REQUEST FOR A SPECIAL PROJECT 2013–2015

MEMBER STATE: Italy

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Project Title: Development of a perturbation strategy for convection-permitting ensemble forecasting over Italy

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ITCONV	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2013	
Would you accept support for 1 year only, if necessary?	YES x	NO ☐

Computer resources required for 2013-2015: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2015.)	**2013**	**2014**	**2015**
High Performance Computing Facility (units)	1,500,000	1,500,000	1,500,000
Data storage capacity (total archive volume) (gigabytes)	200	200	200

*An electronic copy of this form **must be sent** via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): ……

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.

Principal Investigator: Chiara Marsigli

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Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Purpose of this project

The aim of this project is to study a good perturbation strategy for the development of convention-permitting ensemble forecasting based on COSMO over an Italian domain.

This project represents the second step of a work which has started thanks to the SPITCONV Special Project (2010-2012), where preliminary tests of COSMO model perturbations suitable for the convection-permitting scale were conducted on case studies. In particular, perturbations of the parameters of the physics schemes of the COSMO model run at 2.8km resolution were tested over an Italian domain. Then, the impact of boundary condition perturbations from 2 different mesoscale ensembles (COSMO-LEPS and COSMO-SREPS) was also assessed on a case study basis.

Now a new Special Project is required to be able to lead this project to a mature phase. Most of the work will focus on the development of a strategy for initial condition perturbation based on a LETKF scheme which has been developed within the COSMO Consortium. New COSMO model perturbation approaches for this scale will also be tested.

Scientific plan

The passage from ensemble forecasts issued at O(10km) scale to a convection-permitting scale is not at all straightforward and should be addressed in a comprehensive scientific framework. How to build such an ensemble is presently matter of investigation in some institutions, in Europe and outside Europe. In few countries such systems are now reaching the operational status.

It is widely recognised that for this spatio-temporal scale a crucial ingredient is a good perturbation strategy for Initial Conditions (ICs), providing both a good data assimilation at the small scale and the possibility of using the ensembles also for short integration time.

In the COSMO Consortium, a lot of effort has been devoted to the development of a LETKF (Localised Ensemble Transform Kalman Filter) scheme for providing COSMO model analyses at

the km-scale (KENDA system). This system may provide both an analysis for the deterministic model run and perturbed ICs for an ensemble.
In view of the development of an ensemble system based on COSMO for the convection-permitting scale over an Italian domain, it is planned to implement and study this scheme to provide IC perturbations for such an ensemble. Similar activities will be on-going in other COSMO Countries, permitting good exchanges and coordination of the work.

A more detailed planning is here presented.

First of all, a "reference" ensemble, with no IC perturbations at the small scale is necessary. This will be obtained in the last part of the SPITCONV SP (end of year 2012), implementing a suite with a "basic set-up" ensemble, run with the COSMO model run at 2.8km resolution over a North-West Mediterranean domain. The basic set-up consists of a simple downscaling of COSMO-LEPS/COSMO-HYBEPS (the e-suite of COSMO-LEPS, where 4 extra members are run, driven by few operational deterministic global model runs) with COSMO run at 2.8km and 50 levels. Parameter perturbations are applied to the COSMO model, selected thanks to the previous experiments. This suite will run in autumn 2012 thanks to the BUs of the SPITCONV Special Project, and a statistical assessment of its skill will be performed. This suite will constitute the reference run against which to test further development carried on during the new Special Project.
The choice of the specific period is due to the fact that autumn 2012 encloses the Special Observing Period of the Hymex Project(www.hymex-project.org), which will provide an ideal framework for this kind of work: a dense and rich observation network will be set up and collected thanks to the SOP effort of the Hymex Project; other experimental ensembles will be running, permitting comparison of the results; North-West Mediterranean is one of the main sites of interest for the Project. The opportunity of this project framework will be best exploited for the testing of the LETKF scheme, when observation network made available through the Hymex Project could be extensively exploited for the ensemble data assimilation task.
In the period 2013-2014 it is planned implemented and test novel perturbation strategies to the 2.8km ensemble, which will be re-run with different set-ups but over the same period. IC perturbations will be applied and tested, based on the LETKF scheme developed in the last years in the COSMO Consortium, which is now ready to conduct tests.
The full development and implementation of KENDA for providing suitable perturbations for initializing the 2.8km ensemble over Italy will require deep analyses and intensive testing. Some of the issues to be addressed are: number of ensemble members in KENDA, how to provide BC perturbations to the KENDA ensemble, which cycling period to choose, how do deal with observations with different densities, how to include model error.

Main technical steps of this task will be:

- implementation of KENDA
- implementation of the COSMO model version suitable for use in combination with KENDA
- preparation of the scripts for getting observed data from MARS archive
- realization of idealized experiments with KENDA, to get acquainted with the system
- test the KENDA code for the data assimilation with the COSMO model at 2.8km, in a data assimilation cycle where a small ensemble is run with update period of 1-3h.
- test the sensitivity of the KENDA data assimilation cycle to the specific set-up

The KENDA derived IC perturbations will be compared with an “economic” choice of IC perturbations, based on interpolating the COSMO-LEPS IC perturbations to the 2.8km grid, and applying them to the 2.8km deterministic analysis.

It is of particular interest to determine how to get BC perturbations. They could be obtained by the EPS members directly or an intermediate step with COSMO-LEPS can be chosen. The choice between this two options will require a dedicated testing, also in dependence on horizontal resolution of the driving systems.

Beside this study, the impact of model perturbations will be also addressed, by considering new parameters to be perturbed and by testing the “stochastic tendencies” methodology which is being implemented in the COSMO model thanks to a work carried on at CNMCA.

This extensive testing will hopefully permit to define an “optimised” set-up of KENDA for providing IC perturbations to a 2.8km ensemble, a set of model perturbations for COSMO at 2.8km, a choice for the BC perturbation, which could be combined in a test on a “complete” ensemble set-up.

Therefore, in 2015 an ensemble suite at 2.8 km adopting the defined perturbation strategy will be run and evaluated over a long enough period, in order to permit a robust statistical evaluation of its performances.

Use of the requested computer resources

The computer resources will be used mainly for running the LETKF scheme and the COSMO model in ensemble mode. The LETKF scheme implies running a data assimilation ensemble. Even if this has a short forecast range, it requires continuous cycling, which makes the use of computer resources substantial. Furthermore, the 2.8km forecasting ensemble should be tested in cascade, with a 24-36h forecast range. Tests should address: impact of IC perturbations, impact of BC perturbations and impact of model perturbations, thus requiring several runs.

Use of ECMWF software and data infrastructure

ECMWF grib and netcdf utilities will be necessary for this study. Use of the MARS archive is also foreseen, both to get boundary data and observations. The data obtained from the experiments will be stored in the ECFS system.

Technical characteristics of the code to be used

Both COSMO and KENDA are written in f90 and make use of GRIB and NetCDF data input.

Relevance to ECMWF's objectives

The relevance to ECMWF's objective resides mainly in assessing the usefulness of EPS to drive regional systems in cascade and in the experimentation on ECMWF machines of a high-resolution assimilation cycle based on ensemble data assimilation, where EPS boundaries will also be tested.