SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Hirlam-Aladin Probabilistic Systems
Computer Project Account:	spnogeps
Start Year - End Year :	2012 - 2014
Principal Investigator(s)	Inger-Lise Frogner
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Other Researchers (Name/Affiliation):	Kai Sattler (DMI), Xiaohua Yang (DMI), Andrew Singleton (MET Norway), Alex Deckmyn (RMI), Sibbo van der Veen (KNMI), Bjørn Stensen (SMHI), Ole Vignes (MET Norway), Ulf Andrae (SMHI)

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

This project utilized competence in the Eumetnet SRNWP consortia Hirlam and Aladin for maintaining and developing probabilistic forecast systems for the short (up to ~60h) and very short (up to ~36h) ranges in Europe. Probabilistic prediction in the short and very short ranges is a prominent component of the two consortia. The development of probabilistic forecasting in Hirlam / Aladin consists of preparing for and establishing an operational pan-European GLAMEPS for the short range, run as a Time-critical facility (TCF) Option 2 (TCF_2) at ECMWF; experimenting with options for extensions of GLAMEPS for upgrading to a new version (GLAMEPSv2) and experimenting scientifically and technically with ensembles of non-hydrostatic modelling with convection-permitting resolution (HarmonEPS) for the very short range in sub-European domains.

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

The working conditions at ECMWF are very good thanks to a helpful and collaborative staff at ECMWF.

Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

Special projects are a very good way to get additional resources for running experiments, and I fully understand the need for application and reporting. However, I would suggest to have the reporting in phase with the accounting year. This is for two reasons:

1) To have reporting in phase with the accounting year would mean moving the reporting to the beginning of the year following the accounting year, in that way you can report for the whole past year, and your last progress report after the three-year period will also be you final report. As it is now, one needs to provide both a progress report in June the last year (six months before the project ends), and a final report June next year for the same project (six months after the project ends). This is unnecessary and can be one report if reporting is moved to eg January.
2) When you have a new special project you are asked to report after only six months, as it is now. Six months is a short time, and there is a chance that there are not so much results to report yet, as running experiments and analysing the results takes time.

Summary of results

(This section should comprise up to 10 pages and can be replaced by a short summary plus an existing scientific report on the project.)

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

Activity 1.

Preparing for and establishing an operational pan-European GLAMEPSv1 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 (GLAMEPSv2);

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.

Activity 1: GLAMEPSv1

This activity was completed as GLAMEPSv1 became operational in 2012.

Short description of GLAMEPSv1: 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 in GLAMEPSv1 were 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 as well as stochastic physics. Initial state uncertainties were taken into account in two ways: 1) Ensemble perturbations imported from the global ECMWF 51-member IFS ENS (this system also provides perturbations at the lateral boundaries during the prediction period), 2) initial state perturbations were included by running three different assimilation cycles in parallel with different models and model versions, and by perturbing the surface observations in the two HIRLAM versions. All LAM-members also ran with a separate data-assimilation cycling for the ground surface, yielding a unique surface analysis per ensemble member. GLAMEPSv1 was 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 IFS ENS were used as well as the deterministic EC forecast in the following way, yielding 54 GLAMEPS members:

- GLAMEPS members 01 - 13: HirEPS_S based on IFS ENS 00 + 01-12
- GLAMEPS members 14 - 26: HirEPS_K based on IFS ENS 00 + 13-24
- GLAMEPS members 27 - 39: AladEPS based on IFS ENS 00 + 25 -36
- GLAMEPS members 40 - 53: IFS ENS 37 – 50 were added to the GLAMEPS ensembles
- GLAMEPS member 54: EC DET added.

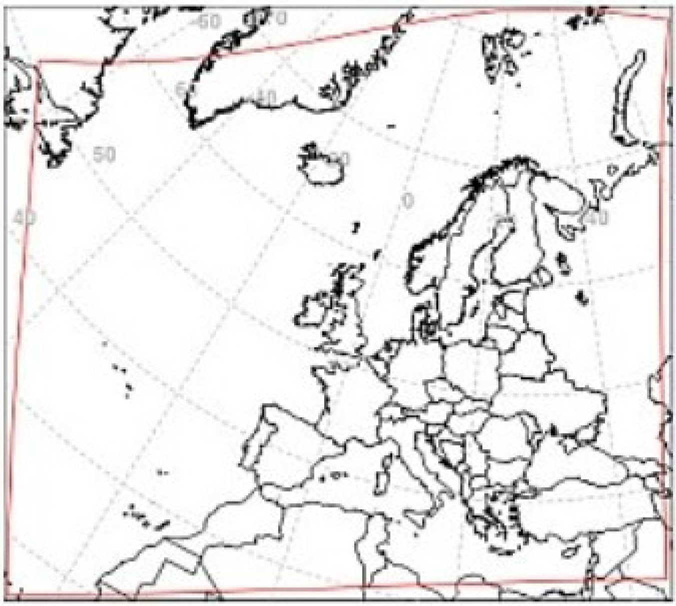

Figure 1: GLAMEPSv1 domains. Black domain is the Aladin grid (Lambert conical), red domain is the Hirlam domain (rotated lat-lon).

The integration domains for GLAMEPSv1 are shown in figure 1. GLAMEPSv1 was routinely monitored and verified together with IFS ENS, and shows an improvement compared to IFS ENS. An example is shown in figure 2, where GLAMEPSv1 and IFS ENS for Brier Skill Score for T2m for May 2014 are compared.

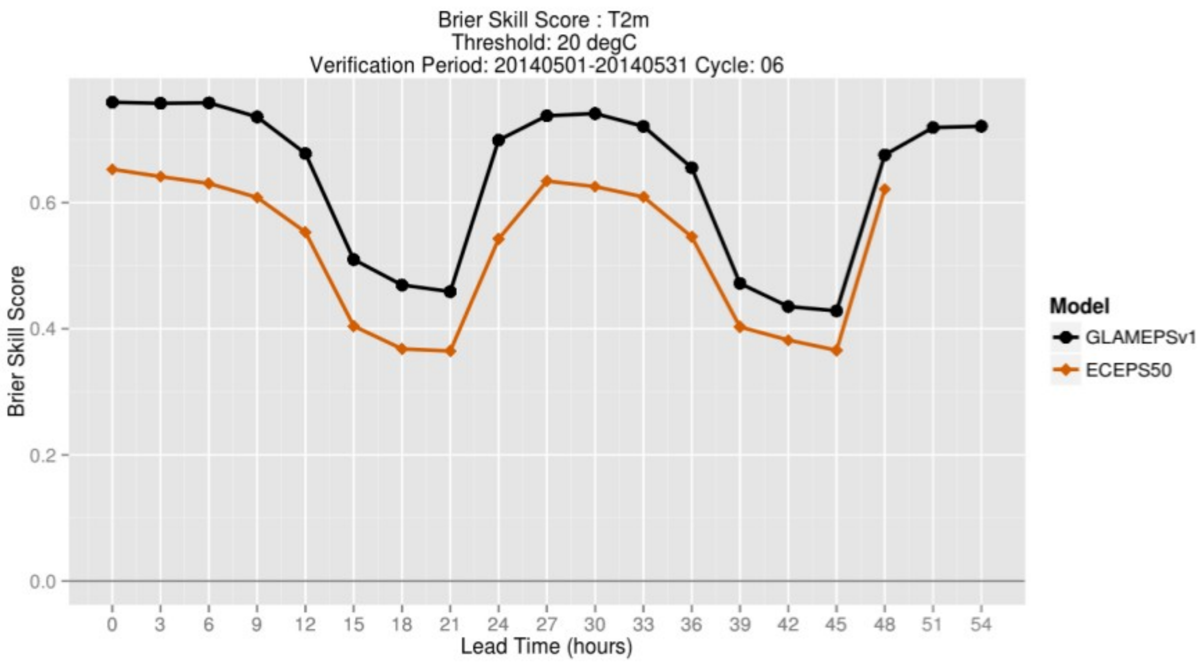

Figure 2: Brier Skill Score for T2m for May 2014, GLAMEPSv1 in black and IFS ENS in orange, for a threshold of +20 deg C.

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 in 2012, which replaced version 0 and was run daily at 06 and 18 UTC. In 2014 GLAMEPSv2 was introduced (see below) and currently work is ongoing to upgrade to a version 3. GLAMEPS runs under Member state time-critical option 2.

Activity 2: preparing for GLAMEPSv2

This activity was completed as GLAMEPSv2 became operational in 2014.

The main differences between v1 and v2 are:

- GLAMEPS 4 times per day (lagged ensembles).
- Increased resolution (~8 km)

There was several requests from users of GLAMEPS to have it available four times a day. GLAMEPSv2 is now running with half the number of members compared to v1, but with lagging to keep the number of members at the same level as v1. At the same time the resolution is increased to 8 km.

- Increased the number of Alaro ensemble members at the expense of the IFS ENS members.

The number of Alaro members is increased to the level of HIRLAM members, replacing the IFS ENS members that were part of v1.

- Calibration

Calibration of v2 has been tested extensively, and it is presently in the operational suite.

GLAMEPSv2 was monitored together with GLAMEPSv1 and IFS ENS for a few months before the switch from v1 to v2. . An example of verification is shown in figure 3. Generally GLAMEPSv2 scores as well as GLAMEPSv1, hence continuing to score better then IFS ENS.

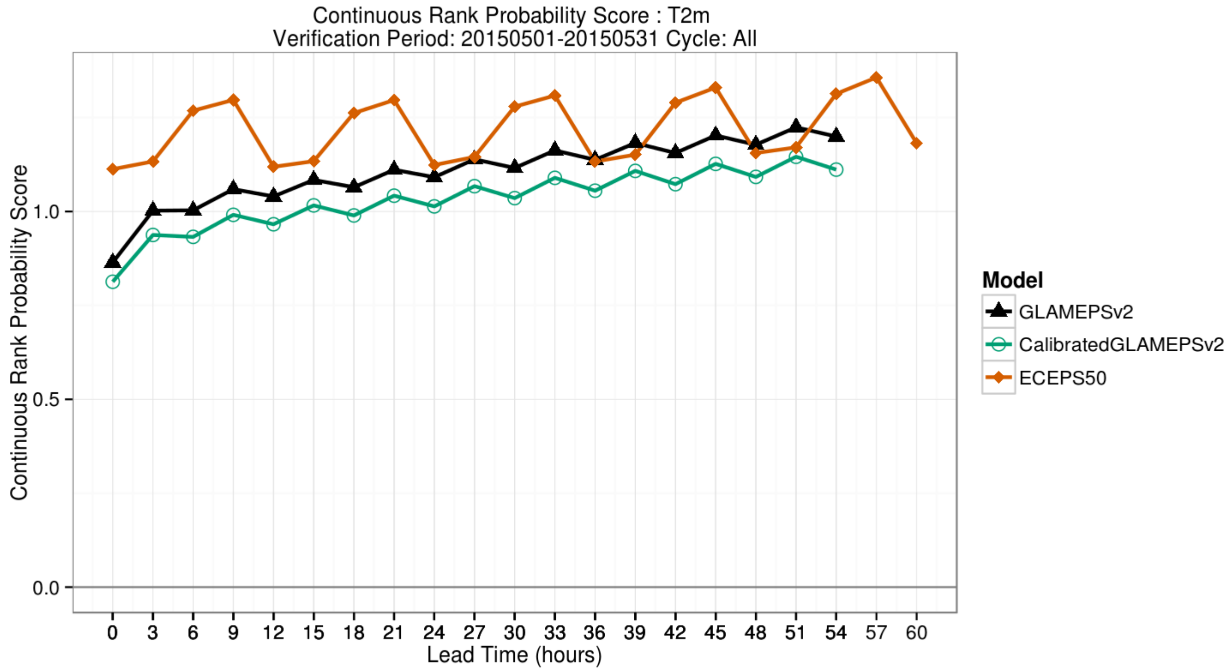

Figure 3: Continuous rank probability score (CRPS) for two meter temperature for May 2015. The score is negatively oriented, so the lower the better. GLAMEPSv2 (black), IFS ENS (orange) and calibrated GLAMESPv2 (green).

Activity 3: HarmonEPS, convection-permitting EPS

HarmonEPS is the name of the ensemble prediction systems for the very short range (<36h) on so-called convection-permitting scales that has been developed in this project. The basic model tool is the non-hydrostatic Harmonie with Alaro and Arome physics. The development towards a cloud-permitting, meso-scale model system (Harmonie) had considerable progress during this special project period, and a prototype system for HarmonEPS is available for HIRLAM member states. Experiments were done on a few selected sub-European domains. 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.

In figure 4 an example of HarmonEPS, calibrated HarmonEPS and IFS ENS is shown for CRPS for 10 meter wind speed, for the 2.5 month long Olympic experiment period for the region of Sochi.

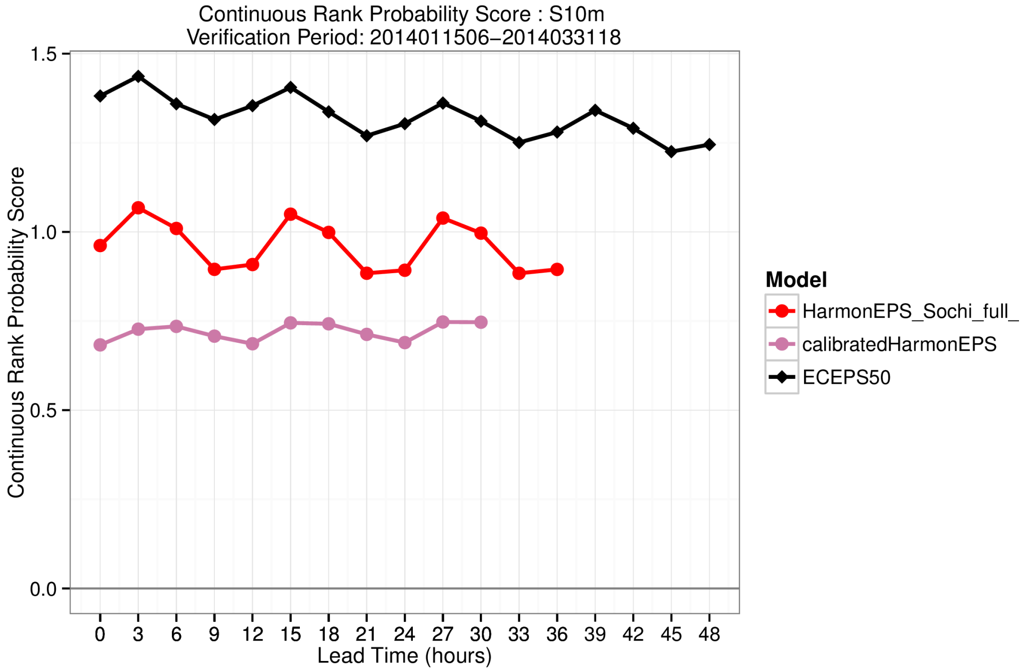

Figure 4: Continuous rank probability score (CRPS) for ten meter wind speed for 2.5 month Olympic experiment period. The score is negatively oriented, so the lower the better. IFS ENS (black), HarmonEPS (red) and calibrated HarmonEPS (pink).

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.
During this project several experiments have been completed or started.:
1. Multi-physics approach, using Arome and Alaro physics. This has been tested for several domains and periods, and also compared to SPPT and shows better scores than a single model EPS.
2. Experiment with perturbation of surface parameters (e.g. soil moisture, albedo, snow, SST, LAI, vegetation fraction, roughness length and soil temperature). Only initial sensitivity study so far.
3. SPPT. Initial experiments with simplified “box”-SPPT run so far.
4. Surface physics - study perturbations in momentum, heat and moisture flux parameterizations. Only initial sensitivity study so far.
5. Tuned the CA-scheme for 2.5 km.
6. Explored 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. This gives improved scores, and technical implementation soon to be finalized.
7. Work on lateral boundaries perturbations; random field perturbations and SLAF (scaled, lagged averaged forecasts). Results indicate that SLAF and random field perturbations do as well as using IFS ENS. But more work is needed to confirm this.

ECMWF has kindly produced and made available test sets of IFS ENS to be used as boundary conditions for LAM EPS, both at the present operational resolution of about 32 km, and at 16 km. HarmonEPS experiments have been performed in order to assess the impact of the increased horizontal resolution of the boundary files, and to assess if it is possible to nest directly in the present IFS ENS. The evaluation showed little gain from using higher resolution boundaries from IFS ENS. ECMWF has also provided IFS ENS model levels four times a day for May 2013, and we ran HarmonEPS on this data. 06 and 18 UTC IFS ENS runs use EDA perturbations which are based on 12-hour forecasts (instead of 6-hour forecasts), and we wanted to check if this has an impact on forecast quality of HarmonEPS. We could concluded that we did not see any differences in quality for HarmonEPS of using the 12-hour old EDA perturbations instead of 6-hour old.

List of publications/reports from the project with complete references

Iversen, T., Deckmyn A., Santos, C., Sattler, K., Bremnes, J. B., Feddersen, H and Frogner, I.-L.: Evaluation of 'GLAMEPS'—a proposed multimodel EPS for short range forecasting. Tellus 63A, 513-530. DOI: 10.1111/j.1600-0870.2010.00507.x

Future plans

(Please let us know of any imminent plans regarding a continuation of this research activity, in particular if they are linked to another/new Special Project.)

GLAMEPS.
The continuation of the project consists of further updates to GLAMEPS to version 3:

- change of resolution (to ~ 5km)
- Inflate the initial perturbations coming from IFS ENS
- implementing intended changes for ALARO (perturbations in horizontal diffusion).
- including CAPE Svs

HarmonEPS: many experiments described in the above text will continue in addidtion to new once. All in all extensive experimentation on predictability and LAM EPS systems are to be conducted in the common effort of the HIRLAM and Aladin consortia.

The continuation of this project is linked to the special project "Probabilistic forecasts for short range in Europe" (also called spnogeps).