

The assimilation of surface-sensitive microwave sounder radiances at ECMWF



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Active assimilation of MHS channel 5 (the lowest-peaking in the water vapour band) over land

Here we discuss the impact in NWP of enhancing the use of MHS observations over land. A set of 3 month experiments were run with/without the assimilation of MHS channel 5 (channel 5 experiment/control experiment):

- over low orography, skin temperature >278 K,
- and with dynamically retrieved emissivities [1] (i.e. retrieved from observations at 89GHz, surface emission and reflection). Experiments were run in two periods (following the work in [2]):
- summer (July, August, September) 2006, (i.e. the AMMA [3] period, with the additional assimilation of MERIS data);
- summer (June, July, August)/winter (January, February, March) 2011 (with a richer observational system than in the 2006 experiments).

MHS channel 5 first guess departures

• MHS channel 5 departures from model estimates do not show too large land/sea differences (see Figure 1).

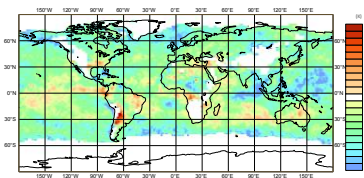


Figure 1 Mean differences between NOAA-19 MHS channel 5 observations and model estimates in the channel 5 experiment before bias correction.

Fit to MHS observations

• The assimilation of channel 5 improves the fit to MHS channel 4 observations (see Figure 6).

• The small increase in the standard deviation for channel 5 in the channel 5 experiment is due to the additional data over land for which the estimate for the surface emission is still poorer than that over sea.

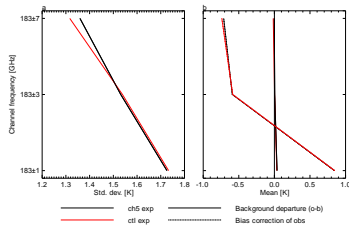


Figure 6 MetOp-A MHS brightness temperature departure statistics in terms of standard deviation (a) and mean (b) of the differences between channel 3, 4 and 5 (i.e. 183+/-1 GHz, 183+/-3 GHz and 183+/-7 GHz) observations and model estimates for the channel 5 experiment (black) and the control experiment (red) for the Southern Hemisphere. The sample of channel 5 observations is 15% greater in the channel 5 experiment than in the control experiment.

Conclusions MHS channel 5 will be operationally assimilated at ECMWF also over land from May 2012 onwards. The impact on the forecast skill of assimilating MHS channel 5 is neutral to positive for different variable and forecast ranges, which is consistent with a relatively small impact of these observations on the analysis.

Impact on the humidity field

• The assimilation of just one extra MHS channel over land has a relevant impact on the mean humidity analysis in both the 2006 and 2011 period (see Figure 2 and Figure 3).

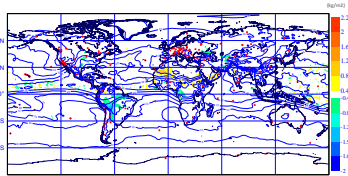


Figure 2 Mean difference between the TCWW analysis in the channel 5 experiment and the control experiment averaged over August 2006. The red dots indicate the location of GPS stations.

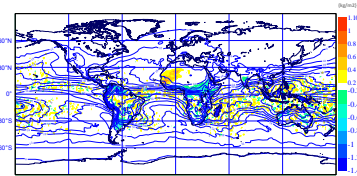


Figure 3 Mean difference between the TCWW analysis in the channel 5 experiment and the control experiment averaged over August 2011.

Validation against GPS TCWW

• The effect on the TCWW is significant both in terms of correlation and mean TCWW difference at a few AMMA stations (see Figure 4).

• The systematic drying over Central Africa during the whole diurnal cycle is consistent with the measurements at the IGS [4] station in Gabon in the 2006 period (see Figure 5). Both the channel 5 experiment and the control experiment show variations of TCWW during the day which follow well what is measured by the GSP stations.

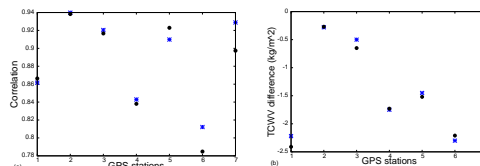


Figure 4 Correlation (a) and average differences (b) between the experiment analysis in the channel 5 experiment (blue asterisks) and in the control experiment (black circles) versus the GPS TCWW at six AMMA stations (Djouougou (Benin), Niamey (Niger), Gao (Mali), Tamale (Ghana), Ouagadougou (Burkina Faso), Tombouctou (Mali)), and at the Gabon IGS station.

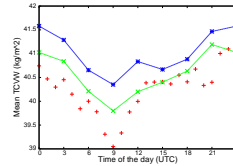


Figure 5 TCWW diurnal cycle at Gabon station for the channel 5 experiment (green crosses), the control experiment (blue asterisks), and GPS measurements (red pluses).

Fit to MERIS TCWW

• The assimilation of channel 5 improves the fit to MERIS TCWW in part of Central Africa (see Figure 7 and Figure 8), and greater number of MERIS observations are assimilated in the same area.

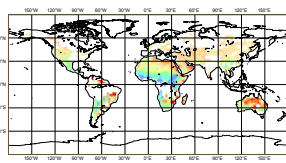


Figure 7 Mean differences between MERIS TCWW observations and model estimates in the channel 5 experiment in the 2011 period.

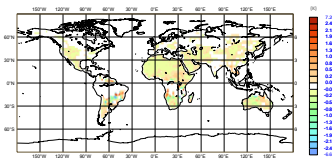


Figure 8 Mean differences of the MERIS TCWW observations departures from model estimates between the channel 5 experiment and the control in the 2011 period.

Active assimilation of MHS water vapour channels over sea ice

A set of data assimilation experiments were run with/without the active assimilation of MHS channel 3 and 4 (the high peaking channels in the water vapour band) over sea ice (sea ice experiment/control experiment):

- dynamic emissivities [4] retrieved at 157GHz (channel 2) are used for the other MHS channels over sea ice,
- the use of MHS water vapour channels is extended also over cold sea (i.e. skin temperature < 278 K).

Conclusions

MHS channel 3 and 4 are good candidates to be assimilated at ECMWF also over sea ice, while the active assimilation of MHS channel 5 requires a better estimation of surface emissivity and cloud screening.

Results

• Dynamic emissivities retrieved at 157GHz provide reasonably good emissivities, without any frequency-dependent correction, for the high peaking water vapour channels (see Figure 9).

• The additional observations over sea ice and cold sea improve the fit to MHS observations (with the exception of channel 5 in the Southern Hemisphere) (see Figure 14).

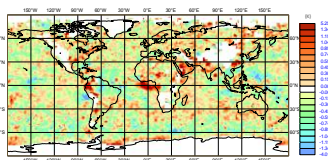


Figure 9 Mean differences between NOAA-18 MHS channel 4 observations and model estimates in the sea ice experiment before bias correction.

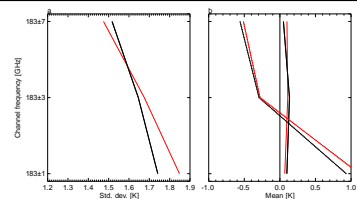


Figure 10 MetOp-A MHS brightness temperature departure statistics in terms of standard deviation (a) and mean (b) of the differences between channel 3, 4 and 5 (i.e. 183+/-1 GHz, 183+/-3 GHz and 183+/-7 GHz) observations and model estimates for the sea ice experiment (black) and the control experiment (red) for the Southern Hemisphere. The sample of channel 4 (5) observations is 60% (25%) greater in the sea ice experiment than in the control.

References

- [1] Karbou, F., E. Gard, F. Rabier (2005), Microwave land emissivity and skin temperature for AMSU-A and -B assimilation over land. Q. J. R. Meteorol. Soc., 132, 2333-2355.
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- [4] Dow, J.M. et al. (2009), The International GNSS Service in a changing landscape of Global Navigation Satellite Systems, J. Geodesy, 83, 1911-98.

Acknowledgments

Enza Di Tomaso was funded by the EUMETSAT fellowship programme. Olivier Bock is gratefully acknowledged for his help with the AMMA GPS data.