REQUEST FOR A SPECIAL PROJECT 2015–2017

MEMBER STATE:	Norway
Principal Investigator[1]:	Inger-Lise Frogner HIRLAM-B Project Leader for Probabilistic forecasting
Affiliation:	Norwegian Meteorological Institute
Address:	P.O. Box 43, Blindern 0313 Oslo, Norway
E-mail:	i.l.frogner@met.no
Other researchers:	Kai Sattler, Jan Barlmeijer, Ole Vignes, Alex Deckmyn, Henrik Feddersen, John bjørnar Bremnes, Sibbo van der Veen, Geert Smet, Xiaohua Yang, Juha Kilpinen, Maurice Scmeits, Pau Escriba, Alfons Callado, Andrew Singleton, Thomas Nipen, Bjørn Stensen
Project Title:	Probabilistic forecasts for short range in Europe

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ___________________	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2015	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2015-2017: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2017.)	**2015**	**2016**	**2017**
High Performance Computing Facility (units)	20.000 000	20.000 000	20.000 000
Data storage capacity (total archive volume) (gigabytes)	10000	10000	10000

*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):
27/06/2014

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: Inger-Lise Frogner

Project Title: Probabilistic forecasts for short range in Europe

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) and Norway, the entire project is applied for on behalf of all the member states in the two consortia Hirlam and Aladin taking part in developing probabilistic forecasts for the short range in Europe (GLAMEPS and HarmonEPS).

The development of probabilistic forecasting in Hirlam / Aladin presently consists of the elements:

Activity 1. GLAMEPS: Experimenting with options for upgrading of GLAMEPS.

The Grand Limited Area Modelling Ensemble Prediction System (GLAMEPS) is for operational production as a part of the cooperation between two European consortia for short-range NWP: High Resolution Limited Area Modelling (HIRLAM) and Aire Limitée Adaptation dynamique developpement INternational (ALADIN). It aims at predicting atmospheric features on spatial scales intermediate between the synoptic, covered by leading global EPS, and the convection-permitting scales. The challenge is to construct a well-calibrated, pan-European ensemble for short-range NWP by accounting for both initial state and model inaccuracies. Model uncertainties are presently taken into account by using a small number of different models and versions, two versions of the HIRLAM model (HirEPS_S and HirEPS_K) and two versions of Alaro (Alo_I and Alo_S). Initial state uncertainties are taken into account in two ways: Ensemble perturbations are imported from the global ECMWF 51-member EPS. This system also provides perturbations at the lateral boundaries during the prediction period. Additional initial state perturbations are included by running two different assimilation cycles in parallel with different models and model versions. All LAM-members also run with a separate data-assimilation cycling for the ground surface, yielding a unique surface analysis per ensemble member. The current GLAMEPS version (v1) is soon to be replaced with v2 that was described here. GLAMEPSv2 is set up for producing a 52-member hydrostatic multi-model EPS on a pan-European integration domain for 54h forecasts with grid mesh width around 8 km. GLAMEPSv2 runs four times a day, at 00, 06, 12 and 18 UTC. GLAMEPSv2 utilises the lagging technique, meaning that only half the number of members is run at each forecast time and then combined with the members ran 6 hours before.

GLAMEPS shows good scores as compared to IFS ENS. An example can be seen in figure 1 which shows the spread and skill for GLAMEPS and IFS ENS for T2m.

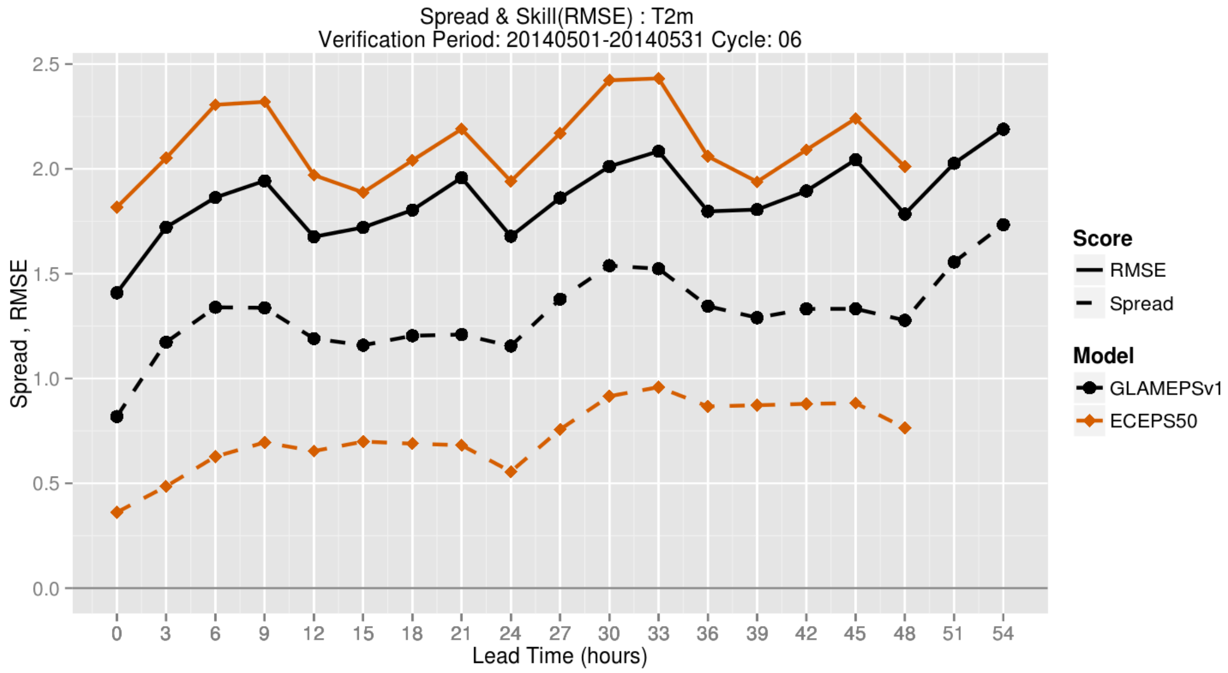

Figure 1: Spread (dashed line) and skill (solid line) for GLAMEPS (black) and IFS ENS (orange) for two meter temperature for May 2014.

Further upgrades of GLAMEPS consists of including CAPE singular vectors, looking at the possibility of further increasing the horizontal resolution, including assimilation also for Alaro-ensembles and evaluating the need for lagging. Also the possibility of having IFS ENS four times a day, as has been discussed, would be suitable for GLAMEPS and would need testing. The main development work will in the future not be on GLAMEPS, but on activity 2 (convection permitting EPS; HarmonEPS).

The computer system billing units for the daily running of GLAMEPS will be taken from national allocations from Hirlam and Aladin countries. For the planned experimental production, SBUs from special project will be needed.

Activity 2. HarmonEPS: Experimenting scientifically and technically with ensembles of non-hydrostatic modelling with convection-permitting resolution (HarmonEPS) for the very short range in sub-European domains.

HarmonEPS is the name of one or several ensemble prediction systems for the very short range (<36h) on so-called convection-permitting scales. The basic model tool will be the non-hydrostatic Harmonie with Alaro and/or Arome physics. The development towards a cloud-permitting, meso-scale model system (Harmonie) has had considerable progress, and a prototype system for HarmonEPS is developed. Experiments will be done on a few selected sub-European domains, thus gaining experience that can eventually lead to a prototype system that member countries can install at their home computers for their own purpose. Also the area of Sochi at the Black sea was such a test area since the Hirlam consortium was engaged in the FROST project (Winter Olympic games in Sochi 2014) and HarmonEPS was one component of this engagement. Some experience has been gained in a few HIRLAM and ALADIN member countries, as well as in other European consortia, but a lot more is necessary, e.g. in order to develop close links to meso-scale data assimilation, physics parameterizations, and the description of the land surface. Given the need for urgent products in real time, it is not envisaged that HarmonEPS should rely on a double nesting strategy (EPS - GLAMEPS- HarmonEPS). From experiments with HarmonEPS nesting in 32km IFS ENS and 16km IFS ENS, it was shown that the gain of the higher resolution IFS ENS on HarmonEPS was marginal and that nesting in the operational IFS ENS is sufficient.

For HarmonEPS a basic research system has been set up and experiments started in 2012. Also a basic version of HarmonEPS with Arome and 3d-Var ran in (quasi-)operational mode for FROST-2014. HarmonEPS has been set up with the possibility to use both Alaro and Arome physics, thus continuing the multi-physics approach introduced in GLAMEPS. An important element is to prepare boundary data as model levels that are needed to run HarmonEPS are not stored operationally.

Experiments will be carried out with different nesting configurations, with data assimilation in the control members and with perturbations of physics, surface and initial conditions. For convection-permitting ensembles, the latter is a greater challenge than for synoptic-scale ensembles like GLAMEPS. The reason is that the forecast errors saturate at lower absolute levels for small-scale systems than for larger scales. As a consequence, very short-range predictions only have reasonable predictability if the estimates of initial states are considerably more accurate than what is considered as sufficient for synoptic scales. A connected practical problem is the short time window available before mesoscale prediction errors are saturated. The methods for estimating initial states must be both accurate and computationally fast. Limited predictability at convection-permitting scales also calls for frequent generation of new forecasts, i.e. Rapid Update Cycling (RUC). An increased initial state accuracy can be obtained by exploiting high-resolution observations (e.g. radar), and by utilizing information on flow-dependent model uncertainty from a EnDa system. The multi-model setup of HarmonEPS accounts for some degree of model uncertainty already. Additionally, the potential will be considered of adding surface (analysis) perturbations and of upper air perturbations in the form of perturbations in physics parameters and SPPT (Stochastically Perturbed Parametrization Tendencies scheme). Cellular Automata (CA) to introduce stochasticity, horizontal communication and convective memory to the parameterization will be tested for the Alaro members of the ensemble. Application of stochastic physics at the process level, rather than multiplying the total physical tendencies, will also be studied.

The following experiments are planned:

- SPPT: First step is basic implementation of complete SPPT in HarmonEPS; then to adapt SPPT to different scales. Verification and tuning and inter comparison of the performance of multi-physics vs Box-SPPT and complete SPPT will be performed.
- Experiment with perturbation of surface parameters will be performed (e.g. soil moisture, albedo, snow, SST, LAI, vegetation fraction, roughness length and soil temperature).
- Surface physics – we will study perturbations in momentum, heat and moisture flux parameterizations.
- Study humidity perturbations: Explore the influence of humidity perturbations in HarmonEPS by including humidity in SV's, and by use of the MSG cloud mask for computing humidity perturbations.
- Make stochastic perturbations for critical threshold for autoconversion (cloud drops>raindrops). Improve freezing computation of supercooled clouds, and apply stochastic perturbations to 'freezing probability per unit time' (given a certain supercooling) in HarmonEPS.
- Include perturbed observations in surface assimilation for the different members.
- Investigate the issue of domain size requirements for DA. Experiment with RUC with cy38. Introduce lagging.
- Nest in ECMWF deterministic model by use of random field perturbations to the initial and lateral boundary conditions. Random field perturbations can simply be the difference

between two ECMWF analyses or forecasts from randomly chosen dates (but same season and same initial hour) scaled to make the perturbations suitably small.

- Study the importance of boundary perturbations in connection with the big jump in resolution from host model to HarmonEPS.
- LETKF: compare its performance with available methods for generating Initial Conditions already implemented in Harmonie.
- Investigate the amplitude of the uncertainty associated with different physical processes in the models. Develop stochastic parameterizations or parameter perturbations that address uncertainty for each sub-grid scale process.
- Make use of parameter perturbations developed in LAEF system.

In Summary

All in all extensive experimentation is planned, mostly with HarmonEPS, but also a few GLAMEPS experiments. As GLAMEPS is an operational system, parallel runs are needed before any updates can be introduced, this is estimated to 5 MSBUs per year. HarmonEPS experiments is estimated to ~1.5 MSBUs for 20 member ensemble for a three week experiment period, per area. 15 MSBUs will then cover app. 10 experiments. Tuning is needed in some experiments, and we need to run for different seasons and areas for each experiment mentioned, hence it is very likely that experiments needs to be repeated. This means that the resources asked for will only cover part of the SBUs needed to full fill the plan described above. The rest of the SBUs will be taken from national resources of the participating countries. The project will benefit substantially if granted SBUs by ECMWF as special project.