REQUEST FOR A SPECIAL PROJECT 2013–2015

MEMBER STATE: Norway

Principal Investigator[1]: Inger-Lise Frogner
HIRLAM-B Project Leader for Probabilistic forecasting

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Project Title:

Hirlam – Aladin Probabilistic Systems

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPNOGEPS** ___________________	
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 2013-2015: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2015.)	**2013**	**2014**	**2015**
High Performance Computing Facility (units)	12.000 000	12.000 000	
Data storage capacity (total archive volume) (gigabytes)	50000	50000	

*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): 27/04/2012

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: Dr. Inger-Lise Frogner

Project Title: SPNOGEPS
Hirlam – Aladin Probabilistic Systems

Extended abstract

Background

This application is for the continuation of the project SPNOGEPS “Hirlam – Aladin Probabilistic Systems” which started in 2012. It is emphasized that even though the present application is made on behalf of the Norwegian Meteorological Institute (met.no) and Norway, the entire project is applied for on behalf of all the member states in the two consortia Hirlam and Aladin for developing probabilistic forecasts for the short range in Europe.

The proposed principal investigator is changed from last year's application. This is because Inger-Lise Frogner replaced Trond Iversen (former PI for SPNOGEPS) as Hirlam project leader for probabilistic forecasting from 1. January 2012 and hence took over the responsibilities also for the special project SPNOGEPS.

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

Activity 1.

Preparing for and establishing an operational pan-European GLAMEPS_v1 for the short range, run as a Time-critical facility (TCF) Option 2 (TCF_2) at ECMWF;

Activity 2.

Experimenting with options for extensions of GLAMEPS for upgrading to a second version (GLAMEPS_v2);

Activity 3.

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

At present stage work is progressing on all the activities 1,2 and 3 with support from SPNOGEPS and additional national resources.

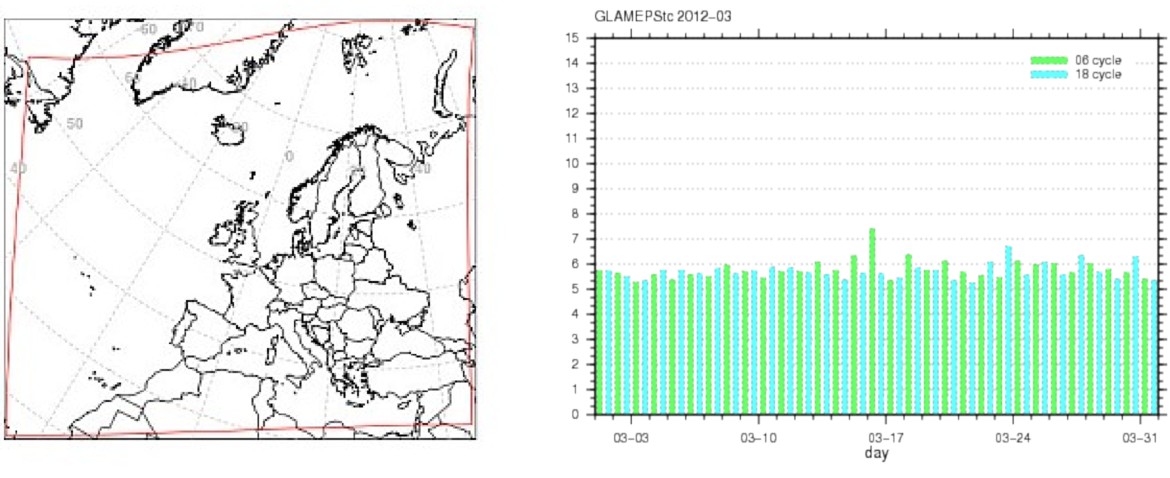

Figure 1: a) GLAMEPS domains. Black domain is the Aladin grid (Lambert conical), red domain is the Hirlam domain (rotated lat-lon). b) GLAMEPS_v1 production times from March 2012.

Activity 1: GLAMEPS_v1

The Grand Limited Area Modelling Ensemble Prediction System (GLAMEPS) is intended 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 HireEPS_K) and AladEPS. 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 three different assimilation cycles in parallel with different models and model versions, but without perturbing the observations. All LAM-members also run with a separate data-assimilation cycling for the ground surface, yielding a unique surface analysis per ensemble member. GLAMEPS is set up for producing a 54-member hydrostatic multi-model EPS on a pan-European integration domain for 54h forecasts with grid mesh width around 11 km. All ensemble members from EC EPS are used as well as the deterministic EC forecast in the following way, yielding 54 GLAMEPS members:

- GLAMEPS members 01 - 13: HirEPS_S based on EC EPS 00 + 01-12
- GLAMEPS members 14 - 26: HirEPS_K based on EC EPS 00 + 13-24
- GLAMEPS members 27 - 39: AladEPS based on EC EPS 00 + 25 -36
- GLAMEPS members 40 - 53: EC EPS 37 – 50 are added to the GLAMEPS ensembles as thay are
- GLAMEPS member 54: EC DET added as it is.

The integration domains for GLAMEPS_v1 are shown in figure 1a. In March 2010, a test version of GLAMEPS ("version 0") was set up to run twice daily (00 and 12 UTC). This was later updated to GLAMEPS version 1, which has replaced version 0 and is now being run daily at 06 and 18 UTC. The scheduling at ECMWF will only allow GLAMEPS to start around 8 hours after the main observation times 00 and 12 UTC, and since observations from 06 and 18 UTC (respectively) will be available at the time GLAMEPS production can start, we changed to start the forecasts from those times (06 and 18), even if the perturbations at the lateral boundaries and at the initial time will be 6 hours older, and thus have higher amplitudes. Since the beginning of 2012 the production has been stable with few incidents, (see fig. 1b on the production time for GLAMEPS in March 2012). In a letter dated 20 January 2012 ECMWF Director of Operations Walter Zwieflhofer agreed on our request to run GLAMEPS under Member state time-critical option 2 upon the requirement that that GLAMEPS will be fully compliant with the time-critical framework. This work is well under way by Kai Sattler in close cooperation with ECMWF staff. Although GLAMEPS_v1 is running daily we plan to also run it in hindcast mode for two months in summer 2010 and to months in winter 2010-11 to use for comparing further experiments for a version 2 with.

Verification for GLAMEPS_v0 showed considerable improvements over ECMWF EPS for the first 42h (shown in last years application and in Iversen et al., 2011). A new verification system for GLAMEPS based on R is currently being developed. Some preliminary scores are shown in figure 2 and figure 3. Figure 2 is the spread/skill relationship for GLAMEPS_v1 and ECEPS for MSLP. The spread/skill relationship for GLAMEPS_v1 is very good and better than for EC EPS.

In figure 3 CRPSS (continuous ranked probability skill score) is shown for a) MSLP, b) two meter temperature, c) 10 meter wind speed and d) 24h accumulated precipitation for forecast length 24h, with EC EPS as reference (meaning if GLAMEPS is over the zero line it is better than EC EPS, and if it is below the zero line it is worse). As seen from these figures GLAMEPS_v1 shows good skill compared to EC EPS for T2m, ff10 and RR24, especially for the winter period (first half of the figures).

The computer system billing units for the daily running of GLAMEPS_v1 will be taken from national allocations from Hirlam and Aladin countries. For the planned experimental production, EXP_1.1, in hindcast mode for two months in summer 2010 and to months in winter 2010-11, SBUs from SPNOGEPS will be needed.

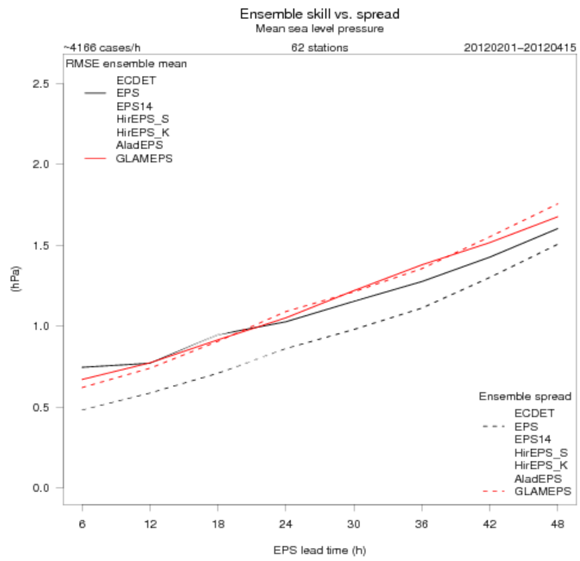

Figure 2: Spread/skill relationship for GLAMEPS (red) and EC EPS (black) for MSLP. Solid lines are RMSE of ensemble mean, dashed lines are ensemble spread.

Figure 3. CRPSS for a) MSLP, b) two meter temperature, c) 10 meter wind speed and d) 24h accumulated precipitation for 24h forecast for GLAMEPS_v1. Reference forecast is EC EPS.

Activity 2: preparing for GLAMEPS_v2

Research and development for potentially further improved GLAMEPS without changing the resolution and keeping the pan-European scope has already been made over the last 3-4 years. These activities are, however, presently not sufficiently mature for including in GLAMEPS_v1, and further configuration experimentation in hindcast mode with a realistic setting compared to GLAMEPS_v2, is needed. There are several possible configuration experiments, and the details will have to await further decisions based on analysis of existing preliminary tests and further experience. The five proposals mentioned here are presently viewed as likely to be followed up, but amendments are possible. They will successively be numbered EXP_2.x, where x=1,2,3,.... Experiments will predominantly be made for the prepared periods in summer 2010 or winter 2010 11. Additional experiments that test out ideas more ad hoc will normally be necessary before full-scale configuration experiments.

• *Calibration*

Calibration experiments using ELR (extended logistic regression) have been initiated in GLAMEPS, hence leaving the BMA track previously used. Three different approaches have been proposed for ELR:

1. Calibrate per lat/lon box of stations and interpolate regression coefficients to grid points if necessary.
2. Perform calibration over the whole model domain using lat/lon and/or elevation as predictors.
3. Regionalize over regional types: sea, land, coast, mountain.

• *Blending with higher-resolution forecasts.*

At present, GLAMEPS utilizes the information provided by the high-resolution (T1279L92) deterministic forecast produced at ECMWF in the simplest way by adding it as a separate member in the ensemble. This information could be exploited in several other ways. A slightly more advanced approached would be to use the deterministic forecast as boundary data for the control forecasts, i.e. switch member no. 00 mentioned above with the deterministic forecast. An even further approach could be to use the deterministic forecast also with a 12h time-lag, and to use these as boundary conditions for e.g. 4km versions of one or several of the model versions. The purpose of this is to obtain predictable components of the higher-resolution flows with particular emphasis on high-impact weather.

• *Blending with ETKF or ETKF-Hybrid./Blending with Hirlam EDA or EDA-Hybrid*

Experiments on these aspects have so far proven promising in the sense that perturbations that are directly related to present analysis uncertainties are taken into account. Preliminary experiments show improvements in ensemble spread during the first 12-24h of the forecasts. Experiments have tentatively also been made in which the ensemble is used to estimate the actual flow dependant model error covariance matrix to be used in the 3D-Var analysis for Hirlam. This is called ETKF-Hybrid. Preliminary experiments have only been made with 12+1 ensemble members, and blending between ETKF-perturbations and EC-EPS51 boundary data are implemented.

• *Perturbations in the lower boundary and atmospheric physics tendencies*

Further experimentation with physics tendencies and lower boundary data is planned. Interaction with physics experts is needed for diagnosing uncertain parameters. Experiments will also be performed where the number of Aladin members is increased, so that there is no need to include members from EC EPS. In this case some of the ensemble members should be based on the same surface analysis, i.e. they are run in pairs.

• *Blending with Hirlam CAPE singular vectors.*

Preliminary experiments have been made to calculate ensemble perturbations based on Hirlam Singular Vectors that maximize convective available potential energy over a target domain after 12h (CAPE SVs). Full-scale testing of the inclusion of CAPE SVs in both Hirlam-versions is ongoing.

Activity 3: HarmonEPS, convection-permitting EPS

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 a 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 will be such a test area since the Hirlam consortium is engaged in the FROST project (Winter Olympic games in Sochi 2014) and HarmonEPS is 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). A ~16km resolution global EPS would be preferable, but direct nesting in operational EC EPS will also be tried. A range of predictability studies will be made in order study the predictability as a function of spatial scale, as well as more technical issues like finding a proper balance between the range of forecast lead time, domain size, ensemble size, and spatial resolution. Preparatory activities have started by making a script system for running Harmonie in ensemble mode. The next step will be to select a few integration domains. Harmonie has also been equipped with the possibility to calculate singular vectors, which will be useful in connection with predictability studies. It is expected that first longer-term configuration experiments with HarmonEPS will start in 2012. For the HarmonEPS experiments it was originally envisaged to do a pure downscaling of the host model. However, in view of the cold-start surface nesting problems it was decided to run HarmonEPS directly with surface DA for each member. It is believed that including surface assimilation in the HarmonEPS runs will be crucial, especially when nesting in the very much coarser operational EPS. Running separately surface assimilations for each member around the same observations is likely to reduce the spread, so ideally one should also include observation perturbations. Even if this will not be technically possible for these first experiments it is believed that including surface assimilation will be beneficial. Also, if possible, it was decided to cycle the control for a couple of weeks with full DA until the start of the experiment period, and continue this full cycling for the control forecast of HarmonEPS through the experiment period. This HarmoneEPS control analysis will then be used as a basis for all the members. The members will then need to be perturbed with the perturbations from the host model (eg EC EPS like this: pert = member – control, and add that to the HarmonEPS control), this is the way things are done in the Norwegian LAMEPS system. For the period 20 January 2011 to 9 February 2011 we already have available EPS data on model levels to be used for HarmonEPS.

Experiments:

1) Nest HarmonEPS in Higher resolution EPS (H-EPS) (06/18UTC) for the test period in 2011. (From 16 km -> 2.5 km). HarmonEPS to be run at 06/18 UTC.
2) Nest HarmonEPS in operational EPS (00/12UTC) for the test period in 2011. (From 32 km -> 2.5 km). HarmonEPS to be run at 06/18UTC.
3) Rerun operational EPS for the test period for 06 and 18 UTC and nest HarmonEPS (06/18UTC) in this
4) Possibly: nest HarmonEPS in GLAMEPS (= double nesting strategy)

From experiment 1 vs experiment 2 we can assess the possibility to run directly from operational EPS as compared to running from a higher resolution H-EPS. This set-up in which we use 00 and 12 UTC runs from EPS and 06 and 18 UTC runs from H-EPS does not allow for a clean comparisons between the two possible nesting strategies, but this would resemble what would be possible in operations. Comparing experiment 1 and 3 will give us the clean comparison between nesting from 16 km and 32 km. The combination of experiments 1-3 should give us an idea if it is possible to nest HarmonEPS directly in operational EPS at 32 km. If not, a decision has to be taken regarding the nesting strategy for HarmonEPS. It can then be necessary to test nesting of HarmonEPS in GLAMEPS, this double nesting is however not seen as ideal as it will be very time consuming.

• Later experiments: ETKF/EDA. Presently we do not have enough observations in the limited areas possible for HarmonEPS, and more observations like satellite, radar and GPS needs to be included. Data assimilation in Harmonie needs to be developed further to include high resolution observations and 3h cycling in

Harmonie. This will probably not be possible before the end of the year. Perturbations of model tendencies and the lower boundary surface parameters should be made in close contact with the relevant experts in those areas. All in all, considerable experimentation will be needed, involving high forecast frequency (Rapid Update Cycling). Tools that are easy to use to obtain basic diagnosis of forecast quality are essential, with an emphasis on weather elements relevant for the meso-scale.

In Summary

Operational GLAMEPS_v1, paid by national SBUs, is estimated to 15 MSBUs per year. For EXP_1.1 and the proposed EXP_2.x in hindcast mode, a major part of the costs will need to be taken from this project. One experiment running for two months costs ~ 2.5 MSBUs. Running ~3 of these each year adds up to ~7.5 MSBUs. The remaining MSBUs applied for will be allocated to the HarmonEPS experiments. The cost of the HarmonEPS experiments is estimated to ~1.5 MSBUs for 20 members per experiment for the three week experiment period planned, per area.

REFERENCES:

Iversen, T., Deckmyn, A., Santos, C, Sattler, K., Bremnes, J. B., Feddersen, H and Frogner, I.-L. 2011: Evaluation of "GLAMEPS" - a proposed multi-model EPS for short range forecasting *Tellus 63A*, accepted article DOI: 10.1111/j.1600-0870.2010.00507.x.