Assimilation of PC at Météo-France

J. Andrey

CNRM-GAME (Météo-France and CNRS)

March 9th, 2015

cnrs

dépasser les frontières

METEO FRANCE

Outline

Outline

Background

- The assimilation of high resolution radiances measured by infrared atmospheric sounders like AIRS or IASI has produced a significant positive impact on forecast quality (McNally et al., 2006; Collard and McNally, 2008; Guidard et al., 2011).
- The operational use of infrared spectra from this sounders is limited to just few channels (for example, only 123 over 8461 IASI channels at Météo-France)
- Many of these channels have very similar spectral signatures, being highly-correlated between them.
- The use of Principal Component Analysis (PCA) can remove a significant fraction of the uncorrelated error present in the observations
- Additionally, the use of PCA in data dissemination would lead to a significant cost reduction as the data volume to be transferred is reduced by a factor around 80

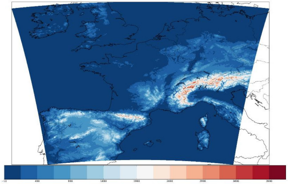
Basic ideas about PCA theory

- *PCA allows the reduction of the dimensionality of a problem by examining the linear relationship between all the variables contained in a multivariate dataset*
- The original set of correlated variables is replaced a smaller number of uncorrelated variables called principal components
- These new variables retain most of the information contained in the original dataset.

$$y^{obs} = A * x^{pcs} + residuals$$

The MF model AROME

- AROME is the limited-area convection-permitted model currently in use at Météo-France
- Geographical domain: from 8°E to 12°W in longitude, and 38°N to 52°N in latitude
- Current version runs on 60 hydrid sigma levels (model top at 1 hPa) with a mesh of 2.5 km.
- Next version, to be operational by end of March, will have 90 levels and a mesh of 1.3 km. Model top will be lowered to 10 hPa
- $\Rightarrow$ Potential problems could appear as many of the PC eigenvectors have some sensitivity above 10 hPa



AROME domain

Open questions on PC assimilation

1. Are reconstructed radiances (RR) from the PCs disseminated by Eumetsat comparable to the original radiances (RAW)?
   Is their assimilation as efficient as the assimilation of original radiance?
   Which ingredients of the assimilation need to be tuned to achieve a comparable assimilation (observation error covariance matrix, eg.)?

2. Can we assimilate the same PC scores in AROME with a low model top than in ARPEGE ou ECMWF/IFS?
   How to produce a new basis of eigenvectors which may be suitable for assimilation in "low top model" models?

3. Is there a need / benefit to produce a new basis of eigenvectors to "denoise" IASI signal for AROME?

The first point will be discussed here.

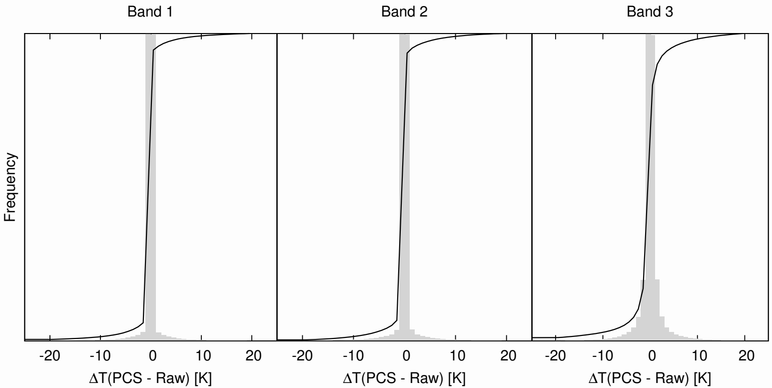
Outline

Methodology

- An algorithm to reconstruct IASI radiances from the PCs was developed at MF to be used in MF global model, ARPEGE. (Job from S. Guedj, Associate Scientis of NWP-SAF at MF) It was used in this work.
- I have focused on 314-the channel dataset routinely monitored at Météo-France
- Two different experiments have been run to compute the differences between the RR and Raw radiances, and their respective departures from the AROME guess-values used in the DA.
- A one month window from November 8th to December 8th 2014 was chosen.
- The spatial domain used correspond to the AROME domain model.
- The differences between RR and RAW radiances has been computed for the following cases:
  1. All observations
  2. Day/night observations
  3. Land/sea observations
  4. Clear/cloudy observations
  5. 3 different terrain elevation observation classes

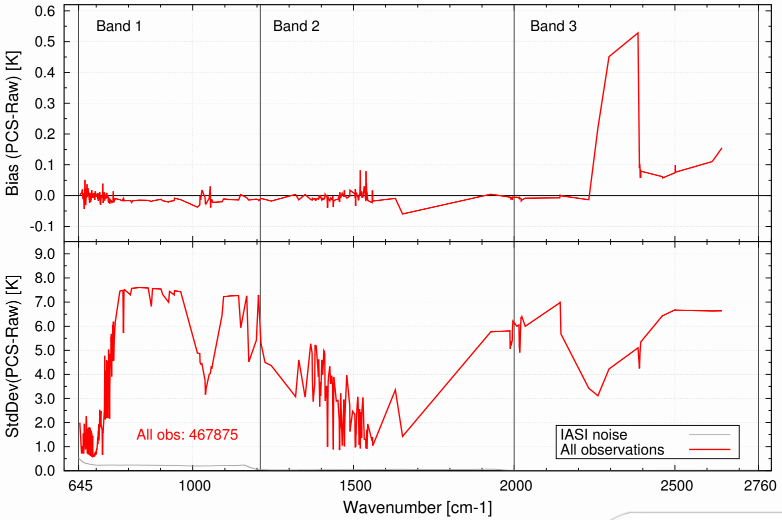
Outline

Global differences. Band statistics

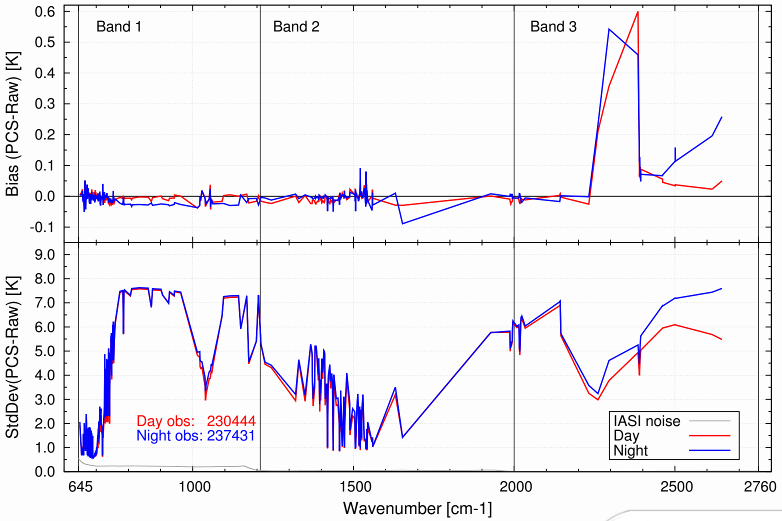


- A narrow differences distribution is observed for bands 1 and 2 (88.2% and 86.6% of the values between -1 and 1 K respectively).
- This percentage falls to 65.4% in band 3. A higher dispersion in the differences should be expected here.

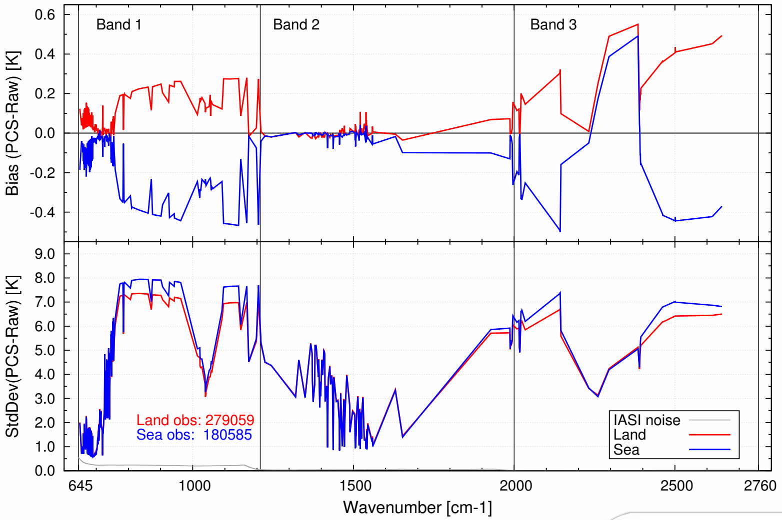
Global differences. Channel statistics



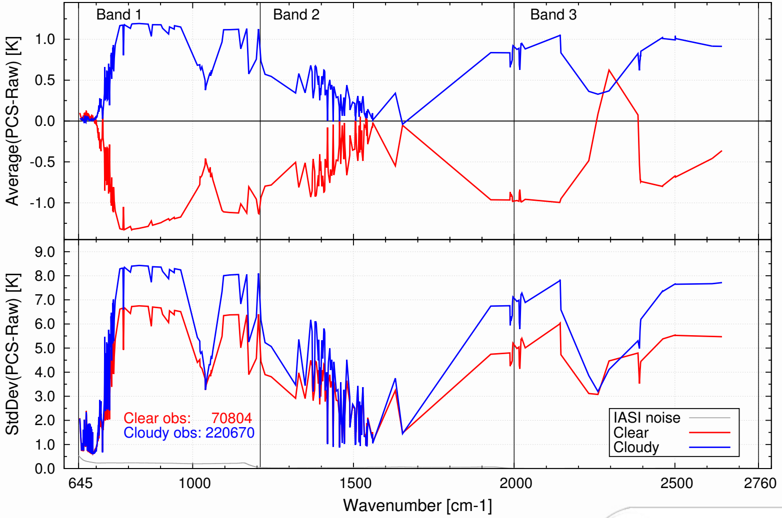
Day/Night differences. Channel statistics



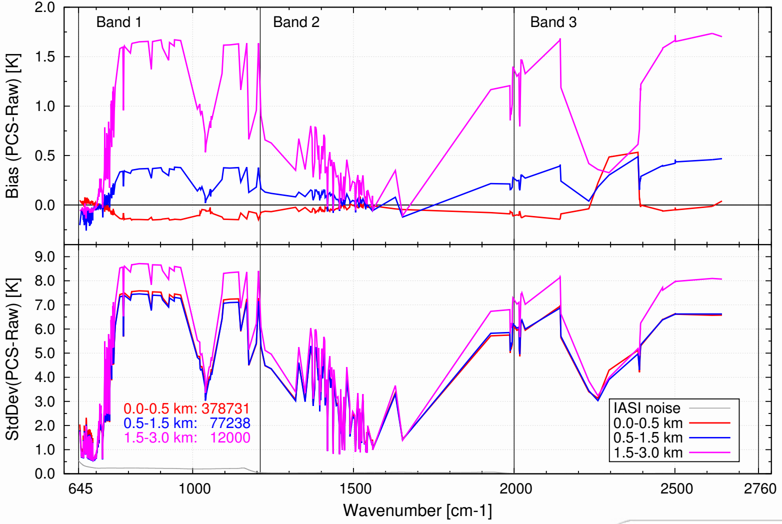
Land/Sea differences. Channel statistics



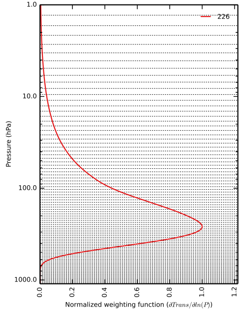
Clear/Cloudy skies differences. Channel statistics

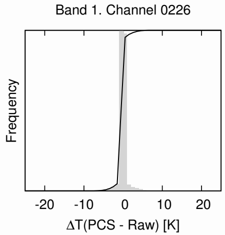


Elevation differences. Channel statistics

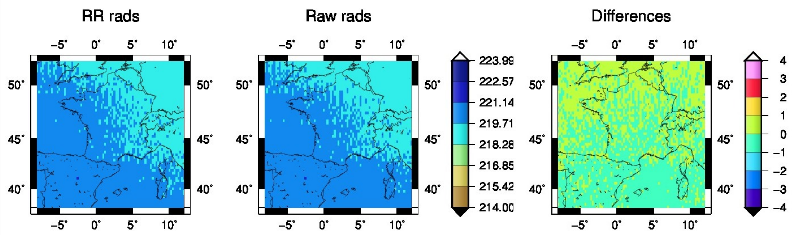


Differences in channel 226

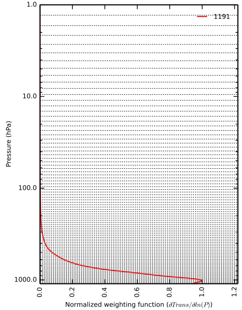


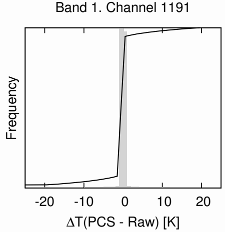


- Temperature channel
- 91.2% of the difference in the range $[-1, 1]$
- Difference magnitude proportional of Latitude

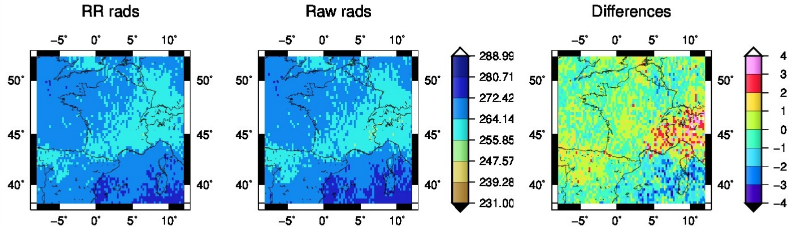


Differences in channel 1191

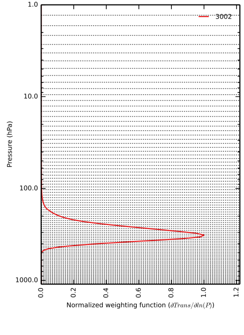


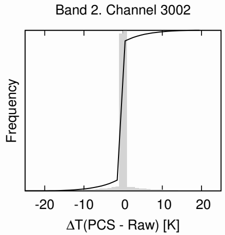


- Window channel
- 85.5% of the difference in the range $[-1, 1]$
- Difference magnitude proportional of Latitude

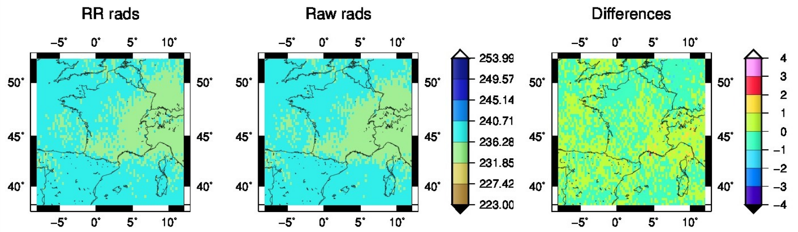


Differences in channel 3002

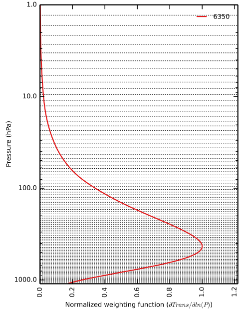


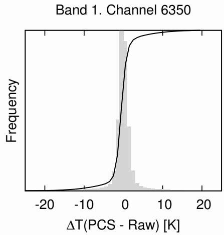


- Water vapour channel
- 86.7% of the difference in the range $[-1, 1]$

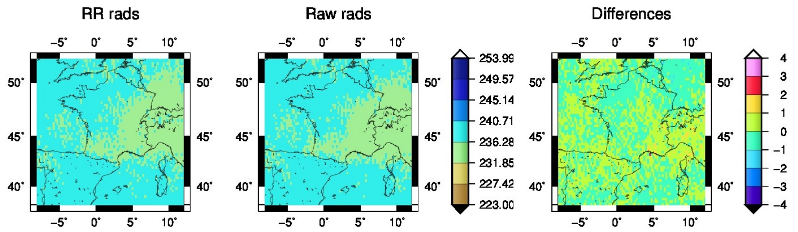


Differences in channel 6350





- Channel in band 3. Currently not used
- 56.2% of the difference in the range $[-1, 1]$



Outline

Summary and conclusions I

1. Global differences
   - Well behaviour in Bias for band 1 and 2.
   - Possible problem in Bias for band 3. Need to check the origin of this peaks. RR Algorithm?
   - The stddev spectra presents a similar structure to that of IASI spectrum. Is there a dependency of the differences with IASI radiance temperature?
2. Differences in particular cases

   2.1 Day/Night observations
   - RR have a slightly better behaviour during the day than during the night.
   - We still have the problem of Bias in band 3.

   2.2 Land/Sea observations
   - Inverse behaviour of differences in band 1
   - Similar behaviour of differences in band 2
   - Problem of Bias in band 3.

   2.3 Clear/Cloudy observations
   - Inverse behaviour of differences in band 1 and 2
   - STdDev significantly lower in for clear observations.

   2.4 Elevation differences
   - the Bias behaviour of low terrain elevation layer is inverted and become more and more positive according to the orography

Summary and conclusions II

3. Channel differences
   3.1 Band 1. Channel 0226
   - Temperature channel.
   - Most of the differences fall into the -1,1 range (91.1%)
   - Differences increase with latitude

   3.2 Band 1. Channel 1191
   - Window channel.
   - Most of the differences fall into the -1,1 range (85.5.1%)
   - Negative differences in the Mediterranean sea
   - Positive differences in the Alps cause by the orography

   3.3 Band 2. Channel 3002
   - Water vapour channel.
   - Most of the differences fall into the -1,1 range (86.7%)
   - No spatial dependencies of the differences
   - Positive differences in the Alps cause by the orography. Channel sensitivity close to the sea level

   3.4 Band 3. Channel 6250
   - Band 3 channel. Not currently used at Météo-France
   - Reduced percentage of differences into the $]-1,1]$ range: 56.7%
   - No spatial dependencies of the differences

Outline

CNRS dépasser les frontières METEO FRANCE

Future works

- Verify Band 3 reconstruction
- Check performance of RR in a 1D-Var DA system, profiting the IASI-NG OSSE profiles database, (tuning of error covariance matrix, channel selection...)
- Assimilation of RR radiances rom EUMETSAT PCs in AROME for the current time window
- Assimilation of ECMWF PCs in AROME at a longer term

Thank you for your attention