REQUEST FOR A SPECIAL PROJECT 2018–2020

MEMBER STATE: Italy, Germany, Switzerland

This form needs to be submitted via the relevant National Meteorological Service.

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Project Title:

Investigation of case studies using COSMO-based deterministic and ensemble systems

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** COLEPS___________________	
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)	2.100.000	2.100.000	2.100.000
Accumulated data storage (total archive volume)[2]	(GB)	600	1200	1800

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):
12 July 2017

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.

Principal Investigator: Montani Andrea

Project Title: Investigation of case studies using COSMO-based deterministic and ensemble systems

Extended abstract

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 will be evaluated by ECMWF as well as the Scientific and Technical Advisory Committees. The evaluation of the requests is 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.

Large requests asking for 10,000,000 SBUs or more will receive a detailed review by members of the Scientific Advisory Committee.

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

Main goal

To assess the sensitivity of COSMO forecast skill to the use of the newly implemented Bechtold convection scheme.

Motivation

Hitherto, only the Tiedtke convection scheme was available when COSMO was run in convection-parameterised mode, with horizontal resolutions up to about 5 km. The parameterisation of convection in limited-area models is an important source of uncertainty as regards the spatio-temporal forecast of precipitation. Therefore, the development and implementation of ensemble systems where either Tiedtke or Bechtold scheme can be used by the ensemble members, provides an opportunity to upgrade state-of-the-art probabilistic systems at the convection-parameterised scale and, in particular, COSMO-LEPS, the operational ensemble system of the COSMO consortium. Before such implementation, it is necessary to assess how the COSMO runs performed with the Bechtold scheme (hereafter, COSMO-B) relate to those using the operational Tiedtke scheme (hereafter, COSMO-T). It is clear that COSMO-B are likely to be different from COSMO-T on a case-by-case basis; nevertheless, the average skill of the COSMO-B runs needs to be indistinguishable, from a statistical point of view, from that provided by the COSMO-T ones. This because in a a well-constructed ensemble, the skill of each individual member, averaged over a large number of events, should be approximately identical not to introduced biases and/or systematic errors in the ensemble member distribution. Therefore, the use of the Bechtold scheme is proposed as a perturbation for the COSMO-LEPS ensemble, relatively to how uncertainties in the model representation of the cumulus convection can be described and quantified.

The investigation will be performed assessing both the deterministic and probabilistic skill of COSMO with the two convection schemes, which will be evaluated for a number of case studies as well as over continuous periods.

Expected results

Operational implementation of the Bechtold scheme in some members of COSMO-LEPS ensemble and in some deterministic operational suites. Results of the thorough evaluation of the Bechtold cumulus convection scheme performance within the COSMO model.

Description of Individual Sub-Tasks

SubTask1: tests of COSMO-B in deterministic mode

For a number of past cases of heavy precipitation (about 10 events), the performance of COSMO-B and COSMO-T will be investigated in deterministic mode, with particular attention to the types of forecast errors (e.g. location, timing, intensity) provided by the different convection schemes in terms of precipitation. The runs will be carried out over integration domains covering Central-Southern Europe and Italy, at the horizontal resolutions of about 7 and 5 km. Case studies will include both summer and winter events, characterized by “warm rain” and wintry showers respectively, so as to evaluate the skill of the convection schemes for the different weather types. “Standard” verification scores will be used to assess the performance of the systems, including the mean error, the mean absolute error, the root mean square error, the probability of detection, the threat score, the success ratio and the bias. Novel spatial verification techniques (e.g. SAL measure) will be also used to assess the performance of the COSMO runs. The possibility to use the Versus package already installed and maintained at ECMWF is also envisaged.
The main differences of performance between COSMO-B and COSMO-T runs will be highlighted and recommendations relative to possible tuning of the Bechtold scheme will be proposed.

Deliverables

For the investigated case studies, assessment of the skill of COSMO-B and COSMO-T in terms of the above-mentioned scores so as to have a detail description of the potential strengths and weaknesses of the individual convection schemes.

SubTask2: test of COSMO-B in ensemble mode

Implementation of a test suite to run a 10-member ensemble (referred to as **cleps_10b**), where the ensemble members are provided by COSMO-B using the same initial and boundary conditions as members 11-20 of the operational COSMO-LEPS (which has 20 members, all run with Tiedtke scheme); the suite will be run over continuous periods. The integrations will be performed with a set-up very similar to COSMO-LEPS, testing also the impact of single-precision mode and SPPT. In addition to that, the performance of cleps_10b will be assessed and compared to that of **cleps_10t**, the 10-member ensemble provided by members 11-20 of COSMO-LEPS; in particular the spread/skill relation of the two 10-member ensemble is terms of total precipitation, 2-metre temperature and 2-metre dew-point temperature will be studied. This task is the most demanding from a computational point of view and needs to be implemented and performed on ECMWF super-computing platforms.

Deliverables

Assessment of the individual skill of cleps_10b and cleps_10t for different verification times, computed over the full verification period as well as for particular cases.

SubTask3: COSMO-B and COSMO-T in ensemble mode

Implementation of **cleps_20bt**, where members from cleps_10b are added to members 1-10 of COSMO-LEPS; therefore, cleps_20bt will have 10 members run with Bechtold plus 10 members run with Tiedtke and no duplication of boundary conditions; comparison of cleps-20bt vs COSMO-LEPS will be carried out over continuous periods well as on a case study basis, like in Task 2. The skill of the two ensembles will be compared and the spread/skill in terms of total precipitation, 2-metre temperature and 2-metre dew-point temperature will be studied.

Deliverables

Assessment of the skill of cleps_20bt and COSMO-LEPS using the same measures as in Task 2.

As already pointed out, the assessment of the skill of the different deterministic and ensemble systems will be mainly performed in terms of precipitation, although attention will be also paid to other surface variables.

Computer resources

Since one single run of COSMO-LEPS in operational configuration (511x415x40 grid points, 7km, 40 model levels, 132 hours of forecast range) costs about 2000 Billing Units (hereafter, BUs), the computer time to run the 10-member suite (cleps_10b) will cost 20.000 BUs. Therefore, the cost for an experimentation of about 90 days will amount to approximately 2.000.000 BUs. As for the deterministic runs of subTask 1 (10 cases), an overall cost of about 100.000 BUs is envisaged, considering also the possible tests at higher resolutions.

This brings the overall requests to 2.100.000 BUs per year.

Depending on the results, the set-up of the systems could be partly modified and the cost could slightly change.

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", 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 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 parameterisation schemes.

Since the very beginning of the code development, both "int2lm" and "cosmo" have been parallelised using the MPI library for message passing on distributed memory machines. With regard to the more demanding code "cosmo", it has to be underlined that this code is portable and can run on any parallel machine providing MPI. At the moment, "cosmo" is implemented for both operational and research use on several platforms, including Cray XC40 clusters (the ECMWF machine where the COSMO-LEPS time-critical application runs, using 20 nodes for a total of 720 total tasks), NEC SX8, INTEL/AMD Linux clusters.