The Use of Microwave Surface Sensitive Observations over Land and over Sea-Ice at Météo-France

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Observations from AMSU-A & AMSU-B instruments provide relevant information about the vertical structure of the temperature and the humidity. However, the use of these observations in the context of data assimilation is still bellow requirements. In fact, AMSU observations which are sensitive to the surface are usually not assimilated because of large uncertainties about the surface temperature and emissivity (English 2007). Efforts have been undertaken at Météo-France in order to improve the representation of the surface at microwave frequencies. New methods for land emissivity and surface temperature modelling anchored on satellite microwave observations were tested. The methods, fully described in Karbou *et al.* (2006), were interfaced with the RTTOV model. (1) The first method is based on the use of averaged emissivity estimates calculated within the assimilation system two weeks prior to the assimilation period; (2) the second one uses a dynamically varying emissivity derived at each pixel using one surface channel or a selection of surface channels, and (3) finally the third method combines the two previous ones since it uses averaged emissivities and dynamically estimated skin temperature at each pixel using observations from one surface channel. The relevance of each of the three methods to assimilate microwave observations over land was investigated using AMSU-A, AMSU-B. The performance of the three methods were studied in terms of observation departures from first guess and from the analysis and also in terms of analysis and forecast impacts. The second method was found to be the most promising one for the French operational ARPEGE system and was operationally implemented in July 2008 (Karbou et al. 2010a).

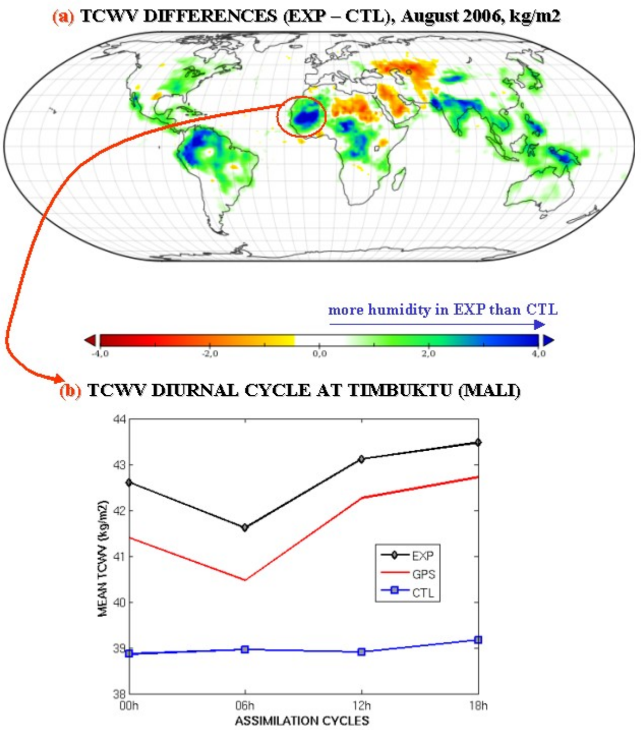

Figure 1 : (a) Mean TCWV analysis differences (experiment minus control) during August 2006. Negative (positive) values indicate that the control assimilation is more moist (dry) than the experiment. (b) Diurnal cycle of TCWV near TOMBOUKTOU estimated using GPS measurements and using analyses from CTL and from EXP assimilation experiments. Statistics are for 45 days (from 01/08/2006 to 14/09/2006)

Once the new land emissivity model implemented, strategies were explored to assimilate, for the first time ever, surface sensitive observations. Studies were undertaken to assimilate observations sensitive to the atmospheric boundary layer over land. In addition to a control experiment, a two-month experiment was run during the summer 2006. The latter assimilated low level temperature and humidity observations from AMSU over land. The assimilation of these observations impacts key parameters of the water cycle (Karbou et al. 2010b). An important change of the analyzed atmospheric fields and of the precipitation forecasts over the Tropics has been noted. Our experiment emphasizes the atmosphere moistening in India, South America and in West Africa together with a drying over Arabia and

North-East Africa (see Figure 1). The humidity change not only concerns the surface but also many levels of the atmosphere, up to 500 hPa. The humidity change was successfully evaluated using independent GPS data. The changes result in a better-organized African monsoon with a stronger ITCZ. Forecast errors were reduced over the Tropics leading to significant forecast improvements at higher latitudes at 48h and 72h ranges.

Over sea ice, the description of the emissivity is still unrealistic in the models (constant value of 0.99 for AMSU-B for instance). Consequently, almost no AMSU-A nor AMSU-B observations are assimilated over high latitudes. Bouchard et al. (2010) tested the surface emissivity model initially developed over land to improve the assimilation of AMSU observations over Antarctica and surrounding sea ice. The results were encouraging even though some residual biases were noticed over sea ice for AMSU-B observations. Since then, more in depth studies were undertaken to propose a new sea ice emissivity model suitable for microwave observations. The model is based on a direct retrieval of surface emissivity at one window channel (channel 3 for AMSU-A and channel 1 for AMSU-B). For AMSU-B observations, the sea ice emissivity model integrates a non linear frequency parameterization to describe the emissivity change from 89 GHz to 183 GHz. The performance of this model was examined : (a) many more AMSU observations are assimilated (b) RTTOV simulations are closer to the observations (see Figure 2) and (c) forecast skills are improved.

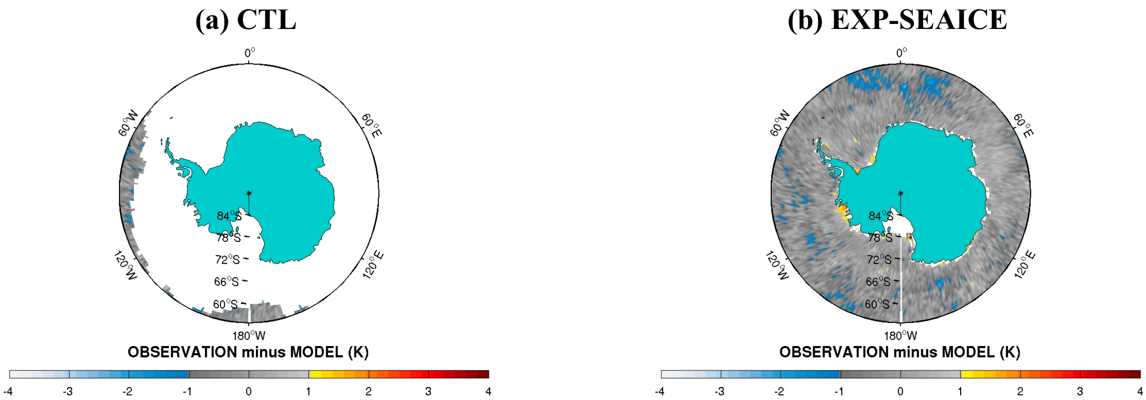

Figure 2 : Departures from First guess for assimilated AMSU-B channel 5 (183.31 ± 7.0 GHz) observations from (a) a CTL experiment and from (b) an experiment making use of a new sea ice emissivity model. Statistics are for 2 weeks (from 25/12/2008 to 06/01/2009)

REFERENCES

Bouchard, A., F. Rabier, V. Guidard, F. Karbou, 2010, Enhancement of satellite data assimilation over Antarctica, Monthly Weather Review, in press.

English, S., 2007: The importance of accurate skin temperature in assimilating radiances from satellite sounding instruments. IEEE Trans. On Geoscience and Remote sens., 46, 403–408.

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

Karbou, F., E. Gérard, F. Rabier, 2010a, Global 4D-Var assimilation and forecast experiments using AMSU observations over land. Part-I: Impact of various land surface emissivity parameterizations, *Weather and Forecasting*, 25, 5–19.

Karbou, F., F. Rabier, J-P. Lafore, J-L. Redelsperger, O. Bock, 2010b, Global 4D-Var assimilation and forecast experiments using AMSU observations over land. Part II: Impact of assimilating surface sensitive channels on the African Monsoon during AMMA, *Weather and Forecasting*, 25, 20–36.