Regime-dependent evaluation of convective processes for high-resolution modelling over complex terrains using TEAMx observations.

(Proposer: Claudia Acquistapace)

Background and Scientific Context

The Alps are a hotspot for convection initiation, and many studies show that they are also often the sites of extreme events such as heavy precipitation and large hail. In summer 2025, the TEAMx measurement campaign was conducted to collect high-resolution ground-based observations and gain insights into how convective processes initiate over complex orography. Various sites equipped with microwave radiometers at different elevations monitored temperature and humidity distributions, while a network of distributed Doppler lidars collected wind profiles around the valleys. In addition, a 94 GhZ cloud radar collected scanning and zenith pointing observations for more than 1 month. Daily high-resolution model runs of ICON and ICON with ARPAE setup at 1km and 500m were stored for the entire campaign duration.
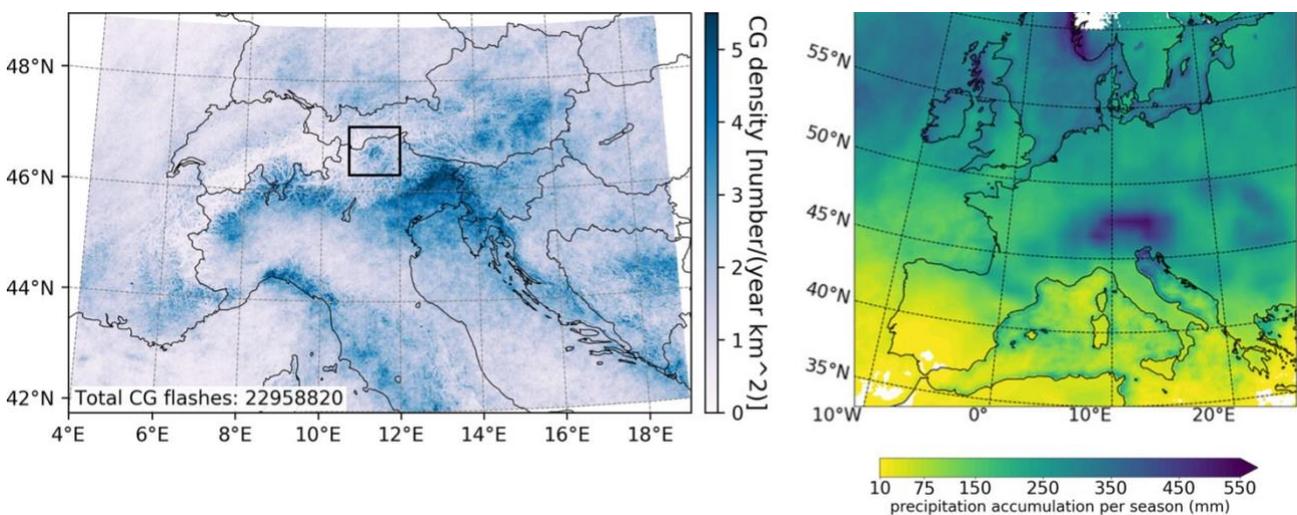

Figure 1: Left: Density of lightning flashes, Manzato et al., 2022, Right: Precipitation accumulation in summer, from 10 y climatology of IMERG, Lombardo and Bitting, 2024

In this project, the aim is to exploit this rich dataset to evaluate the model's performance in representing moist dynamical processes over complex terrain in a statistical way. In fact, we want to move away from a case study-based analysis in favor of a comprehensive analysis that can segregate days based on the synoptic situation and derive for each condition a statistical description of the main atmospheric variables, namely, temperature, wind, humidity, cloud, and precipitation, leveraging the model and observational datasets to their full potential. For each variable, the task is to identify the best analysis to perform for a proper comparison. Also, possible research directions to explore within the collaboration with ARPAE include dedicated extra runs to test different model-physical setups (e.g., turbulence, convection) or an ensemble run to study predictability for a few selected cases. This could complement the runs over the whole period that were provided by DWD, studying in detail some specific process, thanks to the high-resolution observations.

Research Objectives and Questions

The main objectives of the PhD can be listed as follows:

1) **Characterize moist dynamical processes over complex terrains of the study domain** in observations and in model data as a function of different synoptic conditions.
2) **Identify how such processes interact with large-scale atmospheric dynamics** as observed from satellite data and/or regional models and reanalysis products.

3) Conduct a statistical **evaluation based on the different observational datasets for NWP high resolution and LES model evaluation** on the study domain (collaborations with ICON GLORI)

Methodology and Approach
The main methods include postprocessing and analyzing multiplatform observations, understanding and addressing the challenges associated with each instrument, and compiling them into meaningful statistics. The challenge is aggregating the data because different instruments operated over different periods, so not all the data are available for the same period. Moreover, standard methods for extracting model output and postprocessing for model data will be used, and model runs can be performed. The remote sensing data sources will be ground-based and satellite sensors covering the visible, infrared, and microwave spectral domains. The model data will be ICON across different setups (including the ARPAE setup) and resolutions. Calibration and retrieval methodologies, as well as statistical analysis methods, will be used.

Expected Results and Scientific Contribution
We expect the position to produce two main scientific publications where different aspects of moist convection will be analyzed.

Required Skills and Background
We expect the PhD candidate to have a MSc degree in remote sensing, geosciences, physics, engineering, or a related field, some experience with data analysis and programming (e.g., Python, MATLAB), fluency in English, and the ability to work in a group. Familiarity with satellite data and geospatial tools is an asset.

Training and Research Environment
The project will be supervised by a team of experts and will be based at the Department of Geosciences of the University of Padua. Dr. Claudia Acquistapace will provide support for observation analysis and for developing a model evaluation framework. Dr. Chiara Marsigli and/or Thomas Gastaldo (ARPAE) will supervise the student and provide support for the model's data interpretation and analysis. Also, Dr. Annika Oertel (KIT) will be part of the supervisory board to contribute to the model evaluation and potential modifications to the model setup. As a collaboration in a supervision framework, available infrastructures (e.g., computing facilities at CINECA, satellite data access with EUMETSAT), and training opportunities, including courses (ICON trainings at DWD), summer schools, conference participation, and visiting periods in Italy and abroad, are planned.

Collaborations and Funding Context (Optional)
Additional funds: Montalcini.
Collaborations: Chiara Marsigli, Thomas Gastaldo (ARPAE, Bologna, Italy), Annika Oertel (KIT - Karlsruhe Institute of Technology, Germany)

References (Optional)
Lombardo, K., and M. Bitting, 2024: A Climatology of Convective Precipitation over Europe. Mon. Wea. Rev., 152, 1555–1585,
Manzato, A., S. Serafin, M. M. Miglietta, D. Kirshbaum, and W. Schulz, 2022: A Pan-Alpine Climatology of Lightning and Convective Initiation. *Mon. Wea. Rev.*, **150**, 2213–2230, https://doi.org/10.1175/MWR-D-21-0149.1