

An update on the assimilation of ATMS data at ECMWF

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Introduction

The Advanced Technology Microwave Sounder (ATMS) is the new microwave radiometer for temperature and humidity sounding flown on the Suomi-NPP (S-NPP) platform. It continues the AMSU-A and MHS heritage, providing temperature and humidity sounding information. A successful exploitation of the data is important for Numerical Weather Prediction.

ATMS has been assimilated operationally in the ECMWF system since 25 September 2012 (see Bormann et al. 2013). We use the data after averaging over 3 neighbouring scan positions and 3 scan lines to reduce the noise. Channels 6-15 and 18-22 are assimilated in clear conditions. Surface sensitive data over land or sea-ice were excluded in this initial configuration. Assimilation trials showed a neutral to positive forecast impact when ATMS was added to a system that already uses data from 5 AMSU-A and 3 MHS instruments (Fig. 1). Comparisons between observations and short-term forecasts showed an overall good performance of the instrument, with some evidence of striping noise.

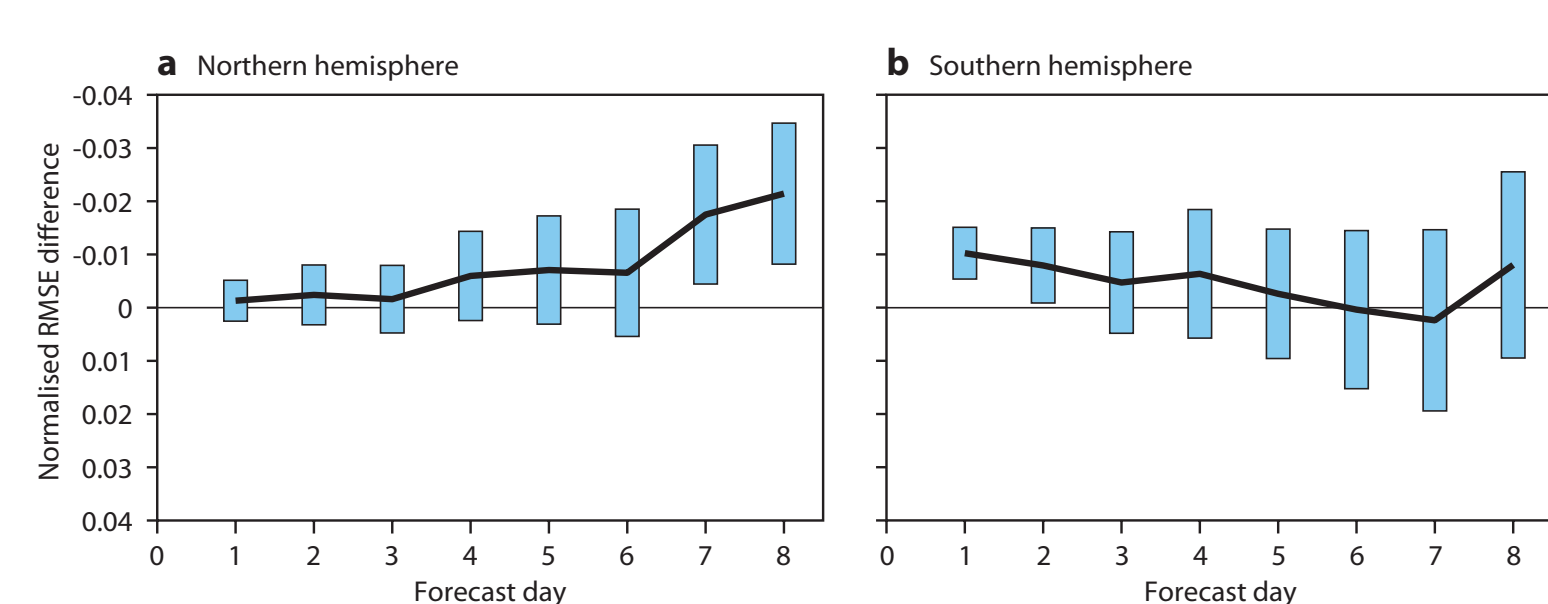


Figure 1 Normalised differences in the root mean square error of the 500 hPa geopotential for the Northern (left) and the Southern Hemisphere (right) as a function of forecast range from a total of 102 cases over the periods 15 December 2011 - 6 February 2012 and 28 June - 31 August 2012. The experiments have been conducted with ECMWF's assimilation system, at a spatial resolution of T511 (~40 km) (with a final incremental analysis resolution of T255 ~ 80 km). Error bars indicate 95 % confidence intervals.

Assimilation experiments with a depleted observing system

To further compare the ATMS and AMSU-A/MHS impacts, assimilation trials have also been conducted with a depleted observing system:

Control: Baseline assimilation experiment in which no radiance data from polar-orbiting instruments were assimilated. Only conventional observations together with GPS radio occultation data, AMVs, and scatterometer winds were assimilated.

AMSU-A/MHS: As Control, but with AMSU-A and MHS from NOAA-18 added.

ATMS_Full: As Control, but with ATMS added.

ATMS_AsAMSU: As ATMS_Full, but mimicking the AMSU-A/MHS use, i.e. only the equivalent scan-positions were assimilated as in the AMSU-A/MHS case, and the two additional humidity channels available from ATMS were also excluded.

The experiments cover the period 1 July 2012 - 31 August 2012, and otherwise use the same setup as the ones with the full observing system. Note that for AMSU-A we exclude the outermost 3 scan-positions on either side due to bias issues (9 for MHS), but for ATMS we do not find such a cautious approach necessary.

Figure 2 compares the forecast impact of the ATMS and AMSU-A/MHS experiments against the control:

- In the absence of other radiance observations from polar-orbiting satellites, a single ATMS or a single AMSU-A/MHS have a very large positive forecast impact.
- Used in a similar way, ATMS and AMSU-A/MHS have a similar impact (compare AMSU-A/MHS - Control and ATMS_AsAMSU - Control).
- The additional scan-positions used with ATMS and the two humidity channels lead to some benefits (compare ATMS_Full - Control and ATMS_AsAMSU - Control).

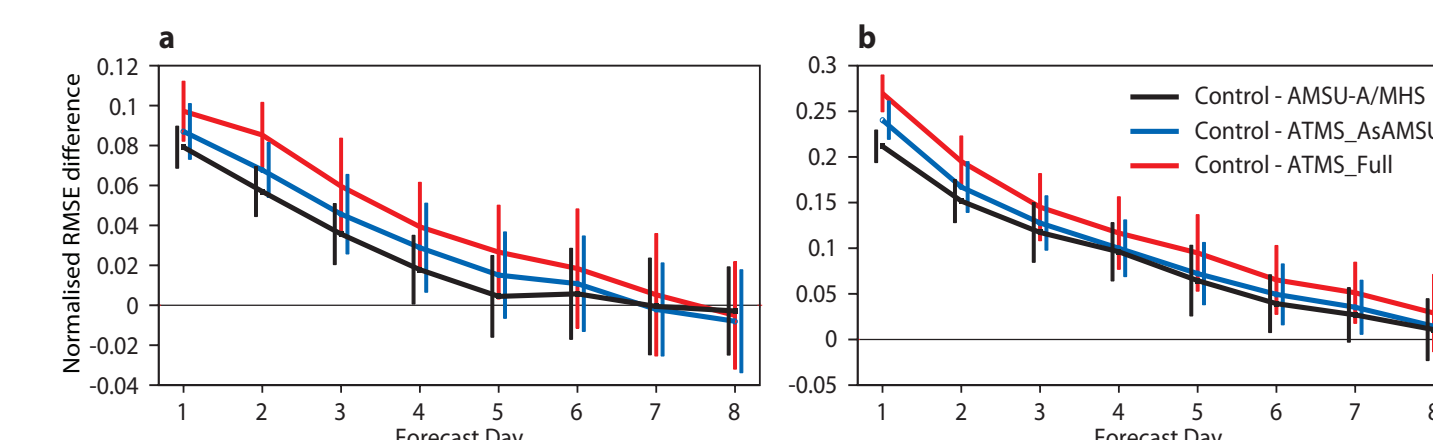


Figure 2 Normalised differences in the root mean squared forecast error as a function of forecast range (days) for the baseline experiments. The three lines indicate differences to the Control for the AMSU-A/MHS, ATMS_Full, and ATMS_AsAMSU experiments, respectively, as indicated in the legend. The vertical bars indicate 95 % confidence intervals. Each experiment has been verified against the operational analysis, with a total of 62 cases. a) For the 500 hPa geopotential over the Northern Hemisphere extra-tropics. b) As a), but for the Southern Hemisphere extra-tropics.

Use of data over land and sea-ice

The initial implementation of ATMS was restricted to data over sea for surface-sensitive channels as the assimilation of surface-sensitive channels over land and sea-ice is more difficult. Here we report on the addition of this surface-sensitive data.

Experiments

Experiments were carried out to include the assimilation of ATMS data over land and sea ice, as follows. Three sets of experiments were run:

Control: the same as the operational 4D-VAR system at ECMWF, including data from 6 AMSU-A instruments, and 4 MHS instruments. ATMS is also used as per the current operational system.

ATMS over land: As control but with ATMS humidity channels (18 - 22) and temperature surface-sensitive channels (6 - 8) actively assimilated over land.

ATMS over land and sea-ice: As 'ATMS over land' with the additional temperature and humidity ATMS channels (6 - 8 and 18 - 22) also actively assimilated over sea-ice.

Note that the land emissivity and sea-ice emissivities were taken from a dynamic retrieval scheme, developed for AMSU-A and MHS (Karbou et al 2006, Di Tomaso et al 2013), where the emissivity is calculated from the measured radiances of an ATMS window channel prior to the assimilation. We use emissivities retrieved from channel 3 for the temperature-sounding channels over land and sea-ice, and channel 16 emissivities for the humidity-sounding channels over land and channel 17 over sea-ice. The experiments were run in the 39R1 version of the ECMWF system at T511 resolution (~40km), and covered two periods: 1.5 months in January - February 2013 and 3.5 months in April - July 2013.

Results

The background departures of used data were similar for ATMS and AMSU-A/MHS for equivalent channels as shown in Figures 3 and 4, confirming that the scheme works equally well for ATMS.

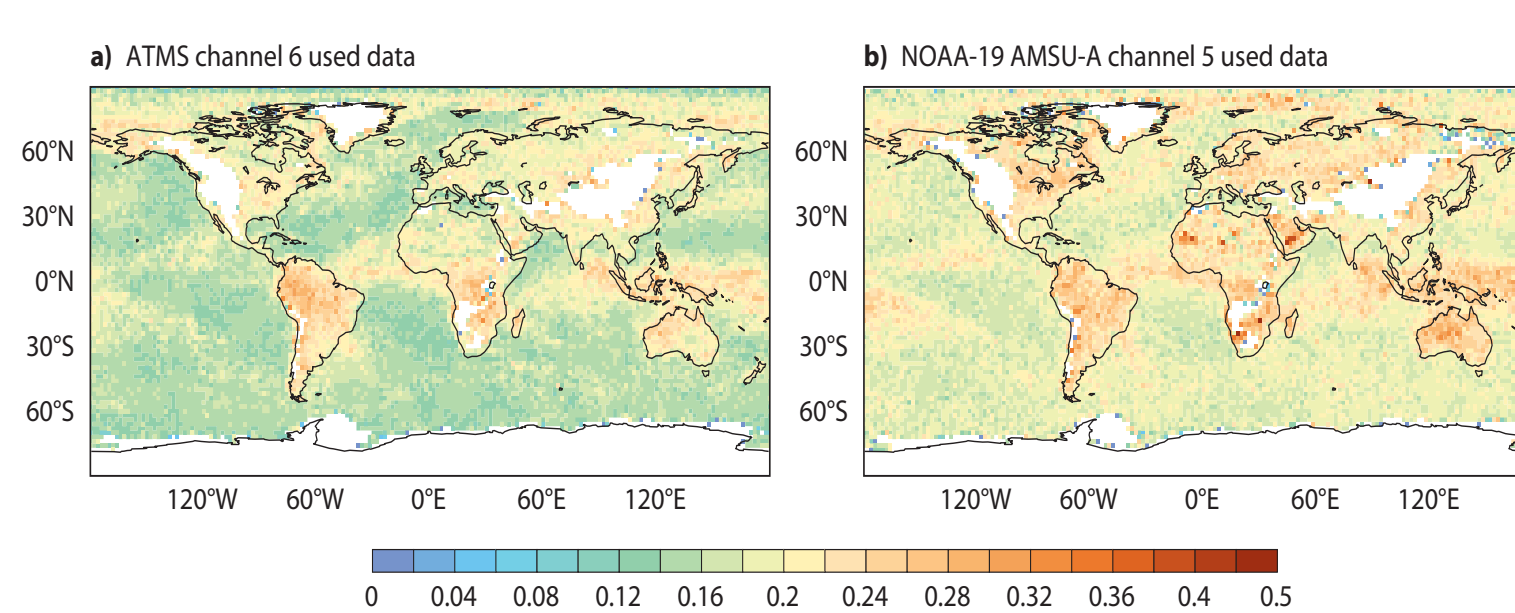


Figure 3 Standard deviation of background departures for a) ATMS channel 6 used data and b) NOAA-19 AMSU-A channel 5 used data for the 'ATMS over land and sea-ice' experiment. These channels are equivalent and are the lowest peaking actively assimilated temperature channels with the highest surface-sensitivity. NOAA-19 and Suomi-NPP satellites have similar afternoon equatorial crossing times.

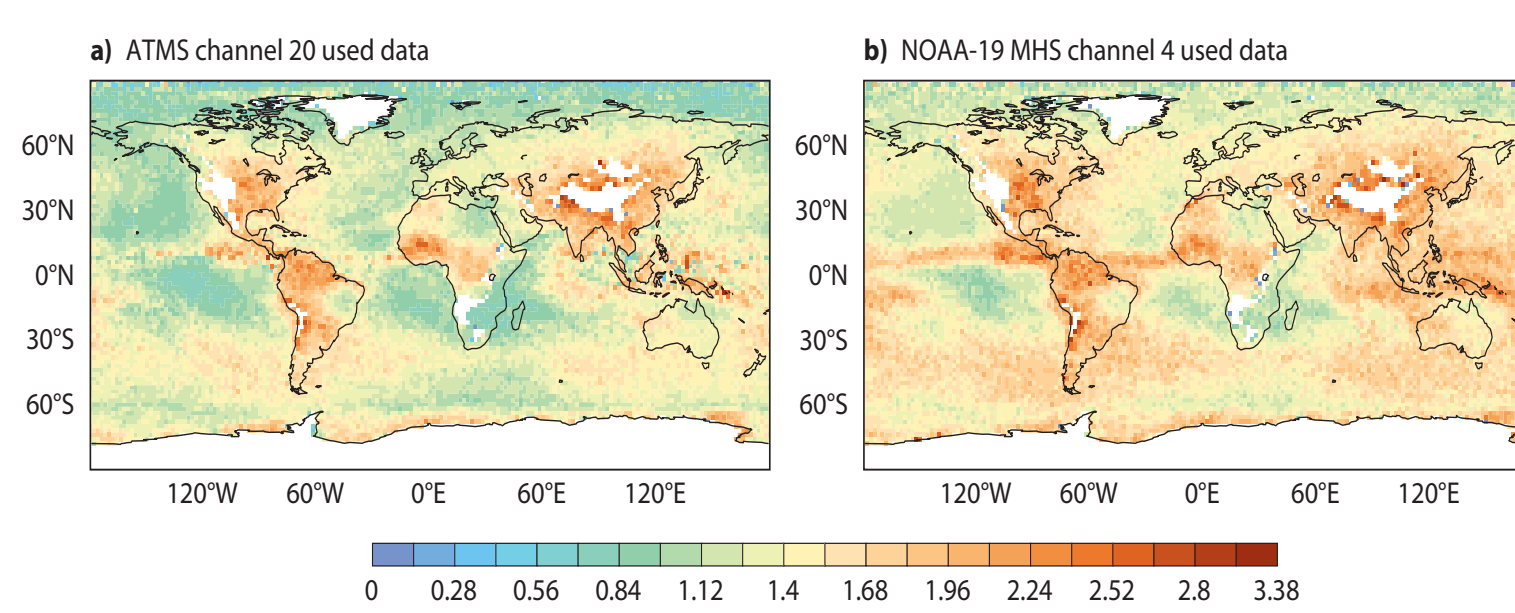


Figure 4 Standard deviation of background departures for a) ATMS channel 20 used data and b) NOAA-19 MHS channel 4 used data for the 'ATMS over land and sea-ice' experiment. These channels are equivalent and are the lowest peaking humidity channels which are assimilated over sea-ice (channel 5 MHS and 18 ATMS are assimilated over land but not sea-ice).

Standard deviation of background departures for AMSU-A and MHS were reduced when ATMS was assimilated over land and sea-ice, compared to the control, indicating a better quality of the short-range forecast:

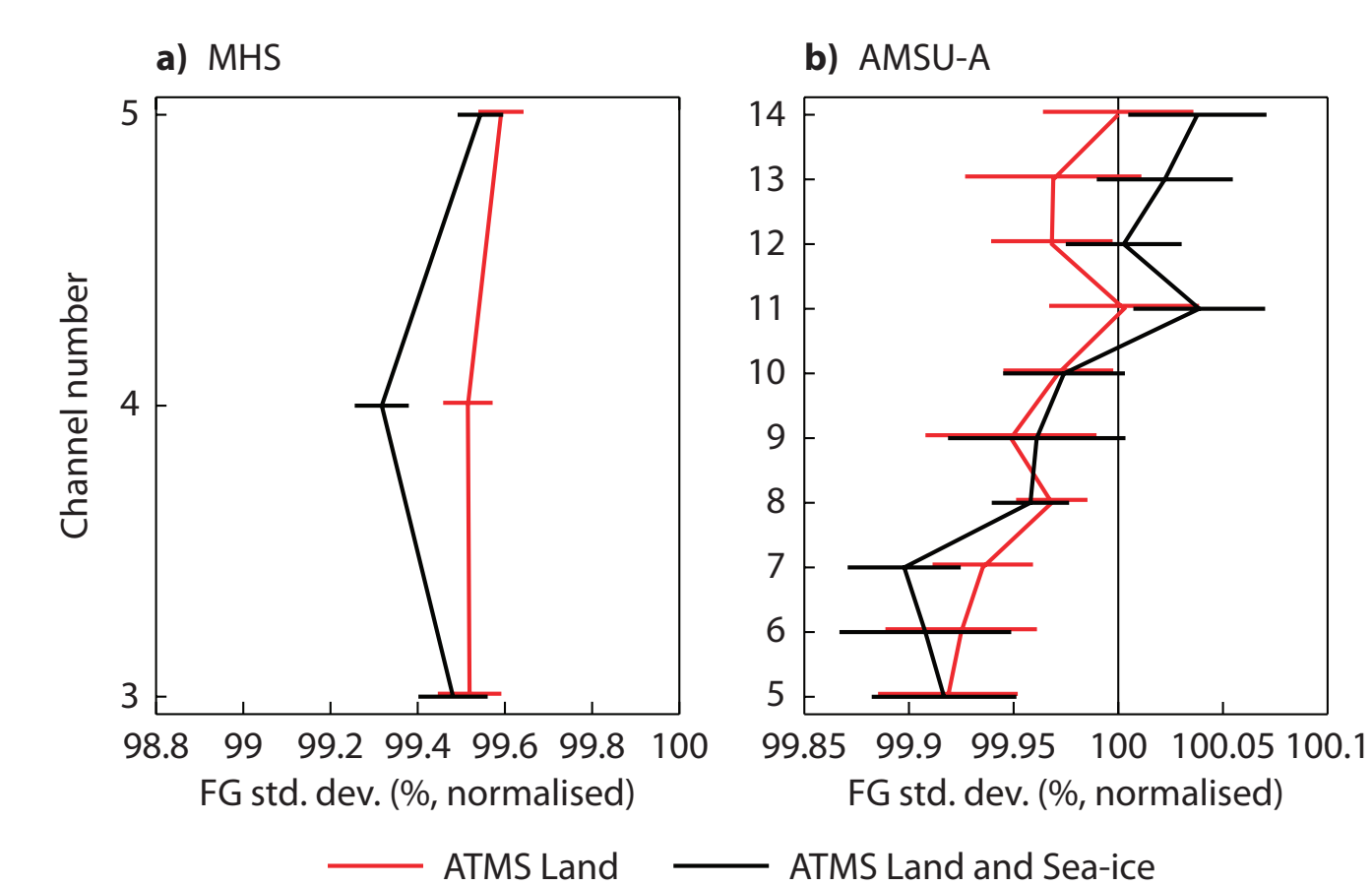


Figure 5 Normalised difference in the standard deviation of background departures between the experiments and the control for a) MHS and b) AMSU-A. Values are for used data averaged globally and over all satellites for the summer and winter periods combined. Values are normalised to the control so that a shift left indicates a reduction. The vertical bars indicate 95 % confidence intervals.

Forecast scores were neutral overall for the introduction of ATMS over land and sea-ice, as shown in Figure 7 for 500hPa geopotential height for example.

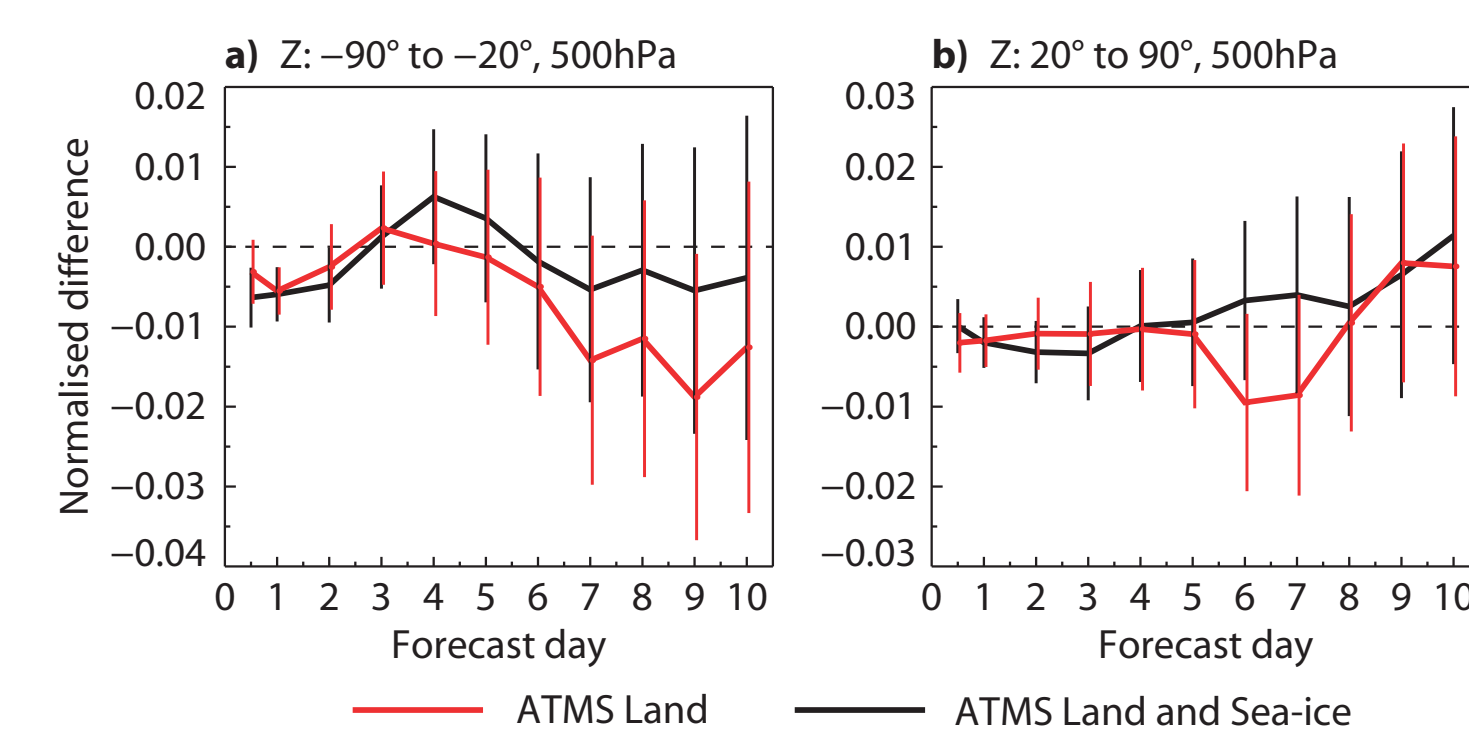


Figure 6 Normalised differences in the root mean squared forecast error of 500hPa geopotential averaged over a) the Northern Hemisphere extra-tropics and b) the Southern Hemisphere extra-tropics. Values are shown as a function of forecast range (days) and the vertical bars indicate 95 % confidence intervals. Each experiment has been verified against the own analysis, with a total of 127 - 147 cases.

Conclusions

Experiments with a depleted observing system highlight how ATMS performs overall in a comparable way as AMSU-A/MHS.

Experiments assimilating ATMS surface-sensitive channels over land and sea-ice showed a decreased standard deviation of background departures for MHS and AMSU-A and that the ATMS background departures over land and sea-ice were comparable to those of AMSU-A and MHS. Forecast scores were neutral.

References

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- Karbou, F., E. Gérard and F. Rabier, 2006: Microwave land emissivity and skin temperature for AMSU-A and -B assimilation over land. *Q.J. Roy. Met. Soc.*, **132**, 2333-2355.

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