SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2024
Project Title:	Short-range re-analysis and forecast to investigate extreme weather events using COSMO and ICON model
Computer Project Account:	SPITGARB
Principal Investigator(s):	Valeria Garbero (mcy0), valeria.garbero@arpa.piemonte.it
Affiliation:	Arpa Piemonte, Italy
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Massimo Milelli (mcy), massimo.milelli@cimafoundation.org
Start date of the project:	January 2022
Expected end date:	December 2024

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year (2023)		Current year (2024)	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	900.000	750.000	900.000	123.653
Data storage capacity	(Gbytes)	400	350	500	500

Summary of project objectives (10 lines max)

The aim of the project is to utilize advanced numerical modeling to analyze recent case studies, identify critical issues, and enhance the forecasting of future events. This includes not only heavy precipitation but also heat waves, strong winds, and other extreme weather conditions. The COSMO and ICON models will be employed at high horizontal resolution to re-analyze and reforecast past extreme events. Various model configurations will be tested using new physical parameterization schemes and different initial and boundary conditions to determine the optimal configuration for accurately representing severe events on small temporal and spatial scales. Temperature, relative humidity, and wind will be compared with observations from meteorological stations and radiometers using standard statistical indices (MB, RMSE, etc.). Precipitation will be verified using an innovative fuzzy technique that compares data estimated by the national radar mosaic with simulated maps.

Summary of problems encountered (10 lines max)

None.

Summary of plans for the continuation of the project (10 lines max)

The project will continue by analyzing additional case studies selected in agreement with the Civil Protection Department, with a focus on the ICON model, which has become the reference model in the COSMO Consortium and has been adopted by ARPAE as the reference model (ICON-2I). Both heavy precipitation events over Italy and heat waves over Turin will be investigated. Various model configurations will be tested to determine which best reproduces these events.

List of publications/reports from the project with complete references

Paper in preparation.

Summary of results

If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

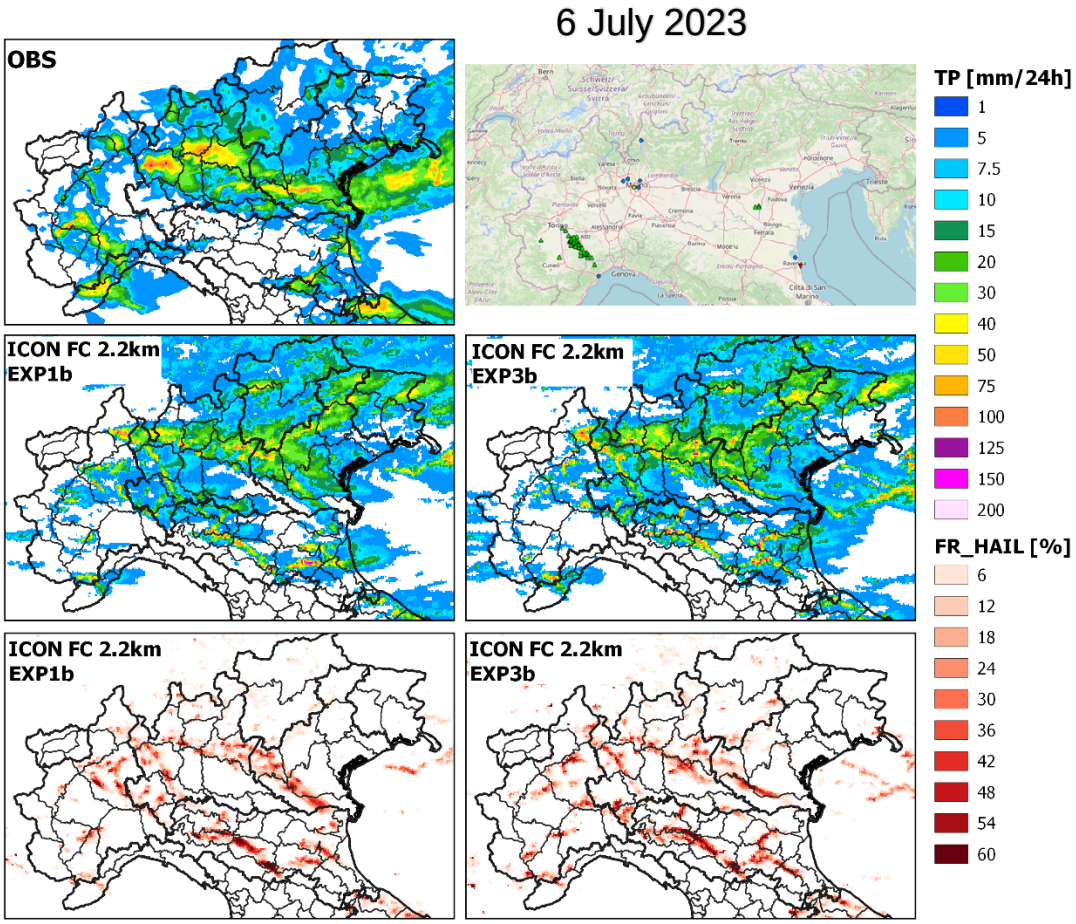
Since July 2023 and June 2024 other case studies, selected in agreement with the Italian Department of Civil Protection, have been investigated: 6 and 24 July 2023, two events characterized by exceptional hailstorms that affected northern Italy.

Simulations were conducted using ICON at 2 km resolution to evaluate different physical parameterizations concerning convection and microphysics. The characteristics of the tested configurations are illustrated below:

- **EXP1**: ICON re-forecast with initial conditions provided by ICON-EU analyses at 6 km and boundary conditions provided by ICON-EU forecasts every 3 hours; only shallow convection is parameterized.
- **EXP2**: ICON re-forecast with initial conditions provided by ICON-EU analyses at 6 km and boundary conditions provided by ICON-EU forecasts every 3 hours; shallow and deep convection parameterizations are active, while mid-level convection is not parameterized.

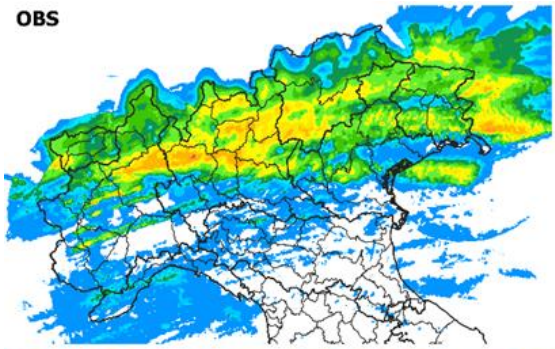
- **EXP3**: ICON re-forecast with initial conditions provided by ICON-EU analyses at 6 km and boundary conditions provided by ICON-EU forecasts every 3 hours; convection is not parameterized (free convection).
- **EXP1b**: Configuration same as EXP1, except for the 'double-moment scheme' for microphysics, which allows hail prediction.
- **EXP3b**: Configuration same as EXP3, except for the 'double-moment scheme' for microphysics, which allows hail prediction.

The results were not very satisfactory for the 6 July event, as none of the configurations outperformed the operational one (ICON-IT from the Operational Center for Meteorology (CNMCA) of Italian Air Force). They were unable to predict the violent thunderstorms that occurred in southern Piedmont, which were associated with severe hailstorms. If we focus on the configurations that implement the double scheme for microphysics and allow for calculating the expected mm of hail in the output, we see that the percentage of hail relative to the total precipitation is high, indicating the possibility of widespread hail events. However, the fact that the precipitation pattern predicted by the configurations differs from the observed one implies that the localization of hailstorms is itself incorrect.



Concerning the 24 July event, although the new simulations did not accurately reproduce the event, they did predict intense precipitation also over the plains, particularly the EXP1b configuration, unlike what was predicted by the operational runs of the models. Additionally, the forecasted percentage of hail in the total precipitation correctly indicated extensive hailstorms, suggesting it as a promising tool for hail prediction. Further investigations will be conducted for this purpose.

24 July 2023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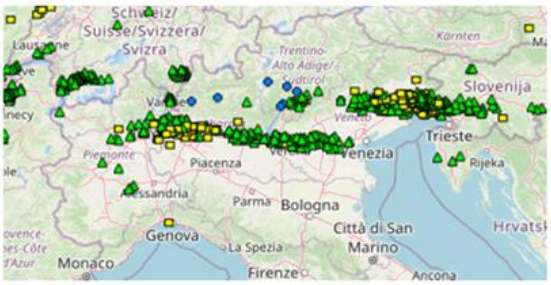
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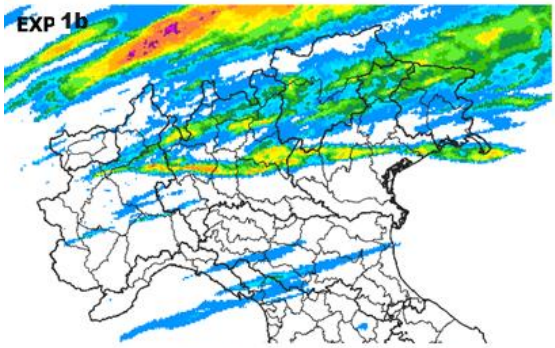
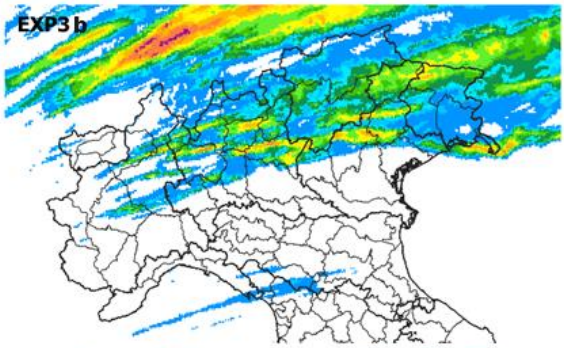

EXP 1b


EXP3 b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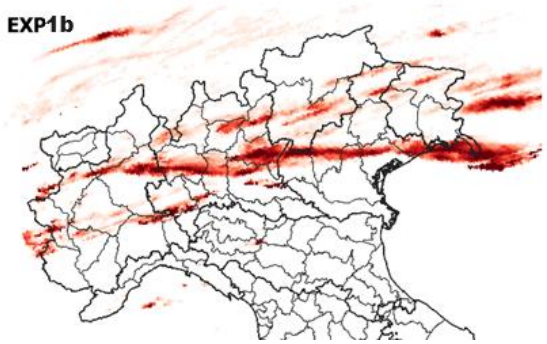
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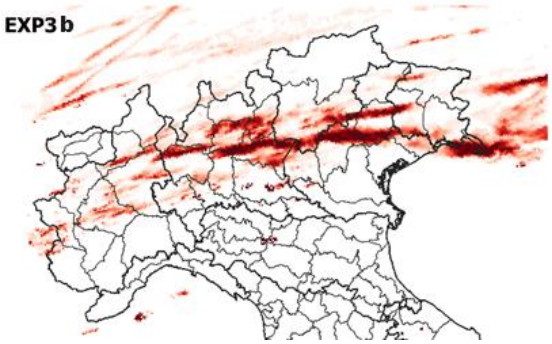
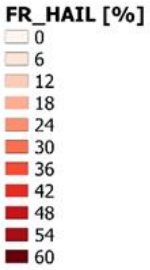

EXP3b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