<u>LATE</u> REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Italy

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Project Title:

Numerical studies for short-range forecast and nowcasting in complex terrain areas

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2020	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for the years: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	500000	900000	x
Accumulated data storage (total archive volume)[2]	(GB)	300	300	x

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 an annual progress report of the project's activities, etc.

[2] 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.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages).

Following submission by the relevant Member State the Special Project requests the evaluation will be based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

All accepted project requests will be published on the ECMWF website.

Motivation and work plan

In recent years, intense meteorological events have occurred with an increasing frequency. We can no longer speak of randomness, but of an ongoing change that involves the whole atmosphere and has an impact on our society. Studying these extreme events and activating adaptation countermeasures becomes an obligation. From a meteorological point of view, therefore, it is important to understand genesis and evolution of the perturbations that produce extreme precipitation events or the persistence of the anticyclones that lead to intense heat waves, and at the same time to develop and improve forecasting and nowcasting tools.

In the framework of the EU Project RISK-GEST (PITEM RISK, Interreg 2014-2020 Alcotra IT-FR), it is proposed to study the area included among Liguria, Piedmont and PACA (Provence-Alpes-Côte d'Azur), where floods and flash floods are quite frequent due to its orographic characteristics with the sea close to high altitude mountains. The aim of the project is to use the most advanced numerical modeling to analyze case studies from the recent past, in order to identify critical issues and improve the forecast of future events. Two different meteorological model, COSMO and ICON, with horizontal resolution reaching 1-3 km, will be used to study some extreme events, thanks also to the assimilation of the observed data, which are present in large quantities over the study region. The data assimilation should improve the definition of the initial condition of the model, which is essential for the development of the forecast. The use of new physical parameterization schemes (currently under development and testing) could also be useful for improving the meteorological and, consequently, hydrological forecast.

For each test case, the comparison between different models, used operationally by the other partners (COSMO and ICON at Arpa Piemonte, WRF at CIMA Foundation and MOLOCH at Arpa Liguria), can bring benefits to understand the best way to represent severe events on rather small time and space scales.

On a practical point of view, the foreseen simulations for each test case will be the following:

- ctrl run with operational setup
- test with different assimilation technique: nudging of 2 meter relative humidity, 2 meter temperature and 10 meter wind provided by meteorological stations (non-gts data), heat latent nudging and data assimilation of radar reflectivity volumes.

- test with different initial and boundary conditions (IFS and ICON)
- test with different parameterization schemes (convection, turbulence)
- test with different models, ICON and COSMO

The simulation results will be compared to observations provided by meteorological stations using standard statistic indices as RMSE and Mean Error (t2m, ws10m, rh2m), while precipitation will be evaluated by means of fuzzy and object verification (precipitation). An interesting comparison will be also conducted between the performance of the 2 different models, COSMO and ICON.

Computer resources

Although the runs will be deterministic (no use of the EPS is foreseen), the enhanced horizontal resolution, the number of test cases and the different set-up configurations will require a relatively large number of Billing Units (hereafter BUs) and of storage capacity. Therefore an overall cost of about 500000 BUs in 2020 and 900000 BUs in 2021 is envisaged.

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.

References

Jolliffe, I. T. and Stephenson, D. B., 2003. Forecast Verification: A Practitioner's Guide in Atmospheric Science, Wiley, 240pp

Ebert, E. E., 2008. Fuzzy verification of high-resolution gridded forecasts: a review and proposed framework, Meteorological Applications, 15, 51-64

Davis, C., Brown, B. and Bullock, R., 2006. Object-Based Verification of Precipitation Forecasts. Part I: Methodology and Application to Mesoscale Rain Areas. Mon. Wea. Rev., 134, 1772-1784

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