REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBERSTATE: Italy

Principal Investigator[1]: Chiara Marsigli

Affiliation: ARPA-SIMC

Address: Viale Silvani 6

40122 Bologna

Italy

E-mail: cmarsigli@arpa.emr.it

Other researchers: Tiziana Paccagnella (ARPA-SIMC)

Virginia Poli (ARPA-SIMC)

Andrea Montani (ARPA-SIMC)

Lucio Torrisi (CNMCA)

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.)	2016	
Would you accept support for 1 year only, if necessary?	YES x	NO ☐

Computer resources required for 2016-2018: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2018.)		**2016**	**2017**	**2018**
High Performance Computing Facility	(units)	3,000,000	3,000,000	3,000,000
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): .....

[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.

Continue overleaf

Principal Investigator: Chiara Marsigli

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

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 develop a complete perturbation strategy for the convention-permitting ensemble over Italy based on the COSMO model (COSMO-IT-EPS). This project represents the third step of a work which has started thanks to the SPITCONV Special Project (2010-2012).
During the first phase, 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.
The second phase (SPITCONV Special Project for the period 2013-2015) permitted to lead this project to a mature phase. The work has focused on studying the performance of the LETKF scheme of the COSMO Consortium KENDA to provide ICs to the ensemble COSMO-IT-EPS, including an OSSE. COSMO model perturbation based on the SPPT scheme have also been tested.

Now the COSMO-IT-EPS system is ready for being run over a period long enough to permit a statistic evaluation of its performance (in autumn 2015). The implementation will include use of SPPT and PP for model perturbation and BCs from either ECMWF ENS and COSMO-ME-EPS. Once this test is made, the system will become pre-operational in Italy, on internal resources.

The third phase (2016-2018, this SP) is aimed at further developing the use of the LETKF scheme for providing perturbed ICs to the ensemble and at testing the combination of the different perturbations which are being developed in COSMO (physics and soil). This will permit to carry out studies for improving COSMO-IT-EPS. In fact, while the pre-operational and operational systems will be run on internal resources, all the tests for the system further developments and upgrades will be carried out on ECMWF resources, thanks to this SP and to Italian resources. This

choice is motivated by both the need of many resources for running and maintaining such a system and by the strong dependence of it from ECMWF suites and facilities (observations from MARS archive, BCs from ECMWF ENS, suites for testing already implemented and running at ECMWF).

Scientific plan

In the COSMO Consortium, a big 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 can provide both an analysis for the deterministic model run and perturbed ICs for ensemble forecasting. The system is now being tested in few COSMO Countries and the DA scheme itself is still under development, mainly with the purpose of assimilating several diverse non-conventional observations.

ARPA-SIMC has implemented the KENDA system on the ECMWF machines, under SMS, thanks to the previous SPs, with the main purpose of using it to provide ICs to the COSMO-IT-EPS ensemble. The forecast ensemble it is planned to get BCs from COSMO-ME-EPS.
It should be reminded that the DA cycle has been implemented by cycling a prediction step, where the COSMO ensemble is run, and an update step, where the KENDA code is run. In the prediction step, the 20 COSMO integrations and 2.8 km receives BCs from ECMWF ENS (and also ICs for the cold start).
The system is currently under test on case studies and sensitivity studies are being carried out, in order to set the parameters of the scheme. In the next future, more options will become available, including the possibility of using more non-convectional data. Therefore the work about KENDA will deal with testing the several new features of the scheme.
The parameters which are now being investigated are: horizontal and vertical localization, inflation methodology, quality check.
It is also planned to implement and investigate the impact of: the representation of the model error by adding perturbations to the COSMO runs (SPPT, soil perturbations), the Latent Heat Nudging in the COSMO runs of the estimated precipitation, a two-step assimilation of conventional and non-conventional observations. Part of this work will be carried out thanks to the SPITCONV SP (second half of 2015), but the work is planned to continue during next year.
Once this first tests are performed, it is planned to enrich the assimilation system by including more non-convectional data and testing their impact on the resulting analyses. This impact will be assessed both by evaluating the quality of the analyses themselves and by objectively evaluating the performances of the ensemble forecasting system initialized with these analyses. This is the main purpose of the next three years.

The first step will be to assimilate the 3D radar data of reflectivity and wind from the Italian radar network. Testing the assimilation of radar data will require also to address issues like: how to set the localization radius for the radar data, how to benefit from the high spatial and temporal density of the data (thinning and superobbing), test and tune the two-steps assimilation when radar and conventional data, which have very different spatio-temporal coverage, are both assimilated.
Furthermore, in the next future it will become possible to assimilate also satellite derived products (e.g. cloud top height, radiances, …) and it is planned to test the impact of the new data which will become available thanks to the KENDA development on the resulting analyses.

This work will be carried on the existing iteps_suite_sms, implemented on ECMWF machine.
Main technical steps will be:

- upgrade the suite by implementing the new features:
    - adding an option for the LHN assimilation in the COSMO runs, including a task for reading the estimated precipitation data
    - create a task for reading the 3D radar data and adding an option for their assimilation in the KENDA cycle
    - adding an option for the multi-step assimilation in the KENDA cycle (already available in the KENDA code)
    - adding options for including the assimilation of the new data which will become available with the development of KENDA (mainly satellite data), including tasks for reading the new data
    - creating new tasks for computing the statistics on the assimilation performance
- update of COSMO and KENDA versions and compilation of the codes
- run the assimilation in all the configurations which should be tested, either on selected case studies or on continuous periods (e.g. 1-2 weeks)
- run the COSMO-IT-EPS ensemble in cascades for the selected cases, initialized with the analyses obtained in the different configurations

The tests for the KENDA development should be carried out mainly on selected cases, since running the assimilation scheme is computationally very expensive.

Beside the development of the data assimilation system, aiming at providing ICs to the ensemble and the related test of the impact on ensemble performances, other aspects of the ensemble perturbation strategy should also be further developed.
Mainly, it is planned to work on the improvement of the perturbation methodology. At the end of 2015 it will be objectively tested the inclusion of SPPT in the ensemble, also in combination with few parameter perturbation. Depending on the outcome of this evaluation, it will be planned a

further development of this method (new parameters to be perturbed, different set-up of the SPPT scheme, extension of the SPPT e.g. to perturbation of the soil model). On top of this, a new stochastic physics scheme is under development in the COSMO Consortium, therefore it is planned to test its impact on the ensemble performance. Finally, the issue of combining all the new perturbations into a unique ensemble system should also be addressed, before putting the different methodologies together in the operational system.

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 48h forecast range. Tests should address: impact of IC perturbations and impact of model perturbations, thus requiring several runs.

At present, one run of the full assimilation cycle (24h, 20 members) costs about 75.000 SBU, for 24h (one case), while one run of the forecast ensemble (10 members, 48h) costs about 52.000 SBU.

Therefore the run of one case study with KENDA + running of the forecast ensemble is cascade costs about 127.000 SBU. This explains the amount of resources required per year, considering about 20 tests performed per year (2.6 M SBU), to which trials and code testing should be added.

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 in assessing the usefulness of ENS to drive an high-resolution assimilation cycle based on ensemble data assimilation, where ENS boundaries are used for driving COSMO in the predictions step, and in driving the forecasting ensemble (with or without the intermediate step with COSMO-ME-EPS).