Towards the assimilation of surface sensitive satellite microwave observations over land at Météo-France

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Satellite microwave measurements have large atmospheric and surface information contents and are known to be very useful for Numerical Weather Prediction. However these observations are still not fully used over land because of non negligible uncertainties about land emissivity and surface temperature. Recent developments have been carried out at Météo-France in order to propose new methods for land emissivity and surface temperature modelling anchored on satellite microwave observations. The methods, fully described in Karbou *et al.* (2006), have been 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 dynamically varying emissivities 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 the use of the new methods to assimilate microwave observations over land has been investigated using AMSU-A, AMSU-B and SSM/I observations. The performances of the three methods have been studied in terms of observation departures from first guess and analysis and also in terms of analysis and forecast impacts. So far periods of test have been chosen around the August-September 2005 and 2006 AMMA periods (African Monsoon Multidisplinary Analyses, Redelsperger *et al.*, 2006; Parker *et al.*, 2008). The results show that an important amount of data is assimilated when the land surface emissivity and/or the surface temperature is updated. Even sounding channels that receive a lesser contribution from the surface take advantage of this modification (see Figure 1). The assimilation of surface sensitive channels over land with improved land surface characteristics modelling appears to have a strong impact on the hydrological cycle both in analysis/first guess and short to medium range forecast and is globally beneficial to our analysis and forecast system.

The 2005 experiments show that assimilating AMSU surface sensitive channels over land leads to a moistening in the Tropics and Southern Hemisphere (mainly over sea) and a drying in the Northern Extratropics (mainly over land). Globally similar effects are induced by the three land emissivity / surface temperature schemes, with local differences, as for example, over half North of Africa where the drying – associated to a strong reduction of precipitation - is maximum with the second method (dynamic computation of emissivity), as shown in Figure 2. As a result, the ITCZ moves towards the South, which is an encouraging feature (especially for the AMMA community) as our model usually suffers from spurious heavy rain rates in this region. Very similar results to those obtained with AMSU data have been found when assimilating SSM/I channels over land. The impact on forecast skills is globally neutral to positive for geopotential, temperature and humidity. Differences in the response of each of the methods are noticeable but more investigation is needed to decide between them for an operational implementation. These results should be considered as preliminary results and need to be re-evaluated in the light of other developments, such as the variational bias correction (VarBC) as developed at ECMWF (Dee, 2005; Auligné *et al*., 2007) – ongoing experiments under evaluation -, the tuning of observation error over land and the introduction of error correlation between channels.

References

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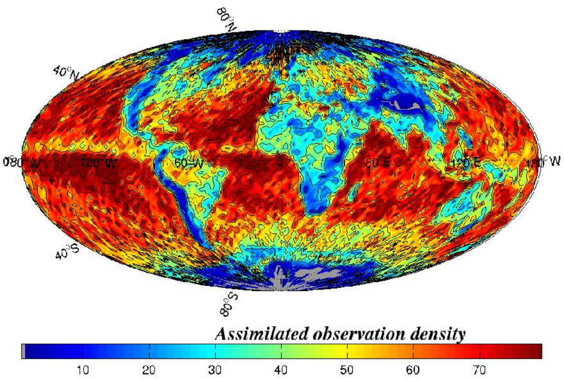
(a) Control



(b) Experiment

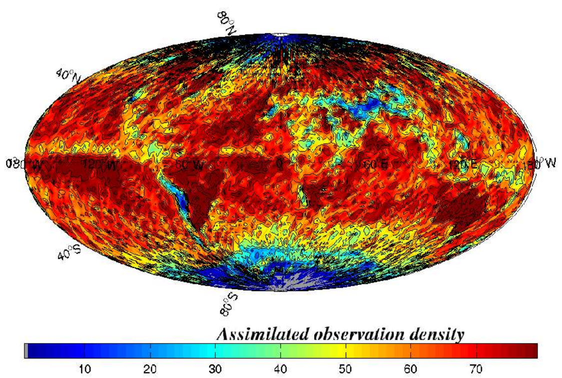


Figure 1*:* Density of assimilated observations (number of assimilated observations over a 2°x2° grid) from AMSU-A channel 7 and over August 2006. Results are given for (a) the control and for (b) an experiment that uses dynamically varying emissivities derived at AMSU-A channel 3.

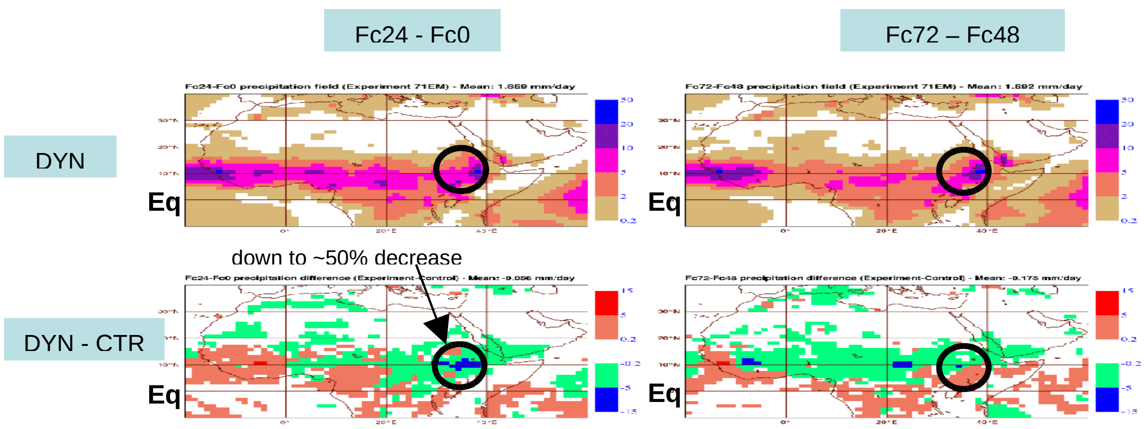


Figure 2*:* Mean 24-hour cumulated precipitation field (15 August-3 September 2005) over half North of Africa at day 1 (left panels) and day 3 (right panels) forecast ranges for the experiment using surface sensitive channels over land based on method 2 (top panels) and the difference between this experiment and the reference run (without AMSU surface sensitive channels over land) (bottom panels). Units are in mm.day^{-1}.