COST Action CA19109 "MedCyclones" – Working Group 1

Deliverable D1.5

Scientific peer-reviewed overview article addressed to the scientific community on the challenges in forecasting high-impact weather in the Mediterranean

October 2024

As planned, the main initiative within the WG1 has reached to a relevant conclusion and the results have been published on Weather and Climate Dynamics, an Open Access journal edited by Copernicus with high impact factor that will ensure a wide dissemination.

The MIP (Model Intercomparison Project) of the WG1, led by Florian Pantillon and Silvio Davolio, has been a research initiative aimed at exploiting different modelling systems, available within the community, to deeply analyze a common case study of a high-impact cyclone in the Mediterranean, in order to better understand dynamics and predictability. The rationale behind the model intercomparison was to adopt a common model setup (details are provided in Deliverable 1.1) and to investigate on the one hand the systematic response of changes in the representation of physical processes (e.g. convection) among a range of models and configurations; on the other hand, understanding the processes responsible for weak model performances in cyclones intensity and tracks.

The paper has been finally accepted for publication on Weather and Climate Dynamics (Ed Copernicus) in August 2024

The crucial representation of deep convection for the cyclogenesis of medicane Ianos

Florian Pantillon ✉, Silvio Davolio, Elenio Avolio, Carlos Calvo-Sancho, Diego S. Carrió, Stavros Dafis, Emmanouil Flaounas, Emanuele Silvio Gentile, Juan Jesus Gonzalez-Aleman, Suzanne Gray, Mario Marcello Miglietta, Platon Patlakas, Ioannis Pytharoulis, Didier Ricard, Antonio Ricchi, and Claudio Sanchez

Figure 1 : Pantillon, F., Davolio, S., Avolio, E., Calvo-Sancho, C., Carrió, D. S., Dafis, S., Flaounas, E., Gentile, E. S., Gonzalez-Aleman, J. J., Gray, S., Miglietta, M. M., Patlakas, P., Pytharoulis, I., Ricard, D., Ricchi, A., and Sanchez, C.: The crucial representation of deep convection for the cyclogenesis of medicane Ianos, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-1105, 2024.

The 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.

Moreover, the same case study has stimulated further investigations, and the collaboration among several WG1 members has brought to a second paper, which deeply investigates the physical mechanisms responsible for medicane Ianos development.
Therefore, in a sort of companion paper, the authors disentangled the link between sea-surface fluxes and upper-level baroclinic dynamics. They found that the divergent outflow due to preceding precipitation was key to create a favourable large-scale environment for the development of Ianos.
The paper has been finally accepted for publication on Weather and Climate Dynamics (Ed Copernicus) in August 2024.

How a warmer Mediterranean preconditions the upper-level environment for the development of Medicane Ianos

Claudio Sanchez, Suzanne Gray, Ambrogio Volonte, Florian Pantillon, Segolene Berthou, and Silvio Davolio

Figure 2 : Sanchez, C., Gray, S., Volonte, A., Pantillon, F., Berthou, S., and Davolio, S.: How a warmer Mediterranean preconditions the upper-level environment for the development of Medicane Ianos, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-2431, 2023.

In this study, numerical simulations showed that preceding convection was essential for the subsequent development of Ianos, highlighting the importance of the interactions between near-surface small-scale diabatic processes and the upper-level quasi-geostrophic flow. A warmer SST strengthens the processes and thus enables Ianos to be predicted in simulations initiated at the earlier times that failed to generate the medicane with control SSTs.
Links between sea-surface fluxes and upper-level baroclinic processes were highlighted. In particular: (i) a bubble of low-valued potential vorticity (PV) formed within a trough above where Ianos developed, diabatic processes associated with a preceding precipitation event triggered a balanced divergent flow in the upper-levels which contributed to the creation and maintenance this low-PV bubble, as shown by results from a semi-geostrophic inversion tool. (ii) Upper-level geostrophic vorticity advection associated with the low-PV bubble forced quasi-geostrophic ascent during Ianos's cyclogenesis. (iii) Diabatic processes dominated by deep convection formed a

vertical PV tower in Ianos and continued to produce diabatically-induced divergent outflow aloft, thus sustaining Ianos's development. Simulations missing any of these three elements do not develop medicane Ianos.