SPECIAL PROJECT PROGRESS REPORT

Reporting year	2017
Project Title:	Initial and lateral boundary perturbations for Convective Permitting Ensemble Prediction Systems
Computer Project Account:	spnokolt
Principal Investigator(s):	Ulf Andrae
Affiliation:	SMHI 60176 Norrköping Sweden
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Not applicable
Start date of the project:	2016-01-01
Expected end date:	2017-12-31

Computer resources allocated/used for the current year and the previous one

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	20M	19M	20M	20M
Data storage capacity	(Gbytes)	2500GB	2500GB	2500GB	2500GB

Summary of project objectives

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. A first goal is to establish the quality of the new HARMONIE version harmonie-40h1 with respect to the current operational one, harmonie-38h1.2.

Summary of problems encountered

One of the tasks for this year was to investigate the usage of hourly IFS ENS data with hourly resolution as initial and boundary data for HARMONIE. The retrieval of the 50 members from MARS in near real time turned out to be a non trivial task and required a major rewriting of the MARS request strategy in HARMONIE. It also triggered some concerned emails from the MARS user support about our aggressive usage of the MARS server. With support from ECMWF we managed to speed up and control the requests but it's still unclear if we have the optimal/fastest strategy for requesting data from MARS.

Summary of results of the current year

Introduction

The ensemble system used in MetCoOp is an offspring of harmonEPS developed within the HIRLAM programme. For simplicity we will hereafter refer to the system as MEPS as in MetCoOp EPS. MEPS has been operational at SMHI and MET Norway since mid November 2016. For the details of MEPS see Andrae et.al. (2016). The main activities during the past 12 months includes the correction of the SST interpolation for IFS ENS data and a continued comparison of MEPS results using SLAF or IFS ENS data. Both activities are discussed below.

Interpolation of SST

In Andrae (2016) we concluded that an erroneous usage of SST as a land sea mask (LSM) caused a cold bias along the coasts of Scandinavia large enough to degrade the general scores for usage of the first ten members of IFS ENS compared to IFS HRES using the SLAF method (hereafter referred to as SLAF) to make the comparison inconclusive. In figure 1 we see the T2M bias with a clear cold bias along the coast. The reason we use SST as a LSM in the first place is because SST and LSM is not consistent from MARS for data retrieved on e.g. a lat/lon grid. For e.g. IFS HRES the SST analysis can be used since this is undefined of land, which is not the case for SST forecast data as in the case of IFS ENS data. For IFS ENS data we implemented a fall back option to use LSM with some safeguards with a satisfactory result as can be seen in the verification in figure 2. On average the difference in T2M scores are now very small and the remaining differences are expected to come from the resolution differences in the original data.

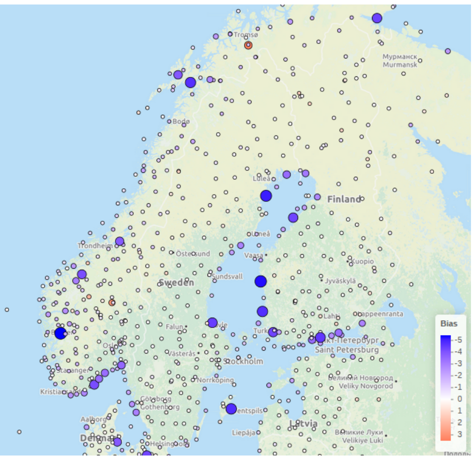

Figure 1: T2M bias characteristics for MEPS using IFS-ENS before correction.

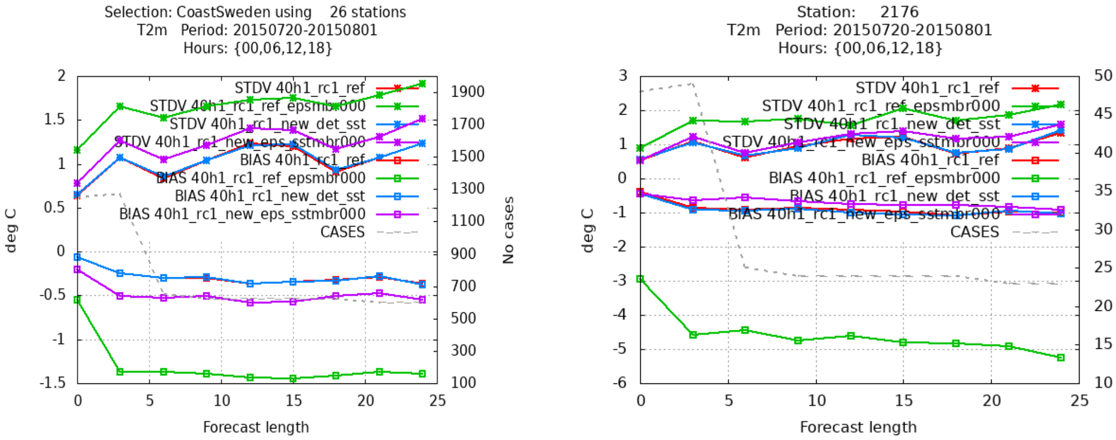

Figure 2: T2M bias (squares) and stdv (stars) for the coast of Sweden (left) and for a single station (right). The different curves shows: old interpolation of IFS HRES(red), old interpolation IFS ENS (green), new interpolation IFS HRES (blue), new interpolation IFS ENS (purple).

Comparison of usage of IFS ENS or IFS HRES data

With a corrected SST interpolation a new comparison was done for the same period using IFS ENS data or SLAF. For most parameters the spread/skill relationship is still in favour for SLAF, see figure 3 where MSLP and T2M are shown. We also see that adding an inflation factor of 1.4 to the IFS ENS perturbations improves the spread for IFS ENS data. In spite of the good performance of SLAF there are some inherent properties that makes it interesting further investage the usage if IFS ENS data. Due to the lagging procedure in SLAF the number of members that can be constructed is limited and we the current formulation we are bound to 10 members. Further a tuning of the perturbation for each member is required to make sure that the size of the perturbations are of similar size.

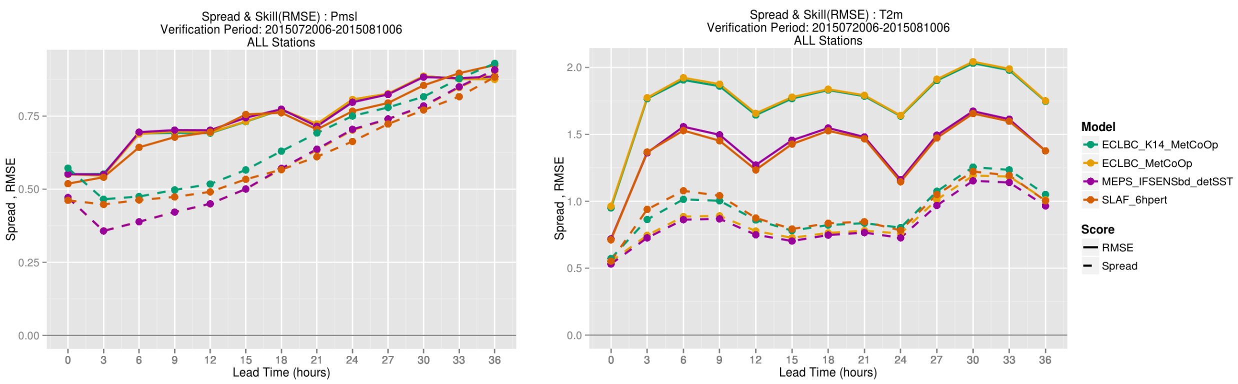

Figure 3: Spread(dashed) and skill (solid) for July 2015 comparing IFS ENS with and without corrected SST and inflation against SLAF. See table 1 for description of the experiments.

The new IFS cycle 43R1, with higher resolution and hourly boundary data available four times a day, provides new opportunities to compare the methods. To test this a period in March 2017 were tested and given the earlier experience the IFS ENS perturbation were inflated with a factor of 1.4. A comparison of the deterministic scores for the control members in the two experiments shows that they are of comparable skill (not shown) so that the differences we see does not origin from any differences in the deterministic sense.

The spread/skill difference for MSLP can be used as an overall diagnostic of the performance of the system. In figure 4 we see that with the inflation the spread is much larger than the skill for IFS ENS which is clearly undesirable. For parameters such as T2M and U10m we see however that using IFS ENS data with inflation performs slightly better.

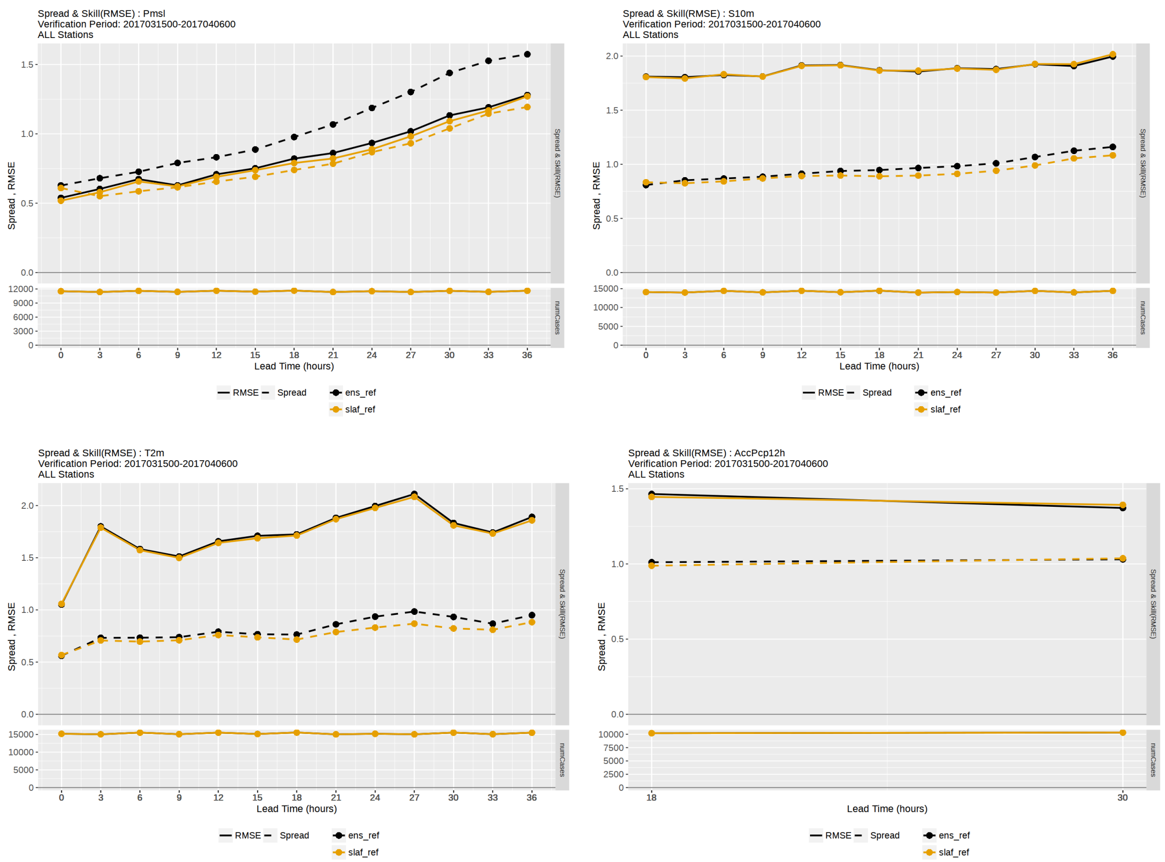

Figure 4: Spread(dashed) and skill (solid) for MSLP (top left), 10m wind speed (top right), T2M (bottom left) and 12h accumulated precipitation (bottom right). See table 1 for description of the experiments.

If we switch off the inflation we find that we still have a larger spread at the last half of the forecast range investigated, figure 5. We also see that for the wind and temperature the spread is somewhat lower. An investigation of the MSLP spread/skill relation for IFS ENS shows that it varies with time (not shown) so the respons in MEPS may vary accordingly and it's difficult to draw any conclusions about the long term impact of inflation without running experiments over longer periods.
In MEPS we have recently implemented the surface perturbation method developed by Bouttier et.al. (2016). Perturbing various surface parameters such as soil temperature, soil moisture and SST has a clear positive impact on especially the near surface temperature and relative humidity and to a smaller extent on wind and precipitation, Singleton (2017). For further experimentation we therefore suggest to address the spread in the surface parameters by using the surface perturbations. For the overall spread/skill, as diagnosed by MSLP, we intend to rely on the IFS ENS spread without inflating the differences.

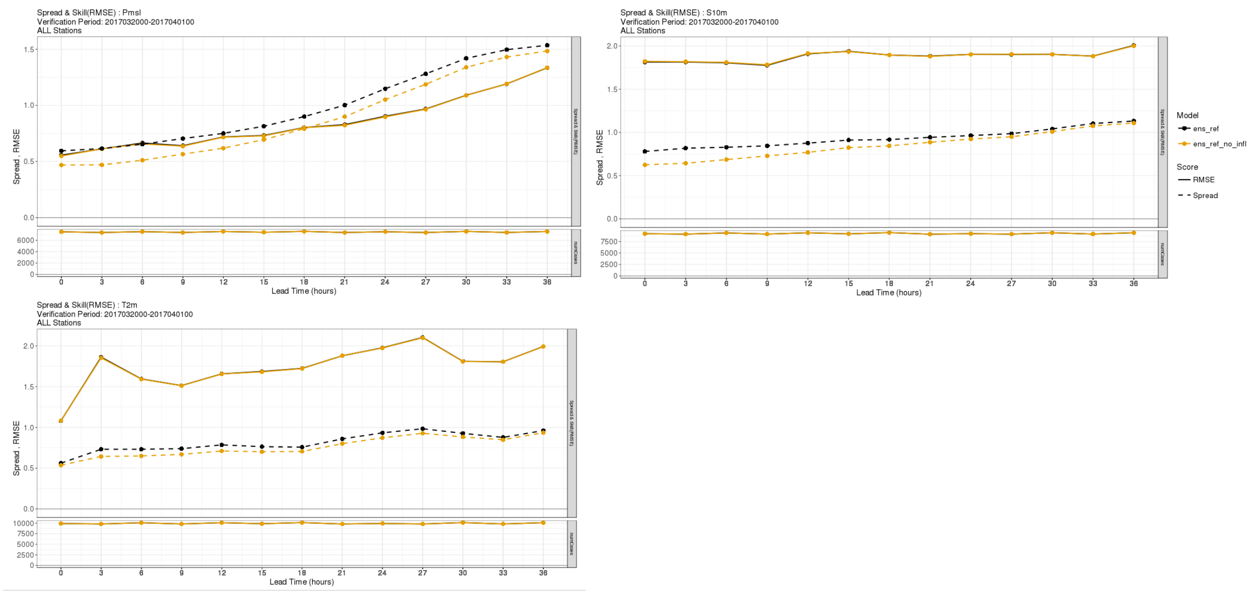

Figure 5: Spread(dashed) and skill (solid) for MSLP (top left), 10m wind speed (top right) and T2M (bottom right). See table 1 for description of the experiments.

Table 1: Experiment properties

Experiment	**Period**	**Properties**
ECLBC_MetCoOp	201507	MEPS using first ten IFS ENS members
ECLBC_K14_MetCoOp	201507	MEPS using first ten IFS ENS members, initial perturbations inflated with a factor of 1.4.
MEPS_IFSENSbd_detSST	201507	MEPS using first ten IFS ENS members, corrected SST
SLAF_6hpert	201507	MEPS using IFS HRES boundaries
ens_ref	201703	MEPS using first ten IFS ENS 43R1 members, hourly boundaries, initial perturbations inflated with a factor of 1.4.
ens_ref_no_infl	201703	MEPS using first ten IFS ENS 43R1 members, hourly boundaries
slaf_ref	201703	MEPS using IFS HRES boundaries

Summary of plans for the continuation of the project

For further experimentation we will run a period for the summer of 2017 with surface perturbations included and use the first ten IFS ENS members without any further inflation and compare it with SLAF. We will also investigate if the usage of clustering methods can allow a better control of the spread in the ensemble.

References

Andrae, U., 2017: Initial and lateral boundary perturbations for Convective Permitting Ensemble Prediction Systems, ECMWF special project progress report, https://www.ecmwf.int/sites/default/files/special_projects/2016/spnokolt-2016-report1.pdf

Andrae, U. and the MetCoOp Team, 2017: The MetCoOp ensemble MEPS. *HIRLAM Newsletter*, 8, 98-103.

Bouttier, F., Raynaud, L., Nuissier, O. and Ménétrier, B. (2016), Sensitivity of the AROME ensemble to initial and surface perturbations during HyMeX. Q.J.R. Meteorol. Soc., 142: 390–403. doi:10.1002/qj.2622

Singleton et.al, 2017: Surface perturbation in HarmonEPS, Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting 2017, 3-7/04/2017, Helsinki, Finland, http://www.umr-cnrm.fr/aladin/IMG/pdf/surfaceperturbationsinharmoneps.pdf