MetMed

10th International Conference on Meteorology and Climatology of the Mediterranean

Toulouse (France) 19-21 May 2025

Book of Abstracts

Organization

CNRM

METEO FRANCE

ACAM
Associació Catalana de Meteorologia

Support

Tethys
Revista de meteorologia y climatologia mediterrània

UIB Universitat de les Illes Balears

UIBCongres[1]
[1] Organització de Congressos Fundació Universitat-Empresa de les Illes Balears

HI LIAISE

AGENCE NATIONALE DE LA RECHERCHE
ANR

cnrs

General Information

Location of the Meeting

Météo-France, Centre International de Conférences, 42, avenue Gaspard Coriolis
31057 Toulouse cedex 1 (France)

Organization

Météo-France, Centre National de Recherches Météorologiques (CNRM), Associació Catalana de Meteorologia (ACAM)

Support

Tethys, Journal of Mediterranean Meteorology & Climatology; University of the Balearic Islands (UIB); UIBcongrés; HILIAISE project (Agence nationale de la recherché); CNRS

Chair of the conference

A. Boone (Météo-France, France)
M.A. Jiménez (University of Balearic Islands, Spain)
P. Le Moigne (Météo-France, France)

Scientific Committee

Marta Alarcón (Universitat Politènica de Catalunya, Spain)
Aaron Boone (CNRM/MeteoFrance/CNRS, France)
Joan Bech (University of Barcelona, Spain)
Martin Best (Metoffice, UK)
Clement Brochet (CNRM/MeteoFrance/CNRS, France)
Silvio Davolio (CNR-ISAC/Università di Milano, Italy)
Oscar Hartogensis (Wageningen University, The Netherlands)
Lionel Jarlan (CESBIO, France)
Maria A. Jiménez (University of the Balearic Islands, Spain)
Patrick Le Moigne (CNRM/MeteoFrance, France)
Jordi Mazón (Technical University of Catalonia/ACAM, Spain)
Juan Pedro Montávez (University of Murcia, Spain)
Raquel Niclos (University of Valencia, Spain)
Laure Raynaud (CNRM/MeteoFrance, France)
Romualdo Romero (University of the Balearic Islands, Spain)
Maja Telišman-Prtenjak (University of Zagreb, Croatia)
Dino Zardi (University of Trento, Italy)

Organizing Committee

A. Boone (Météo-France, France)
M.A. Jiménez (University of Balearic Islands, Spain)
P. Le Moigne (Météo-France, France)

Table of contents

Openning talk: Drivers of climate variability and change in the Western Mediterranean

Francisco J. Doblas Reyes

General Earth Sciences, Barcelona Supercomputing Center

The Western Mediterranean is experiencing an accelerated rate of warming compared with the rest of the planet. This is also an area where climate projections for the rest of the Century tend to agree in indicating warmer temperature increase than the global mean and a tendency towards reduced average precipitation and increased precipitation extremes. This current reality and the climate projections suggest an increased vulnerability of both climate-sensitive socioeconomic systems and ecosystems in the area. However, there is less information about the drivers of these climatic changes and the trustworthiness of the sources of climate information available for climate adaptation and climate-related risk assessment. This presentation will describe the current sources of climate projections for the Western Mediterranean, the emergence of complementary sources, the role of climate attribution of both observed trends and extreme events, and some of the atmospheric circulation mechanisms that play a role in the spread of possible climate futures for the region. The presentation will include a discussion with examples of the role of climate services for adaptation, mitigation, and risk assessment to allow Western Mediterranean societies and ecosystems to become more resilient towards current and future climate changes.

S1. Climatology

Invited talk: Mediterranean precipitation has remained largely stable over time, primarily influenced by the natural variability of atmospheric circulation

Sergio Vicente Serrano

Instituto Pirenaico de Ecología, Consejo Superior de Investigaciones Científicas (IPE-CSIC), Zaragoza, Spain, Laboratorio de Climatología y Servicios Climáticos (LCSC), CSIC–Universidad de Zaragoza

While advanced climate models predict a significant reduction in future rainfall across the region, recent observational studies also indicate decreasing precipitation levels, often attributed to human-induced climate change. However, other researchers emphasize the considerable variability in Mediterranean precipitation driven by atmospheric circulation patterns, suggesting long-term stability. Given these differing perspectives, a comprehensive assessment of precipitation trends is necessary, incorporating high-quality, densely distributed observational data and comparisons between climate model simulations and historical records.

To address this issue, we leveraged a dataset from over 23,000 precipitation stations, compiled through a collaborative effort across the Mediterranean region. This two-year initiative resulted in an unprecedentedly detailed dataset, allowing for a highly accurate representation of precipitation evolution in both historical and high-resolution spatial contexts. The dataset underwent rigorous quality control, reconstruction, and homogeneity adjustments, ensuring reliability. Additionally, we overcame data-sharing restrictions imposed by some national meteorological organizations through an innovative software-sharing approach, enabling broader access to the underlying information.

Using non-parametric statistical methods, we analyzed annual and seasonal precipitation trends over the long term, isolating the influence of atmospheric circulation by considering key regional atmospheric indices. Furthermore, we assessed the consistency of climate model simulations by comparing historical precipitation trends from both CMIP5 and CMIP6 experiments with observational records. Our findings indicate that Mediterranean precipitation has exhibited variability on both multi-decadal and annual timescales but remains overall stable. Moreover, the small number of significant precipitation trends across periods and regions are likely driven by internal atmospheric variability. Notably, we found limited evidence of direct human influence on large-scale or regional atmospheric circulation mechanisms. Moreover, our results align with CMIP6 simulations, both of which indicate no clear long-term trend in Mediterranean precipitation.

O1.2. Understanding Wind Energy Potential in the Context of Climate Change: The Crucial Impact of Large Multi-Model Ensembles on Projection Robustness

Francesco Ferrari, Andrea Lira Loarca, Andrea Mazzino

Università degli studi di Genova

Given the enormous complexity of the climate system and the resulting uncertainties affecting simulations that aim to describe its evolution, the best approach to gaining insights into future trends of atmospheric variables, is to consider an ensemble of different models and derive statistical conclusions about the projected evolution.
This study investigates the potential impacts of climate change on wind patterns and wind energy resources projected for the year 2100 using a large ensemble from the CORDEX initiative (Coordinated Regional Climate Downscaling Experiment) of Global Climate Models (GCMs) regional downscaling using different Regional Climate Models (RCMs). Starting from a 21 RCM-GCM ensemble, various metrics have been adopted to evaluate the potential evolution of wind resources both in the near future (2035–2060) and toward the end of the century (2075–2100) under climate change scenario RCP8.5. Wind energy resources were compared with individual model simulations for the baseline period (1979–200).
Our findings indicate that, across the full ensemble, there is no clear or consistent signal of significant changes attributable to climate change. However, analysis of smaller subsets of models yields highly divergent results, with some suggesting substantial alterations in wind resources while others show negligible or opposing changes. This variability highlights the inherent risks of drawing conclusions from limited model samples. The study demonstrates the critical importance of utilizing large, diverse model ensembles to ensure robustness and reliability in climate impact assessments. Failure to do so can lead to biased interpretations, undermining the validity of wind energy projections and potentially compromising energy planning and policy decisions. These results emphasize the need for careful ensemble selection and comprehensive analysis in climate-energy research.

O1.3. The correlation of long-range Saharan Dust Advections with the precipitation and radiative budget in the central Mediterranean

Lorenzo Silvestri [1], Miriam Saraceni [2], Chiara Petroselli [2], Stefano Crocchianti [2], Paolina Bongiannini Cerlini [2], David Cappelletti [2]

[1] University of Modena and Reggio Emilia
[2] University of Perugia

Since its proximity to the Saharan desert, it is natural to assume that the weather and climate of the Mediterranean region are influenced by Saharan Dust Advections (SDAs). However, a thorough assessment of the climatological effect of dust on rainfall and radiation over the central Mediterranean region is lacking in the literature.

This work analyses 10 years (from 2009 to 2018) of long-range Saharan Dust Advections (SDAs) and their correlation with the precipitation and radiative budget over the central Mediterranean region. The identification of the SDAs is based on back-trajectories of air mass and complementary measurements of the dust deposited at the site of Monte Martano in Central Italy. The associated synoptic Circulation Weather Types (CWT), precipitation and radiation variables have been estimated by using ERA5 and CAMS reanalysis, satellite data and raingauge observations. It is found that the 50% of all SDAs occur under a CWT characterized by an upper level trough over the western Mediterranean and a high pressure system over the eastern Mediterranean. Strong southerly winds, large vertical integral of water vapour transport and a positive anomaly of 2m temperature are associated with dust uplift and transport. The effect of dust on rainfall intensity puts forward the important modulation of the aerosol effects on the radiative budget with a latitudinal dependence. On dusty days, intense rainfall increases over the northern central Mediterranean and light rainfall is suppressed in the southern central Mediterranean, pointing out a relevant correlation between dust and the intensification of extreme events. Other than affecting rainfall intensity, the stronger surface heating over the southern central Mediterranean, which is correlated to a higher dust optical depth, causes a local maximum of sea surface temperature (SST) and near-surface temperature anomaly.

Future research should explore the potential interactions between dust, deep convection, and orography in the northern Central Mediterranean and the connections between dust, SST anomalies, and Mediterranean Cyclones in the southern Central Mediterranean.

O1.4. The Dieci e Lode project: Climate data from Former Italian Colonies and their Digitalization

Dino Zardi[1], Michele Brunetti[2], Marina Baldi[3], Maria Carmen Beltrano[4], Eva De Vecchis[4], Fabio Leali[4], Samuele Giampietro[4], Luigi Iafrate[5], Veronica Manara[6], Sergio Pisani[4], Federico Stefanini[6], Francesco Sudati[6], Alessia Tadiello[4], Maurizio Maugeri[6], Alessandro Ceppi[7]

[1] *University of Trento, Trento,Italy*
[2] *CNR - Institute of Atmospheric Sciences and Climate (ISAC), Bologna, Italy*
[3] *CNR - Institute of BioEconomy (IBE), Rome, Italy*
[4] *Italian Association of Atmospheric Sciences and Meteorology (AISAM), Rovereto, Italy*
[5] *Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA), Rome, Italy*
[6] *University of Milan, Department of Environmental Science and Policy, Milan, Italy*
[7] *Politecnico di Milano - Department of Civil and Environmental Engineering (DICA), Milan, Italy*

Dieci e Lode is a collaborative initiative gathering researchers from various institutions under the Italian Association of Atmospheric Sciences and Meteorology (AISAM). The project aims to rescue and digitise meteorological data collected in former Italian colonies and territories.
Italy has played a pivotal role in the history of meteorology, contributing to the invention of key instruments and establishing the first international observation network. Over the past three centuries, a vast repository of invaluable meteorological data has been accumulated in Italian archives. Despite efforts to preserve parts of this heritage, a significant amount of data remains in paper form, making it vulnerable to deterioration and at risk of loss. These records hold immense value for scientific research and practical applications in meteorology and climate studies, particularly for assessing climate change.
Among the data yet to be recovered, a substantial portion pertains to observations from former Italian colonies and territories, including Eritrea, Somalia, Ethiopia, Libya, the Dodecanese, Albania, Dalmatia, and Istria, collected between the late 19th and early 20th centuries. The project aims to conduct an in-depth search for meteorological records from these regions during that period.
The primary source for this investigation will be the National Meteorological Archive at the Council for Research in Agricultural Economy (CREA) in Rome, specifically the Historical Central Library of Italian Meteorology. The project plans to digitise approximately 40,000 pages through extensive photographic scanning to publish these data sheets and volumes online.
This initiative marks an essential step toward reconstructing the historical climate of these regions, where meteorological records are still sparse. Such data will provide a critical context for modern observations, enhancing their significance for studying ongoing climate change.

Additionally, the project will explore citizen science activities to extract numerical data from the digitised records. These efforts will align with AISAM's other initiatives, such as the Cli-DaRe@School project involving collaboration with Italian schools and students. A feasibility study will also evaluate the potential for integrating advanced Optical Character Recognition (OCR) technology to support these activities.

O1.5. Extreme Rainfalls frequency, intensity and duration in the Western Mediterranean and their response to a climate change signal

Yseut Bahuet-Bourret, Daniel Argüeso

University of Balearic Islands

The Western Mediterranean Region is favorable to autumnal extreme rainfalls by its proximity to the warmed Mediterranean Sea and complex topography. Extreme rainfall events are also frequent in summer with convective storms in mountainous areas mostly. While globally extreme rainfalls are expected to intensify with warming, there is no consensus yet on how extreme rainfall events in the Mediterranean region will respond to climate change. Here, we specifically investigate how the frequency, intensity and duration of extreme rainfalls respond to a high-emission climate change scenario.

We use two 10-year period WRF experiments (present climate and Pseudo-Global Warming) at 2-km spatial resolution and 10 min output of rains to quantify the response of extreme rainfall events to a high-emission climate change signal. We analyze intense rainfall at different frequencies: 10 minutes, hourly and daily. We find that our simulation at very high spatio-temporal resolution represents accurately the probability of occurrence and intensity of extreme rainfalls measured in the present, as well as the seasonal geographical repartition of those events.

We show that sub-daily extreme rains are more frequent in a future context and that this response is greater than the one of daily extreme rains. We therefore explore further how this difference of response between daily and sub-daily extremes is related to changes in extremes' intensity and duration. This work highlights the relevance of examining extreme rainfall changes at higher frequencies, as the sub-daily changes provide crucial insights into the evolving nature of extreme events.

O1.6. Multi-scale assessment of high-resolution reanalyses precipitation fields over Italy

Francesco Cavalleri[1], Cristian Lussana[2], Francesca Viterbo[3], Michele Brunetti[4], Riccardo Bonanno[3], Veronica Manara[1], Matteo Lacavalla[3], Simone Sperati[3], Mario Raffa[5], Valerio Capecchi[1], Davide Cesari[6], Antonio Giordani[7], Ines Maria Luisa Cerenzia[8], Maurizio Maugeri[1]

[1] Environmental Science and Policy Department (ESP), University of Milan, Milan 20133, Italy
[2] Division for Climate Services, the Norwegian Meteorological Institute, Oslo 0313, Norway
[3] Sustainable Development and Energy Resources Department, Research on Electric Systems (RSE), Milan 20134, Italy
[4] Institute of Atmospheric Sciences and Climate, National Research Council (CNR-ISAC), Bologna 40129, Italy
[5] Euro-Mediterranean Center on Climate Change (CMCC), Caserta 81100, Italy
[6] Regional Agency for Environmental Prevention and Energy of Emilia-Romagna (ARPAE), Bologna 40139, Italy
[7] Department of Physics and Astronomy (DIFA), University of Bologna, Bologna 40127, Italy
[8] RED-Risk, Engineering+Development, Pavia 27100, Italy

The Mediterranean region is widely recognized as a climate change hotspot, experiencing amplified warming and significant hydrological changes compared to global averages. Understanding precipitation patterns in this region and in its many different sub-regional environments is crucial for addressing the challenges posed by climate variability and extremes. This study evaluates the performance of high-resolution regional reanalyses in reproducing precipitation patterns over Italy, a region characterized by sea-land interactions and complex orography.

Nine reanalysis products were assessed, with the ECMWF global reanalysis ERA5 serving as a reference benchmark. The evaluated datasets included European products (COSMO-REA6, CERRA) and Italy-specific high-resolution products (BOLAM, MERIDA, MERIDA-HRES, MOLOCH, SPHERA, VHR-REA_IT), each based on different modelling frameworks and parameterizations. Validation was conducted using wavelet techniques to determine the effective resolution of daily precipitation fields, as well as statistical analyses of intense precipitation events through frequency distributions. Independent validation employed in-situ observations and gridded observational datasets.

Results highlighted the critical role of high-resolution reanalyses in capturing precipitation dynamics over Italy. The capability of reanalyses to depict daily precipitation patterns was assessed, highlighting a maximum radius of precipitation misplacement of about 15 km, with notably lower skills during summer. Climatological

fields from reanalyses exhibited significant biases, with overestimations of precipitation identified in the Po Valley and the Alps, and underestimations noted along the North-West coast, the Apennines, and Southern Italy.

A key finding was the identification of non-stable deviations from observations in annual precipitation accumulations when compared to a time-consistent observational dataset (UniMi/ISAC-CNR). This variability should be considered when using reanalyses for understanding long-term precipitation in the Mediterranean region.

The outcomes of this study emphasize the importance of leveraging high-resolution reanalyses to better understand precipitation patterns. These insights are critical for improving regional climate models, supporting climate adaptation strategies, and enhancing our understanding of the impacts of a changing climate on Mediterranean precipitation regimes.

O1.7. The X-RISK-CC WebGIS: an interactive platform for mapping current and future climate extremes in the Alps

Elena Maines[1], Alice Crespi[1], Piero Campalani[1], Sebastian Lehner[2], Živa Vlahović[3], Maja Žun[3], Marc Zebisch[1]

[1] Center for Climate Change and Transformation, Eurac Research, Bolzano, Italy
[2] Department for Climate System and Climate Impact, GeoSphere Austria, Vienna, Austria
[3] Slovenian Environment Agency, Ministry of the Environment, Climate and Energy, Ljubljana, Slovenia

The Alps have experienced several hazardous weather events in recent decades, impacting human and natural systems directly and through cascading effects. Since climate change is expected to modify the frequency and intensity of such extremes, with complex and potentially irreversible environmental and socio-economic consequences, robust information on current and future weather extremes is crucial for guiding effective risk management and adaptation. The X-RISK-CC project aims to support risk managers and policymakers in the Alpine regions in addressing the compound risks of climate extremes by developing risk management measures based on elaborated climate-change scenarios and risk pathways. To foster climate-informed decision making and the transferability of results, a webGIS platform for the Alps translating climate data into accessible and actionable insights was designed for multiple user types, including researchers, risk managers and general public.

The WebGIS includes interactive maps of 20 indices describing current and future characteristics of climate extremes, including heavy rain, strong wind, heatwaves, drought and also compound events, over the whole Alpine region. Current conditions are represented based on reanalysis data over 1991-2020, while future changes are derived from a selected subset of EURO-CORDEX projections under four Global Warming Levels (GWL, +1.5, +2, +3, +4 °C) with respect to current conditions, corresponding to a GWL of +1 °C with respect to the preindustrial period.

The platform allows users to select specific indices, explore spatial patterns, derive season-specific analyses and examine the full spectrum of the model ensemble. Moreover, users can access aggregated information at the NUTS3 level, including summary tables detailing projected regional changes and boxplots displaying the ensemble spread across the GWLs. The ability to download all available data in customized formats enables their smooth integration into further modelling and local planning processes. The platform is complemented by technical documentation, scientific synthesis and analysis reports in selected study areas across the Alps.

The contribution will present the contents and functionalities of the X-RISK-CC WebGIS, the methods applied, and some insights into future weather extremes in the Alps which

can be derived from the interactive platform depicticting, for example, the intensification in magnitude and frequency of heat and drought related extremes.

The presented work has received funding from Interreg Alpine Space Program 2021-27 under the project number ASP0100101, “How to adapt to changing weather eXtremes and associated compound and cascading RISKs in the context of Climate Change” (X-RISK-CC).

O1.8. Distinguishing effects form Mediterranean vs continental influence in trends and spatial patterns of precipitation in a south-alpine transect from the Po plain to the Alpine divide from daily observations in the timespan 1923-2022

Sebastiano Carpentari[1], Dino Zardi[2]

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

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

A dataset of daily precipitation was created spanning 1923-2022. Some 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.

Seven 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 for the theoretical fitting exponential model. 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. R95pTOT and R99pTOT indices indicate a westward-to-eastward shift in their maxima within the domain. Furthermore, the Precipitation Concentration Index suggests that, over the past century, the continental areas within the domain have seen an increase in highly irregular precipitation distribution, while pre-alpine territories have not. 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.

O1.9. Characterization of the Urban Pollution Island through in-situ observations in Rome (Italy)

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

[1] Physics Department, Sapienza University of Rome, Rome, 00185, Italy
[2] CNR, Institute of Atmospheric Sciences and Climate (ISAC), via del Fosso del Cavaliere 100, Rome, 00133
[3] Italian National Agency for New Technologies, Energy and the Environment (ENEA), Via Anguillarese 301, Santa Maria di Galeria (Rome), 00123, Italy

Outdoor air pollution is recognized as one of the major threats affecting urban areas, where more than half of the world's population currently lives, and where emissions of harmful substances related to human activities, such as vehicular traffic and domestic heating, are concentrated. The higher concentration of air pollutants in the city compared to its rural surroundings is known as Urban Pollution Island (UPI). The liveability of cities is also compromised by the more intense atmospheric warming compared to rural surroundings primarily due to the large extent of built-up surfaces, giving rise to the phenomenon known as Urban Heat Island (UHI).

Although the scientific community has now recognized that UHI and UPI could interact with each other, the debate about the determination of the atmospheric phenomena responsible for triggering or weakening the UHI-UPI relationship is still open.

In this context, this contribution aims to quantify and characterize the UPI in the urban area of Rome (Italy) by exploiting in-situ measurements of air pollutant concentrations collected over the period 2018-2023 by air quality stations belonging to the monitoring network managed by the Regional Agency for Environmental Protection (ARPA Lazio). The meteorological variables dataset is provided by dense networks of instruments [ADB1] providing quality-checked datasets of WMO-compliant.

Here, different procedures for the determination of UPI are proposed and tested. Moreover, the temporal variability of UPI is studied both for atmospheric particulate matters (PM10 and PM2.5) and for the main trace gases present in metropolitan areas (NO2, NO, and O3). Furthermore, the UHI-UPI relationship during peculiar atmospheric events is investigated. For example, the UHI-UPI association is analyzed by selecting days with specific meteorological (heatwaves, calm wind, atmospheric stagnation) or air quality (desert dust advection, lockdown period) conditions.

The results of the present study will help to deepen our understanding of UPI, providing useful information for the scientific community and stakeholders driving urban planning and pollution control actions.

P1.1. Environmental Characteristics Associated with the Tropical Transition of Mediterranean Cyclones

Lisa Bernini

University of Genoa, Italy / CIMA Foundation, Savona, Italy

Cyclonic perturbations in the Mediterranean region sometimes acquire characteristics typical of tropical cyclones, such as a deep inner warm core. In these cases, they become very intense structures, that can cause large precipitations and significant damage. In this study, the environmental conditions during the intensification of cyclones are investigated using reanalysis data. A comparison of the conditions associated with the evolution of classical cold-core extratropical cyclones and those associated with the development of tropical-like disturbances highlights the characteristics that favor the conversion: a strong potential vorticity intrusion and a much larger potential intensity. For those cyclones, our study hints at a link between the disequilibrium created by the potential vorticity intrusion and the cold anomaly in the mid-troposphere triggering the high potential intensity.

P1.2. Hail Hazard in the Mediterranean (H2Med)

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
[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? These are among the most frequent and significant questions for the scientific community, stakeholders and decision-making structures. The project tackles these open issues by investigating hailstorms in the Mediterranean region through the synergistic application of satellite observations, meteorological reanalysis and climatic modelling. Focusing on determining the atmospheric variables most relevant for the formation and intensification of hail-bearing storms, we delineate specific metrics describing the hail formation potentially applicable at operational level.

The proposal stems from the 22-yearlong database of hail episodes described by Laviola et al. (2022), whereby events associated with large and extreme hail (above 2 and 10 cm in diameter, respectively) were preliminarily identified and shown to be on a 30% increase trend. Extending and refining this climatology at daily scale, the large-scale and mesoscale atmospheric scenarios that trigger hail events in the central Mediterranean area are investigated through a cluster analysis with the use of meteorological reanalysis data in the recent past. Hail-prone conditions are associated with the optimization of a hail-proxy index based on environmental variables extracted from global and regional reanalysis products. Such index and the reference hail-prone conditions are then be investigated in the ensemble of climate model projections to outline the future evolution of hail-precursors triggering and sustaining deep convection over the Mediterranean basin to the end of the century. This investigation will be also exploited to identify the environmental key variables controlling hail hazards in the recent past, and prospect future changes of storm extremization. The first-year results presented in this work delineate a new paradigm of knowledge 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.

Laviola S., G. Monte, E. Cattani, V. Levizzani, 2022: Hail Climatology in the Mediterranean Basin Using the GPM Constellation (1999-2021). Remote Sensing, 14(17), 4320. https://doi.org/10.3390/rs14174320

P1.3. Extreme Precipitation and Related Weather Types over Croatia in the Period 2000-2024

Dunja Plačko-Vršnak, Tomislava Hojsak

Croatian Meteorological and Hydrological Service

In this study, a classification of weather types over Croatia for cases with extreme precipitation during the period 2000-2024 has been carried out. Croatia is divided in six climatological sub-regions, and the criterion for daily extreme precipitation differs for every station in each sub-region and is based on climatological return period of 10, 50 or 100 years. The return period is defined as a value that is expected to be equalled or exceeded on average once every interval of time (T) (with a probability of 1/T). In this study, the return values are estimated by fitting the Generalised Extreme Value Distribution (GEV) to the highest annual one-day precipitation amounts. The analysed data series cover the 1961-2020 period. The maximum likelihood method was used for the estimation of three GEV parameters.

During the 2000-2024 period, 129 extreme precipitation events were observed within 100 days. The highest daily amount (287,5 mm) was measured at the main meteorological station in Rijeka, in the North Adriatic, on 29 September 2022.

The extremes occur almost throughout the year, and are most frequent in September (27 %) and October (16 %). Nine extremes recorded had climatological return period of 100 years, most often in the South Adriatic (including islands). The year with the highest number of extremes was 2014.

The classification of weather types (developed by Poje in 1965) for cases with extreme precipitation is done according to surface and upper-level pressure fields. The method is subjective, based on experience of forecasters. This approach is highly sensitive to minor differences in the route or location of synoptic systems in conjunction with the complex topography and sea-land exchange.

Out of 29 weather types, 14 were detected during days with extreme precipitation. More than half of these cases were connected with the influence of the depression (52 %). The most frequent (44 %) weather type is C1 – the eastern (front) sector of cyclone where the center is positioned westward of Croatia, most often over the Gulf of Genoa and in the North Adriatic. Upper-level pressure charts (AT 500 hPa) were analyzed to determine the prevailing large-scale flow that existed in the days with extreme precipitation. The most common flow regime is the SW, observed with a frequency of 39 %. The second most frequent flow regime is an upper-level low, with a frequency of 27 %.

P1.4. Pollen and climate change: 30 years of data reveal some trends in Catalonia

Marta Alarcón, Maria del Carme Casas Castillo, Raül Rodriguez Solà, Jordina Belmonte

Universitat Politècnica de Catalunya

Respiratory allergies caused by the presence in the air of aerosols of biological origin such as pollen and fungal spores have increased significantly in recent years. Different studies indicate that global warming is leading to an advance in the onset of pollination and an increase in the annual integrals of some types of pollen. This work analyses the trends in the last 30 years of pollen dynamics at different aerobiological sampling stations in Catalonia (NE of the Iberian Peninsula) and their relationship with seasonal temperature changes. In a more global context, the relationship between the main patterns of climatic variability in the Euro-Mediterranean region (Western Mediterranean Oscillation, WeMO; North Atlantic Oscillation, NAO; Artic Oscillation, AO) and pollen trends is also analysed. The study focuses on the most abundant pollen types in the territory, with allergenic capacity: Amaranthaceae, Artemisia, Betula, Corylus, Cupressaceae, Fraxinus, Olea, Plantago, Platanus, Poaceae, Quercus and Urticaceae. The start date of pollen season shows a statistically significant advance in some localities for spring taxa, as well as an increase in the Annual Pollen Integral (APIn), in parallel with an increase in temperatures in the months of March to June. In Europe, the positive phase of the NAO during the winter months is associated with greater sunshine and less precipitation in the western Mediterranean region (Martín-Vide and López-Bustins, 2006). Positive and high winter WeMO index values have also been correlated with greater sunshine in the northeast of the Iberian Peninsula (López-Bustins et al., 2008). In our study, we obtain significant correlations between these indices and the advance in the start date of the pollen season of some taxa such as Platanus, abundant for its ornamental use in cities such as Barcelona or Girona, as well as in the APIn and the value of the concentration in the peak date.

References

Martín-Vide J, López-Bustins JA (2006) The Western Mediterranean Oscillation and rainfall in the Iberian Peninsula. Int J Biometeorol 26: 1455−1475.

López-Bustins JA, Martín-Vide J, Sánchez-Lorenzo A (2008). Iberia winter rainfall trends based upon changes in teleconnection and circulation patterns. Glob Planet Change 63: 171e176.

P1.5. Statistical analysis of snow episodes in Mallorca using CERRA reanalysis

Mar Vich, Maria Boira

Universitat de les Illes Balears

Snowfall events in Mallorca, though rare in its Mediterranean climate, are significant due to their impact on local infrastructure, public safety, and daily activities. These events, which can disrupt transportation and essential services, occur predominantly in the Serra de Tramuntana region. This study builds on previous efforts to analyze snow episodes from 1985 to 2020, utilizing meteorological data from the Copernicus European Regional ReAnalysis (CERRA) to investigate their intensity, duration, seasonality, and spatial distribution.

The research highlights trends in temporal variability and geographical patterns. Preliminary findings reveal a strong seasonal component, with snow episodes peaking in winter and early spring, typically lasting two to three days. These insights enhance our understanding of the complexity of snowfall in Mallorca and lay the groundwork for future studies on the climatological mechanisms driving these phenomena.

S2. Processes and mechanisms

Invited talk: The role of the Meteorological Service of Catalonia in the LIAISE campaign

Josep Ramon Miró Cubells, Esther Batalla León, Jordi Cateura Sabri, Pere Cladera Preto, Estel Figueres Saborit, Abel Flores Famades, Eugeni Lozano Blanco, Txema Medina Mas, Montse Aran Roura, Clara Brucet Vinyals

Meteorological Service of Catalonia

The Mediterranean basin lies in a climatic transition zone between subtropical and temperate climates, resulting in highly irregular weather patterns conditioned also by a highly heterogeneous terrain, with heavily anthropized areas, particularly near the coast. In this context, the Ebro Valley, located in the NE of the Iberian Peninsula, is a semi-arid zone surrounded by the Pyrenees, the Iberian Range, and a coastal range near the Mediterranean Sea, which isolates it from the main moisture flows. An important portion of this valley has an irrigation system that covers the lowest parts, altering locally the atmospheric boundary layer (ABL) growth and structure and the near-surface atmospheric conditions. The coexistence of rain-fed and irrigated zones within a small area creates a suitable environment, making it an ideal location for studies and research campaigns.

In July 2021, an observational campaign was conducted in this area as part of the Land Surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) project. The goal of LIAISE is to improve our understanding of the impact of human activities on the water cycle, particularly in terms of land-atmosphere-hydrology interactions in semi-arid environments on the Iberian Peninsula. The campaign generated a comprehensive database, combining surface-based and aircraft measurements of surface and hydrological fluxes, as well as properties of the ABL. The data collection involved multiple institutions, including two observation periods: the Intensive Observation Period (IOP), which ran from April to September 2021, and the Special Observation Period (SOP), which took place in July 2021.

The SMC was deeply interested in the campaign, contributing with data from its Surface Energy Balance (SEB) stations, the Windrass wind profiler, and Automatic Weather Stations (AWS) with minute-level frequency. The SMC also provided daily briefings to help plan the campaign's daily activities. The data collected during the campaign is expected to enhance the SMC's evapotranspiration products and improve the parameterizations.

Following the campaign, the SMC maintained the instrumentation deployed at the Mollerussa site, including a SEB station and the Windrass wind profiler. Additionally, the SMC operates a dense network of AWS across the region of interest, complemented by high-resolution precipitation data from its radar network. These datasets, which include long historical records, are valuable for researchers involved in the LIAISE project, enabling studies on trends or any other analyses requiring historical data.

O2.2. Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE): 1st mesoscale modelling intercomparison, what have we learned?

Maria Antònia Jiménez[1], Joan Cuxart Rodamilans[1], Aaron Boone[2], Patrick Le Moigne[2], Tanguy Lunel[2], Jordi Mercader[3], Josep R. Miró[3], Martin Best[4], Jennifer K. Brooke[4]

[1] Universitat de les Illes Balears
[2] Centre Nationale de Recherches Meteorologiques - Meteo France
[3] Servei Meteorològic de Catalunya
[4] Metoffice

Land surface-atmosphere interactions determine the properties of the atmospheric boundary-layer (ABL), and in the case of semi-arid regions the water availability in the root zone layer is an important factor. To investigate this issue, the LIAISE initiative (Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment) organized an observational campaign in the eastern Ebro river sub-basin in the summer of 2021, focusing on the effect of surface heterogeneities on the ABL in a semi-arid environment that includes a large irrigated area.

With the aim of understanding the performance of numerical models for the studied region, a mesoscale modelling intercomparison was carried out for a three-day case study in July 2016. The intercomparison consisted of three models, Meso-NH, Unified Model (UM) and WRF, running with two embedded domains, with corresponding horizontal resolutions of 2km and 400m, and similar vertical grids.

The mesoscale circulations generated by the three models are similar and accurate when compared to the surface observations. However, the models do not perform as well over the irrigated areas as in the rest of the domain, which is related to a misrepresentation of the surface heterogeneities due to: (i) limitations in the surface model (such as neglecting irrigation or imposing an imbalance equal to 0), (ii) non-realistic surface parameters and initialization (irrigated, rainfed... zones), (iii) parameterizations departing from reality (turbulence, advection and radiation have well-known limitations, especially in complex terrain). Land-surface temperature patterns are well captured by the models although there are large differences in the surface energy balance terms (especially in H, LE and G fluxes).

The results show that model limitations in such a complex terrain region require careful selection of model options to obtain realistic results. Future work will explore the parameterizations in surface model (for instance, by adding irrigation) and constrain the surface climatological database to make it as close to reality as possible (reproduce the complexity/heterogeneity of the region as in Lunel et al., 2023). All these steps are important in order to reduce the model biases found in this experiment.

O2.3. Irrigation contrasts through the morning transition

Jennifer K. Brooke

Met Office

The Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) campaign was conducted in July 2021 primarily to investigate the role of irrigation in modulating the boundary layer evolution in the Catalan region of northeastern Spain. Contrasts in near-surface meteorological parameters and boundary layer thermodynamic profiles at an irrigated and rainfed (arid) site were established during the morning transition.

Evapotranspiration dominated the flux partitioning at the irrigated site (Bowen ratio of 0.07--1.1), whilst sensible heat flux dominated at the rainfed (arid) site (Bowen ratio greater than 10.0). The cumulative evapotranspiration during July 2021 was a factor of 10 greater at the irrigated site than at the rainfed (arid) site.

The presence of irrigation was shown to modulate the vertical gradients of turbulence, temperature, and moisture. Irrigation is shown to have a significant effect on the development of the boundary layer including during the morning transition. The morning transition mean buoyancy flux was 2.8 times smaller at the irrigated site (1.1 m2/m2) compared with the rainfed (arid) site (3.1 m2/m2), with a resultant delay in the near-surface buoyancy-flux crossover time (30-min to 90-min) at the irrigated site. At the start of the morning transition (sunrise), the average screen-level (50 m) temperature was -1.2 K (-1.9 K) colder at the irrigated site relative to the rainfed (arid) site. The colder temperatures at sunrise at the irrigated site are predominately the result of colder boundary layer thermodynamic profile from the previous day. At the end of the morning transition (convective onset), temperature differences between the two sites extend through much of the boundary layer and increased in magnitude. The average screen-level (50 m) temperature difference was -3.6 K (-2.4 K) colder at the irrigated site relative to the rainfed (arid) site. There was considerable day-to-day variability in temperature contrasts at a regional level (-2.4 to -6.0 K).

O2.4. Investigating the slope-normal structure of first- and second-order turbulence moments in anabatic winds from diverse field observations.

Sofia Farina, Dino Zardi

University of Trento, Italy

The atmospheric boundary layer (ABL) in mountainous regions is characterised by various airflows, originating from complex landform forcing. In particular daily-periodic thermally-driven circulations develop over inclines under clear sky and in the absence of major synoptic forcing. These airflows, as well as the turbulence associated with them, affect a variety of processes, including surface-atmosphere exchanges of momentum, energy and mass, and transport across a variety of scales. They may also contribute to the initiation of orographic convection.

Here, we focus on the simplest of these flows, namely slope winds. In particular, the slope-normal structure of turbulence is investigated, over diverse slope configurations and properties, analyzing data from measurement campaigns performed under the projects METCRAX, MATERHORN, and MAP-RIVIERA. The near-surface structure of the first- and second-order moments of velocity and temperature are examined. Despite the diversity of situations covered by the field measurements, results reveal intercomparable structures. After their onset, anabatic winds rarely reach a really steady state, but rather continuously evolve in time with increasing intensity. The height of the wind speed maximum turns out to be challenging to determine, due to the scarce data at upper levels, however it increases with time until the evening transition. Furthermore, small but nonnegligible negative slope-normal velocity components are often detected. Unlike what is usually found in katabatic winds, the turbulent kinetic energy (TKE) increases in the first meters above ground before reaching an asymptotic value at higher levels. A clear linear relationship emerges between surface turbulent fluxes of heat and momentum, as well as between the jet height, the slope angle, the buoyancy frequency of the ambient atmosphere and the friction velocity. Finally, the normalized standard deviations of temperature exhibit a fairly good scaling with Obukhov length, albeit with a structure different from the one which is commonly found over flat terrain. Preliminary results from ongoing efforts to investigate these flows within the current initiative TEAMx - Multi-scale transport and exchange processes in the atmosphere over mountains – programme and experiment (http://www.teamx-programme.org/) are also presented.

O2.5. Statistical analysis of sea breeze conditions on a complex terrain island as seen from the CERRA reanalysis

Alex Serra Nieto[1], Maria Antònia Jiménez[1], Aina Maimó-Far[2]

[1] Universitat de les Illes Balears
[2] University College Dublin

The sea breeze (SB) is a local wind circulation generated in coastal regions by the horizontal thermal gradient observed during the day due to the different heat capacities of the sea and land surfaces. SB is strongly influenced by the local conditions (such as the shape of the coast or the surface heterogeneities). In particular, in regions with complex topography, slope winds strongly influence the SB characteristics as, for instance, the propagation of the flow inland or the spatial and temporal scales of the maximum wind. Therefore, high spatial resolution data are needed to properly study the physical mechanisms that take place under SB conditions.

In this study, we explore the ability of the Copernicus Regional Reanalysis for Europe (CERRA) to reproduce the SB mechanisms given its spatial and temporal resolution of 5.5 km and 3 hours. The Palma basin (Mallorca, western Mediterranean Sea) is taken as an example of an island with complex terrain. Data from CERRA (2009-2020) are taken complemented by three other sources of observations: automatic weather stations (AWS) operated by the Spanish Meteorological Agency, satellite-derived surface temperatures, and radiosoundings.

A new methodology for selecting SB events has been developed using the CERRA data, based on Grau et al (2021). The characteristics of the SB events show a good agreement with those selected from the AWS. CERRA is able to reproduce SB patterns, showing a cold and moist air advection from the sea. It is also able to reproduce the horizontal thermal gradient and the vertical structure of the SB front as it propagates inland. CERRA has some difficulties in reproducing SB events, which are strongly conditioned by the topography of the basin, due to the insufficient spatial resolution to include the surface heterogeneities of the Palma basin.

O2.6. Meteo-climatological characterisation of the city of Trento in the Alps from a network of surface micro-stations in the urban and sub-urban area

Andrea Perbellini[1], Lorenzo Giovannini[1], Nadia Vendrame[1], Francesca Alba[1], Giovanna Ulrici[2], Dino Zardi[1]

[1] Univesity of Trento
[2] City of Trento

Trento is a mid-sized city in the central Italian Alps (46849N, 11879E) at 200 m MSL in the Adige Valley, which is the southern stretch of the main geographic corridor running approximately in the south-north direction on the Italian side of the Alps. About 56,000 inhabitants live in the inner city, whereas about 60 000live in the surrounding suburban area. In fact, in the last 30 years, the city has grown, especially in the northern region, and incorporated some smaller urban conglomerations that had previously existed as suburbs. As part of a cooperation project with the Office for Parks Gardens of the City of Trento and the companies MeteoBlue GMbH and Pessl Instruments, a network of 13 mirco-stations (including a thermometer, a hygrometer and a rain gauge) has been recently installed at different points in the area to complement existing weather stations operated by institutional bodies, to monitor atmospheric variables and their different regimes depending on land use and position. The analysis allowed estimating the strength of the urban heat island, under various weather and seasons, and the mitigating effect of green areas.

O2.7. Atmospheric Drivers of Compound Events Related to Winter Excess Mortality in Spain

Ginés Garnés Morales, Pedro Jiménez Guerrero, Salvador Gil Guirado, Ester García Fernández, Leandro C. Segado Moreno, Eloisa Raluy López, Juan Pedro Montávez

Regional Atmospheric Modeling Group, Department of Physics, Regional Campus of International Excellence (CEIR) "Campus Mare Nostrum", University of Murcia, Murcia, Spain

Numerous studies have demonstrated the impacts of extreme meteorological events and air pollution on public health. Nonetheless, only a few consider the synergy of both factors (compound events) when analyzing mortality rates from an atmospheric perspective. This work aims to establish connections between mortality excesses in Spain during wintertime, extreme atmospheric events, and the circulation patterns involved in these episodes. For that, daily mortality rate data at a provincial level is used for the 2015-2022 period.

First, winter mortality extremes were categorized and associated with preceding extreme atmospheric conditions. The results show that most mortality extremes succeed extreme atmospheric conditions, with a time lag that depends on the location and variable considered. For instance, in Madrid, the variables that better explain mortality include maximum and minimum temperature, nitrogen dioxide (NO2), particulate matter (PM10), and their combinations. Their influences from previous days are significant for more than half of cases, especially when the compound event comprising extreme minimum temperature and high levels of NO2 occurs, with a median lag of about one week.

Once all days potentially associated with mortality extremes were identified, they were classified into different atmospheric circulation types (CTs) based on sea-level pressure (SLP), temperature at 850 mb, and geopotential height at 500 mb. This classification uses daily average fields derived from ERA5 reanalysis over a domain covering the entire Iberian Peninsula. For each resulting CT, mean fields of temperature, NO2, and PM10 were computed using CAMS reanalysis data. Additionally, the efficiency of each CT in all provinces was assessed. The results show that most cases of extreme mortality are linked to anticyclonic systems and warm temperatures at high levels, which can lead to very cold conditions at the ground level and contribute to air stagnation. This phenomenon may impact multiple provinces simultaneously or within a short timeframe, suggesting that early warning systems should consider these events to alert vulnerable populations and prevent nationwide high mortality rates.

O2.8. Heavy precipitation over northern Italy and atmospheric rivers in the Mediterranean

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], Marco Verdecchia[4], Federico Grazzini[5], Valentina Colaiuda[6]

[1] Dipartimento di Scienze della Terra, Università di Milano, Milan (Italy)
[2] CNR-ISAC, Bologna (Italy)
[3] Center of Excellence CETEMPS, University of L'Aquila, Coppito (L'Aquila) (Italy)
[4] Department of Physical and Chemical Sciences, University of L'Aquila, Coppito (L'Aquila) (Italy)
[5] Arpae Hydro-Meteorological and Climate Service, Bologna (Italy)
[6] Regional Civil Protection Agency - Abruzzo Region, L'Aquila (Italy)

Several recent studies have revealed the importance of remote sources of water vapour to feed the precipitation systems in the Mediterranean basin, in addition to the local contribution due to evaporation from the sea. In some of the most severe flooding events over northern Italy, and the Alpine area in particular, the transport of moisture organized along narrow a corridor, known as atmospheric river, was a critical ingredient for the occurrence of extreme rainfall.

The national project ARMEX, funded by the Italian Ministry of Universities and Research, aims at exploring atmospheric rivers in the Mediterranean and their connection with extreme hydrometeorological events over Italy. It involves expertise in both meteorological and hydrological modelling as well as in remote sensing monitoring.

On the one hand, a detection algorithm, designed for the open oceans, has been adapted to the peculiar complex morphology of the region and applied to conduct a climatological investigation, exploiting ERA5 reanalysis. The aim is to assess the presence and the frequency of atmospheric rivers in the Mediterranean and their possible relationship with extreme hydrometeorological events over northern Italy during the last decades. On the other hand, high-resolution numerical simulations are used in a case-study approach to investigate dynamical mechanisms and impacts of atmospheric rivers, and to delineate their characteristics. In this context, a tracking method that exploits satellite observations has been developed to reinforce numerical forecasts and for a real-time monitoring application.

O2.9. A Moist Static Energy Budget for Mediterranean Tropical-Like Cyclones: The Case Study of Ianos Cyclone

Miriam Saraceni[1], Lorenzo Silvestri[2], Paolina Bongiannini Cerlini[3]

[1] Interuniversity Research Center, CIRIAF, University of Perugia
[2] Department of Engineering Enzo Ferrari, University of Modena and Reggio Emilia
[3] Department of Physics and Geology, University of Perugia,

This research presents a detailed analysis of the energy dynamics of Mediterranean tropical-like cyclones, Medicanes, by using a moist static energy (MSE) budget framework. Medicanes are hybrid cyclonic systems that exhibit characteristics of both extratropical and tropical cyclones, making their classification and prediction difficult. Using high-resolution ERA5 reanalysis data, we analyzed, as a case study, the life cycle of Ianos, one of the strongest recorded Medicanes, employing the vertically integrated MSE spatial variance budget to quantify the contributions of different energy sources to the cyclone's development. The chosen study area was approximately 2500 km2 covering the entire cyclone track. The budget was calculated after tracking Ianos and applying the Hart phase space analysis to assess the cyclone phases. The results show that the MSE budget can reveal that a balance between convection and dynamical factors drove the cyclone development. The interplay between vertical and horizontal advection, in particular the upward transport of moist air and the lateral inflow of warm, moist air and cold, dry air, was a key mechanism driving the evolution of Ianos, followed by surface fluxes and radiative feedback. By analyzing what process contributes most to the increase in MSE variance, we concluded that Ianos could be assimilated in the tropical framework within a radius of 600 km around the cyclone centre, but only during its intense phase. In this way, the budget can contribute as a diagnostic tool to the ongoing debate regarding Medicanes classification.

O2.10. The unusually low snowfall level of Storm Juliette in Mallorca, February 2023

Mar Vich, Romualdo Romero

Universitat de les Illes Balears

Storm Juliette brought significant winter impacts to Mallorca on February 27, 2023, with snow levels that were much lower than initially forecasted. This unexpected behavior raised questions about the atmospheric mechanisms responsible for the snow level reduction. One potential explanation is the melting effect, a cooling process caused by the melting of falling snowflakes in a saturated layer of air, which can locally lower temperatures enough to allow snow to reach lower altitudes.

To investigate this hypothesis, simulations were conducted using the TRAM model, initialized with GFS data from February 26 at 00 UTC. The model setup featured the Kain-Fritsch-2 convection scheme and a triangular resolution of 3 km, equivalent to a rectangular resolution of 2x2 km. Initial results suggest that the melting effect may have played a significant role in driving the observed lower snow levels during Storm Juliette's peak on February 27, although further analysis is needed to confirm the extent of its influence. These findings highlight the potential importance of incorporating the melting effect into forecasting methodologies for winter storms in similar environments.

P2.1. Characterisation of the nocturnal locally-driven circulations in the eastern Ebro basin from surface observations

Maria Antònia Jiménez, Antoni Grau Ferrer, Lluís Cuadros Vidal, Daniel Martínez-Villagrasa, Joan Cuxart Rodamilans

Universitat de les Illes Balears

The eastern Ebro basin consists of a vast irrigated plain surrounded by rainfed slopes and wooded mountain ranges, but open to the west to the agricultural western Ebro basin. Previous studies based on observations suggest that these features determine the local circulation in the area. Here, a network of automatic weather stations is used to analyse a period of 18 years (2003-2021). A filtering procedure is developed to select the events with a predominance of nocturnal local circulations, based on the detection of clear skies and weak winds.

Most of the selected nights take place in the warm months of the year (from March to October) and the beginning of the night is characterised by the presence of the *Marinada* (corresponding to the sea breeze that crosses the Catalan coastal mountain range), a cold and humid advection of maritime origin. The statistical analysis of the filtered data shows the predominance of easterly winds during the night, associated with downslope circulations. For some locations, local features modulate these directions. There is often a pool of cold air in the lower parts of the basin, which is more intense in winter.

The filter is modified to select fog events (mean wind is reduced and no clear sky condition is applied). The results show that long lasting fog episodes are frequent during winter in the lower parts of the basin.

P2.2. The uRban hEat and pollution iSlands inTerAction in Rome and possible miTigation strategies (RESTART) project: activities overview and perspectives

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

[1] Physics Department, Sapienza University of Rome, Rome, 00185, Italy
[2] Department of Physics and Astronomy "Augusto Righi", University of Bologna, via Irnerio 46, 40126, Bologna, Italy
[3] CNR, Institute of Atmospheric Sciences and Climate (ISAC), via del Fosso del Cavaliere 100, Rome, 00133 Italy
[4] Italian National Agency for New Technologies, Energy and the Environment (ENEA), Via Anguillarese 301, Santa Maria di Galeria (Rome), 00123, Italy; Physics Department, Sapienza University of Rome, Rome, 00185, Italy

Urban areas, where a significant percentage of the global population resides, experience warmer temperatures and higher concentrations of harmful substances compared to rural areas. This phenomenon gives rise to the Urban Heat Island (UHI) and Urban Pollution Island (UPI) effects. Understanding the physical processes that govern the interaction between these two phenomena is crucial for effective urban planning and climate change mitigation and adaptation strategies.

In this context, the key issues of the "Urban hEat and pollution iSlands inTerAction in Rome and possible mitigation strategies" (RESTART) project are presented. Funded by the Italian Ministry of University and Research, RESTART aims to investigate the relationship between UHI and UPI in Rome (Italy). The project offers a series of mitigation strategies, including tailored Nature-Based Solutions (NBS) such as green areas, green walls/roofs, trees, and ready-to-use guidelines for improving well-being and livability in urban environments.

The project consists of two phases: an observational phase and a modelling phase. The first phase involves examining data collected by ground-based weather and air quality monitoring instruments in Rome belonging to international observatories and dense networks. This dataset allows us to determine the current state of UHI and UPI in Rome, analyse the meteorological processes affecting these phenomena, identify possible links between them, and investigate how severe/low pollution events and extreme weather events could interact and trigger their occurrence.

The environmental vulnerabilities identified in the first phase drive the numerical investigation of city-scale ventilation, heat transport, and air pollutant removal/accumulation in the second phase. The most up-to-date numerical modelling

chain combines cutting-edge simulations with mesoscale and dispersion models (Weather Research & Forecasting Model – WRF – and Atmospheric Dispersion Modelling System – ADMS-Urban) to simulate the connection between UHI and UPI in both pre- and post-NBS implementation scenarios. The thermodynamic and chemical processes governing UHI and UPI are also analyzed, focusing on thermal comfort, pollutant dispersion, and photochemical tropospheric ozone reactions.

The outcomes from the combination of numerical and experimental analyses will provide general recommendations and guidelines to be disseminated to the scientific community, the public, and policymakers.

S3. Remote and in-situ measurements

Invited talk: Remote sensing of aerosols using geostationary meteorological satellites: what contribution for monitoring wildfires emissions?

Xavier Ceamanos[1], Daniel Juncu[1], Mael Es-Sayeh[1], Maximilien Patou[2], Quentin Coopman[3], Maya George[4], Jerome Riedi[3], Mark Parrington[5], Cathy Clerbaux[4], Bruno Six[3]

[1] *CNRM, Météo-France, CNRS, Université de Toulouse*
[2] *CNRS, CNES, UAR 2877 - ICARE Data and Services Center*
[3] *CNRS, UMR 8518 – LOA - Laboratoire d'Optique Atmosphérique, Univ. Lille*
[4] *LATMOS/IPSL, Sorbonne Université, UVSQ, CNRS*
[5] *European Centre for Medium-Range Weather Forecasts, Reading, RG2 9AX*

Biomass burning is today the main source of air pollution in many parts of the world. This predominance is set to increase in the coming years, due to the growing number of devastating forest fires caused by climate change. The harmful gases (e.g. CO) and particles contained in the smoke emitted by fires can alter air quality downstream, both locally and remotely, due to the recurrent long-range transport of biomass burning plumes. Here, we demonstrate how observations of atmospheric aerosol particles, retrieved from geostationary orbiting meteorological satellites, can be used to study the emission, transport and evolution of wildfire smoke plumes. First, we present the algorithms developed at CNRM to retrieve aerosol optical depth maps from images acquired by geostationary satellites operated by various international agencies. In particular, we describe the iAERUS-GEO algorithm for monitoring aerosols at sub-hourly frequencies from the second (and soon third) generation of Meteosat satellites operated by EUMETSAT. Next, we illustrate the potential of these high temporal resolution observations through the fires that occurred in September 2024 in northern Portugal. In addition, we focus on the mega-fires that occurred in the summer of 2020 in the western USA, and the transport of the smoke emitted across the Atlantic Ocean to Europe. In this case, a constellation of geostationary satellites is used to extend the geographical coverage of aerosol observations. The retrieved aerosol optical depth is compared, in the study region and along simulated air parcel trajectories, with ground-based instruments, other satellite observations and model analyses from the Copernicus Atmospheric Monitoring Service. The results show the potential of geostationary aerosol observations, particularly in comparison with observations retrieved from polar orbiting satellites, for understanding the emission, transport and processing of biomass burning emissions worldwide.

O3.2. Negative dipole charge structure of thunderstorm clouds during Saharan dust flow in Corsica

Gabriel Hausknost[1], Sylvain Coquillat[1], Dominique Lambert[1], Stéphane Pédeboy[2], Pierre de Guibert[1], Eric Gonneau[1]

[1] Laboratoire d'Aérologie (LAERO), Université de Toulouse, CNRS, IRD, UT3, Toulouse
[2] Météorage, Pau

The SAETTA network has observed thunderstorms in Corsica since 2014. Among these events, a specific category - accounting for 54 thunderstorm days, i.e., 5% of all thunderstorm days in Corsica - exhibits anomalously electrified thunderstorms characterized by a negative charge on top and a positive charge below. These are referred to as “negative dipoles”. Those events occur from April to October, especially in June and July. They are fairly evenly distributed across the study area and occur mainly at night. Contrariwise, classical thunderstorms in Corsica occur mainly above mountains and at daytime. According to Coquillat et al. (2022), negative dipoles in Corsica show high speed movement, trigger during Saharan dust flows, and seem to be associated with elevated convection. Analyses of radiosondes and ERA-5 reanalysis of each negative dipole situation show a dry and warm layer above the surface with a temperature inversion near the ground that prevents the triggering of convection close to the surface. Additionally, those data show higher wind speed and southern wind direction at all altitudes in the case of negative dipoles, possibly allowing a better advection and a lower alteration of Saharan dust in Corsica. The METEORAGE network, operated by Meteo-France and Vaisala, highlights a higher frequency and intensity of positive cloud-to-ground lightnings for those events, and a ratio of 89.4% of negative intra-cloud lightnings among all the intra-cloud lightnings, which is consistent with the supposed negative dipole structure. We wonder about the radiative effect of Saharan dust, like the backscattering of radiations caused by aerosols that cool the surface (temperature inversion) and the absorption of radiations that warm and destabilize the free atmosphere (elevated convection). The observation of the cloud top temperature confirms the relatively not very intense convection in a majority of cases (about 60% of all negative dipole events in Corsica with a cloud top temperature warmer than -50° C), which could coincide with insufficient development of the ice phase at high altitude, usually positively charged.

Coquillat, Sylvain et al. « Six Years of Electrified Convection over the Island of Corsica Monitored by SAETTA: General Trends and Anomalously Electrified Thunderstorms during African Dust South Flow Events ». Atmospheric Research 275 (septembre 2022): 106227. https://doi.org/10.1016/j.atmosres.2022.106227.

O3.3. Impact of Relative Humidity on Precipitation Characteristics during LIAISE-2021 field campaign

Francesc Polls, Eric Peinó, Mireia Udina, Joan Bech

Universitat de Barcelona

Evaporation of precipitation beneath cloud layer is a well-known phenomenon that contributes to the underestimation of quantitative precipitation estimates (QPE) by weather radar. The objective of this study is to explore the potential impact of relative humidity on precipitation characteristics using data at two sites from co-located automatic weather stations (AWS) that provide ground-level air temperature, pressure, and relative humidity, along with data from disdrometers, Micro Rain Radars, and C-band radar operational observations from the Meteorological Service of Catalonia. The study was conducted over the Land Surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) domain, located in the eastern Ebro Valley in Catalonia (NE Spain). This area is characterized by intense agricultural activity and is divided into two sub-areas: an irrigated area and a rainfed area, separated by an artificial channel.

A previous study in the same area showed that differences in relative humidity between irrigated and rainfed areas tend to disappear before rainfall onset. For this reason, this study evaluates relative humidity characteristics before each rainfall event, rather than comparing irrigated and rainfed areas. Results reveal a distinct behaviour approximately in the first 18 minutes of rainfall, depending on whether the event follows periods of high (moist) or low (dry) relative humidity. The analysis indicates that the time lag between weather radar precipitation detection (ca. 600 meters above ground level) and disdrometer detection at ground level differs under moist and dry conditions, finding a 5-minute delay in dry cases compared to moist cases. Furthermore, although precipitation characteristics at altitude are similar at the onset of rainfall, at the surface, the disdrometer shows statistically significant differences in parameters such as reflectivity, rainfall rate, and drop size distribution, suggesting an enhanced effect of evaporation in dry cases. This study was supported by projects RTI2018-098693-B-C32 and PID2021-124253OB-I00.

O3.4. Evaluation of Rainfall Parameters from GPM-DPR with Disdrometer Data in the Northeastern Iberian Peninsula

Eric Peinó[1], Joan Bech[1], Francesc Polls[1], Mireia Udina[1], Marco Petracca[2], Elisa Adirosi[2], Sergi Gonzalez[3], Brice Boudevillain[4]

[1] Dept. Applied physics - Meteorology, Universitat de Barcelona, Barcelona, Spain
[2] National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Rome, Italy
[3] WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland
[4] Institute for Geosciences and Environmental Research, University Grenoble Alpes, CNRS, INRAE, IRD, Grenoble INP, IGE, 38000 Grenoble, France

Assessing global precipitation trends with confidence under the influence of climate change remains a significant challenge for the scientific community. Accurate and reliable global-scale observations of precipitation, extending to climatological time scales, are essential to address this challenge. The Dual-frequency Precipitation Radar (DPR) aboard the Core Satellite of the Global Precipitation Measurement (GPM) mission operating at Ka and Ku bands is one of the few active sensors capable of providing three-dimensional measurements of precipitation structure and characteristics on a global scale.

This study evaluates the performance of the GPM DPR Version 07 in estimating precipitation intensity, radar reflectivity factors (ZKu and ZKa), and Drop Size Distribution (DSD) parameters, including the weighted mean diameter (Dm) and intercept parameter (Nw). To achieve this, data from seven OTT Parsivel1 and Parsivel2 disdrometers located across diverse topographic regions in northeastern Iberian Peninsula were used as reference.

The comparison revealed that the DPR algorithm overestimates Dm by approximately 0.1 mm at low to moderate precipitation rates (0.1–4 mm/h) and by 0.4 mm at higher rates (>4 mm/h). Conversely, Nw is underestimated, with discrepancies reaching up to 6 dB at moderate precipitation rates (4–8 mm/h). The lowest errors were observed for radar reflectivity factor and Dm, whereas agreement was poorer for Nw and the rainfall index.

The limited accuracy of GPM DPR's rainfall index measurement may be attributed to the use of predefined constants in the algorithm's relationships between rainfall rate and Dm. This highlights the need for further investigation into the retrieval algorithms to enhance their performance. Expanding disdrometer datasets will be crucial for improving precipitation sampling and refining these algorithms.

O3.5. New perspectives and advancements in satellite-based analyses and characterization of Medicanes

Leo Pio D'Adderio[1], Paolo Sanò[1], Daniele Casella[1], Stefano Sebastianelli[1], Jean-Francois Rysman[2], Valentina di Francesca[3], Derrick Herndon[4], Giulia Panegrossi[1]

[1] National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Italy
[2] LMD & LadHyX, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris, Palaiseau, France
[3] CESBIO, Université de Toulouse, CNES/CNRS/INRAE/IRD/UT3
[4] Cooperative Institute of Meteorological Satellite Studies (CIMSS) - University of Wisconsin-Madison

Medicanes (Mediterraean Hurricane) are meteorological events with the potential to cause devastating floods, storm surges and windstorms, often resulting in significant disruption and casualties. During their mature phase, they exhibit phenomenological features typical of tropical (or sub-tropical) cyclones, such as a warm core (WC), a cloud-free eye surrounded by spiraling rain bands around the center, a closed vortex associated to strong near-surface winds, and heavy precipitation. Generally, these cyclones originate from extra-tropical cyclones showing a cut-off from the main flow allowing the intrusion of relatively warm stratospheric air (warm seclusion). More rarely, they undergo the so-called tropical-like cyclone (TLC) transition during their mature phase, exhibiting at some point a deep axi-symmetric WC of diabatic origin (i.e., sustained by the latent heat release due to air-sea interaction and moist convection), and deep convection (DC) in proximity of the center. The term Medicane generally refers to both types of cyclones regardless of the thermodynamical and microphysical processes originating them.

The present work provides an overview of recent studies on the use of satellite observations to monitor and to characterize the WC, the DC, the presence of a closed eye surrounded by a ring-shaped band of intense winds showing up during the cyclone's evolution, and to identify the TLC transition. Relevant progresses on this topic are being accomplished within the ESA project "Earth Observations as a cornerstone to the understanding and prediction of tropical-like cyclone risk in the Mediterranean (MEDICANES)". The detection and characterization of WC and DC are based on satellite passive microwave (PMW) measurements from different radiometers onboard Low earth Orbit (LEO) satellites. Although the DC is a useful proxy to identify the possible tropical transition, it could affect the channels used to detect and characterize the WC. The techniques and the methodologies originally developed for tropical cyclones to correct this issue, have been tuned for the Mediterranean cyclones by developing different machine learning (ML) modules to reconstruct the brightness temperature field. In addition, deep learning (DL) algorithms combining LEO and geostationary visible and infrared measurements for near real time detection and tracking of the Medicanes's

center of rotation have been also developed and tested. New developments and applications within the ESA MEDICANES on a large dataset of Medicanes cases occurred between year 2000 and 2023 will be presented.

O3.6. Multi-sensor Approach for Satellite Hail Advection (MASHA): a new technique to support the nowcasting of hailstorms

Sante Laviola[1], Federico Vermi[2], Giulio Monte[1], Elsa Cattani[1]

[1] *CNR-ISAC*
[2] *Università di Napoli Parthenope*

The Multi-sensor Approach for Satellite Hail Advection (MASHA) is a new multi-instrument technique conceived for real-time tracking of hail-bearing clouds. MASHA can identify hail clouds from satellite measurements and monitor the evolution of hail-bearing systems every 5 min, combining the strength of the MicroWave Cloud Classification-Hail (MWCC-H) method to detect hail through the whole GPM sensor constellation (Laviola et al., 2020a-b) with the high temporal rate of the Meteosat Rapid Scan Service (MSG-RSS). This opens the way to operational applications of MASHA method by offering an unprecedented support to the nowcasting of hailstorms and to regional numerical weather predictions.

Recent applications experimented the ingestion in the MASHA scheme of lightning strikes and radar hail indices. This new configuration of the final products significantly refines the reconstruction of hail maps when the GPM constellation overpasses are missing. The result is a near-real time, more consistent and high-resolution hail map described by a proper Hail Severity Index (HSI). Recent applications demonstrate the ability of the MASHA technique to identify severe flash flood events in mountain catchments. These results draw new perspectives to optimally investigate hydro-meteorological events over mountain areas where more traditional methodologies might underestimate the severity of events. Thus, the MASHA scheme provides a useful tool in support to nowcasting systems of hailstorms and severe weather over complex areas.

References

Laviola S., V. Levizzani, R. R. Ferraro, and J. Beauchamp: Hailstorm Detection by Satellite Microwave Radiometers. Remote Sens. 2020a, 12(4), 621; https://doi.org/10.3390/rs12040621

Laviola S., G. Monte, V. Levizzani, R. R. Ferraro, and J. Beauchamp: A new method for hail detection from the GPM constellation. A prospective for a global hailstorm climatology. Remote Sens. 2020b, 12(21), 3553; https://doi.org/10.3390/rs12213553

P3.1. The Boundary-layer Air Quality-analysis Using Network of INstruments Supersite: goals and perspectives

Annalisa Di Bernardino[1], Stefano Casadio[2,3], Anna Maria Iannarelli[2], Monica Campanelli[4], Giampietro Casasanta[4], Henri Diémoz[5], Cristiana Bassani[6], Gabriele Mevi[2], Anna Maria Siani[2], Massimo Cardaci[2], Tatiana Di Iorio[7], Stefano Decesari[8], Enrico Cadau[9], Angelika Dehn[3], Philippe Goryl[3]

[1] Sapienza University of Rome, Italy
[2] SERCO Italy, Frascati (RM), Italy
[3] ESA/ESRIN, Frascati (RM), Italy
[4] CNR-ISAC Tor Vergata, Rome, Italy
[5] ARPA Valle d'Aosta, Aosta, Italy
[6] CNR-IIA, Monterotondo (RM), Italy
[7] ENEA Casaccia (RM), Italy
[8] CNR-ISAC Bologna, Italy
[9] Sardegna Clima APS, Fonni (NU), Italy

The Boundary-layer Air Quality-analysis Using Network of Instruments (BAQUNIN) project has been promoted by the European Space Agency to establish an experimental research infrastructure for the in-depth investigation of the planetary and urban boundary layers and for the validation of present and future satellite atmospheric products.

The BAQUNIN supersite consists of three observatories in Rome, Italy, managed by different research institutions. These are located in the city center (Atmospheric Physics Laboratory of Sapienza University) and in the neighbouring semi-rural (CNR-ISAC Tor Vergata) and rural (CNR-IIA Montelibretti) areas. To the best of our knowledge, BAQUNIN is one of the first "distributed" supersites in the world to involve several passive and active ground-based instruments installed in multiple urban and suburban environments in a highly polluted megacity. The configuration of the supersite allows to (i) monitor atmospheric pollution and atmospheric constituents, (ii) provide an urban boundary layer characterization, and (iii) provide reference products for satellite and models validation in urban, semi-rural, and rural contexts in the middle of the Mediterranean basin and with peculiar anemological characteristics such as coastal weather regimes.

Since 2016, the supersite has been collecting continuous surface and columnar atmospheric measurements of thermodynamic variables, particulate matter, and trace gases, also providing long-term datasets for climatological studies. Data is made available to citizens, scientific and Cal/Val communities, both through the project website (www.baqunin.eu) and the portals of international networks (e.g., Pandonia Global Network, International SKYNET DataCenter, Aerosol Robotic Network, European

Brewer Network, COllaborative Carbon Column Observing Network), to which some of the BAQUNIN instruments belong.

Scientific exploitation of atmospheric data is carried out in collaboration with several associated Italian observatories, located in maritime (ENEA, Lampedusa), alpine (ARPA Valle d'Aosta), Po Valley (CNR-ISAC Bologna), and Arctic (ENEA, Thule) environments. In this framework, fruitful collaborations and knowledge exchanges are promoted.

The BAQUNIN-APL observatory is equipped to host ground-based instruments for inter-comparison/inter-calibration campaigns in a challenging urban environment. Thanks to its unique characteristics, APL has been officially selected as an ACTRIS-Italia inter-calibration/validation facility.

In this contribution, the main characteristics of the BAQUNIN supersite are described, providing information about the complex instrumental suite operations/maintenance and the produced data.

The project adopts a policy of free sharing of its validated dataset with the community.

P3.2. An overview of the air quality in the Pyrenees and its relationship with heat waves

Mireia Udina[1], Víctor Marín[1], Cristina Campos[1], Laura Trapero[2], Eulàlia Busquets[1], Yolanda Sola[1], Joan Bech[1]

[1] Universitat de Barcelona
[2] Andorra Recerca + Innovació

Tropospheric ozone (O_3) is a secondary atmospheric pollutant formed through photochemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) under the influence of solar radiation. Ozone formation and accumulation are particularly relevant during the summer when high temperatures intensify photochemical reactions and can be advected by recirculations or formed in the presence of precursors during heat wave episodes (Ning et al., 2020; Jaén et al., 2021). Instead, nitrogen dioxide (NO2) concentrations mainly increase during winter with stagnant stability conditions and enhanced by the presence of thermal inversions. In this study we present an analysis of the pollutant concentrations in the Pyrenees and we also seek to find its relationship with heat wave episodes.

A total of 20 ozone monitoring air quality stations located in the cross-border area of the Pyrenees are analyzed for the 5-year period from 2019 to 2023. Results show that the information threshold is exceeded occasionally in Bellver, Berga, Montsec, Torrelisa and Lourdes. We also found that urban locations such as Prat Gran (Andorra) and Iturrama (Basque Country) have lower mean ozone levels while rural places such as Montsec (Catalunya) and Torrelisa (Aragón) register the highest mean ozone levels. Using ERA5 data a total of 17 heat wave periods are selected during 5 years, including a total of 105 days. The highest ozone concentrations occurred in summer and during these heat wave periods (defined as 3 or more consecutive days that exceed the P99 of hourly temperatures). On the other hand, the spatial distribution of NO2 vertical tropospheric column from Sentinel 5P revealed localized maximums during winter season. This study was performed in the framework of the project "Towards a climate resilient cross-border mountain community in the Pyrenees (LIFE22-IPC-ES-LIFE PYRENEES4CLIMA)".

Jaén, C., Udina, M., & Bech, J. (2021). Analysis of two heat wave driven ozone episodes in Barcelona and surrounding region: Meteorological and photochemical modeling. Atmospheric Environment, 246, 118037. https://doi.org/10.1016/j.atmosenv.2020.118037

Ning, G., Yim, S. H. L., Yang, Y., Gu, Y., & Dong, G. (2020). Modulations of synoptic and climatic changes on ozone pollution and its health risks in mountain-basin areas. Atmospheric Environment, 240, 117808. https://doi.org/10.1016/j.atmosenv.2020.117808

P3.3. Increasing LST and SAT trends over the Iberian Peninsula using EOS-Aqua MODIS data

Joan Vedrí [1], Sara Arribas[1], Martí Perelló[1], Raquel Niclòs[1], Enric Valor[1], Vicente García-Santos[1], Maria Antònia Jiménez[2]

[1] Departament of Earth Physics and Thermodynamics, University of Valencia
[2] Department of Physics, University of Balearic Islands

Land Surface Temperature (LST) and Surface Air Temperature (SAT) have a key role in the study of the effects of climate change. Both are defined as Essential Climate Variables (ECV) by the WCRP-GCOS. In this work, the evolution of both variables is studied over the Iberian Peninsula (IP) with products derived from EOS-Aqua MODIS data (at 1 km spatial resolution) in the period 2002-2021. IP is bathed by the Mediterranean Sea and the Atlantic Ocean and also has a complex orography. These two factors create a heterogeneous temperature spatial distribution over a region which has been suffering a faster increase in its temperature than other regions.

We utilized the LST retrieved from MYD11A1(v.6.1) product. It offers 2 daily images for our study area, one at daytime (13:00 - 15:00 UTC) and the other at nighttime (1:00 - 3:00 UTC). For SAT retrieval several methods were compared, being the XGBoost method the most accurate. We obtained 3 models to retrieve the daily maximum, minimum and mean temperatures with uncertainties between 1.8 and 1.1 K. As input variables for the XGBoost model we used LST, NDVI and Albedo products from MODIS (MYD11A1, MYD13A2 and MCD43A3, respectively), and geographical and topographical variables. Afterwards, we applied the seasonal Mann-Kendall test and the Theil-Sen estimator to obtain the temperature trends with its magnitude at a 0.05 significance level. They were implemented for the mean LST and SAT of each season and year in each pixel.

Results for LST show a warming trend of 1.0 K/decade at daytime and of 0.7 K/decade at nighttime. SAT also reveals a positive trend of 0.8 K/decade at daytime and of 0.6 K/decade at nighttime. Analyzing each season separately we observed a summer lengthening, a winter start delay and an increase of summer nighttime temperatures (tropical and equatorial nights). These trends were compared with vegetation and topographical variables.

P3.4. Assessment of high spatiotemporal land surface temperature maps generated with operative GOOGLE EARTH engine applications

Vicente Garcia Santos

Department of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, 46100 Valencia, Spain

Land Surface Temperature (LST) is an Essential Climate Variable, estimated by sensors on board satellites, which show a trade-off between their spatial and temporal resolution. Current spatial and temporal resolutions are not adequate for disciplines such as high-precision agriculture, urban decision making, and planning on how to mitigate overheating of cities, for which LST maps at 50-100 m resolution every few days are desirable. This situation has led to the development of disaggregation techniques, in order to enhance the spatial resolution of daily LST products, which unfortunately are usually complex and difficult to apply in practice. However, currently there exist two operative downscaled 10-m LST products available to the end user, which are implemented in the Google Earth Engine (GEE) tool. They are the Daily Ten-ST-GEE and LST-downscaling-GEE systems. In the present study, both 10-m LST products were assessed and their accuracy was validated with reference temperature data measured in several dedicated field campaigns for different types of crops in two sites in Spain. In general terms, both methods showed a good correlation factor against, R2, of 0.74 for Daily Ten-ST-GEE and 0.94 for LST-downscaling-GEE, but the poor results of the first method in a highly heterogeneous site (RMSE of 5.8 K) make the second one the most suitable (RMSE of 3.6 K) to obtain high spatiotemporal resolution LST maps.

P3.5. Characterizing the Transition Zone Between Clouds and Aerosols Across Europe using Satellite and Ground-Based Lidar

Jaume Ruiz de Morales[1], Josep Calbó[1], Josep-Abel González[1], Hendrik Andersen[2], Jan Cermak[2], Julia Fuchs[2], Yolanda Sola[3]

[1] Department of Physics, Universitat de Girona, Girona, Catalonia, Spain
[2] Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
[3] Department of Applied Physics - Meteorology, Universitat de Barcelona, Barcelona, Catalonia, Spain

The cloud-aerosol transition zone (TZ) has gained significant attention within the scientific community due to its potential impact on the Earth's radiation budget. Observational data concerning the TZ, particularly its vertical structure, remains limited. To address this gap, two methodologies were established to account TZ situations from active remote sensing retrievals. The first methodology used ground-based Automatic Low power Lidars and Ceilometers (ALC), while the second used the CALIOP lidar onboard the CALIPSO Satellite. For the ceilometer-based approach, a sensitivity analysis was conducted to evaluate the impact of varying the backscatter and signal-to-noise ratio thresholds used for cloud detection in the Cloudnetpy algorithm from ACTRIS Cloudnet. Cases that changed cloud detection when varying those thresholds from a strict to a relaxed situation were classified as TZ occurrences. This methodology was applied to a Vaisala CL31 ceilometer located in Girona (NE Spain), as well as several ALC systems across the European Cloudnet network. The processing of CALIOP data involved the application of several filters, subsequently identifying the TZ as the atmospheric layers within the no-confidence range (NCR) of the Cloud-Aerosol Discrimination (CAD) score, and the Cirrus fringes (CAD = 106). These methodologies enabled assessing the vertical distribution and frequency of clouds, aerosols, and the TZ.

The results reveal a gradual transition in backscatter retrievals from cloud to cloud-free environments, with suspended particles located near cloud boundaries inducing higher backscatter values than those detected at greater distances. From a local, ground-based perspective, in Girona, a 9.3% variation in cloud occurrence, with an uncertainty range of 5 to 20%, is attributed to TZ conditions. However, when analyzing the whole vertical profile, TZ conditions were as frequent as cloudy ones. From the satellite perspective, TZ layers were categorized into three groups depending on their optical characteristics: (i) Cluster 1, layers with properties between high-altitude ice clouds and aerosols (e.g. wispy cloud fragments); (ii) Cluster 2, layers with properties between water clouds and aerosols at lower altitudes (e.g. hydrated aerosols); (iii) Layers classified as Cirrus fringes. Cluster 1 and Cirrus fringes layers predominate in central Europe and the North Atlantic Ocean. In contrast, Cluster 2 layers are more frequent in the Mediterranean

region. These results highlight the widespread presence of TZ conditions and show its geographic patterns and vertical distribution.

P3.6. On the use of wind field characteristics for the detection of the mature phase of medicanes

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

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

The term ‘Medicane’ refers to cyclones that originate in the Mediterranean basin generally as extra-tropical then evolving into systems similar to tropical cyclones (TC). In particular, during the mature phase they show a warm core (WC) and a quasi-calm free cloud eye surrounded by a ring-shaped band of strong winds. In the frame of the ESA project “Earth Observations as a cornerstone to the understanding and prediction of tropical-like cyclone risk in the Mediterranean (MEDICANES)” this work aims to characterize the surface wind field associated with the different medicanes’ phases. To this end, all the useful Advanced SCATterometer (ASCAT) overpasses on board MetOp satellites for 10 medicanes from 2011 to 2024 are considered. Furthermore, to relate the surface wind field to the microphysical and thermodynamical processes, both the occurrence and the properties of satellite-based deep convection (DC) and WC are considered. To derive the medicane’s rotational center (RC), exploiting both ASCAT wind speed and direction measurements, we developed the Medicane Rotational Center Automated Detection (MeRCAD) algorithm. Then, the radius of maximum wind (RMW) is computed. The results show that during mature phase a ring-shaped band of very strong winds occurs around the RC, and the RMW decreases sharply compared to the development stage. All the relationships between the RMW and the maximum sustained wind (Vmax) and both the minimum (P) and the gradient (∇MSLP) of the mean sea level pressure suggest that the RMW can be used as a proxy for the medicanes’ intensification phase detection. Moreover, in the tropical-like phase, i.e. with a well-defined WC, a DC core is detected in the proximity of RC within the RMW. However, at the time of some ASCAT overpasses, although the wind characteristics are consistent with the mature phase, a lack of both DC core close to the RC and WC occurs. Conversely, it can also happen that, although the WC is well defined, the ring-shaped band of maximum winds is not present at all. This means that to detect the tropical-like transition also microphysical and thermodynamical properties must be considered. Finally, it is worth noting that the number of useful ASCAT overpasses is quite limited due to the low number of MetOp satellites and to the scanning geometry. To overcome this problem, both the wind radars (WindRAD) on board the Feng Yun FY-3E satellites and the HSCAT microwave scatterometers on board the HY-2 satellites will be used.

S4. Numerical modelling

Invited talk: The AROBASE coupled numerical prediction system at kilometer-scale: first results illustrated on North-Western Mediterranean severe events in fall 2024

Cindy Lebeaupin Brossier[1], Florence Sevault[1], Sylvie Malardel[1], Marie-Noëlle Bouin[1,2], Jonathan Beuvier[1], Soline Bielli[1], Fleur Nicolay[1], Alice Dalphinet[3]

[1] CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France
[2] Laboratoire d'Océanographie Physique et Spatiale, Ifremer, University of Brest, CNRS, IRD, Brest, France
[3] Météo-France, DIROP/MAR/RD, Toulouse, France

The AROBASE project aims to assemble a kilometer-scale limited-area multi-coupled modelling system of the physico-chemical atmosphere, the ocean (including sea-ice and marine biogeochemistry), waves and land surfaces (soil, vegetation, cities, snow, lakes and rivers). Such multi-coupled system will first help to improve the understanding and representation of the exchange processes between the compartments of the meteorological and environmental system at fine scale. It is also a new tool for high-resolution numerical weather prediction to better monitor and anticipate meteorological phenomena and their consequences. AROBASE finally prepares the new generation of regional climate models that aim to reach the kilometer resolution.

The first AROBASE forecast demonstrator is applied daily over the Continental France area since late August 2024 and couples the AROME numerical weather prediction model at 1.3 km resolution and the NEMO ocean model with a 1/36° resolution. The first results of the AROBASE platform will be presented during the conference, with a focus on the air-sea interactions implied during severe meteorological situations that affected the North-Western Mediterranean region during fall 2024. The future plans including the insertion of the MFWAM interactive wave model will also be presented.

O4.2. Status and Ongoing Improvements of AEMET-γ SREPS: The Ensemble Prediction System at AEMET

Juan Jose Gomez Navarro, Alfons Callado-Pallarès

Spanish Meteorological Agency (AEMET)

AEMET-γSREPS is a multi-NWP model and multi-boundary Limited Area Ensemble Prediction System (LAM-EPS) that has been developed and is operational at AEMET. Since its launch in 2016, it has been effectively employed by AEMET forecasting offices across three critical domains: the Iberian Peninsula, the Canary Islands, and the Antarctic Peninsula. These regions are simulated bi-daily at 00 and 12 UTC with a spatial resolution of 2.5 km and lead times extending up to 72 hours. The primary objective of γSREPS is to substantially enhance the accuracy of operational forecasts focussing on High Impact Weather (HIW) events, especially convective ones in the Mediterranean Region, while providing a thorough assessment of their predictability.

The ensemble prediction system comprises 20 members generated from four state-of-the-art regional mesoscale non-hydrostatic convection-permitting NWP models—HARMONIE-AROME (ACCORD-HIRLAM), ALARO (ACCORD-ALADIN), WRF-ARW (NCAR-NOAA), and NMMB (NCEP-NOAA)—with boundary conditions sourced from five global NWP models: ECMWF-IFS, NCEP-GFS, Météo-France-ARPÈGE, JMA-GSM (Japan Meteorological Agency), and CMC-GEM (Canadian Meteorological Centre). This multi-model and multi-boundary framework effectively captures and addresses uncertainties associated with NWP models, initial conditions, and boundary conditions. Notably, this methodology produces a very good skill-spread relationships compared to traditional EPS techniques that rely on single NWP models, especially in forecasting precipitation and HIW events.

γSREPS is part of an operational suite that not only executes the models on High Performance Computing Facilities (currently hosted on the ECMWF supercomputer in Bologna) but also generates a diverse collection of spatial and point products, all accessible to forecasting offices through integrated visualization platforms developed by AEMET. This approach not only consolidates γSREPS products but also harmonizes them with outputs from complementary AEMET forecasting systems, including deterministic runs from HARMONIE-AROME and the IFS ensemble, enabling forecasters to implement a "poor man ensemble" conceptual integration for optimal predictions and timely warnings.

Looking ahead, AEMET-γSREPS intends to evolve by enlarging Iberian Peninsula domain and expanding its ensemble size and diversifying boundary conditions to encompass those from the Global ICON model. Additionally, further integration of mesoscale NWP models, such as ICON-LAM and GEM-LAM, will enhance its predictive capabilities, further solidifying its status as a premier ensemble prediction system in meteorological forecasting.

O4.3. The crucial representation of convection for the cyclogenesis of medicane Ianos

Florian Pantillon[1], Silvio Davolio[2], Elenio Avolio[3], Carlos Calvo Sancho[4], Diego Carrió[5], Stavros Dafis[6], Emanuele Gentile[7], Juan Jesus Gonzalez Aleman[8], Suzanne Gray[9], Marcello Miglietta[3], Platon Patlakas[10], Ioannis Pytharoulis[11], Didier Ricard[12], Antonio Ricchi[13], Claudio Sanchez[14], Emmanouil Flaounas[15]

[1] *LAERO, Université de Toulouse*
[2] *Università degli Studi di Milano*
[3] *CNR-ISAC*
[4] *Universidad de Valladolid*
[5] *University of the Balearic Islands*
[6] *National Observatory of Athens*
[7] *Princeton University*
[8] *AEMET*
[9] *University of Reading*
[10] *National and Kapodistrian University of Athens*
[11] *Aristotle University of Thessaloniki*
[12] *CNRM*
[13] *University of L'Aquila*
[14] *MetOffice*
[15] *ETH*

We present a model intercomparison study to improve the prediction and understanding of Mediterranean cyclone dynamics. It is based on a collective effort with five mesoscale models to look for a robust response among ten numerical frameworks used in the community involved in the networking activity of the EU COST Action "MedCyclones". The obtained multi-model, multi-physics ensemble is applied to the high-impact medicane Ianos of September 2020 with focus on the cyclogenesis phase, which was poorly forecast by numerical weather prediction systems. Models systematically perform better when initialised from operational IFS analysis data compared to the widely used ERA5 reanalysis. Reducing horizontal grid spacing from 10 km with parameterised convection to convection-permitting 2 km further improves the cyclone track and intensity. This highlights the critical role of deep convection during the early development stage. Higher resolution enhances convective activity, which improves the phasing of the cyclone with an upper-level jet and its subsequent intensification and evolution. This upscale impact of convection matches a conceptual model of upscale error growth in the midlatitudes, while it emphasises the crucial interplay between convective and baroclinic processes during medicane cyclogenesis. The ten numerical frameworks show robust agreement but also reveal model specifics that should be taken into consideration, such as the need for a parameterization of deep convection even at 2 km horizontal grid spacing in some models. While they require

generalisation to other cases of Mediterranean cyclones, the results provide guidance for the next generation of global convection-permitting models in weather and climate.

O4.4. Coupled ocean-wave-atmosphere modeling of a cold wake producing Mediterranean cyclone

Sophia E. Brumer[1], Florian Pantillon[1], Joris Pianezze[1], Antonio Ricchi[2]

[1] CNRS, Laboratoire d'Aérologie, Toulouse, France
[2] University of L'Aquila, CETEMPS, CNR-ISMAR, Italy

Strong Mediterranean cyclones displaying characteristics of tropical cyclones (TC), known as medicanes, can produce cold wakes as evidenced by remotely sensed sea surface temperature data. Coupled ocean-atmosphere simulations have demonstrated how a cold wake negatively feedbacks on a TC's intensity by inhibiting air-sea heat fluxes. This was the case of medicane Ianos which produced an intensive cold wake (ΔSST>4C) before hitting Greece during the third week of September 2020.

Complex air-sea interactions governing Ianos's intensity and structure are studied in a series of high resolution (1.8 km) coupled ocean-wave-atmosphere simulations. The coupled framework consists of the atmospheric model Meso-NH, the 3rd generation wave model WAVEWATCH III®, and the oceanic model CROCO. We contrast the impact of ocean-atmosphere coupling without waves to full 3 way coupling with and without accounting for sea spray physics. Waves and sea spray accentuate the asymmetry of the storm. They negatively impact Ianos' intensity contrary to what is expected for very strong TCs. Sea spray cools Ianos' warm core while waves promote ocean mixing further increasing the cold wake response. Two separate cold wakes are formed with large scale freshening in the second one. Ocean temperature budget analysis reveals key processes and interplay between storm induced and local dynamics linked to ocean eddies. This study highlights the necessity of coupled ocean-wave-atmosphere modeling to adequately simulate tropical-like Mediterranean cyclones.

O4.5. On the role of air-sea interaction in developing destructive Tropical-Like Cyclones DANIEL

Antonio Ricchi[1], Rossella Ferretti[1], Florian Pantillon[2], Piero Serafini[1], Stavros Dafis[3], Milena Mena[4], Riccardo Martellucci[4] and Diego Saúl Carrió[5]

[1]University of L'Aquila/CETEMPS (Italy)
[2]Laboratory d'Aérologie (France)
[3]National Observatory of Athens
[4]National Institute of Oceanography and Applied Geophysics (Italy)
[5]Universitat de les Illes Balears

Between Sept. 4, 2023, and Sept. 12, 2023, a cyclogenesis develops close to the Greek coast in the Ionian Sea. The evolution of this cyclone is divided into two phases: a strongly baroclinic one with intense orographic precipitation in Greece, and a final barotropic phase with the formation of an intense tropical-like cyclone (TLC) impacting Libya. In this work, we investigate this TLC (named "Daniel") initially using the standalone WRF model with different sea surface temperature sources, until the use of the coupled atmosphere-ocean models. Preliminary results show that SST plays a crucial role in the intensification and tropicalization of the cyclone, with a strong impact not only along the cyclone track but especially in the neighbouring areas, where high values of heat transport a precipitable water are found. We also observe how the use of a coupled model as a digital twin, shows strengths in the quality of the simulation and the physics of the process, but highlights some critical issues in the configuration of the marine model, which at small technical variations produces intense changes in the structure of the ocean and atmosphere.

O4.6. Towards a better understanding and simulation of heavy precipitation events: the catastrophic flash flood of the Francolí River basin in Catalonia, north-eastern Spain

David Ramonell, Arnau Amengual, Diego Carrió, Romualdo Romero

Grup de Meteorologia, Departament de Física, Universitat de les Illes Balears (Spain)

Mediterranean Spain is characterised by its complex and densely urbanised topography, featuring numerous small-to-medium-sized, steep basins. Consequently, it faces significant exposure to flash flooding, especially during late summer and early autumn, when heavy precipitation events (HPEs) are more frequent. Furthermore, as this region has been identified as a climate change hotspot, it confronts additional risks as global warming intensifies the hydrologic cycle, resulting in an expected boost in the frequency and severity of flash floods. Our research aims to achieve new insights on the physical mechanisms behind the formation of HPEs in the Spanish Mediterranean region, using the potentialities of hydrological numerical modelling as an advanced validation tool of rainfall simulations. Here, we focused on the 22 October 2019 HPE which led to the catastrophic flash flood episode of the Francolí River in Catalonia, resulting in economic losses of EUR 44 million and six fatalities. Initially, radar-derived precipitation estimates were used to force the hydrologic Kinematic Local Excess Model. Once calibrated, it accurately reproduced the discharge observations at Tarragona's stream gauge. Afterwards, a set of high grid resolution precipitation fields was obtained through numerical weather simulations using the (a) WRF mesoscale model and (b) the new Triangle-based Regional Atmospheric Model (TRAM-UIB). These precipitation fields were then employed to initialise the hydrologic model. Lastly, utilising the model and the configuration with the most accurate precipitation fields, sensitivity experiments were carried out to understand the effect of sea surface temperatures and topography in the meteorological fields related to the genesis of flash flood-producing HPEs. Results show that, all simulated precipitation fields reproduce the flash flood-inducing HPE over the catchment, yet only a few realistically recreate the spatio-temporal distribution according to radar precipitation estimates. Forcing the hydrologic model with the most accurate rainfall simulation, results in a very good run-off at the basin's outlet, hence achieving a successful HPE simulation by means of hydrologic validation. Subsequent sensitivity experiments based on this simulation, highlight the role of sea surface temperatures in rainfall quantity and resulting discharge, while topography contributes through mechanical uplift and modulates the spatio-temporal distribution of precipitation at catchment scale. Therefore, both factors are of instrumental importance for the development of this HPE and catastrophic flash flood episode.

O4.7. Comparison of Microphysical Characteristics of Precipitation Between Modeled Data and Observations Over Complex Terrain

Eulàlia Busquets, Mireia Udina, Joan Bech, Francesc Polls

University of Barcelona

Rainfall microphysics is a key parameter in a wide range of atmospheric science applications, including precipitation forecasting, soil erosion studies, and radar-based remote sensing. In numerical weather prediction models, microphysical schemes simulate precipitation species (such as rain, snow, or graupel) and their interaction, as well as the size distribution of the precipitating particles. In the Weather Research and Forecasting (WRF) Model, a variety of microphysical schemes are available, including both bin and bulk strategies. Specifically, bulk schemes can predict between three and seven hydrometeor species and may account for only the mixing ratio (single-moment schemes) or both the mixing ratio and number concentration (double-moment schemes). The choice of microphysical scheme is critical for model accuracy, yet these decisions are often non-intuitive.

This study aims to compare various microphysical scheme outputs from the WRF model with observational data from surface-based instruments, such as disdrometers. The study focuses on episodes of winter precipitation over the Pyrenees mountain region (Spain). Simulations were conducted using WRF version 4.5.1, initialized with ERA5 reanalysis data. The model configuration included three nested domains, with a 1.5 km × 1.5 km grid size in the inner domain. Preliminary results reveal that modeled raindrop size distributions observed at instrumental sites were linked to stratiform precipitation and weak shallow convection processes. Furthermore, accretion appeared to be a dominant microphysical process during the evolution of certain modeled precipitation events. This study is supported by Spanish project ARTEMIS (PID2021-124253OB-I00).

O4.8. Simulations of thermally-driven winds: combined effect of slope and sea-breezes

Adeline Montlaur[1], Santiago Arias[1], Jose I. Rojas[1], Maria Antònia Jiménez[2]

[1] Universitat Politècnica de Catalunya
[2] Universitat de les Illes Balears

Thermally-driven winds, such as slope winds and land- and sea-breezes, typically exhibit lower intensity than synoptic wind regimes. However, they offer the significant advantage of being highly periodic, making them particularly appealing for wind energy production, an increasingly urgent need in the current context of decarbonisation of energy systems. In this study, we aim to simulate the generation and behaviour of thermally-driven winds in the Llobregat river delta, located in the northeast of the Iberian Peninsula. This coastal region is influenced by both sea breezes and slope winds due to the proximity of the Garraf mountains. Our objective is to analyse the combined effect of these wind systems on local wind dynamics. To that end, we use a simple 2D computational domain, where temperature and terrain roughness data are used as inputs of the model, and a realistic slope angle is applied to replicate the topography. Temperature measurements at various heights were collected over two years using a meteorological mast located in the study area. From this dataset, several days characterized by prominent thermally-driven winds were selected to set up and validate the simulations. The numerical simulations, which are based on the incompressible Navier-Stokes equations under the Boussinesq approximation, were conducted using the open-source computational fluid dynamics software OpenFOAM. Results include vertical profiles of temperature and wind velocity at specific times of the day, as well as their temporal evolution throughout the day. These results are then compared with wind speed measurements obtained from anemometers mounted on the meteorological mast, providing insights into the accuracy of the model and the combined influence of sea breezes and slope winds in this region.

O4.9. Assessing a dry soil layer parameterization for bare soil evaporation during the LIAISE field campaign with SURFEX-ISBA

Belén Martí[1], Jannis Gröh[2,3,4], Guylaine Canut[1], Aaron Boone[1]

[1] CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France
[2] Institute of Crop Science and Resource Conservations (INRES), Soil Science and Soil Ecology, University of Bonn, Bonn, Germany
[3] Institute of Bio- and Geosciences - Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, Jülich, Germany
[4] Research Area 1 Landscape Functioning, Isotope Biogeochemistry and Gas Fluxes, Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Germany

Bare soil evaporation is generally overestimated in Land Surface Models (LSM), this being one of the most relevant factors for transpiration being underestimated globally (Chang et al. 2018). In this study, we characterize the processes that drive bare soil evaporation by simulating evapotranspiration (ET) at several sites from the Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) campaign by the means of ISBA land surface model within the SURFEX platform. The LIAISE campaign ran from April through September 2021 in a semi-arid region within the Ebro basin. Several dry-down periods were studied using different soil resistance parameterizations within ISBA for an irrigated alfalfa field and a rainfed natural grass site.

At the alfalfa site, the ground was nearly bare at the onset of the study period, however the field was covered by vegetation with a height of 70 cm height about 2 weeks later: this allowed us to study the transition from baresoil to transpiration-dominated ET. First, during consideration of the continuous change of LAI and vegetation height (rather than using the usually imposed 10 day average values) reduced the RMSE of simulated ET against observations by over 25W/m² for the overall time period. However, bare soil evaporation was overestimated after irrigation when vegetation did not cover the ground and the soil was saturated and drying down. This process was better captured by the implementation of a soil resistance. Standard widely-used empirical resistances proved insufficient whereas the parameterization of soil resistance based on a dry surface layer (DSL) proved to be the better choice. Its implementation resulted on a 30% improvement in ET, corresponding to a RMSE of the order of 50W/m², comparable to the error of the observed energy budget residual.

The dry natural grass site consisted in sparse vegetation. The sensible heat flux dominated the turbulence fluxes with maximums of near 300W/m², while the ET average daily maximum was close to 50W/m². When vegetation does not cover the soil, bare soil evaporation is overestimated and the implementation of a DSL reduced the overall ET error by 20%. In summary, it was found that a DSL parameterization improves bare soil evaporation in semiarid conditions at two contrasting sites in semi-arid

conditions compared to that simulated with a set of more commonly used soil resistance methods in land surface models where bare soil evaporation is known to be systematically overestimated.

O4.10. Characterizing Atmospheric Boundary Layer Turbulence in the Gulf of Lion: A Meso-NH Modeling and Lidar Measurement Comparative Study

Tanguy Lunel[1,2], Didier Ricard[1] and Maxime Thiébaut[2]

[1] *Centre National de Recherches Météorologiques*
[2] *France Energies Marines*

This study presents an analysis of the atmospheric boundary layer (ABL) turbulence in the Gulf of Lion, a critical region for the development of offshore wind energy in the Mediterranean Sea. The turbulence is spatially characterised using the Meso-NH model at both mesoscale and Large Eddy Simulation resolutions. The model is used to investigate the interactions and dynamics of a coastal ABL, providing insights into the spatial and temporal variability of turbulence. The model results are also compared with turbulence measurements obtained from a wind lidar profiler installed on Planier Island, located approximately 10 km off Marseille. The lidar measurements provide high-resolution data on the mean wind field and turbulent flow, allowing a critical interpretation of both model and lidar profiler results. This comparative approach allows a better understanding of the turbulence characteristics, which is essential to optimise the performance and reliability of wind turbines, but also to better understand the coastal meteorology in the Mediterranean Sea.

O4.11. Exploring Aerosol Impacts on the Urban Heat Island Effect in WRF Simulations for Paris: Insights from the WCRP CORDEX FPS URB-RCC STAGE-0

Eloisa Raluy López, Leandro C. Segado Moreno, Ginés Garnés Morales, Ester García Fernández, Pedro Jiménez Guerrero, Juan Pedro Montávez

Regional Atmospheric Modeling Group, Department of Physics, Regional Campus of International Excellence (CEIR) "Campus Mare Nostrum", University of Murcia, Murcia, Spain

Urban areas host the majority of the global population, making them hotspots for the impacts of climate change, including heat waves, heavy precipitation, and droughts. Decision-makers require high-quality climate information to develop effective adaptation and mitigation strategies for addressing climate change in cities. However, significant challenges remain in accurately simulating the interactions between urban areas and regional climate systems. To advance the understanding of urban environments and their interactions with regional climate, the WCRP CORDEX Flagship Pilot Study URB-RCC has been launched. This coordinated effort brings together various atmospheric modeling groups to conduct a series of simulations using different regional climate models (RCMs) with urban schemes. The STAGE-0 simulations focus on the Paris region for the period between April and September 2020, encompassing both a heatwave and a heavy precipitation event.

This study presents a comparison of two simulations conducted as part of the FPS URB-RCC, both performed using the WRF model by the Regional Atmospheric Modeling Group at the University of Murcia. The first simulation represents the control configuration (CTRL), a common setup adopted by all modeling groups using WRF. It incorporates land cover information based on LANDMATE PFT data, including Local Climate Zones (LCZs), and employs the BEP+BEM urban scheme. Additionally, aerosol climatology is derived from the MERRA2 reanalysis. The second simulation (CHEM) was conducted with WRF-Chem. The CHEM experiment retains the same physical configuration as the CTRL experiment but replaces predefined aerosols with an online coupling to atmospheric chemistry and aerosol transport. Furthermore, it accounts for various pollutant species.

The results show that both experiments are able to reasonably reproduce the urban heat island (UHI) phenomenon. The main differences between the simulations are related to changes in the daily cycle of urban-rural temperature differences. Specifically, the inclusion of chemistry leads to a general cooling of both rural and urban areas. These results highlight the impacts of aerosols and pollution on the WCRP CORDEX FPS URB-RCC STAGE-0 simulations performed with WRF, both in urban-rural temperatures and in the magnitude and daily cycle of the UHI effect in the city of Paris.

Acknowledgements: The authors acknowledge the ECCE project (PID2020-115693RB-I00) of the Ministerio de Ciencia e Innovación/Agencia Estatal de Investigación (MCIN/AEI/10.13039/501100011033). ERL thanks her predoctoral contract FPU (FPU21/02464) to the Ministerio de Universidades of Spain.

O4.12. Assessing the Impact of High-Resolution Anthropogenic Emissions on Air Quality Simulations: A Case Study over the Region of Murcia

Leandro C. Segado Moreno, Eloisa Raluy López, Ginés Garnés Morales, Ester García Fernández, Juan Pedro Montávez, Pedro Jiménez Guerrero

University of Murcia

Air pollution remains a pressing global challenge, with significant repercussions for public health, ecosystems, and the climate system. In this context, anthropogenic emissions play a key role in deteriorating air quality. These emissions not only contribute directly to atmospheric pollution but also drive the formation of secondary pollutants, such as tropospheric ozone (O_3), through complex chemical reactions. As a result, atmospheric models have become indispensable tools for studying these processes, enabling us to predict pollution dynamics. However, the accuracy of these models is often constrained by the resolution and quality of the emission inventories they employ. This limitation is particularly critical for simulating urban-scale pollution events or extreme air quality episodes, where proper spatial and temporal variability is essential.

To tackle this issue, we have employed a regional, high-resolution (1 km spatial, hourly frequency) anthropogenic emissions inventory developed using municipal-level data on traffic, industrial, and urban emissions provided by the Regional Government of Murcia. The aim was to assess how these fine-scale emissions influence air quality simulations compared to the widely used CAMS (Copernicus Atmosphere Monitoring Service) anthropogenic emissions inventory, which operates at a coarser resolution (0.1° spatial, monthly frequency). We conducted a series of simulations using the Weather Research and Forecasting model coupled with chemistry (WRF-Chem) to evaluate the impact of these high-resolution emissions during extreme pollution episodes.

The results revealed substantial differences in spatial pollutant patterns, with the high-resolution inventory capturing more localized variations and better aligning with observations from ground-based monitoring stations. For example, tropospheric ozone concentrations during these episodes showed improved correlation with observed data, particularly in urban and industrial areas. These findings demonstrate the added value of incorporating fine-scale anthropogenic emission data sets into air quality models. High-resolution inventories enhance the representation of spatial and temporal emission variability, enabling more accurate predictions of extreme pollution events and their potential impacts on human health and the environment.

P4.1. Better understanding of evapotranspiration in semi-arid environments with ISBA

Belén Martí, Maëlle Goupil, Aaron Boone

CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France

Land surface models (LSM) were originally developed to provide atmospheric models with surface flux boundary conditions for turbulence and radiation parameterizations based on the solution of a surface energy budget. Over time, a greater accuracy of LSMs was required and applications to hydrology and agronomy were developed. The incorporation of processes to meet such requirements is still ongoing. Therefore, within the same LSM, several physics options for site characterization can be considered as valid approximations. In particular, the Interaction Soil Biosphere Atmosphere (ISBA) model within the SURFEX platform contains both a composite and a multi-energy budget ("multi-source") configuration. Furthermore, the use of a widely-used canopy resistance scheme proposed by Jarvis (1976) has been replaced by a more realistic and complex Assimilation-stomatal conductance (A-gs) scheme (Calvet et al., 1998). A comparison in a semiarid context, where LSM have more difficulties, is presented to identify the differences and challenges of the different configurations.

The Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) campaign took place in the semi-arid region within the Ebro basin in the Iberian Peninsula, which consists of two distinct areas separated by a canal. The first one is flood irrigated and the other is mainly rain-fed, resulting in a strong contrast in water availability over a 30 km radius due to anthropization. In both areas, energy budget stations with complementary measurements were installed on locations with different standard crops such as alfalfa, corn, an apple grove, an almond grove, a vineyard and natural grass.

The goal of this study is to contribute to ongoing research which seeks to improve ET estimates coming from LSMs. To that end, this study presents the results from an irrigated by flooding corn site with forcing of the observations. Estimates of the latent heat flux with a Jarvis configuration provide an improvement from a composite to a multi-energy budget scheme with a ME of 55 and 43 W/m² and a RMSE of 120 and 103 W/m² respectively. The A-gs composite scheme configuration underestimates the evapotranspiration with a ME of -25 and a RMSE of 93 improving on the Jarvis' estimates. Further, we present some results using additional model physics options.

P4.2. Updates to WRFv4.3 Model Operational at SMC

Manel Bravo Blanco, Jordi Mercader Carbó, Jordi Moré Pratdesaba

Servei Meteorològic de Catalunya

At SMC, we operate WRF version 4.3 for our forecasts. Verification against our AWS reveals an overestimation of wind speed, a dry bias, and insufficient diurnal temperature range. To address these performance issues, a revised model configuration and updated geographical information were implemented in the spring of 2025.

We updated the soil texture, land-use category, and background albedo databases. In the model configuration, modifications include adjustments to the parameters table, nudging settings, and most notably, a transition from the Noah land-surface model to Noah-MP.

Results from a year-long comparison for 2024 demonstrate improvements in surface temperature, humidity, and wind speed.

P4.3. Three Decades of high-Resolution ERA5 Downscaling over the Italian domain: Validation and Applications in Hydrology, Meteorology, and Climate Analysis

Paolo Stocchi[1], Francesco Cavalleri[2], Silvio Davolio[3], Michele Brunetti[1], Stefania Camici[4], Mohsin Tariq[1]

[1] Institute of Atmospheric Sciences and Climate, National Research Council (CNR-ISAC), Bologna 40129, Italy
[2] Environmental Science and Policy Department (ESP), University of Milan, Milan 20133, Italy
[3] University of Milan, Department of Earth Sciences "Ardito Desio"
[4] Research Institute for Geohydrological Protection, National Research Council, (CNR-IRPI) Perugia, Italy

This study presents a detailed assessment of very high-resolution reanalysis data covering the entire Italian territory and the broader Alpine domain for the three-decade period 1990-2020. The dataset was generated using a dynamical downscaling of ERA5 reanalysis with the convection-permitting model MOLOCH, implemented at a fine grid spacing of 1.8 km.

Validation against high-resolution observational datasets (GRIPHO, ARCIS, and the ISAC-CNR precipitation and temperature dataset) and comparisons with similar downscaled reanalysis products (ERA5-LAND, CERRA-LAND, MERIDA-HRES) confirm the dataset's reliability in reproducing key meteorological variables, such as temperature and precipitation. Importantly, the dataset leads in capturing higher-order statistics, including intensity and extremes.

The dataset's versatility is illustrated through multi-disciplinary applications. In hydrology, it enables high-resolution drought characterization; in meteorology, it supports the analysis of extreme weather events and orographic effects. In climate research, it provides valuable insights into long-term trends and variability.

This work underscores the importance of very high-resolution datasets in advancing our understanding of the complex interactions between natural processes and human activities, especially in regions with challenging topography like the Alps. It establishes a strong foundation for future research and practical applications, including disaster risk management, water resource planning, and climate adaptation strategies.

S5. Interdisciplinary studies

Invited talk: Coupled Fire-Atmosphere modelling: Some Findings and current challenges based on Portuguese case studies

Rui Salgado[1], Flavio T. Couto[1], Cátia Campos[1], Filippe Santos[1], Roberta Baggio[2], Jean-Baptiste Filippi[2]

[1] Universidade de Évora, Center for Sci-tech Research in Earth System and Energy (CREATE)
[2] Centre National de la Recherche Scientifique (CNRS)

High-resolution atmospheric models and their coupling with fire propagation models are powerful tools for better understanding the behaviour of rural fires and their effects on the atmosphere. Portugal is one of the European countries with most burned area and numerous ignitions. In 2017, Portugal was affected by several mega-fires with burned areas larger than 10 000 hectares, some of which led to the formation of convective clouds: pyro-cumulus (pyroCu) and pyro-cumulonimbus (pyroCb). These phenomena can significantly influence the evolution of fire fronts by altering surface winds and raising spread rates, creating extra difficulties for firefighting and increasing burned areas.

These rural fires of 2017 were the starting point for studying the atmospheric environment that favours ignitions and fire spread and the effects of fires on the atmosphere, particularly the generation of pyroconvection. In this study, Pedrogão Grande (June 17) and the Quiaios (October 15) mega-fires are chosen as case studies for numerical simulations with the MesoNH atmospheric model coupled with the ForeFire fire propagation model. The simulations show the development of pyroCu and pyroCb clouds produced by intense convective updrafts due the heat fluxes generated generated during combustion. The simulations have improved our understanding of the evolution of the fire environment and the role played by downbursts originating from pyroCb clouds and provided insights about numerical modelling of pyro-convective clouds using Meso-NH/ForeFire simulations.

Finally, we use the results obtained in this work to illustrate the current state-of-the-art of coupled fire-atmosphere modelling, its limitations and challenges.

O5.2. Meteorological drivers of offshore wind ramping in the Mediterranean and its role within Europe

Aina Maimó-Far, Conor Sweeney

University College Dublin

The growth of renewable energy sources (RES) has made energy systems increasingly dependent on weather, a trend expected to intensify in the coming years. One of the key challenges in this context is the occurrence of ramps, rapid changes in energy generation that can pose risks to grid stability. The deployment of large offshore wind farms, which are often highly concentrated in specific locations, is likely to amplify this challenge, as ramps from these farms can significantly impact national renewable energy generation. This study focuses on the Mediterranean basin, examining its unique meteorological conditions while placing its dynamics within a broader European context to better understand regional variability and interconnections.

In this work, we use ERA5 reanalysis data to drive energy conversion models and analyze weather regimes, allowing for an assessment of offshore wind ramping at long temporal scales. We analyse offshore wind ramps in the Mediterranean, focusing on their frequency and intensity, temporal patterns, and spatial characteristics. By linking these ramps to large-scale weather regimes, we evaluate how ramp characteristics and meteorological drivers shape regional differences, particularly in comparison to the rest of Europe. Finally, we explore the potential for reducing ramp impacts through the addition of solar energy, comparing standard wind-only configurations to potential hybrid wind-solar offshore installations. Our findings aim to enhance the understanding of meteorological influences on renewable energy variability and support the development of strategies for improved grid stability.

O5.3. Synoptic weather patterns associated to large wildfires in the croatian Adriatic

Tomislava Hojsak, Dunja Plačko-Vršnak

Croatian Meteorological and Hydrological Service

Fire activity is closely related to weather factors shuch as drought, heat, and low relative humidity that contribute to the drying of fuel. Within such flammable conditions, certain weather types can induce a fire-spread favourable environment.

The intention of this work is to detect synoptic weather patterns that promote fire spread and are favourable for unpredictable fire behaviour.

The analysis was performed using the fire data set obtained from the Croatian Firefighting Association. Based on fires with burnt area larger than 400 ha over a 20-year period (between 2005 and 2024), the days with conditions favourable for fire spread and unpredictable behaviour were detected. Most of the large fires occurred in Dalmatia, with a total of 74 fires detected during that period. Almost 90% of fires occurred in July and August. For days with large fires, prevailing weather type was determined according to the Poje classification of surface weather types. Additionally, the upper-level circulation patterns on 500 hPa isobaric surface were determined.

Out of the 29 Poje weather types, 17 were detected in the observed period. Two of the most frequent types are associated with the non-gradient field (35 %). These are persistent weather types in which the intensity of the general circulation of the atmosphere is reduced, and diurnal heating results in moderate to strong winds of coastal circulation that can promote fire spread. If some moisture is present, then dry thunderstorms may occur, mostly during the passage of weakened fronts that bypass the area or pass through it, introducing short-term strengthening of wind and wind shear. From the upper level circulation patterns, the most frequent were those connected to the upper level ridge (G, GNW and GSW) with more than 50 % occurrence rate. The upper-level ridge is related to warm and dry air advection and stable weather, but strong low-level winds and instability may develop due to strong heating at the surface.

Extreme fires in the observed period most often occurred during the transitional weather types with strong winds (ES, SES), an anticyclone (V2) or within the non-gradient field (Bc) accompanied by strengthening of wind in front of the approaching cyclone. At the same time, the other conditions necessary for the development of extreme fires were also met – complex topography and availability of large amount of dry fuel, but not necessarily extremely dry.

O5.4. Live fuel moisture content estimation using remote sensing and numerical modelling approach

Filippe Lemos Maia Santo[1,2], Flavio Tiago Couto[1,3], Maria José Monteiro[4], Nuno de Almeida Ribeiro[1,3], Patrick Le Moigne[5], Rui Salgado[1,3]

[1] Center for sci-tech Research in EArth sysTem and Energy (CREATE), Instituto de Investigação e Formação Avançada (IIFA), Universidade de Évora
[2] Earth Remote Sensing Laboratory (EaRSLab)
[3] Departamento de Física, Escola de Ciências e Tecnologia (ECT), Universidade de Évora, Rua Romão Ramalho 59, 7000-671, Évora, Portugal
[4] Instituto Português do Mar e da Atmosfera
[5] Centre National de Recherches Météorologiques, Université de Toulouse, Météo-France, CNRS

Climate change has led to an increase in wildfires, particularly on the Iberian Peninsula. In recent years, Portugal suffered several devastating wildfires, such as in 2003, 2005, and 2017. In 2024, the situation repeated itself, with several large-scale wildfires occurring in the Central region during September. Wildfires are directly related to the availability of combustible material, weather conditions, and ignition factors. Currently, land use and occupation management is a way to reduce wildfires. Identifying areas with higher fuel availability is essential for wildfire prevention in this context. This work aims to improve the live fuel moisture content (LFMC) representation across mainland Portugal, using remote sensing and numerical modelling through a machine learning approach. First, a product was developed to estimate LFMC for Portugal based on remote sensing, through satellite imagery, and machine learning (LFMC-RS). Next, numerical simulations were performed with the MESO-NH (research) and AROME (operational) models, non-hydrostatic mesoscale atmospheric models, producing forcing files to initialize the SURFEX surface model. All output variables from the SURFEX model were utilized as predictors in a machine learning classifier to estimate the LFMC (LFMC-SFX). These results are useful for understanding the FMC spatiotemporal variability in Portugal The research received financial support from the Foundation for Science and Technology, I.P. (FCT) through the PyroC.pt initiative (Ref. PCIF/MPG/0175/2019) along with a PhD Grant (2022.11960.BD). This work also was co-funded by the European Union through the European Regional Development Fund (FEDER) in the framework of the Interreg VI-A España-Portugal (POCTEP) 2021–2027, FIREPOCTEP+ (0139_FIREPOCTEP_MAS_6_E).

O5.5. Climate and society: Changing narratives of social stability

Ester García Fernández, Salvador Gil-Guirado, Ginés Garnés-Morales, Leandro Cristian Segado-Moreno, Eloisa Raluy-López, Pedro Jiménez-Guerrero, Juan Pedro Montávez

University of Murcia

Climate change is one of the main challenges facing today's society globally, with impacts that are uneven in intensity and form (Hoegh-Guldberg et al., 2018). Its environmental consequences include rising global average temperatures, receding sea ice, which raises sea and ocean levels, and the increasing frequency and intensity of Extreme Weather Events (EWE).

An EWE is defined as a weather event that occurs outside normal patterns, both in intensity and duration, in a specific area and period (Seneviratne et al., 2012). They include extreme temperatures, droughts and heavy precipitation, such as snowfall and floods. Their impact is devastating and includes human losses, diseases resulting from exposure, forced displacement, destruction of infrastructure, damage to crops, death of animals and overwhelming economic losses.

However, one of the most significant indirect consequences is the generation of an unstable social climate, facilitating tensions and conflicts between human groups. This concept has been referred to as 'multiplying threats'. According to Koubi et al. (2014), this situation is more common in societies marked by social inequalities and unstable political systems. However, Bell and Keys (2018) argue that it is more affluent populations who experience greater fear of losing their well-being, leading to social destabilisation and conflict. Moreover, such forced migration often generates tensions in receiving areas with limited capacities to manage these flows.

Despite this evidence, uncertainty about the future impact of EWE on social stability can only be resolved by the knowledge generated by the scientific community through data and observations. In this context, this paper analyses the evolution of social conflicts influenced by EWE on a global scale. For this purpose, a bibliometric review of studies published since 2000 in high impact journals has been carried out. This approach allows for the identification of possible trends and changes in the understanding of the risk that EWE pose to social stability, providing a comprehensive picture of this link and its implications. Preliminary results suggest that this type of study has increased especially since 2007, being particularly pronounced between 2016-2021. It highlights the independent analysis by type of EWE and social conflict, determining the importance of spatial scale and impact.

S6. Statistical and AI-based methods

Invited talk: Leveraging machine learning for regional climate emulation and extreme event attribution

Jorge Baño Medina

Institute of Physics of Cantabria

Recent advances in machine learning have made significant strides in climate modeling, offering new ways to analyze and study climate variability and change. Regional Climate Models (RCMs) are essential for studying regional climate dynamics, but their high computational costs constrain the generation of large ensembles of simulations across multiple emission scenarios, GCMs, and time periods, limiting the ability to produce more robust estimates of climate change uncertainty at regional scales. RCM emulators powered by deep learning provide a cost-effective solution, enabling century-long simulations by learning from only short RCM runs. However, challenges remain regarding their transferability to different periods, scenarios, and Global Climate Models (GCMs), than the ones used during training. In this talk we will talk about the potential and limitations of two types of emulation approaches: perfect prognosis (PP) and model output statistics (MOS). On the other hand, AI-driven models such as Graphcast, Pangu Weather, and others show great promise for (storyline) climate attribution analysis of extreme events. For instance, for an impactful extreme atmosphere river in the Western United States, AI-driven simulations show a 5-6% increase in water vapor in the area in a "climate change scenario", which is consistent with results from dynamical models. These AI models, offering fast inference times, can process large ensembles quickly, making real-time climate attribution possible.

O6.2. Improving prediction of heavy rainfall in the Mediterranean with Neural Networks using both observation and Numerical Weather Prediction data

Killian Pujol Nicolas[1], Roberta Baggio[2], Jean-Baptiste Filippi[2], Dominique Lambert[1], Jean-François Muzy[2], Florian Pantillon[1]

[1] Laboratoire d'Aérologie (LAERO), Université de Toulouse, CNRS, IRD, UT3, Toulouse
[2] Laboratoire Sciences Pour L'Environnement (SPE), Université de Corse, CNRS, Corte

Forecasting Heavy Precipitation Events (HPE) in the Mediterranean is crucial but challenging due to the complexity of the processes involved. In this context, Artificial Intelligence methods have recently proven to be competitive with state-of-the-art Numerical Weather Prediction (NWP). Our work focuses on improving the prediction of the occurrence of HPE over periods from 1 h to 24 h based on Neural Network (NN) models. It uses both ground-station observations (OBS) and data from Meteo France's Arome and Arpege NWP models, on two regions with oceanic and Mediterranean climates for the period 2016-2018. Our verification metric is the Peirce Skill Score (PSS).

Our results show that the NN model using only OBS or NWP data performs better for shorter and longer rainfall accumulation period, respectively. In contrast, a hybrid method combining both OBS and NWP data offers the best performance and remains stable with the rainfall accumulation period. The hybrid method also improves the performance in predicting increasingly intense rainfall, from the 5 % to the 0.1 % rarest events. We also find that the choice of a balanced loss function---i.e. one that takes into account the under-representation of rare events---is crucial for not missing actual events and significantly improves performance. Therefore, we propose a balanced loss function based on the PSS that improves greatly the prediction of HPE. Finally, the hybrid method is particularly well suited for the prediction of HPE in the Mediterranean climate, especially during the fall season, period during which most HPE occur.

O6.3. Predicting Air Quality at Municipal Level

Juan Pedro Montávez, Leandro C. Segado Moreno, Eloisa Raluy López, Ginés Garnés Morales, Salvador Gil Guirado, Pedro Jiménez Guerrero

Regional Modelling Atmospheric Group, Department of Physics, University of Murcia

The estimation of air quality at the municipal level is essential to protect public health. Air quality is measured by means of expensive air pollution stations that are usually not sufficient due to the great spatial and temporal variability of the concentration of pollutants. This work presents a methodology to obtain the air quality index for all the municipalities of the Region of Murcia (49) from a set of measurement stations (11).

The developed methodology is based on machine learning techniques. The model presented (RFRM) learns the spatio-temporal relationships between the points where the stations are located and the municipal pollution series, using a series of hourly predictions at one kilometer of spatial resolution, obtained by means of the WRF-CHIMERE modeling system for a 10-year period. The municipal series of Ozone, Nitrogen Oxides, and Particulate Matter are obtained as an average of the model series weighted by the inhabited areas and their population from the very high resolution cadastre data. Thus, for each time step where observed data are available, our model will generate the pollutant series for each municipality.

To test the model, we have used the measurement campaigns of a mobile unit carried out during two complete years, covering almost all the municipalities of the Region. The results indicate that for Ozone the prediction is almost perfect with correlations above 0.9. For Nitrogen Oxides and particulate matter, the results are acceptable, with correlations above 0.7 in 90% of the cases. The system is being applied operationally in the Region of Murcia.

O6.4. Mapping of ERA5 meteorological features to lightning occurrence via AI

Alessio Pedullá

DICCA, Università degli Studi di Genova, Italy

Lightning represents a significant natural hazard with implications for wildfires, aviation, telecommunications, and human safety. Despite its critical impacts, the physics driving lightning remains only partially understood, particularly in the context of climate change. This research focuses on leveraging artificial intelligence (AI) to explore lightning activity in Italy, bridging observational data with meteorological features.

The study's first phase involves pairing lightning observations from the LAMPINET network with meteorological variables derived from ERA5 reanalysis data. An AI model is being developed to map lightning occurrence based on key atmospheric features critical for cloud electrification and lightning formation. This phase aims to refine the understanding of lightning-environment relationships and establish a benchmark for model performance.

The insights gained will lay the foundation for the study's second phase, where the AI model will be applied to meteorological features derived from EURO-CORDEX climate projections. This future work will investigate how climate change scenarios, such as RCP8.5, could impact lightning activity across the Italian region, offering a deeper understanding of potential regional disparities.

By integrating AI with meteorological data, this research represents a novel approach to studying lightning and its interactions with the environment, providing insights into present-day lightning patterns and setting the stage for assessing future risks related to climate change.

P6.1. Machine Learning-based joint postprocessing of ensemble air and dew point temperature forecasts

Josep R. Miró, Enric Casellas Masana, Maria Cortès Simó, Jordi Moré Pratdesaba

Meteorological Service of Catalonia

Uncertainty in numerical weather prediction (NWP) models arises from various sources, including initial conditions and model parameterizations. Ensemble forecasts, created by perturbing initial conditions or using diverse model physics, help capture and quantify this uncertainty. However, these forecasts often contain biases and dispersion errors, traditionally corrected using non-homogeneous Gaussian regression, also known as Ensemble Model Output Statistics (EMOS) (Gneiting et al., 2005). More recently, machine learning methods, such as Distributional Regression Networks (DRN) (Rasp and Lerch, 2018), have demonstrated effectiveness in modeling nonlinear relationships between predictors and forecast distributions, often yielding comparable or superior performance.

Univariate distributions are commonly used to postprocess variables independently. However, variables like wind components or temperature and dew point exhibit strong interdependencies, motivating a multivariate approach to preserve their joint behavior. A common strategy is to adjust each variable separately and then apply a copula to restore dependencies between them. For instance, Lakatos et al. (2023) apply Ensemble Copula Coupling to jointly postprocess temperature, wind speed, and precipitation. Alternatively, an integrated approach uses multivariate distributions directly, such as a bivariate Gaussian distribution for wind components (Schuhen et al., 2012). Both approaches ensure physically consistent variable pairs, like temperature and dew point, while capturing their dependencies.

This study introduces a bivariate Gaussian DRN to jointly postprocess air temperature and dew point temperature using forecasts from the multi-model ensemble of the Meteorological Service of Catalonia.

Gneiting, T., Raftery, A. E., Westveld, A. H., & Goldman, T. (2005). Calibrated probabilistic forecasting using ensemble model output statistics and minimum CRPS estimation. Monthly Weather Review, 133(5), 1098-1118.

Lakatos, M., Lerch, S., Hemri, S., & Baran, S. (2023). Comparison of multivariate post-processing methods using global ECMWF ensemble forecasts. Quarterly Journal of the Royal Meteorological Society, 149(752), 856-877.

Rasp, S., & Lerch, S. (2018). Neural networks for postprocessing ensemble weather forecasts. Monthly Weather Review, 146(11), 3885-3900.

Schuhen, N., Thorarinsdottir, T. L., & Gneiting, T. (2012). Ensemble model output statistics for wind vectors. Monthly weather review, 140(10), 3204-3219.

P6.2. Assessing the Accuracy of Local Temperature Predictions with GraphCast: A Case Study of Three Mediterranean Regions

Ihcene Djouama, Kadache Nabil, Rachid Seghir

LASTIC Laboratory, Department of Computer Science, University of Batna 2, F´esdis, Batna, 05078, Algeria

GraphCast is a medium-range global weather forecast model that utilizes machine learning to generate medium-term weather forecasts up to 10 days in advance. In this study, we evaluate the performance of this model by applying it to three geographical areas with a Mediterranean climate: Italy, Algeria (Aures), and France (Toulouse). The model was trained on data from the European Research Area (ERA5) platform, covering the period from 1979 to 2017, with 37 pressure levels and a resolution of 0.25°. GraphCast generates forecasts focusing specifically on the temperature at 2 meters for the hours 00:00, 06:00, 12:00, and 18:00.

Our analysis evaluates the GraphCast model by examining how its predictions align with two datasets: ERA5 and OpenMeteo. We assess whether the GraphCast predictions closely resemble the values provided by ERA5 and OpenMeteo. When GraphCast's forecasts are similar to these datasets, it indicates high-quality predictions. The analysis reveals that GraphCast provides accurate forecasts for the first five days; however, its precision diminishes from the 6th day onward.

In addition, the machine learning model is characterized by a near-instantaneous response time, unlike numerical weather prediction (NWP) models, which require extremely expensive computational resources and, at times, excessive response times. The results show that this type of solution is very promising and has the potential to outperform NWP models, particularly at the local level. To improve GraphCast's performance, we recommend enhancing its training stage by incorporating denser datasets and including as many parameters as possible, due to the strong correlation among the factors influencing accurate weather forecasts.

P6.3. Machine learning forecast of Platanus pollen season parameters: The role of meteorological variables

Pol Bagan[1], Jordi Sellarès[1], Maria del Carme Casas Castillo[1], Marta Alarcón,[1] Raül Rodriguez Solà[1], Jordina Belmonte[2]

[1] Universitat Politècnica de Catalunya (UPC)
[2] Universitat Autònoma de Barcelona (UAB)

Forecasting pollen production and seasonality is a crucial topic due to the significant impact of pollen levels on human health. These processes depend on both meteorological and non-meteorological factors (abundance of the plant and human actions). In this study, we investigate which meteorological variables, or combinations thereof, are most effective for forecasting the pollen parameters Annual Pollen Integral (APIn) and pollination start date (Start), peak date (Peak), and end date (End) as well as the pollination duration (Length). To achieve this, we use the daily pollen concentrations of plane tree (Platanus) in four locations in Catalonia for the period 1994-2024 and the corresponding daily meteorological data to construct annual time series (features) for supervised learning in machine learning models. Using correlation matrices and principal component analysis (PCA), we identify compact sets of features capable of predicting the parameters that define the pollen season and evaluate their influence on prediction accuracy. The analysis reveals that features obtained from temperature, under various transformations, are the most effective predictors of Platanus pollen season parameters. APIn is the most difficult parameter to predict, likely due to its greater dependence on non-meteorological factors.

MetMed