(LATE) REQUEST FOR A SPECIAL PROJECT 2012–2014

MEMBER STATE: FRANCE

Principal Investigator[1]: François BOUTTIER

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Project Title: Continental winter weather prediction with the AROME ensemble prediction system

If this is a continuation of an existing project, please state the computer project account assigned previously.	(new project)	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2012	
Would you accept support for 1 year only, if necessary?	YES ☐	~~NO~~ ☐

Computer resources required for 2012-2014: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2014.)	**2012**	**2013**	**2014**
High Performance Computing Facility (units)	4,000,000	5,000,000	6,000,000
Data storage capacity (total archive volume) (gigabytes)	4,000Gb	4,000Gb	4,000Gb

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): 16. January 2012

Le Directeur général adjo
Olivier GUPTA

Continue overleaf

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Extended abstract

[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.

Description for project "Continental winter weather prediction with the AROME ensemble prediction system"

1) Introduction.

The basis of this proposal is to improve the value of ensemble prediction systems in winter weather situations. Two main tasks are planned. One is the evaluation and tuning of a limited-area ensemble prediction system based on the AROME model at an horizontal resolution of about 2km. The domain and test periods will focus on significant wintertime weather events such as low clouds, fog, frost, snowfall, and high winds over Central Europe. The other task is the development and testing, for preoperational purposes, of forecast improvements by expanding the representation of model errors , of initial conditions errors, and of perturbations to lateral boundary boundary conditions (LBCs). It is planned to focus on boundary layer physics, because low-level errors are often significant for wintertime weather prediction over land.

Examples of scientific questions to address are: the role of the radiative properties of land surfaces and low clouds, ensemble perturbation techniques for sheets of low clouds and fog, the usefulness of perturbing various land surface fields, identifying an appropriate stochastic perturbation scheme for the stable planetary boundary layer. The longer-term objective is the development of perturbation strategies for locally influenced phenomena in high-resolution operational ensembles, to be used in conjunction with the larger-scale LBC perturbations provided by global ensembles such as ECMWF's EPS.

2) Developing high-resolution ensembles for Central Europe

Until now, high-resolution short-range ensemble predictions over Central Europe have been studied using horizontal resolutions of the order of 10km. In the Aladin/Hirlam consortium, (quasi-) operational ensembles have typically used the HIRLAM, ALADIN or ALARO models. They have demonstrated that some added value can be produced (compared to direct exploitation of EPS output) thanks to the higher model resolution, which improves probabilistic forecasts of low-level wind, gusts, temperature, humidity and precipitation (Wang 2011, Theis et al 2009, Clark et al 2011, Horányi et al. 2011). As demonstrated in Météo-France (Vié et al, 2010), even better forecasts can be obtained using the AROME model at kilometric resolutions and with smaller domains, in both deterministic and ensemble prediction runs. The higher resolution delivers clear benefits for the ensemble prediction of thunderstorms and high precipitation, because the largest convective clouds (and their uncertainty) can be explicitly simulated, as documented in the literature. There has been less work on winter weather events, but it is believed that substantial added value will stem in these cases from:

- a more realistic depiction of mountain range and valleys, particularly with respect to foehn effects and the trapping of cold air and low clouds in the valleys and foothills, which can lead to extreme local variability (and, often, uncertainty) of temperature, sunshine, wind and precipitation;
- a better representation of land surface effects, for instance humidity sources from lakes and large rivers, which can strongly influence wintertime weather in such areas, with consequences on local forecasts for cities, airports and motorways; uncertainties on snow cover may play a role, too;

- a more explicit representation of the formation, advection and dissipation of fog and low clouds, which have an indirect effect on the prediction of temperature and the occurrence of frost;
- the detailed representation of cloud microphysics and of the vertical PBL structure is likely to help in the prediction of the precipitation phase (snow vs liquid rain), which is very important for human activities.

A baseline version of the AROME ensemble prediction system has been developed at Météo-France, which comprises LBC coupling to a global ensemble (PEARP), perturbations of initial conditions using an AROME ensemble data assimilation (EDA, brousseau et al 2011), and a representation of atmospheric model errors using a limited area version of ECMWF's SPPT scheme (stochastic perturbations of physics tendencies, Palmer et al 2009). This system has good probabilistic scores over France in the warm season, particularly with respect to Mediterranean rain events, synoptically forced weather, and thunderstorms. It is proposed to investigate its performance for the lesser known wintertime conditions that occur in Central Europe, using a relocated version of the AROME-2.5km model as prepared by the Hungarian Meteorological Service. A dedicated set of AROME ensemble predictions will be run and evaluated over several weeks. Probabilistic scores will be investigated using verification against observations (national synops and raingauges, aircraft reports, radars, satellite cloud products). It will be interesting to compare the AROME ensemble performance against lower-resolution LAM ensembles (with more members) and the EPS over the same area.

Some ensemble characteristics can be adjusted if the necessary computing power is available, e.g. the strength, correlations and nature of the tendencies perturbed by the SPPT scheme; the variance of perturbations applied to observations and surface fields in the EDA; the criteria used to cluster the PEARP forecasts when preparing the LBCs. A small number of impact experiment will be carried out to determine if the peculiarities of wintertime weather warrant the development of situation-specific perturbation strategies, particularly in terms of obtaining the correct ensemble spread for key weather parameters.

3) Representing low-level model error

Most existing ensemble prediction systems lack spread in low-level output parameters. Multiphysics approaches are known to improve spread, although it is not very satisfactory that they tend to produce ensembles whose member-to-member differences are dominated by systematic biases. Stochastic physics approaches can help with the representation of mesoscale model errors (Berner et al 2011). It is known from the NWP physical parametrisation community that NWP models have issues representing surface fluxes, the structure of stable boundary layers, and capping inversions. Ideally, the related model uncertainties should be represented as dedicated perturbations in ensemble prediction systems. It is planned to develop them in high-resolution, small-domain ensembles such as AROME ensembles, because most of their forecast uncertainties at upper levels will already be handled by the LBC perturbations by larger-scale ensembles. In this project, it is proposed to focus on the perturbation of processes that are likely to be relevant for wintertime NWP:

- the radiative balance at the surface, by perturbing the albedo and the radiative properties of the surface and clouds,
- the surface energy budget, by perturbing the mixing length, soil moisture and temperature, and the snow cover,
- the formation/dissipation of fog and low clouds, by perturbing the low-level humidity and cloud/ice water content, possibly using object displacement methods,
- the rain/snow transition, by perturbing the PBL temperature, and the relevant microphysical processes.

There may not be enough human resources to develop perturbation strategies for all these processes within the project, nevertheless the intention is to, at least, evaluate to what extent existing perturbation techniques (such as EDA perturbations of the soil and snow assimilation systems) need improvement in order to provide a satisfactory ensemble reliability in high-impact winter weather. Some simple 2D model tendency perturbations can be tested using the existing SPPT software.

The work will be carried out in coordination with the HIRLAM/ALADIN community. It will use the IFS software.

Technical requirements

The estimate for the computer resources is conservative, and based on the 2011 experience of running AROME-France ensemble prediction tests using Météo-France resources on C1A and ECFS. It is planned to test each set of modifications by running (typically) 15-21 days of 12-member AROME ensemble forecasts at 24-h range. This is the minimum experiment length required to reliably identify the average impact of modifications. About ten sets of impact experiments need to be run each year in order to achieve the scientific objectives. A substantial part of the experimentation will be run using a smaller domain than AROME-France, centred over Hungary.

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