Assimilation of GOES16 ABI radiances in ARPEGE model

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Introduction

A large part of assimilated observations in the global ARPEGE model of Météo-France comes from infrared radiances. Even if the majority of these data are provided by hyperspectral instruments such as IASI, CrIS and AIRS, geostationary imagers provide in clear sky conditions frequent data over the same area. Up to now, observations from geostationary infrared sounders were assimilated in the global model as Clear Sky Radiances which represent an average of clear radiances present over a spatial grid. Here we presents a study on the assimilation of GOES-16 ABI radiances in the global model ARPEGE.

Experimental set up

Only 3 channels sensitive to upper-tropospheric water vapour and temperature (640 nm, 860 nm and 1380 nm) have been considered for the assimilation. These 3 channels have not been used over sea ice.

	Sea		Land
Channel	clear sky	low clouds	clear sky only
2 - 6150nm	Yes	Yes	Z > 1000 m
3 - 7000nm	Yes	Yes	Z > 1000 m
4 - 7400nm	Yes	No	No

For each channel, observation errors are specified considering surface and cloud conditions and are given in the following table.

	Sea		Land
Channel	clear sky	low clouds	clear sky only
2 - 6150nm	1.2 K	1.2 K	1.8 K
3 - 7000nm	1.2 K	1.3 K	1.8 K
4 - 7400nm	1.2 K	-	-

Inter-channel observation error correlations (obtained from a Desroziers diagnostic) were considered and specified in the following correlation matrix of observation errors :

$$C_R = \begin{array}{c} \begin{array}{ccc} \mathbf{2} & \mathbf{3} & \mathbf{4} \end{array} \\ \begin{pmatrix} 1.00 & 0.92 & 0.59 \\ 0.92 & 1.00 & 0.76 \\ 0.59 & 0.76 & 1.00 \end{pmatrix} \end{array}$$

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Biais correction

VarBC is used to compute the biais correction. It performs well with a strong spatial dependency. Figure 1 shows an example of bias correction for channel 2 (left) on November 10, 2020. Same patterns are observed throughout the duration of the experiment. The bias correction also shows a strong dependence on the assimilation base time. This should be taken into account in future work. Figure 1 shows the evolution of the bias correction throughout September 2020.

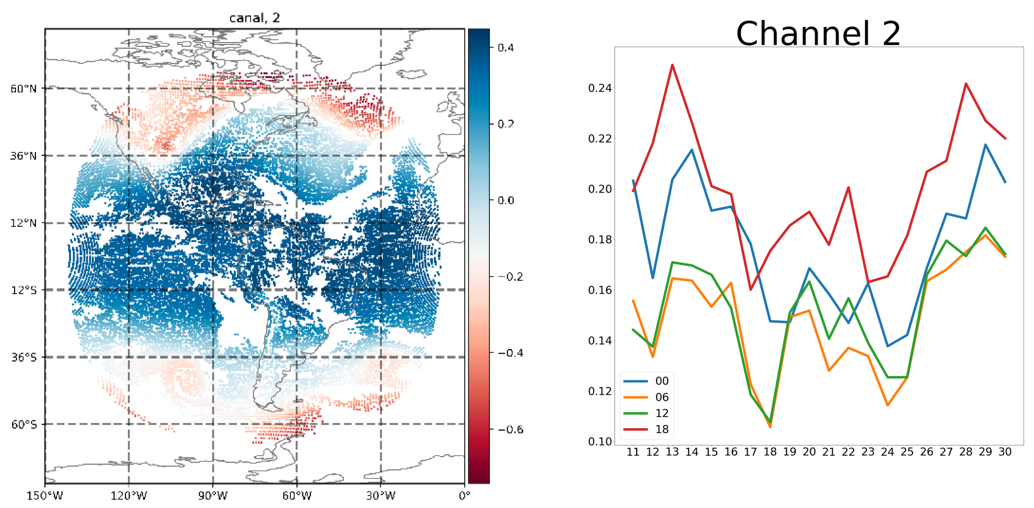

Figure 1: Biais correction (K) for channel 2 on November 10, 2020 (left). Evolution of Biais correction (K) for channel 2 throughout November 2020 for the 4 analysis times (right)

Impact on analysis

The assimilation of GOES16 ABI radiances allows for better analysis. For example (Figure 2), the standard deviation of the first guess departure of ATMS over tropics is improved, especially for humidity channels. Same results are obtained for AMSUA or MHS and over extratropical regions.

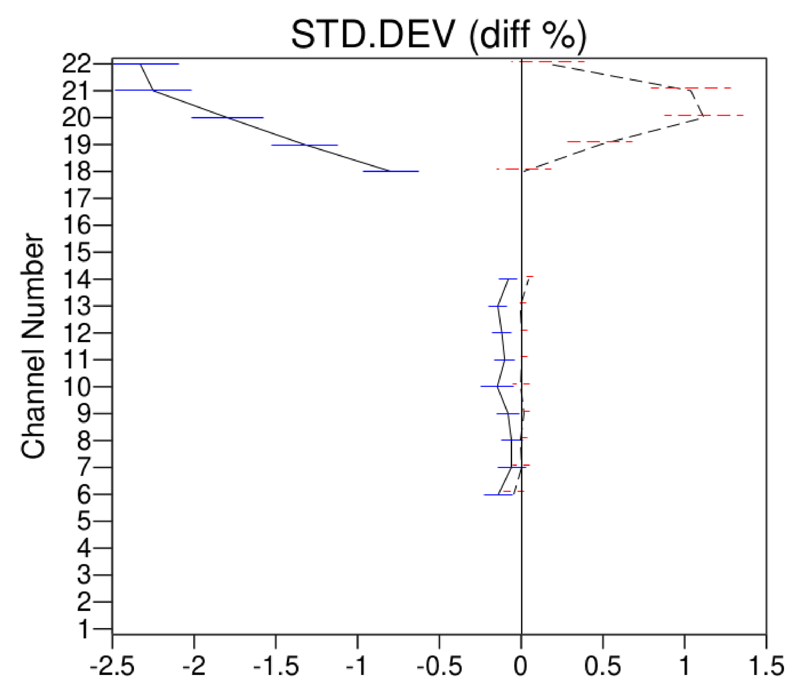

Figure 2: Difference of the standard deviation of the first guess departure (solid lines) between a control experiment and an experiment assimilating ABI radiances for ATMS over tropics over a period from September 10, 2020 to December 10, 2020. Horizontal blue lines represent the confidence interval.

Impact on forecast scores

The assimilation of GOES16 ABI channels 2, 3 and 4 leads to an improvement of the forecasts on each of the three main domains (Tropics, and extra-tropical regions of the Northern and Southern hemispheres).
The most significant improvement is in mid-troposphere temperature forecasts in the tropics at all forecast ranges. For each of the three main domains, the forecast of the temperature in the stratosphere is significantly improved. Degradations of the temperature forecast in the very low layers remain. Work is in progress to understand the origin of this degradation and to deal with it.
The results on the moisture fields show an improvement on the three main domains up to 40 hours of forecast in mid-troposphere and upper troposphere. The same degradation than in temperature fields is noticed in the very low layers. A degradation of the humidity near the tropopause is shown and could be related to numerical aspects.

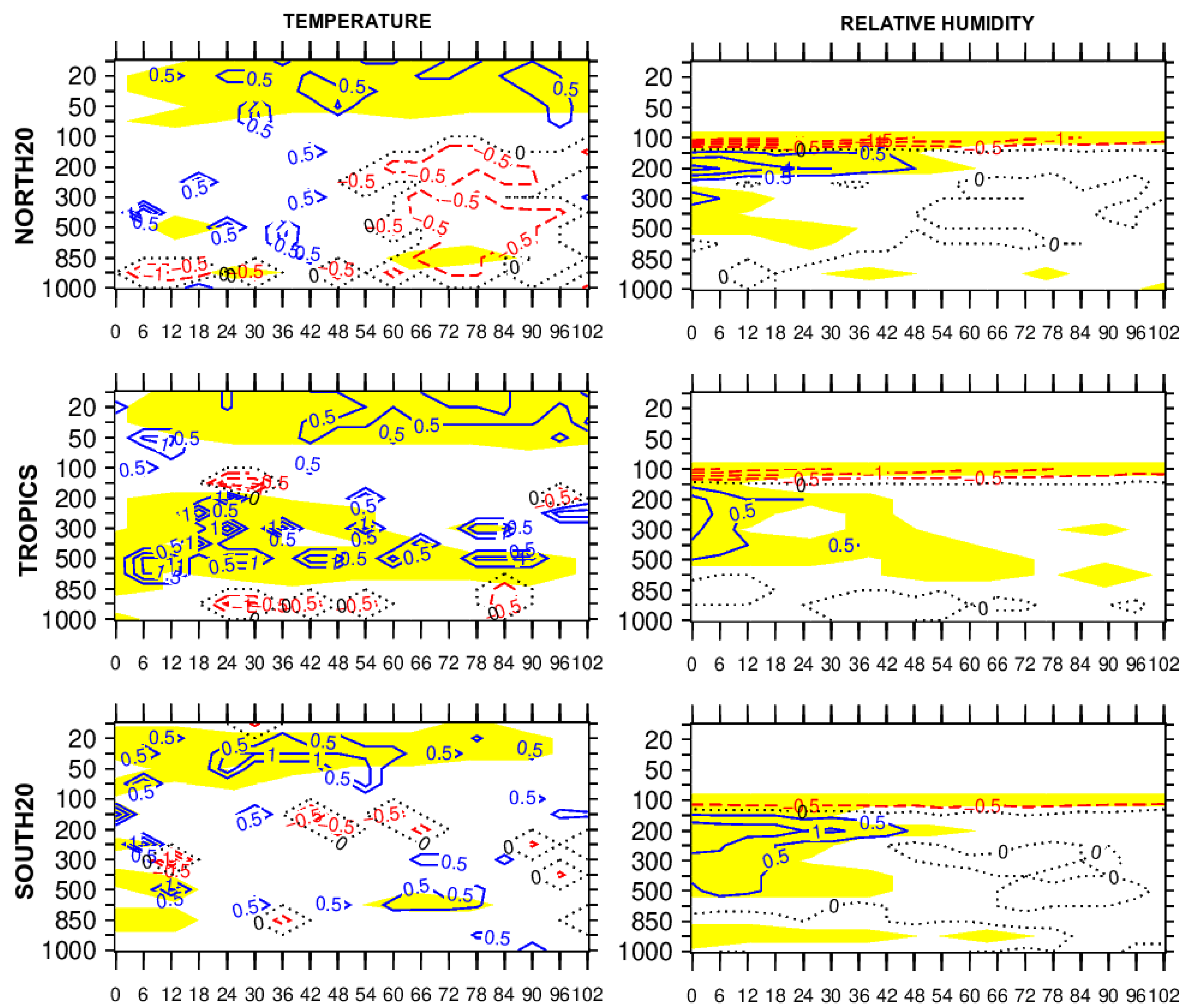

Figure 3: Relative difference of Root Mean Square Error with respect to the ECMWF analysis between a control experiment and an experiment assmilating GOES16 ABI channels 2,3 and 4 over a period from September 10, 2020 to December 14, 2020. Blue isolines stand for improvement compared to the control experiment. Yellow areas represent a significant difference.

Conclusions

The assimilation of GOES16 ABI channels sensitive to upper-tropospheric water vapour and temperature leads to improvement of the forecast (especially over tropics) and will be put in operations in a near future. Future studies will be conducted to evaluated GOES16 ABI radiances against former ABI products.