AMSU-A assimilation over sea ice in HIRLAM 3D-Var
Impact studies for the period February–March 2005

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ABSTRACT

This note presents HIRLAM impact experiments with assimilation of AMSU-A (Advanced Microwave Sounding Unit A) over sea ice for the months of February and March 2005. Impact is discussed both in terms of average statistics and in terms of a case study of a situation with particularly large differences between the experiments with and without AMSU-A assimilation over sea ice.

The analysis shows that due to the scarcity of other observations in Arctice and Ocean regions, there are cases where the impact of the added AMSU-A observations can remain in the model for a long period. The statistics shows a generally positive to neutral impact of the added observations

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1 Introduction

In the IOMASA project met.no in cooperation with its project partners develops processing methods to enable benefitial use of AMSU-A observations over sea ice. AMSU-A is assimilated in the present version of the HIRLAM 3D-Var assimilation system at met.no, but is only used over ocean (see Schyberg et al, 2003). Some potential is foreseen in these observations in sea-ice covered Arctic areas where few other observations are available.

Thyness, Tveter and Schyberg (2005a) described the data flow and adaptations made in the HIRLAM 3D-Var system to assimilate AMSU-A observations over sea ice, and the same authors (Thyness, Tveter and Schyberg, 2005b) described the use of sea ice input in the processing. The method includes a scheme for using sea ice retrievals as input to an algorithm for determining the sea ice surface emissivities in the AMSU-A channels.

Thyness, Tveter and Schyberg (2005a) also presented an initial impact study for AMSU-A over sea ice for the month of December 2004. The initial impact of assimilating AMSU-A over ice in HIRLAM 3D-Var described there was slightly negative. This was not unexpected, as tuning of observation error statistics and rejection thresholds still was at an early stage.

This note describes a new impact study performed after correction of several bugs and further tuning of the assimilation system. The period covered by this experiment is 8 February 2005 to 31 March 2005.

2 Experiment setup

For a detailed description of the methods used for data input, preprocessing, quality control, bias correction and assimilation see Thyness, Tveter and Schyberg, 2005a.

The impact study is set up with a "reference" and an "experiment". The reference is chosen to be fairly close to the operational met.no HIRLAM version, except it has no assimilation of satellite observations (operationally QuikScat ocean wind data and AMSU-A over ocean is used). The experiment differs from the reference in one way, namely by assimilating AMSU-A soundings over sea ice. Differences between these two runs is therefore directly attributable to assimilation of these observations. By not using satellite data over ocean in any of the runs, it is easier to discover any impact of using AMSU-A observation over sea ice.

In the present experiment we have not yet included channels which are much influenced by surface emissivity (the 5 lowermost of the 15 AMSU-A channels). AMSU-A channels that receive almost all their radiation from the surface (Ch 1–3, 15) have not been used over ocean in our operational runs, and will probably not be used over sea ice either. Channels that get some contribution from the surface, but are not included here, will be attempted to be assimilated at a later stage.

The channels that not are being assimilated, are however run through the assimilation system in passive mode, which means that they can be compared with simulated values with the emissivity formulation implemented, for production of statistics and evaluation.

In the next section we will present results from verification against observations and comparison between the forecasts from the two cycles.

3 Results and discussion

For verification the forecasts originating from the midnight cycle (forecast range up to 48 hrs) are used. The forecasts are verified at the main synoptic hours (0Z, 6Z, 12Z, 18Z). Only

EWGLAM stations are used in the verification. These are SYNOP and radiosonde observations mainly located over central Europe which are believed to have a certain reliability.

The bulk of the EWGLAM stations are located in central Europe, and thus far away from the Arctic area where we add AMSU-A observations. Therefore we have also produced statistics for a second set of verification stations, consisting of a subset of the EWGLAM stations located in the Nordic countries, also including several North Atlantic and Arctic stations. We expect the added AMSU-A observations to have a bigger effect in the region close to the observation.

The root mean square difference (RMS) as well as standard devation of differences (STD)and bias are calculated. If the experiment has a significantly smaller RMS or STD than the reference, the experiment is considered to be better than the reference.

3.1 Verifying statistics

Fig. 1 shows verification against surface observations as a function of forecast range for the whole EWGLAM dataset. We see that the curves for the reference and experiment are quite close to each other, as could be expected since a large fraction of the stations are located far away from the region where we expect the two runs to differ. It can nevertheless be seen that the experiment scores slightly better for mean sea level pressure.

In Fig. 2 we have only included the Northern station dataset, and here we see larger differences between the curves, particularly for the sea level pressure (MSLP), where the experiment scores better for the period.

In Fig. 3 we present timeseries for the daily contribution to MSLP errors (averaged over all forecast ranges from 6 to 48 hrs) in the reference and experiment. Such plots are useful in locating whether the impact seen stems from a single case or is more general. Usually in such impact studies we see cases of both positive and negative impact and need some duration of the time period to get a significant result. This is the case also here. In general we seem to have longer periods where the experiment is better than the control run, confirming the statistics shown above for the whole period.

Particularly we see that the differences in the verification scores are larger for the Northern dataset, as could be expected. There are periods where the reference has large errors around 28 February, 6 March and 14 March where the AMSU-A observations seem to be able to improve the forecast skills quite a bit.

Fig. 4 shows verification against radiosondes, giving a verification of the vertical profiles of the runs. The improvement in the experiment is seen in the mid and lower part of the troposphere.

3.2 A case study

The timeseries plot presented above showed significant differences between the two runs on 14 March, so a more detailed analysis of the meteorological situation at 14 March 00 UTC was conducted.

In Fig. 5 we present 24 hrs forecasts from the two runs valid at this time. The figure shows a small section of the total NWP model domain.

In general the two runs give very similar results away from the Arctic. However, there is a low pressure system in the Barentz Sea between Norway and Spitzbergen which is different in shape, strength and position. There are significant differences in this area, elsewhere differences are smaller.

In this region there is a notherly flow southwards from the sea ice regions. The upper air charts shows that over parts of the area such a flow extends to the mid and upper troposphere. This means that influences of added observations above the sea ice can propagate southwards into the area where the large differences between reference and experiment are found.

For verifying which of the two forecasts is closest to reality, it is of interest to compare with model analyses over the area. Usually the differences between the analyses of the reference and experiment are much smaller than differences between forecasts from the reference and the experiment. In Fig. 6 we present analyses from the two cycles valid at the same time. We find surprisingly large differences between the two analyses, and observe that the differences between the two 24h forecasts are basically maintained in the analysis. There are areas where the difference between the two analyses is more than 10 hPa.

The reason for this must be that there are very few conventional observations in the region which by assimilation can make the two cycles approach each other. There is almost no conventional observations in the Barentz sea where the two low pressure systems are located. We do have quite a few observation stations on the coast of Northern Norway as well as in Spitzbergen, but in these areas there are not so large differences between the two cycles. These two different anayses can therefore not be used for verification.

To get a view of which of the two cycles has the analyses (and forecasts) closest to reality, we remain with two Island observations in the area, Bjørnøya and Hopen. A blown up chart with some selected observations is shown in Fig. 7.

Bjørnøya is somewhat to the west of the low pressure centre. Even if the fit is not very good with either of the models, this station fits the analysis from the experiment run significantly better than the reference. The same is the case for the station at Hopen Island.

In this situation impact of the added AMSU-A observations remains in the model for a long time and affects the simulated circualtion pattern in the Barentz sea. It seems that the added AMSU-A information over ice is clearly benefitial.

4 Conclusions and further work

Use of AMSU-A data over sea ice now gives a neutral to positive impact. The impact study showed periods of large errors in MSLP where improvements were found in the experiment. The time period of the experiment seems too short to conclude definitely, but the results are encouraging.

A case study demonstrated that added AMSU-A observations over sea ice had a positive impact in data sparse regions surrounding the sea ice with the given flow regime. In this region the impact was kept in the assimilation cycle for some time due to the scarcity of other observations.

Work remains on improving the sea ice emissivity formulation including surface channels actively as well as further tuning of quality control.

References

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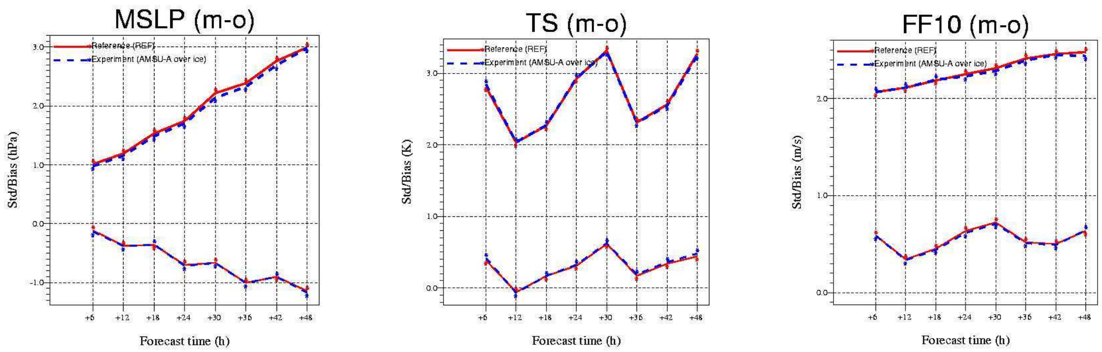
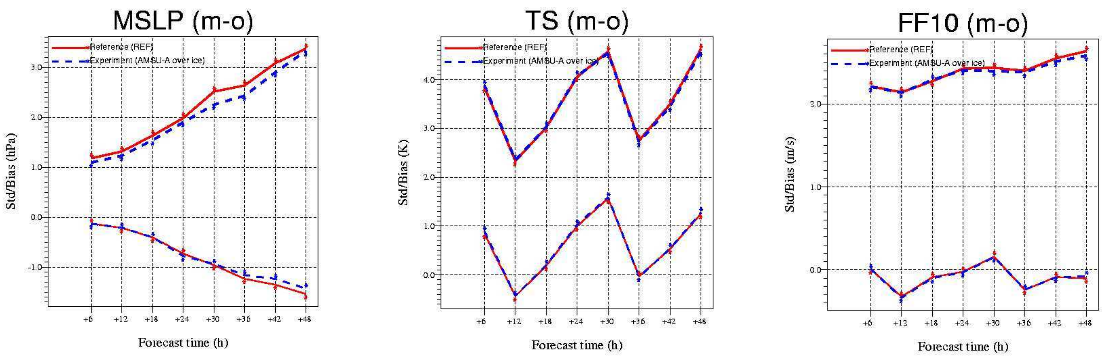


Figure 1: Mean Sea Level Pressure (MSLP), 2m temperature (T2m) and 10m windspeed (FF10) error as a function of forecast length, in the reference and experiment. All EWGLAM observations.



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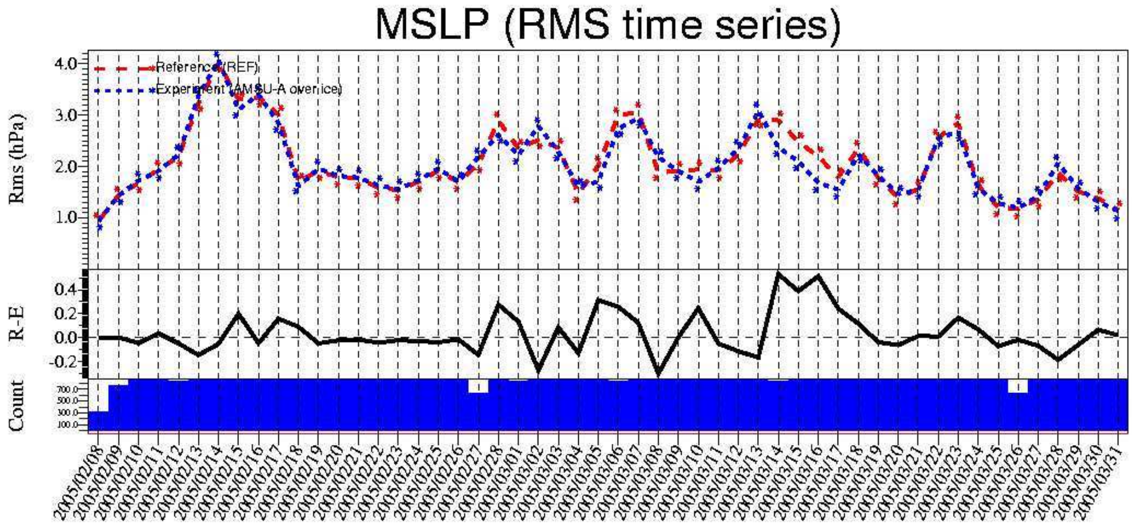

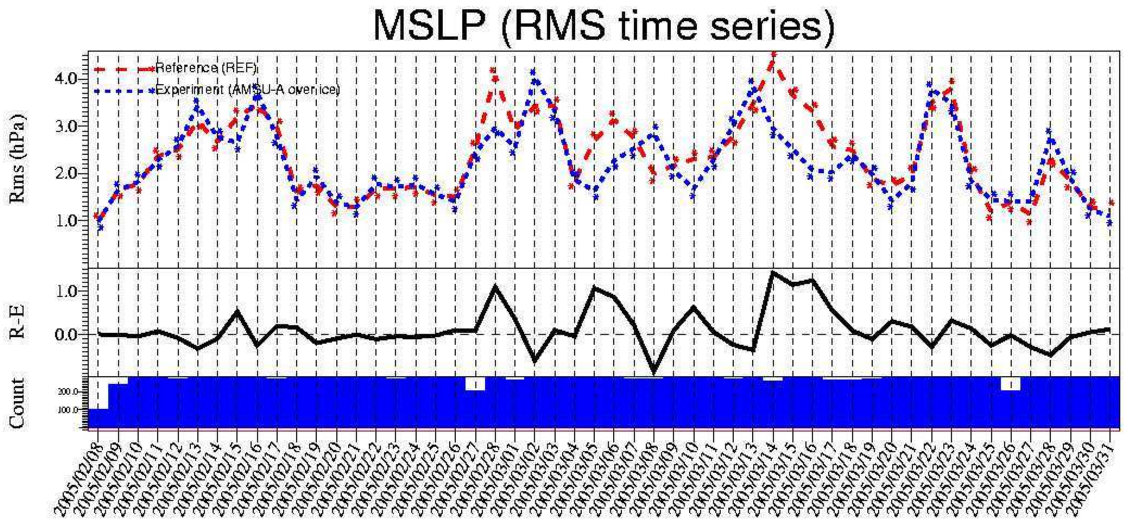

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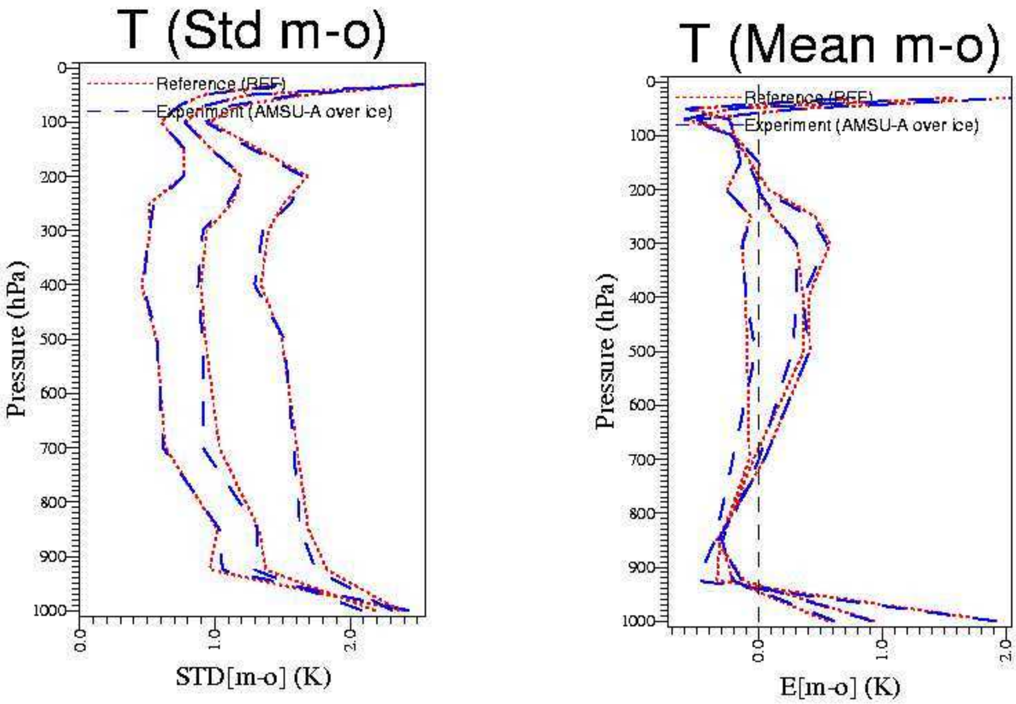

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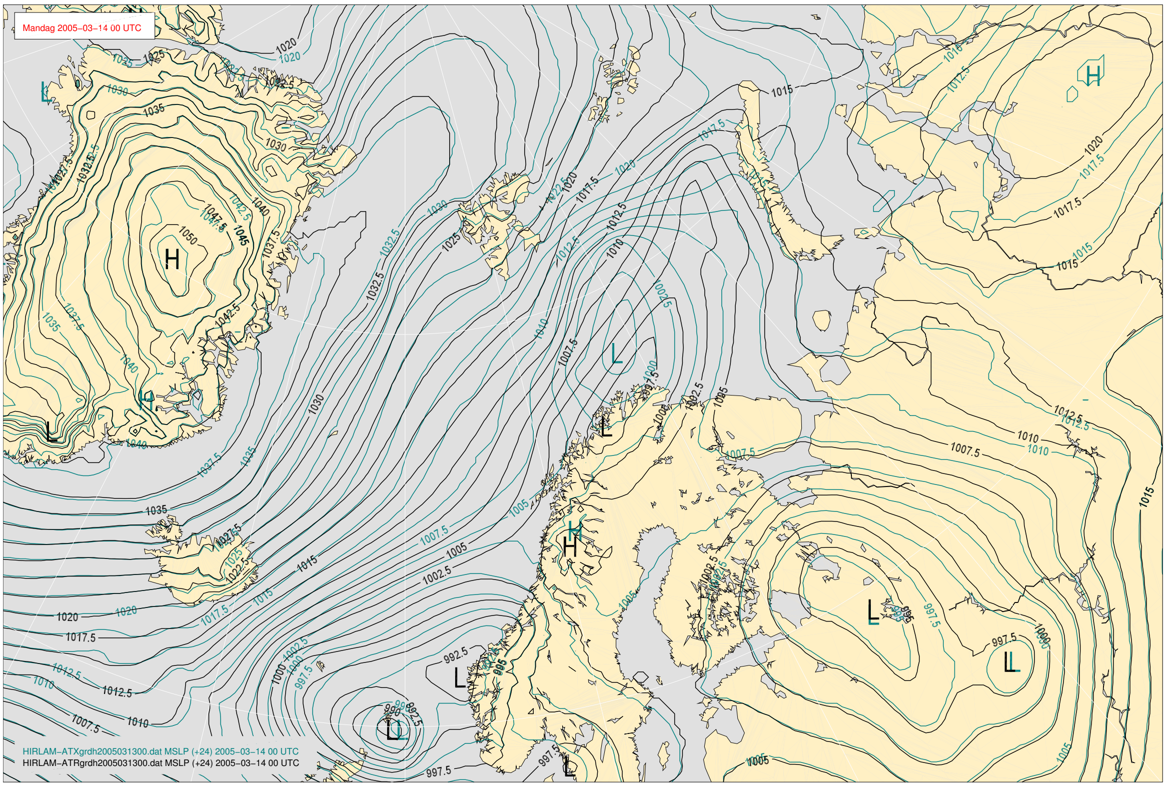

Figure 5: Weather situation 14 March 2005 00UTC, 24 hrs forecast. Black: reference, green: experiment using AMSU-A over sea ice.

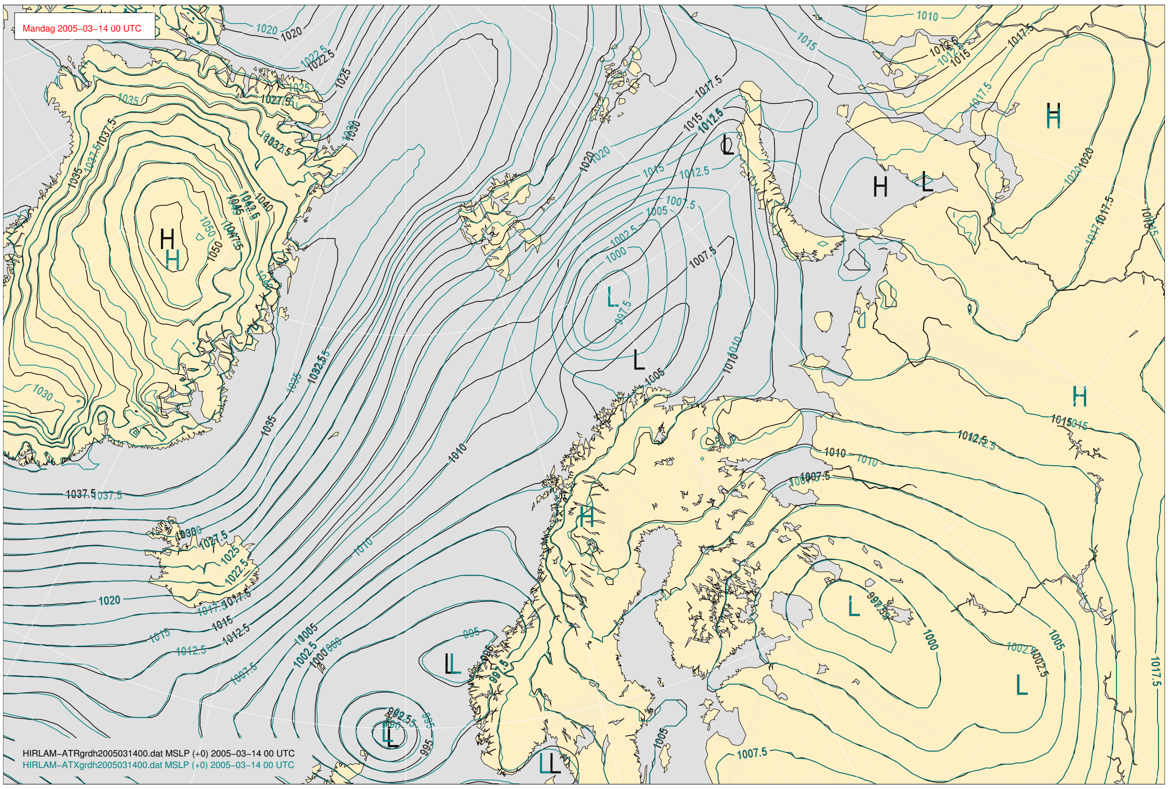

Figure 6: Weather situation 14 March 2005 00UTC, analysis. Black: reference, green: experiment using AMSU-A over sea ice.

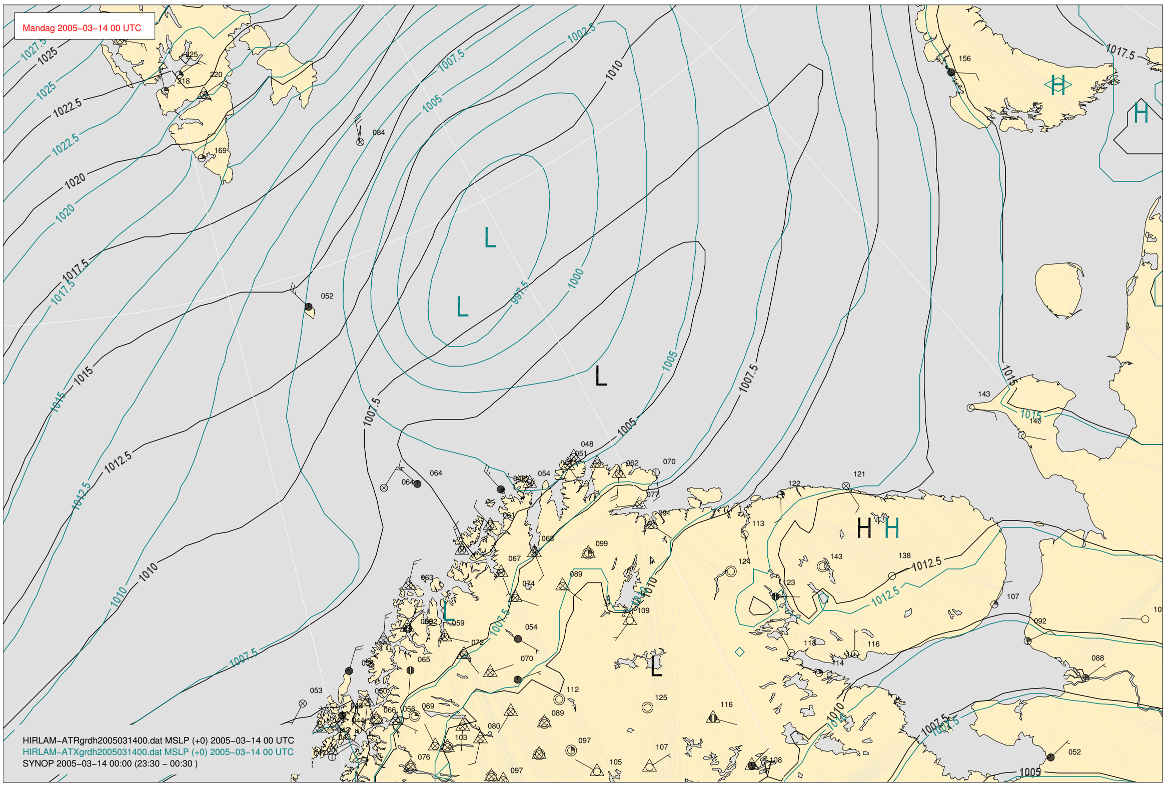

Figure 7: Weather situation 14 March 2005 00UTC, analysis and selected observations. Black: reference, green: experiment using AMSU-A over sea ice.