

# The use of reconstructed radiances to assimilate the full IASI spectrum at ECMWF

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## Outline

- 1) Brief review of the evolution of assimilation trials based on the use of PC data
- 2) Assimilation of reconstructed radiances representative of the full IASI spectrum in band 1 and band 2
- 3) Preliminary results obtained using reconstructed radiances in an assimilation system with inflated humidity background errors

## Evolution of 4D-Var assimilation trials based on the use of Principal Component (PC) data

- 1) **Prototype system (only conventional and IASI observations):** direct assimilation of PC scores derived from channels in the short wave band of IASI
  
- 2) **Full data assimilation system (all operational observations - satellite and conventional):**
  - i) *direct assimilation* of PC scores derived from the 191 long wave IASI channels used in operations (Matricardi and McNally 2013)
  - ii) *direct assimilation* of PC scores derived from 305 IASI channels (Matricardi and McNally 2014, Matricardi and McNally 2015)
  
- 3) **Full data assimilation system focused on maximising the spectral information of IASI using the full set of channels in IASI band 1 and 2**

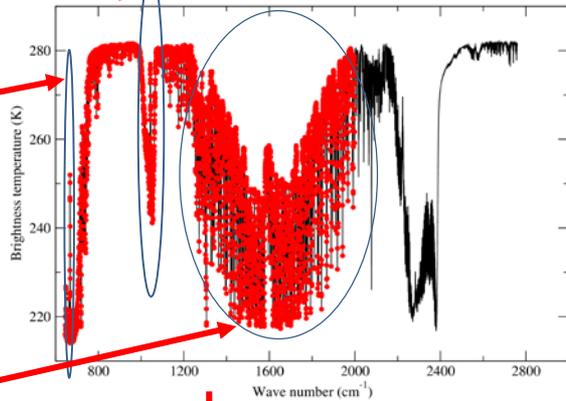
# Assimilation of IASI reconstructed radiances (cycle 42r1)

The full number (5421) of IASI channels in Band 1 and Band 2 (64% of the total number)

Ozone

Stratospheric temperature

Water vapour



Using Principal Component Analysis (PCA) we can encapsulate the vast majority of the information in the 5421 IASI channels in a smaller number of variables

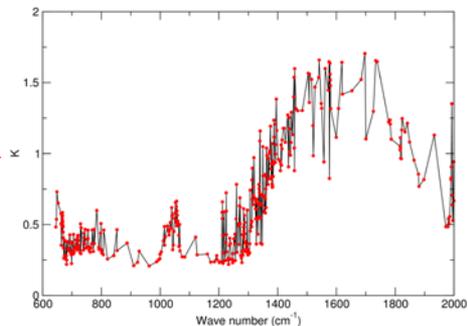
The leading eigenvectors,  $A$ , of a covariance matrix describing the variations of the IASI's spectrum are used to calculate  $m \ll 5421$  PC scores and Reconstructed Radiances

PC scores ( $p$ ):  
 $p = A^T r$

Reconstructed Radiances ( $\tilde{r}$ ):  
 $\tilde{r} = A p$

We have selected *400 reconstructed radiances* to represent most of the information contained in *5421 raw radiances*

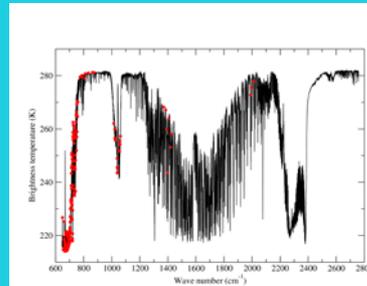
The 400 reconstructed radiances used in the assimilation trials



Motivation for the assimilation of reconstructed radiances

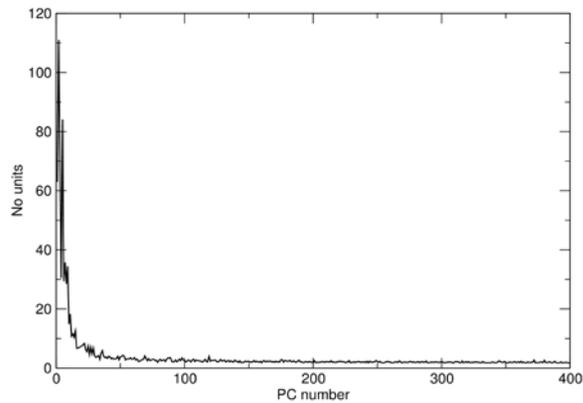
Exploit the full information content of IASI

We currently use only 2% of the available IASI channels

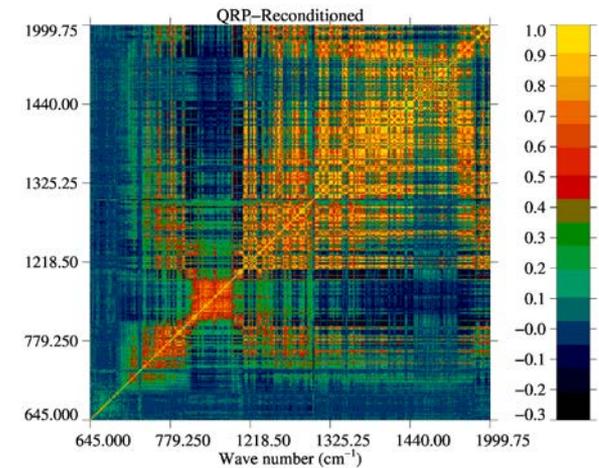
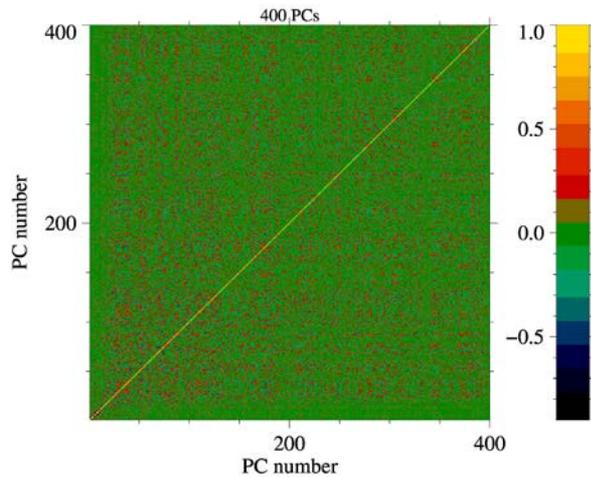
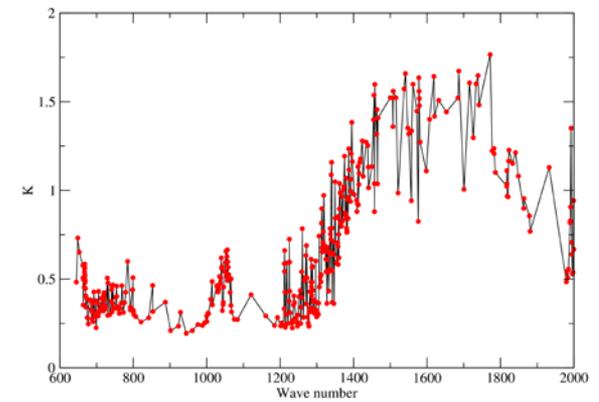


# In all experiments we use a full error covariance matrix for IASI

Desroziers's estimate of PC error



Reconstructed Radiances



**To assess the performance of the assimilation system based on reconstructed radiances we have devised the following experiment design:**

- 1) RAD** : the operational 4D-Var system where we assimilate radiances from 191 IASI channels.
- 2) REC\_RAD**: identical to RAD but we replace the 191 operational IASI channels with 400 reconstructed IASI radiances

Experiments (cycle 41R2 – T637- 137 L) are currently covering the period 20 July 2015 – 20 July 2016.

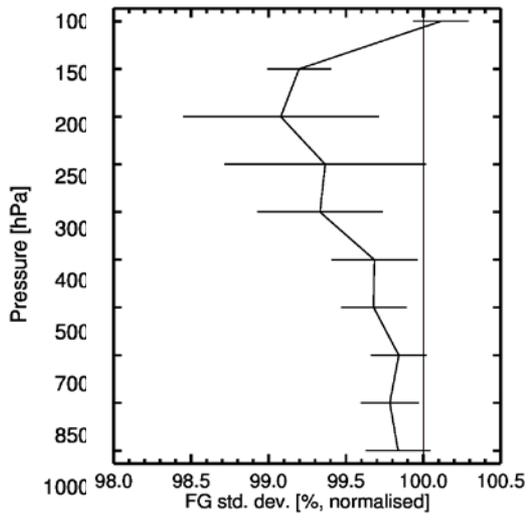
**The 4D-Var simulation of reconstructed radiances has been carried out using the PC-RTTOV (Matricardi 2010) fast RT model.**

Twelve months of 4D-Var assimilation trials show that the assimilation of 400 reconstructed radiances produces an improved humidity analysis compared to the operational system

Verification against RADIOSONDES

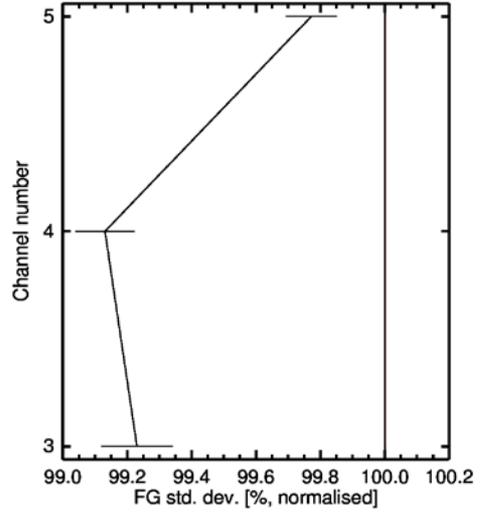
Verification against MWHS

REC\_RAD better ← → REC\_RAD worse



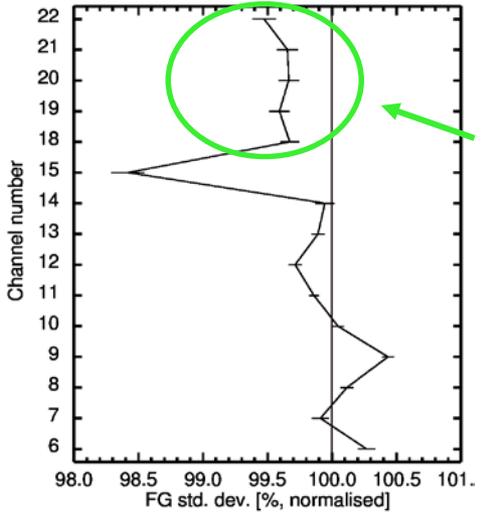
Standard deviation of first guess departures

Values less than 100% indicate that the use of 400 reconstructed radiances produce a reduction of the standard deviation compared to the use of the operational 191 channels

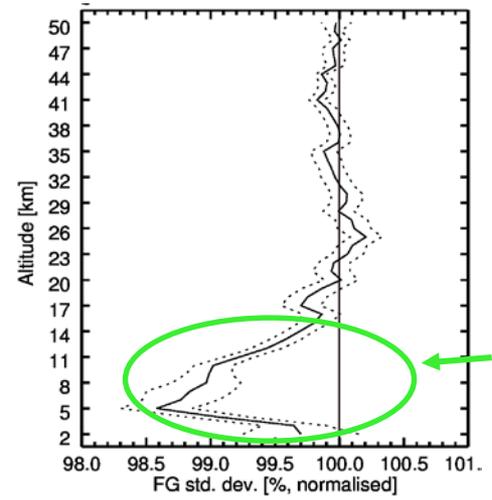


Verification against ATMS

Verification against GPSRO



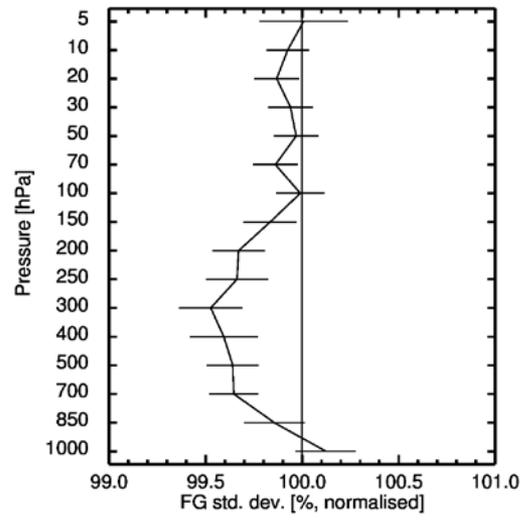
Water vapour sounding channels



Water vapour information

Twelve months of 4D-Var assimilation trials show that the assimilation of 400 reconstructed radiances produces an improved temperature analysis in the stratosphere but there is evidence of a degradation of the temperature analysis in some regions of the troposphere

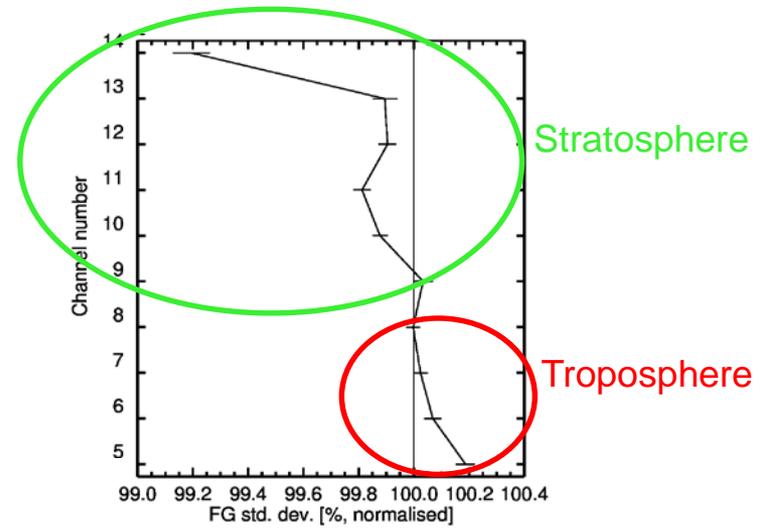
Verification against RADIOSONDES



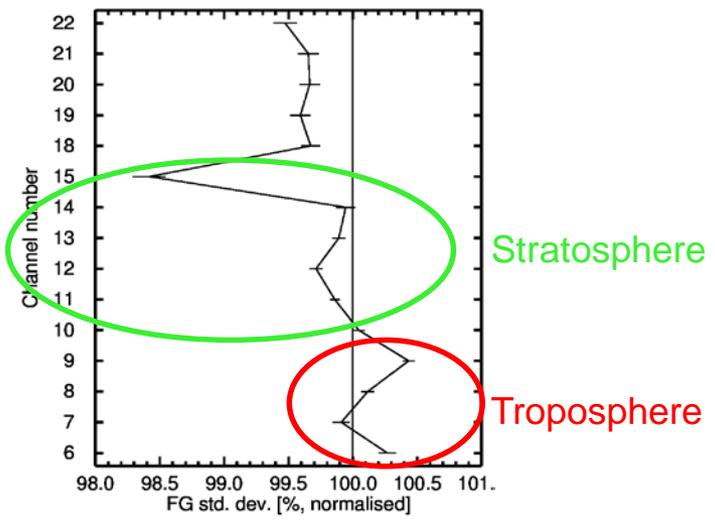
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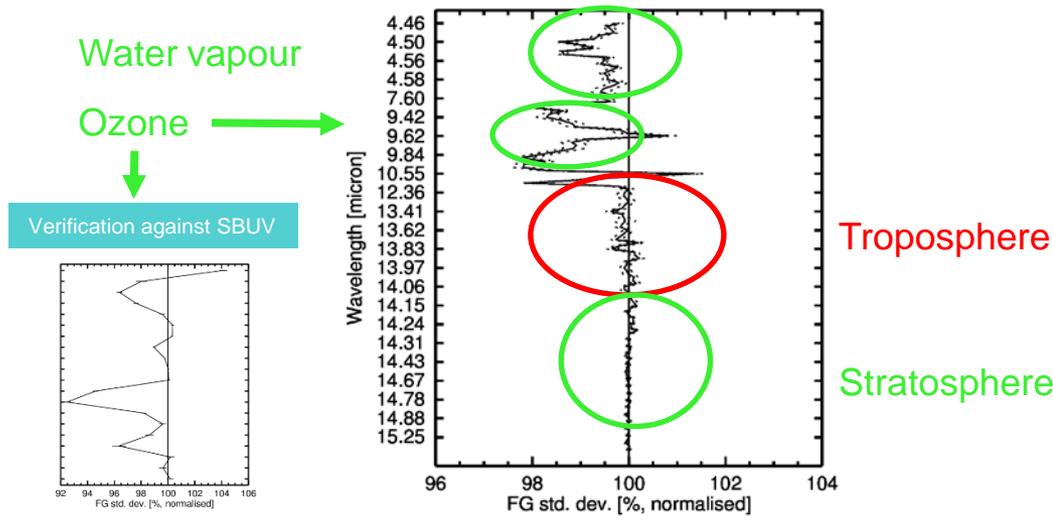
Verification against AMSU-A



Verification against ATMS

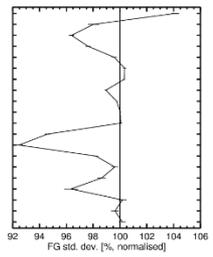


Verification against AIRS



Water vapour  
Ozone

Verification against SBUV



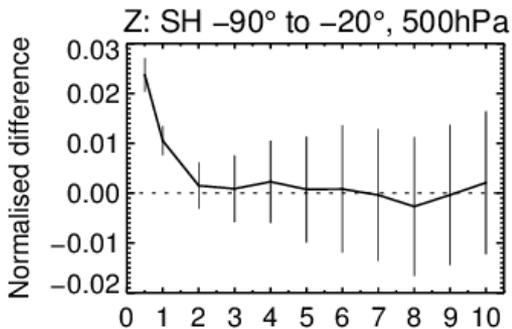
# Forecast rms errors: REC\_RAD-OPE

Southern Hemisphere

Tropics

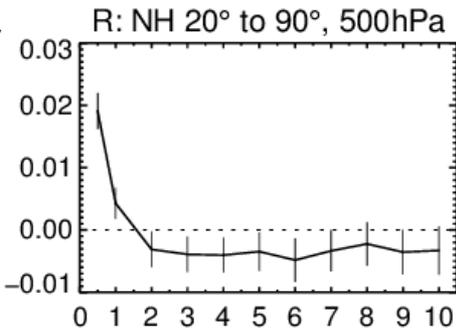
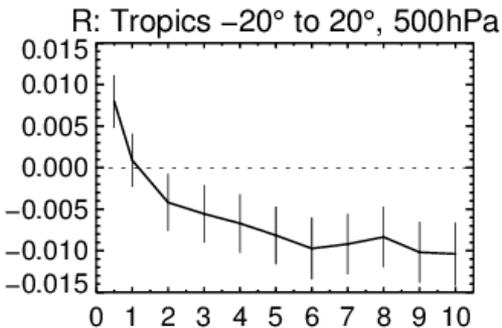
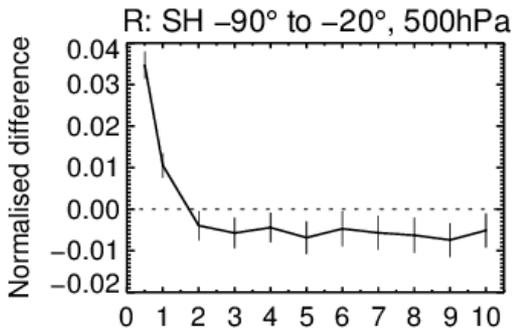
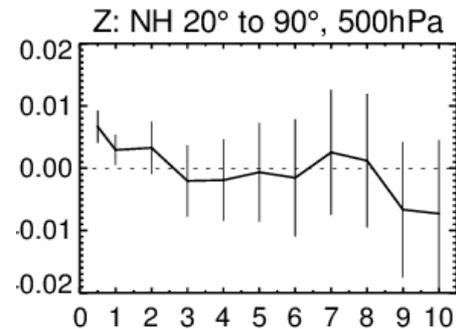
Northern Hemisphere

500hPa  
Geopotential



*REC\_RAD worse*

*REC\_RAD better*



500hPa  
Relative humidity

## Possible origin of the degraded temperature analysis in the troposphere

- 1) Imbalance between the temperature information from the long wave IASI temperature sounding channels and the temperature information from the mid wave IASI humidity sounding channels (i.e. the latter dominates).
- 2) Humidity background errors are too small

## Possible strategies for improving the temperature analysis

- 1) Blacklist channels in the water vapour band.
- 2) Use the latest formulation of the humidity background errors (i.e. cycle 43R1)
- 3) Diagnose a new observation error covariance matrix based directly on reconstructed radiance first guess departures

## Challenge

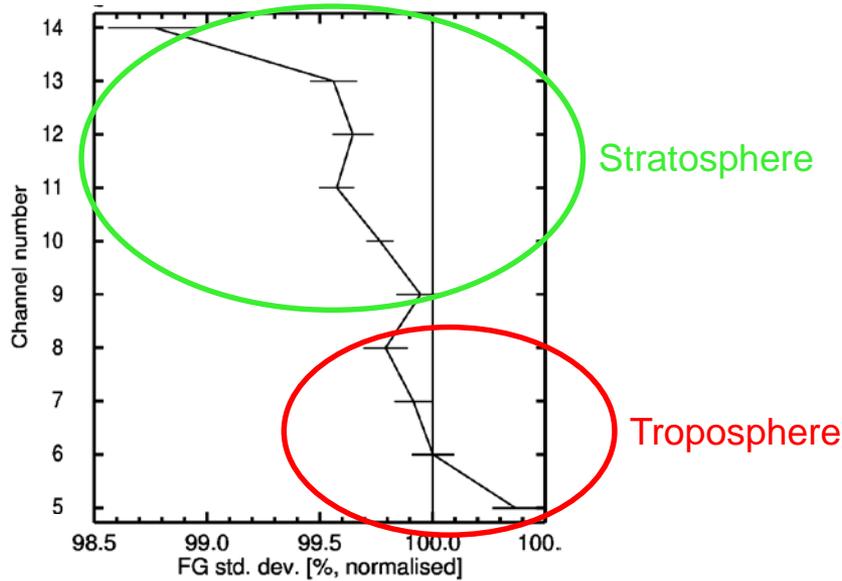
Improve the temperature analysis whilst preserving the improvements made in the humidity analysis

# Results for a one month assimilation trial carried out using increased background humidity errors

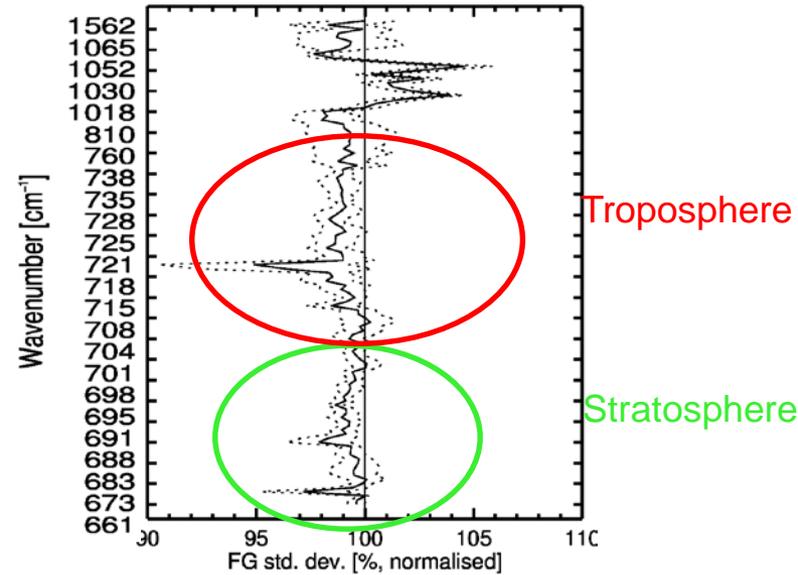
Standard deviation of first guess departures

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Verification against AMSU-A

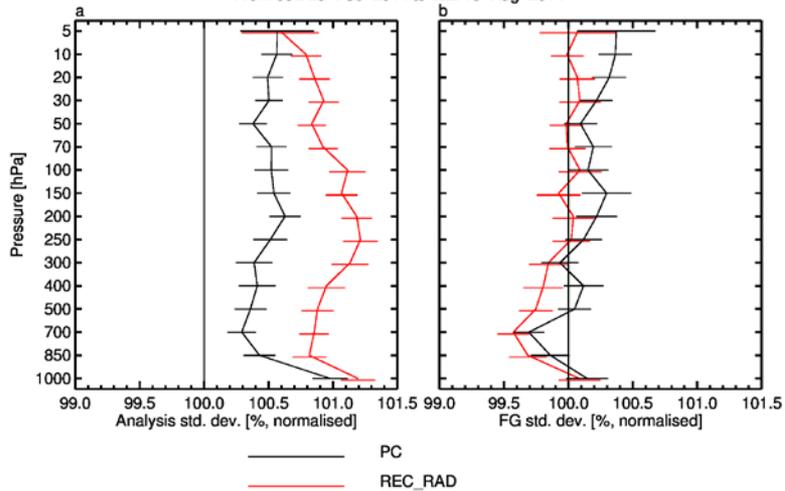


Verification against CrIS

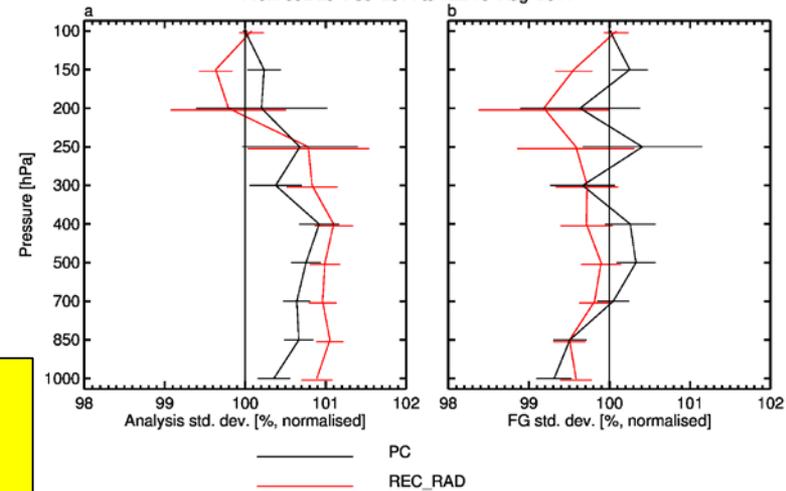


- Extensive assimilation trials carried out using IASI reconstructed radiances suggest that there are benefits for the humidity analysis and for the temperature analysis in the upper atmosphere. There are, however, some issues with the temperature analysis in the troposphere.
- Preliminary results obtained using inflated background humidity errors suggest that there are beneficial effects on the temperature analysis in the troposphere.
- We will focus on the consolidation of the results obtained so far in view of a possible operational implementation of the reconstructed radiances.

Instrument(s): TEMP-T Area(s): N.Hemis S.Hemis Tropics  
 From 00Z 20-Feb-2014 to 12Z 15-Aug-2014

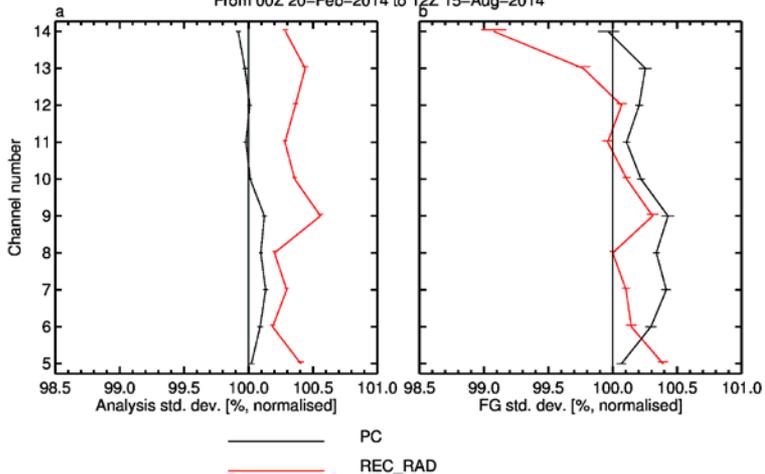


Instrument(s): TEMP-q Area(s): N.Hemis S.Hemis Tropics  
 From 00Z 20-Feb-2014 to 12Z 15-Aug-2014



Values less than 100% indicate that the use of 400 reconstructed radiances or 400 PC scores produce a reduction of the standard deviation compared to the use of the operational 191 channels

Instrument(s): AQUA metop-a metop-b noaa-15 noaa-16 noaa-18 noaa-19 - AMSU-A  
 Area(s): N.Hemis S.Hemis Tropics  
 From 00Z 20-Feb-2014 to 12Z 15-Aug-2014



Instrument(s): NPP ATMS Tb Area(s): N.Hemis S.Hemis Tropics  
 From 00Z 20-Feb-2014 to 12Z 15-Aug-2014

