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Comparison of CPTEC AIRS L2 intercomparison and validation with Met Office IASI L2 intercomparison and validation

S. Costa

INPE/CPTEC/DSA

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NWPSAF Visiting Scientist Report
Comparison of CPTEC AIRS L2 intercomparison and validation with Met Office IASI L2 intercomparison and validation.

Simone Costa
INPE/CPTEC/DSA

Introduction:

Knowledge of temperature and humidity field distribution is essential for a wide variety of applications, such as meteorological weather forecast, data assimilation and nowcasting. In other to provide temperature and humidity fields, retrieval schemes base on the radiances observed by satellite have been developed and freely distributed to the meteorological centers. In general, sounding retrieval are based on modifying the surface and atmospheric temperature/moisture profiles in a manner such that brightness temperatures calculated agree with those observed from satellite, within some uncertainty estimate.

Satellite and Environmental System Division (DSA) of Center for Weather Forecast and Climatic Studies – (CPTEC/INPE) receives data from different sensors and employ operationally six different sounding retrievals schemes in near real time:

- Ma et al, 1999 (sounder/GOES10);
- IAPP - International ATOVS Processing (HIRS/ NOAA18)
- IMAPP - International MODIS/AIRS Processing Package (MODIS/TERRA, MODIS/AQUA and AIRS/AQUA)
- Susskind et al. , 2003 (AIRS/AQUA).

Costa et al. (2009) analysed the performance of the above retrieval schemes and initial results showed that the IMAPP algorithm applied to AIRS/AQUA sensor data can capture interesting features, which are not captured at all by other methods. It was unclear if this was due to real skill in the IMAPP system, or a chance result, but it merited further investigation. Understanding the performance of different methods using different approaches to optimising the information contained in the spectra, different RT models and different constraints, could show which scientific strategies are proving most successful in extracting the finer scale information from hyperspectral measurements.

In this context, the NWPSAF approved a visiting scientist visit to the Met Office in order to compare with 1D-var and study sensitivity to some 1D-var parameters. The study aimed to compare two different and independent retrievals applied to AIRS sensor in order to see what consistency there is between them and in particular which scientific retrievals options are giving most encouraging results. The results present here are only preliminary, more data and investigation must be done in order to have better conclusions.

Methodology

This study aimed to compare the IMAPP scheme with the NWPSAF one-dimensional variational scheme (1DVar) version 3.1, which is an NWPSAF supported software package. It was more straightforward to use the Met Office implementation of the scheme which is used for operational processing of AIRS (Cameron ????). IMAPP was developed from the operational Earth Observing System processing software developed at NASA and Jet Propulsion Laboratory. The two sounding retrievals were compared with the radiosonde data from the mini-BARCA experimental campaign in Brazil. The campaign, which was aimed to understand the Amazon region as a regional entity, occurred during 9 to 30th June 2008.

The Met-Office archive of operational files are kept only for 6 months and these are needed to re-run the operational 1D-var AIRS processing, so the retrieval cannot easily repeated using the background that was operational at the time. However June 2008 was a standard test period for changes, so it was possible to run a trial that will be quite similar to the operational set-up. In this study we wanted to see the performance of the 1D-var for all observations, so some of the checks for normal operational processing were removed. In particular data were processed for almost all values of initial cost (the rejection threshold was increased from 0.7 to 7.0, which is the maximum 1D-Var cost for an observation to be considered to have properly converged). The Observed and Background (O-B) window check was reduced from -2K to -10K and the maximum cloud cost increased from 0.4 to 10. This changes is for increasing the data available for the study. However it must be kept in mind that many observations which would not be considered for operational assimilation were processed in the study. The normal Met Office channel selection for AIRS is very conversative. For this study initial runs used more channels but later experiments used the operational set (see Annex 1).

Results

Figure 1 shows the vertical temperature profiles observed by radiosondes for Carolina (06:00 UTC) and Rio Branco (18:00 UTC) using all the retrievals system at DSA. Additionally, it presents the vertical profiles retrieved by IMAPP-AIRS (product resolution 50 km). The retrieval is the closest observation to the radiosonde. The IMAPP algorithm captures much of the structure in the temperature vertical structure close at the surface, such as the temperature inversion. This good performance by the AIRS sounder matches the aspiration for the instrument because it provides radiances in thousands of channels for single field of view, yielding to significant increase of information about gases absorption and emission, mainly close to surface. However in practise such performance has remained elusive. Therefore it is important to understand whether this structure represents real skill or simply a chance fit of a more loosely constrained analysis system (which could generate erroneous structure as easily as real structure).

Similar comparisons were developed using Met Office 1 D-Var retrievals. All points of the 1D-var products that were in a distance smaller than 100 km from radiosonde launch site were considered in the study. The 1D-Var background and retrieval temperature profiles were compared with radiosonde observations and retrievals profiles (IMAPP) (Figure 2). Blue lines are the deviation of 1D-var retrieval in relation to 1D-var background, while green lines are the deviation of 1D-var retrieval to IMAPP retrieval. Black and magenta lines are the deviation of observed profile (radiosonde) and 1D-Var background, and deviation of 1D-var background in relation to IMAPP retrieval.

Assuming the first guess error covariance matrix that runs operationally on the 1DVAR system (Fig. 2), it is found that Met Office retrievals also captured interesting features observed in the radiosonde profiles, such as:

- the temperature inversion close to surface (Fig. 2 c) in agreement with IMAPP results;
- the humidity structure around 700 – 1000 hPa in Fig. 2b is not captured by IMAPP or the background but some 1D-var retrievals capture it very well.
- constant humidity layer around 800 – 950 hPa in Fig. 2c in the background but both IMAPP and 1D-var put in more structure which does not agree.

In particular the radiosonde humidity profile in Fig. 2 b presents a significant reduction in the mixing ratio from 17 g/kg to 12g/kg in the lowest 50 hPa. Some of the Met Office retrievals also capture this reduction and it seems that this feature does not come from the background. This reduction is not well captured by IMAPP retrieval. In general, the Met Office retrievals seem to represent better the mixing ratio features than the IMAPP retrievals when compared with radiosonde data.

Fig. 3 shows the profiles of difference for temperature for the same data shown in Fig. 2. In this study, differences between Met Office and IMAPP temperature retrievals are usually smaller than +/- 2 K, except close to surface, where differences are bigger (up to 4.5 K). Temperature from radiosonde is around 2.0–3.0 K warmer than the Met Office background between 600 and 850 hPa. The difference between the Met Office retrieval and background temperature is smaller than -/+0.5 K for all levels. For several profiles the IMAPP retrievals following structure on a vertical scale in the radiosonde profiles which the 1D-var retrievals make no attempt to analyse. In other words IMAPP is generating finer vertical scales than 1D-var, and in this limited sample this structure appears to often fit the radiosonde rather well. Note in particular Fig. 3C where the Radiosonde-Background and Retrieval-IMAPP are almost a mirror image.

For the Met Office retrieval system was performed other four sensitivities tests:

1) New B matrix (Wlasak formulation) (Fig 4a);
2) As test 1 but with observation errors halved (Fig 4b);
3) As test 1 with operational channel selection (Fig. 4c) e,
4) As test 2 but with original error in the water vapour band (Fig. 4d).

Figure 4 shows the results of the sensitivities tests only for that profile which presents the temperature inversion close to surface (i.e. Carolina, 22 June 2008 at 06:00 UTC). It is clear from 4a that IMAPP is achieving structure in the vertical on a scale theoretically resolvable with AIRS but which is not achieved using the 1D-var.

It is notice that for tests 2 and 4 the difference between the Met Office retrieval and background is bigger than operational mode, mainly because in change in the errors associated to the band 2. It is clear that the 1D-var was very sensitive to the specification of these errors and that halving the error led to unstable behaviour of the analysis system, with severe noise amplification. It is clear from comparison of 4b and 4d that the majority but importantly not all this instablity arises from excessively low errors in the water vapour band. This shows that simply lowering observation errors is not the solution to achieving the structure achieved in the IMAPP retrievals. However a small reduction in observation error may still be justified, and given the high sensitivity to a large reduction in error, may yet have a large impact.

Comparing 4a and 4c shows clearly that the channel selection is having little impact although it was not possible to carry out the experiment with the exact channel selection used for IMAPP.

For these cases, the difference between IMAPP and Met Office retrieval were bigger than using the operational system.

Final Remarks

The results demonstrate that IMAPP and 1Dvar are able to reconstruct some structure in the retrievals in agreement with radiosonde observation. This performance is associated to the AIRS sensor which provides radiances in thousands of channels for single field of view, yielding to significant increase of information about gases absorption and emission, mainly close to surface. IMAPP takes advantage of the full AIRS spectral resolution. However the 1D-var results use only 100 carefully selected channels. The experiments using more or fewer channel showed no sensitivity and there is no evidence to suggest that the channel selection was a major cause of difference between IMAPP and 1D-var results. The results are for only a limited number of case studies and conclusions can not be reached without a more comprehensive data and detailed investigation. However these initial results may indicate IMAPP has structure lacked by 1D-var for temperature, whereas 1D-var is generating more structure for water vapour. Simply changing channel selection or lowering observation for these cases did not make a difference to the 1D-var result. It appears to be a more fundamental problem. However it appears possible that optimal estimation as applied to variational analysis of AIRS longwave CO2 measurements is failing to extract information on the finest scales. IMAPP is definitely creating a profile with more structure. However 1D-var puts in excessive vertical temperature structure when excessively low observation errors are assumed, especially in the water vapour. In conclusion is is likely that there is scope for improving the impact of AIRS with the current channel selection.

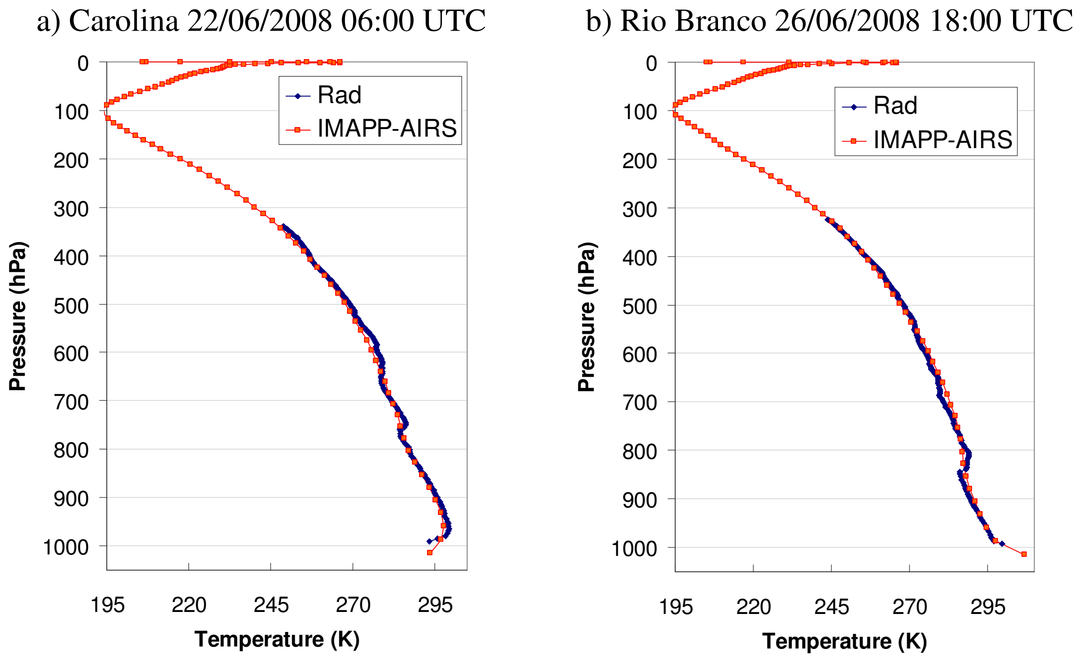
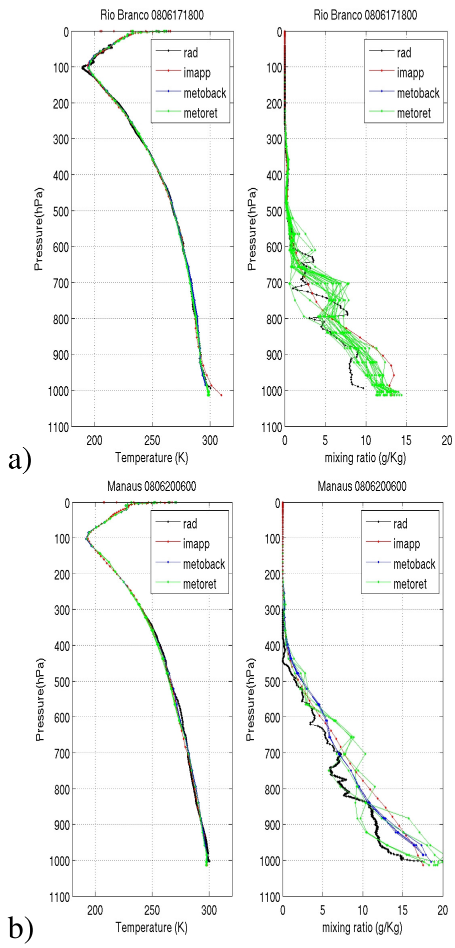


Figure 1 – Temperature vertical profiles from IMAPP (AIRS) and radiosonde.



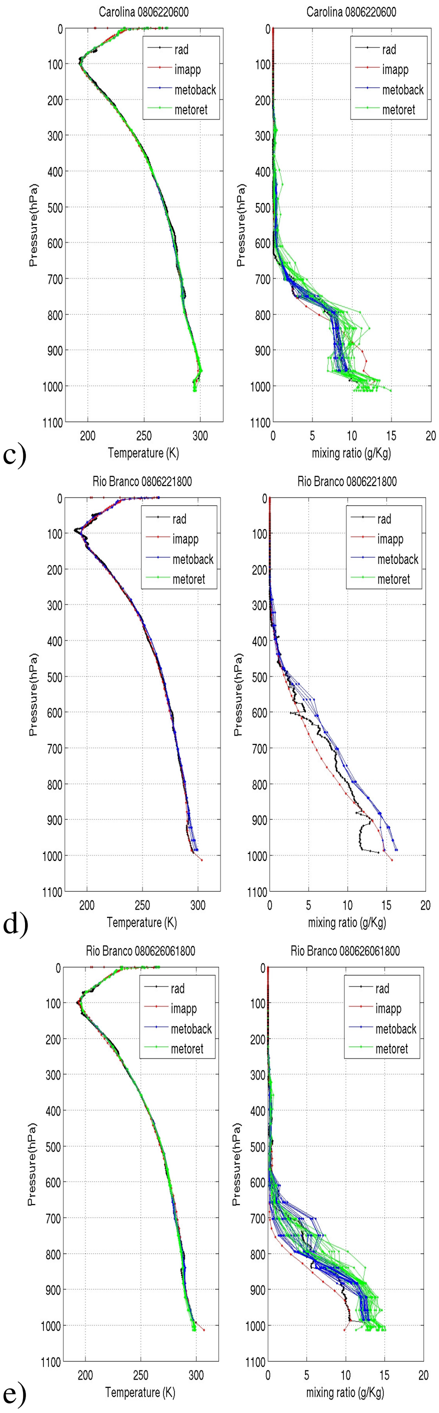
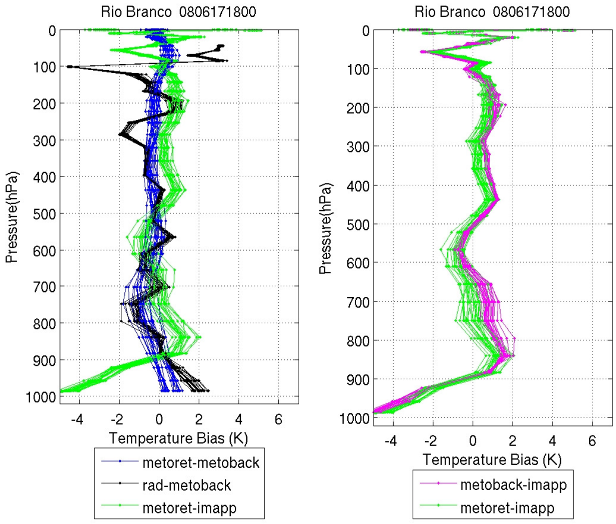


Figure 2 – Temperature and mixing ratio vertical profiles. Black, red, blue and green lines are the radiosonde, IMAPP retrieval, Met Office background and Met Office retrievals, respectively. The Met Office profiles were generated assuming the first guess error covariance matrix that runs operationally on the 1DVAR system.


Rio Branco 0806171800
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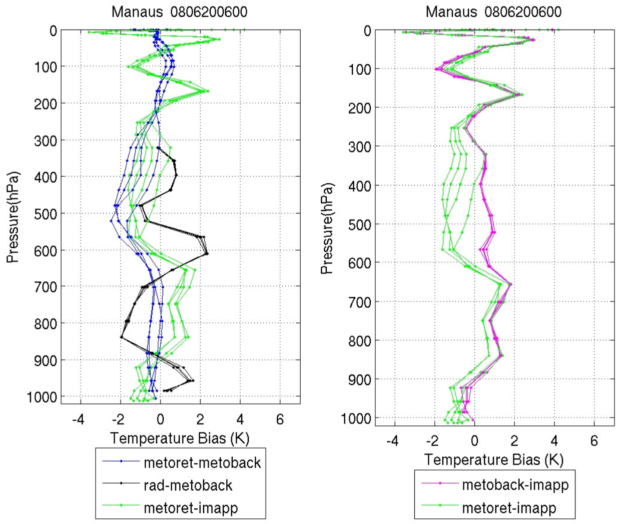
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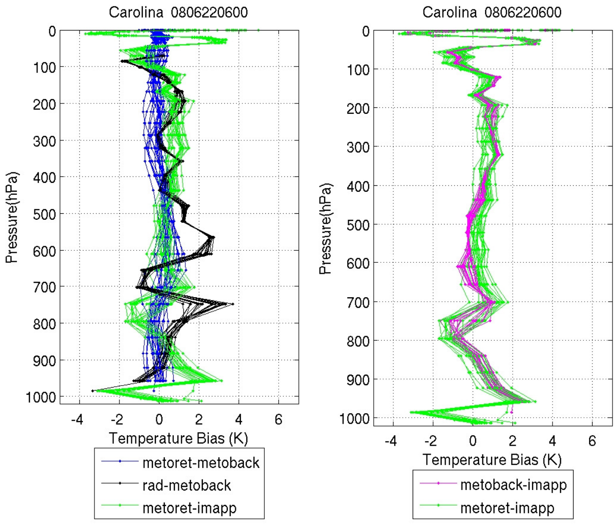
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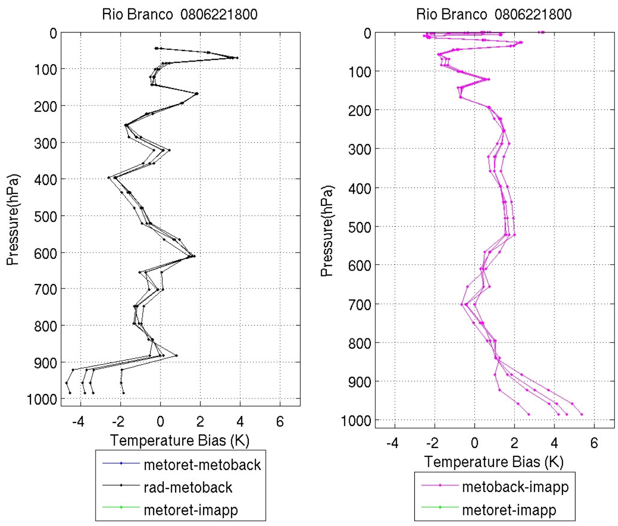
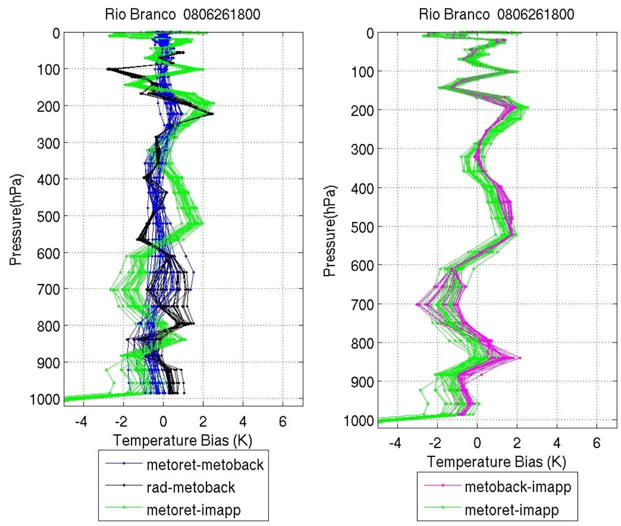


d)



e)

Figure 3 – Comparison between the temperature vertical profiles from Met Office retrieval (metret), Met Office background (metback), radiosonde (rad) and IMAPP retrieval (imapp).

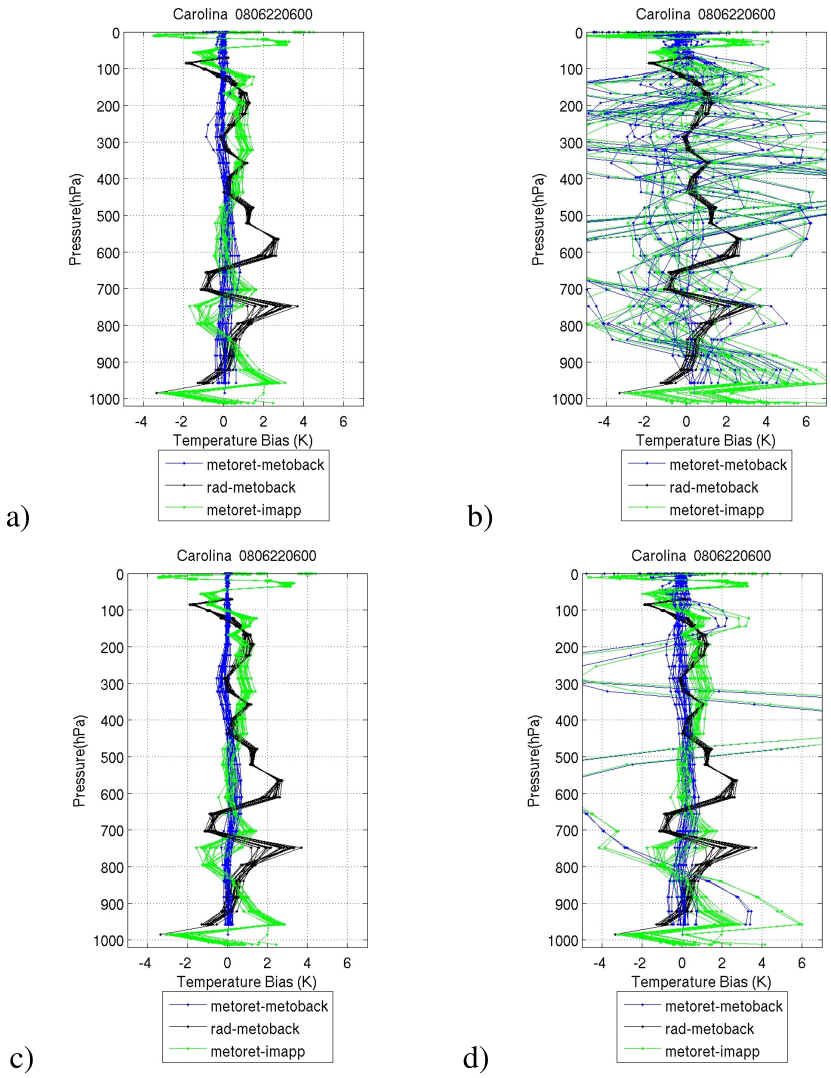


Figure 4 – Comparison between the temperature vertical profiles from Met Office retrieval (metret), Met Office background (metback), radiosonde (rad) and IMAPP retrieval (imapp) assuming different retrievals setups.

Annex 1: Channel selections

Channels in Met Office enhanced selection

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Channels in operational selection

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