-support tool for assessing urban planning and climate adaptation strategies, with direct implications for enhancing resilience in cities facing growing environmental pressures.

Il microclima della chiesa di S.Panfilo di Tornimparte (AQ): analisi e applicazione di indici microclimatici

Silvia Ferrarese, Davide Bertoni, Eleonora Racca

University of Turin, Italy

Nella conservazione dei beni culturali rivestono particolare importanza il monitoraggio e la valutazione del microclima relativo all'opera stessa. In questo lavoro consideriamo le condizioni microclimatiche della Chiesa di San Panfilo di Tornimparte (AQ) dove è stata condotta una campagna di misura microclimatica (Ferrarese et al., 2023). La chiesa (XII-XIII secolo) è di grande interesse storico ed artistico in quanto ospita nel presbiterio un ciclo di affreschi del pittore rinascimentale Saturnino Gatti (1494).

Le condizioni microclimatiche sono state misurate per circa un anno in diversi punti all'interno della chiesa e in due siti all'esterno: un primo in prossimità dell'edificio e un secondo presso la più vicina stazione meteorologica. Il presente lavoro si propone di descrivere la campagna di monitoraggio e le misure effettuate

durante tutto l'anno e quindi di analizzare le condizioni microclimatiche interne ed esterne. Il clima storico all'interno della chiesa è stato identificato applicando la normativa corrente e la discussione dei risultati ha permesso di identificare eventi potenzialmente pericolosi per la conservazione degli affreschi.

Le condizioni interne ed esterne sono state confrontate utilizzando alcuni indici statistici: PI (Performance Index), IME (Index of Microclimatic Excursion), IMV (Index of Microclimatic Variability), NDR (Normalized Diurnal Range), RHratio (ratio in Relative Humidity) e il raggio minimo dei micropori vuoti (Racca et al., 2024).

I risultati mostrano che tutti gli indici sono in grado di distinguere tra condizioni interne ed esterne, mentre IME, IMV e NDR sono anche sensibili alle diverse condizioni all'interno della chiesa. Tra gli indici, l'IMV sembra descrivere meglio le condizioni microclimatiche, poiché è definito utilizzando sia la temperatura che l'umidità relativa e non dipende da soglie basate sugli standard o sull'esperienza dei curatori. Gli indici si sono dimostrati uno strumento utile per confrontare diverse condizioni microclimatiche e potrebbero essere inclusi nelle pratiche per la valutazione del microclima.

Assessment of Soiling on PV Systems through Satellite-Derived Irradiance Measurements

<u>Enrico Cesare Maggioni</u>[1], Alessandro Perotto[1], Alessandro Borroni[1], Francesco Spada[1], Raffaele Salerno[2]

[1]Ideam srl, Italy; [2]Meteo Expert (Mopi srl), Italy

Soiling deposition is a widespread issue affecting photovoltaic (PV) systems of all types, with varying characteristics depending on the geographical location, the season, the prevailing weather conditions, and the geometry of the system (e.g., tilt angle, panel type, surface treatments, etc). There are instruments capable of estimating the presence of soiling on PV panels, such as optical measurement sensors that analyze the type of deposited particles, or comparative techniques like the daily manual cleaning of radiometers. However, these methods are typically expensive and complex, making them unsuitable and economically unfeasible for Commercial & Industrial (C&I) systems. The objective of this study is to estimate the degree of soiling through a comparison between ground-based irradiance measurements using radiometers and irradiance data derived from MSG (Meteosat Second Generation) meteorological satellite observations. By analyzing these two data sources—one affected by soiling and the other independent from it—it was possible to develop a Performance Ratio Index capable of assessing the degree of soiling on the ground-based radiometer, and consequently, the level of soiling on the photovoltaic system itself. Post-processing techniques (such as filtering out low irradiance values, applying temporal moving windows of variable size, etc.) were required to isolate the information related to soiling while eliminating other sources of noise and interference present in the measured data. A comparison with dry and wet deposition events of atmospheric pollutants (dust and PM10), using data from the CAMS (Copernicus Atmosphere Monitoring Service) project, enabled the evaluation of the system's ability to correctly identify major soiling events, contributing to its calibration and optimization. This automated system for detecting the soiling level in PV installations is particularly suitable for operational use in C&I systems, which can benefit from targeted cleaning interventions that offer a positive economic return when significant soiling is detected.

The Impact of Fuel Moisture Initialization on WRF-SFIRE Simulations of Mediterranean Wildfires

<u>Simona Rinaldi</u>[1], Adam Kochanski[2], Craig B Clements[2], Silvana Di Sabatino[1], Laura Sandra Leo[1]

[1]University of Bologna, Italy; [2]San Jose State University, San Jose, CA, USA

Wildfires have become increasingly frequent in southern Europe, particularly in Spain, Portugal, Italy, and Greece. Although fire is a natural component of Mediterranean ecosystems, the expansion of recreational use of natural and forest areas has increased the number of human-caused fires. Climate change further exacerbates this situation, intensifying extreme temperatures and droughts and altering two of the three primary drivers of wildfires: fuel and weather.

The Canadian Forest Fire Weather Index (CFWI) is a meteorologically based index widely adopted to estimate fire danger. It requires only temperature, wind speed, relative humidity, and precipitation as input, and consists of six components: three fuel-moisture codes and three fire behavior indices. Although originally developed for Canadian boreal conditions, the CFWI has been applied in Mediterranean regions due to its simplicity and reliance on standard meteorological data. Studies have shown its ability in capturing fire danger in Mediterranean environments, though further evaluation has been recommended, especially in drier landscapes. However, the CFWI is a fire weather index that does not explicitly resolve the moisture content in the basic fuel moisture classes (1h, 10h, 100h, 1000h) required for the initialization of the fuel moisture in modeling systems based on the Rothermel model, such as WRF-SFIRE. This work investigates the integration of fuel moisture into wildfire simulations of Italian case studies using the coupled atmosphere-fire model WRF-SFIRE. The model includes a predictive time lag dead fuel moisture model to resolve spatial and temporal variability in the fuel moisture content, and the influence of fuel flammability on fire spread. This study examines various methods for treating the fuel moisture in the model. We compare the results of simulations performed under three approaches: (i) uniform fuel moisture initialization kept constant during the simulation, (ii) dynamic fuel moisture modeling using a time-lag model initialized from the equilibrium moisture content, and (iii) dynamic fuel moisture modeling with initialization based on fuel moisture values derived from FWI moisture codes. The objectives of this study are multiple. First, to evaluate the skill of WRF-SFIRE in reproducing Italian wildfire events. Second, to quantify the impact of spatial fuel moisture variability in the fuel-moisture initialization on fire spread simulations. A further objective is to assess whether FWI codes can reliably be mapped to dead-fuel moisture classes for initializing WRF-SFIRE. Finally, the study aims to evaluate the capability of WRF to reproduce CFWI time series and thresholds, and to examine the potential of WRF-derived FWI as a diagnostic tool for fire danger in Mediterranean regions.

Research project implemented under the National Recovery and Resilience Plan (NRRP), Project title "National Biodiversity Future Center -NBFC". CUP J33C22001190001

MERCOLEDI’ 11 febbraio 2026

9:00am - 9:30am

Invited speaker: Dr.ssa Daniela Famulari

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**

Micrometeorology’s Role in Today’s Research: Challenges and Perspectives

Daniela Famulari

CNR, Italy

Micrometeorology plays a fundamental role in atmospheric science by providing the high-frequency observations needed to quantify surface–atmosphere exchanges and to understand boundary-layer processes across heterogeneous and complex landscapes. Current research priorities include improving our understanding of canopy–atmosphere interactions and integrating micrometeorological measurements with high-resolution modeling and remote-sensing products.

An area where micrometeorology is becoming increasingly important—but remains underrepresented, particularly in mid-latitude regions such as the Mediterranean—is the quantification of dry and wet deposition of reactive and greenhouse gases. Long-term, high-quality deposition measurements are still rare, and micrometeorological techniques offer some of the few direct, ecosystem-scale approaches for estimating deposition velocities and fluxes in real-world, heterogeneous environments. Strengthening these measurements is essential for constraining nutrient and pollutant budgets, improving atmospheric chemical-transport modeling, and deepening our understanding of biosphere–atmosphere coupling.

New tools and approaches—such as advanced turbulence sensors, distributed flux networks, machine-learning methods for data gap-filling, and large-eddy simulations coupled with land-surface models—are helping to better capture small-scale processes and enhance weather and climate predictions. Yet many open questions remain, particularly when scaling observations from individual sites to broader regions or comparing data collected with different protocols across networks. Additional challenges, including irregular terrain, shifting airflow patterns, and heterogeneous land cover, continue to complicate flux estimation and the closure of the surface energy balance.

At the regional level, micrometeorology is gaining momentum across a wide range of applications: from agro-ecosystem monitoring and carbon-cycle research to urban pollution and climate studies, as well as investigations in mountain and coastal environments, emission inventories, and deposition assessments. National infrastructures—such as coordinated networks like ICOS, which provide consistent long-term flux and concentration datasets—offer essential support for this growing research landscape.

9:30am - 11:00am

MICROMETEOROLOGIA-I

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**

Session Chair: **Stefano Serafin**

Session Chair: **SILVANA DI SABATINO**

A Co-Spectral Budget Approach: A New Perspective on Stratification Effects on Momentum Transfer over Tall Forested Canopies

Luca Mortarini[1], Gabriel Katul[2]

[1]Università di Milano, Italy; [2]Duke University

The turbulent exchange of momentum within and above tall forested canopies plays a central role in regulating surface–atmosphere interactions, particularly in complex ecosystems such as the Amazon rainforest. The dense and heterogeneous canopy structure interacts strongly with the flow, challenging the applicability of classical boundary-layer concepts that assume the presence of a well-defined inertial sublayer. Under non-neutral stratification, these assumptions are further weakened as large coherent structures and submeso motions introduce additional variability and intermittency. Observations from the Amazon Tall Tower Observatory (ATTO) indicate that convective structures from the outer layer in unstable stratification and low-frequency submeso motions in stable conditions disrupt the conventional boundary-layer and mixing-layer frameworks.

To address these challenges, a scale-wise co-spectral budget model is developed to analyze the vertical velocity spectrum $E_{ww}(k_x)$ and its relationship to vertical momentum transport. The model explicitly balances mechanical production, pressure decorrelation, and longitudinal buoyancy production or destruction in the momentum co-spectral budget. Results reveal that the momentum flux co-spectrum $F_{wu}(k_x)$ depends not only on $E_{ww}(k_x)$ but also on the longitudinal heat-flux co-spectrum $F_{u\theta}(k_x)$.

Across both stable and unstable regimes, the scaling of $F_{wu}(k_x)$ is primarily governed by $F_{u\theta}(k_x)$, while $E_{ww}(k_x)$ exhibits more variable behavior. The analysis identifies a robust $k_x^{-7/3}$ scaling in $F_{u\theta}(k_x)$ across the inertial subrange, whereas the classical Kolmogorov $k_x^{-5/3}$ scaling in $E_{ww}(k_x)$ is not universally observed. Moreover, the de-correlation time between longitudinal and vertical velocity fluctuations follows $\varepsilon^{-1/3}k_x^{-2/3}$ within the inertial subrange but remains nearly constant for larger scales, independent of stability. These findings highlight the critical role of stratification and canopy structure in shaping multi-scale momentum exchange in the roughness sublayer.

Micrometeorological Observations of Ozone Deposition and NO Emissions in a Temperate Deciduous Forest of the Po Valley

Davide Plebani[1,2], Angelo Finco[1], Riccardo Marzuoli[1], Giacomo Gerosa[1]

[1]Università Cattolica del Sacro Cuore, Italy; [2]Department of Earth and Environmental Sciences, KU Leuven, Belgium

Dry deposition of ozone (O_3) can occur through different pathways, primarily stomatal and non-stomatal. While stomatal uptake is well studied, non-stomatal processes, such as chemical reactions with nitric oxide (NO) and volatile organic compounds, are often overlooked. In particular, the reaction with NO can represent a highly efficient sink, potentially accounting for up to ~20% of total O_3 deposition (Finco et al., 2018).

NO is mainly emitted from soils microbial processes, with forest soils constituting an important global source. Numerous studies have shown that following rainfall events, NO emissions may exhibit strong peaks lasting several days.

The work presented here aimed to investigate O_3 and NO dynamics within a forest ecosystem by comparing summer periods characterized by low and high NO emissions. Measurements were conducted at Bosco Fontana Nature Reserve, a mixed oak–hornbeam forest in the Po Valley. The analysis is based on data collected through eddy covariance flux measurements of O_3 and NO at two heights (above and below canopy), measurements of vertical concentration of gasses, and measurements of soil NO fluxes obtained by means of dynamic soil chambers.

Results provide new evidence of the role of soil-derived NO in forest–atmosphere O_3 exchanges. Periods of elevated soil NO emissions corresponded to increased NO concentrations near the surface (2 and 8 m), indicating a direct influence of soils on the lower atmosphere. At the same time, higher O_3 deposition velocities were observed at 8 and 40 m, consistent with the strengthening of the chemical sink.

Overall, findings emphasize the importance of soil-emitted NO in enhancing non-stomatal O_3 removal in forests, highlighting the need to integrate this process into dry deposition parameterizations.

Disentangling Mechanisms Controlling Atmospheric Transport and Mixing Processes Over Mountain Areas at Different Space and Timescales (DECIPHER): Overview of the preliminary Field Campaigns of the project DECIPHER

Akanksha Rajput[1], Elena Barbaro[2], Francesco Barbano[3], Alessandro Bracci[4], Warren R.L. Cairns[2], Sebastiano Carpentari[1], Massimo Cassiani[1,5], Giulio Cozzi[2], Fabrizio de Blasi[2], Costanza Di Felice Fabrizi[1,11], Paolo Di Girolamo[6], Davide Dionisi[7], Marco Di Paolantonio[7], Silvana Di Sabatino[3], Giorgio Doglioni[1], Eleonora Favaro[2,8], Angelo Finco[9], Jacopo Gabrieli[2], Giacomo Gerosa[9], Lorenzo Giovannini[1], Riccardo Marzuoli[9], Christian Nardon[1], Davide Plebani[9,14], Davide Poggi[10], Federico Porcù[3], Claudia Rossetti[2], Mira Shivani Sankar[11,12], Donato Summa[13], Nadia Vendrame[11], Dino Zardi[1,11]

[1]Department of Civil, Environmental and Mechanical Engineering (DICAM), University of Trento, Trento, Italy; [2]Institute of Polar Sciences, National Research Council (CNR-ISP), Venice, Italy; [3]Department of Physics and Astronomy "Augusto Righi" (DIFA), University of Bologna, Bologna, Italy; [4]Institute of Atmospheric Sciences and Climate, National Research Council (CNR-ISAC), Bologna, Italy; [5]Stiftelsen NILU, Kjeller, Norway; [6]Department of Health Sciences (DISS), University of Basilicata, Potenza, Italy; [7]Institute of Marine Sciences, National Research Council (CNR-ISMAR), Rome, Italy; [8]Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Venice, Italy; [9]Faculty of Mathematical, Physical and Natural Sciences, Catholic University of the Sacred Heart, Brescia, Italy; [10]Department of Environment, Land and Infrastructure Engineering (DIATI), Politecnico di Torino, Turin, Italy; [11]Center Agriculture, Food Environment (C3A), University of Trento, Trento, Italy; [12]University School for Advanced Studies IUSS Pavia, Pavia, Italy; [13]Institute of Methodologies for Environmental Analysis, National Research Council (IMAA-CNR), Tito Scalo, Italy; [14]Department of Earth and Environmental Sciences, KU Leuven, Leuven, 3000, Belgium

DECIPHER (Disentangling mechanisms controlling atmospheric transport and mixing over mountains across space–time scales) investigates multi-scale exchanges of energy, momentum, and tracers between the surface and atmosphere, with a focus on thermally driven flows in the Italian Alps. We report the project's initial observational phase, comprising two coordinated field campaigns along with an overview of topography, instrumentation, and weather during the field campaigns, and present selected case studies.

The first campaign (23 July-29 October 2024) took place at Col Margherita (2543 m ASL) in the Eastern Italian Alps. Here, optical particle counter (OPC) measurements were taken to characterize the fine (diameter < 1 μm) and coarse (diameter ≥ 1 μm) fractions of aerosols over the site. Two episodes of enhanced coarse-mode aerosol at Col Margherita were identified and further investigated using Doppler and Raman lidars and standard meteorological data from Passo Valles (2032 m a.s.l.), 3 km downslope.

The second field campaign (2 October-10 November 2024) was carried out in the Monte Baldo mountain range on a steep east-facing slope. A two-level eddy covariance tower, complemented by a four-way net radiometer, soil sensors, and thermohygrometers distributed along the slope, was deployed to investigate surface-layer processes and turbulent fluxes associated with slope-wind systems. A typical day with fully developed thermally-driven slope winds was highlighted using eddy covariance tower measurements.

Together, the two campaigns represent preparatory efforts aimed at informing and supporting a larger observational initiative scheduled for summer 2025 at the Monte Baldo site under the international cooperation initiative TEAMx (Multi-scale transport and exchange processes in the atmosphere over mountains - programme and experiment).

Velocità di deposizione per l'ozono sotto e sopra chioma: quali sono i principali driver della deposizione di ozono?

Angelo Finco[1], **Davide Plebani**[1,2], **Riccardo Marzuoli**[1], **Giacomo Gerosa**[1]
[1]Università Cattolica del Sacro Cuore, Italy; [2]KU Leuven, Department of Earth and Environmental Sciences, Belgium

La chioma forestale rappresenta un'interfaccia cruciale per i processi di scambio tra atmosfera e biosfera, in cui la chimica atmosferica gioca un ruolo determinante nella regolazione della qualità dell'aria, del bilancio energetico e del ciclo del carbonio. In questo contesto, l'ozono troposferico emerge come un attore chiave: da un lato costituisce un ossidante reattivo in grado di degradare composti organici volatili biogenici (BVOC) emessi dalla vegetazione, modulando la formazione di aerosol secondari e radicali ossidrilici; dall'altro, rappresenta un fattore di stress per le piante, influenzando la fisiologia fogliare e gli scambi gassosi. Nonostante i progressi sperimentali e modellistici, la chimica *intra-canopy* rimane tuttora non completamente compresa, a causa della complessità delle interazioni tra microclima, emissioni biogeniche e processi di deposizione (Monson & Holland, 2001; Goldstein et al., 2004). La comprensione delle dinamiche dell'ozono all'interno della chioma, incluse le sue interazioni con superfici fogliari, emissioni biogeniche e processi microclimatici, è quindi essenziale per valutare l'impatto delle foreste sulla composizione atmosferica e, reciprocamente, gli effetti della qualità dell'aria sulla funzionalità ecosistemica.

La velocità di deposizione rappresenta infatti uno dei due principali driver della deposizione. In questo lavoro verranno analizzati i dati di velocità deposizione per l'ozono, ottenute tramite la tecnica dell'*eddy covariance* da misure effettuate al di sopra (40 m) e all'interno (8 m) della *canopy* forestale di Bosco Fontana (Marmirolo, MN). Verrà mostrata l'influenza dei principali driver ambientali (temperatura, umidità relativa, radiazione, *friction velocity*, accoppiamento/disaccoppiamento tra chioma e atmosfera), vegetativi (presenza o meno di foglie) ed emissivi (emissione di NO dal suolo) in due annate contrastanti dal punto di vista meteorologico.

Eddy covariance measurements of CO2, heat fluxes and radiation fluxes across an urban-to-rural gradient in the Paris area

Laura Bignotti, **Jérémie Depuydt, Pedro-Henrique Herig-Coimbra, Alain Fortineau, Anais Feron, Patrick Stella, Erwan Personne, Pauline Buysse, Carmen Kalalian, Benjamin Loubet**
ECOSYS, INRAE, AgroParisTech, Université Paris-Saclay, Palaiseau, FR, France

Urban areas, responsible of over 70% of CO_2 emissions, are one of the most important sources of GHG gases. Accurate quantification of city emissions through direct observations is crucial for assessing the effectiveness the adopted mitigation strategies.

As part of the ICOS Cities project (https://www.icos-cp.eu/projects/icos-cities), four eddy covariance towers were installed in the Paris area to capture the variability of CO_2, heat and radiation fluxes across an urban-to-rural gradient. The selected sites were chosen to be representative of a highly urbanised and densely built-up area (Jussieu), an urban forest (Vincennes), a semi-urban area (Saclay) and a heterogeneous area combining highly urbanised zones with vegetated patches (Romainville). Additionally, the observations from the urban sites were integrated with the EC flux measurements from the ecosystem sites of Fontainebleau (FR-FON, forest) and Grignon (FR-GRI, crop).

CO_2 and heat flux measurements showed seasonal dynamics that reflected the respective degrees of urbanisation of the sites and the presence of biogenic sinks. At the urban sites of Jussieu and Romainville, the sensible heat flux, H, was generally higher than the latent heat flux, LE. At Jussieu in particular, H remained positive throughout the day and night, indicating the presence of a local heat source. In contrast, the forested site of Vincennes exhibited higher latent heat fluxes than in Jussieu and Romainville, often with similar intensity to sensible heat fluxes. Our analysis identified both Jussieu and Romainville as net sources of CO_2, with the highest daily emissions during the winter months, and slight daytime CO_2 uptake during summer. However, the two sites displayed distinct diurnal CO_2 flux patterns due to the different temporal variability of dominant emission sources (stationary combustion and traffic) or to people commuting from the city center (Jussieu) during the day to residential areas (Romainville) at night. The mixed urban forest of Vincennes showed instead strong biogenic signature, with CO_2 fluxes characterized by daytime uptake (down to -10 μmol $m^{-2}s^{-1}$) during the growing season. A comparison between EC flux measurements and emission inventories estimates for the city of Paris will be presented.

Validation of the mechanistic Clifton's model for non-stomatal resistances in a broadleaf forest

Alessandro Marzo, Davide Plebani, Angelo Finco, Riccardo Marzuoli, Giacomo A. Gerosa
Università Cattolica del Sacro Cuore, Italy

Ozone dry deposition to vegetated surfaces is caused by stomatal uptake made by plant leaves and by ozone disruption on external vegetal surfaces, like leaf cuticles, and soil.

Although the stomatal deposition pathway has been widely studied because of its implications for the negative effect of ozone on plant growth and productivity, the non-stomatal deposition pathways have been scarcely addressed for long time, and they are not completely understood yet.

In 2020, Clifton et al. proposed for the first time a mechanistic model to predict non-stomatal deposition of ozone on dry and wet leaf cuticles as well as on soils. However, the model was purely theoretical, and no attempts were made to validate it using real measurements on the field.

This work presents the first attempt to calibrate and validate Clifton's model of non-stomatal resistances for a broadleaf forest. For this purpose, the total ozone deposition resistance obtained by implementing the Clifton's model was compared with that derived from the eddy covariance flux measurements made in 2021 and 2022 at Bosco Fontana (Italy). Moreover, the resistance partitioning allowed a closer comparison with the cuticular resistances predicted by the model.

The soil deposition resistance of ozone was then compared with that measured by means of automatic soil chambers at the same site in 2024 and 2025.

The results showed good agreement with the Clifton's prediction for the cuticular resistance, and less satisfactory agreement with soil resistance to O3 deposition. This seems to be due to the litter that covers the soil beneath the forest canopy, which alters the expected responses of Clifton's model for (bare) soils.

Clifton's model has the potential to describe non-stomatal deposition in forests. However, it requires modification to account for real field conditions in which litter covers forest soils, and to account for chemical sinks in the trunk space, which are completely neglected by the model.

11:00am - 11:30am **Coffee Break**

11:30am - 12:00pm

MICROMETEOROLOGIA-II

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**

Session Chair: **Stefano Serafin**

Session Chair: **SILVANA DI SABATINO**

Valutazione sperimentale e numerica dell'impatto della vegetazione urbana sulla dispersione degli inquinanti provenienti da fonti di traffico

Serena Romano[1], **Bidesh Sengupta**[2], **Carlo Cintolesi**[2], **Giovanni Leuzzi**[1], **Annalisa Di Bernardino**[1], **Silvana Di Sabatino**[2], **Paolo Monti**[1]

[1]University of Rome "La Sapienza", Italy; [2]University of Bologna, Italy

Il presente studio mira a valutare l'impatto degli elementi urbani e vegetativi sulla dispersione degli inquinanti provenienti da fonti di traffico all'interno dello strato di canopia urbana, con particolare attenzione alla microscala urbana e allo strato pedonale. L'inquinamento atmosferico urbano di origine veicolare rappresenta un rilevante rischio per la salute pubblica, soprattutto quando tende ad accumularsi al livello pedonale, dove i cittadini risultano maggiormente esposti. La complessità del tessuto urbano influisce in modo significativo sulle dinamiche del flusso d'aria, potendo determinare effetti inattesi sull'efficienza dei processi di dispersione degli inquinanti.

Come caso di studio è stato selezionato un quartiere del centro storico di Bologna (Italia), caratterizzato dalla presenza di strade ad alto traffico, alberature stradali e aree verdi. La via principale e le aree circostanti vengono analizzate in dettaglio per indagare la relazione tra ventilazione e complessità del tessuto urbano, con l'obiettivo di riprodurre realisticamente tale interazione. Le dinamiche del flusso d'aria e la distribuzione della concentrazione degli inquinanti sono state investigate combinando esperimenti di laboratorio e simulazioni numeriche ad alta risoluzione. Le dinamiche dello strato di canopia e i meccanismi di dispersione degli inquinanti sono riprodotti sperimentalmente sfruttando il canale idraulico del Dipartimento di Ingegneria Civile, Edile e Ambientale dell'Università di Roma "La Sapienza" e un modello in scala (1:1000) dell'area di interesse. I risultati sperimentali sono stati impiegati per la validazione del modello numerico. L'impiego di un modello Reynolds-Averaged Navier–Stokes (RANS) consente di approfondire il ruolo delle caratteristiche turbolente nelle interazioni tra vegetazione, vento e inquinanti. Le simulazioni sono inoltre condotte con dati di input realistici, ottenuti dalle stazioni di monitoraggio cittadine, per analizzare nel dettaglio l'interazione tra morfologia urbana e condizioni meteorologiche reali.

Lo studio presentato fa parte di un progetto più ampio volto alla creazione di un catalogo di Nature Based Solutions, considerando sia gli effetti positivi che quelli potenzialmente negativi (GREEN POLIS, PRIN 2022).

Impact of Processing Techniques on Flux Estimates and Surface Energy Balance Closure in Complex Terrain

Sebastiano Carpentari[1], **Mira Shivani Sankar**[2,3], **Nadia Vendrame**[2], **Dino Zardi**[1,2], **Lorenzo Giovannini**[1]

[1]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy; [2]Center Agriculture Food Environment (C3A), University of Trento, San Michele all'Adige, Italy; [3]University School for Advanced Studies IUSS Pavia, Pavia, Italy

The surface energy balance (SEB), i.e., the partitioning of the energy exchange between the Earth's surface and the atmosphere, is crucial for defining atmospheric boundary layer characteristics and evolution. An accurate assessment of its components is essential for a variety of applications. However, measurements of the SEB terms are still affected by uncertainties. In particular, eddy-covariance measurements of turbulent heat fluxes typically do not balance the available energy. Studies suggest this discrepancy primarily results from advection driven by secondary circulations, prevalent over heterogeneous and complex terrain as a consequence of differential heating.

This study aims to analyze the eddy-covariance measurements from a tower located in Mezzolombardo, in the Alpine Adige Valley (Trentino - Italy), to investigate the SEB closure. The analysis focuses on the assessment of the relationship between SEB non-closure, surface heterogeneity, and the resulting development of local and mesoscale thermally-driven circulations. Objective criteria to select days with the development of thermally-driven circulations are used, refining the method proposed by Lehner et al. (2019). The impact of various eddy-covariance data processing techniques, including averaging and rotation approaches, on flux estimates and SEB closure is quantified. Moreover, analyses conducted on other Alpine sites within diverse complex terrains (e.g., valley floor, valley slope, mountain top) will also be presented.

The overall results provide a systematic quantification of the non-closure of the SEB in several typical Alpine contexts, highlighting similarities and differences between sites located in various topographic and land cover settings and under different meteorological conditions.

The present work is part of the INTERFACE project (INvestigating ThE suRFACe Energy balance over mountain areas), which is performed in the framework of the TEAMx research programme.

12:00pm - 1:00pm

PREVISIONI-I

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**

Session Chair: **Raffaele Salerno**

AI-driven analysis of hail events from radiosonde and synthetic soundings

Alessio Pedullà

Università degli studi di Genova, Italy

Hailstorms represent one of the most damaging convective phenomena, with severe consequences for agriculture, infrastructure, and society. Their prediction remains challenging due to the multiscale nature of the processes involved, from mesoscale dynamics to microphysical growth mechanisms. In this study, Artificial Intelligence (AI) is employed to identify atmospheric conditions favorable to hail over the Continental United States (CONUS). Vertical atmospheric profiles from radiosonde soundings serve as predictors, while hail occurrences are derived from NOAA ground-based observations, allowing the problem to be framed as a binary classification (hail vs. no-hail).

An Extreme Gradient Boosting (XGBoost) model was trained using a balanced strategy to mitigate class imbalance and tested on the original unbalanced dataset. The model exhibited robust performance, successfully discriminating hail-producing environments. To assess the robustness and transferability of the approach, a comparison was performed between results obtained using real radiosonde data and synthetic soundings extracted from the GFS model. The analysis highlights a trade-off between model skill and data availability, suggesting opportunities for application in regions with limited sounding coverage, such as Italy.

Finally, SHAP-based interpretability analysis confirmed the physical consistency of key predictors and offered new insights into their role in hail formation.

Enhancing satellite data assimilation in the convection-permitting regional ICON model

Marcello Grenzi[1], **Thomas Gastaldo**[2,3], **Virginia Poli**[2,3], **Chiara Marsigli**[3], **Carlo Cacciamani**[2], **Tijana Janjic**[4], **Alberto Carrassi**[1]

[1]University of Bologna, Italy; [2]ItaliaMeteo Agency, Italy; [3]Arpae Emilia-Romagna, Italy; [4]Catholic University of Eichstätt-Ingolstadt, Germany

Accurate representation of atmospheric dynamics at convection scale remains a major challenge for numerical models and a key factor in operational weather predictions. Reliable initial conditions, generated through data assimilation using observations from multiple platforms, are essential to improve forecasts in deep convection environments. In this study, the ICOsahedral Non-hydrostatic (ICON) model is applied at convection-permitting scale over Italy, following the operational configuration of Arpae Emilia-Romagna and adopted by the ItaliaMeteo Agency. ICON is coupled with the Local Ensemble Transform Kalman Filter (LETKF) within the Kilometre-scale Ensemble Data Assimilation (KENDA) system. Focusing on a poorly predicted extreme convective storm in the Marche region, we show the positive impact of convection-scale data assimilation based on conventional and radar observations. Nevertheless, precipitation remains substantially underestimated when relying solely on these datasets. We highlight the crucial role of low-level moisture convergence in convection initiation and the significant undersampling of humidity in conventional data. To address this, we investigate the added value of humidity-sensitive microwave radiances from polar satellites, still rarely employed in limited-area models worldwide. Assimilation of clear-sky observations from the Microwave Humidity Sounder (MHS) leads to notable improvements in precipitation forecasts. To extend further the rich multi-platform dataset, infrared all-sky radiances in water vapor absorption channels from the geostationary Meteosat Second Generation SEVIRI instrument are integrated, providing higher spatial and temporal resolution. The relative contributions of these observation types are analyzed, including their positive effects on surface and upper-level variables and convective indices. This study also supports the future operational assimilation of satellite radiances in the Arpae and ItaliaMeteo system.

Improving predictability of convective storms using icon hectometric-scale ensembles

Matteo Siena[1], **Thomas Gastaldo**[2,3], **Chiara Marsigli**[2,3], **Paolo Ruggieri**[1], **Silvana Di Sabatino**[1]

[1]Alma Mater Studiorum - Università di Bologna, Italy; [2]ARPAE Emilia-Romagna; [3]Agenzia Italiameteo

Extreme precipitation events represent a growing global challenge, particularly affecting the Mediterranean basin, where their frequency and intensity continue to rise. Accurate numerical weather prediction models are crucial to effectively forecast these events; however, operational models often struggle with capturing the precise magnitude and location of intense convective storms. This limitation mainly arises from coarse model resolution and reliance on convection parameterizations. This study explores the potential benefits of hectometric-scale numerical modelling (500-meter resolution) by employing the ICON model to investigate the devastating floods that impacted Italy's Marche region in September 2022 and another hail-driven case study affecting the Black forest and the Swabian-Jura region in Germany in August 2023. Through sensitivity tests and ensemble simulations, we demonstrate substantial improvements in the representation of extreme precipitation events. Our results show that hectometric-scale simulations, combined with explicit convection and the Smagorinsky turbulence scheme, significantly enhance the accuracy and realism of precipitation forecasts compared to traditional coarser-resolution operational setups. Further, a focus on perturbations of microphysical cloud parameters is analysed. The study highlights the crucial influence of initial and boundary conditions and choice of microphysics schemes on forecast quality, with specific ensemble members clearly outperforming others due to their accurate representation of critical atmospheric features, such as wind convergence and moisture transport. These findings underline the necessity and added value of very high-

resolution ensemble modelling approaches, coupled with advanced turbulence parameterizations, for improving the predictability of extreme convective rainfall and hail.

Nowcasting radar e tecniche di machine learning per un innovativo sistema di allertamento del nodo idraulico Milanese

Manuel Mazza[1], **Enrico Gambini**[1], **Gabriele Franch**[2], **Rishabh Wanjari**[2], **Alessandro Ceppi**[1]

[1]Dipartimento di Ingegneria Civile e Ambientale (D.I.C.A), Politecnico di Milano, Milano, Italia; [2]Fondazione Bruno Kessler, Trento, Italia

Negli ultimi decenni, il cambiamento climatico ha portato a un aumento significativo della frequenza e dell'intensità di eventi meteorologici estremi, come forti precipitazioni e piene improvvise, con conseguente incremento del rischio idrogeologico e della vulnerabilità di ecosistemi e infrastrutture urbane. Tali fenomeni, caratterizzati da forte variabilità spaziale e temporale, risultano particolarmente impattanti nelle aree urbane, dove la copertura impermeabile del suolo, l'alta densità abitativa e la presenza di infrastrutture critiche amplificano le conseguenze di allagamenti ed esondazioni.

Il sistema idraulico di Milano rappresenta un caso emblematico: corsi d'acqua naturali e canali artificiali si intrecciano strettamente con il tessuto urbano. In particolare, le piene del Fiume Seveso causano allagamenti ricorrenti nel quartiere Niguarda, a nord della città, provocando danni diffusi a persone, infrastrutture e mobilità.

In questo scenario, la capacità di prevedere con precisione variabili meteorologiche e idrologiche a brevissimo termine risulta fondamentale per gestire il rischio e sviluppare sistemi di allerta tempestivi. Questo studio propone l'impiego di modelli di machine learning, come LDCast e GPTCast, sviluppati dalla Fondazione Bruno Kessler di Trento, per la previsione radar in chiave nowcasting. Le stime prodotte da questi modelli vengono poi utilizzate sia come input per modelli idrologici fisicamente basati sia in algoritmi di intelligenza artificiale sviluppati dal Politecnico di Milano.

L'obiettivo dello studio è valutare le prestazioni complessive del sistema previsionale e dimostrare come esso possa rappresentare un importante passo avanti nell'implementazione di sistemi di allerta a brevissimo termine.

1:00pm - 2:00pm

Pausa Pranzo

Location: **Centro Paolo VI - Via Gezio Calini 30**

2:00pm - 3:30pm

POSTER SESSION 02

Location: **Centro Paolo VI - Via Gezio Calini 30**

Diagnosing and modeling structural uncertainty in Monin–Obukhov Similarity Theory using hierarchical Bayesian and latent process inference

Pierluigi Renan Guaita[1,2], **Angelo Finco**[1], **Riccardo Marzuoli**[1], **Giacomo Gerosa**[1]

[1]Mathematics and Physics, Catholic University of the Sacred Heart, Brescia, Italy; [2]Department of Applied Computational Mathematics and Statistics, University of Notre Dame, Notre Dame, IN, USA

The Monin–Obukhov Similarity Theory (MOST) provides the framework for describing turbulent exchanges of momentum and scalars in the atmospheric surface layer. Despite its wide application, systematic deviations between MOST predictions and observations persist under non-ideal conditions, such as strong instability, weak turbulence, surface heterogeneity, and the existence of sources and sinks for momentum or scalars. In this study, we quantify the magnitude and structure of these uncertainties using a Bayesian framework applied to virtual potential temperature gradients measured over Bosco Fontana, a deciduous broadleaf forest in Marmirolo (MN), Italy. We reformulate the classical MOST relationship for the mean virtual potential temperature difference as a hierarchical Bayesian model that explicitly separates random measurement noise from structured model error. The hierarchical term allows deviations from MOST to vary systematically with atmospheric stability, while still sharing a common underlying distribution. Posterior estimates are obtained using Markov Chain Monte Carlo sampling, and model diagnostics are used to identify regions of parameter space where MOST assumptions fail. Building on this, we introduce a latent process inference approach to simulate unobserved mechanisms that contribute to MOST shortcomings. These latent processes act as data-driven hypotheses, enabling the formulation of new parametric corrections and extensions of similarity relationships under weakened assumptions. Results and proposed model extensions will be presented in the poster.

Comparison of single-layer and multi-layer models in predicting ozone dry deposition and phytotoxic ozone dose in a broadleaf forest

Giacomo A. Gerosa, **Pierluigi Renan Guaita**, **Niccolò Cabrini**, **Riccardo Marzuoli**

Università Cattolica del Sacro Cuore, Italy

Ozone deposition to vegetated surfaces is commonly estimated by 1-D dry deposition models which implement ozone uptake by leaf stomata and ozone disruption on leaf cuticles, branches and soil.

These models use resistance networks where ozone flux is considered as an electric current and ozone concentrations as electric potentials.

Simple models treat the vegetation as a single big-leaf with certain features, while more recent models divide the canopy vertically into multiple layers with a certain number of leaves or branches.

In this work, the total ozone deposition predicted by the two types of models was compared with the vertical ozone flux measured in a broadleaf forest from 2013 to 2022.

Moreover, the ozone concentrations calculated at the top of the canopy using the two model schemes were used to calculate the stomatal uptake and the phytotoxic ozone dose with the indicator (POD1) adopted by UN/ECE to assess the ozone risk for vegetation in Europe.

Aerodynamic resistances were calculated hour by hour according to the MOST and the stomatal resistances were modeled according to Jarvis (1976), while cuticular and soil resistances were kept as constant. Simulations were performed under well-mixed conditions and under different stability conditions, as well as under real soil water content and full water supply for roots, and under isothermal vertical profile of temperature or with measured temperature profile within the canopy.

Results revealed discrepancies between the modeled and the measured total ozone deposition which were attributed to the chemical sink of O3 due to the NO in the trunk space, as found by Finco et al (2018), but that were not modeled in both deposition schemes. Once this missing chemical sink was added, the multilayer model performed better than the single-layer one and predictions were close to the measured fluxes.

Instead, the ozone doses predicted as POD1 by the two models were similar and quite close to the measured ones. However, when the ozone dose absorbed by the whole plant is required - instead of the dose absorbed by a single leaf at the top of the canopy, as defined by UN/ECE- the multilayer model predicted doses that were 40% greater than those predicted by the single-layer model.

Long term surface budgets from 20-years data series of the ISAC-Lecce Micrometeorological Station.

Paolo Martano[1], **Cosimo Elefante**[2], **Fabio Grasso**[1]
[1]CNR, Italy; [2]Regione Puglia, Italy

Data series from October 2005 to September 2025 from the ISAC-Lecce Micrometeorological Station database (www.basesperimentale.le.isac.cnr.it) have been analyzed with main attention to the surface water budget and possible 20-years trends. The results are presented as 6-months averages dividing the hydrological year in wet season (October-March) and dry season (April-September), after applying post processing corrections on the half-hour surface fluxes in the database and using the energy budget closure as validation. 20-year trends in surface and soil temperature and surface fluxes show a pronounced increase of all temperatures and sensible heat fluxes, together with a decrease of the latent heat fluxes and a marked increase of the surface-air temperature difference. Together with the observed precipitation tendency to migrate towards the dry season, the observed trends imply a decrease in the calculated annual net infiltration, in agreement with the decreasing trend of groundwater levels measured in the last years in two wells of the underlying aquifer.

Soil Greenhouse Gas Emissions Under Flood Stress: Insights from a Pear Orchard in Emilia-Romagna

Daniela Famulari
CNR, Italy

Direct measurements of greenhouse gas fluxes (CO_2 and N_2O) were conducted to evaluate the mitigation potential of agricultural management over a pear crop under real cultivation conditions in Emilia-Romagna. Net CO_2 fluxes were measured using the eddy covariance technique, while N_2O emissions were monitored via dynamic chambers coupled with a high-precision gas analyzer.

The pear orchard in Conselice (RA) was impacted in the first year by the May 2023 flood, which disrupted normal crop function. Post-flood, the system shifted from a CO_2 sink to a net source, and N_2O emissions increased due to anaerobic conditions promoting denitrification. The anaerobic soil conditions, elevated temperatures, and nutrient input from floodwaters (e.g., sewage, manure) likely enhanced denitrification, driving this response. Although nitrogen input during the flood could not be quantified, the event acted as a large-scale fertilization, disrupting the planned GHG balance assessment

Measurements continued through 2024, capturing critical data on flux variability and environmental response over a more representative year.

Investigating the surface energy balance closure over mountain areas: results from the INTERFACE project

Lorenzo Giovannini[1], **Sebastiano Carpentari**[1], **Martina Destro**[2], **Manuela Lehner**[2], **Roberto Monsorno**[3], **Mathias W. Rotach**[2], **Mira Shivani Sankar**[4,5], **Beth Saunders**[2], **Mohammadamin Soltaninezhad**[3], **Stefano Tondini**[3], **Nadia Vendrame**[4], **Dino Zardi**[1,4]
[1]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy; [2]Department of Atmospheric and Cryospheric Sciences, University of Innsbruck, Innsbruck, Austria; [3]Center for Sensing Solutions, Eurac Research, Bolzano, Italy; [4]Center Agriculture Food Environment (C3A), University of Trento, San Michele all'Adige, Italy; [5]University School for Advanced Studies IUSS Pavia, Pavia, Italy

This contribution presents an overview of the activities and results of the INTERFACE project. The project aims to quantify the non-closure of the surface energy balance at different sites in the Alpine environment, where processes related to the lack of closure, i.e., advection due to the development of thermally-driven circulations, are expected to be particularly significant. This objective is addressed by combining flux station and unmanned aerial system (UAS) measurements. The use of the UAS allows spatially distributed measurements around the eddy-covariance sites, which are crucial for the estimation of advection.

The analysis of eddy-covariance data from various sites representative of different Alpine contexts (e.g., valley floor, valley slope, mountain top) and climatic settings (North and South of the main Alpine crest)

allows a systematic quantification and comparison of the characteristics of the surface energy balance, including the lack of closure. Particular attention is given to the evaluation of the role of thermally-driven circulations in the non-closure of the surface energy balance, selecting, by means of objective criteria, days with well-developed slope and valley circulations.

The INTERFACE project contributes to the TEAMx international research programme, which aims to improve our understanding of exchange processes in the atmosphere over mountains.

Multi-scale investiGation of natuRe-basEd solutions for thE mitigatioN of urban heat and POLlution ISland (GREEN-POLIS) - PRIN Project

Carlo Cintolesi[1], Paolo Monti[2], Lorenzo Giovannini[3], Bidesh Sengupta[1], Dario Di Santo[3], Giulia Ravizza Garibaldi[2], Serena Romano[2], Silvana Di Sabatino[1]

[1]University of Bologna, Italy; [2]University of Rome “La Sapienza”; [3]University of Trento

GREEN-POLIS is a two-year research project involving the University of Rome ‘La Sapienza’, Trento and Bologna, founded in 2023 under the PRIN 2022 scheme by the Italian Ministry of University and Research. The project studies the efficacy of selected Nature-Based Solutions (NBSs) in mitigating the negative effects caused by urban climate change, specifically the Urban Heat Island (UHI) and the Urban Pollution Island (UPI). The analyses are conducted in a multiscale perspective, ranging from the street and building scale to the neighbourhood scale, up to the city scale. The final objective is to provide evidence-based analysis, grounded in a rigorous scientific approach, to build a robust and systemic knowledge of the most effective urban NBSs, their potential benefits, as well as the possible side effects.

Such a challenge is addressed by implementing an investigation that starts with the detailed analysis of microscale effects of NBSs on the in-city ventilation, temperature, and pollutant dispersion in prototypical urban geometries, through the use of laboratory experiments and high-resolution numerical simulations. Subsequently, specific building-scale models are applied to improve urban numerical parameterisations for mesoscale meteorological models, allowing for the analysis of an extensive implementation of NBSs within an urban area.

Selected neighbourhoods and the entire city of Bologna, a recognised hotspot of climate change and air pollution, are taken as a practical case study that will be investigated experimentally through an ad hoc experimental campaign, and numerically through building-resolved simulations as well as mesoscale simulations at the city scale. The overall objective of the project will be discussed, giving an overview of the different results obtained. Additionally, key findings obtained through high-resolution simulations at building scales will be discussed.

Field Test of the Effect of Various Trend Removal Methods on Eddy Covariance Results at Various Measurement Sites

Patrizia Favaron

Servizi Territorio srl, Italy

The Eddy Covariance method relies on the assumption that the wind, temperature, and scalar data series fed as input are stationary up to order 2.

Order 1 stationarity is usually enforced by subtracting the “trends” from the original signals and calculating the second-order moments (variances and covariances) on the residuals so obtained.

To date, many definitions are available for these trends, and various identification methods have been described for each.

The question then arises as to whether these different definitions and computing approaches impact the final eddy covariance results and to what extent.

Studies on this subject have been conducted in the past, for example, within the AmeriFlux community and with respect to the FLUXNET network.

There is still interest in extending these results to micro-meteorological networks for environmental protection, such as SHAKEUP by ARPA Lombardia.

This study was then conducted using data from SHAKEUP sites, characterized by heterogeneous contexts, including suburban and rural areas in Lombardy.

The best results were achieved when site and context dependencies were considered when choosing the method.

Assessing SUHI dynamics in Italian Cities using ECOSTRESS data

Antonio Esposito[1,2], Gianluca Pappaccogli[1], Piero Lionello[1], Riccardo Buccolieri[1]

[1]University of Salento, Department of Biological and Environmental Sciences and Technologies, Italy;
[2]University of Salento, Department of Mathematics and Physics, Italy

This study investigates the phenomenon of the surface urban heat island (SUHI), which refers to the elevated land surface temperatures (LST) observed in urban areas compared to surrounding rural landscapes. SUHI is one of the most obvious indicators of anthropogenic alteration of the environment and directly influences local microclimates, human health, and urban sustainability. Understanding its spatial and temporal patterns is essential for developing effective adaptation and mitigation strategies in the context of global climate change.
The research focuses on a comparative analysis of several large Italian metropolitan areas, using high-resolution thermal data acquired by ECOSTRESS (Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station). This sensor offers a spatial resolution of 70x70 meters and provides frequent observations throughout the diurnal cycle, allowing the detection of fine-scale thermal variations in different

urban fabrics and times of day. These capabilities allow for a more detailed characterization of the intensity, persistence, and variability of the urban heat island effect than is possible with sensors with lower temporal and spatial resolution.

To better interpret the observed thermal patterns, LST data derived from ECOSTRESS are integrated with land use and land cover information from the Copernicus Urban Atlas. This approach allows for the assessment of SUHI gradients at different levels of urbanization and building density, distinguishing the specific thermal footprints associated with industrial zones, compact urban cores, and suburban or peri-urban areas.

In addition, a long-term temporal analysis is performed to assess the potential of ECOSTRESS data for monitoring SUHI dynamics over multiple seasons and under extreme weather conditions such as heat waves. By identifying areas most prone to excessive overheating, the study provides crucial insights into urban vulnerability and thermal inequality.

Ultimately, this work contributes to improving the understanding of urban thermal environments and their spatio-temporal complexity, providing a solid scientific basis for evidence-based urban planning. The results support the design of climate-sensitive strategies, including the enhancement of green infrastructure, cool materials, and adaptive urban morphologies, aimed at strengthening urban resilience in a time of global warming.

This work is supported by: Progetto “RETE - Resilience of the Electric Transmission grid to Extreme events” (PNRR innovation grants) (CUP F83C22000740001).

Acknowledgements: This work is supported by ICSC – Centro Nazionale di Ricerca in High Performance Computing, Big Data and Quantum Computing, funded by European Union – NextGenerationEU (CUP F83C22000740001).

On the effect of surface roughness on turbulence and mixing at a sheared density interface

Giulia Ravizza Garibaldi[1], Annalisa Di Bernardino[1], Giovanni Leuzzi[1], Agnese Pini[1], Giorgio Querzoli[2], Paolo Monti[1]

[1]Università di Roma "La Sapienza", Italy; [2]Università degli Studi di Cagliari, Italy

This study investigates experimentally how surface roughness affects turbulence and vertical mixing at a sheared density interface forming at the top of a gravity current flowing on a flat surface. The experiments were conducted in a water channel using the lock-exchange technique. Two cases were considered: one in which the channel bottom was smooth and the other when it was made rough by means of a series of parallelepiped elements about one-sixth the height of the gravity current. Feature-Tracking and Planar Laser-Induced Fluorescence techniques were used to measure fluid velocity and density. The results show a general sensitivity of the mean and turbulent flow variables on the surface characteristics. For the rough case, the density interface is thinner and some of the main parameters involved in the turbulence kinetic energy equation, e.g., buoyancy P, production B and its dissipation rate ε are higher. Similarly, turbulent diffusivities of mass and momentum also depend on roughness, although their ratio remains virtually unchanged going from the smooth to the rough surface. Furthermore, a balance between P, B, and ε was observed in both cases across the whole density interface, thus verifying the applicability of established buoyancy laws proposed in the past (Osborne, 1980). Finally, some of the results are consistent with existing field data and numerical simulations, e.g., mixing coefficient agrees reasonably well with literature data irrespective of surface characteristics.

MODIS (2001-2022) snow cover variability over the Italian territory: a focus on the Alps and Appennines chain

Cecilia Delia Almagioni, Davide Fugazza, Veronica Manara, Maurizio Maugeri

Università degli Studi di Milano, Italy

Snow cover plays an essential role in regulating the Earth’s climate but it has significant impacts on human well-being in several parts of the world (e.g. source of freshwater for agriculture and human consumption, source of energy for hydroelectric power). In this study the distribution of snow cover variables over the whole Italian territory which includes the southern part of the Alps and the Apennines chain between 2000 and 2022 using MODIS data acquired from Terra and Aqua platform are analyzed. After preprocessing the data to obtain a binary snow/no-snow field, the start (SOS), length (LOS), and end (EOS) of the snow season were calculated. The LOS mean values which range from 0 to 365 days show the highest values over the Alpine chain with a mean value of about 90 days for elevations above 500 m a.s.l. Conversely, the lowest values are seen over the Po Plain area with about 5 days for elevations lower than 500 m a.s.l. Moving to the south, the Apennine region show higher values again for higher elevations with a mean value of 6 days in the West region and to 10 days in the East region. For all regions LOS clearly depends on elevation, but the large variability in values at the same altitude highlights the influence of other factors (e.g., slope, aspect, latitude, and longitude). Regarding the temporal evolution, the east region of the Apennines is the only region where the series shows a significant trend of -3.2 days per decade. When different elevation bands are considered the LOS series shows a significant negative trend only at elevations higher than 3500 m a.s.l. especially due to the signal observed over the Alps of about -5.1 and -0.6 days per decade.

To further explore snow cover changes, ERA5-Land reanalysis snow cover was analyzed. A good correlation between MODIS-derived snow metrics and reanalysis over the 21-year period was found. Given this, ERA5-Land snow cover trends across its entire time (1951-2022) were further evaluated, offering a longer-term perspective on snow cover variability in the region.

Monitoraggio dei temporali grandinigeni attraverso la combinazione di tecniche radar e dati di fulminazione

Federico Vermi[1], **Vincenzo Capozzi**[1], **Giulio Monte**[2], **Giorgio Budillon**[1], **Sante Laviola**[2]
[1]Università di Napoli "Parthenope", Napoli, Italia; [2]Consiglio Nazionale delle Ricerche, Istituto di Scienze dell'Atmosfera e del Clima, Bologna, Italia

I radar meteorologici sono strumenti fondamentali per la misura e la stima della grandine e sono in grado di fornire informazioni chiave per dedurre la severità delle precipitazioni convettive. Ad oggi, gli approcci più innovativi si avvantaggiano di radar a doppia polarizzazione, che permettono di misurare la precipitazione grandinigena attraverso la riflettività differenziale e altri parametri polarimetrici (e.g. Bechini and Chandrasekar, 2015). Allo stesso tempo, sono state proposte molteplici tecniche che si basano sulla singola polarizzazione. Questi metodi utilizzano misure di riflettività orizzontale per individuare alcune variabili "proxy" dei processi fisici connessi allo sviluppo della grandine. Tuttavia, le misure da radar sono influenzate da alcuni errori sistematici che, localmente, possono rendere incerta la stima del rischio grandine. Per superare queste limitazioni, sono stati sviluppati alcuni algoritmi basati su un'opportuna integrazione di dati radar con altre variabili meteorologiche, come i dati provenienti da strumentazione in-situ o da satellite (e.g. Kunz and Kugel, 2015; Capozzi et al., 2018).

In questo studio, si propone un metodo che possa sfruttare la combinazione dei dati radar con i dati di fulminazione, con il fine ultimo di individuare i temporali grandinigeni in evoluzione. Recentemente, è stata condotta un'analisi sulla relazione che si instaura tra i chicchi di grandine e l'attività di fulminazione nelle nubi convettive sul territorio italiano, dalla quale sono emersi risultati molto promettenti (Vermi et al., 2025). In particolare, l'analisi effettuata si è concentrata su una caratteristica specifica dell'attività di fulminazione, ovvero il cosiddetto "lightning jump" (LJ), che si può definire come un brusco aumento del numero totale di fulmini, che si verifica tipicamente nelle prime fasi di sviluppo di un temporale. Per il 77% dei casi di studio indagati, il segnale di LJ è in grado di classificare correttamente un temporale grandinigeno. Inoltre, la rilevazione del lightning jump permette di definire una serie di indicatori come il *numero di LJ misurati*, la loro *intensità* e l'*anticipo con cui si prevede la grandinata* (in minuti), utili ad ipotizzare quale sarà il diametro massimo dei chicchi di grandine. Infatti, tutti i trend di questi indicatori crescono all'aumentare delle dimensioni dei chicchi di grandine e divengono ancor più robusti in caso di grandine grossa (diametro dei chicchi ≥ 5 cm): in tali circostanze, si rilevano *mediamente* 7 LJ per evento, un aumento nell'attività di fulminazione di 35 volte in poche decine di minuti e circa 60 minuti di anticipo tra l'osservazione del primo LJ e la caduta dei chicchi di grandine al suolo. A partire da questi risultati, opportune combinazioni di radar a singola o doppia polarizzazione con le variabili connesse alle fulminazioni potrebbero condurre ad un miglioramento delle performance di algoritmi che si occupano del riconoscimento e del monitoraggio dei temporali grandinigeni in modalità operativa (e.g. Capozzi et al., 2022).

Riferimenti bibliografici

Bechini, R. and Chandrasekar, V., 2015. A Semisupervised Robust Hydrometeor Classification Method for Dual-Polarization Radar Applications. Journal Of Atmospheric and Oceanic Technology, 32, 22-47. https://doi.org/10.1175/JTECH-D-14-00097.1

Capozzi, V., Picciotti, E., Mazzarella, V. and Marzano, F. S., 2018. Fuzzy-logic detection and probability of hail exploiting short-range X-band. Atmospheric Research, 201, 17-33. https://doi.org/10.1016/j.atmosres.2017.10.006.

Capozzi, V., Mazzarella, V., De Vivo, C., Annella, C., Greco, A., Fusco, G. and Budillon, G., 2022. A Network of X-Band Meteorological Radars to Support the Motorway System (Campania Region Meteorological Radar Network Project). Remote Sensing, 14(9), 2221. https://doi.org/10.3390/rs14092221

Kunz, M. and Kugel, P.I.S., 2015. Detection of hail signatures from single-polarization C-band radar reflectivity. Atmos. Res., 2015, 153, 565-577. https://doi.org/10.1016/j.atmosres.2014.09.010.

Vermi, F., Capozzi, V., Monte, G., Budillon, G. and Laviola, S., 2025. Lightning jump as precursor of very large hail occurrence: first evidence in the Italian territory. Bull. of Atmos. Sci.& Technol, 6, 21. https://doi.org/10.1007/s42865-025-00104-2.

Optimal analysis of severe hailstorms in Italy by combining satellite retrievals, synoptic analysis and climate modelling projections

Sante Laviola[1], **Enrico Arnone**[2], **Giorgio Budillon**[3], **Elsa Cattani**[1], **Giulio Monte**[1], **Nicola Cortesi**[2], **Vincenzo Capozzi**[3], **Alberto Fucci**[3], **Giannetta Fusco**[3], **Claudio Cassardo**[2]
[1]CNR-ISAC, Italy; [2]Università di Torino; [3]Università "Parthenope" di Napoli

In the framework of the Hail Hazard in the Mediterranean (H2Med) project, the Multi-sensor Approach for Satellite Hail Advection (MASHA) technique is applied to study severe hail events occurred in Italy during the last years. MASHA reconstruction of hail patterns allows to identify the severity of events, the trajectory of storm and the lifetime of hail clusters into the clouds. Each event is then investigated through the Principal Component Analysis and cluster analysis in aim to identify the large-scale atmospheric conditions that trigger and reinforce hail and super hail events classified by MASHA. The multivariate statistical approach based on Principal Component Analysis and cluster analysis is applied to some atmospheric fields and thermodynamic indices derived from ERA5 reanalysis. Then, a set atmospheric types favouring hail formation is provided. Finally, future changes of the occurrence of large and extreme hail events over the whole Mediterranean basin is derived from CMIP6 climate model projections for the 21st century under different SSPs scenarios.

From case studies to a preliminary climatology of hailstorms in the Alps using the MASHA satellite product

Costanza Di Felice Fabrizi[1], **Sante Laviola**[2], **Dino Zardi**[1]

[1]University of Trento, Italy; [2]Institute of Atmospheric Sciences and Climate (ISAC), National Research Council of Italy (CNR)

The Alpine orography plays a crucial role in modulating convective storm dynamics, yet the initiation and development of severe convection, including hail-producing storms, remain only partially understood. This study presents a case study analysis of convective events observed in the Alpine region, using national composite radar data provided by the Department of Civil Protection, the MASHA satellite product (Laviola et al., 2025, in submission) for the estimation of hail probability, and ground reports from the European Severe Weather Database (ESWD). MASHA is a hybrid advanced satellite technique capable of detecting the hail-bearing convection developing in the Mediterranean basin every 5 min at very high spatial resolution (3-5 km). The selected cases, characterised by significant hail episodes, are analysed to study the spatio-temporal evolution of convective cells and to assess the capabilities of the MASHA method in detecting hail probability. By integrating these three methods, the aim is to assess the consistency and limitations of satellite algorithms in complex terrain environments. This research is part of the broader TIM (Thunderstorm Intensification from Mountains to Plains) project promoted by ESSL, with the aim of improving the understanding of convective phenomena in mountain environments and their implications for impact prediction and mitigation.

Building on this qualitative validation, the MASHA dataset is now being used to perform a preliminary climatological analysis of hail events over the Alpine arc for the recent 5–6 summer seasons. This extended investigation aims to identify spatial patterns and temporal variability of hail occurrence, providing new insights into the influence of complex orography on convective activity.

Analisi dinamica di un evento di trasporto transatlantico di aerosol da incendi canadesi seguito da trasporto di polveri sahariane

Francesca Calastrini[1,3], **Andrea Orlandi**[2], **Gianni Messeri**[1,3], **Alessandro Zaldei**[1], **Carolina Vagnoli**[1], **Giovanni Gualtieri**[1], **Tommaso Giordano**[1], **Simone Putzolu**[1], **Beniamino Gioli**[1]

[1]Istituto di BioEconomia IBE-CNR, 50145 Florence, Italy; [2]ENEA, SSPT-CLIMAR, 40121 Bologna, Italy; [3]Consorzio LaMMa, 50019 Sesto Fiorentino, Florence, Italy

Dal mese di maggio 2025, gravissimi incendi boschivi hanno colpito vaste aree del territorio canadese, in particolare le province di Saskatchewan, Manitoba e Ontario. Tali eventi sono stati ricondotti alle severe condizioni di temperatura ed aridità del suolo connesse al cambiamento climatico. Come conseguenza, ingenti quantitativi di particolato derivante dagli incendi sono stati immessi in atmosfera, interessando la troposfera e la bassa stratosfera. Gli intensi venti occidentali che caratterizzano le alte quote delle medie latitudini hanno trasportato i fumi attraverso l'Atlantico settentrionale, fino ad interessare, a partite dai primi di giugno, l'Europa centro-occidentale, sia in quota che negli strati più bassi. L'analisi correlata delle back-trajectories ottenute dal modello Hysplit, delle elaborazioni di immagini satellitari e dei dati prodotti dalla modellistica CAMS, ha permesso di individuare alcune delle fasi salienti del trasporto di aerosol derivante dagli incendi canadesi, evidenziando poi il sopraggiungere di una non trascurabile componente di particolato di origine sahariana. Sfruttando i dati registrati dalla rete di stazioni AirQino (https://www.airqino.it), è stata svolta un'analisi delle serie temporali dei valori di concentrazione di PM10 e PM2.5 misurati durante le prime due decadi del mese di giugno. Le stazioni AirQino, che integrano sensori per la rilevazione dei principali inquinanti atmosferici, di gas serra e di parametri meteorologici, attualmente garantiscono una notevole copertura del territorio italiano e sono operativi con alcuni punti di misura in Francia (Cannes e Marsiglia), Spagna (Barcellona), Ungheria (Budapest e Debrecen) e Romania (Bucarest). In particolare, le misure su base oraria di concentrazione di PM10 e PM2.5 hanno permesso di valutare l'evoluzione temporale e spaziale degli eventi connessi al trasporto dei fumi provenienti dagli incendi canadesi e del contributo desertico sahariano.

From vertical profiles to horizontal scanning: innovative applications of the Raymetrics Aerosol Profiler at the BAQUNIN Supersite

Lorenzo Veltri Gomes[1], **Annalisa Di Bernardino**[2], **Nicola Ferrante**[1], **Stefano Casadio**[1,3]

[1]SERCO Italia SpA, Roma; [2]Dipartimento di Fisica, Sapienza Università di Roma; [3]EOP-GMQ, ESA/ESRIN, Frascati, Roma

The *Boundary-layer Air Quality-analysis Using Network of INstruments* (BAQUNIN) supersite has been operational since 2017, providing high-quality atmospheric composition data for both scientific research and satellite validation activities. BAQUNIN involves the coordination and the synergistic exploitation of a number of ground-based instruments operated at the Sapienza University campus (downtown Rome), CNR-ISAC (Tor Vergata), and CNR-IIA (Montelibretti), i.e., across urban, semi-rural, and rural sites around Rome. The supersite, promoted by the European Space Agency (ESA) and the EUropean METeorological SATellite system (EUMETSAT), is designed to validate current and future satellite products (trace gases, greenhouse gases, aerosols, clouds) and to investigate the physical processes driving boundary layer evolution in complex Mediterranean urban environments.

Within the BAQUNIN framework, the *Raymetrics Aerosol Profiler* (RAP) represents a key instrument continuously operating at the Sapienza site since 2021. RAP is a single-wavelength elastic lidar (1064 nm) acquiring vertical profiles of aerosol backscatter and extinction up to 15 km with high spatial (3.75 m) and temporal (10 s) resolution.

Following a 2024 refurbishment, RAP has been upgraded with full scanning capability, enabling novel observation strategies. In particular, the Horizontal Pointing Mode (HPM) allows the system to probe the

lowest portion of the urban boundary layer over distances up to 5 km, a region typically inaccessible to conventional lidars and ceilometers, at very high spatial and temporal resolution (3.75m, 10 sec).

Operating RAP in HPM provides unique observational capabilities for the validation of aerosol loads and atmospheric corrections in very high-resolution satellite optical missions, as it captures spatial and temporal scales directly comparable to those of satellite products. Thus, RAP strengthens BAQUNIN's role as a unique infrastructure for investigating aerosol dynamics in the urban boundary layer and for supporting the calibration and validation of new-generation satellite observations.

Convection characterization with a synergistic active and passive, GEO and LEO observation strategy

Elsa Cattani[1], Federico Vermi[2], Giulio Monte[1], Aida Galfione[3], Alessandro Battaglia[3], Sante Laviola[1]
[1]Consiglio Nazionale delle Ricerche, Italy; [2]Università di Napoli "Parthenope"; [3]Politecnico di Torino

Convection plays a crucial role in redistributing energy within Earth's atmosphere and is often associated with cloud formation and severe weather events, including hailstorms that can cause significant damage to infrastructure and property. In recent decades, Italy and the broader Mediterranean Basin have experienced a rising trend in such extreme events, highlighting the need for improved observational capabilities and retrieval methodologies to analyze convective storms, particularly those producing hail.

This is the primary objective of the PRIN 2022 project *"Convection Characterization via Synergistic GEO and LEO Satellite Observations"*, which aims to investigate convection using data from the EarthCARE (EC) mission—featuring the highly sensitive 94-GHz Cloud Profiling Radar (CPR) with Doppler capability—alongside observations from the METEOSAT Rapid Scan Service (RSS).

This study presents analyses of convective case studies that occurred over the Mediterranean region in 2024 and 2025. Convective clouds are examined using convection products from the EUMETSAT Satellite Application Facility in support of nowcasting and very short-range forecasting, derived from Meteosat RSS data. Additional insights into updrafts and overshooting tops are obtained through EarthCARE CPR measurements, including radar reflectivity and vertical velocity profiles. The Multi-sensor Approach for Satellite Hail Advection (MASHA), a novel multi-instrument technique designed for real-time tracking of hail-producing clouds, further complements the analysis.

Key case studies are discussed to assess the complementarity and effectiveness of combining active and passive, GEO and LEO satellite observations, with particular focus on the challenges of interpreting Doppler velocity data for identifying updrafts within convective systems.

Snow estimates and validation of the radar products of the EarthCARE mission with ground measurements from a 24 GHz radar vertical profiler and two disdrometers at the Italian Antarctic Station "Mario Zucchelli"

Giacomo Roversi[1,2], Alessandro Bracci[3], Luca Baldini[2], Hajime Okamoto[4], Kaori Sato[4]
[1]Department of Environmental Sciences, Informatics and Statistics (DAIS), Ca' Foscari University, Venice, Italy; [2]Institute of Atmospheric Sciences and Climate (CNR-ISAC), Rome, Italy; [3]Institute of Atmospheric Sciences and Climate (CNR-ISAC), Bologna, Italy; [4]Research Institute for Applied Mechanics (RIAM), Kyushu University, Fukuoka, Japan

Snow precipitation plays a crucial role in the global water cycle and energy balance of Earth's climate system, particularly in Polar regions, where it significantly impacts the ice mass balance of polar caps and ice sheets.

The EarthCARE mission, a collaborative effort between ESA and JAXA, is designed to capture the microphysical variability of clouds and precipitation. Its W-band (94 GHz) Cloud Profiling Radar (CPR) enables tracking the formation and evolution of precipitation. But quantitative snowfall remote sensing presents challenges due to the highly variable microphysical and electromagnetic properties of ice crystals and aggregates on small spatial and temporal scales, which is not fully captured but the retrieval algorithms. Moreover, spaceborne radars cannot sample the lowest atmospheric layers because of ground clutter. This makes the estimation of the snowfall at the surface very challenging when significant variations in precipitation occur within the few hundred meters above the ground (Bracci et al., 2022).

To address this, a methodology for estimating reflectivity and Doppler velocity at 94 GHz from K-band (24 GHz) Doppler spectra collected by a Micro Rain Radar (MRR, Metek) and coincident disdrometer observations has been developed and tested in Antarctica (Bracci et al., 2023). This method, known as K2W, exploits the synergy between two commonly available Antarctic instruments to validate satellite-based W-band radar products.

With the release of EarthCARE's first L2 CPR products for December 2024 and January 2025, this approach has been replicated using EarthCARE overpasses near the Italian Antarctic station "Mario Zucchelli" (MZS), where an MRR and a disdrometer have been operational since 2016 in the framework of the project "Antarctic Precipitation Properties" (APP) of the Italian National Antarctic Research Program (PNRA), also integrating data from a weather station and a ceilometer from the ENEA Italian Antarctic Meteo-Climatological Observatory (IAMCO).

Snowfall events at MZS coinciding with an EarthCARE overpass (point-to-line distance < 20 km) happened on seven occasions since the start of EarthCARE data delivery, with five virga occurrences and at least one good match (April, 30th 2025). A comparison of retrieved physical quantities from ground-based and satellite observations is presented and critically analysed. A statistical analysis on the long time series quantifies the expected frequency of virga occurrence at MZS.

Validazione di dati GNSS-meteo con radiosondaggi: prestazioni di una nuova rete su mare per il monitoraggio atmosferico

Andrea Antonini[1], Luca Fibbi[1], Alberto Ortolani[1], Francesco Fibbi[1], Bernardo Gozzini[1], Matteo Gemignani[2], Irene Marsili[2], Alessandro Filippeschi[2], Salvo Marcuccio[2], Antonio Turi[2]

[1]Consorzio LAMMA; [2]Università di Pisa, Dipartimento di Ingegneria Civile e Industriale - Laboratorio di Sistemi Spaziali

Negli ultimi anni, l'utilizzo dei segnali provenienti dalle costellazioni di Global Navigation Satellite Systems (GNSS) si è affermato come una tecnica affidabile per la stima continua del contenuto di vapore acqueo atmosferico, attraverso la determinazione del ritardo zenitale troposferico (Zenith Tropospheric Delay, ZTD). Nell'ambito di alcuni progetti INTERREG (PROTERINA-3 Évolution, PROTERINA4Future) è stata realizzata una nuova infrastruttura GNSS-meteo per il monitoraggio integrato delle condizioni atmosferiche su mare tramite sistemi installati a bordo di una flotta di navi di linea operativa sull'alto Tirreno. Tale infrastruttura combina reti di ricevitori GNSS permanenti con stazioni meteorologiche di superficie, consentendo la generazione in tempo quasi reale di prodotti come ZTD, Integrated Water Vapor (IWV) e parametri termoigrometrici superficiali, con elevata risoluzione temporale e spaziale.

Al fine di validare le prestazioni del sistema e quantificare l'accuratezza dei prodotti derivati, è stata organizzata una campagna di radiosondaggi sperimentali a basso costo presso le stazioni della rete, con il rilascio di palloni meteorologici dotati di sensori per la misura diretta dei profili verticali di temperatura, pressione e umidità relativa. Le osservazioni dei radiosondaggi, considerate lo standard di riferimento per la calibrazione e la validazione dei modelli atmosferici, sono state confrontate con le stime simultanee fornite dalla rete GNSS e dai sensori a terra.

Il presente lavoro descrive da un lato le prestazioni del sistema GNSS-meteo di osservazione, il primo operativo per un lungo periodo (oltre 4 anni), dall'altro il sistema di radiosondaggio a basso costo sviluppato appositamente per la validazione. Sono stati analizzati i dati di confronto per i lanci effettuati durante differenti stagioni e con diverse condizioni atmosferiche. I risultati mostrano una buona correlazione tra i valori di IWV derivati da GNSS e quelli stimati dai radiosondaggi. Il lavoro presenta infine anche un confronto tra queste osservazioni ed i dati ottenuti da modelli di rianalisi (MERRA-2, ERA5). Questa validazione dimostra l'affidabilità di entrambi i sistemi di misura - GNSS-meteo e radiosondaggi sperimentali - ponendoli come utili strumenti da utilizzare in maniera complementare o in alternativa a sistemi di misura convenzionali.

Gli effetti del vento sulle misure dei disdrometri e dei pluviometri: applicazioni ai siti di Pescara e Roma

Leone Parasporo[1], Elisa Adirosi[1], Luca Baldini[1], Mario Montopoli[1,5], Enrico Chinchella[2,3], Arianna Cauteruccio[2,3], Luca Giovanni Lanza[2,3], Tommaso Caloiero[4]

[1]Consiglio Nazionale delle Ricerche, Istituto di Scienze dell'Atmosfera e del Clima (CNR-ISAC), Roma, 00133, Italia.; [2]Dipartimento di Ingegneria Civile, Chimica e Ambientale, Università di Genova, Genova, Italia.; [3]WMO Measurement Lead Centre "B. Castelli" on Precipitation Intensity, Italia.; [4]Consiglio Nazionale delle Ricerche, Istituto di ricerca per la protezione idrogeologica (CNR-IRPI), Via Cavour 4/6, 87036 Rende, Italia.; [5]Centro di Eccellenza in Telerilevamento E Modellistica Previsionale di eventi Severi, L'Aquila, Italia.

I pluviometri e i disdrometri sono strumenti fondamentali per ottenere informazioni dirette sulle caratteristiche delle precipitazioni in un determinato sito. Tuttavia, le loro misure possono essere influenzate dalla presenza del vento. In questo studio sono stati identificati e quantificati gli effetti indotti da questo fattore ambientale. In particolare, per valutare le prestazioni del disdrometro in condizioni di vento, sono stati analizzati i dati raccolti da due disdrometri Thies Clima LPM e da sensori di vento installati nelle città di Pescara e Roma.

Il set di dati copre per Pescara il periodo da luglio 2021 ad agosto 2024, sebbene includa interruzioni significative, mentre per Roma gli interi anni 2023 e 2024. In primo luogo, lo studio presenta le principali caratteristiche dei siti in termini di distribuzione del vento e della pioggia, nonché le loro distribuzioni congiunte. Quindi, vengono quantificati gli effetti del vento sulle misure dei disdrometri in termini di errore sistematico associato alla stima della DSD (Drop Size Distribution).

I risultati indicano che a Pescara le DSD non corrette dal vento differiscono, in media, del 10.6 % in termini di errore medio assoluto percentuale rispetto alle DSD corrette e a Roma del 6.3 %. Le correzioni sulle DSD si riflettono sui valori di intensità di precipitazione. In questo caso, le differenze tra le intensità di precipitazione ottenute da DSD non corrette per effetto del vento e da DSD corrette sono di 0.26 mm/h per Pescara e 0.23 m/h per Roma in termini della radice dell'errore quadratico medio. Tali differenze risultano statisticamente significative.

Successivamente, poiché il vento ha effetti anche sulla misura pluviometrica, e tale effetto varia al variare delle dimensioni delle gocce (e quindi della DSD) i dati disdrometrici corretti sono stati utilizzati per correggere le misure di precipitazione di un pluviometro posto a qualche metro dal disdrometro di Roma e di due pluviometri installati nei pressi del disdrometro di Pescara, nonché di una rete di 25 pluviometri nella regione Calabria. Gli effetti della correzione sono valutati confrontando i valori corretti con quelli non corretti. Queste differenze sono risultate statisticamente significative.

Urban Microclimate Insights from Rooftop and Canyon Sensors: Temperature Differences, Drivers, and Diurnal Cycles

Lorenzo Marinelli, Andrea Cecilia, Giampietro Casasanta, Alessandro Conidi, Igor Petenko, Stefania Argentini

National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Via Fosso del Cavaliere 100, 00133 Rome, Italy

Understanding temperature variations within the complex Urban Canopy Layer (UCL) is challenging due to limitations and discrepancies between temperature measurements taken in urban canyons or in other more practical nearby positions, such as rooftops. The key question is then how much these measurements differ and what factors contribute to these differences. According to the guidance of the World Meteorological Organization (WMO), measurements within urban canyons are recommended, while rooftop observations are not encouraged for urban monitoring due to “potentially anomalous microclimatic conditions”. Questions about the representativeness of rooftop data are particularly relevant given the increasing number of rooftop sensors deployed through citizen science. This study aimed to address this knowledge gap by comparing temperatures within the UCL using two sensors: one located on a rooftop, and the other positioned within the canyon. The temperature difference between these two nearby locations followed a clear diurnal cycle, peaking at over 1 °C between 12:00 and 16:00 local time, with the canyon warmer than the rooftop. This daytime warming was primarily driven by solar radiation and, to a lesser extent, by wind speed, but only under clear-sky conditions. During the rest of the day, the temperature difference remained negligible.

This methodology was extended to a broader network of low-cost temperature sensors located near rooftop stations deployed in the city of Rome, and similar results were found.

Cup vs Ultrasonic Anemometer Wind Speed Comparison at Sites Characterised by Different Speed Distributions

Patrizia Favaron
Servizi Territorio srl, Italy

In many practical applications (e.g., wind energy assessment, atmospheric pollutant dispersion modelling, and others), knowledge of wind speed is of paramount importance, and errors in its measurement may hamper the application usefulness of technical results.

To date, most wind speed measurements have been conducted using cup anemometers. These sensors are known to show measurement distortions under slow wind conditions, the frequency of which is significant at locations worldwide.

This study aimed to investigate the impact of these measurement distortions at sites characterized by different wind speed statistical distributions, and was conducted by comparing the 10-min average speed from cup and 3D sonic anemometers at various SHAKEUP sites (ARPA Lombardia).

The results show a cup anemometer-induced change in the measured wind statistics, particularly at low wind speed regimes. The medium and high wind speed regimes showed substantial agreement.

Possible strategies for mitigating the statistical perturbation are also considered and discussed in view of applications (e.g., dispersion modeling).

Application of the latent twins approach for atmospheric state retrieval from IASI satellite observations

Michele Martinazzo[1], Cristina Sgattoni[2], Marco Menarini[3], Chiara Zugarini[4], Luca Sgheri[4], Tiziano Maestri[1]
[1]University of Bologna, Italy; [2]IBE CNR, Italy; [3]ISAC CNR, Italy; [4]IAC CNR, Italy

In recent years, data-driven approaches have emerged as alternatives to traditional physics-based retrievals, taking advantage of machine learning techniques such as learnable pseudoinverse, random forests, or deep learning architectures. These methodologies generally rely on training datasets derived from simulations or observational databases and exploit non-linear relationships between measured radiances and atmospheric parameters without explicit forward modeling. In this work, a deep learning architecture, based on the latent twins approach (originally introduced in theoretical works such as Chung et al., 2025), is applied to IASI spectra, with the goal to assess the robustness of this method for retrieving atmospheric profiles, including temperature, water vapor, ozone, surface emissivity, and surface temperature, in real-world clear-sky conditions. The algorithm is first applied on synthetic radiances derived from the NWP SAF database using the fast radiative transfer code sigma-IASI/F2N (Masiello et al, 2024). After validating the architecture on synthetic data, the algorithm is applied to IASI Level 1C observations, along with their corresponding Level 2 products which serve as reference to evaluate the reconstruction accuracy of the autoencoder-based retrieval. The retrieval performances are discussed along with possible strategies to provide an error analysis for the reconstructed thermodynamical profiles.

CNR-ISAC Network of Remote Sensing Instruments for Air Quality Studies and Satellite Validations

Andrè Achilli[1,2], Elisa Castelli[1], Paolo Pettinari[1], Enzo Papandrea[1], Massimo Valeri[3], Francescopiero Calzolari[1], Claudio Campenni[1]
[1]CNR-ISAC, Italy; [2]UNIBO, Italy; [3]Serco s.p.a, Italy

Continuous monitoring of pollutants and greenhouse gas vertical concentrations in the atmosphere allows for air quality studies of a region and for long-term studies of trends and seasonal behaviors. Ground-based remote sensing instruments are usually exploited for this scope.

Since 2021, CNR-ISAC has managed two MAX-DOAS SkySpec-2D, one in Rome Tor Vergata and the other in San Pietro Capofiume, located in the middle of the Po Valley. These instruments measure scattered atmospheric spectra in the UV-VIS range. From them, we retrieve the total vertical column densities of NO2 and O3. We also apply our algorithm DEAP to retrieve the tropospheric profiles of NO2 and aerosol extinction, and their integrated value of tropospheric concentration and aerosol optical depth. These instruments are compliant with the FRM4DOAS network, an ESA activity aimed at harmonizing operations from DOAS instruments all around the world. Since mid-2024, in the framework of the PNRR-EMM project, we expanded the net of SkySpec in Italy by installing two new instruments, one in Monte Cimone at 2165m a.s.l., and the other in Bologna at the CNR-ISAC facility. Here we also installed a Fourier Transform Spectrometer (FTS), the EM27/SUN. It measures direct-sun spectra in the NIR range, from which we retrieve total columns and dry-air mole fractions of CO2, CO, CH4, and H2O. The instrument is part of the COCCON network, which supports the TCCON network, made of IFS125 HR FTS. By the end of 2025, we plan to install one IFS125 HR in the Bologna CNR facility in the frame of the project PNRR-ITINERIS. In addition to air quality studies, these measurements are useful for satellite validation purposes. This activity is important as satellite data quality must continuously be upheld by ground-based measurements.

Here we will report an overview of the instruments' operations, the retrieved products, and comparisons against satellites.

Environmental observations comparison in Italy: NOAA and Meteonetwork sensor networks

Ilaria Ferrando[1], Abubakr Khalid Ahmed Albashir[1], Gabrio Pinnizzotto[1], Elisa Bertazzini[1], Bianca Federici[1], Catia Benedetto[2], Francesco Vespe[2], Domenico Sguerso[1]

[1]Department of Civil, Chemical and Environmental Engineering, University of Genoa, Italy;
[2]Telecommunications and Navigation Office, Italian Space Agency

Meteonetwork (MNW) is a Citizen Weather Stations (CWSs) initiative established in 2002 and continuously operating since then. It provides high spatial-density meteorological coverage across Italy. This study evaluates the consistency between MNW and National Oceanic and Atmospheric Administration (NOAA) observations for temperature (T) and pressure (P). NOAA stations located in Italy were selected as reference sites, while MNW stations within a 10 km radius were paired accordingly. A total of 49 NOAA and 93 MNW stations were analyzed using data collected on five fixed days per month from January 2023 to April 2025. The average acquisition frequency was 5 minutes for MNW (for both T and P), and 20 minutes and 3 hours for NOAA temperature and pressure data, respectively.

To ensure comparability, MNW observations were synchronized both temporally and altimetrically. Temperature values were adjusted to match the elevation of the corresponding NOAA station, while pressure data, already reduced to mean sea level in both networks, required no further correction. Temperature (ΔT) and pressure (ΔP) differences were computed for each station pair. Outliers were filtered using the Interquartile Range (IQR) method, and the 90th percentile of the RMSE of the filtered differences was adopted as the performance threshold for MNW stations.

The comparison yielded the following statistics for ΔP: mean = 0.34, standard deviation = 0.44, RMSE = 1.13, and 90th percentile of RMSE = 2.08 hPa; and for ΔT: mean = –0.33, standard deviation = 1.10, RMSE = 1.27, and 90th percentile of RMSE = 1.90 °C. These results demonstrate the stability and strong coherence between the two networks, highlighting MNW potential for meteorological applications that require dense and real-time observations.

This study represents a preliminary step toward evaluating the consistency of the main environmental sensor networks in Italy, with future analyses planned to include MISTRAl portal data.

Spatial and temporal variability of the urban heat island in the city of Bologna, Italy

Hadis Allahyari, Erika Brattich, Andrea Faggi, Silvana Di Sabatino

Dipartimento di Fisica “Augusto Righi”, Università di Bologna

The phenomenon of the urban heat island (UHI) has been observed since 1810 when a British scientist, Luke Howard, observed that the city of London is warmer than the rural surrounding. Since then, the concept of UHI has been well documented a, with many studies investigating the factors responsible for its formation and development, namely a decrease in vegetation and evapotranspiration, a rise in low-albedo, dark surfaces, and an increase in anthropogenic heat output in the urban cores. However, since the UHI is significantly affected by the geographic features and climatic conditions, the understanding of the topic remains quite limited especially in some areas. For instance, a significant gap remains in understanding the interaction of the UHI with heat waves (HW) conditions, with contrasting results in different areas. This study examines how UHI patterns change in space and time during extreme heat events in the city of Bologna, situated in the Po Valley in Italy, a well-known climate change and pollution hotspot. By combining an LCZ-based approach with the calculation of thermal comfort indices to assess the degree of human heat stress among different types of urban morphologies, the study aims to provide a better understanding of the UHI and HW interactions at the urban scale. The results indicate that the UHI in the area is significantly higher at nighttime, when the historic core of Bologna with dense LCZs (layers 2 and 3) experiences higher thermal stress. The level of heat stress reaches maximum levels during the HW period, in which greener or more open LCZs mitigate thermal discomfort. These results may be useful for informing targeted urban planning strategies for climate adaptation in the area.

A significant tornado event near a dryline bulge in Northern Italy

Francesco De Martin[1], Federico Pavan[1], Nicola Carlon[2], Guido Cioni[3], Christopher Rozoff[4], Virginia Poli[5,6], Sebastiano Carpentari[7], Mario Marcello Miglietta[8]

[1]Department of Physics and Astronomy, Alma Mater Studiorum - University of Bologna, Bologna, Italy; [2]Radarmeteo, Due Carrare, Italy; [3]Meteonetwork, Milan, Italy; [4]U.S. National Science Foundation, National Center of Atmospheric Research, Boulder, Colorado; [5]Hydro-Meteo-Climate Structure, Regional Agency for Prevention, Environment and Energy of Emilia-Romagna, Bologna, Italy; [6]ItaliaMeteo Agency, Bologna, Italy; [7]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy; [8]Institute of Atmospheric Sciences and Climate (CNR-ISAC), National Research Council of Italy, Padua, Italy

A multi-scale observational analysis of a 1.6 km wide IF3 tornado in Northern Italy is conducted using radar and sounding data, ground weather stations, and damage surveys. The tornado occurred close to Alfonsine, along the Adriatic coast, on July 22, 2023, in one of the most tornado-prone regions of Europe. An initially hail-bearing supercell (which produced hailstones up to 10 cm in diameter) became tornadic as it approached a dryline bulge. During the transition from a hail-dominant to tornadic storm, the long-lived supercell generated a damaging Rear-Flank Downdraft (RFD) surge, with unusually cold wind gusts reaching 40 m/s. A dry and hot air mass from the southwest was partially ingested by the mesocyclone just before the tornadogenesis occurrence. At the same moment, the storm was also ingesting from the east a maritime air mass with very high values of equivalent potential temperature. A seamless wind damage pattern, transitioning from damage caused by straight-line wind gusts to tornadic damage, suggests that the tornado may have developed from the stretching of small-scale pre-tornadic vertical vorticity maxima within the RFD. As in other case of significant tornadoes in Northern Italy, the environment was characterized by strong deep layer shear and conditional instability, but weak low-level wind shear. However, numerical simulations indicate that along the dryline the low-level storm relative helicity and vertical vorticity were stronger, suggesting a higher tornado potential. The tornado resulted in only 14 injuries, likely because it impacted a sparsely populated area. Considering that past significant tornadoes in the region affected much more densely populated areas, and since no tornado warnings or shelters are currently in place, there are growing concerns about the potential catastrophic consequences of a future significant tornado in the highly populated areas of northeastern Italy.

On the role of ocean structure in Valencia Flood development.

Antonio Ricchi[1,2], Marcello Miglietta[1,2], Carlos Sancho[3], Rossella Ferretti[4]

[1]Università of L'Aquila, University of L'Aquila, Department of Physics and Chemical Sciences, Italy; [2]CETEMPS (Center of Excellence in Telesensing of Environment and Model Prediction of Severe Events), Italy; [3]CNR-ISAC, Italy, Padua; [4]University of Valladolid

On 29 October 2024, an intense supercell formed along the Valencian coastal area. The storm brought about 600 mm of rainfall with extensive damage and casualties. Although the large scale atmospheric patterns that trigger the event is quite marked and relevant, the role of the sea structure is not totally clear. WRF (Weather Research and Forecasting system) simulations were conducted to examine how oceanic factors – sea surface temperature (SST), SST anomalies, upper-ocean vertical stratification, and ocean heat content – influenced the development of the extreme weather event over Valencia area. The model was run at a resolution of 3-1 km, with the SLAB Ocean model activated in order to model the structure of the mixed layer depth consistently with the atmosphere. Simulations, under this configuration, is capable of represent the phenomenon very realistically, in space and time. The intensity reached by the control simulation is about 590 mm/12hr, close to the observed reality. We used observed SST, mixed layer depth produced by the CMEMS model reanalysis and anomalies are based on the CMEMS dataset 1987-2010. The results suggest that ocean–atmosphere interactions accounted for around 25% of the storm's peak intensity, while storm genesis and track remained largely unaffected to ocean structure. Among the tested factors, pronounced upper-ocean stratification and vertical lapse rate enhanced surface latent heat fluxes and invigorated convection, thereby intensifying the storm. In contrast, SST anomalies had only a minor, spatially inconsistent influence due to their patchy distribution prior to the event. These findings underscore the importance of accurately representing upper- ocean structure and heat content in mesoscale models to improve forecasts of extreme Mediterranean weather events.

Heatwaves, droughts, and compound events: implications for thermo-hygrometric well-being in Europe

Annalisa Di Bernardino, Anna Maria Siani

Dipartimento di Fisica, Sapienza Università di Roma

In recent decades, Europe has experienced a marked intensification of extreme weather events, with notable implications for population thermo-hygrometric well-being. This study investigates time series of atmospheric variables from the ERA5-Land and ERA5-Heat datasets, provided by the Copernicus Climate Change Service (C3S), spanning the period 1961–2024. Extreme events are identified with respect to the 1961–1990 climatological baseline. The analysis examines spatial and temporal variations in the frequency and intensity of heatwaves, identified using 2-m air temperature, and droughts, quantified through the Standardized Precipitation Evapotranspiration Index (SPEI), as well as their co-occurrence as compound events. The associated impacts on thermo-hygrometric stress are assessed using the Universal Thermal Climate Index (UTCI), derived from ERA5-Heat data. Four daily event-based scenarios, identified from the analysed datasets, are considered: (i) a reference case without extremes, (ii) heatwaves only, (iii) droughts only, and (iv) compound heatwave–drought events.

The results reveal a clear temporal evolution of these events, with significant increases in frequency and severity, particularly in recent decades, and demonstrate that the co-occurrence of heatwaves and droughts amplifies the risk of thermo-hygrometric stress compared to single events. Therefore, this study provides an integrated assessment of extreme climate risks, contributing to a better understanding of the thermo-hygrometric stress under extreme conditions.

The findings of this research are particularly relevant for urban planners and policymakers, as they can highlight the social implications of extreme climate events and can guide the design of tailored adaptation strategies. In particular, the results can support the development of **early warning systems**, inform the **planning of resilient urban infrastructures**, and provide actionable insights to enhance the resilience of European communities.

Modelling outdoor thermal comfort in a urban study area of Lecce (Italy) under current and future scenarios

Francesco Giangrande[1], Gianluca Pappaccogli[1], Fabio Ippolito[1], Rohinton Emmanuel[2], Riccardo Buccolieri[1]

[1]Dipartimento di Scienze e Tecnologie Biologiche ed Ambientali, University of Salento, S.P. 6 Lecce-Monteroni, 73100 Lecce; [2]School of Computing, Engineering and Built Environment, Glasgow Caledonian University, Glasgow G4 0BA, UK

This study investigates outdoor thermal comfort conditions in a selected area of Lecce (southern Italy) through the Universal Thermal Climate Index (UTCI), employing a microclimate modeling approach. The analysis is conducted using the ENVI-met software, a three-dimensional Computational Fluid Dynamics (CFD) model designed for simulating surface–plant–air interactions at the microscale.

In the first phase, two scenarios are simulated: (A) the current configuration of the study area and (B) a redesigned future scenario developed within an urban redevelopment plan approved by the Municipality of Lecce, as part of the *Ministerial Experimental Program of Interventions for Adaptation to Climate Change in Urban Areas* (Ministero della Transizione Ecologica, 2021). Meteorological inputs are derived from ERA5 reanalysis data for the period 1991–2020, from which a representative summer day is applied to both scenarios. This phase aims to assess the microclimatic effects and improvements in outdoor thermal comfort associated with mitigation strategies, including the introduction of permeable surfaces, increased vegetation and shading and water features (fountain).

In the second phase, Scenario B is further analyzed under projected future climate conditions, using climate projections as meteorological inputs. The objective is to evaluate the effectiveness of the proposed mitigation measures in enhancing outdoor thermal comfort across three future time horizons: near-term (2021–2040), mid-term (2041–2060), and long-term (2081–2100) (Lee et al., 2021).

Overall, the study quantitatively highlights the potential benefits of climate-sensitive urban design strategies, showing how nature-based and structural interventions can mitigate urban heat stress and enhance thermal comfort under both current and future climatic conditions.

References

Lee, J.-Y., Marotzke, J., Bala, G., Cao, L., Corti, S., Dunne, J. P., Engelbrecht, F., Fischer, E., Fyfe, J. C., Jones, C., Maycock, A., Mutemi, O., Ndiaye, O., Panickal, S., Zhou, T., et al. (2021). Future global climate: Scenario-based projections and near-term information (Capitolo 4). In IPCC, Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Ministero della Transizione Ecologica. *Decreto direttoriale n. 117 del 15 aprile 2021*, Programma sperimentale di interventi per l'adattamento ai cambiamenti climatici in ambito urbano — Gazzetta Ufficiale della Repubblica Italiana, Serie Generale n. 135, 8 giugno 2021.

Role of Organic Nitrates in Secondary Organic Aerosol in Beijing

Eleonora Aruffo[1], Junfeng Wang[2], Piero Chiacchiaretta[3], Alessandra Mascitelli[3], Ning Zhang[2], Piero Di Carlo[3]

[1]University of Chieti Pescara, Department of Science, Italy; [2]Jiangsu Key Laboratory of Atmospheric Environment Monitoring and Pollution Control, Collaborative Innovation Center of Atmospheric Environment and Equipment Technology, Joint International Research Laboratory of Climate and Environment Change (ILCEC), School of Environmental Science and Engineering, Nanjing University of Information Science and Technology, Nanjing 210044, China; [3]University of Chieti Pescara, Department of Innovative Technologies in Medicine & Dentistry, Italy

The production and chemical composition of Secondary Organic Aerosols (SOA) are key factors in urban air quality. Analyzing data from a summer campaign in Beijing, conducted in 2017, we found nocturnal peaks of NOz (NOy - NOx) up to 40 ppb, correlated with nocturnal high concentrations of NO and NO2 and SOA formation the following day. We employed the Framework for 0-D Atmospheric Modeling (F0AM), based on the Master Chemical Mechanism (MCM), coupled with the Washington Aerosol Module, based on SIMPOL mechanism for the particle phase modeling, to run simulations investigating the speciation of ONs in both gas and particle phases anf to correlate the nocturnal NOz peaks, which we suggested are mainly in the gas phase, with the diurnal particle growth events observed in Beijing.

Studio delle caratteristiche del medicane Qendresa utilizzando due tecniche di assimilazione dati nel modello WRF

Cristiano D'Amico[1], Matteo Nastasi[1], Diego Saùl Carriò Carriò[2], Antonio Ricchi[1], Rossella Ferretti[1]

[1]University of L'Aquila, Italy; [2]Universitat de les Illes Balears, Spain

Il presente lavoro è incentrato sullo studio delle caratteristiche meteorologiche del ciclone simil-tropicale Qendresa, verificatosi nel Mediterraneo centrale tra il 6 e l'8 novembre 2014, utilizzando il modello WRF ad area limitata. Qendresa ha avuto origine nelle prime ore del 6 novembre attraverso il processo di "lee cyclogenesis" sul versante orientale della catena dell'Atlante. Successivamente il ciclone si è approfondito spostandosi verso l'isola di Pantelleria, per poi traslare verso sud-est, attraversando l'isola di Linosa, dove il suo nucleo ha raggiunto il minimo assoluto di pressione al livello del mare. Il sistema ha proseguito poi verso Malta e, già indebolito, si è spostato al largo della costa orientale della Sicilia, descrivendo una traiettoria ad anello durante la mattina dell'8 novembre, prima di spostarsi definitivamente verso est, in direzione della Grecia. Complessivamente, l'evento ha provocato tre vittime e ingenti danni strutturali nelle aree colpite.

L'obiettivo principale di questo lavoro è quello di riprodurre la struttura e l'evoluzione del ciclone, raggiungendo la migliore coerenza possibile con le osservazioni disponibili, durante il periodo di 36 ore dalle

00 UTC del 7 novembre alle 12 UTC dell'8 novembre 2014. Per migliorare l'identificazione dei processi fisici chiave e aumentare l'accuratezza della traccia simulata del ciclone, nel modello sono stati assimilati dati osservativi e di rianalisi a diversi livelli verticali e intervalli temporali. Sono stati testati due approcci di assimilazione dei dati: il filtro di Kalman d'insieme (EnKF) e l'assimilazione dei dati variazionali tridimensionali (3DVar).

Misure di concentrazione di CO2 presso la stazione di Plateau Rosa: analisi degli eventi estremi attraverso due modelli di dispersione lagrangiani

Mirsada Cravero[1], Silvia Ferrarese[1], Francesco Apadula[2], Giulia Zazzeri[2], Matteo M. Musso[1], Silvia Trini Castelli[3]

[1]Department of Physics, University of Turin, Turin, Italy; [2]Ricerca sul Sistema Energetico - RSE S.p.A., Milan, Italy; [3]CNR - Institute of Atmospheric Sciences and Climate (ISAC), Turin, Italy

Sulle Alpi nord-occidentali, alla quota di 3480 m s.l.m., presso la stazione di Plateau Rosa, la concentrazione di diossido di carbonio atmosferico viene misurata dal 1989, continuativamente dal 1993. L'altitudine a cui si trova la stazione e la distanza da fonti antropogeniche permettono di ottenere misure di background di concentrazione di gas serra e di inquinanti.

A partire dall'analisi della serie pluritrentennale di concentrazioni di CO_2, sono stati selezionati i valori di background, che costituiscono circa l'80% dell'intero dataset. Tali valori sono stati utilizzati per il calcolo del growth rate della CO_2 atmosferica, con risultati in accordo con quelli di stazioni di rilevanza globale.

L'intera serie di misure di CO_2 rivela, inoltre, l'influenza di masse d'aria con concentrazione variabile rispetto al background, come conseguenza della circolazione alla scala locale o alla mesoscala. In questo lavoro è stato sviluppato un metodo per l'identificazione degli eventi estremi e delle aree di provenienza delle particelle d'aria; tali episodi, numericamente limitati, sono stati quindi studiati applicando due diversi modelli di dispersione lagrangiani: MILORD e FLEXPART-WRF. Il primo è stato utilizzato per simulazioni long-range per tutti gli episodi di concentrazione classificata come estrema, mentre il secondo è stato applicato allo studio del trasporto alla mesoscala e alla scala regionale durante alcuni eventi.

I risultati rivelano come, durante gli episodi di picco, le principali aree di provenienza dei traccianti siano ravvisabili sulle zone fortemente industrializzate dell'Europa, mentre la circolazione atmosferica, durante i medesimi episodi, sia tipicamente ciclonica.

Particulate Matter and Heatwave compound events, the case study of Bologna, Italy

Andrea Faggi[1], Tiziano Maestri[1], Laura Tositti[2], Alessandro Zappi[2], Michele Martinazzo[1], Giorgia Proietti Pelliccia[1], Silvana Di Sabatino[1], Hadis Allahyari[1], Erika Brattich[1]

[1]Department of Physics and Astronomy "Augusto Righi", Alma Mater Studiorum - Università di Bologna, Bologna, 40120, Italy; [2]Department of Chemistry "Giacomo Ciamician", Alma Mater Studiorum - Università di Bologna, Bologna, 40120, Italy

Climate change plays a fundamental role in the intensification of extreme weather events, such as heatwaves (HWs), droughts and floods. In the last year, intensity, frequency and duration of such events have increased, and climate projections indicate further worsening in the coming years. As concerns health risks, extreme heat exposure can exacerbate cardiovascular and respiratory diseases. The negative effects of HWs can be intensified by concurrent deterioration of air quality. This connection is a widely researched topic, especially for specific pollutants, like tropospheric ozone. However, so far, few studies have investigated the association between particulate matter (PM) enhancements and HWs.

This study concerns the analysis of an intense compound event of HW and PM enhancement occurred in Bologna (Italy) during July 2023. The multidisciplinary approach implemented offers both an original method for investigating such events and a detailed description of the phenomenon by using ground-based sensors, remote-sensing measurements, satellite products and reanalysis data. The identification of compound events is conducted through extreme heat indices, i.e. the Excess Heat Factor and the Warm Spell Duration Index, and through novel index for PM based on the seasonal variability of PM. Seven compound events are found and cover about the 25% of the study period, 85 days out of 334 between January and November 2023. The analysis highlights the role of the African anticyclone in driving both the HW and the increase in PM concentrations. Besides the detailed analysis of the large-scale synoptic pattern, this is confirmed by measurements from a ground-based optical particle counter along with aerosol chemical speciation and satellite aerosol products.

These results can help policy makers in organizing more suitable responses to such compound events. Integrating Urban Heat Island analysis can offer further insights about the different negative impacts these events pose over people living in distinct urban areas.

Numerical simulations of two giant hail events in northeastern Italy with WRF-HAILCAST

Francesco Sioni[1], Antonio Palmeri[2], Andrea Perbellini[2], Sebastiano Carpentari[2], Agostino Manzato[1,3], Lorenzo Giovannini[2]

[1]ARPA FVG, Palmanova, Italy; [2]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy; [3]ISAC-CNR, Bologna, Italy

The northeastern Italian plains are highly prone to severe convective storms, often producing large to giant hailstones due to specific orographic features. This study wants to numerically simulate and to analyze two such extreme events: a supercell on 1 August 2021 that generated hailstones up to 9 cm in diameter, and the 24 July 2023 outbreak, during which two supercells developed—one producing a European record-

breaking 19 cm hailstone. Remarkably, both events produced their largest hail in the same area, near Azzano Decimo.

Numerical simulations were performed with the WRF model at 1 km resolution, coupled with the HAILCAST hail growth scheme. For the 2021 event, several configurations were tested, showing that initialization with IFS data provided the best performance. Realistic hail sizes and storm structure were reproduced only when radiosonde data from Udine Rivolto were assimilated through nudging.

The 2023 event was also simulated using the same configuration, but this setup yielded suboptimal results. Nudging degraded the simulation, as the radiosonde profile was substantially less unstable than the simulated surrounding environment, driving the model away from equilibrium and producing unrealistic convection. The most accurate results (with hailstones of sizes around 10 cm) were obtained using ERA5 initialization without data assimilation.

Comparison of the two events shows that, despite similar synoptic-scale conditions, they differ markedly in low-level moisture advection and instability, limiting dynamic and thermodynamic analogies. Analysis of the simulated updrafts—based on maximum vertical velocity, updraft area, updraft helicity, and liquid water content—shows that the 2023 event reached values nearly three times higher than those of 2021.

These results confirm, for simulations based on real events, a hypothesis previously supported only by idealized studies: hailstone size is not directly proportional to convective instability (e.g., CAPE), but depends primarily on the residence time of hail within the updraft, which can be effectively estimated through the analysis of the updraft morphology (i.e. updraft area).

The Bayesian sinking in Porticello: a predictable convective windstorm?

Francesco De Martin[1], Mario Marcello Miglietta[2], Thomas Gastaldo[3,4], Michele Martinazzo[1], Federico Pavan[1], Matteo Siena[1], Silvana Di Sabatino[1]

[1]Department of Physics and Astronomy, Alma Mater Studiorum - University of Bologna, Bologna, Italy; [2]Institute of Atmospheric Sciences and Climate (CNR-ISAC), National Research Council of Italy, Padua, Italy; [3]Hydro-Meteo-Climate Structure, Regional Agency for Prevention, Environment and Energy of Emilia-Romagna, Bologna, Italy; [4]ItaliaMeteo Agency, Bologna, Italy

The Bayesian yacht sank in Porticello, Sicily, at 0206 UTC on 19 August 2024 during a thunderstorm. Of the 22 people on board, 7 lost their lives. An in-depth analysis of available observations highlighted that the ship was likely struck by a quasi-linear convective system. Satellite images showed a Mesoscale Convective System over the Tyrrhenian Sea between 2300 UTC on 18 August 2024 and 0300 UTC on 19 August 2024, with convective cells that lasted less than 1h. The storm motion of the cell that hit Porticello was not consistent with that expected for a right mover supercell, suggesting that supercells were not present during the event. A few videos taken along the coast captured very intense northwesterly wind gusts, with no evidence of rotating winds or waterspouts. Before sinking, the yacht drifted southeastward, pushed by the northwesterly wind. Data from weather stations revealed classic downburst features, such as an increase in pressure and a drop in potential temperature corresponding to the strongest gusts. No signs of mesocyclones (e.g. sudden pressure drop) were detected.

The predictability of the event was also investigated. Operational simulations performed one day ahead with the ICON-2I model, running at 2.2 km horizontal resolution over a domain centred on Italy, pointed out that a convective wind gust hazard could have been expected over the southern Tyrrhenian Sea that night. Furthermore, the satellite analysis showed that the storm developed 3h before the accident and kept a coherent trajectory during its lifetime, suggesting that there may have been enough time to warn people. Lastly, we remark that radar data were unavailable in the area affected by the storm, which is a significant limitation for nowcasting, early warning systems, post-event analysis and research.

Atmospheric flow over schematic urban environment in a rotating water tank

Enrico Ferrero[1], Massimiliano Manfrin[2], Valentina Andreoli[2], Sara Rubinetti[1]

[1]Università del Piemonte Orientale, Italy; [2]Università di Torino, Italy

This study investigates the interaction between simplified urban-like obstacles and boundary layer flows under rotational effects, through laboratory experiments in a rotating water tank. Idealized building arrays were used to analyze how obstacle geometry influences flow separation, vortex formation, turbulence, and momentum transfer at the urban scale. The Rossby number (Ro) was varied to explore different regimes where rotational effects compete with inertial forces. Results, are presented in terms of flow and turbulence fields. Then, vertical profiles are analysed in order to identfy the effect of rotation both inside and out side the canions. The results contribute to the understanding of how rotation modifies boundary layer flow interactions with urban geometries, providing experimental insights relevant for urban flow modeling and environmental applications.

Modeling and Validation of Thermal Activity Using WRF Simulations and Paragliders Flight Data

Christian Nardon[1,2], Enrico Gambini[1], Enrico Maggioni[3], Alessandro Perotto[3], Raffaele Salerno[4], Alessandro Ceppi[1]

[1]Department of Civil and Environmental Engineering (D.I.C.A.), Politecnico di Milano, Milano, Italy; [2]Department of Civil, Environmental and Mechanical Engineering (D.I.C.A.M.), University of Trento, Trento, Italy; [3]Ideam Srl, Cinisello Balsamo, Milano, Italy; [4]Meteo Expert, Segrate, Milano, Italy

Thermals arise from differential heating of the Earth's surface, producing buoyant updrafts that are essential for sustaining altitude in non-motorized aviation. This study investigates the development of thermals within the atmospheric boundary layer (ABL) using a very high-resolution numerical model.

The Weather Research and Forecasting (WRF) model is employed to simulate the formation and dynamics of vertical velocities over a specific pre-alpine area in the north of Italy. The model performance is evaluated using Global Positioning System (GPS) flight data collected by paragliders during several summer days in July 2023.

The results show that the meteorological model can reasonably reproduce the spatial distribution of thermals, particularly in identifying areas where they are less likely to occur. These findings highlight the potential of high-resolution numerical models for improving thermal forecasting in recreational aviation, with implications for flight planning and safety in non-motorized flight activities.

Modal Decomposition of Multiscale Medicane Dynamics

Christian Natale Gencarelli[1], Leonardo Primavera[2], Giuseppe Ciardullo[2], Jacopo Settino[2], Francesco Carbone[3]

[1]CNR-IGAG, Italy; [2]Physics Department, University of Calabria, Italy; [3]CNR-IIA, Italy

Medicanes are tropical-like storms with growing impacts in the Mediterranean basin. This study examines the multiscale dynamics of two representative events, Qendresa (2014) and Ianos (2020), using high-resolution WRF simulations at 1 km and sensitivity tests on physical parameterizations.

Proper Orthogonal Decomposition (POD) is applied to temperature and wind fields to identify dominant modes, while Empirical Mode Decomposition (EMD) and Hilbert Spectral Analysis (HSA) capture temporal variability and multifractal features. Results show a vertically stratified energy distribution, with stronger coherence in the boundary layer and more isotropic structures in the upper troposphere.

This data-driven approach highlights key mechanisms of rapid intensification and improves understanding of cyclone predictability and mesoscale turbulence in the region.

Identificazione degli schemi di circolazione atmosferica associati ad eventi di grandine nell'Italia settentrionale

Vincenzo Capozzi[1], Alberto Fucci[1], Giorgio Budillon[1], Giannetta Fusco[1], Sante Laviola[2], Elsa Cattani[2], Giulio Monte[2], Enrico Arnone[3], Nicola Cortesi[3], Claudio Cassardo[3]

[1]Dipartimento di Science e Tecnologie, Università degli Studi di Napoli "Parthenope", Napoli, Italia; [2]Instituto di Scienze dell'Atmosfera e del Clima, Consiglio Nazionale delle Ricerche (ISAC-CNR), Bologna, Italia; [3]Dipartimento di Fisica, Università di Torino, Italia

Le grandinate costituiscono uno dei fenomeni meteorologici più impattanti per la società e le attività umane. I cambiamenti climatici stanno modificando i contesti ambientali in cui queste si sviluppano, influenzando fattori cruciali come l'umidità nei bassi strati, l'instabilità convettiva, i processi microfisici e il wind shear verticale. Ciò assume particolare rilevanza nel bacino del Mediterraneo, riconosciuto come un "hotspot climatico" e tra le aree più esposte al rischio di grandine a livello globale. Nonostante l'elevata frequenza e i rischi associati, resta ancora incompleta la conoscenza delle condizioni meteorologiche su scala sinottica che favoriscono lo sviluppo di questi eventi.

In questo studio, basato sulla climatologia satellitare giornaliera delle grandinate proposta da Laviola et al. (2022), sono stati analizzati i principali pattern spaziali estivi di grandine di grandi dimensioni (>2 cm) nell'Italia settentrionale (44.0-47.0°N, 6.0-14.0°E) ed i relativi schemi di circolazione atmosferica associati. Per l'analisi sono state impiegate la Principal Component Analysis e la Cluster Analysis, utilizzando diversi campi atmosferici derivati da rianalisi ERA5. Per garantire coerenza e omogeneità nei dati, l'indagine è stata condotta sul periodo 2014-2023.

I risultati evidenziano che la distribuzione spaziale degli eventi di grandine in Italia settentrionale si organizza in tre clusters principali, ben distinti fra loro. Il primo riguarda prevalentemente il Nord-Est, il secondo interessa soprattutto la Pianura Padana, mentre il terzo è localizzato nel settore nord-occidentale. Gli schemi circolatori associati ai primi due cluster mostrano la presenza di una saccatura sul Mediterraneo occidentale, che convoglia sull'Italia settentrionale un flusso caldo-umido da sud-ovest, accompagnato da un marcato gradiente termico a 850 hPa. Il terzo schema è invece legato a un'area ciclonica sull'Europa occidentale, caratterizzata da un forte contrasto termico sulla Francia e da un intenso flusso sud-occidentale di origine subtropicale verso l'Italia. Tra gli elementi comuni e determinanti in tutti i casi figurano il trasporto anomalo di vapore acqueo tra 2 e 5 km di quota, che favorisce un'elevata disponibilità di acqua liquida per la convezione, e la divergenza dei venti in alta troposfera.

Dal confronto tra i sottoperiodi 2014-2018 e 2019-2023, emerge un aumento significativo del contributo del terzo schema al numero totale di eventi, passato dal 19.6% al 31.8%. Ciò indica un incremento, sia in termini assoluti sia relativi, della frequenza delle grandinate nel Nord-Ovest italiano.

References

Laviola, S.; Monte, G.; Cattani, E.; Levizzani, V. Hail Climatology in the Mediterranean Basin Using the GPM Constellation (1999–2021). Remote Sens. 2022, 14, 4320. https://doi.org/10.3390/rs14174320.

Mechanisms of nitrogen-containing organic matter production in atmospheric aerosols in typical megacities in Myanmar: Coastal and Inland Cities of Yangon and Mandalay as an Example

Ning Zhang[1], Eleonora Aruffo[2], Junfeng Wang[1], Jialiang Feng[3], Alessandra Mascitelli[2], Piero Chiacchiaretta[2], Piero Di Carlo[2]

[1]Nanjing University of Information Science and Technology; [2]Università degli Studi "G. D'Annunzio" – Chieti; [3]Shanghai University

Nitrogen-containing organic compounds (NOCs) represent key light-absorbing components of atmospheric $PM_{2.5}$, yet the sources and formation mechanisms of nitrophenolic species remain unclear. Thirty-six $PM_{2.5}$ samples collected during winter and summer from Yangon and Mandalay, Myanmar, were analyzed using UHPLC–Orbitrap MS. A total of 562–1318 organic compounds (average 1064) were identified in the ESI– mode, with NOCs accounting for 14–21% of molecular numbers and 13–35% of total concentrations.

Nitrophenolic compounds, defined by O/N ≥ 3 and AI > 0.5, were mainly distributed in zones C, F, and G of the Van Krevelen diagram and dominated the aromatic NOC fraction. Two ubiquitous nitrophenols—nitrocatechol ($C_6H_5NO_4$) and dimethylnitrocatechol ($C_8H_9NO_4$)—were detected in all samples and exhibited strong positive correlations, suggesting similar sources and transformation pathways. Their relative abundances showed distinct humidity dependence, with $C_6H_5NO_4$ favored under dry conditions (RH < 50%) and $C_8H_9NO_4$ under humid conditions (RH > 60%).

These findings highlight the significant role of nitrophenolic compounds in brown carbon formation and secondary processes in tropical aerosols, providing key mechanistic insights for subsequent modeling of their humidity-dependent formation pathways.

3:30pm - 4:30pm

OSSERVAZIONI-I

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**
Session Chair: **Piero Di Carlo**
Session Chair: **Silvia Ferrarese**

Enhancing Medicanes’ feature identification: A Deep-learning Automated Warm Core Detection System Based on Microwave Anomaly Scoring

Zelda Ailine Luconi[1], Chinmaya Saran[2], Leo Pio D’Adderio[3], Daniele Casella[3], Paolo Sanò[3], Daniele D’Armiento[3], Stefano Sebastianelli[3], Giulia Panegrossi[3]
[1]Trento University, Trento, Italy; [2]Princeton University, Princeton, NJ, USA; [3]National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Rome, Italy

Medicanes (MEDIterraean HurriCANES) are meteorological events with the potential to cause devastating floods, storm surges, and windstorms, often leading to significant disruption and casualties. During their mature phase, they exhibit phenomenological features typical of tropical cyclones, notably the warm core (WC), a warm area spanning the mid-to-upper troposphere. The critical need for rapid, automated identification of this feature motivates this work.

This study details the development of an automated WC identification system in the context of the ESA MEDICANES project (https://medicanes.isac.cnr.it/) that exploits passive microwave measurements from Low Earth Orbit (LEO) satellites, using four channels within the oxygen absorption band as input. The data corpus for this study was derived from approximately 30,000 satellite overpasses across three instruments from 2000–2020, encompassing 770 Mediterranean cyclones.

The base algorithm is a Convolutional Autoencoder-based Semi-Supervised Anomaly Detection (AE-SAD) model, trained primarily on "normal" (non-WC) atmospheric cases, complemented by a limited set of labelled “anomalies” (WC cases). The model’s efficacy is founded on reconstruction error: normal inputs are reconstructed with minimal error, whereas the distinctive features of WC anomalies are characterized by a significantly higher error, utilized as the anomaly score. Preliminary results suggest the AE-SAD system provides robust differentiation, with high reconstruction error scores reliably flagging WC events.

To rigorously validate the model's performance, accuracy, and overall utility, the study compares systematically the AE-SAD model against a comparative algorithm, quantified using standard metrics such as the F1-score and Area Under the Curve (AUC), implicitly prioritizing Recall, as both metrics reward models that correctly identify the minority class (the rare medicanes). This research is anticipated to provide a critical, automatic tool for the near-real-time identification of medicanes' WC, significantly improving lead time for hazard prediction and risk assessment in the Mediterranean region.

Methane source identification and vertical profiling from hyperspectral infrared satellite observations: a Physics-Informed Neural Network-based inversion approach

Rocco Giosa, Giuliano Liuzzi, Carmine Serio, Pamela Pasquariello, Marco D'emilio, Guido Masiello
University of Basilicata, Italy

Methane (CH_4) monitoring is a global priority for climate mitigation strategies, as highlighted by initiatives such as the Global Methane Pledge. While satellite observations have advanced our ability to quantify methane emissions across scales, current products do not provide information on the vertical distribution of CH_4, a key parameter for identifying emission sources and understanding atmospheric processes. In this context, Physics-Informed Neural Networks (PINNs) offer new opportunities by embedding physical constraints into machine learning models, thereby enhancing both accuracy and efficiency compared to traditional retrieval methods. The PRIN-MVP (Methane Vertical Profiling) project develops a PINN-based approach to retrieve CH_4 vertical profiles from hyperspectral infrared observations. The methodology was trained and tested on about one million synthetic spectra simulated under clear-sky conditions with the σ-IASI/F2N radiative transfer model, supported by auxiliary atmospheric parameters. To optimize the information content, only the most sensitive spectral channels, identified through Averaging Kernel analysis, were retained. Both spectral data and atmospheric profiles were compressed using principal component analysis (PCA). The model was validated using real spectra relating to two case studies: the Mediterranean basin in spring 2025, during episodes of Saharan dust intrusion, and the sabotage of the Nord Stream gas pipeline in the Baltic Sea. Results demonstrate that the PINN-based approach accurately identifies anthropogenic methane emissions and consistently reconstructs vertical profiles of CH_4. This work highlights the potential of PINNs for regional-scale methane monitoring and contributes to the development of innovative tools for atmospheric greenhouse gas analysis. In the future, the model could be extended to CO_2.

Monitoring the Antarctic Ozone Hole with IASI: Simultaneous Retrieval of O_3 and HNO_3 in Cloudy and Clear-Sky Conditions

Guido Masiello[1], **Tiziano Maestri**[2], **Carmine Serio**[1], **Giuliano Liuzzi**[1], **Michele Martinazzo**[2], **Federico Donat**[1], **Lorenzo Cassini**[1], **Rocco Giosa**[1], **Pamela Pasquariello**[1], **Marco D'Emilio**[1], **Raffaele Inglese**[1], **Sara Venafra**[3]

[1]University of Basilicata, Italy; [2]University of Bologna, Italy; [3]Italian Space Agency, Italy

Each austral spring, the Antarctic ozone hole develops and reaches its maximum extent between October and November, before disappearing in December as stratospheric temperatures rise. The seasonal warming inhibits the formation of Polar Stratospheric Clouds (PSCs), which provide the surfaces that catalyze the reactions responsible for ozone destruction. PSCs appear when temperatures fall below 195 K, enabling the condensation of nitric acid and water vapor into crystalline particles (mainly $HNO_3 \cdot 3H_2O$ or NAT). Ozone depletion is routinely monitored from space by UV–visible instruments such as OMI (the Ozone Monitoring Instrument) and TROPOMI (Tropospheric Monitoring Instrument). However, their dependence on reflected sunlight limits their capability during the polar night and under persistent cloudy conditions, typical of the Antarctic winter, when the interior of the continent remains largely unobserved. In addition, these sensors are insensitive to nitric acid and water vapor in the gas phase. Microwave limb sounders, such as MLS/AURA, provide complementary HNO_3 data but at coarse spatial resolution and without information on the thermodynamic state of the Upper Troposphere–Lower Stratosphere (UT/LS). Recent improvements in radiative transfer modeling have made it possible to retrieve temperature, ozone, and nitric acid simultaneously from IASI (Infrared Atmospheric Sounding Interferometer) infrared spectra, even in cloudy scenes. The model we developed is specifically designed to exploit IASI's high spectral resolution, enabling the retrieval of key atmospheric parameters over Antarctica in both clear and cloudy conditions, thus extending observational coverage during the polar night. Analysis of IASI observations from 2021–2023 reveals a deeper and more extended ozone hole than shown by ECMWF analyses that assimilate OMI and TROPOMI data. The results indicate a clear relationship between decreasing HNO_3 concentrations and temperatures below 195 K, confirming the formation of NAT particles. Spatial patterns of HNO_3 retrieved from IASI closely match those from MLS/AURA, highlighting the robustness of our approach in capturing ozone–nitric acid interactions in the cold and cloud-covered Antarctic atmosphere.

Sistema per il confronto continuo tra prodotti di precipitazione: focus sull'area italiana.

Marco Petracca[1], **Alexander Toniazzo**[2], **Nicoletta Roberto**[2], **Silvia Puca**[2]

[1]CNR-ISAC, Rome, Italy; [2]DPC, Rome, Italy

Nell'ambito della convenzione tra il CNR-ISAC e il Dipartimento della Protezione Civile (DPC) è in fase di sviluppo un nuovo strumento per la validazione e il confronto continuo, in near real time (NRT), di diversi prodotti di precipitazione provenienti sia da piattaforme satellitari sia da misure, stime e osservazioni a terra. L'obiettivo principale è fornire un sistema integrato, automatizzato e scalabile in grado di monitorare e valutare in maniera costante l'affidabilità, la qualità e la coerenza dei diversi prodotti disponibili, con particolare enfasi sull'area italiana, dove la complessità orografica e climatica rende particolarmente interessante l'analisi proposta.

La metodologia adottata trae origine dall'esperienza consolidata nel progetto europeo H SAF di EUMETSAT ed è stata ampliata per includere un ventaglio di analisi a diverse scale temporali: dal singolo evento, all'analisi giornaliera, mensile, stagionale e di lungo periodo. Attualmente il sistema integra oltre 20 prodotti di precipitazione provenienti da sensori satellitari, reti pluviometriche e misure radar internazionali e consente di effettuare più di 60 confronti sull'intero globo.

I risultati ottenuti dimostrano le potenzialità dello strumento nell'evidenziare differenze sistematiche, complementarità e criticità tra prodotti, fornendo statistiche dettagliate sui singoli confronti (indici di accuratezza, bias, correlazioni, distribuzioni spaziali e temporali) e una visione d'insieme utile al monitoraggio e alla valutazione comparativa dei prodotti. Tale approccio fornisce al tempo stesso una base solida per attività di calibrazione e miglioramento dei prodotti di stima della precipitazione, oltre che per supportare decisioni operative e strategie di gestione del rischio idro-meteorologico.

L'obiettivo a medio termine è l'ampliamento progressivo del numero di prodotti gestiti e delle tipologie di confronti effettuati, così da costruire un quadro sempre più completo e robusto delle performance dei diversi prodotti di stima delle precipitazioni. L'architettura, concepita come flessibile ed estendibile, potrà essere ulteriormente potenziata con l'integrazione di nuovi dati, metodologie avanzate di confronto basate anche su tecniche di machine learning, e strumenti di visualizzazione interattiva atti a facilitare l'esplorazione e la disseminazione dei risultati verso comunità scientifica, enti istituzionali e utenti finali.

4:30pm - 5:00pm **Coffee Break**

5:00pm - 6:30pm **OSSERVAZIONI-II**

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**

Session Chair: **Piero Di Carlo**

Session Chair: **Silvia Ferrarese**

Ground-Based Investigation of Cloud Properties on the Antarctic Plateau using Infrared Spectral Radiance Data

Elisa Fabbri[1], Tiziano Maestri[1], Federico Donat[1], Michele Martinazzo[1], Guido Masiello[2], Giuliano Liuzzi[2], Luca Palchetti[3], Gianluca Di Natale[3], Massimo Del Guasta[3], Giovanni Bianchini[3]

[1]Università di Bologna, Department of Physics and Astronomy, Italy (IT); [2]University of Basilicata, Department of Engineering, Potenza (IT); [3]Institute of Optics, National Research Council, Firenze

Clouds are a crucial regulator of the Earth's radiation budget (ERB), making the detection and characterization of their properties essential for meteorological research. However, observing clouds in the Antarctic region is challenging: direct in situ data are limited by extreme environmental conditions, while satellites face difficulties in distinguishing clouds from the underlying snow or ice (Cossich et al., 2021). The scarcity of reliable measurements also contributes to the poor representation of Antarctic clouds in General Circulation Models (GCMs), where cloud microphysics parameterizations are often based on mid-latitude or tropical data (Lachlan-Cope, 2010; Bromwich et al., 2012).

This study aims at characterizing in detail the properties of Antarctic clouds by analyzing their seasonal variability and correlation with surface variables, and to develop a parameterization of ice cloud effective dimensions as a function of the thermodynamic conditions of the layer. To achieve this, we use an extensive dataset of spectrally resolved downwelling radiances in the far- and mid-infrared spectral range (200–1000 cm^{-1}), collected by the REFIR-PAD spectroradiometer (Radiation Explorer in the Far Infrared – Prototype for Applications and Development) installed at Concordia Research Station, Antarctica, spanning 2013–2020.

The radiances are processed using the Cloud Identification and Classification (CIC) algorithm (Maestri et al., 2019; Donat et al., 2024) to identify cloud layers and classify their phase (ice or mixed). These spectra are then used as input to the Simultaneous Atmospheric and Cloud Retrieval (SACR) algorithm (Di Natale et al., 2020), which retrieves cloud optical depth, effective dimensions, and atmospheric profiles of water vapor and temperature. Retrievals are further constrained by a-priori information on cloud-base and cloud-top heights, obtained from the Polar Threshold (PT) algorithm (Van Tricht et al., 2014) applied to collocated lidar backscatter profiles.

Results indicate that, despite strong seasonal temperature variations (213–257 K in summer; ~195–245 K in other seasons), the occurrence of both ice and mixed-phase clouds is consistently associated with relatively warmer near-surface air. Seasonal analysis further reveals a pronounced semi-annual cycle in cloud occurrence and ice cloud optical depth, superimposed on the expected annual variability. Finally, a parameterization of ice cloud effective diameters as a function of layer temperature and ice water content is developed and evaluated against existing literature.

LUCE: Present status of the ASI-NASA space lidar mission aimed to disclose the secrets on the coupled atmosphere-ocean-land system

Paolo Di Girolamo[1], LUCE Team[2]

[1]Università degli Studi della Basilicata, Italy; [2]Agenzia Spaziale Italiana, Italy

The LUCE mission, formerly CALIGOLA, is an advanced multi-purpose space lidar mission, exploiting elastic (Rayleigh-Mie), depolarized, Raman and fluorescent lidar echoes from atmospheric and ocean constituents, with a focus on atmospheric and oceanic observation aimed at characterizing the Ocean-Earth-Atmosphere system and the mutual interactions within it. This mission has been conceived by the Italian Space Agency (ASI) with the aim to provide the international scientific community with an unprecedented dataset of geophysical parameters capable of increasing scientific knowledge in the areas of atmospheric, aquatic, terrestrial, cryospheric and hydrological sciences. The Italian Space Agency is partnering with NASA on this exciting new space lidar mission. The mission is planned to be launched in 2032, with an expected lifetime of 3-5 years. Scientific studies in support of the mission are ongoing, commissioned by the Italian Space Agency to University of Basilicata and ISMAR-CNR. A Phase A study, commissioned by the Italian Space Agency to Leonardo S.p.A. and focusing of the technological feasibility of the lidar payload, was carried out starting in October 2022 and has recently bridged into a Phase A/B1 study (kick-off in March 2025). Phase A/B1 activities for the platform and the end-to-end system, commissioned by the Italian Space Agency to Thales Alenia Space, have also started, with kick-off in March 2025. In September 2023, NASA-LARC initiated a pre-formulation study to assess the feasibility of a possible contribution to the LUCE mission focused on development of the detection system and sampling chain and the implementation of data down link capabilities. The pre-formulation study ended in September 2024, and, after a successful Mission Concept Review, a phase A/formulation study started in January 2025. This presentation will provide details on current status and future steps of this groundbreaking multidisciplinary lidar mission.

Far and mid infrared cloud modelling and retrievals

Tiziano Maestri[1], Michele Martinazzo[1], Elisa Fabbri[1], Guido Masiello[2], Giuliano Liuzzi[2]

[1]Physics and Astronomy department "Augusto Righi", Univ. of Bologna; [2]Department of Engineering, Univ. of Basilicata, Potenza

In anticipation of the forthcoming launch of ESA's 9th Earth Explorer, the Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM) satellite, substantial effort is being devoted to the development of advanced algorithms and databases to fully exploit the mission spectrally resolved radiance measurements across the 100–1600 cm-1 interval.

Within this framework, we present recent advances in the sigma-FORUM fast radiative transfer model [Masiello et al., 2024], designed to provide accurate and computationally efficient simulations of FIR radiances under cloudy-sky conditions. A key new feature is the implementation of a temperature-dependent optical property dataset for column aggregate ice particles [Ren et al., 2025], covering the 160–270 K range.

This addition enables a more consistent treatment of the radiative impact of ice clouds in the far-infrared, where sensitivity to ice particle microphysics is significant.

The relevance of the new dataset for the interpretation of FORUM observations is assessed through multiple-scattering simulations of far-infrared outgoing longwave radiation, performed across a range of representative ice cloud conditions.

Finally, the performance of the iota retrieval scheme (Martinazzo, Maestri et al., in prep.), integrating sigma-FORUM with a Tang Chou adjustment scheme [Tang et al., 2019], are evaluated both on simulated and measured cloudy-sky observations from the Infrared Atmospheric Sounding Interferometer, IASI.

The impact of tree canopy cover and imperviousness on air temperature using low cost sensors on public transportation in Rome, Italy

Andrea Cecilia[1], Lorenzo Marinelli[1], Costanza Borghi[2], Giampietro Casasanta[1], Gherardo Chirici[2], Alessandro Conidi[1], Marianna Conte[1], Juri Iurato[3], Igor Petenko[1], Stefania Argentini[1]

[1]National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC); [2]Department of Agricultural, Food, Environmental and Forestry Sciences and Technologies (DAGRI), University of Florence; [3]Iotopon S.R.L.

This study investigates the relationship between Air Temperature (AT), tree canopy cover, and imperviousness in Rome, Italy, using a novel approach based on low-cost sensors mounted on public buses. The system operates autonomously, requiring no on-site personnel, and provides continuous measurements across the entire urban area and at all hours of the day. Data were collected over 53 clear-sky summer days under stable meteorological condi- tions and aggregated onto a 500 m grid after quality control and normaliza- tion. Results show a strong linear correlation between AT and canopy cover during morning hours, with an estimated cooling potential of up to −1.6°C at 100% cover. This effect disappears after the onset of the sea breeze, high- lighting the role of wind in suppressing local cooling. At night, AT exhibits a strong linear increase with imperviousness, with differences up to 3.6°C be- tween fully urbanized and non-urbanized areas. The diurnal cycle of Urban Heat Island (UHI) intensity, derived from the imperviousness-based method, is consistent with theory and previous studies, showing negligible values dur- ing daytime and peaks of 3–4°C at night. By leveraging automated, citywide measurements with low-cost sensors, this study provides new insights into the spatial and temporal variability of urban heat and supports the development of targeted adaptation strategies.

Comparative assessment of High-Performance Naturally-Ventilated Radiation Shields for air temperature measurements

Marcellino Salvador[1], Giuseppe Visalli[1], Sofia Tuzzi[1], Mauro Trevisan[1], Arturo Pucillo[1], Stefano Micheletti[2], Dino Zardi[3,4]

[1]Regional Environmental Agency of Friuli Venezia Giulia (ARPA-FVG); [2]Regional Environmental Agency of Veneto (ARPAV); [3]Department of Civil, Environmental and Mechanical Engineering (DICAM), University of Trento, Italy; [4]Center Agriculture Food Environment (C3A), University of Trento, Italy

Accurate air temperature measurements in environmental monitoring networks are essential for various applications in meteorology, hydrology, climatology and ecology. Hence, manufacturers of weather stations have been continuously introducing new improvements to take advantage of technological progress and achieve precise measurements and, as much as possible, unaffected by spurious effects. However, while electronic temperature sensors have reached very high levels of accuracy and reliability, radiation shields (RS) remain the most critical component affecting measurement quality. In the last decades, following the increasing diffusion of electronic systems worldwide, the traditional Stevenson screens, as well as their American counterpart, the Cotton Regional Shelter (CRS), have been widely replaced either by Passive Radiation Shields (PRSs), i. e. shields that do not include any active device to prevent sensor overheating, or by Forces Aspiration Radiation Shields (FARS), which instead include systems ensuring suitable sensor ventilation. This study presents a field intercomparison of four of the most advanced PRSs commonly used in operational meteorological applications. During eight months (April-November 2024), identical temperature sensors, protected by different shields, were installed in an experimental field in Friuli Venezia Giulia (Italy). The resulting data were compared using objective statistical analyses based on multiple criteria. Results indicate that the BAR-3, while highly responsive, is prone to overcooling in wet conditions and overheating at low solar elevations. The RAD10 offers good moisture protection and balanced performance, particularly in humid climates, but responds more slowly. The SMART provides reliable behavior in most conditions, especially in dry or temperate climates, with good responsiveness and limited moisture retention. The COMET shows the best nighttime performance and strong moisture shielding, but is the most susceptible to daytime overheating and has the lowest responsiveness due to its thermal inertia. Results from this study provide scientific support for the identification of possible new reference instruments for operational air temperature measurements, as far as traditional shelters are no longer a global standard.

Project Hail Hazard in the Mediterranean (H2Med): results and future perspectives

Sante Laviola[1,3], Enrico Arnoe[2], Giorgio Budillon[3], Vincenzo Capozzi[3], Giulio Monte[1], Elsa Cattani[1], Nicola Cortesi[2], Alberto Fucci[3], Giannetta Fusco[3], Claudio Cassardo[2]

[1]CNR-ISAC, Italy; [2]Università di Torino; [3]Università di Napoli Parthenope

How does climate change impact extreme events and which is the future change of their dynamics? How will the ongoing and future changing climate control the evolution and intensification of severe storms? The Hail Hazard in the Mediterranean (H2Med) project tackles these open issues by investigating hailstorms in the Mediterranean region through the synergistic application of satellite observations, meteorological reanalysis and climatic modelling. Extending and refining the preliminary 22-year climatology proposed in Laviola et al. (2022; 2023) at daily scale, the large-scale and mesoscale atmospheric scenarios that trigger

hail events in some regions of the central Mediterranean area are investigated through a cluster analysis using ERA5 reanalysis data. Hail-prone conditions associated with the optimization of a hail-proxy index (based on reanalysis products) are also investigated through the ensemble of climate model projections to outline the future evolution of hail events over the Mediterranean Basin.

The results of this project offer a new paradigm of knowledge and operative tools for better understanding the effects of climate change on hailstorms by using hail-bearing convective systems as a driver for evaluating the potential impact of future changes in the Mediterranean basin. Thus, a new vulnerability map, where past events, current occurrences and future scenarios will be stressed, will be generated to serve the scientific community, operational forecasters, stakeholders such as insurance companies and policymakers.

References

Hail Hazard in the Mediterranean (H2Med) website: https://h2med.isac.cnr.it

Laviola, S., G. Monte, E. Cattani, and V. Levizzani, 2022: Hail climatology in the Mediterranean Basin using the GPM constellation (1999–2021), Remote Sens., 14(17), 4320, https://doi.org/10.3390/rs14174320.

Laviola, S., G. Monte, E. Cattani, and V. Levizzani, 2023: How hail hazards are changing around the Mediterranean, Eos, 104, https://doi.org/10.1029/2023EO230070. Published on 27 February 2023.

8:00pm - 11:00pm **DINNER**

GIOVEDI' 12 febbraio 2026

9:00am - 9:30am

Invited speaker: Prof. Dino Zardi

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**

Investigating multi-scale transport and exchange processes associated with slope winds: the TEAMx 2025 campaign on Monte Baldo.

Dino Zardi[1,2], Francesco Barbano[3], Elena Barbaro[4], Alessandro Bracci[5], Christophe Brun[6], Warren R. L. Cairns[4], Sebastiano Carpentari[1], Massimo Cassiani[1,7], Franz Conen[8], Giulio Cozzi[4], Costanza Di Felice Fabrizi[2,9], Paolo Di Girolamo[10], Luca Di Liberto[5], Davide Dionisi[11], Marco Di Paolantonio[11], Silvana Di Sabatino[3], Giorgio Doglioni[1], Annika Einbock[8], Angelo Finco[12], Giacomo Gerosa[12], Lorenzo Giovannini[1], Riccardo Marzuoli[12], Christian Nardon[1], Ahmed Njimongbet[1], Fedinando Pasqualini[5], Nathan Philippot[6], Davide Plebani[12,13], Davide Poggi[14], Federico Porcù[3], Akanksha Rajput[1], Claudia Rossetti[4], Mira Shivani Sankar[2,15], Donato Summa[16], Nadia Vendrame[2]

[1]Department of Civil, Environmental and Mechanical Engineering (DICAM), University of Trento, Trento, Italy.; [2]Center Agriculture Food Environment (C3A), University of Trento, Trento, Italy.; [3]Department of Physics and Astronomy “Augusto Righi”, University of Bologna, Italy.; [4]Institute of Polar Sciences, National Research Council (CNR-ISP), Italy.; [5]Institute of Atmospheric Sciences and Climate, National Research Council (CNR-ISAC), Italy.; [6]Laboratoire des Écoulements Géophysiques et Industriels (LEGI), Université Grenoble Alpes, France.; [7]Stiftelsen NILU, Kjeller, Norwa; [8]Department of Environmental Sciences, University of Basel, Switzerland.; [9]National Doctoral School in Polar Sciences, University of Venice “Ca' Foscari”, Italy.; [10]Department of Health Sciences (DISS), University of Basilicata, Potenza, Italy.; [11]Institute of Marine Sciences, National Research Council (CNR-ISMAR), Rome, Italy.; [12]Faculty of Mathematical, Physical and Natural Sciences, Catholic University of the Sacred Heart, Brescia, Italy.; [13]Department of Earth and Environmental Sciences, KU Leuven, Belgium.; [14]Department of Environment, Land and Infrastructure Engineering (DIATI), Politecnico di Torino, Italy.; [15]University School for Advanced Studies (IUSS Pavia), Pavia, Italy.; [16]Institute of Methodologies for Environmental Analysis, National Research Council (IMAA-CNR), Tito Scalo, Italy.

Atmospheric transport processes over mountainous terrains are intrinsically affected by a variety of landforms, surface covers, atmospheric stability situations and interactions among different airflows, typical occurring on multiple space and time scales. Our understanding of the interplay of such factors is still far from being fully understood. In particular, the peculiar properties of atmospheric turbulence controlling the exchanges of momentum, heat and mass between the land surface, the atmospheric boundary layer and upper levels are still largely unexplored.

As a contribution to filling these gaps, the research project DECIPHER implemented observational and modelling actions aimed at disentangling mechanisms controlling atmospheric transport and mixing processes over mountain areas at different space- and timescales, in the framework of the larger international research effort TEAMx (Serafin et al. 2018, Rotach et al. 2021).

As part of the project, field measurements were performed at selected areas to investigate transport and exchange processes associated with thermally-driven slope winds and other local winds, and their connections with various ambient and weather conditions.

In particular, an intensive field campaign was organised over an east-facing steep slope of Monte Baldo (45°39'56.0"N, 10°49'10.9"E), an approximately north-south oriented mountain range in the Southern Alps. Several different instruments were operated from mid-June to mid-October 2025 to cover atmospheric processes at different scales. Turbulent processes were monitored through multi-level flux towers installed at different elevations, along with thermohygrometers distributed along the slope to capture the vertical structure of the ambient atmosphere. Mass and optical sensors monitored concentrations and properties of particulate matter. The 3-D structures of local along- and cross-slope winds and vertical temperature profiles were also observed with multiple wind lidars based at different points. Moreover, tropospheric profiles were obtained from a tethered balloon and a Raman lidar. Further non-conventional measurements included high-frequency profiling of turbulence near the surface and distributed soil moisture monitoring using a cosmic-ray neutron sensor.

Preliminary outcomes from the analysis of the resulting huge dataset allow for identifying interesting patterns of local circulations and their connections with turbulence structure, as well as with the surrounding flow and stability conditions, under different weather situations.

Besides research achievements, DECIPHER was also a remarkable and unique opportunity to consolidate relationships of scientific cooperation among the numerous partners involved, and to successfully test new observational techniques and logistic solutions for the nontrivial deployment of such a major field campaign. Hence it contributed to build-up It was a great opportunity for growing a scientific community characterised by complementary expertise, a remarkable amount of personnel involved, and the numerosity and diversity of instruments enabled to plan and perform the unusual effort adequate for phenomena, whose complexity would not be captured with any fewer instruments. Buildup of a scientific community

References

Rotach, M.W., Serafin, S., Ward, H.C., Arpagaus, M., Colfescu, I., Cuxart, J., De Wekker, S.F.J., Grubišic, V., Kalthoff, N., Karl, T., Kirshbaum, D.J., Lehner, M., Mobbs, S., Paci, A., Palazzi, E., Bailey, A., Schmidli, J., Wittmann, C., Wohlfahrt, G. and Zardi, D. (2022): A collaborative effort to better understand, measure and model atmospheric exchange processes over mountains. Bulletin of the American Meteorological Society. https://doi.org/10.1175/BAMS-D-21-0232.1

Serafin, S., Adler, B., Cuxart, J., De Wekker, S.F.J., Gohm, A., Grisogono, B., Kalthoff, N., Kirshbaum, D.J., Rotach, M.W., Schmidli, J., Stiperski, I., Večenaj, Ž. and Zardi D. (2018): Exchange Processes in the Atmospheric Boundary Layer Over Mountainous Terrain. Atmosphere, 9, 102. https://doi.org/10.3390/atmos9030102

9:30am - 11:00am

PROCESSI-I
Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**
Session Chair: **Giacomo A. Gerosa**
Session Chair: **Patrizia Favaron**

Fiumi atmosferici nel Mediterraneo ed eventi meteo-idrologici estremi sul centro-nord Italia

Silvio Davolio[1,2], Isacco Sala[1], Alessandro Comunian[1], Daniele Mastrangelo[2], Sante Laviola[2], Giulio Monte[2], Barbara Tomassetti[3], Annalina Lombardi[3,4], Marco Verdecchia[4], Federico Grazzini[5], Valentina Colaiuda[6]

[1]Dipartimento di Scienze della Terra, Università di Milano, Milano, Italy; [2]Istituto di Scienze dell'atmosfera e del clima, Consiglio Nazionale delle Ricerche, (ISAC-CNR), Bologna, Italia; [3]Centro di Eccellenza CETEMPS, Università dell'Aquila, Coppito (L'Aquila), Italia; [4]Dipartimento di Scienze Fisiche e Chimiche, Università dell'Aquila, Coppito (L'Aquila), Italia; [5]ARPAE Servizio IdroMeteoClima, Bologna, Italia; [6]Agenzia Regionale di Protezione Civile – Regione Abruzzo, L'Aquila, Italia

Studi recenti di eventi di precipitazioni estreme e alluvioni che hanno interessato l'Italia centro-settentrionale e l'area alpina in particolare hanno rivelato che oltre al contributo locale dovuto all'evaporazione dal Mar Mediterraneo, una quantità rilevante di umidità può giungere da regioni remote per mezzo di un intenso trasporto confinato all'interno di corridoi lunghi e stretti, noti come fiumi atmosferici.

Il progetto nazionale ARMEX, finanziato nell'ambito PRIN2022 dal Ministero dell'Università e della Ricerca, ha l'obiettivo di esplorare i fiumi atmosferici nel Mediterraneo e la loro connessione con eventi idrometeorologici estremi sull'Italia. Il progetto coinvolge competenze sia nella modellistica meteorologica e idrologica, sia nel monitoraggio da satellite. Vengono qui presentati alcuni risultati del progetto.

Utilizzando le rianalisi ERA5 e il dataset di precipitazioni ArCIS, e applicando un algoritmo di identificazione, opportunamente adattato alla peculiare e complessa morfologia della regione, è stato possibile evidenziare le principali caratteristiche climatologiche dei fiumi atmosferici nel Mediterraneo e la loro connessione con eventi idrometeorologici estremi sul centro-nord Italia dal 1960 ad oggi. Inoltre, attraverso l'analisi di diversi casi studio, simulazioni numeriche ad alta risoluzione hanno dimostrato che la presenza di un intenso fiume atmosferico – proveniente dalle aree tropicali dell'Africa o dall'Atlantico – rappresenta un elemento distintivo degli eventi estremi. Gli esperimenti modellistici hanno permesso di investigare le caratteristiche, i meccanismi dinamici e gli impatti dei fiumi atmosferici, i quali si sono rivelati un ingrediente fondamentale per il verificarsi di precipitazioni estreme. Infine, si sta esplorando la predicibilità a scala sub-stagionale di eventi estremi caratterizzati dalla presenza di fiumi atmosferici.

Bridging Scales in Urban Climate Modelling: A Multisource Analysis of Thermo-Hygrometric Dynamics in the Coastal City of Bari, Italy

Gianluca Pappaccogli[1], Andrea Zonato[2], Alberto Martilli[3], Riccardo Buccolieri[1], Piero Lionello[1]

[1]DiSTeBA - Univ of Salento, Lecce, Italy; [2]CIMA Research Foundation, Savona, Italy; [3]Environmental Department, CIEMAT, Madrid, Spain

The thermal and moisture regimes of coastal cities arise from the interplay between mesoscale atmospheric circulations and local urban form, creating highly heterogeneous microclimates that directly affect heat exposure, energy demand, and outdoor comfort. This study presents an integrated multi-source approach to evaluate thermo-hygrometric variability in Bari (southern Italy), a representative Mediterranean coastal city characterized by strong land–sea interactions. The analysis combines in situ observations, remote-sensing data, and urban-canopy modelling to disentangle the relative roles of mesoscale forcing and microscale heterogeneity. Eight canyon-level sensors were deployed across districts with distinct morphology, vegetation density, and distance from the coastline, continuously monitoring air temperature and, at five sites, relative humidity during the summer of 2023. These measurements were complemented with high-resolution ECOSTRESS land-surface-temperature (LST) data and numerical simulations from the Multi-Layer Urban Canopy Model (MLUCM BEP+BEM) driven by ERA5 reanalysis. Morphological and radiative parameters around each site were quantified within a 500 m radius following the Local Climate Zone (LCZ) classification. Statistical analyses based on repeated-measures ANOVA quantified temporal and spatial variability in air temperature and humidity, enabling a robust assessment of the significance of observed differences. Results show that nocturnal temperature differences across Bari are relatively limited (< 2 °C), while after sunrise, the development of a sea–land-breeze circulation induces marked divergence among sites. Inland neighbourhoods warm and dry rapidly, reaching up to 5–6 °C higher air temperatures than coastal areas, which remain moderated by maritime ventilation. Conversely, relative humidity exhibits an inverse pattern, increasing along the coastline and decreasing inland. Evening cooling is slower in dense central districts due to greater heat storage, a pattern also captured by ECOSTRESS LST data. These findings highlight the dual control exerted by mesoscale dynamics and local morphology, with compact built-up zones and impervious surfaces amplifying daytime heat accumulation and delaying nocturnal release. Simulations with MLUCM BEP+BEM reproduce the observed intra-urban variability with notable accuracy, outperforming ERA5 near-surface reanalysis fields. Model-sensitivity tests demonstrate that the choice of boundary forcing significantly affects MLUCM BEP+BEM performance: sea-based forcings yield the best agreement near the coastline, while interpolated configurations perform better inland. Across all scenarios, the model captures microscale-driven variability of comparable magnitude to mesoscale contributions, confirming its suitability for reproducing canopy-layer processes under different urban and meteorological conditions. Overall, this research demonstrates that integrating mesoscale and microscale datasets provides a coherent framework for interpreting the spatial structure of thermal and moisture fields in coastal cities. The multi-source methodology—combining field measurements, satellite observations, and a physics-based urban-canopy model—offers a transferable approach for diagnosing urban heat exposure and informing climate adaptation. In particular, the MLUCM BEP+BEM model proves effective in distinguishing coastal–inland gradients and quantifying the influence of urban form and land cover on local climate. These results

underscore the need for multiscale assessments to support energy-efficient urban design, improve outdoor comfort, and enhance resilience strategies in Mediterranean coastal environments increasingly exposed to heat stress and climate change.

Acknowledgements: This work is supported by ICSC – Centro Nazionale di Ricerca in High Performance Computing, Big Data and Quantum Computing, funded by European Union – NextGenerationEU (CUP F83C22000740001).

Reference: Pappaccogli, G., Zonato, A., Martilli, A., Buccolieri, R., and Lionello, P.: MLUCM BEP+BEM: An offline one-dimensional Multi-Layer Urban Canopy Model based on the BEP+BEM Scheme, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-219, 2025.

The uRban hEat and pollution iSlands inTerAction in Rome and possible miTigation strategies (RESTART) project: final outcomes and lessons learned

Annalisa Di Bernardino[1], Erika Brattich[2], Stefania Argentini[3], Monica Campanelli[3], Giampietro Casasanta[3], Andrea Cecilia[3], Silvana Di Sabatino[2], Margherita Erriu[1], Andrea Faggi[2], Serena Falasca[1,4], Tiziano Maestri[2], Anna Maria Siani[1]

[1]Dipartimento di Fisica, Sapienza Università di Roma; [2]Dipartimento di Fisica "Augusto Righi", Università di Bologna; [3]CNR, Istituto di Scienze dell'Atmosfera e del Clima (ISAC); [4]Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo sostenibile (ENEA)

The project *"Urban hEat and pollution iSlands inTerAction in Rome and possible mitigation strategies" (RESTART)*, funded by the Italian Ministry of University and Research within the PRIN program, investigates the interplay between the Urban Heat Island (UHI) and the Urban Pollution Island (UPI) in Rome over the period 2019-2024. At its concluding stage, the project provides new insights into the drivers and feedbacks linking these phenomena and proposes tailored Nature-Based Solutions (NBS) to improve urban liveability and resilience.

High-temporal resolution meteorological and air quality observations from monitoring networks and international observatories were analysed to assess the current state of UHI and UPI and their links under different meteorological conditions. The analysis confirms that their interaction is strongly modulated by meteorological conditions, with combined effects intensifying during heatwaves and calm wind days.

To capture these dynamics, RESTART employed an innovative multiscale modelling framework that couples the Weather Research and Forecasting (WRF) mesoscale model with the ADMS-Urban dispersion model. This chain proved effective in reproducing spatial patterns of meteorological variables and pollutant concentrations, and in evaluating the role of NBS under both current and mitigation scenarios.

In this contribution, the science-based recommendations derived from the project will be discussed. Specifically, the outcomes emphasize the potential of NBS (i.e., urban greening and tree planting) to simultaneously mitigate heat stress and pollution accumulation. By combining high-quality monitoring data with advanced numerical simulations, RESTART contributes to the design of tailored, evidence-based mitigation strategies supporting sustainable and climate-resilient urban planning.

To conclude, the integrated observation–modelling approach developed in RESTART represents not only a valuable decision-support tool for the city of Rome, but also a transferable methodology applicable to other urban areas facing similar climate and air quality challenges.

Micro e nano plastica in atmosfera: una componente irrisolta del sistema aerosol

Silvia Bucci, Ioanna Evangelou, Andreas Stohl

University of Vienna, Austria

Le micro- e nanoplastiche (MNP) stanno emergendo come una nuova e pervasiva componente degli aerosol atmosferici, ma le loro origini, i meccanismi di trasporto e il destino finale nell'atmosfera rimangono in gran parte sconosciuti. A differenza delle particelle aerosol convenzionali, esse derivano da una complessa combinazione di sorgenti continentali, marine e secondarie, e il loro comportamento fisico dipende in modo critico da dimensioni, forma e tipo di polimero. Nonostante la crescente attenzione scientifica, i dati osservativi disponibili sono ancora scarsi e frammentari, raccolti in ambienti eterogenei e mediante metodologie analitiche non uniformi, rendendo difficile ottenere una visione coerente e comparabile del fenomeno.

In questo lavoro vengono analizzate le possibili sorgenti e traiettorie di trasporto atmosferico delle MNP, con l'obiettivo di identificare i processi dominanti che ne controllano la variabilità spaziale e temporale. A partire da osservazioni provenienti da ambienti urbani, suburbani, montani e nuvolosi, lo studio combina l'utilizzo dell'ultima versione del modello di dispersione lagrangiano FLEXPART v11 (adattato per le MNP) con una analisi statistica multi livello, basata su correlazioni e modelli di regressione multipla, per esplorare le relazioni tra le concentrazioni osservate e un insieme di proxy su larga scala rappresentativi delle diverse sorgenti potenziali (suoli agricoli e aridi, aree popolate, spray marino), considerando differenti età di trasporto atmosferico (1–45 giorni).

I risultati indicano che gli indicatori antropici e continentali (popolazione, aree irrigate) presentano correlazioni positive e persistenti soprattutto a brevi tempi di trasporto, mentre le sorgenti a più lungo raggio sembrano essere legate a emissioni di tipo marino e da zone aride. I modelli di regressione evidenziano driver regionali eterogenei e il potenziale contributo del trasporto a lunga distanza evidenziato dai siti montani.

Nel complesso, i risultati dimostrano che, pur in presenza di forti limitazioni osservazionali, è possibile estrarre segnali fisicamente coerenti, fornendo nuove evidenze sui processi che governano la presenza e la trasformazione delle MNP nell'atmosfera, e sottolineando la necessità di miglioramenti nelle tecniche di osservazione e di una maggiore copertura spaziale dei dati.

Characterizing compound floods in Emilia Romagna by pooling precipitation and soil moisture seasonal ensemble re-forecasts

Antonio Giordani[1,2], **Elena Bianco**[1], **Paolo Ruggieri**[1], **Silvana Di Sabatino**[1]
[1]University of Bologna; [2]Agenzia ItaliaMeteo

The rising frequency and severity of compound hydro-meteorological extremes underscore the urgent need to better understand their dynamics and occurrence. Compound events, involving concurrent or sequential natural hazards, often lead to amplified impacts compared to individual events. A recent striking example is the exceptional sequence of heavy rainfall in northern Italy (2023–2024), which triggered widespread flooding in Emilia-Romagna. Flood severity and extent were compounded by prior soil saturation resulting from earlier rainfall, illustrating how antecedent conditions can exacerbate impacts. However, the rarity and unprecedentedness of such events limits their representation in observational records owing to their limited temporal coverage, hence posing substantial challenges for robust statistical characterization. To overcome this, the UNSEEN (Unprecedented Simulated Extremes using ENsembles) approach has recently emerged. UNSEEN is employed by pooling large ensembles of seasonal re-forecasts from numerical weather prediction models to create synthetic time series spanning thousands of years. This enables the analysis of low-probability, high-impact events and the investigation of their dynamical features within a statistically robust framework.

This study applies the UNSEEN methodology to compound flood events within a multivariate framework, focusing on the interaction between precipitation and soil moisture as a key preconditioning driver. Seasonal re-forecasts from the SEAS5 dataset (ECMWF) over 1994-2023 are considered to characterize unprecedented compound floodings in Emilia Romagna. As a first step, the UNSEEN ensemble's ability to represent univariate extremes is assessed to ensure the reliability of the pooled surrogate time series. The surrogate series is then analyzed to distinguish precipitation extremes occurring with and without soil-moisture pre-conditioning, enabling a detailed assessment of their interaction and the associated hydrological responses within the regional river catchments. Results indicate that the UNSEEN ensemble realistically reproduces historical extreme flood events, offering a more robust characterization than observational records alone. Additionally, the river discharge response further differentiates the two event classes, with pre-conditioned events consistently leading to higher river levels, underscoring the amplifying role of antecedent soil moisture to the hydrological system. These findings highlight the value of ensemble-based approaches for better understanding rare compound events and informing more effective adaptation and mitigation strategies in flood-prone areas.

Energetics and Predictability of the Mediterranean Tropical-like Cyclone Ianos through the Moist Static Energy Budget Framework

Paolina Bongioannini Cerlini[1], **Miriam Saraceni**[2], **Lorenzo Silvestri**[3]
[1]Università degli studi di Perugia, Italy; [2]CIRIAF-UNIPG; [3]Università di Modena e Reggio Emilia

Medicanes are high-impact cyclones whose frequency may decline but whose strongest events may intensify in a warming Mediterranean (Romero et al., 2017; Tous et al., 2016). Medicane Ianos (September 2020) stands out as the strongest event on record, causing severe flooding and coastal damage across the Ionian Sea.

We analyze Medicane Ianos using a vertically integrated Moist Static Energy (MSE) variance budget as a process-based diagnostic of convective–dynamical coupling. ERA5 fields are tracked objectively, phases are classified in Hart phase space, and the budget is evaluated over ~2.5×10^5 km^2 along the storm's track. The intensification of Ianos is explained by a delicate balance between vertical moistening and horizontal advection, with surface latent-heat fluxes and radiative tendencies reinforcing the MSE build-up during the mature stage. The energy structure is tropical-like within ~600 km of the center during peak intensity, supporting medicane classification (Flaounas at al., 2022).

We extend this framework by using MSE variance as a convective metric across ensembles to link energetics to track and phase uncertainty. With the ECMWF IFS ensemble with perturbed physical parameterizations, forecast spread in trajectories and transition timing correlates with early-time MSE-tendency components and with the interaction between upper-level PV streamers and near-surface thermodynamic disequilibrium (Saraceni et al., 2023, ACP). This combined approach—MSE-budget + ensemble diagnostics—clarifies when medicanes behave more "tropical-like" (dominant convective moistening) versus "subtropical" (strong baroclinic/advection control), informing the ongoing classification debate.

References

Saraceni, M., Silvestri, L., & Bongioannini Cerlini, P. (2025). Analyzing the Mediterranean Tropical-like Cyclone Ianos Using the Moist Static Energy Budget. *Atmosphere*, 16(5), 562. https://doi.org/10.3390/atmos16050562

Saraceni, M., Silvestri, L., Bechtold, P., & Bongioannini Cerlini, P. (2023). Mediterranean tropical-like cyclone forecasts and analysis using the ECMWF ensemble forecasting system with physical parameterization perturbations. *Atmospheric Chemistry and Physics*, 23, 13883–13909. https://doi.org/10.5194/acp-23-13883-2023

Flaounas, E., Davolio, S., Raveh-Rubin, S., Pantillon, F., Miglietta, M. M., Gaertner, M. A., Hatzaki, M., Homar, V., Khodayar, S., Korres, G., *et al.* (2022). Mediterranean cyclones: Current knowledge and open questions on dynamics, prediction, climatology and impacts. *Weather and Climate Dynamics*, 3(1), 173–208. https://doi.org/10.5194/wcd-3-173-2022

Romero, R., Gaertner, M. A., Sánchez, E., Domínguez, M., González-Alemán, J. J., Miglietta, M. M., Walsh, K. J., Gil, V., Padorno, E., Picornell, M. A., & Romero, R. (2017). Climate change projections of medicanes with a large multi-model ensemble of regional climate models. *Global and Planetary Change*, 151, 134–143. https://doi.org/10.1016/j.gloplacha.2016.10.008

Tous, M., Romero, R., & Ramis, C. (2016). Projected changes in medicanes in the HadGEM3 N512 high-resolution global climate model. *Climate Dynamics*, 47(3–4), 1357–1372. https://doi.org/10.1007/s00382-015-2901-7

11:00am - 11:30am **Coffee Break**

11:30am - 12:15pm

PROCESSI-II

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**
Session Chair: **Giacomo A. Gerosa**
Session Chair: **Patrizia Favaron**

Multi-model high-resolution analysis of Tropical-Like Cyclone Daniel with WRF and ICON: peculiarities and sensitivity to cumulus parametrizations.

Piero Serafini[1,2], Antonio Ricchi[1,2], Chiara Marsigli[3], Renata Pelosini[4,5], Rossella Ferretti[1,2]
[1]University of L'Aquila (UNIVAQ); [2]Center of Excellence in Telesensing of Environment and Model Prediction of Severe Events (CETEMPS); [3]Agenzia Regionale per la Protezione Ambientale Emilia-Romagna (ARPAE); [4]Agenzia Nazionale per la Meteorologia e Climatologia (ItaliaMeteo); [5]Agenzia Regionale per la Protezione Ambientale Piemonte (ARPA Piemonte)

A comparative study of Medicane Daniel (September 2023) is performed using two high-resolution models, WRF and ICON, both configured at ~2 km spatial resolution with comparable domains, timesteps, boundary forcing and settings. A custom optimizer harmonizes the vertical levels discratization and sensitivity experiments test different cumulus parametrizations: fully explicit, shallow-convection, deep-cumulus parameterized and ICON's gray-zone option. Diagnostics include an objective tracker combining mean sea-level pressure and lower-tropospheric geopotential, alongside intensity metrics (central pressure and 10 m wind), precipitation patterns and point validation at Benina (HLLB) for pressure, wind and rainfall. Structural evolution is assessed through Hart's Cyclone Phase Space (CPS) and a novel Temporal Annular Symmetric Mean (TASM), describing the three-dimensional storm structure during its warm-core phase. Both models reproduce Daniel's track, lifecycle and tropical-like features. Explicit convection deepens the cyclone and sharpens wind maxima, but enhances small-scale variability that complicates tracking. Deep-cumulus schemes weaken extremes and broaden rainfall, while shallow-convection options provide a balance, improving precipitation placement and core thermodynamics. Model internal differences also influence results: ICON shows lower efficiency in transferring diabatic heating upward, producing a shallower warm core, whereas WRF tends to generate a stronger vortex to better retain tropical-like characteristics. CPS and TASM consistently indicate a shallow-to-deep warm-core transition and a compact, symmetric structure at peak intensity. Overall, the study highlights the importance of harmonized configurations and suggests that, at gray-zone resolutions, shallow-convection treatments often offer a good compromise for simulating Mediterranean tropical-like cyclones.

The peculiarities of Ianos among Mediterranean tropical-like cyclones

Daniele Nigro[1,3], Lorenzo Giovannini[1,2], Simona Bordoni[1,2], Stavros Dafis[4], Mario Marcello Miglietta[5]
[1]Center Agriculture Food Environment, University of Trento, Trento, Italy; [2]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy; [3]Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo (INGV-OE), Catania, Italy; [4]National Observatory of Athens, Institute for Environmental Research and Sustainable Development, Athens, Greece; [5]nstitute of Atmospheric Sciences and Climate, National Research Council of Italy, CNR-ISAC, Padua, Italy

We analyze 17 Mediterranean cyclones with tropical characteristics using ERA5 reanalysis data to investigate the role of upper-tropospheric processes and their seasonal variations in cyclone development. Our results show that cyclones occurring in September exhibit the strongest moist convection, with Ianos, one of the strongest medicanes on record, representing an extreme case. The development of the warm core is anticorrelated with the value of upper-tropospheric potential vorticity (PV) and correlated with lower tropospheric PV associated with latent heat release. Using back-trajectories analysis, we then investigate the presence of dry intrusions in the early and mature cyclone phases. We show that the Lagrangian definition of dry intrusion, characterized by a descent of 400 hPa in 48 hours, is not satisfied in most of the cyclones considered here. Instead, weaker PV streamers with shallower descent are often observed before cyclogenesis. While a dry intrusion may reduce static stability and intensify convection, leading to an accelerated warm core formation, the eventual warm core intensity appears to depend critically on pre-existing convection and diabatic heating in a close vicinity of the cyclone center. This is the case for Medicane Ianos. In fact, this cyclone presents two marginally descending flows of about 200 hPa in 60 hours associated with shallow PV streamers, one in the early stage and one before the main tropical-like phase. Despite the modest intensity of the PV streamer, Ianos develops the strongest warm core among all cyclones. This motivates us to examine Ianos in detail using a WRF simulation with a grid spacing of 3 km. The simulation confirms the need for a high-resolution model setup to correctly represent the cyclone intensity and capture key mesoscale mechanisms and the dominant contribution of diabatic heating to the cyclone deepening.

A multi-model approach to wet-snow load forecasting on power lines: advances of the WOLF system

Bruno Vitali, Riccardo Bonanno, Matteo Lacavalla

Ricerca sul Sistema Energetico spa, Italy

Wet-snow events are a major cause of severe winter outages in the Italian high- and medium-voltage power networks, due to the accumulation of ice and snow on overhead conductors. It is estimated that, in Italy alone, the annual economic impact of these events exceeds 200 million euros.

To address this issue, RSE initiated a research program more than a decade ago that led to the development of an operational alert system for snow accumulation on overhead lines. The system, known as WOLF (Wet-snow Overload aLert and Forecasting), is designed to forecast wet-snow loads on overhead lines during snowfall events and to provide timely warnings to Italian TSOs and DSOs, enabling them to implement appropriate measures to ensure the reliability and continuity of electricity transmission and distribution. WOLF integrates precipitation and temperature fields from the WRF model with the Makkonen accretion model, which estimates the growth of snow load on a reference conductor in each domain grid cell as a function of the prevailing meteorological conditions.

Over the past ten years, observations collected at the WILD (Wet-snow Ice Laboratory Detection) monitoring station, located in the Cuneo Alps, have supported the refinement of both meteorological forecasting models and snow-sleeve accretion models. Previous case studies have shown that the primary sources of uncertainty in snow-load forecasts stem from the intrinsic limitations of the meteorological fields simulated by the NWP models used to drive the accretion model. Sensitivity analyses performed using different model configurations and global drivers revealed variable performance, without identifying a single optimal setup across the analyzed snowfall events.

The recent availability of NWP model outputs from multiple providers through the Italian open-data hub Mistral (https://meteohub.mistralportal.it/app/datasets) offers new opportunities to address these limitations. In this work, the potential benefits of a multi-model approach are assessed by combining snow-load forecasts derived from different meteorological simulations and by exploring probabilistic post-processing techniques for wet-snow prediction. The results, validated against observations from recent snowfall events in the Alpine region, indicate that this approach is promising. Further research is planned, including evaluation over a larger set of case studies, with the aim of reducing the forecast uncertainty of the WOLF system starting from upcoming winter seasons.

12:45pm - 1:15pm

Invited speaker: Prof. Mirko Piersanti

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**

Space weather as the consequence of Solar Coronal mass Ejection impact on the circumterrestrial environment

Mirko Piersanti[1,2], Giulia D'Angelo[1,3]

[1]Dpt. Of Physical and Chemical Sciences, University of L'Aquila; [2]National Institute of Astrophysics, IAPS, Rome, Italy.; [3]INFN – Sezione di Roma "Tor Vergata", Rome, Italy.

The Solar Wind-Magnetosphere-Ionosphere coupling constitutes an important subject of scientific interest, in particular in the Space Weather context. Briefly, in this process, the energy is transferred from the solar wind to the magnetosphere by means of both the magnetic reconnection at the dayside magnetopause and the viscous-like interaction generated by micro or macro instabilities. On the other hand, the magnetosphere and the ionosphere, strictly connected through the magnetic field lines, can exchange energy and momentum, basically, through three main processes: (1) the transmission of electric fields, (2) the flows of electric charges by means of Field Aligned Current (FAC) and (3) the precipitation and/or outflow of particles. In this work, we study some aspects of the interaction of the interplanetary coronal mass ejections (ICME) of September 6-11, 2017 event with the magnetosphere-ionosphere system. In particular, we analyze the response of the magnetosphere to the impact of the interplanetary shock preceding the ICME, the magnetospheric and the ionospheric disturbance currents, and the geomagnetically induced currents (GIC) that developed over the entire northern hemisphere.

1:15pm - 1:45pm

CLOSURE

Location: **Aula Magna - Centro Paolo VI - Via Gezio Calini 30**