SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2017
Project Title:	Probabilistic forecasts for short range in Europe
Computer Project Account:	spnogeps
Principal Investigator(s):	Inger-Lise Frogner
Affiliation:	Norwegian Meteorological Institute
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	2015
Expected end date:	30 June 2017

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	20MSBUs	17MSBUs	20MSBUs	20MSBUs
Data storage capacity	(Gbytes)	10000	10000	10000	10000

Summary of project objectives

(10 lines max)

The objectives are developing and maintaining probabilistic forecasts for short range in Europe, in the cooperation of two European consortia for short-range NWP: HIRLAM and ALADIN. It consists of two main activities: Activity 1: maintaining and developing The Grand Limited Area Modelling Ensemble Prediction System (GLAMEPS), which runs at ECMWF as Time-Critical facility Option 2 (TCF_2) and Activity 2: 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 any)

(20 lines max)

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

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

Activity 1: GLAMEPS

SBUs from this special project was used for test runs and parallel runs for the new version of GLAMEPS (version 3), which includes increased grid resolution, increased data output frequency (1-hourly), updated model version and inclusion of CAPE singular vectors and inflation of the perturbations at the boundaries, coming from IFS ENS. GLAMEPS is a pan-European multi-model ensemble prediction system run as a cooperation between HIRLAM institutes and Belgian Meteorological Institute. It has been operational since 2011. The daily running of GLAMEPS (version 2) uses SBUs from national resource. The SBUs used for GLAMEPS from this project was for testing the new version (v3) mentioned above. Due to many technical challenges the testing and parallel run for version 3 has been going on for a much longer period than expected. Results from version 3 as compared with version 2 are shown in figure 1. Figure 1 shows the spread-skill relationship for the two versions of GLAMEPS for mean sea level pressure (Pmsl), two meter temperature (T2m), 10 meter wind speed (S10m) and 12 hour accumulated precipitation (AccPcp12h). A well performing system should have spread equal to skill. From figure 1 we see that version 3 has generally better spread-skill relationship than version 2, and also lower RMSE (better skill). The spread for Pmsl for version 3 is too high. When looking at the individual sub-ensembles that GLAMEPS consists off, we see problems that does not show up when looking at the ensemble as a whole, as in figure 1. It has also been stability issues with version 3. On its meeting 22 June the HIRLAM Council decided to stop any further development of GLAMEPS due to lack of personnel resources. GLAMEPS version 2 will continue to run for 1-2 years.

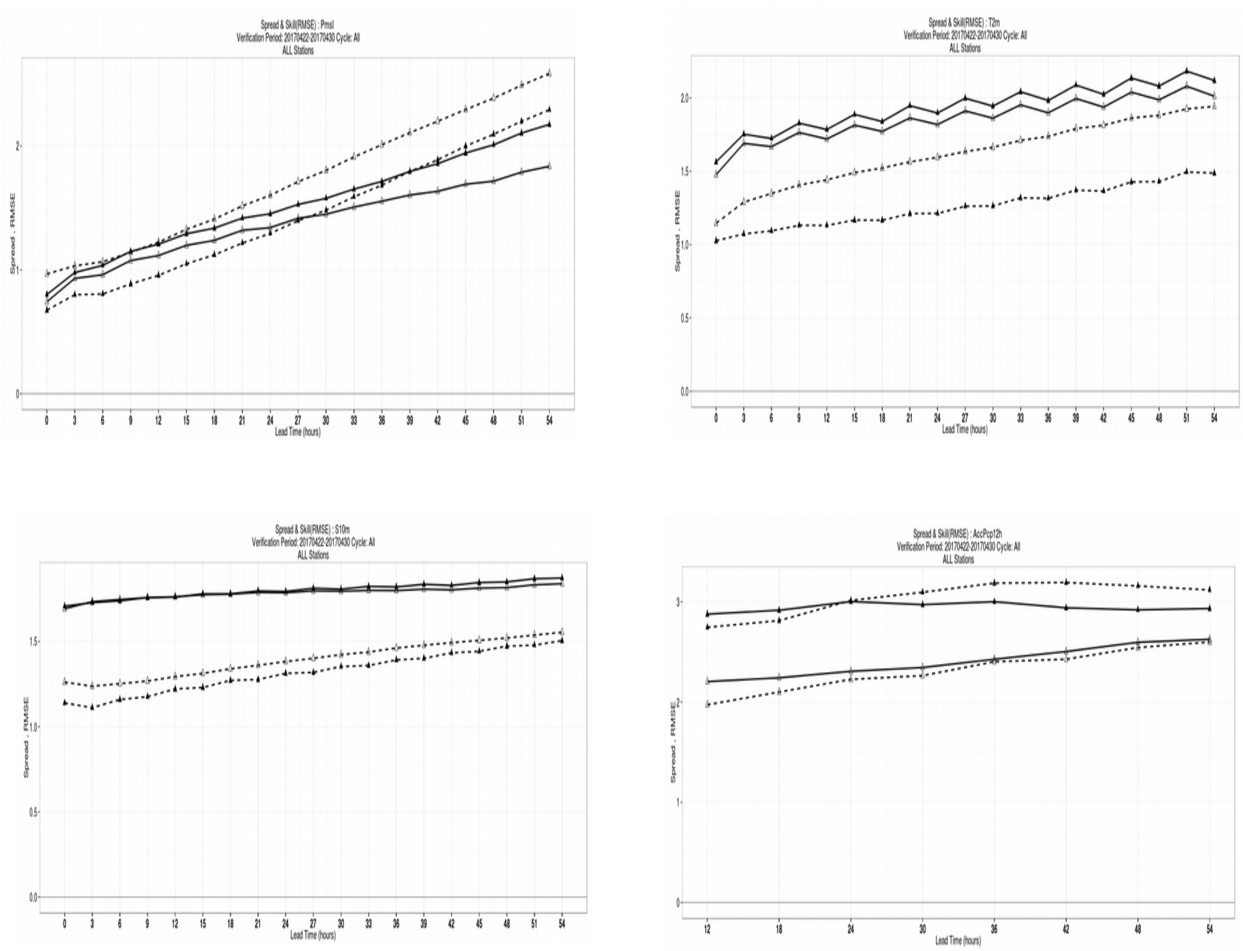

Figure 1: Spread (dashed) and skill (solid) for GLAMEPS version 2 (filled triangles) and GLAMEPS version 3 (open triangles) for April 2017. Upper left: Pmsl, upper rght: T2m, lower left: S10m and lower right: AccPcp12h.

Activity 2: HarmonEPS

HarmonEPS (Frogner et al. 2016) is an ensemble prediction system for the short range (~48h) based on the non-hydrostatic HARMONIE-AROME model configuration in the ALADIN-HIRLAM NWP system (Bengtsson et al. 2017). HarmonEPS is a flexible system and includes a range of possibilities to describe uncertainties in different parts of the system. Improvements in the description of the uncertainties in HarmonEPS are continuing with regard to initial conditions, lateral boundaries, surface and physics. The SBSs from this special project for this year of reporting has been used for initial testing of parameter perturbations. There are several reasons why model uncertainty arises, eg. computational constraints lead to simplifications in the description of the processes, and unresolved processes at the sub-grid scale needs to be parametrized. For representation of model error we are developing a parameter perturbation approach, where sensitive parameters in micro-physics, radiation and turbulence, and possible also surface, are perturbed. Part of this work is also done in the context for SRNWP EPS Phase II project, and one experiment was also run with SBUs from a special project dedicated to this (spitsreps), and that is reported in the special project report for spitsreps.

SBUs from this special project was used to run tests of perturbing a parameter that influences the level of relative humidity required for (low) clouds to form. Predicting low clouds is a challenge, and overall the spread in the ensemble for low clouds is too small. This parameter was chosen based on advice from physics experts, with the expectation that perturbing this parameter could enhance the spread in HarmonEPS and possibly also improve the mean state. However, one should not expect too much from perturbing just one parameter, so rather this was a test on how parameter perturbations can be expected to perform in HarmonEPS. In this first trial with perturbing this parameter, random perturbations was used for each members and for each cycle, but kept constant in time and space. A two and a half week period in May-June 2016 over the MetCoOp-domain (figure 2) was run with 10+1 members perturbing this parameter, and it is compared to a reference experiment without this perturbation, but otherwise identical.

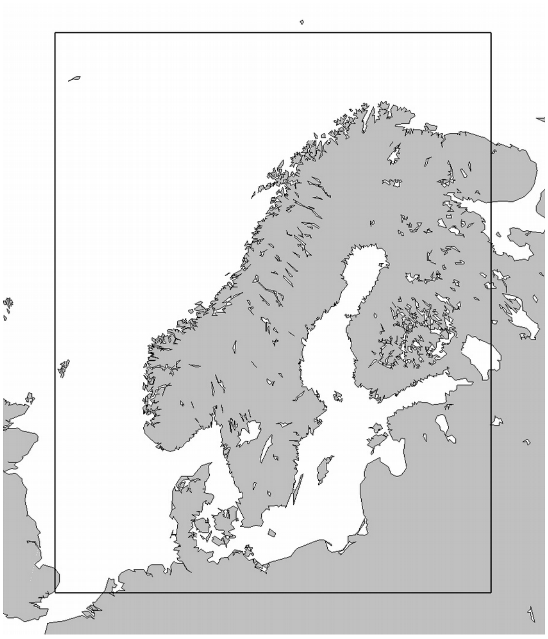

Figure 2: The integration domain, 750x960 points with 2.5 km horizontal grid spacing and 65 levels in the vertical.

In figure 3 the spread-skill is shown. For the basic weather parameters like two meter temperature (upper left), precipitation and 10 meter wind speed (not shown) there is no difference between the run with and without perturbing this parameter. However, the expected impact was on clouds, and we can see a small impact on the spread for total clouds (upper right), cloud base hight (lower left) and most impact on low clouds (lower right).

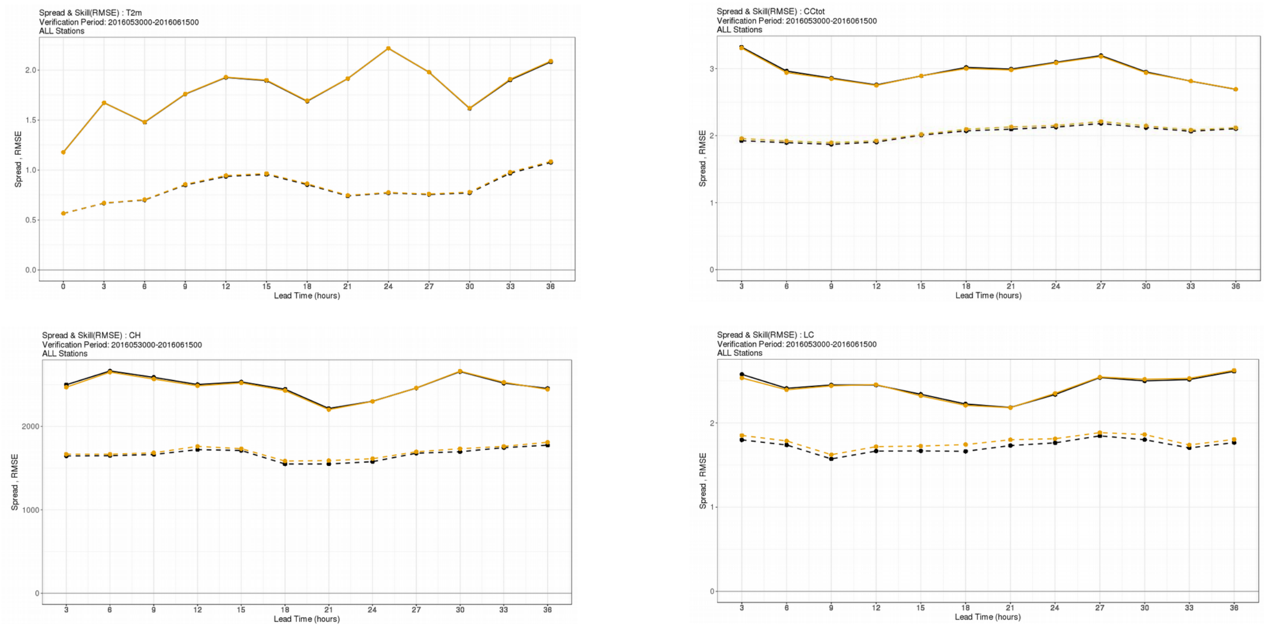

Figure 3: Spread (dashed) and skill (solid) for HarmonEPS with perturbation of humidity parameter (yellow) and reference run without (black) for T2m (upper left), Total cloud cover (upper right), cloud base hight (lower left) and low clouds (lower right).

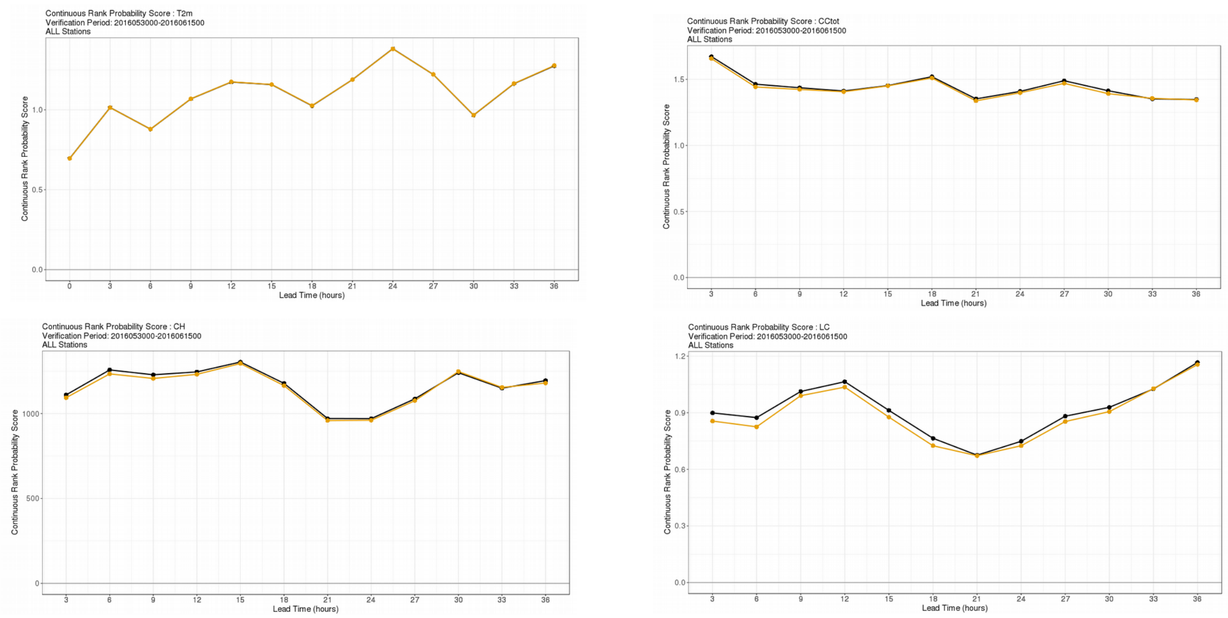

Figure 4: CRPS for HarmonEPS with perturbation of humidity parameter (yellow) and reference run without (black) for T2m (upper left), Total cloud cover (upper right), cloud base hight (lower left) and low clouds (lower right).

In figure 4 the Continuous Rank Probability Score (CRPS) is shown for the same parameters (note that CRPS is a negatively oriented score). Also here we see a small improvement for low clouds. CRPS is an integrated score over all thresholds. To look more into detail how the perturbations influence the scores when looking at different thresholds, the area under the ROC-curve as a function of threshold is shown in figure 5. From figure 5 we see that the main improvement for low clouds is visible for all thresholds, for this forecast time. This hold for forecast lengths up to about 30 hours (not shown). For cloud base hight (right panel in figure 5) we see that the improvements are largest for the lower thresholds, meaning for lower cloud base heights. As low cloud base hight can have high impact on e.g. air traffic, it is encouraging to see this improvement.

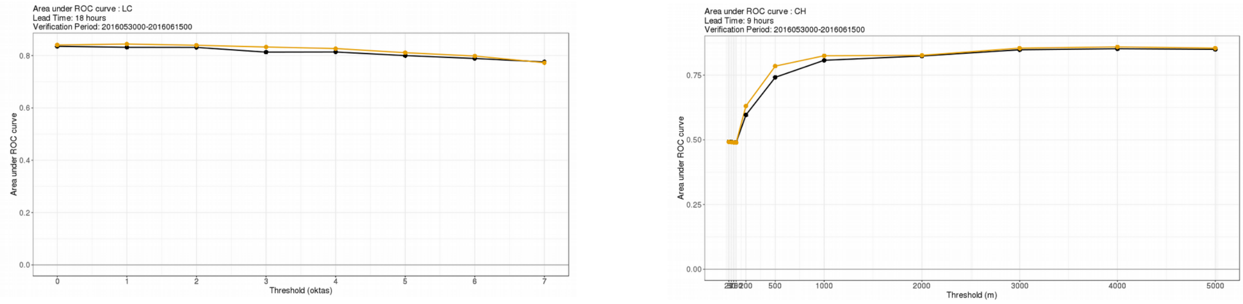

Figure 5: Area under ROC curve for low clouds for a forecast length of +18h as a function of threshold (left) and cloud base height for forecast length of +9h as a function of threshold (right) for HarmonEPS with perturbation of humidity parameter (yellow) and reference run without (black).

These first results from perturbing a parameter that influences the clouds is promising. We used random perturbations, but kept constant in time and space during the integration. As model error are related to weather patterns, it should be correlated in space and time. In an ongoing experiment we are perturbing the same parameter that is used here, but now with a spatio-temporal structure computed using the Cellular Automata (CA) scheme (Bengtsson et. Al 2011). Results from this is not ready yet, and it is run on another account than reported here. However, the first technical trial with the perturbed parameter with the structure of CA was done with spnogeps. An example of the pattern is in figure 6.

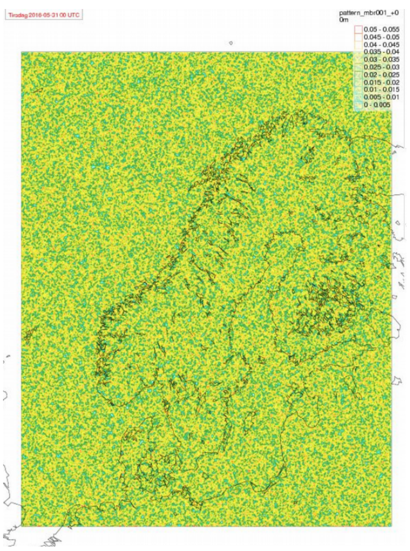

Figure 6: Example of how the perturbation of the humidity parameter looks like when applying the CA-pattern.

References:

Bengtsson, L., U. Andrae, T. Aspelien, Y. Batrak, J. Calvo, W. de Rooy, E. Gleeson, B. Hansen-Sass, M. Homleid, M. Hortal, K. Ivarsson, G. Lenderink, S. Niemelä, K.P. Nielsen, J. Onvlee, L. Rontu, P. Samuelsson, D.S. Muñoz, A. Subias, S. Tijm, V. Toll, X. Yang, and M.Ø. Køltzow, 2017: The HARMONIE–AROME Model Configuration in the ALADIN–HIRLAM NWP System. *Mon. Wea. Rev.*, **145**, 1919–1935, https://doi.org/10.1175/MWR-D-16-0417.1

Bengtsson, L., H. Körnich, E. Källén, and G. Svensson, 2011: Large-Scale Dynamical Response to Subgrid-Scale Organization Provided by Cellular Automata. *J. Atmos. Sci.*, **68**, 3132–3144, https://doi.org/10.1175/JAS-D-10-05028.1

Frogner, I., T. Nipen, A. Singleton, J.B. Bremnes, and O. Vignes, 2016: Ensemble Prediction with Different Spatial Resolutions for the 2014 Sochi Winter Olympic Games: The Effects of Calibration and Multimodel Approaches. *Wea. Forecasting*, **31**, 1833–1851, https://doi.org/10.1175/WAF-D-16-0048.1

List of publications/reports from the project with complete references

None. HarmonEPS publication, which includes results obtained by using SBUs from this project, is under preparation.

Summary of plans for the continuation of the project

(10 lines max)

The project ends in 2017, and the resources for 2017 are all spent, so there will be no more activity in this project.