REQUEST FOR A SPECIAL PROJECT 2022–2024

MEMBER STATE: Italy

Principal Investigator[1]**:** Valeria Garbero (mcy0), valeria.garbero@arpa.piemonte.it

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Project Title: Short-range re-analysis and forecast to investigate extreme weather events using COSMO and ICON model

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP**ITGARB	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2022	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2022-2024: (To make changes to an existing project please submit an amended version of the original form.)		**2022**	**2023**	**2024**
High Performance Computing Facility	(SBU)	900000	900000	900000
Accumulated data storage (total archive volume)[2]	(GB)	300	400	500

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

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Extended abstract

In the last decades extreme weather events have increased significantly. At the same time Numerical Weather Prediction (NWP) has made huge progress thanks to more, and better assimilated, observations, higher computing power and progress in our understanding of dynamics and physics. Despite the advances, being able to correctly predict in space and time the precipitation pattern in rather complex terrain remains a big challenge.

The aim of the project is to use the most advanced numerical modelling to analyse case studies from the recent past, in order to identify critical issues and improve the forecast of future events, not only in case of strong precipitation, but also for instance in case of heat waves, strong wind, etc. The COSMO and ICON models will be used at high horizontal resolution to re-analyse and re-forecast past extreme events. Different model configurations will be tested using new physical parameterization schemes and different initial and boundary conditions, in order to find out which is the best configuration representing the severe events on rather small time and space scales.

The following simulations are planned to be performed using the COSMO and ICON models:

- ctrl run with currently operational setup of the models
- run with different assimilation techniques: LETKF provided by ARPAE or COMET, heat latent nudging and assimilation of radar reflectivity volumes
- run with different initial and boundary conditions (IFS and ICON)
- run with different parameterization schemes (turbulence, urban, ..)

The results will be evaluated to highlight the impact of parameterization, data assimilation and initial and boundary condition on the model performance and to provide an interesting comparison among the 2 different models, ICON and COSMO. Temperature, relative humidity and wind will be compared with the observations provided by meteorological stations and radiometers using standard statistic indices (MB, RMSE, etc.). Precipitation will be verified using the innovative fuzzy technique that compares the data estimated by the national radar mosaic with the simulated maps.

Computer resources

A large number of simulations is planned to be able to test all the described configurations and the two different models, so a relatively large number of Billing Units (900000 Bus per year) and of storage capacity will be required.

Technical characteristics of the codes

In the framework of this special project, the following F90 codes will be used:

- INT2LM, an interpolation program which performs the interpolation from coarse grid model data to COSMO initial and/or boundary data. The following coarse grid models are possible (at the moment): ICON (the global German grid point model), IFS (the global ECMWF spectral model), GFS (global US model), UM (UK Met Office Unified Model) and COSMO (when the COSMO model is nested into itself);

- COSMO, a non-hydrostatic limited-area atmospheric prediction model. This code has been designed for both operational forecasts and various scientific applications on the meso-beta (from 5 to 50 km) and meso-gamma (from 500 m to 1 km) scale. COSMO model is based on the primitive thermo-hydrodynamical equations describing compressible flow in a moist atmosphere. The model equations are formulated in rotated geographical coordinates and a generalized terrain following height coordinate. A variety of physical processes are taken into account by parametrisation schemes.

- ICON-LAM, the icosahedral non-hydrostatic limited-area atmospheric prediction model of the ICON global model. This model is operational in DWD's forecast system in January 2015 and will replace COSMO as the future operational model in the Consortium. Compared to traditional approaches such as the latitude-longitude grid, icosahedral grids provide a nearly homogeneous coverage of the globe. Furthermore, ICON provides a two-way nesting capability. This means that the grid spacing can be locally refined within one simulation. It is especially interesting to run ICON for regional domains with LBC data from DWD or ECMWF and to compare ICON-LAM forecasts against COSMO-model forecasts.

Since the very beginning of the code development, INT2LM and COSMO software have been parallelised using the MPI library for message passing on distributed memory machines. It has to be underlined that these codes are portable and can run on any parallel machine providing MPI. At the moment, they are implemented for both operational and research use on several platforms, including Cray XC40 clusters, NEC SX8, INTEL/AMD Linux clusters.

ICON uses the more recent FORTRAN2003 standard and a hybrid OpenMP/MPI parallelization leading to a better computational performance on today's CPU architectures. Hybrid parallelization means that the advantages of a coarse-grained MPI parallelization are combined with the advantages of a fine-grained OpenMP parallelization.