COST Action CA19109 “MedCyclones” – Working Group 1

Deliverable D1.2

Documentation addressed to stakeholders on protocols and techniques for assessing forecast performance, tailored to the needs of weather prediction centres (constantly updated)

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Three specific research initiatives developed within the COST Action have provided results and indication concerning the assessment of forecast performance. The main results in this context are detailed below.

3T: Tracks Task Team

A key and critical issue in verifying forecasts of Mediterranean cyclones concerns the identification of cyclone tracks, since it is very sensitive to the tracking algorithm. As a consequence, there is no reference dataset of tracks for Mediterranean cyclones such as for tropical cyclones. Moreover, all cyclone tracking methods have limitations which are outcomes of the diagnostics used to identify cyclone centres in gridded datasets and track them in time.
The purpose and the delivered result of 3T initiative is to develop a new diagnostic tool that combines different cyclone tracking methods in order to produce a common cyclone tracks dataset. This dataset is composed only by composite cyclone tracks that concentrate the agreement of different cyclone tracking methods. Therefore, the final product of 3T concerns the “best” outcome of combined cyclone tracking tools.
In the course of 3T activities, 10 different tracking algorithms have been applied to the ERA5 reanalysis dataset for the period 1979-2020 to produce composite tracks based on the agreement between algorithms.
This dataset is now available, and a scientific paper was published on Weather and Climate Dynamics (Copernicus Ed.) and available in open access https://doi.org/10.5194/wcd-4-639-2023.
This provides both a robust approach to track cyclones in any gridded data such as a numerical weather prediction model, and a collection of "best-tracks" to assess forecast performance.
The dataset has been already exploited in several research activities. Just to mention some of them:

1. Process based classification of Mediterranean cyclones, within WG2, that led to a scientific paper recently submitted and currently under revision https://doi.org/10.5194/egusphere-2023-1247

2. The concept is applied also to the website for real time cyclone forecasting developed in the framework of DynForMed initiative (see below).

DynForMed: Dynamics and operational Forecasts of Mediterranean cyclones

A huge community effort on Dynamics and operational Forecasts of Mediterranean cyclones (DynForMed) has focused on developing a prototype website with operational forecast information on Mediterranean cyclones. The goal is to provide a central platform with predicted cyclone track and intensity for researchers, forecasters and stakeholders. Such centralized information is currently lacking for the Mediterranean and often leads to confusion. To this end, deterministic forecasts from 8 operational systems have been provided on a daily routine by participants and cyclones have been tracked up to 7 days ahead. This activity built a database that can be used as a forecasting benchmark for whoever wishes to contribute and can be really valuable for operational centres willing to assess their model performance.

The prototype was hosted at ETHZ until the end of 2023, available on an internal website:
https://data.iac.ethz.ch/cost/

Recently, the web site was migrated to the National and Kapodistrian University of Athens (NKUA) where it is operational and future developments are planned in order to keep it active beyond the end of the Action:

https://medcyclones.eu/dynformed/

Interactive graphics have been already implemented and allow to show and compare the forecast characteristics of the Mediterranean cyclones. These enhancements are designed to create a dynamic and engaging user experience, making it easier than ever to explore and understand cyclone forecasts.

One key upgrade that took place during the migration phase is the **Composite Tracks Approach**. This enhancement involves the exploitation and implementation of the "composite tracks" methodology, a concept developed by the 3T initiative described above. This approach (for more detail see https://doi.org/10.5194/wcd-4-639-2023) aims to refine the selection of cyclone tracks by adopting only those with a high level of agreement among different cyclone tracking algorithms. This ensures that users are presented with the most accurate and reliable cyclone track information. It should be mentioned that for the operational needs of this initiative, seven tracking algorithms are adopted.

The DynForMed team is also actively exploring the addition of new features to enrich the website's capabilities. These potential additions include phase space diagrams tailored for specific cyclone cases and impact-oriented graphics. These features will provide users with deeper insights into cyclone dynamics and their potential effects, further enhancing the utility of the platform.

MIP: Model Intercomparison Project

This research activity is thoroughly described in D1.1 It has been a model intercomparison study to improve the prediction and understanding of Mediterranean cyclone dynamics, based on a collective effort with five mesoscale models to look for a robust response among ten numerical frameworks used in the community. 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.

In terms of assessment of forecast performance, these important results emerged:
1) The use of the same integration domain for all the simulations allowed to have a quite fair intercomparison, even if limited to a single case study. The agreement of the models' results concerning different initial/boundary conditions or model grid-spacing allows to reach robust conclusions on model performances and the reasons behind that. In particular:
- Models systematically perform better when initialized from operational IFS analysis data compared to the widely used ERA5 reanalysis.
- Reducing horizontal grid spacing from 10 km with parameterized convection to convection-permitting 2 km further improves the cyclone track and intensity.

2) Looking upper tropospheric fields at 200 hPa (instead of 300 hPa) revealed important details about the physical mechanisms responsible for intensification of the cyclone.

3) The study 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 emphasizes the crucial interplay between convective and baroclinic processes during medicane cyclogenesis.

4) Objective verification has started based on satellite observations. Using radiative transfer models applied to the meteorological model outputs it is possible to provide brightness temperature or radiance to be compared with observations.

5) The implementation of an ocean model forced with different meteorological forecasts revealed as an useful tool for translating meteorological uncertainty into impact uncertainty.

While these results would require generalization to other cases of Mediterranean cyclones, they provide guidance for the next generation of global convection-permitting models in weather and climate.
However, a common setup and a common methodology have been implemented and may represent a suitable example to be adopted in further research activities involving NWP models and aimed at verifying model performance but based on the investigation of the physical processes and their representation.