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ASSIMILATION OF AIRS HYPERSPECTRAL RADIANCES AT MSC

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1. INTRODUCTION

The AIRS instrument (Atmospheric Infrared Radiance Sounder), launched in 2002, provides 2378 channels covering the infrared spectrum from 3.7 µ to 15.µ. Numerical weather prediction (NWP) centers, including MSC, typically use a subset of 281 channels. AIRS represents a first opportunity to evaluate the impact of such hyperspectral radiances in NWP analyses and forecasts. This is an excellent preparation for IASI (Infrared Atmospheric Sounding Interferometer, ~8400 channels), planned for 2006, which will have an operational status (as opposed to AIRS which will not be replicated). This paper presents the approach chosen at MSC for AIRS assimilation and first results from assimilation cycles.

2. AIRS PROCESSING

2.1 *Channel selection*

MSC still has its forecast model top at 10 hPa. It is planned to raise it to 0.1 hPa in 2007. Thus channels with a significant contribution above the model top cannot be used, essentially those with wavelength higher than 14.5 µ. For the same reason, ozone is not part of the current assimilation system. Hence channels sensitive to ozone cannot be used. Other factors leading to the elimination of channels include: large errors in forward modeling, channels with complex Jacobian shapes (notably among water vapor channels), channels with significant trace gas contributions (e.g. CH_4, CO) and highly redundant surface sensitive channels, mainly those with wavelength smaller than 4.1 µ. In the experiments to be presented here, 105 channels are selected for assimilation.

3.2 Data preparation

The processing steps leading to the assimilation are described in Garand and Beaulne (2004). Essentially these steps are: 1) determination of cloud amount and cloud emissivity involving our adaptation of the CO_2 slicing technique; 2) bias correction from clear fields of view assuming either a constant (flat) bias or a bias which varies linearly with the observed brightness temperature; 3) use the local response function dtau/dp where tau is the total transmittance to determine those radiances which are not affected by clouds. Thus radiances which are sensitive to the middle or upper atmosphere can be assimilated if not sensitive to the presence of lower clouds. The RTTOV radiative transfer model is used. The AIRS files contain one pixel out of 9, i.e. the center pixel in a 3 X 3 array. Recently (July 2005), an alternative file providing the warmest pixel became available. That file will be used in the future which should increase the volume of data judged suitable for assimilation.

2.3 Observation error

The well known Holligsworth and Loonberg (1986) was used to separate the total error obtained from statistics of observed minus calculated radiances (O-P) into is observation and model components. As well inter-channel correlations were studied (Garand et al., 2006).

Fig. 1 shows that separation while Fig. 2 shows the correspondence between wavenumber and channel index. The 105 channels to be assimilated are those from channel index 19-123. The first 18 channels were eventually left out because their contribution above the model top was found non negligible.

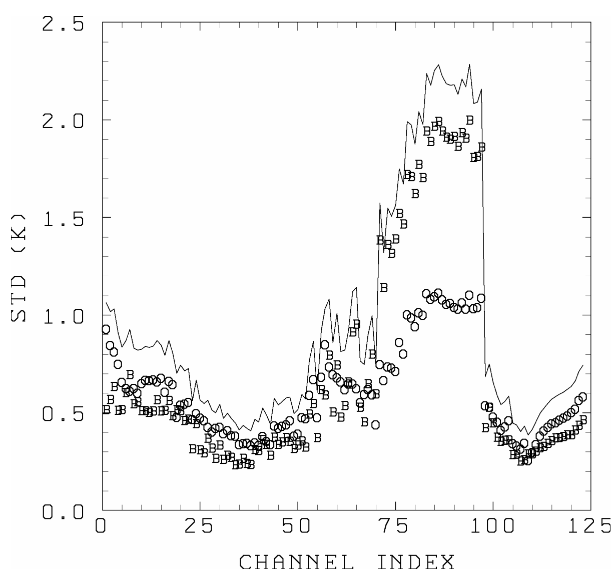

Fig. 1. Separation of the total (O-P) error (K) into its observation (O) and background (B) components.

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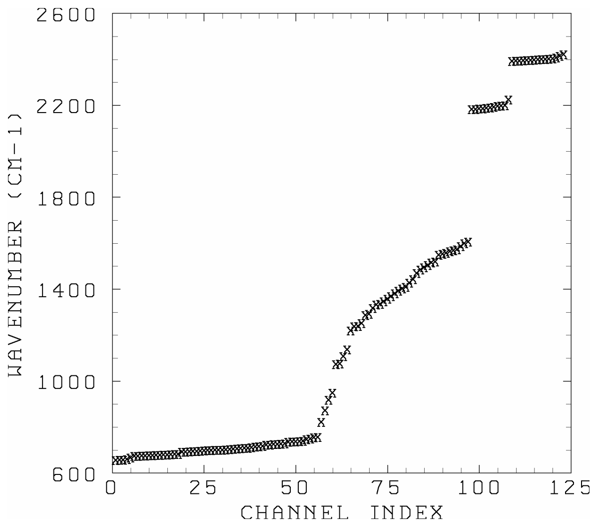

Fig.2. Wavenumber versus channel index corresponding to Fig. 1.

3. ASSIMILATION

3.1 *Setup*

The 3D-Var data assimilation system was used for these first assimilation tests. Currently the 4D-Var system is operational, but the computer resources required to run 4D-Var assimilations are considerable and the turnaround is slow. Therefore the strategy is to do a maximum of tests in 3D-Var mode first. The 2-week period 14-29 February 2004 was selected. The AIRS data were thinned at the scale of 250 km to emulate what is done for AMSU data. All data which were available at that time are assimilated, defining the CONTROL experiment. These include AMSU-A and B from several NOAA satellites and GOES-10 and 12 imager 3 (water vapor channel). AMSU-A data from AQUA, the same satellite carrying AIRS, were not assimilated at that time (implemented in Sept. 2004). Instead of using the observation error estimated in Fig. 1, the total (O-P) variance was used to define the observation error. This was done to compensate for the inter-channel error correlation and again to follow what is done for AMSU data. The CONTROL experiment is compared to CONTROL+AIRS. Forecasts up to 5 days were made.

3.2 Results

Results obtained for these first assimilation cycles are best summarized in terms of 500 hPa correlation anomaly. Results obtained at other levels carry the same general conclusions. Fig. 3 indicates a large positive impact in the southern hemisphere. The gain in predictability is of the order of 6-8 hours on day 5. These results are very comparable to those presented by LeMarshall et al., 2006 (this conference). In contrast, there is no appreciable gain in the northern hemisphere. There is in fact a slight degradation on day 5. This mitigated result in the northern hemisphere is typical of first results obtained at other centers with AIRS. Many more tests are needed including longer time periods, longer forecasts, adjustment of the observation error (including research to properly consider inter-channel error correlations), refining the thinning procedure and quality control. Also the use of the warmest pixel should prove beneficial.

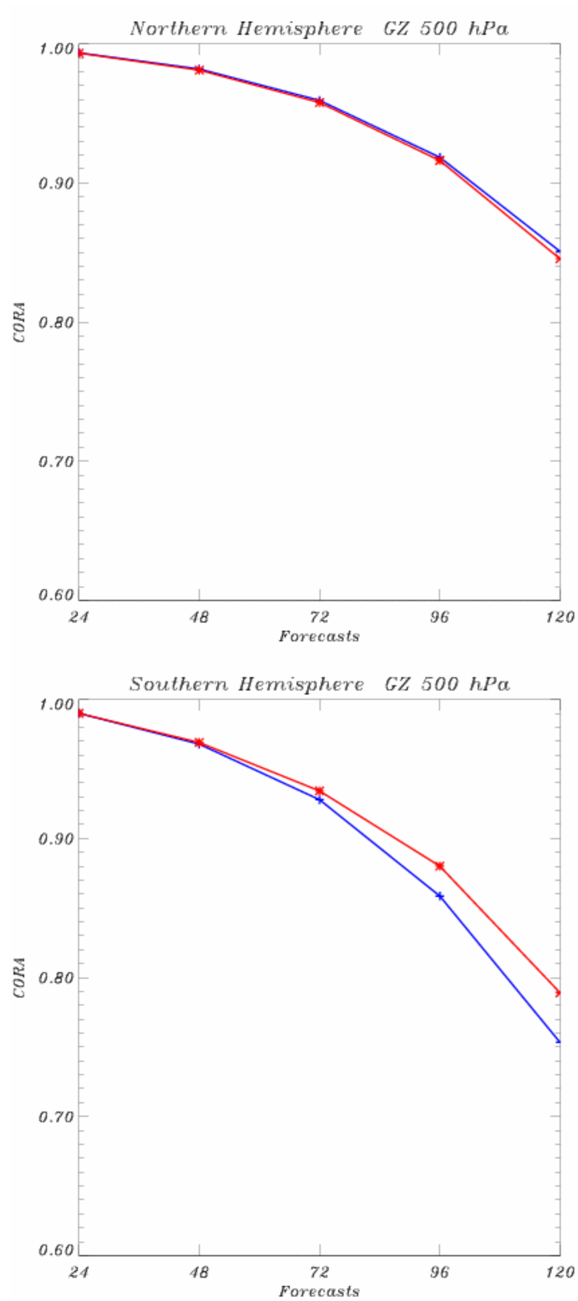

Fig. 3 500 hPa anomaly correlation up to 5 days for the CONTOL (blue) and CONTROL+AIRS (red) experiments in the northern hemisphere (top) and southern hemisphere (bottom). A linear bias correction for AIRS is used.

Fig. 4 compares CONTROL+AIRS cycles made using either a constant brightness temperature correction or one based on a linear dependency with the observation itself. This effect is mostly pronounced in water vapor channels where departure from the constant bias may reach 2 K. The linear bias correction provides slightly better results in the southern hemisphere and near neutral results in the northern hemisphere.

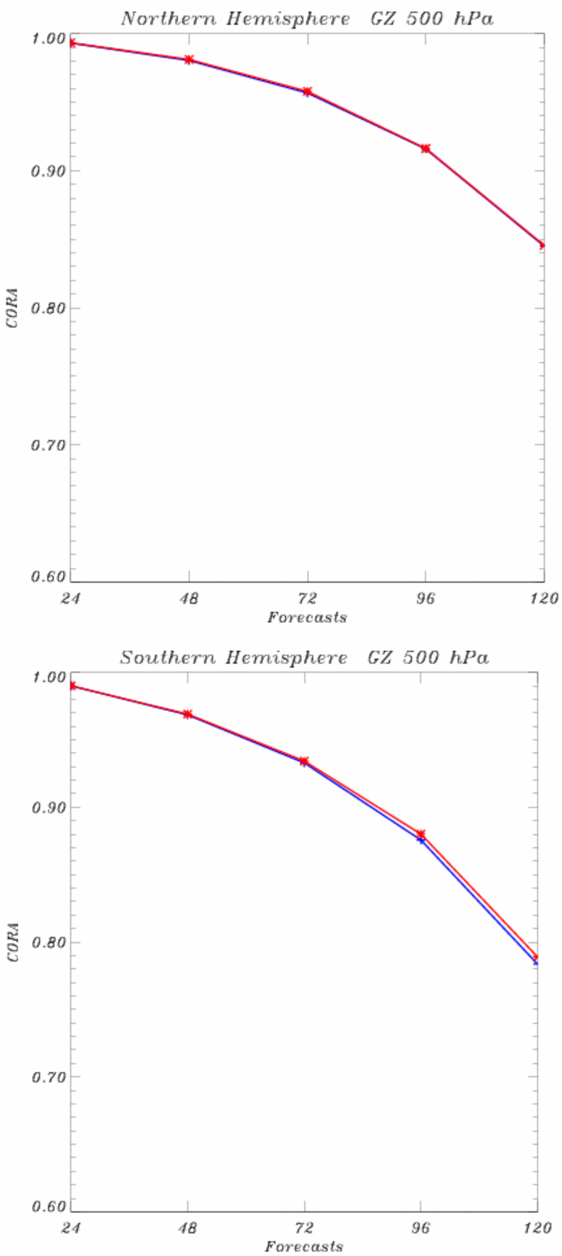

Fig. 4. Same as figure 3, but for CONTROL+AIRS with flat bias correction (blue) compared to CONTROL+AIRS with linear bias correction (red).

4. CONCLUSION

First assimilations tests with AIRS data at MSC show a strong positive impact in the southern hemisphere. We are confident that with further adjustments, positive results will be confirmed in the northern hemisphere as well. More results will be available at the time of the conference. In particular we would like to show the impact of AIRS in the operational 4D-Var system as opposed to that in the 3D-Var system presented here.

5. REFERENCES

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