IASI retrievals over Concordia within the framework of the Concordiasi program in Antarctica.

CONCORDIASI

METEO FRANCE
Toujours un temps d'avance

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Introduction

Antarctica is relatively data sparse in terms of in situ atmospheric measurements, particularly because of very harsh conditions and a high elevation of the Antarctic plateau. Satellite measurements have the potential to fill these data gaps.

The Concordiasi project [1] was designed in the framework of the fourth International Polar Year. This field experiment occurred during Austral springs 2008-2010. Radiosoundings and stratospheric balloons were launched in order to gather additional in situ measurements over Antarctica.

One of the main goals of the Concordiasi campaign is the improvement of the assimilation of satellite data and, in particular, the validation of Infrared Atmospheric Sounding Interferometer [(IASI); on board of the European polar-orbiting satellite MetOp launched in October 2006] radiance assimilation over the southern polar regions.

This study gives an account of the results of the radiosonde measurements of the Austral spring campaign in 2009, in order to validate the use of IASI observations for temperature and humidity over Concordia.

1. Setup of the experiment

A. Infrared observations and retrievals :

✔ IASI=high spectral resolution sounder providing accurate information about the atmospheric temperature and the composition of the atmosphere.
✔ Important radiative impact of clouds on infrared radiances => study in clear-sky conditions determined by in-situ observations and measurements.

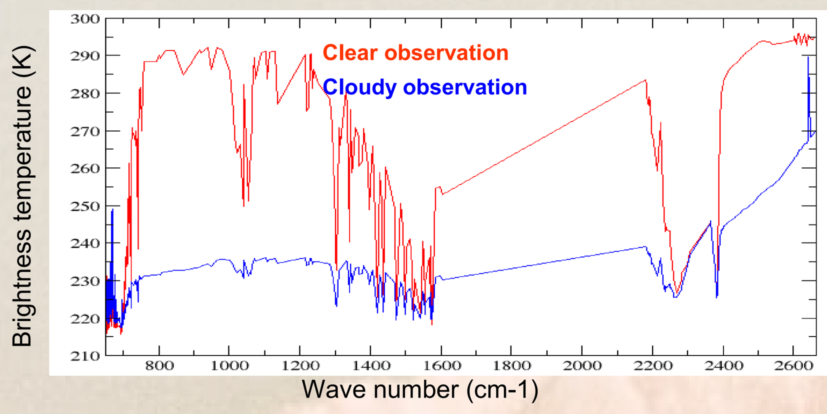


Figure 1 : Brightness temperature depending on the wavenumber for clear observations (red) and cloudy observation (blue).

B. In-situ observations for validation

✔ Measurements made by O. Traullé during his stay at Concordia in November and October 2009 :
Measurements of surface parameters (skin temperature) and wind.
Observation of cloudy conditions.

Olivier Traullé getting the batteries out

✔ Radiosoundings : measurements of the vertical profiles of the atmosphere (temperature and humidity) for the period from the 20th of November until the 12th of December 2009 at 0 UTC.

✔ Baseline Surface Radiation Network (BSRN) data [2] :
Deduction of the surface temperature from the observed upward and downward long-wave radiation measured by the BSRN.
Information about cloudy conditions.

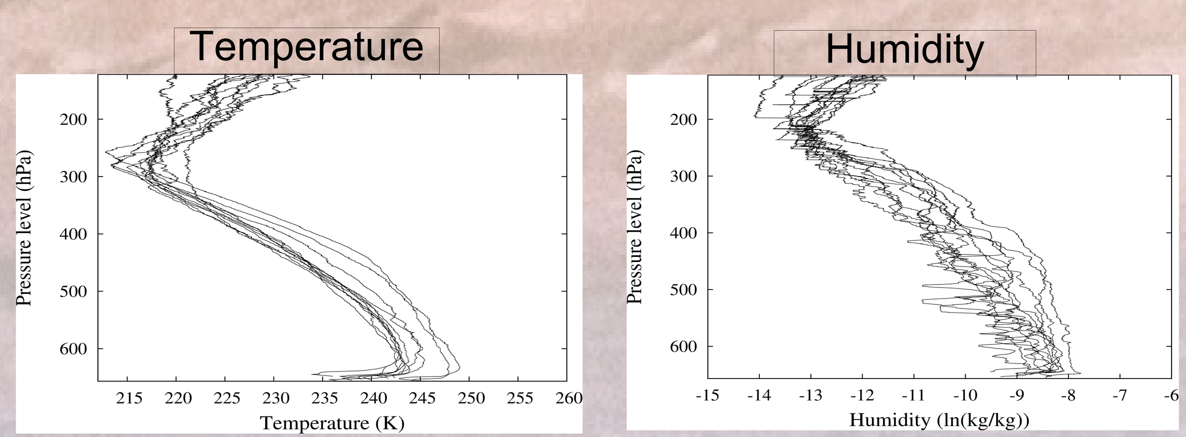
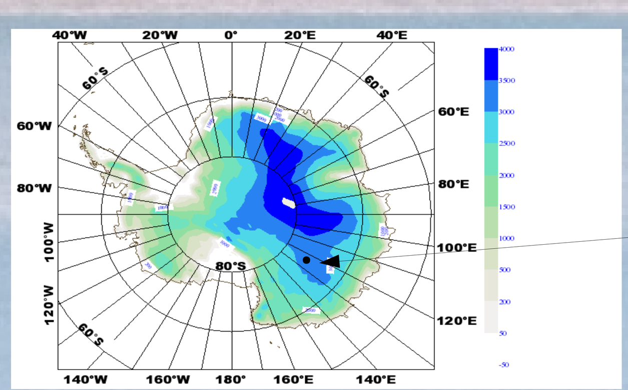


Figure 2 : Profiles of temperature and humidity from radiosoundings and BSRN data (for the surface) for the 11 clear cases of November and December 2009 at Concordia.



2. Description of the 1D-Var scheme

Minimisation of the cost function J :

$$J(x)=\frac{1}{2}(x-x_b)^T B^{-1}(x-x_b)+\frac{1}{2}(H(x)-y)^T R^{-1}(H(x)-y)$$

Choice of 170 channels (based on statistics of difference between observed BT and background and on the shape of the weighting functions).

Observation operator H : RTTOV v8 on 43 levels. ε=0.98

IASI observations. Space and time collocation (37 km away from Concordia and time lapse of 25 min with the RS launching time). Adaptative bias correction (varBC).

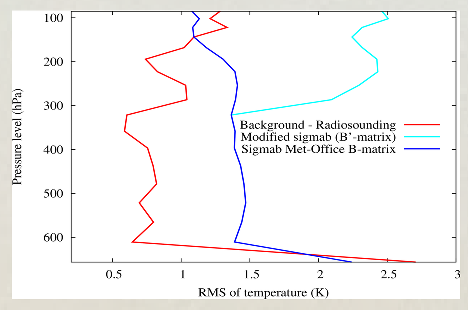
Background profiles from the french global model ARPEGE stretched on Antarctica. Surface temperature and skin temperature from background are used for the retrievals.

NWP-SAF B-matrix : errors for upper-air temperature and humidity are uncorrelated and other correlations are specified.

Operational R-matrix of ARPEGE : diagonal et constant σo for each subset of channels.

3. The 1D-Var experiment

A. Optimization of the B-matrix



✔ In this study, bad estimation of background error standard deviations for stratospheric temperatures => modification of the B-matrix in the stratosphere.
✔ Overestimation of the background variance errors.
✔ Possibility to find a pair of coefficients dividing covariances of the B-matrix on temperature and humidity that provides better retrievals in terms of RMS.

✔ Computation and maximization of the degree of freedom for signal (DFS) [3] : DFS =*Tr*(**I-AB**$^{-1}$)

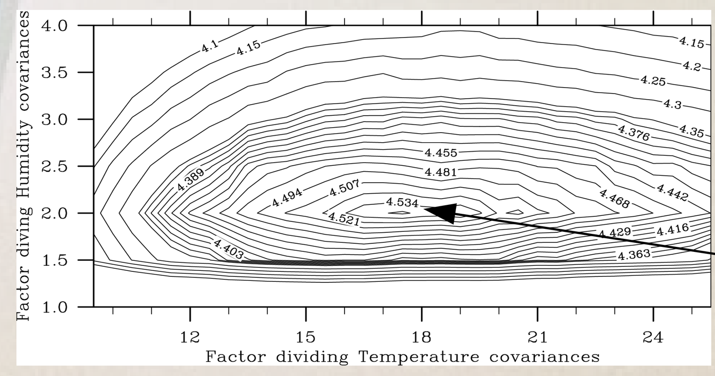


Figure 3: DFS isolines depending on coefficients dividing temperature and humidity covariances when using the Met-Office B-matrix modified for stratospheric temperature and the R-matrix of ARPEGE.

Maximal DFS for αT=17,5 et αQ=2

B. Results

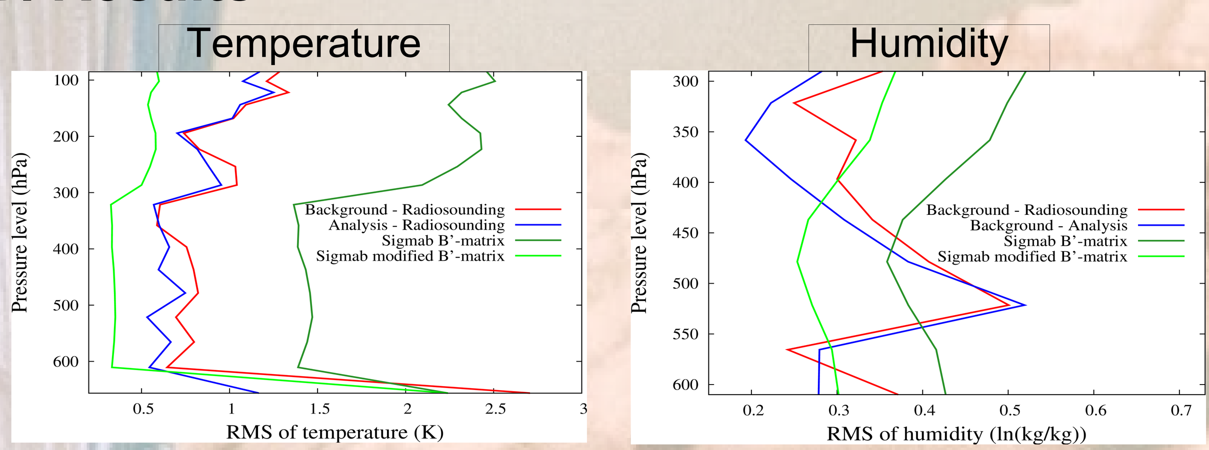


Figure 4 : RMS errors computed with respect to radiosounding for temperature (left) and specific humidity natural logarithm (right) for background profiles and retrieved profiles. Background error standard deviations are represented in green.

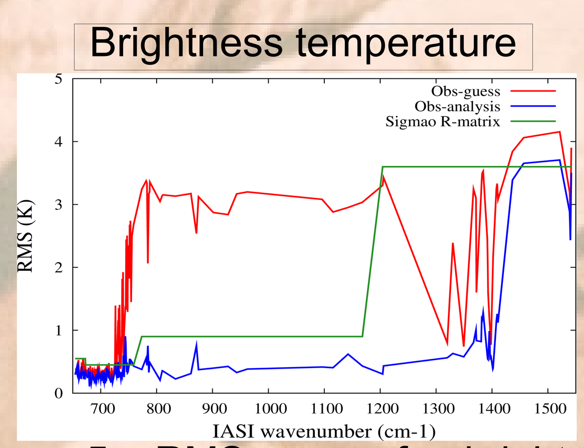


Figure 5 : RMS errors for brightness temperature before (red) and after (blue) analysis compared with IASI observations depending on the IASI wavenumber. σo for the R-matrix of ARPEGE are represented in green.

✔ Reduction in RMS after analysis compared to the background :
• 0,16 K for temperature between 650 and 100 hPa with a decrease of 0.24 K between the surface and 290 hPa and a decrease of 0.073 K between 290 and 80 hPa.
• 0.06 ln(kg/kg) for humidity between 520 and 300 hPa and results almost equal between the surface and 520 hPa.
✔ In terms of brightness temperature, significant reduction of the RMS.
✔ Jacobians give information about the sensitivity of IASI channels. The shape of these jacobians can explain the characteristics of the retrieved profiles.

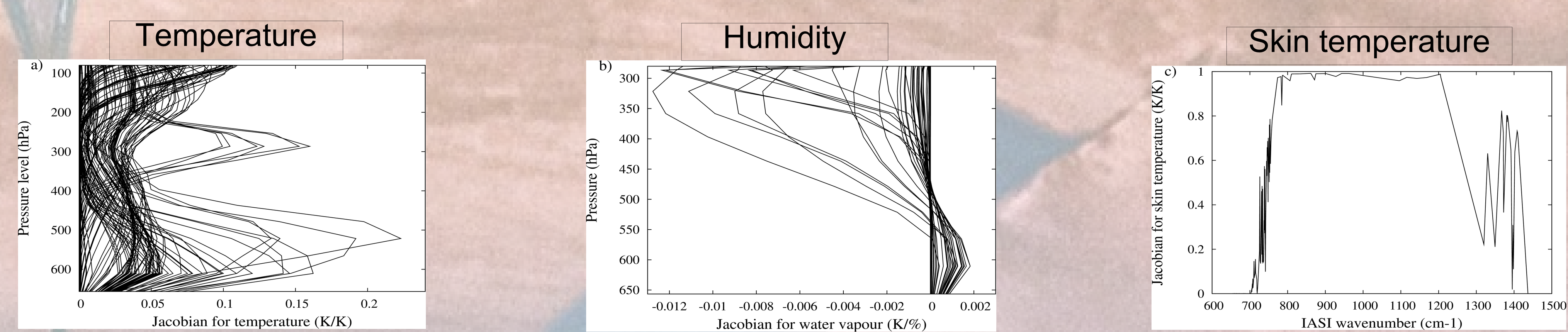


Figure 6 : Temperature (a) and water vapor (b) jacobians of the 170 selected IASI channels at different levels of the RTTOV radiative-transfer model. The jacobian for skin temperature, as a function of IASI wavenumber, is shown on figure c.

✔ High sensitivity of surface wavebands and also water vapor waveband to skin temperature.

✔ Skin temperature retrievals better fit to in-situ observations compared with background skin temperature.

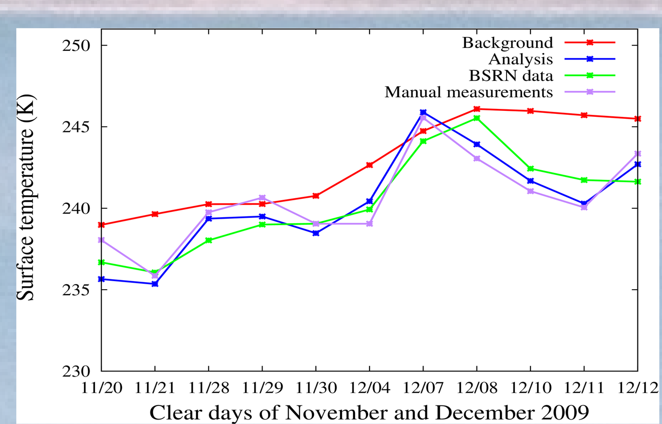


Figure 7 : Surface temperature for clear cases in November and December 2009 for background (red) and analyses (blue) and compared with in-situ measurements.

Conclusion

✔ IASI permits to fill the data gaps in Antarctica.

✔ Good retrievals in clear-sky conditions and in particular of surface parameters : retrieved skin temperatures reproduce accurately measured surface data (BSRN, O. Traullé)

✔ **Outcome of the project :** The Concordiasi campaign was indeed successfully performed in 2010. 19 balloons with drop-sondes were launched during the Austral spring 2010.
=> In addition to information on vortex dynamics, measurements of atmospheric parameters have been acquired over the whole Antarctica and compared with remote sensing measurements.

✔ **Publication : A. Vincensini, A. Bouchard, F. Rabier, V. Guidard, N. Fourrié, and O. Traullé, « IASI retrievals over Concordia within the framework of the Concordiasi program in Antarctica », IEEE Trans. Geosci. Remote Sens. (DOI : 10.1109/TGRS.2011.2177467)**

References :

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