Sensitivity of the ALADIN-HARMONIE/Norway analysis and forecast systems to different observations

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Introduction

Understanding the relative impact of the observations is of primary importance for data assimilation community, in order to assess their optimal use in operational systems. In this poster we present the use of observations in the ALADIN-HARMONIE/Norway data assimilation and forecasting system, their impact by the use of randomization techniques and the impact of experimental observation types, not yet in the reference system; results from the use of background error covariances from downscaled ensemble analysis are also quickly reviewed . A number of observations, conventional and not, have been assimilated over a large period. Their use is shown in the following table.

Type	Parameter (Channel)	Bias correction	Thinning
TEMP	U, V, T, Q, Z	Only T using ECMWF tables	No
SYNOP	Z	No	Temporal and spatial
PILOT (Europrof.)	U, V, Z	No	Redundancy check against TEMP
DRIBU	Z	No	Temporal and spatial
AIREP	U, V, T	No	25 Km horizontal
AMV	U, V	No – Use of quality flags	25 Km horizontal
AMSU-A	5 to 13	Air-mass and scan bias correction	80 Km horizontal
AMSU-B, MHS	3, 4, 5	Air-mass and scan bias correction	80 Km horizontal

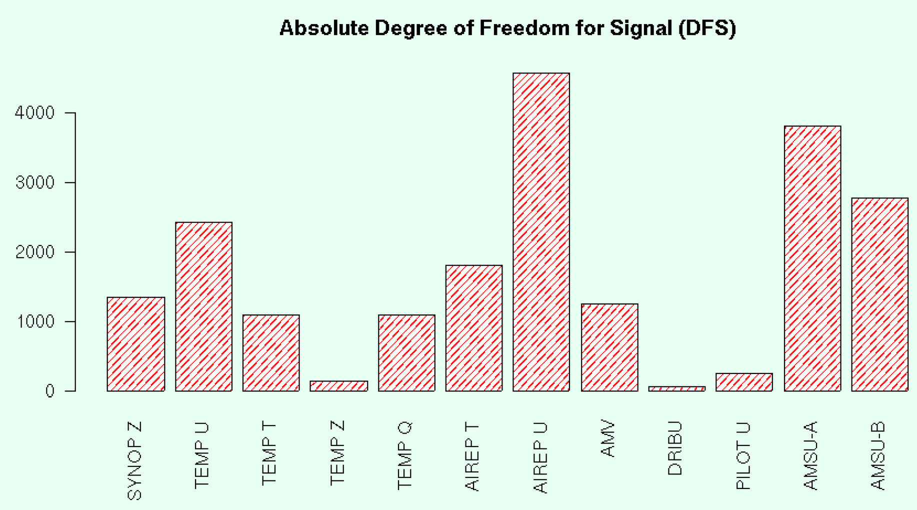
TABLE 1 – Use of Observations in ALADIN-HARMONIE/Norway

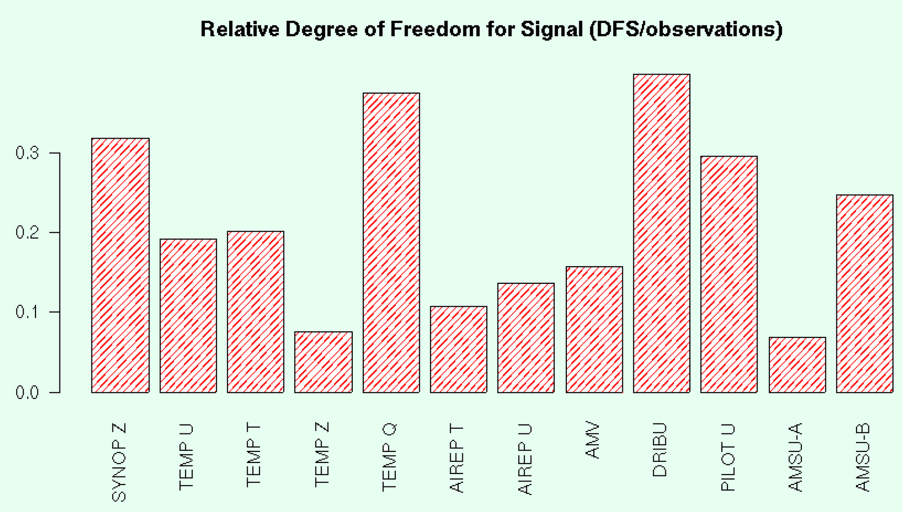
The system takes also advantage of surface analysis by the use of RH and T measurements at 2 meters and wind measurements at 10 m from synoptic stations. However, discussion on the impact of observations on surface analysis is not considered here, but the benefits of performing the surface analysis are shown in the next section. The domain (showed above) has a resolution of 11 Km for a 405x270 computational grid centred over Norway.

Assessment of a strategy for assimilating IASI radiances is not shown here but presented in a separate poster (by Randriamampianina).

Degrees of Freedom for Signal

Degrees of freedom for signal (DFS) indicate the self-sensitivity of analysis to different observation types; they are given by the derivative of the analysis, in observation space, with respect to the observations, and are sensitive to the weight of the observations and to the observation operator formulation. DFS have been computed perturbing all the observations for 5 independent assimilation cycles. Results show that the most important obs in terms of information content carried into the analysis are the wind observations (AIREP, TEMP and PILOT, although the latter are only a few). AMSU-A radiances are very important as well, and also AMSU-B show to have a big information content. Humidity observations (from TEMP) have a great impact on the analysis but there too little of them are present in the assimilation system.

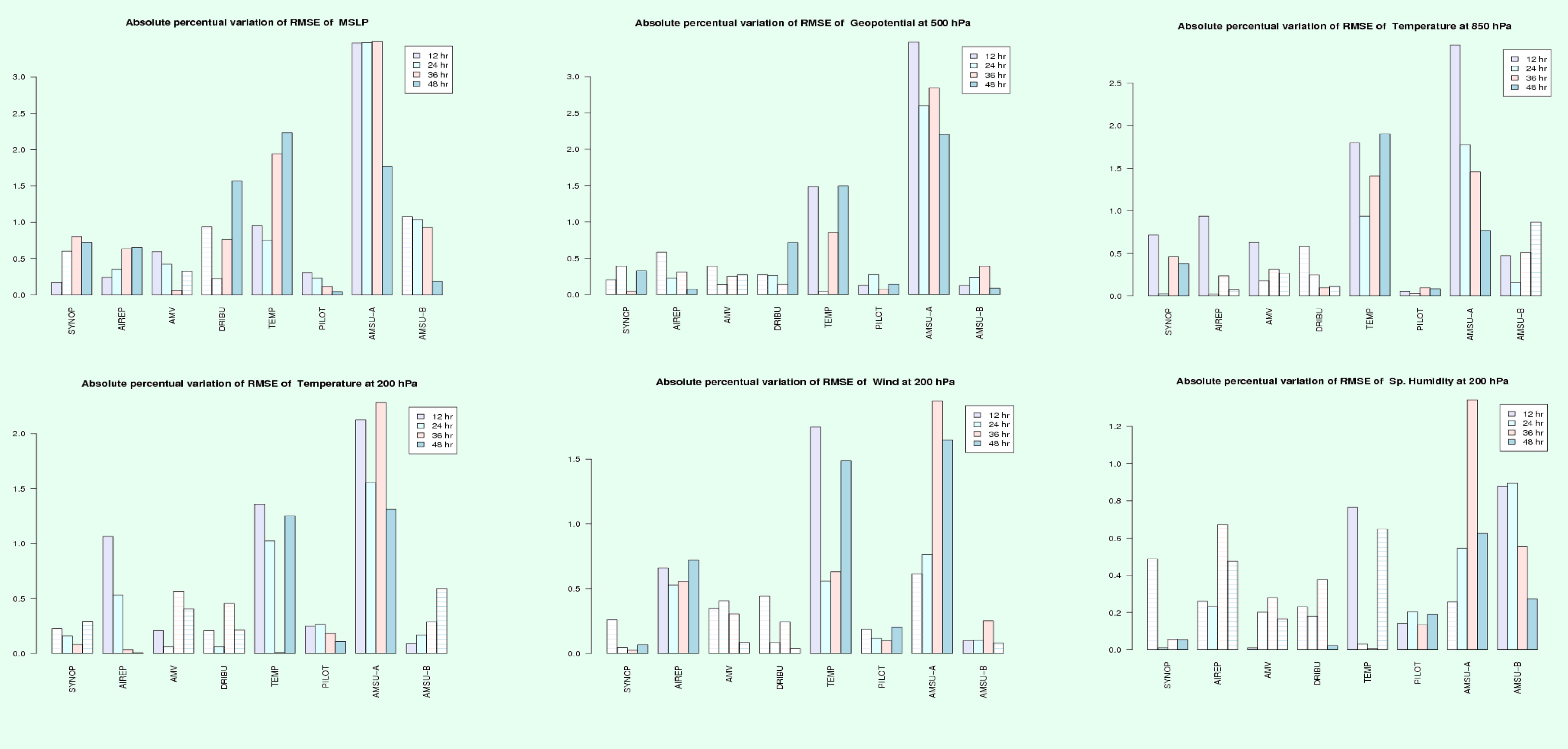




Sensitivity of forecasts to observations

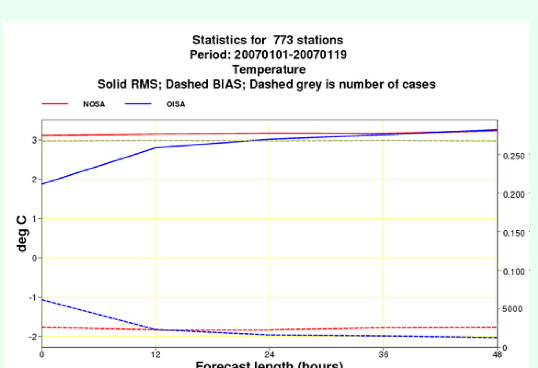
The impact of observation types on forecasts have been studied perturbing each observation group, rerunning the assimilation and comparing the RMSE (between forecasts and analysis valid at forecast time using the reference system) from the reference experiment (all the obs in the above table) with the RMSE from the perturbed experiments. The bigger is the relative variation in RMSE, the more sensitive are the forecasts to the observations group. The perturbation and forecast has been repeated for 4 assimilation cycle, far enough in time each other to ensure ergodicity of results.

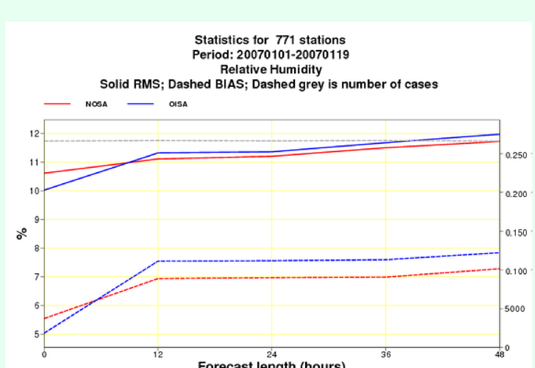
AMSU-A have showed the biggest impact on the forecasts for almost all the parameters, followed by TEMP, whose impact is very strong in the high atmosphere. AIREP observations seem very important for short-range forecasts, especially for temperature fields, while AMSU-B exercises influence mostly for low and high level humidity.



Surface Analysis

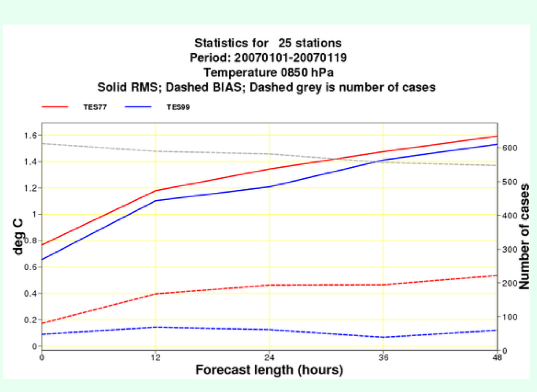
Surface fields are analysed trough an optimal interpolation assimilation system (CANARI) which assimilates temperature and relative humidity at 2 meters from synoptic stations, diagnosing water content, skin temperature and other surface fields. In the current configuration, sea surface temperature is not assimilated directly but taken from the ECMWF analysis and updated before the surface analysis. The benefits of the surface analysis are evident for both surface fields and low atmosphere, as shown in the following pictures.

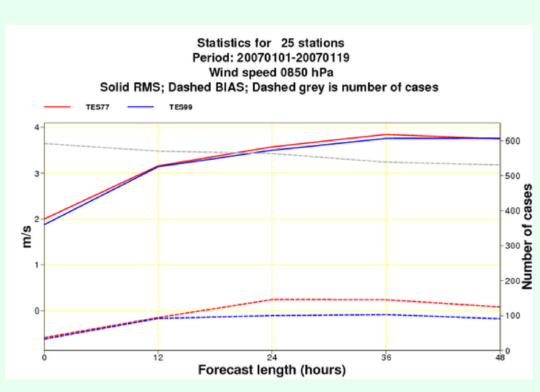


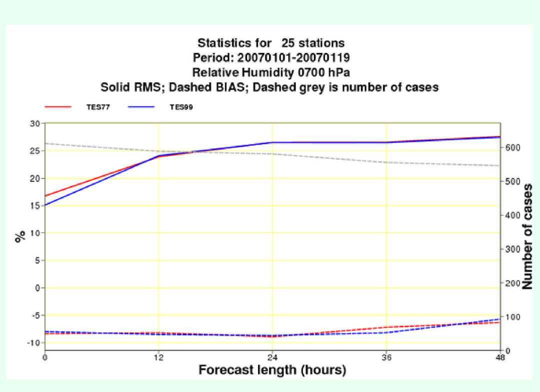


The two top pictures show the positive impact on surface fields, T2M and RH2M, verified against Synop stations and compared to an experiment without surface analysis.

The three pictures indicate the benefits of the surface analysis, performed before the upper-air analysis, on three low-atmosphere parameters, T 850 hPa, Wind 850 hPa and RH 700 hPa respectively.

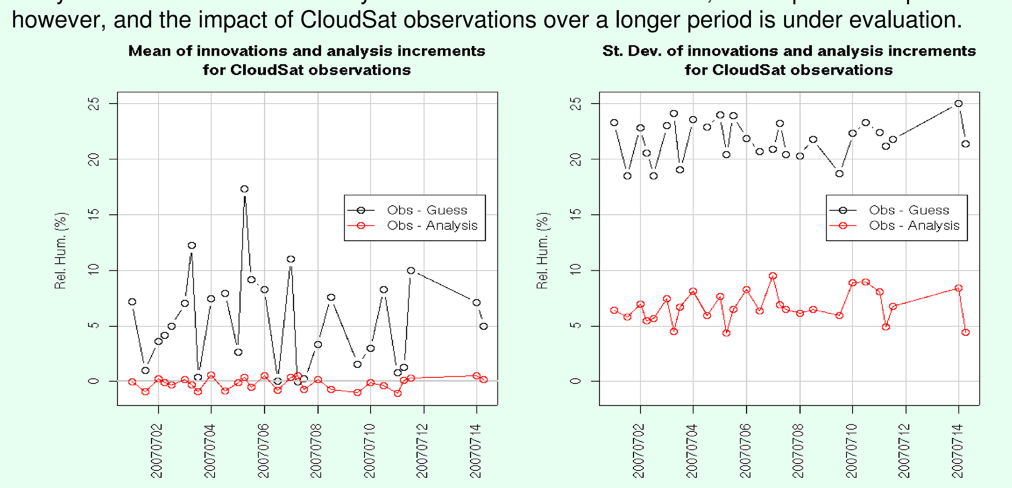


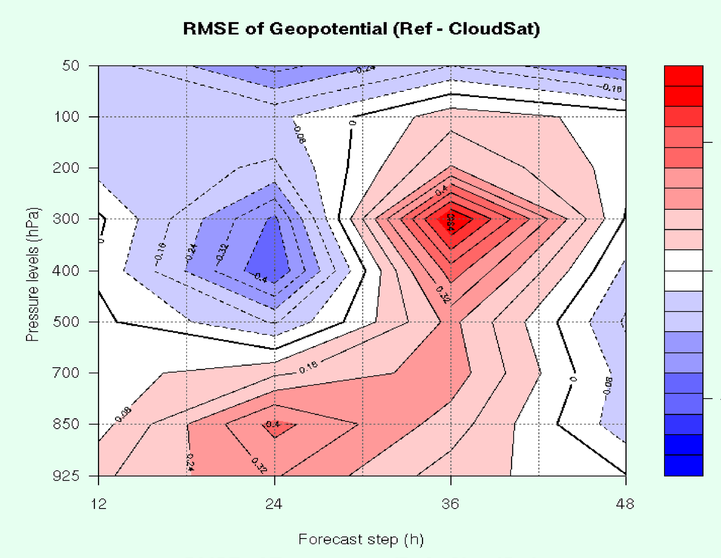




Experimental observations

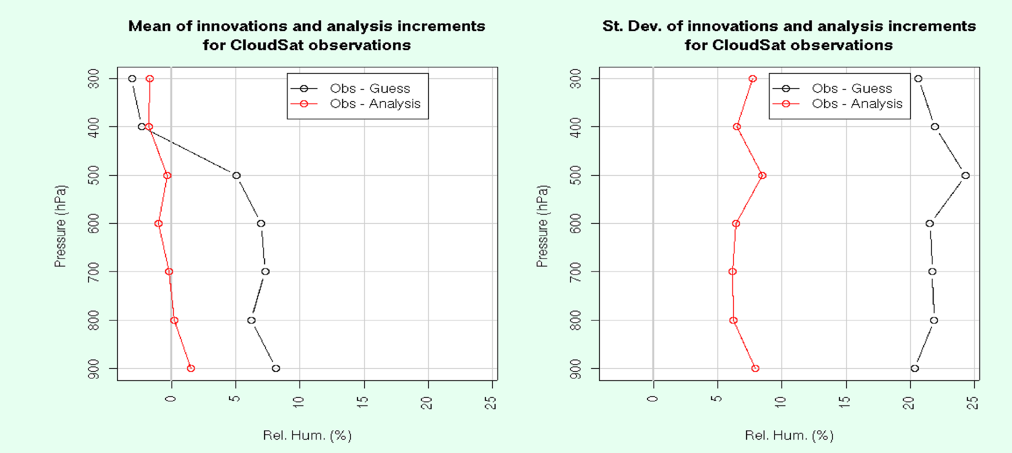
In this section we present recent results for a number of new observations type whose assimilation is under evaluation. A strategy for the assimilation of CloudSat CPR observations have been assessed. It consists of a Bayesian analysis able to produce super-observations of relative humidity, exploiting the ability of CloudSat to detect single and multi layer clouds at very high resolution, both on the vertical and along the satellite track. NWP data to define the "a priori" knowledge of humidity fields come from ECMWF short-range forecasts. A Monte Carlo approach is then used to calculate the errors of the super-observations, simulating the Bayesian analysis' errors. 3DVAR correctly assimilates these observations, and a positive impact is found, especially on mass fields. The verification period is rather small however, and the impact of CloudSat observations over a longer period is under evaluation.

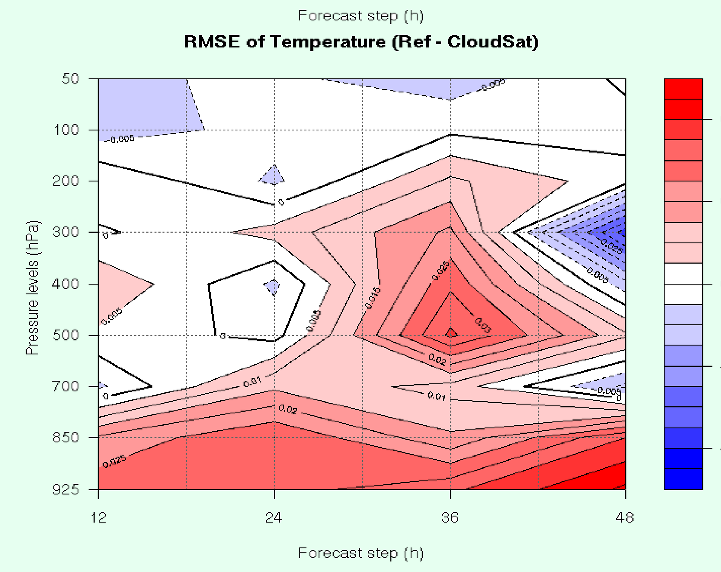




Innovations and residuals statistics for CloudSat observations (mean on the left, st.dev. On the right) calculated by day (top) and by vertical level (bottom). The plots show that the residuals are unbiased and that the weight given to the CloudSat observations is large.

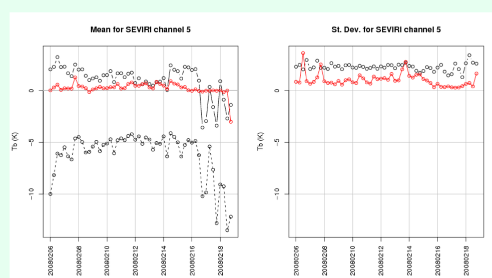
On the right panel, radiosonde verification scores against experiment with all observations in table 1 but without CloudSat assimilation are presented.

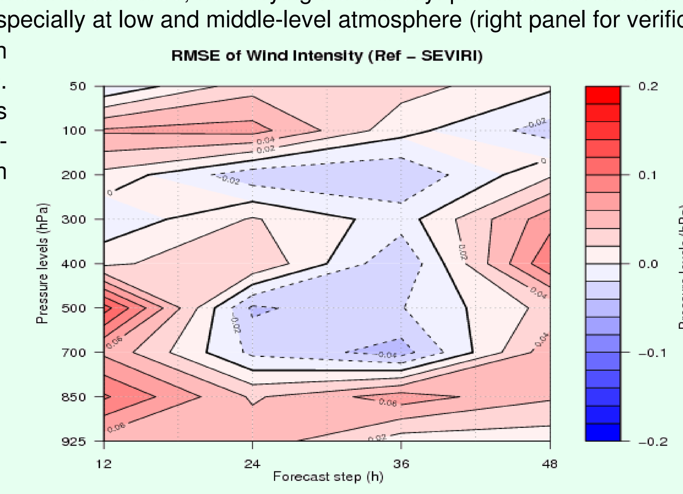


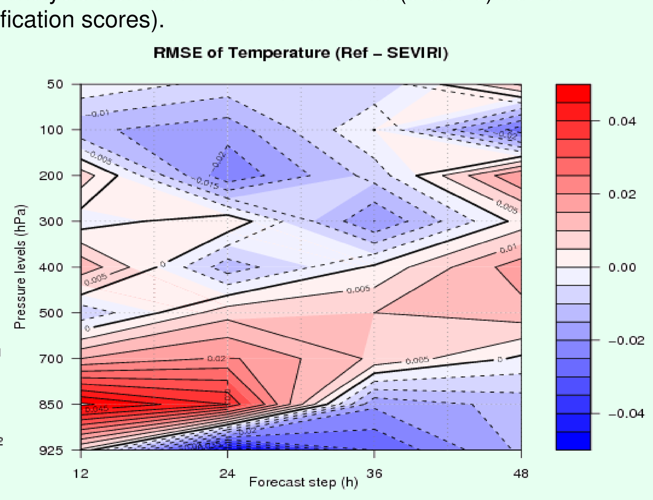


First assimilation trials have been also run with SEVIRI Infrared radiances (channels 5, 6 in clear-sky or above mid-level clouds conditions, channels 7, 9 and 10 in clear-sky above sea). An air-mass bias correction scheme is used, not varying latitudinally. provides reasonable analysis increments for WV channels (5 and 6) but not for the window channels. Impact is promising, especially at low and middle-level atmosphere (right panel for verification scores).

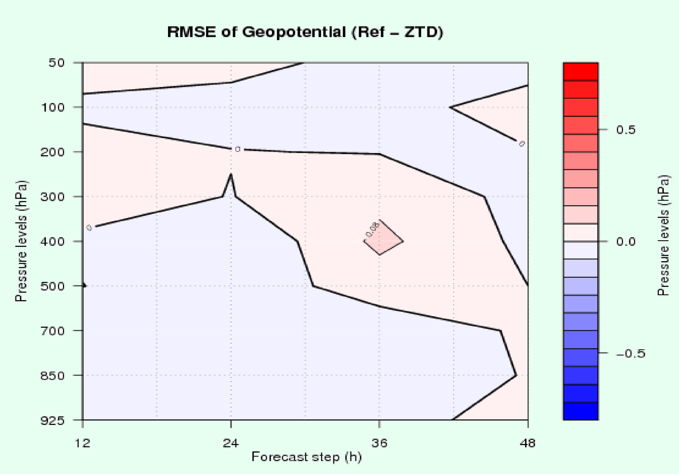
In the future, a variational bias correction scheme will be used for SEVIRI radiances. Pictures show the innovations and residuals statistics for channel 5 (red: obs-an, black: obs-first guess) and impact studies against an experiment without SEVIRI radiances.

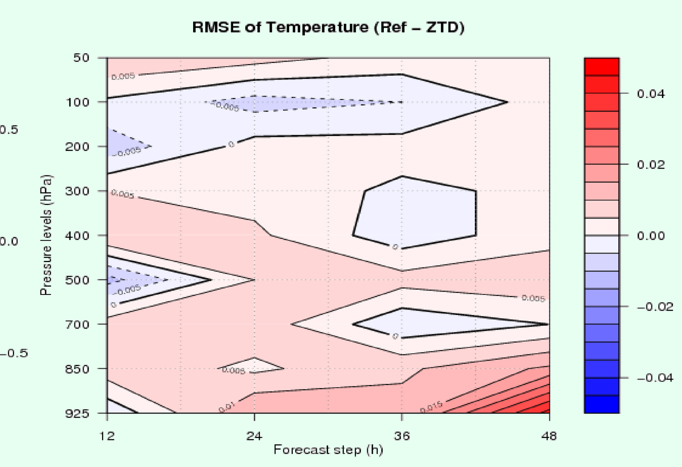






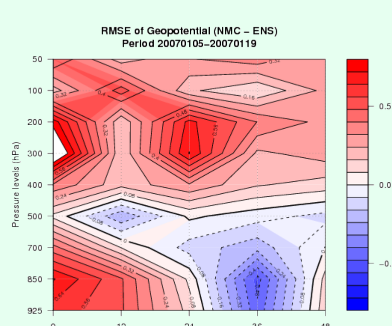
A feasibility study for the assimilation for the assimilation of GPS Zenith Total Delay has been carried out trough the creation of a dataset of reliable GPS stations and data processing centre. This approach leaded to 52 assimilable stations over the Norwegian domain. Trials experiment, that used an overestimation of the delay errors trough the observations minus guess standard deviations have been performed over one month (Feb. 2008).
A flat bias correction is used. Impact on verification against TEMP is small for all the parameters except for temperature, where is positive in general. A more rigorous formulation of observations errors is under evaluation.

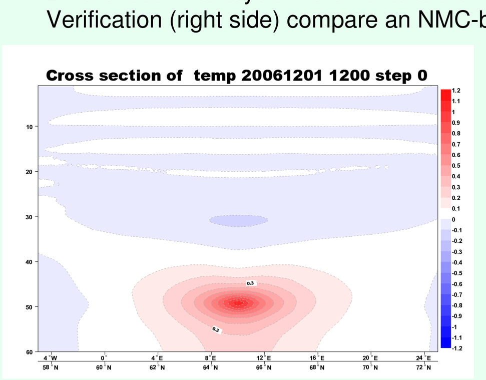


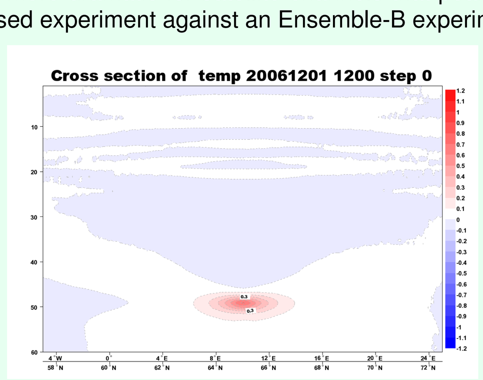


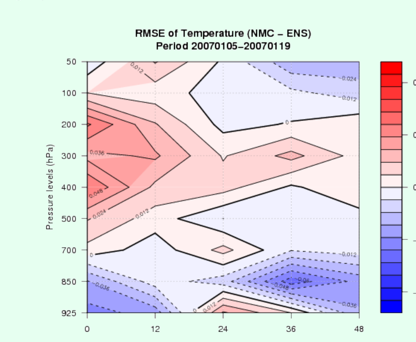
B covariances from downscaled ensemble analysis

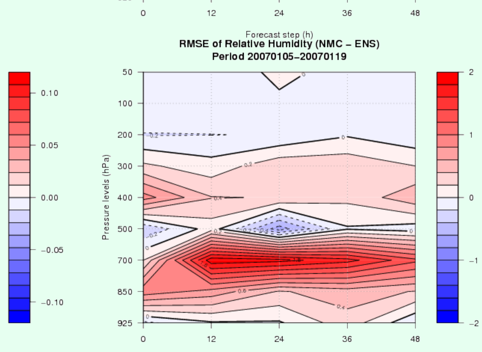
In order to exalt background covariances typical of small scales, ensemble analysis generated at ECMWF (kindly provided by Lars Isaksen) by perturbing observations in the assimilation, have been used after downscaling as initial and lateral boundary conditions for ALADIN-HARMONIE/Norway 6 hours forecasts. The experiment used all the original 10 members, for a period of 1 month (two daily runs), and differences between the true state of the atmosphere and the model forecasts have been simulated as differences between the ensemble mean and the forecasts coming from each of 10 members initial conditions. Background error covariances follow Loik Berre's formulation. Results have been extensively compared with background error covariances obtained through the "NMC" method, for a winter three-months dataset of differences between 48 and 24 hours forecasts. The use of ensemble analysis produced much shorter correlations, especially on the vertical correlations and at large horizontal scales. Variances and cross-covariances present a very similar structure in the two B statistics. Analysis initialized by 3DVAR using ensemble-derived statistic result closer to the background, and the forecasts show a better verification scores after day 1. The two cross-sections on the left show different analysis increments for a 2 K single-obs innovation (temperature from radiosonde at 850 hPa), NMC B (left) against Ensemble B (right). Differences in analysis increments are even more dramatic for satellite channels that peak high in the atmosphere (not shown here). Verification (right side) compare an NMC-based experiment against an Ensemble-B experiment.











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Conclusions

The impact of different observations on analysis and forecasts have been evaluated through the perturbation of observations. The sensitivity of analysis is particularly high with regards to wind measurements, especially from aircrafts, while humidity observations have a large information content but are not very dense if compared with other observed parameters. AMSU-A have the most remarkable impact on forecasts, at all the forecasts steps. Use of background errors derived through ensemble techniques is also of benefit to the optimal assimilation of observations.

Assimilation of other remote-sensed observations types is very promising, although more work for the assessment of their best use has still to be completed.