Assessing the impact of the SAPHIR microwave sounder on board Megha-Tropiques into the ARPEGE global model

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The Megha-Tropiques satellite is a joined Indo-French mission (CNES/ISRO) dedicated to the study of the water cycle and energy budget in Tropical regions. The core payload is composed by three radiometric instruments, amongst which, the microwave sounder SAPHIR. With six channels, SAPHIR provides information on atmospheric water vapour at different altitudes. The main original feature of Megha-Tropiques is to provide observations with a high time frequency thanks to its orbit that makes a slight angle with the Earth's equatorial plane. Therefore it is possible to observe a given area over the Tropics 3 to 6 times per day. In consequence, the number of humidity observations provided by microwave instruments is significantly increased along the Tropical belt.

Figure 1 illustrates the large fraction of the Tropics, which is observed during a 6-hour assimilation window. One can also see on Figure 1 that the main characteristics of the water vapour field observed with SAPHIR (Figure 1-(a)), such as dry air areas over South America and the Southern Pacific Ocean (red areas), are also present in the ARPEGE 6-hour forecast (Figure 1-(b)). Large discrepancies can also be noticed between observed and simulated brightness temperatures in rainy areas (blue areas), like for the mesoscale convective systems crossing West Africa. Indeed the use of observations, in cloudy and rainy systems, is more challenging than in clear sky conditions and are not simulated nor assimilated yet within the ARPEGE operational forecasting system.

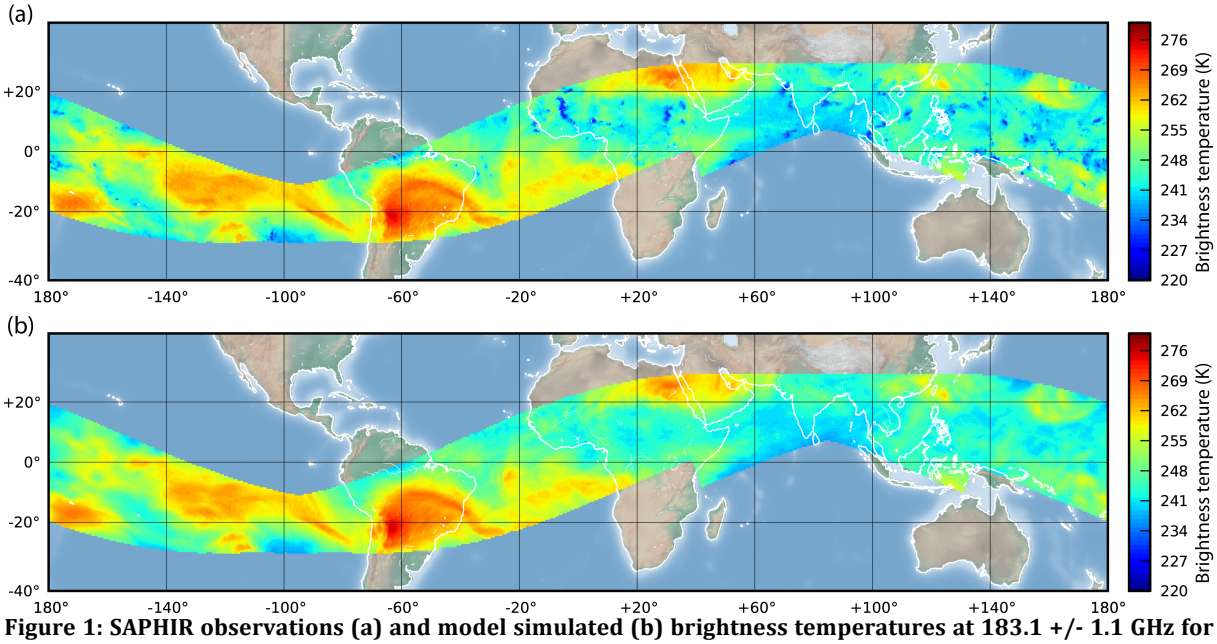

Figure 1: SAPHIR observations (a) and model simulated (b) brightness temperatures at 183.1 +/- 1.1 GHz for the ARPEGE 6-hour assimilation window on July 2nd, 2012 at 0h00 UTC.

The SAPHIR brightness temperatures have been assimilated in a recent version of the ARPEGE 4D-Var assimilation system over a two-month period in Summer 2012

(experiment noted EXP below); its impact is assessed compared to an experiment only monitoring SAPHIR (noted CTRL below). Figure 2-(a) shows the better agreement of model simulated brightness temperatures and observations that can be noted in the EXP with respect to the CTRL experiment, for SAPHIR observations and MHS on board MetOp-A. A similar improvement of innovation statistics was also found for other microwave sounders such as AMSU-B on board NOAA-18 or MHS on board NOAA-19, as well as for Infrared water vapour channels of SEVIRI/Meteosat-10 or HIRS/MetOp-A (not shown). These improvements in the EXP experiment with respect the CTRL experiment demonstrate the positive synergy of Megha-Tropiques data with the present observing system.

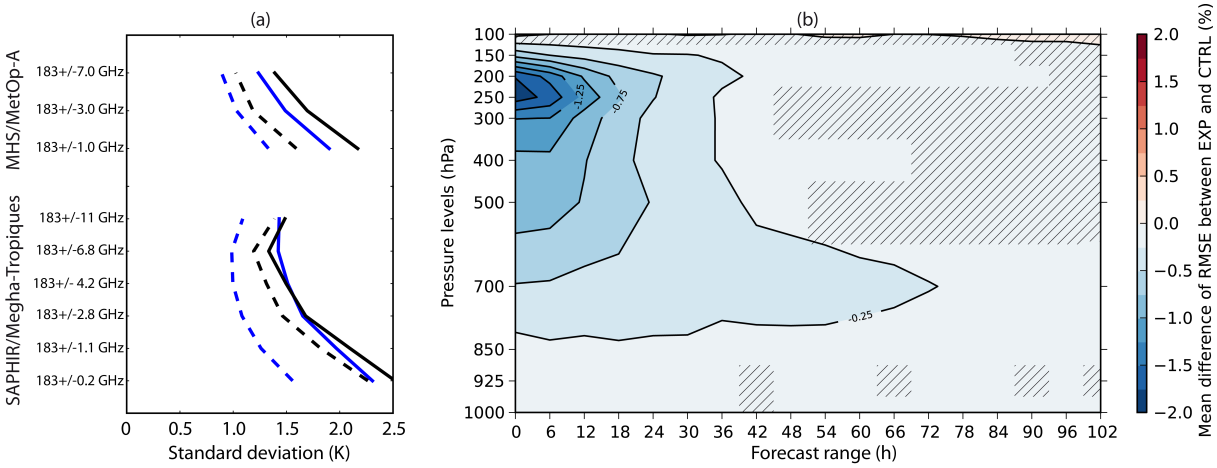

Figure 2: (a) Standard deviation of first guess departures (full lines) and of analysis departures (dashed lines) for the CTRL (black lines) and the EXP experiments (blue lines) over the tropical band, for SAPHIR and MHS/MetOp-A. (b) Difference of Root Mean Square Error between the EXP and the CTRL experiments compared to ECMWF analysis as function of forecast range. An improvement in the EXP experiment corresponds to a negative difference of RMSE. Areas that are not dashed indicate differences of RMSE which are significant at the 99% level of confidence.

In order to evaluate differences in the EXP and the CTRL model forecasts, relative humidity fields are compared with ECMWF operational analyses which are used on a regular grid of 1.5°. The comparison reveals that the most significant improvement can be found during the first 12 hours of forecast between 400 and 150hPa (Figure 2-(b)); it represents a relative decrease of roughly 10% of the RMSE between the CTRL and the ECMWF analysis. A statistically significant impact can also be seen up to 72 hours of forecast between 800 and 700hPa but represent a smaller relative reduction of the RMSE of the CTRL, between 1% and 2%. This improvement up to 72 hours at 700 hPa can also be identified by comparisons with radiosonde data, with a similar magnitude of 1% to 2% (not shown).

Plans are made to assimilate SAPHIR data in a future version of the Météo France operational global forecasting system ARPEGE, as well as in the four regional models ALADIN along the Tropical belt covering French Overseas Territories. More details on SAPHIR data impact evaluation can be found in Chambon et al. (2014).

Reference:

Philippe Chambon, Louis-François Meunier, Frank Guillaume, Jean-Marcel Piriou, Rémy Roca and Jean-François Mahfouf, 2014: Investigating the impact of the water vapour sounding observations from SAPHIR on board Megha-Tropiques into the ARPEGE global model (In preparation for Q. J. R. Meteorol. Soc.)