COST Action CA19109 "MedCyclones" – Working Group 3

Deliverable D3.3

Mid-term report describing scientific production so far and setting research orientations.

10 November 2022

Activities are organized in cooperative research initiatives, each involving several participants and led by a coordinator. These activities have reached a different degree of maturity and for each of them we provide in the following a brief description of the scope, main scientific results so far and perspectives. We also try to highlight connections and synergies among different activities, even across the WGs. One of the main goals of WG3 is the support of novel scientific initiatives to contribute to the improved knowledge of Mediterranean cyclones and their consequent impacts. A first community work has been achieved through the publication of the Mediterranean cyclones review paper, direct result of networking within the COST Action, where we included a dedicated section on cyclone impacts, including socio-economic and environmental dimensions
Flaounas E., et al., 2021: Mediterranean cyclones: Current knowledge and open questions on dynamics, prediction, climatology and impacts. Weather and Climate Dynamics, 3, 173-208, https://doi.org/10.5194/wcd-3-173-2022
The following scientific initiatives have been activated during the first two years. Some of them has just started.

1. Mediterranean cyclones and lightning (lead: David Schultz)

The group involves about 20 scientists with expertise on convection and lightning activity. The initiative is expected to lead to tools that could potentially homogenize lightning activity modelling and visualize relative risk towards accommodating the needs of meteorological services and early warning systems.

2. Impact of cyclones on dust mobilization and transport (lead: Jonilda Kushta)

This initiative, led by the Cyprus Institute, is oriented towards the study of specific cases of Mediterranean cyclones and associated dust events. The first case study is the Ianos Mediterranean Cyclone. It was considered of high priority to first assess the impact of wind data assimilation on model performance.
The AELOUS wind lidar, launched in 2018, developed by the European Space Agency, captures wind vector component profiles along the line of sight of the instrument. These datasets, which include Rayleigh-clear and Mie-cloudy winds, have been assimilated into the WRF-Chem model input data and were tested for the potential improvement in the model's predictive capability. From the group collaboration it was made feasible to compare the Dust Optical Depth to total atmospheric

column observations from the spaceborne MIDAS (ModIs Dust AeroSol) instrument. Comparisons were also made with dust surface concentrations of coarse particulate matter (PM10) using the open-access database of the European Monitoring and Evaluation Programme (EMEP). Lastly, model outputs were compared against satellite Lidar climatology of Vertical Aerosol Structure, LIVAS, observations for a spatially detailed analysis, available from the partners.

3. ImCyCoast: Impact of cyclones on the sea state and coastal flooding (lead: Christian Ferrarin)

Aim

This initiative is strictly related with WG1 Model Intercomparison initiative, since it exploits simulation outputs provided by different modelling systems. This initiative aims at investigating the response of coastal sea level (storm surge) and sea state (waves) to Mediterranean cyclones. As a first step, medicane Ianos will be considered as a case study, but other events will be considered later (e.g. Zorbas).

Scientific production

For an intense Mediterranean tropical-like cyclone (Ianos, September 2020), the atmospheric model ensemble was used as a forcing for coupled hydrodynamic-wave models to evaluate the uncertainty associated with the cyclones impacting the coast and to characterize the impact of Mediterranean cyclones accounting for the combined action of storm surge and waves. The probabilistic approach, developed through the application of an ensemble of numerical experiments, provided insights into model uncertainty when resolving storms and into the limits of the probabilistic forecast of impacts. The ensemble mean and spread were used for defining sea level and wave hazard scenarios. To provide an overview of the expected potential hazard and its uncertainty associated with Ianos, the temporal maximum values of the sea level and the significant wave height computed using the ensemble mean and spread were used. The combined use of meteorological and ocean models enabled the analysis of extreme sea conditions. The ensemble approach demonstrated to be an useful tool for providing information on flood risk management plans, since simulated hazard conditions represent a fundamental component of the coastal risk assessment to be combined with the vulnerability and exposure of the specific coastal segment.
This methodology and the results are described in detail in a paper recently submitted to Natural Hazards and Earth System Sciences:
Ferrarin C., Pantillon F., Davolio S., Bajo M., Miglietta M. M., Avolio E., Carrió D. S., Pytharoulis I., Sanchez C., Patlakas P., González-Alemán J. J., Flaounas E., 2022: Assessing the coastal hazard of medicane Ianos through ensemble modelling.

Research perspectives

The multi-model / multi-physics approach can be easily extended to operational forecasting for providing in advance information on the coastal areas potentially affected by hazardous sea conditions. The ensemble results can be used to develop dynamic flood maps of specific coastal areas, thus forecasting the potential flood impact of such extreme phenomena.
Other events will be analysed applying the same methodology.

4. Review on the socio-economic impacts of Mediterranean cyclones (lead: Samira Khodayar)
The group aims to summarize all knowledge gained in the last decades regarding the socio-economic impacts of Mediterranean cyclones and identify existing gaps highlighting future perspectives on this subject in a review paper. The aim of this scientific manuscript in preparation (submission foreseen by December 2022) is to contribute to go beyond the current state of knowledge regarding the impacts of Mediterranean cyclones, to efficiently design integrated responses toward climate change impacts, by providing a revision of existing knowledge regarding the socio-economic impacts of Medcyclones in the Mediterranean area. As a consequence of this collaborative effort, the main knowledge gaps in the societal impacts of cyclones in the Mediterranean are identified, and the vulnerability of the main socio-economic sectors is assessed.

5. Preparation of an impact database in the Mediterranean
The foreseen database will gather open-access freely available databases or access to related information. This action is taking place in collaboration with the European Severe Storms Lab (ESSL), European Flood Fatalities (EUFF), and similar initiatives around the Mediterranean.

General Future Perspectives in the framework of WG3

1. An improved knowledge about the intrinsic relationship between Mediterranean cyclones and high-impact weather is needed. In this context, the state of the art suffers from the **lack of systematic quantification of cyclones' contribution to Mediterranean high-impact weathe**r (Flaounas et al. 2022).

2. The **need to step from hazard forecasts** (such as heavy rainfall, wind gusts, etc.) **to impact-based forecasts** is essential (Taylor et al., 2018; Zhang et al., 2019).

3. New research lines on the socio-economic impacts of Medcyclones e.g. in relation to fires.

4. Mapping stakeholders and establishing a close relationship is key for an efficient co-definition and co-design of needs and tools.