REQUEST FOR A SPECIAL PROJECT 2018–2020

MEMBER STATE:	Germany, Greece, Italy This form needs to be submitted via the relevant National Meteorological Service.
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Project Title: **Testbed for the Evaluation of COSMO Model Versions**

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPITRASP**	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2018	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for 2018-2020: (To make changes to an existing project please submit an amended version of the original form.)		**2018**	**2019**	**2020**
High Performance Computing Facility	(SBU)	5.000.000	5.000.000	5.000.000
Accumulated data storage (total archive volume)[2]	(GB)	1000	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): 30Th June 2017

Principal Investigator: Amalia Iriza, Andrea Montani

[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.

Project Title: **Testbed for the Evaluation of COSMO Model Versions**

Extended abstract

Introduction

The aim of the **"Testbed for the Evaluation of COSMO Model Versions"** Special Project is to employ the software environment built on the ECMWF platform during the SPITRASP projects (2013-2015, 2016-2018) with the aim to perform rigorous testing. This procedure includes the generation of objective verification statistics, for any COSMO model test-version prior to its official release.

The evaluation of new model versions is taken into account before operational implementation (release of an official version) and is performed according to source code management procedures. This type of carefully controlled verification procedure is useful in deciding whether the upgrade of the model from a test version to a new official release is advisable.

Apart from simple evaluation of the model performance, the testing of new model versions in the frame of the numerical weather prediction test suite offers the possibility to assess the impact resulted from new implementation of developments for the representation of various numerical or physical processes, especially for convection permitting model resolutions.

The NWP test suite currently represents a benchmark for rigorous testing of all new model resolutions. This testing procedure allows the model developers to produce guidelines for the selection of a new operational implementation of the model. On the other hand, the test suite also offers the research community baselines against which new techniques and their impact 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), Russia (RHM) and Israel (IMS). 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.

Five model versions have been installed and tested up to now. These versions have been evaluated in the framework of the SPITRASP special projects. 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 was updated in order to perform tests and evaluate higher resolution (convection permitting) COSMO model (2.8 horizontal resolution) during the COSMO NWP Meteorological Test Suite Special Project (2016-2018). 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 **Testbed for the evaluation of COSMO model versions Special Project** that will continue the activities started in the previous two special projects will ensure the usage of a verification platform as a benchmark for the COSMO community in order to evaluate new versions of the model against exiting operational ones, prior to their official release. This platform will also provide standards against which the impacts of new developments in the model should be evaluated.

New model implementation and verification approaches that will better facilitate the comparison of various model versions will be explored during the duration of the project. The aim is to isolate as much as possible the impact of new code developments (e.g. minimising initial conditions and boundary conditions effect) and to employ techniques that can reveal the relevant performance of each model version that is tested.

The testbed platform evaluated the statistical quality of a new COSMO version prior to its official release, in comparison with the previous official release (operational). The statistical measures already defined will be applied both for COSMO 7km and COSMO 2.8 km horizontal resolution.

However, given the flexible characteristics of the test suite, the design for each set of full tests (model implementation and verification measures) can be adapted to the needs of the developers, relevant area experts and verification experts, as well as to the requirements of model users. Depending on the parameters of interest that need to be analysed (surface and upper air parameters, total cloud cover, precipitation, etc.), the statistical methods employed by the scientists involved in the test suite can be adapted to meet the requirements of the developers.

Both the 7km and the 2.8km model will be integrated and evaluated for a common domain and depending on the specific test requirements on different subdomains. The extent of the verified area will be adapted so that most of the COSMO countries will be covered. Each country will be able to analyse the test suite verification results for its own domain, due to the local storage of the data on the ECFS system. The data assimilation system that can affect the quality of each NWP implementation is not taken into account in the process of the test suite.

New versions of the model will be considered "valid" and will be accepted for official release and operational implementation if the different sets of verification results show a positive impact compared to the previous model version over the common domain or if the results are neutral.

Phase I: Model set-up

During the first phase of the test suite, activities concerning the installation of the model will be performed. This procedure will require the following steps:

- all the necessary external parameters files need to be available for both model resolutions (topography, lakes, land use, land-sea mask...)
- the various namelists are needed for both model resolutions
- new versions of the interpolation program INT2LM will be compiled as soon as they are available
- each COSMO version to be tested will be compiled

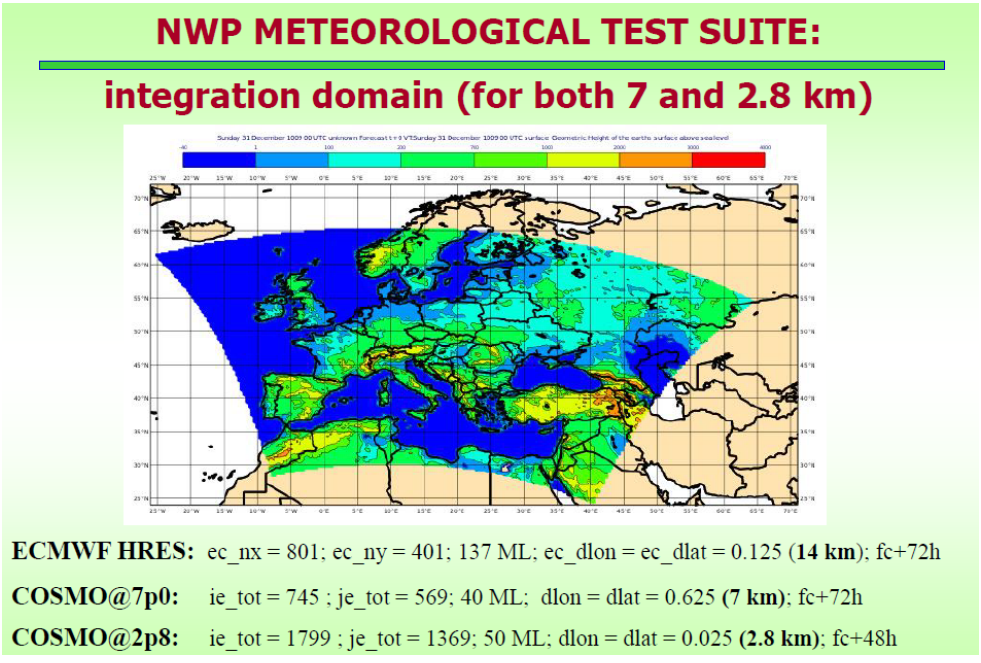

Figure 1. Integration domain for the COSMO 7km and 2.8km resolutions.

The model at the two horizontal resolutions will be run on the domain presented in Figure 1, with the possibility to adapt the integration area to the needs of the model developers and verification experts.

Phase II: Model Configuration and Execution of Runs

The testbed will be used for new versions of the COSMO model prior to their official release, both for the 7km and the 2.8km horizontal resolutions. The model set-up for the tests will follow the operational characteristics in most meteorological services. Configurations of each model versions will take into account the developments introduced in each version respectively, with an emphasis on the most important new features.

The primary initial and lateral boundary conditions for the COSMO 7km horizontal resolution will be provided by the ECMWF IFS system, with the possibility to extend the tests to a comparison using also the soil fields provided by the ICON global model as lower boundary conditions. Initial and lateral boundary conditions for the COSMO 2.8km horizontal resolution will be obtained through interpolation form the corresponding COSMO 7km model. In order to reduce the effect of the IC, running the experiment in hindcast model will also be explored. The adaptation of this approach depends on an evaluation (computer resources and verification procedures) that will be performed before the beginning of this special project and will be additional to the approach described in this document.

For both model resolutions, the tests will be performed for daily runs initialized by the 00UTC data. The model at the 7km horizontal resolution will be run for 72 hours, while the run period for the 2.8km resolution will be 48 hours.

Testing and evaluation procedures will be concentrated on two extended periods of time (retrospective): January 2013 and July 2013. These periods of interest cover a broad range of weather regimes ranging from null, weak and strong events that took place over the domain of interest. Simulations periods can vary, depending on the new features implemented in each version of the model and the developments that need to be evaluated.

One COSMO-model run at 2.8 km (50 model levels) costs approximately 37000 BUs, while one COSMO-model run at 7.0 km (40 model levels) costs approximately 4000 BUs. As mentioned before, both configurations are tested for 60 days, this bringing the cost to (370000 + 4000) * 60 = 2460000 BUs.
Since two model releases per year are envisaged, the overall cost, considering also the interpolation from ECMWF to COSMO grid, grows to about 5000000 BUs per year.

Phase III: Model Output Verification - The VERSUS System

VERSUS (VERification System Unified Survey) software has been previously implemented and is running on a dedicated virtual machine with administration profile, at ECMWF. This system is based on LAMP open source software (Linux operating system, Apache HTTP Server, MySQL database software and PHP) as principal components to build a viable general purpose web server. The administrator profile required by VERSUS allows an easier handling of the various software packages needed to sustain the system, such as MySql, PHP, R, Jpgraph etc.

The VERSUS system and the model output verification procedure is performed on a machine separate from the one used for the model runs. The two machines are set up with a direct connection in order to speed up the transfer of model output.

The verification system (ms-versus virtual machine) is accessed by authorized users only, through the **NoMachine** utility at ecgate. Following the login, the user needs to open the browser

(Firefox), to have the webgui at localhost with VERSUS web access as it is required for verification use.

The test suite incorporates an objective model verification procedure performed with the VERSUS system. Verifications include grid to point comparisons between point observations and gridded surface and upper-air model output. Observations datasets are retrieved from the MARS database and interpolated with various methods to areas of variable radii, depending on the parameter of interest. Verification modules are adapted based on the parameter of interest and include classical scores such as BIAS and RMSE for surface parameters, performance diagrams for precipitation, BIAS, MAE and RMSE for upper air parameters. Other statistical measures contained in the VERSUS system can also be used, depending on the requirements of the model developers and users. Confidence intervals can also be used to complement these results (where appropriate). Verification scores are computed for each retrospective month, for various station stratifications (the entire integration domain or different sub-domains of interest, also depending on the new features introduced in each model version). These scores will be used to produce and plot aggregated (extensive) statistics, enabling the extraction of reliable feedback needed by the COSMO community.

The possibility to use other software than Versus is also envisaged (R based libraries); the support of ECMWF staff will be asked for the installation of new software packages on ecgate.

Phase IV: Additional steps

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

- hindcast mode model runs;
- soil field initialisation;
- set up a wider simulation area for the COSMO convection permitting horizontal resolution;
- perform additional verification activities, possibly with an additional verification package.

Use of ECMWF computer resources, software and data infrastructure

The computer resources will be used in order to run the COSMO model and for the model verification using the VERSUS software. The 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 VERSUS software, the dedicated machine at ECMWF – equipped with the necessary web services (like APACHE, Web Browser, PHP typical of a LAMP system) will be used for internal use only (no need of Internet surfing).

Given the fact that not all the consortium members are ECMWF participating countries, the special access rights should be provided to them for the duration of this project, with rights 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**", the interpolation program used to perform the interpolation from coarse grid model data to COSMO initial and/or lateral boundary conditions. The ECMWF IFS files will be used as initial and lateral boundary conditions data for the COSMO 7km model. Following this procedure, 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. 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",** the verification software installation used for the evaluation of various COSMO model versions. This code follows the specifications of the available dedicated machine. Together with the main software, all the necessary accompanied software (R language, grib_api, SWING, BufrDC) has also been previously installed and appropriately configured.

Deliverables:

The detailed guidelines for the proper use and execution of each NWP test using this platform that were prepared during the previous special project related to this activity will be revised, considering both model resolutions (7km and 2.8km) and all the additional activities described above. A detailed description of all steps will be included, from the compilation of a new COSMO model test version to the final production of the graphics for the statistical scores extracted.