REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: Norway

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Project Title: Initial and lateral boundary perturbations for Convective Permitting Ensemble Prediction Systems

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: 2016 (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)	20 (MSBU)	20 (MSBU)	0
Data storage capacity (total archive volume) (gigabytes)	2500 GB	2500 GB	0

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): 30.06.2015

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.

Principal Investigator: Morten Køltzow

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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.

It is emphasized that even though the present application is made on behalf of the Norwegian Meteorological Institute (Met-Norway), the entire project is applied for on behalf of both Met-Norway and the Swedish Meteorological and Hydrological Institute (SMHI). Met-Norway and SMHI has a Meteorological Co-operation on Operational NWP (MetCoOp) and aim for operational runs with a Convective Permitting Ensemble Prediction System (CPEPS) in 2016.

Aim of the project

The aim of the project is to explore strategies for initial condition perturbations and lateral boundary conditions/perturbations for CPEPSs. The methods that will be tested are Scaled Lagged Average Forecasting (SLAF) and the use of perturbations based on IFS-ENS.

Background

Met-Norway and SMHI plan for a joint operational CPEPS from 2016. The system will most likely include one control run and 8 members utilizing HPC capacities in both countries.

The model tool will be the non-hydrostatic Harmonie system. Harmonie is the result of the common model development between the two European consortia for short-range NWP: High Resolution Limited Area Modelling (HIRLAM) and Aire Limitee Adaption dynamique development International (ALADIN). With in this cooperation a prototype system for HarmonEPS is developed which will be utilized. A horizontal resolution of 2,5km, 65 vertical levels and lead times up to +36hr on the domain in Figure 1 will be used.

An ensemble system should ideally give a sharp (as possible), but reliable forecast. To do this it needs to take into account the uncertainty associated with initial and lateral boundary conditions and model formulation. With respect to spatial scales and predictability this is a very different task for a global synoptic scale forecasts and for regional mesoscale forecasts. Different choices of initial (and lateral boundary) perturbation-strategies for large-scale ensemble systems are well documented. Perturbations depending on the actual atmospheric state has proved to be crucial (i.e. the singular vector approach at ECMWF by Buizza et al., 1993, 2000, Buizza 1994; Molteni et al, 1996 and the breeding technique at NCEP by Toth and Kalnay 1993, 1997). However, for convective permitting EPSs the effect of different strategies for initial and lateral perturbations are not well documented, although the most common practise has been to use information from a global EPS (i.e. IFS-ENS). This is i.e. done by adding the perturbations from the global system to the analysis done in the control run of the regional set-up. The initial perturbations of such global systems are often targeted for longer lead times (and phenomena on other spatial and temporal scales) than what regional convective permitting systems are employed for. Another issue is the possibility to do re-runs on historical periods as data required as lateral boundary conditions are not stored today. In addition, consideration of which of the global members to use is an issue since the global coarse resolution EPS often consist of more members than what is affordable for the convective-permitting system.

Another approach is to use SLAF (Kalnay, 2003). Here, the perturbations are based on the differences between deterministic forecasts from recent cycles (i.e. from IFS-HRES). Recent experiments show promising results using SLAF for a CPEPS over Spain (García-Moya et al, 2015). With this latter approach several of the problematic issues mentioned for the approach using a global EPS is avoided. It is therefore interesting to further investigate the effect the two different approaches has on the quality of the forecasts.

Scientific plan

To do a proper comparison of the two strategies it is needed to include periods when IFS-ENS input is available for 4 cycles per day (similar to IFS-HIRES). In addition, the use of member selection scheme (e.g. Montani et al. 2011) should be considered. We also believe that there is sensitivity to the choice of scaling of the perturbations for both methods and sensitivity tests should be included. The benefits of multi-model/physics on objective scores is well documented (i.e. Iversen et al, 2011), but is beyond the scope of the experiments planned in this experiments. However, the suggested evaluation of two different physic parameterization packages in activity 1 can give some indications of the usefulness of multi-physics for this particular set-up. The comparison of SLAF and IFS-ENS perturbation strategies will be done under activity 2.

Activity 1 – Evaluation of latest model cycle

The Harmonie system includes AROME and ALARO physics parameterizations. AROME is targeted for ~2,5km horizontal resolution while ALARO is targeted at slightly coarser resolution. However, for convective-permitting EPS, ALARO has been used with 2,5km horizontal resolution. To evaluate the latest model version simulations with AROME and ALARO physics will be done for 4 periods (one per season), each of 3 weeks. Hopefully, the results confirm that the latest version of the Harmonie system is skilful for the particular area of interest. The results also give a first insight to what can be gained with a multi-physics approach for this particular domain. In total we need to run 6 experiments in this activity as the control runs in activity 2 can be used for two of the periods. Estimated use for simulation of each period is 0,5MSBU and a total estimate of activity 1 is therefor 3MBU. We will only store a limited part of the model output and need 1TB storage capacity.

Activity 2 – Best practise for initial and lateral boundary perturbations

The two different approaches for initial and lateral perturbations will be tested for two periods of 3 weeks. Preferably a summer and a winter period will be chosen. The IFS-ENS strategy will be tested with three different choices of scaling of the perturbations to investigate the sensitivity. Note that the SLAF-method will be tested with respect to scaling factor at an earlier stage on the national HPC capacities. In addition, the effect of employing a member selection scheme should be tested on minimum one period and based on this used (or not used) for the rest of the experiments. A summary of the experiments are given in Table 1. Note that this activity can not start before ECMWF disseminate boundary conditions from IFS-ENS for four cycles per day (soon to happen) and that we have been able to save lateral boundary conditions for interesting periods. Each period is estimated to use slightly less than 4MSBU and in total the 9 experiments is then estimated to need 36MSBU. We will only store a limited part of the model output and need in total 4TB storage capacity.

	SLAF Scaling K1	IFS-ENS Scaling K1	IFS-ENS Member selection Scaling K1	IFS-ENS Member selection Scaling K2	IFS-ENS Member selection Scaling K3
Period 1	**X**	**X**	**X**	**X**	**X**
Period 2	**X**		**X**	**X**	**X**

Table 1. Summary of experiments comparing SLAF and IFS-ENS generated initial and lateral perturbations.

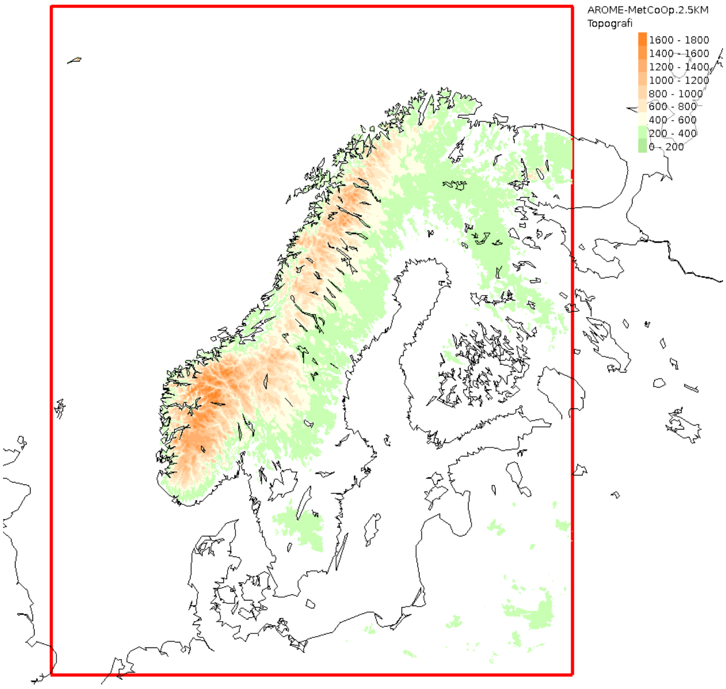

Figure 1: The joint Swedish and Norwegian Convective Permitting Ensemble Prediction System domain. Colours indicate model topography (2,5km horizontal grid spacing).

Results

The results from the described experiments will be used to optimize the operational set-up of the joint SMHI/Met-Norway operational CPEPS. In addition to this specific purpose, the scientific questions raised in this project are relevant for a wider community (e.g. Met Services running regional CPEPSs). The results should point in a direction for optimal use of resources in generating perturbations and lateral boundaries for regional EPS systems in an operational setting.

The results will be communicated in relevant forums, i.e. in yearly meetings in the HIRLAM/ALADIN consortia. The results should most likely also have the potential for (a part of) a peer-review paper.

References

Buizza, R. 1994. *Localization of optimal perturbations using a projection Operator*. Q. J. R. Meteor. Soc. 120, 1647–1682.

Buizza, R., Tribbia, J., Molteni, F. and Palmer, T. N. 1993. *Computation of optimal unstable structures for a numerical weather prediction model*. Tellus 45A, 388–407

Buizza, R., Barkmeijer, J., Palmer, T. N. and Richardson, D. 2000. *Current status and future developments of the ECMWF ensemble prediction system.* Meteorol. Appl. 6, 1–14.

García-Moya, J. A., A. Callado, P. Escriba,, 2015, *SLAF implementation in HarmonEPS: First results*, Presentation at ALADIN-HIRLAM The 25th Workshop All Staff Meeting: http://www.cnrm.meteo.fr/aladin/IMG/pdf/slaf.pdf

IVERSEN, Trond et al. *Evaluation of 'GLAMEPS'—a proposed multimodel EPS for short range forecasting*. Tellus A, [S.l.], v. 63, n. 3, may. 2011. ISSN 1600-0870. doi:http://dx.doi.org/10.3402/tellusa.v63i3.15825.

Kalnay, E, 2003*: Atmospheric modeling, data assimilation and predictability*, Cambridge University Press, p237.

Molteni, F., Buizza, R., Palmer, T. N. and Petroliagis, T. 1996. *The ECMWF ensemble prediction system: methodology and validation*. Q. J. R. Meteorol. Soc.125, 73–119

Montani, A., D. Cesari, C. Marsigli, and T. Paccagnella, 2011, *Seven years of activity in the field of mesoscale ensemble forecasting by the COSMO-LEPS system: main achievements and open challenges.* Tellus, 63A, 605-624.

Toth, Z. and Kalnay, E. 1993. *Ensemble forecasting at NMC: the generation of perturbations*. Bull. Am. Meteorol. Soc. 74, 2317–2330.

Toth, Z. and Kalnay, E. 1997. *Ensemble forecasting at NCEP and the breeding method*. Mon. Wea. Rev. 125, 3297–3319.