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

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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 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
The full number (5421) of IASI channels in Band 1 and Band 2 (64% of the total number) can be encapsulated using Principal Component Analysis (PCA). The vast majority of the information in the 5421 IASI channels is represented 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 PC scores and reconstructed radiances.

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

**Motivation for the assimilation of reconstructed radiances**

Exploit the full information content of IASI. We currently use only 2% of the available IASI channels.

**Assimilation of IASI reconstructed radiances (cycle 42r1)**

The 400 reconstructed radiances used in the assimilation trials.
In all experiments we use a full error covariance matrix for IASI.
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

*REC_RAD better*  
*REC_RAD worse*

- Standard deviation of first guess departures

Verification against MWHS

- 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

- Water vapour sounding channels

Verification against GPSRO

- 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

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 AMSU-A

Verification against ATMS

Verification against AIRS

Verification against SBUV
Forecast rms errors: REC_RAD-OPE

Southern Hemisphere

Tropics

Northern Hemisphere

500hPa Geopotential

500hPa Relative humidity

REC_RAD worse

REC_RAD better
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

Verification against AMSU-A

Verification against CrIS

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.
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.
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.