Status of LETKF with HARMONIE

ALADIN and HIRLAM All-Staff Meeting 2015

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* Special thanks to Mats Hamrud (ECMWF)

Copenhagen, 15th April 2014

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- LETKF versus 3DVAR with HARMONIE
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Introduction

- AEMET is developing a new convection-permitting SREPS to be run at 2.5 km of horizontal resolution
- LETKF algorithm was selected to construct initial states for the ensemble, the reasons for this are explained below
- As HARMONIE model could not hold this technique, in the last 2 years work has been done to migrate LETKF code from IFS
- In this presentation the first results of the performance of LETKF analysis and forecasts compared to 3DVAR, are presented. Only the deterministic mode of LETKF is evaluated.

Reasons for choosing LETKF

- LETKF is computationally very efficient. Plans of AEMET are running a LAMEPS at 2.5 km resolution, 65 levels and 20 members 4 times per day (= a lot of resources!)

Comparison with IFS suite 37R2

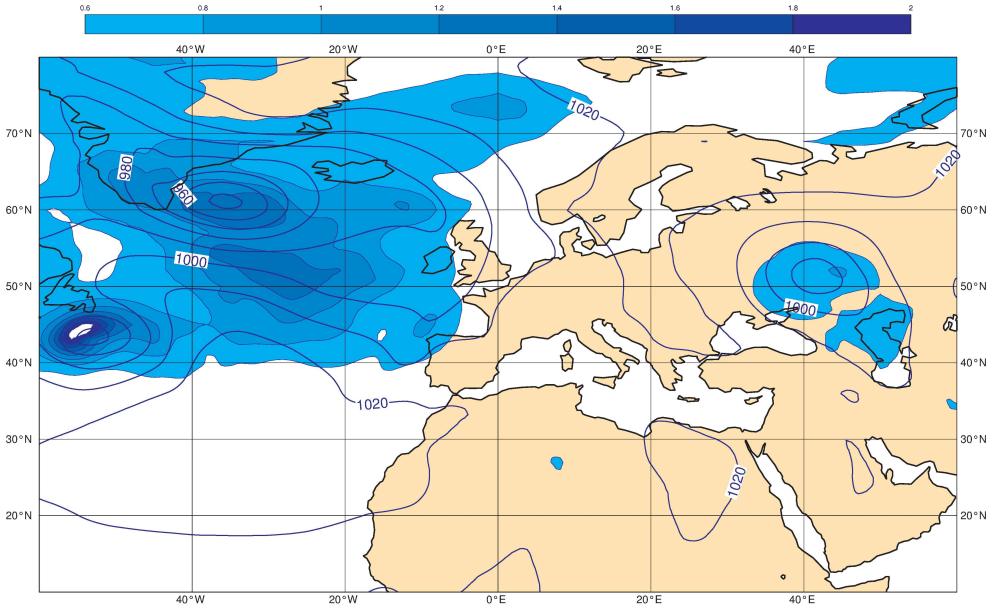
	SBUs for family "analysis"	SBUs for core "analysis task"
4DVAR + 2 minimizations	2504	1904
LETKF + 30 members	2708	288
4DVAR + 3 minimizations	4017	3263
LETKF + 60 members	4970	463
10 member EDA + 2 minimizations	25686	20563
10 member EDA + 3 minimizations	~ 40000	~ 32000

- Several NWP centres have chosen this algorithm (DWD, CMC, JMA, …)

Reasons for choosing LETKF

- ECMWF gave us the possibility of migrating LETKF IFS code to HARMONIE. **This job has been recently finished with HARMONIE version 38h1.1**
- LETKF has flow-dependency in B estimation

The ensemble spread is the variance of B matrix (its diagonal). Here an example of MSLP ensemble mean and spread with IFS



Reasons for no choosing LETKF

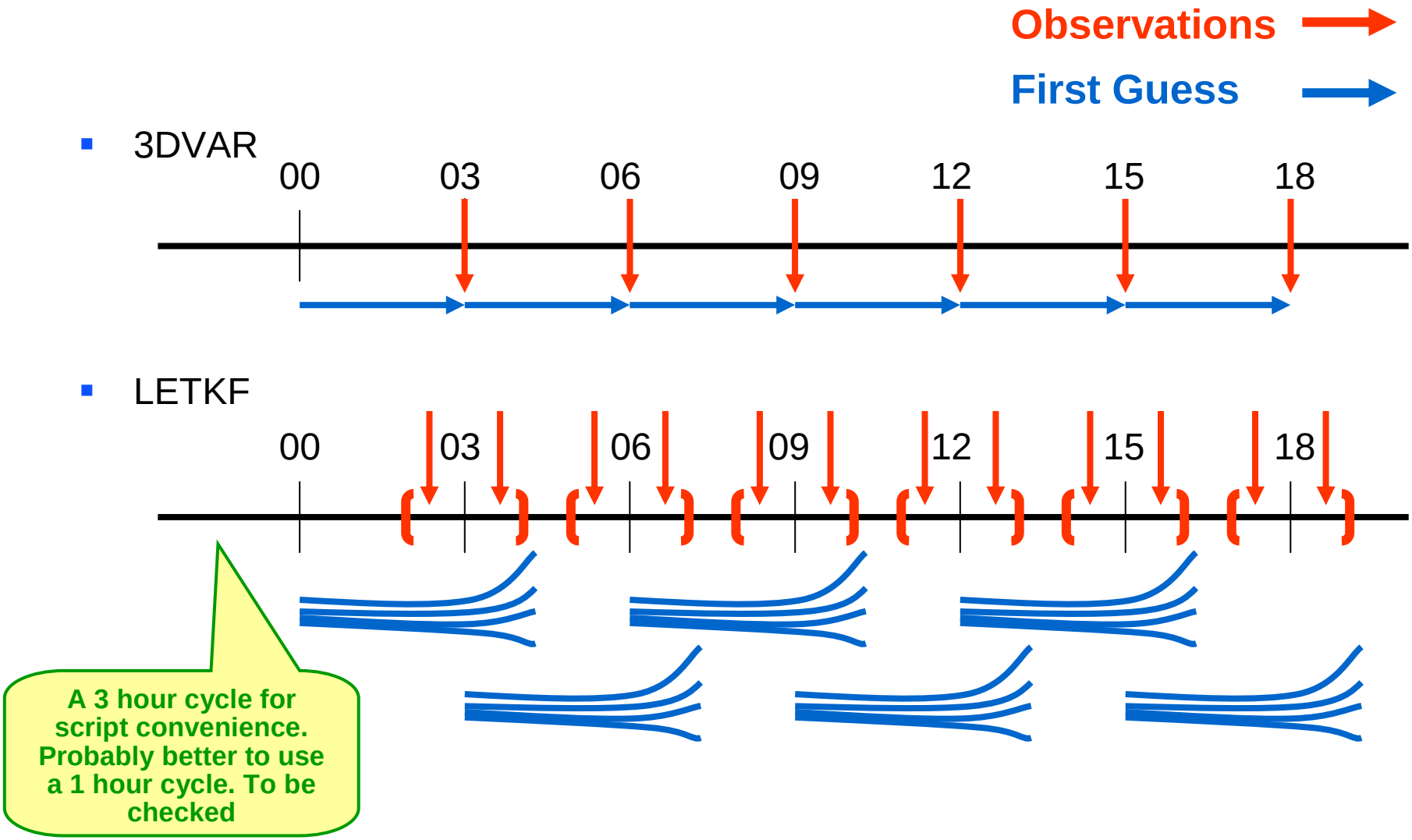
- It uses a low rank B matrix
- Localisation inhibits using distant observations in the assimilation
- Using the non-linear model in the assimilation window seems to result in an analysis that explores too much unstable regions
- It seems to be a limit with the ensemble size and performance? N=120 better than N=60 but similar than N=240…

LETKF versus 3DVAR with HARMONIE

- This exercise is **a first sanity check of LETKF.** Clean comparison to 3DVAR

	3DVAR	**LETKF**
Resolution	2.5 km / 65 levels	2.5 km / 65 levels
Domain	576 x 480	576 x 480
Analysis cycle	3 hours	3 hours
Assimilation window	No	2 hours
First Guess for. length	3 hours	4 hours
Assimilated obs	Conventional	Conventional
Perturbation sfc obs	No	Yes
Perturbation upper obs	No	No
Ensemble members	0	20
Structure functions	Yes	No
Forecast length	36 hours	36 hours
Boundary conditions	IFS-EPS (mbr=0)	IFS-EPS (mbr=0-20)

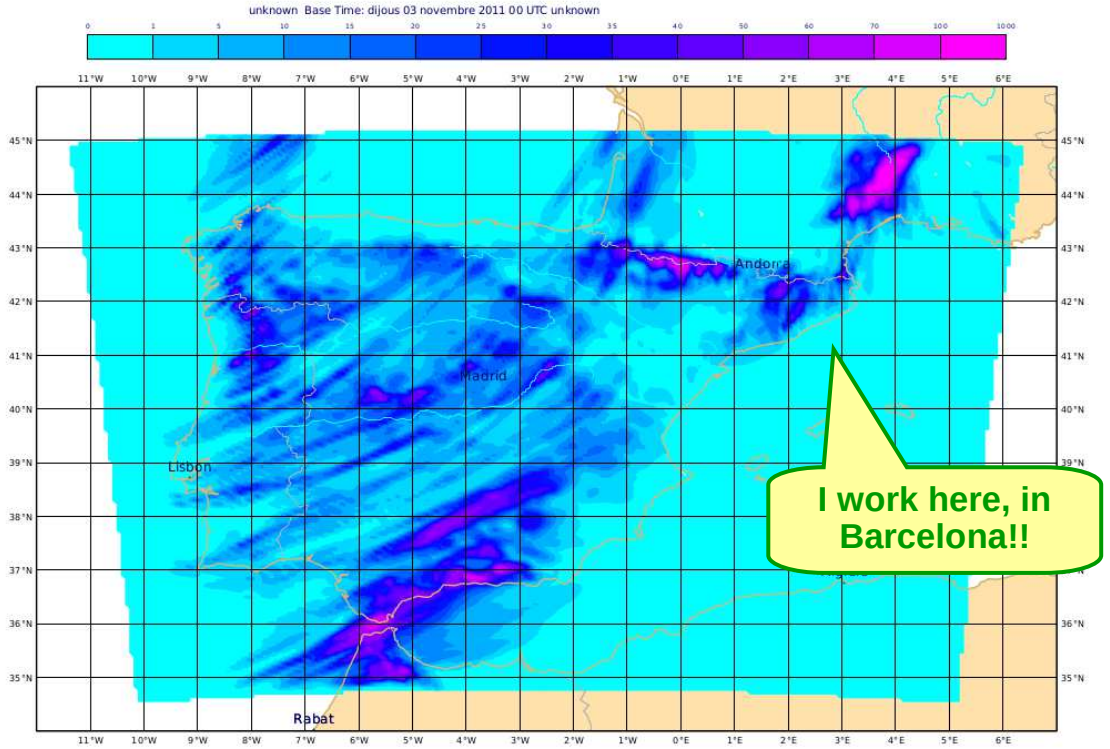
LETKF versus 3DVAR with HARMONIE



LETKF versus 3DVAR with HARMONIE

- Period of study: 2011102300 – 2011110721 = 16 days. NoSWEx autumn test period over IBERIAN peninsula. Convective synoptically driven

Model domain. Accumulated precipitation field showing the strong synoptically driven convection

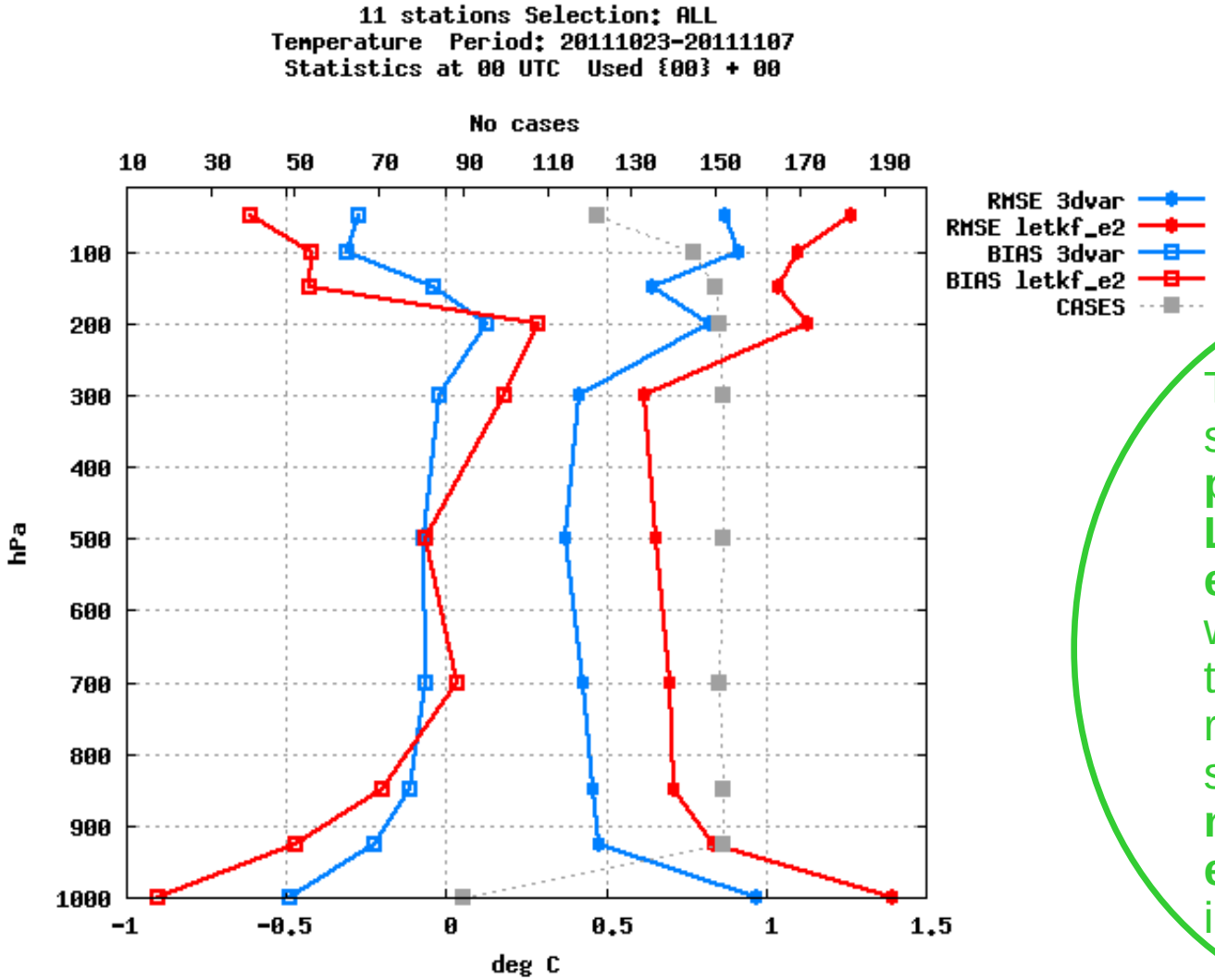


LETKF versus 3DVAR with HARMONIE

- Specific LETKF parameters selected for the first test

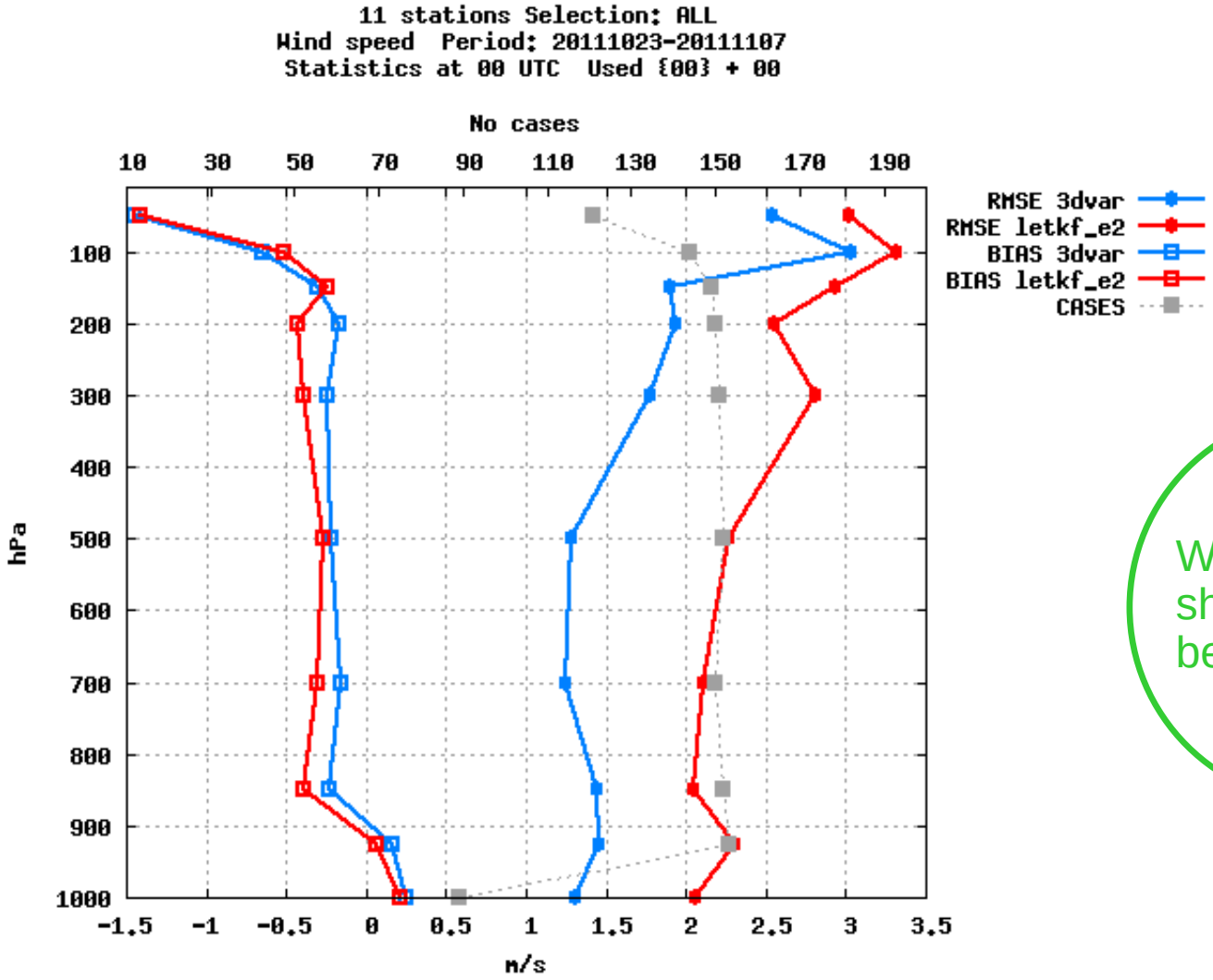
RTPS multiplicative inflation factor	0.95
Additive inflation	No
Vertical localization	ln(p1/p2) = 0.5
Horizontal localization	600 km
Assimilation window length	2 hours
Assimilation cycle	3 hours
Ensemble members	20
Background ensemble forecast length	H+04

LETKF versus 3DVAR with HARMONIE



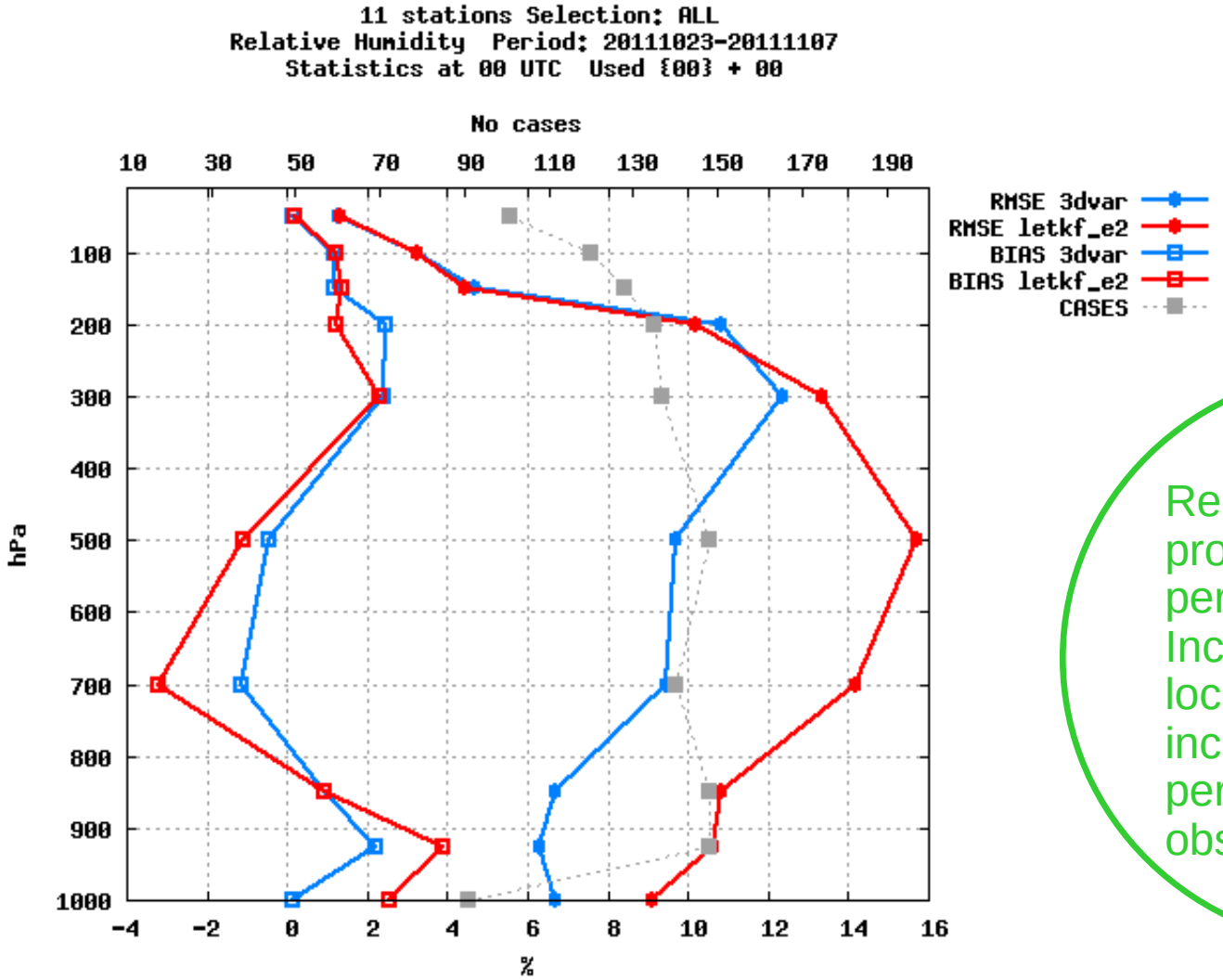
Temperature profile shows **bad performance for LETKF** and **fast error convergence** with lead time. On the other hand, reasonable profile shape means that **no major technical errors are present** in LETKF

LETKF versus 3DVAR with HARMONIE



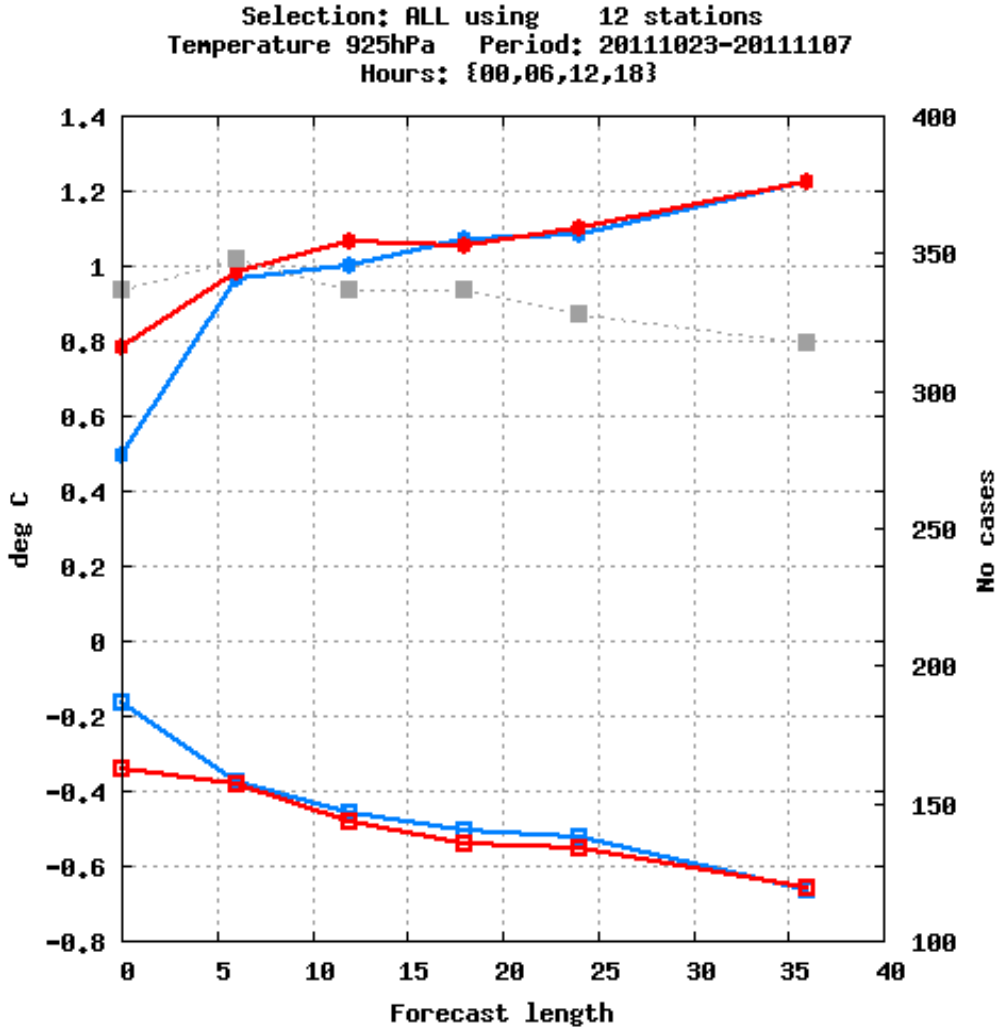
Wind Speed shows a similar behaviour

LETKF versus 3DVAR with HARMONIE



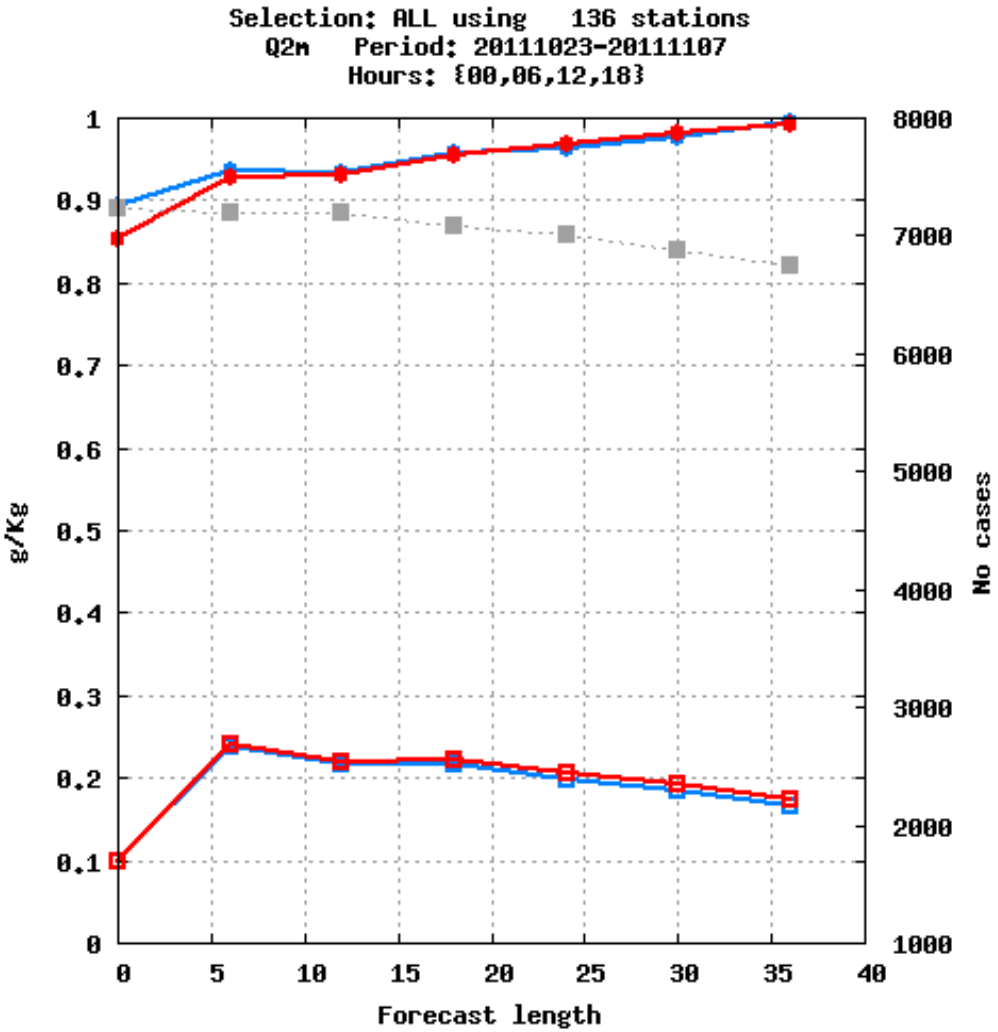
Relative Humidity profile shows similar performance. Increment of localization radii would increase LETKF performance? More obs assimilated…

LETKF versus 3DVAR with HARMONIE



At H+06 analysis update signal is lost. This suggest **presence of unbalances** that transform to gravity waves. Either for 3DVAR and LETKF. This is also seen for 850, 700 and 500 hPa. To check. On the other hand, **are 3DVAR and LETKF giving too/few weight to obs**?

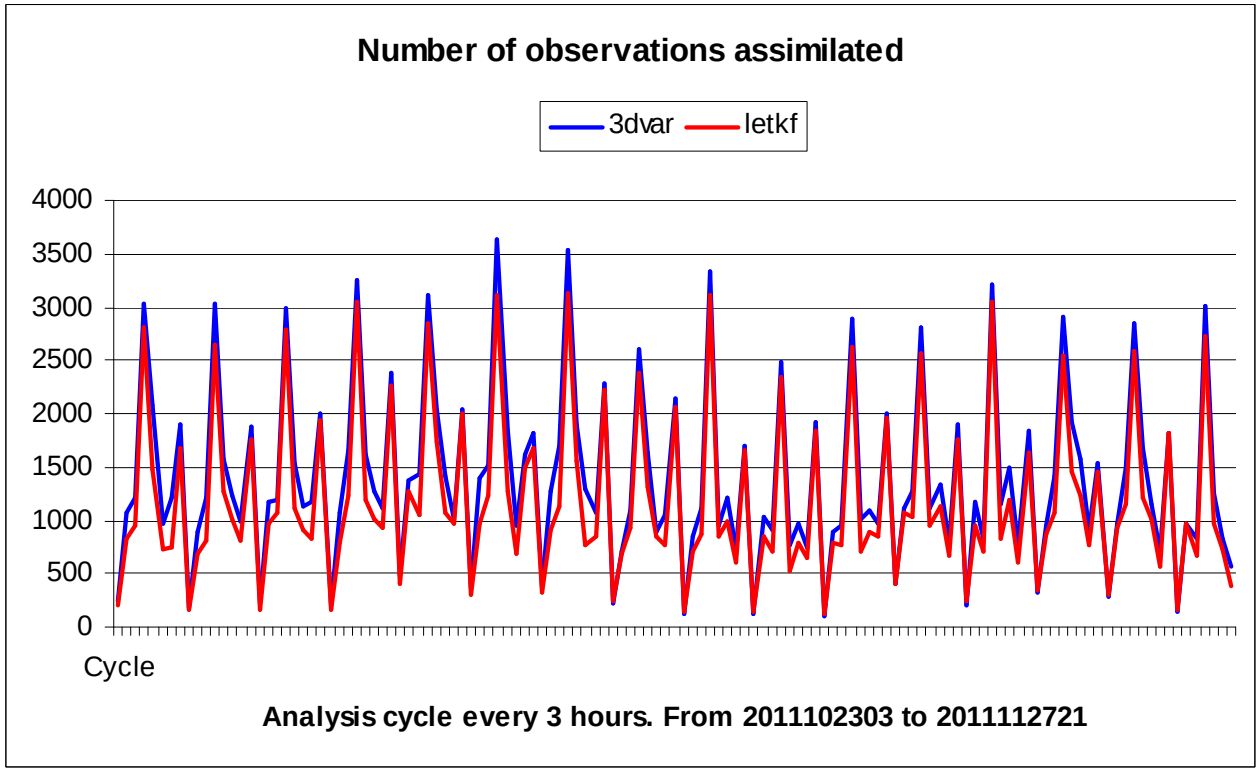
LETKF versus 3DVAR with HARMONIE



Those **fields more column dependant** (MSLP, Precipitation and CC) show **bad performance for LETKF**. **For s10m, and q2m LETKF is better**, which suggests a **good impact of the CANARI ensemble of analyses with perturbed observations**.

LETKF versus 3DVAR with HARMONIE

- What can be wrong with LETKF? Let's take a look to the number of observations that outcomes from Screening in both 3DVAR and LETKF



3DVAR assimilates (roughly) 10% more observations than LETKF. This explains the different performances to some extent. **Why does it happen**?

LETKF versus 3DVAR with HARMONIE

- What can be wrong with LETKF? **Some of the tasks previous to the analysis are not doing the correct job** (wrong namelists, temporal distribution of obs, …)
- The fact that in the very first assimilation cycle, 2011102303 (when background comes purely from mbr000 of ECMWF-EPS either for 3DVAR and LETKF), 3DVAR assimilates more observations than LETKF (238 against 202) suggests that **there is something wrong in one or more tasks that deal with observations before LETKF analysis (Screening, Bator, ...)**

Revision of proper working of treatment of observations before LETKF analysis

LETKF versus 3DVAR with HARMONIE

- What can be wrong with LETKF? One of the filtering step in Screening is the **Background Quality Control**:

$$\frac{(o_i - b_i)^2}{\sigma_{b,i}^2} = \left(1 + \frac{\sigma_{o,i}^2}{\sigma_{b,i}^2}\right) \times K$$

Update of errgrib file in the case of LETKF!!!

- Background error above comes from file **errgrib** which for the LETKF experiments is linked to ${HM_LIB}/const/bias_corr/errgrib0scr. This is not correct, since this errgrib0scr file is a static very coarse resolution error estimation. **For LETKF this file must be updated each cycle taking into account the flow dependent background ensemble**

LETKF versus 3DVAR with HARMONIE

- What can be wrong with LETKF? Do we use a **proper ensemble spread** for the estimation of background error at the analysis time? **Are we too close (far) to (from) observations**?
- 3DVAR and LETKF estimates background errors differently. The former from a 450 members H+06 forecast climatological sample and the latter from a 20 member inflated ensemble. Giving bad errors results in either too much/few weight to observations and the consequent analysis degradation. According to the large differences of both algorithms seen in the verification, **a proper diagnosis of background and observation errors either in the grid or the observation space is crucial**. Spread/skill diagrams, evaluation of relationships between errors and background departures, etc…

Need of better estimation of **background error** in LETKF??

LETKF versus 3DVAR with HARMONIE

- What can be wrong with LETKF? Should we increase the localization radii to allow more observations to be assimilated?
- Better performance of 3DVAR in the vertical suggests that using more observations in the analysis (3DVAR is not local), this is, **increasing the localization radii either in the horizontal and the vertical, could have a positive impact for LETKF**.

Need of increasing localization radii in LETKF??

Summary

- LETKF code migration to HARMONIE version 38h1.1 has been recently finished
- A first sanity check of LETKF has been done comparing it with 3DVAR. While LETKF needs some corrections and a proper tuning, the migration doesn't show major technical errors
- The experiments have been done in a 2.5 km of horizontal resolution over Iberian Peninsula during the NoSWEx period (Autumn 2011)
- It seems that at 6 hours of lead time the analysis signal is lost either in 3DVAR and LETKF. This is probably due to analysis unbalances. This should be somehow addressed
- Verification of q2m and s10m suggest a positive impact of the CANARI ensemble of analyses with perturbed observations in LETKF
- LETKF shows a clear worse performance than 3DVAR

Summary

- LETKF is assimilating roughly 10% less observations than 3DVAR in this configuration. This could explain its worse performance to some extent
- File errgrib needs to be updated each cycle taking into account the flow-dependency
- The number of obs assimilated in the very first cycle, suggests that one or more tasks previous to the LETKF analysis are not doing the correct job. This must be revised
- The quality of the background error estimation in LETKF must be diagnosed looking at the spread/skill and background departures either in the grid and observation spaces. This diagnose will allow us to tune properly LETKF in terms of inflation or ensemble members
- Increasing the localization radii for could have a positive impact in the performance of LETKF, because more obs would be assimilated (looking at 3DVAR results). To test
- Introduction of 1 hour LETKF analysis cycle must be done in a future step

Acknowledgments

- First of all to Mats Hamrud. He has written the LETKF code for IFS and my work has been possible with his remote help.
- Then to Massimo Bonavita and Lars Isaksen for the more scientific discussions during my stage at ECMWF and afterwards
- To Alfons Callado (my office colleague) for his help in a lot of scientific and computing aspects that surrounds our work on NWP
- To José Antonio García-Moya and Carlos Santos because this is a work in group
- To Ulf, Jelena, Magnus, Eoin … and a lot of people from HARMONIE for his help

Any question?

Thanks for your attention

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