REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: Germany, Greece, Italy

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Project Title:	COSMO NWP Meteorological Test Suite

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPITRASP**
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

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.

Would you accept support for 1 year only, if necessary?	YES ☐	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**	
High Performance Computing Facility	(units)	5.000.000	5.000.000	
Data storage capacity (total archive volume)	(gigabytes)	1000	1000	

*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): ……

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Extended abstract

Introduction

The aim of the COSMO NWP Meteorological Test Suite Special Project is to employ the software environment built on the ECMWF platform during the SPITRASP project (2013-2015) with the aim to perform carefully-controlled and rigorous testing, including the calculation of verification statistics, for any COSMO model test-version. NWP COSMO benefits from the evaluation of new model versions prior to consideration for operational implementation (official version) according to source code management procedure. This procedure facilitates the decision whether the upgrade of a model test version to a new release is possible but also give the possibility to evaluate the impact that all implemented numerical or physical processes advances bring to convection permitting model resolutions.

By conducting controlled testing to a NWP model, including the generation of objective verification statistics, it can be possible to provide community with guidance for selecting a new operational implementation. In the same time, such designated testing also provides the research community with baselines against which the impacts of new techniques can be evaluated on a larger spatial and temporal domain.

COSMO (Consortium for Small-scale Modeling) is an European group for numerical weather prediction with participating meteorological services from Germany (DWD), Greece (HNMS), Italy (USAM), Switzerland (MeteoSwiss), Poland (IMGW), Romania (NMA) and Russia (RHM). The general goal of the consortium is to develop, improve and maintain a non-hydrostatic limited area modelling system to be used for both operational and research applications by the members of COSMO.

Until now, three model versions have been installed and evaluated in the framework of the SPITRASP special project and more model versions are expected to be tested using this platform.

Scientific Plan

In the framework of NWP Meteorological Test Suite ECMWF Special Project (2013-2015), a platform was developed for the testing of present and future versions of the COSMO model (7 km horizontal resolution) within a well-defined framework. This platform will also be updated in order to perform tests and evaluate higher resolution (convection permitting) COSMO model (2.8 horizontal resolution). The software environment will be available and accessible to each COSMO member to perform a standardised evaluation of each released model version for both resolutions of the model. The COSMO NWP Meteorological Test Suite platform provides the COSMO community with standards against which the impacts of new developments in the model should be evaluated.

The test suite addresses the statistical quality of a COSMO version in comparison with the previous release. The statistical measures already defined will be applied both for COSMO 7km and COSMO 2.8 km horizontal resolution but the design for each test can be altered in consultation with the developers, relevant area experts, and verification experts. The statistical measures predominantly vary depending on the array of parameters to be evaluated (e.g. wind speed, dew point temperature, precipitation, 2m temperature). The comparison of the model versions for validation will be carried out on an extensive common domain which covers most part of the COSMO countries for the 7 km resolution. For the 2.8 km resolution, the COSMO model will be integrated on a representative domain according to the needs of the consortium.

The results will be stored locally so that each country will be able to extract verification results for its own region of interest. Consequently, it will rely upon each country the decision to adopt or not the new version. It should be noted that the relative performance of each NWP model implementation, can be also affected by the assimilation of different data or the use of other boundary conditions but these factors are not included in this testing procedure. Finally, a new version of the model will be considered validated or accepted if the set of verification results show a positive impact on the common domain or if the results are neutral.

Phase I- Model set-up

The 7km version of the COSMO model will be primarily used for these tests, following the operational resolution in most meteorological services. In the same time, the outputs of the 7km runs will provide IC for the higher resolution (2.8km) tests when these will be performed. The domain involved in calculation will cover the COSMO countries (with some extension) and a good part of European Russia. Grid definition (total number of grid points is 383761) is as follows:

- 751x511 grid points
- 40 vertical levels
- rotated coordinates:
  - pol latitude = 40
  - pol longitude = -170
- coordinates of the lowest left corner
  - start latitude = -16.125
  - start longitude = -15.75

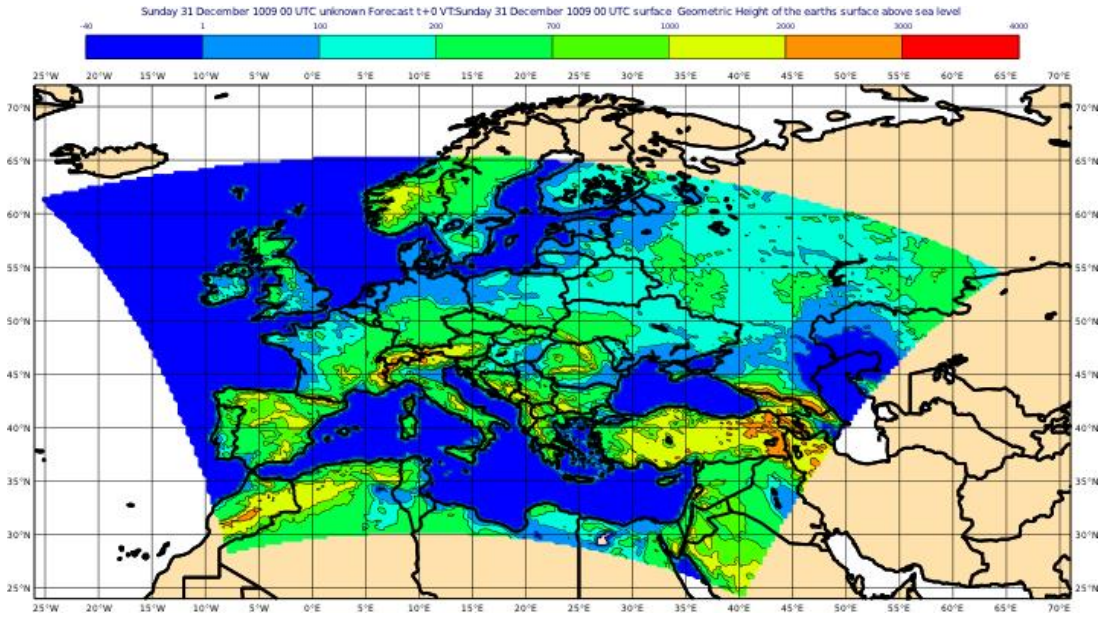

Figure 1. *Integration domain*

Main activities of this phase include the model installation. Regarding the model installation, the necessary steps are the following:

- availability of all the necessary external parameters files for both model resolutions (topography, lakes, land use, land-sea mask...)
- availability of the various namelists for both model resolutions

- compilation of new versions of the interpolation program INT2LM
- compilation of each COSMO version to be tested

The 2.8 km version of the COSMO model will be also used for these performance tests. Grid definition (total number of grid points is 2462831) is as follows:

- 1799x1369 grid points
- 50 vertical levels
- rotated coordinates:
  - pol latitude = 40
  - pol longitude = -170
- coordinates of the lowest left corner
  - start latitude = −19
  - start longitude = -16.6

Phase II: Configuration and the execution of runs

Both the 7km and 2.8km horizontal resolutions of each version of the COSMO model will be used for these tests, following the operational characteristics in most meteorological services.

For the COSMO 7km horizontal resolution, the forecast period of each daily run will be 72 hours, on one daily cycle based on the 00UTC initializing data. For the COSMO 2.8km horizontal resolution, the forecast period of each daily run will be 30 hours, on one daily cycle based on the 00UTC initializing data. The simulation period for each test (both horizontal resolutions) is one month for summer and one month for the winter season (two months total), depending on the code changes that will be implemented in each model version and on the expected impact on model performance. Testing and evaluation focuses on these extended retrospective time periods in order to encapsulate a broad range of weather regimes ranging from null, to weak and strong events that took place over this extended European terrain.

The initial and lateral boundary conditions for the COSMO 7km horizontal resolution will be provided by the ECMWF IFS system. The initial and lateral boundary conditions for the COSMO 2.8km horizontal resolution will be provided by the corresponding COSMO 7km model.

Phase III: Model Output Verification

The model verification will be generated using VERification System Unified Survey (VERSUS) software. VERSUS is LAMP open source software. **LAMP** is an acronym referring to the first letters of Linux (operating system), Apache HTTP Server, MySQL (database software) and PHP, principal components to build a viable general purpose web server.

Under the framework of the previous Special Project, an instance of the VERSUS software has been installed, configured and regularly updated on a linux virtual machine - made available by ecmwf within its virtualization environment - for an easier installation and update of the pre-requisite packages used by VERSUS like MySql, PHP, R, Jpgraph etc. This implies the use of a separate machine than the one used for the COSMO model execution, but the two systems have direct connection for the data transfer.

At present the VERSUS virtual machine has been setup with 2 CPU's and a total RAM of 8Gb. The tests executed until now show that the performance is satisfactory in terms of stability of the system and speed. To connect to the VERSUS virtual machine (ms-versus) NoMachine client is used to open a terminal at ecgate, then ssh -X versus@ms-versus to connect to the virtual machine where VERSUS is installed. Once connected, the user needs to open browser (Firefox), to have the webgui at localhost with VERSUS web access as it is required for verification use.

Objective model verification statistics will be generated with VERSUS using observation datasets retrieved from MARS archive. The verification performed includes grid-to-point comparisons utilized to compare gridded surface and upper-air model data to point observations (interpolated to areas of variable radius depending on the parameter). Verification approaches include, but are not limited to, current standard verification statistics in wide use by the NWP community (e.g. RMSE, bias). In addition, new verification techniques will be applied if necessary (especially for convection permitting model resolution) and the statistics computed will be clearly identified in the information provided to the community with the test results.

A range of variables and properties may be evaluated (e.g. surface and upper-air predictions for temperature, humidity and wind, as well as accumulated precipitation). Verification statistics generated for each retrospective month are will be used to compute and plot specified aggregated statistics and each type of verification metric can be accompanied by confidence intervals (CIs) where appropriate, to facilitate the extraction of reliable conclusions.

Phase IV: Additional steps

After the aforementioned phases are completed, the testing methods can be extended to include:

- Data Assimilation cycle;
- longer temporal simulation for COSMO convection permitting horizontal resolution (72h);
- perform additional verification activities;

Use of ECMWF computer resources, software and data infrastructure

Computer resources will be used in order to run the COSMO model and for the model verification using VERSUS software. Netcdf, grib_api and R utilities (already installed) will be necessary for this project. The model output obtained from the numerical experiments will be stored locally in the ECFS system. Also, to set-up and properly run the VERSUS software, the dedicated machine at ECMWF will be used for internal use only (no need of Internet surfing).

Because not all the consortium members are ECMWF participating countries, during this project the special access rights should be provided to them, restricted to the activities connected with the project tasks as they were described above.

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 ECMWF IFS files will be used as initial and lateral boundary conditions data for the COSMO 7km model, while the output of the COSMO 7km model will be used as initial and lateral boundary conditions data for the COSMO 2.8km model.
- "**COSMO**", the code performing the actual numerical weather prediction with the non-hydrostatic limited-area atmospheric prediction model COSMO. This code has been designed for both operational forecasts and various scientific applications on the meso-beta (from 5 to 50km) and meso-gamma (from 500m to 5km) scale. The 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 parameterisation schemes.
- **VERSUS** software installation follows the specifications of the available machine. Together with the main software, all the necessary accompanied software (R language, grib_api, SWIG, BufrDC) has also been previously installed and appropriately configured.

Deliverables:

Detailed guidelines for the proper use and execution of each NWP test using this platform will be prepared, with additional consideration for the COSMO 2.8km model. A detailed description of all steps will be included, from the compilation of a new COSMO model testing version to the final production of the relevant statistical scores extracted.