Validation of Level1c IASI data: an interactive intercalibration and stand-alone approaches for IASI on board MetOp-A and MetOp-B

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Quality control of satellite data @ LMD

To be fully useful for climate and environmental applications, satellite observations require quality control during the instruments lifetime.

➔ within the frame of the processing and validation of level1 and level2 satellite data combining forward and inverse radiative transfer modeling

- TOVS (NOAA/NASA Pathfinder Programme),
- ATOVS,
- AIRS/Aqua
- IASI/MetOp-A (*)
- IIR/Calipso (*)

➔ within the frame of the GSICS activities (*)

(*) related to CNES activities

Ascertain the quality of “IASI et al.” radiances

A multistep step procedure

What are we looking for?

- Unstability
- Spurious trends
- Night/Day differences
- Asymetric behavior along scan line, …

But also:

- Natural variability
- Natural trends

➔ Two complementary approaches aiming at identifying, and eventually at correcting, deviations or trends:

- The intercalibration approach
- The stand alone approach

Ascertain the quality of "IASI et al." MetOp radiances

A multistep step procedure (cont')

Inter-calibration: IASI in synergy with other sounders

➔ Comparison of observed IASI radiances with radiances observed from other sounders

IASI in stand alone

➔ Comparison of IASI observed BT with simulated BT based on forward RT model + *in situ* (R/S) observations

Aim : identify which instrument deviates from the other(s).

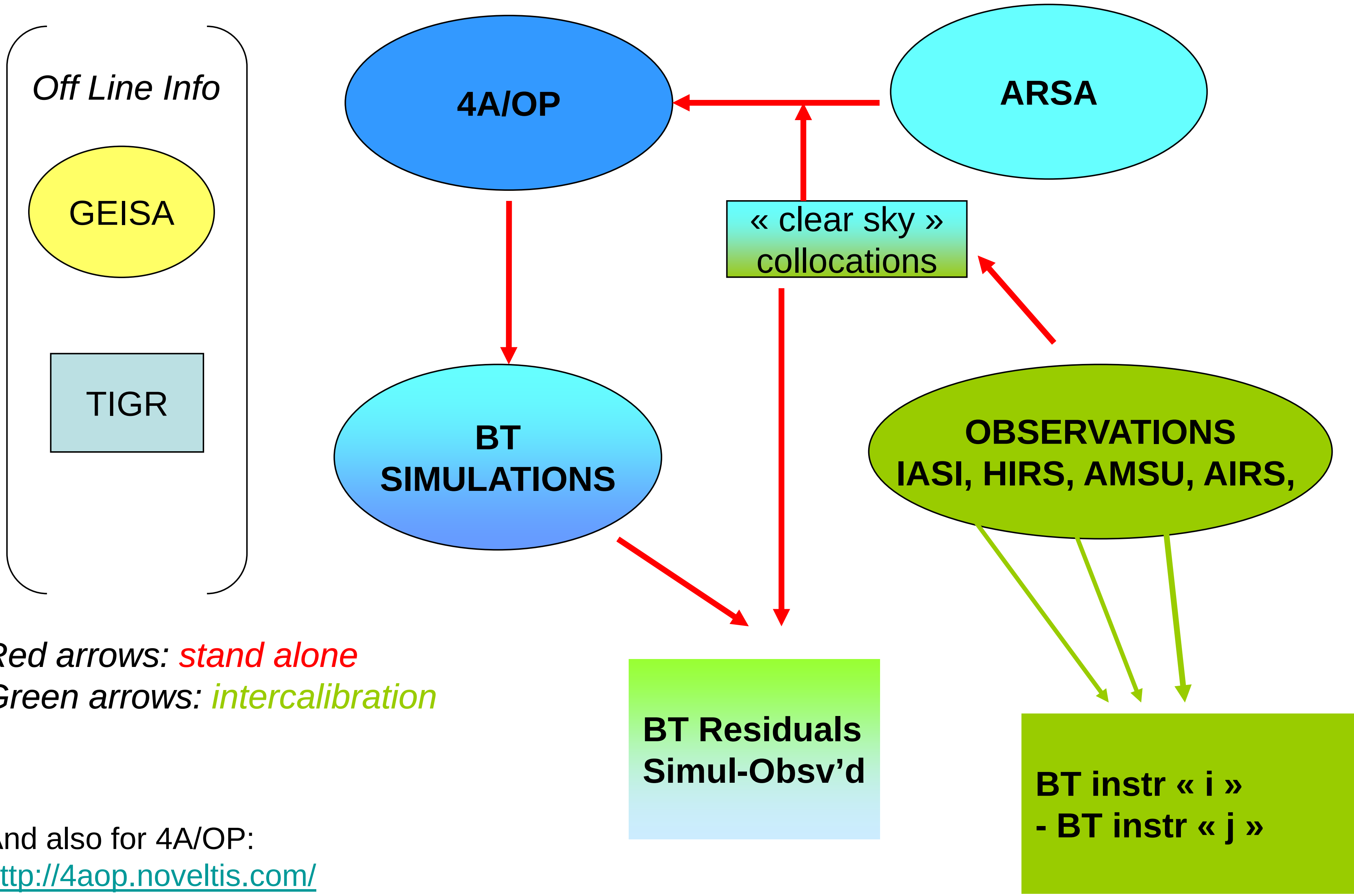
- compare wide ranges of brightness temperatures (clear or cloudy) (inter-calibration)

- study each channel of each instrument, independently of the others (stand alone).

➔inter-calibration developed at LMD for the calibration of Meteosat, based on space and time collocations with instruments on the NOAA series (J. Appl. Meteor., vol 21, 1982).

RT models and databases involved in Radiances QC at LMD

http://ara.abct.lmd.polytechnique.fr/



Red arrows: stand alone

Green arrows: intercalibration

And also for 4A/OP:
http://4aop.noveltis.com/

The ARSA (Analyzed RadioSounding Archive) Database

When collocated with satellite observations, RAOBs may be used to reveal errors or trends

LMD has elaborated the ARSA database:

- starting from observations by worldwide distributed radiosonde stations
- combining them with surface and other auxiliary observations

in order to make it suitable for

- forward and inverse radiative transfer models
- validation of level1 and level2 data

Elaboration of the ARSA database

From the raw radiosonde measurements extracted from ECMWF up to the converged ARSA product ➔ several (fully automatized) steps

1. **develop and apply physically coherent quality control tests:**

- elimination of gross errors, unrealistic jumps and redundant measurements (reports, levels)

- requirements:
  - T(P) be available at least up to 30 hPa, that $H_2O(P)$ be available at least up to 350 hPa,
  - a predefinite number of temperature ***and*** water vapor measurements be (at least) present

- use of the TIGR dataset to eliminate values that deviate by more than a certain number of standard deviation from their respective air-mass (tropical, mid-lat, polar) mean values.

Elaboration of the ARSA database (cont')

2. combine radiosonde measurements with other reliable data sources in order to complete the description of the atmospheric column and surface state:

ozone profiles ,
extrapolation to the upper levels of the atmosphere,
surface characteristics (temperature, emissivity)

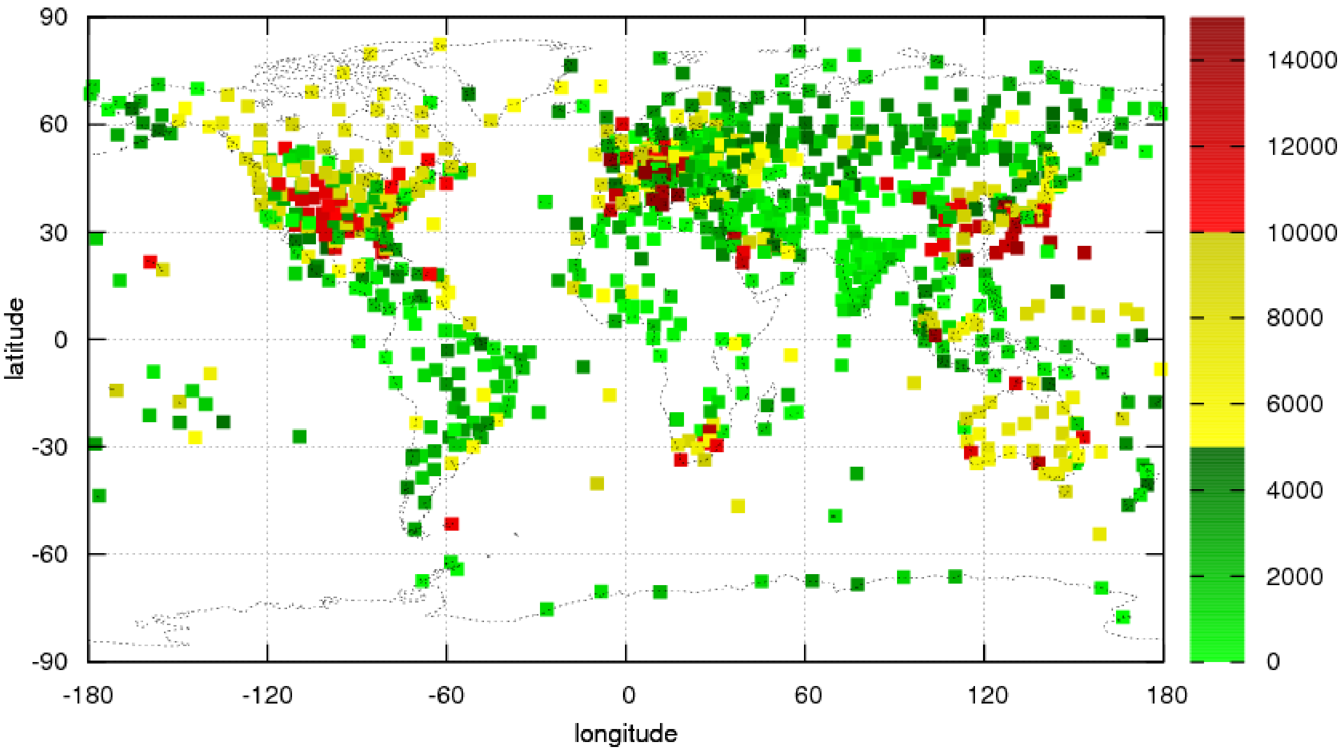
Auxiliary (other than radiosondes) sources of data: QC+Validated

ERA_interim outputs,
Ace_Scisat level2 products

3. Final product

A 43 level description of the atmosphere between surface and 0.0026 hPa including P, T, H_2O, ozone profiles, Surface temperature.
Geolocated + date/time

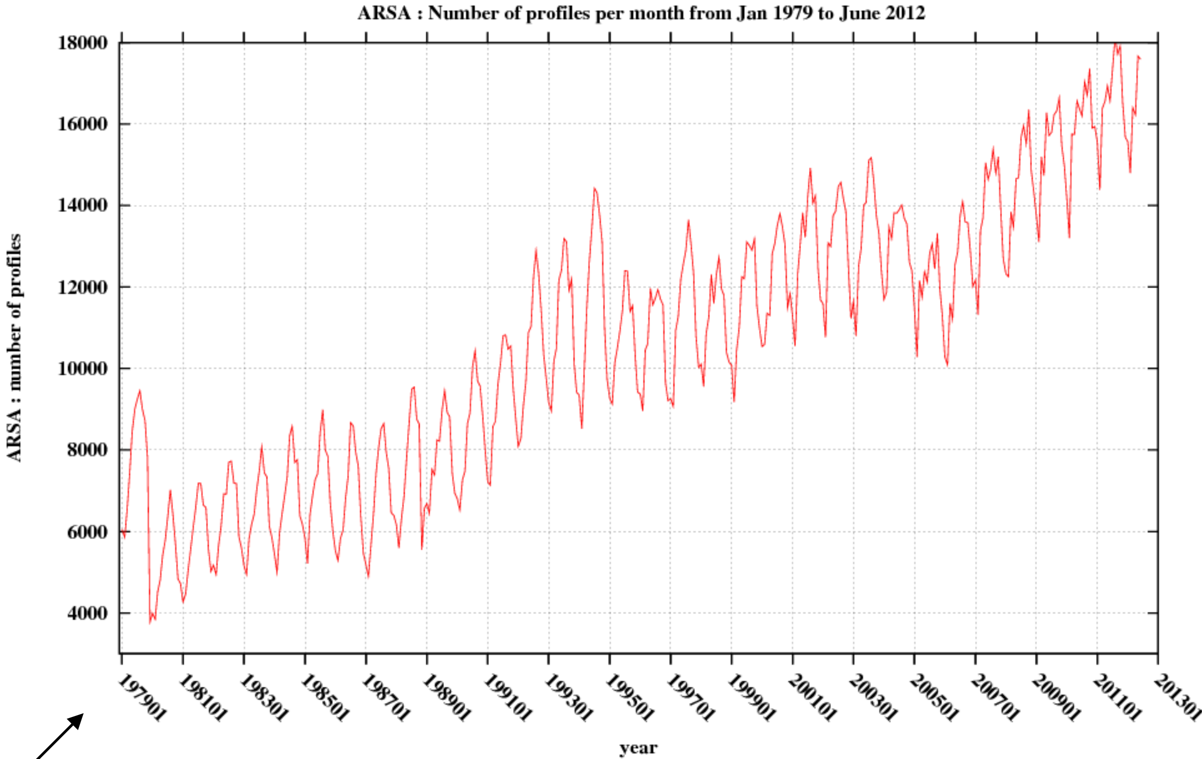
ARSA profiles : number and location: January 1979 to June 2012



stations in most areas of the globe.

- spatial coverage is most complete in Europe and northern America
- sparsest in northern Canada,
- quite poor in Antarctica, equatorial Africa and America, India and mid-lat western Europe.

ARSA profiles : Number of ARSA profiles/month



So far: a total of
> 4.9 million profiles
(from a total of ~22 million
considered)

Jan. 1979

July 2012

ARSA database starts in January 1979 and is extended onwards on a monthly basis.

It is available upon request at LMD.

Stand alone aproach applied to MetOp-A

Casting @LMD; 4A/OP + ARSA + Sat. Observations + Clear/Cloud/Aerosols Flag

- ✓ Identify IASI clear sky scenes **July 2007 to current month**
- ✓ Space time collocations with **ARSA database**
- ✓ **Compute BTs for every IASI, HIRS, AMSU, MHS channel (4A/OP)**
- ✓ Compute BT residuals = $BT_{simulated}(\nu_i)$ - $BT_{observed}(\nu_i)$
- ✓ Compute monthly mean values
- ✓ Plot time series for channels of (particular) interest

Results for MetOp-A approximately 350 colocations/month
-30°,+30°
So far: Sea+night Sea+day Land+night Land+day

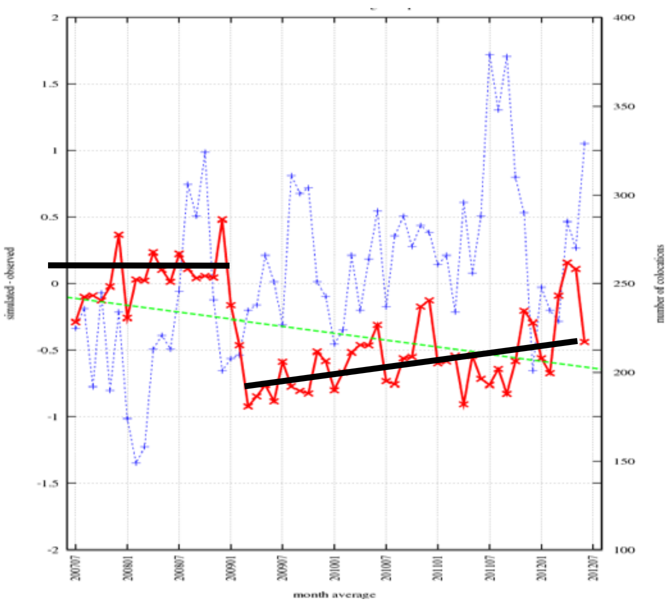
Inter-calibration or Stand Alone

Importance of validating each auxiliary data

An example among many others : Ozone story

Time series July 2007 ➔ Dec. 2012 of monthly averaged BT residuals (in red) for ozone channels

IASI Channel 1635
« Strongly » absorbing



Questions: Why this gap of 1.5 K peak to peak between Dec 2008 and March 2009?
Is it related to the ozone data that were assimilated in ERA_Interim? (OMI, Sciamachy, MLS)?

Answer: Yes, Confirmed by R. Dragani, (priv. Comm., April 2012) pointing a change in assimilation of MLS, OMI, Sciamachy at this period (Dec. 2008).

Conclusion: Try to correct this time series of ozone

Stand Alone Approach

Three applications:

- **Revealing a bias due to the IASI data processing in the 2400-2500 cm^{-1}**
- **Revealing the degradation of the instrumental performances of AMSU-7**
- **Scan angle effect detection**

Stand Alone approach

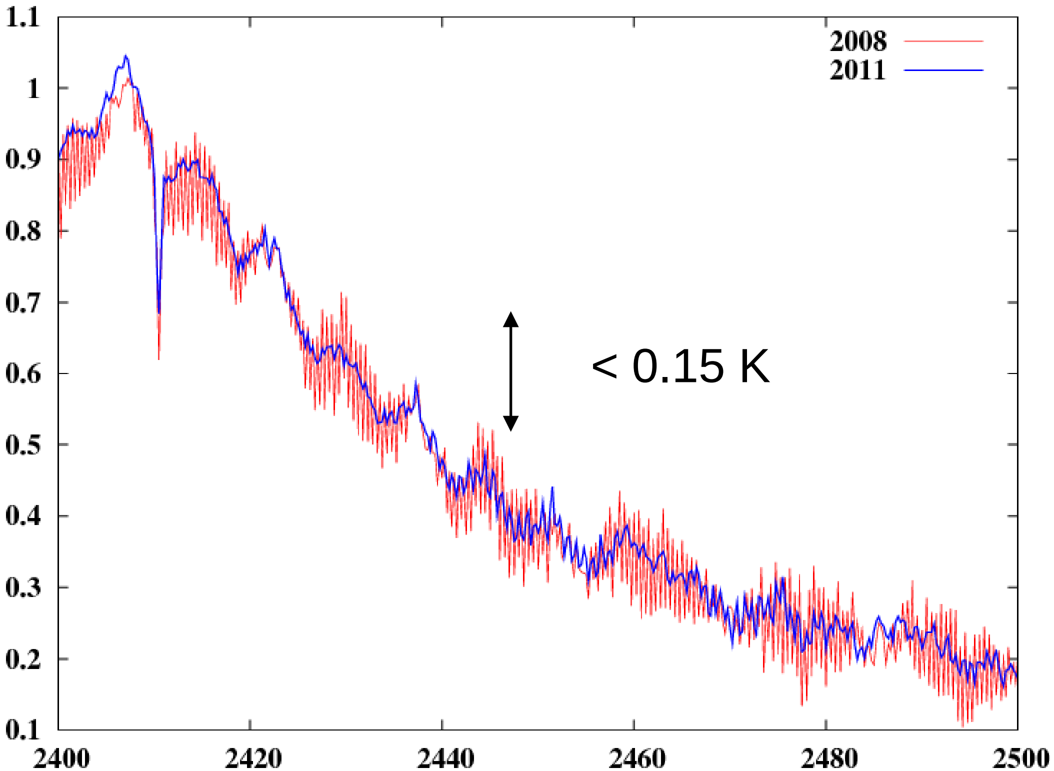
Revealing a bias due to the data processing in the 2400-2500 cm^{-1}

History:
Unexpected variation of BT residuals (red curve) ➔ no plausible explanation @ LMD

Meanwhile at CNES:

Numerical error identified during the data processing from level1a ➔ level1b (Gibbs effects)

Corrected by the TEC (Toulouse) in 2010

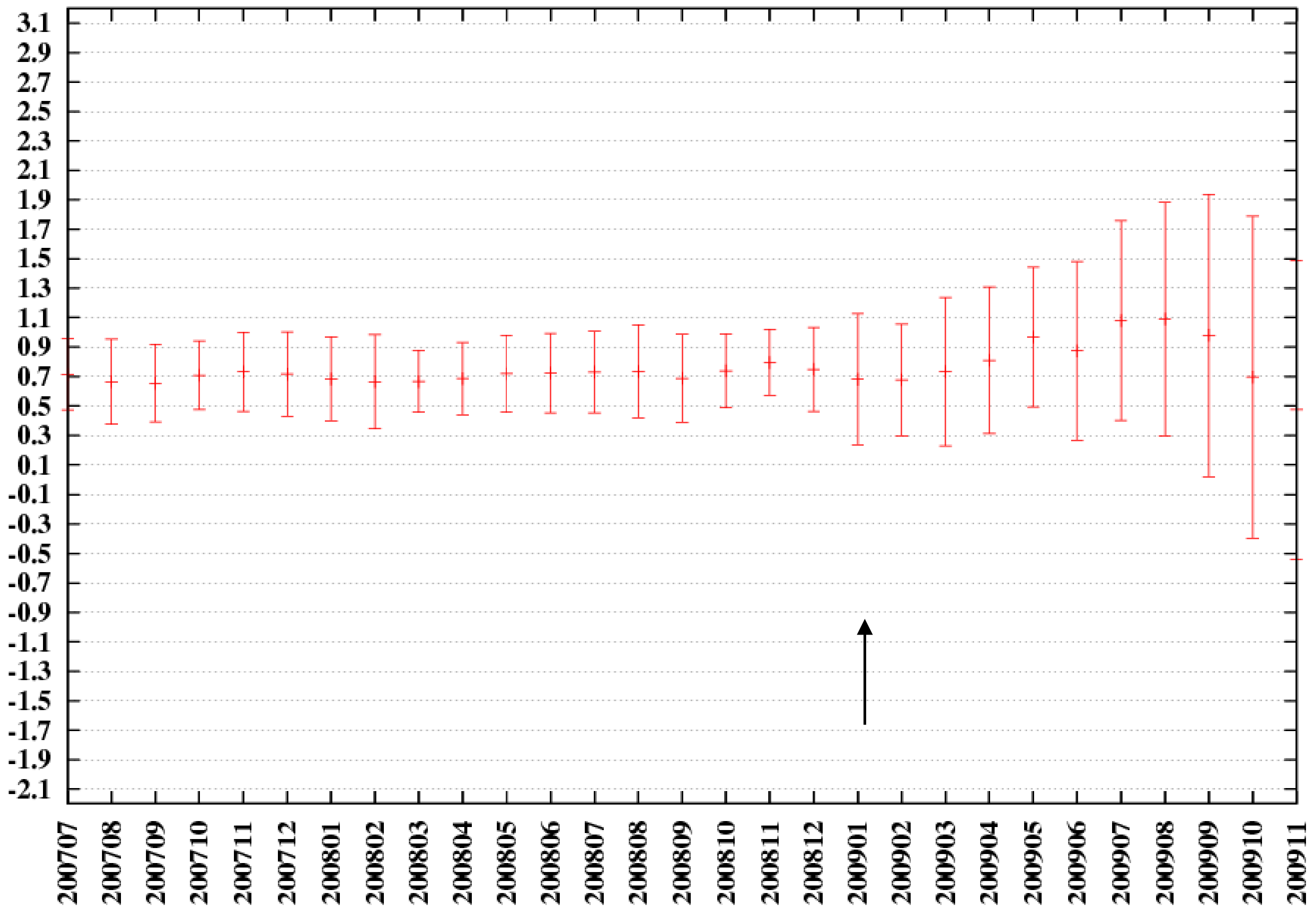


Happy end:
When reprocessed @ LMD after CNES/TEC correction
➔ blue curve : as expected

Stand Alone 4A/OP + ARSA

Revealing the degradation of the instrumental performances

Time series of monthly mean of AMSU-7 BT residuals



Stand alone approach :

Another application : Scan angle effect detection

- ✓ identify IASI clear sky scenes July 2007 to Current month
- ✓ space time collocations with ARSA database
- ✓ compute BT residuals = $BT_{simulated}(\nu_i) - BT_{observed}(\nu_i)$

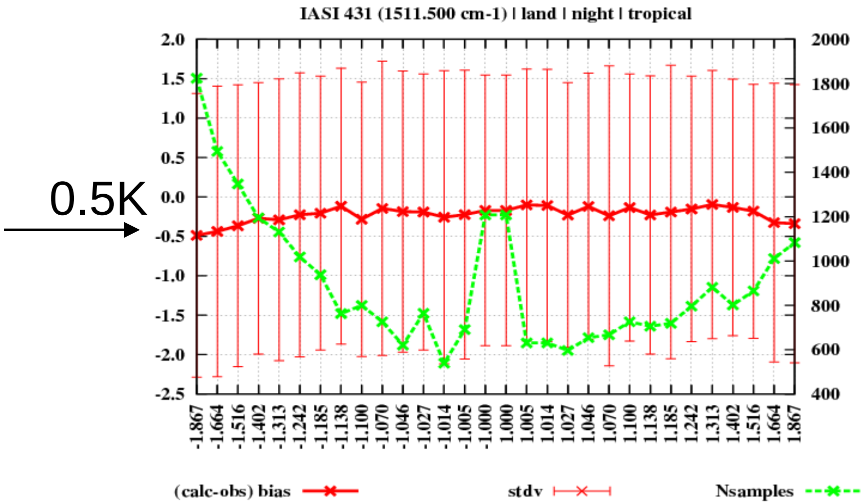
- ✓ compute mean values over the time period for each scan position
- ✓ plot differences versus scan position

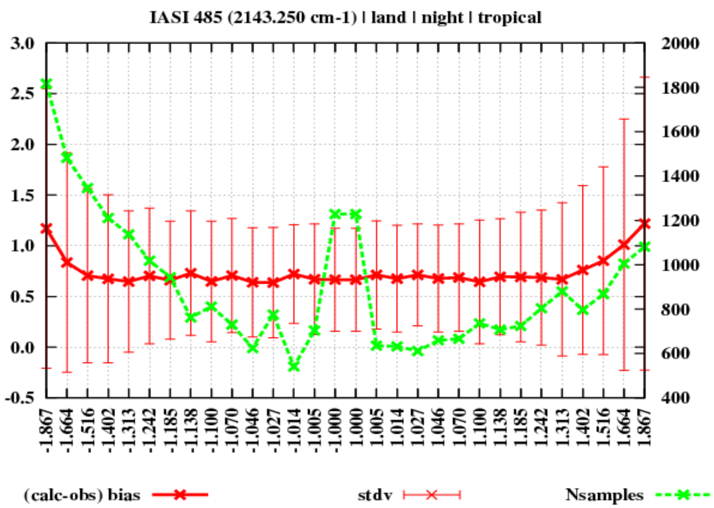
Results for MetOp-A

IASI channels
HIRS4 channels
AMSU-A channels

Scan angle effect detection : IASI/MetOp-A channels

From the computations of mean values of BT residuals July 2007 ➔current month.

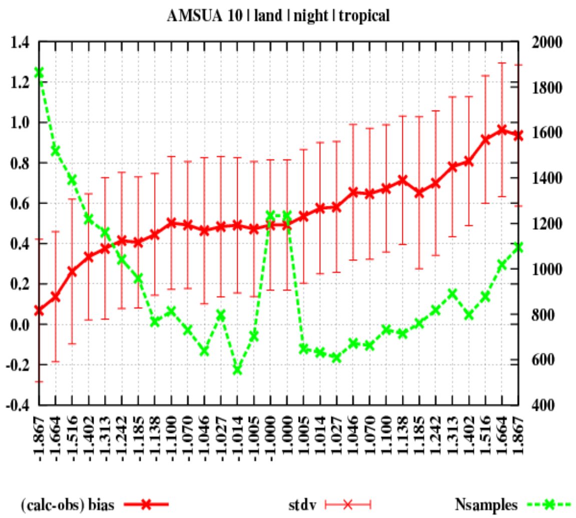




BT residuals of two IASI channels as a function of the position of the IASI spot on the scan line.
From left to right of the x-axis:
Satellite angles at the observation point from -59° to +59°

Scan angle effect detection AMSU/Metop-A Channels

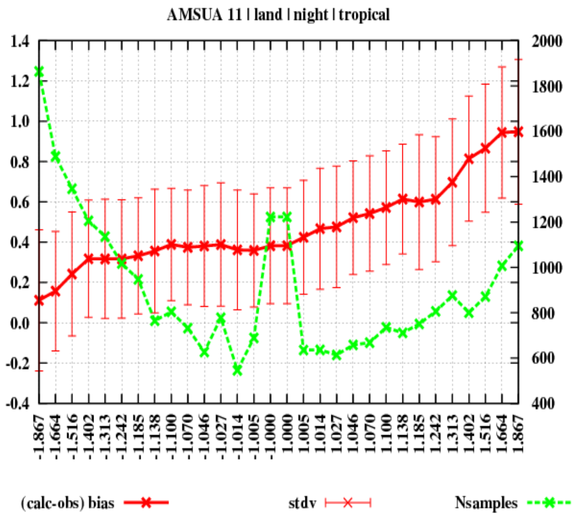
0.9K



AMSUA 10

Study of mean values of BT residuals July 2007 ➔current month as a function of the position of the spot along the scan line

0.9K



AMSU-A 11

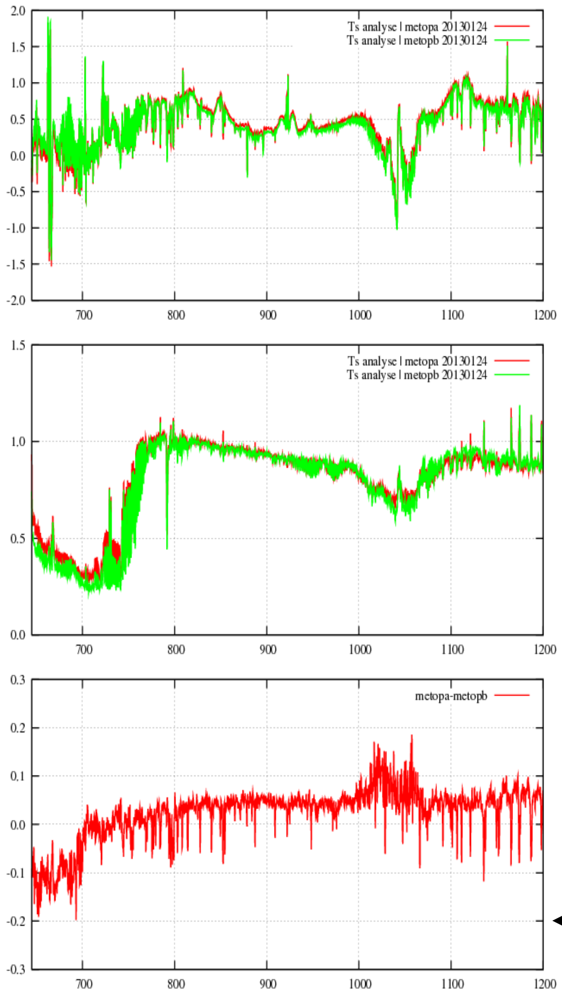
MetOp-A vs MetOp-B
(Very) First Results

- Trial dissemination starting : January 23rd
- De-archiving MetOp-A and MetOp-B through the Ether/CNES/IPSL data centre
- Level 1c, Level 1d archived at LMD (through the AAPP package UKMetOff)

- THANKS ++++ to CNES, Eumetsat, Ether,

Stand alone MetOp-A and MetOp-B for January 2013, 24th

Comparison of BT residuals for IASI/MetOp-A (red) and IASI/MetOp-B (green)
4A/OP colocated with ECMWF analyses. Space time window= 15 km
Clear scenes: MetOp-A cloud flag (*) applied to MetOp-B



0.2 K

-0.2 K

Top:
mean MetOp-A and MetOp-B spectrum
645 ➔ 1200 cm^{-1}

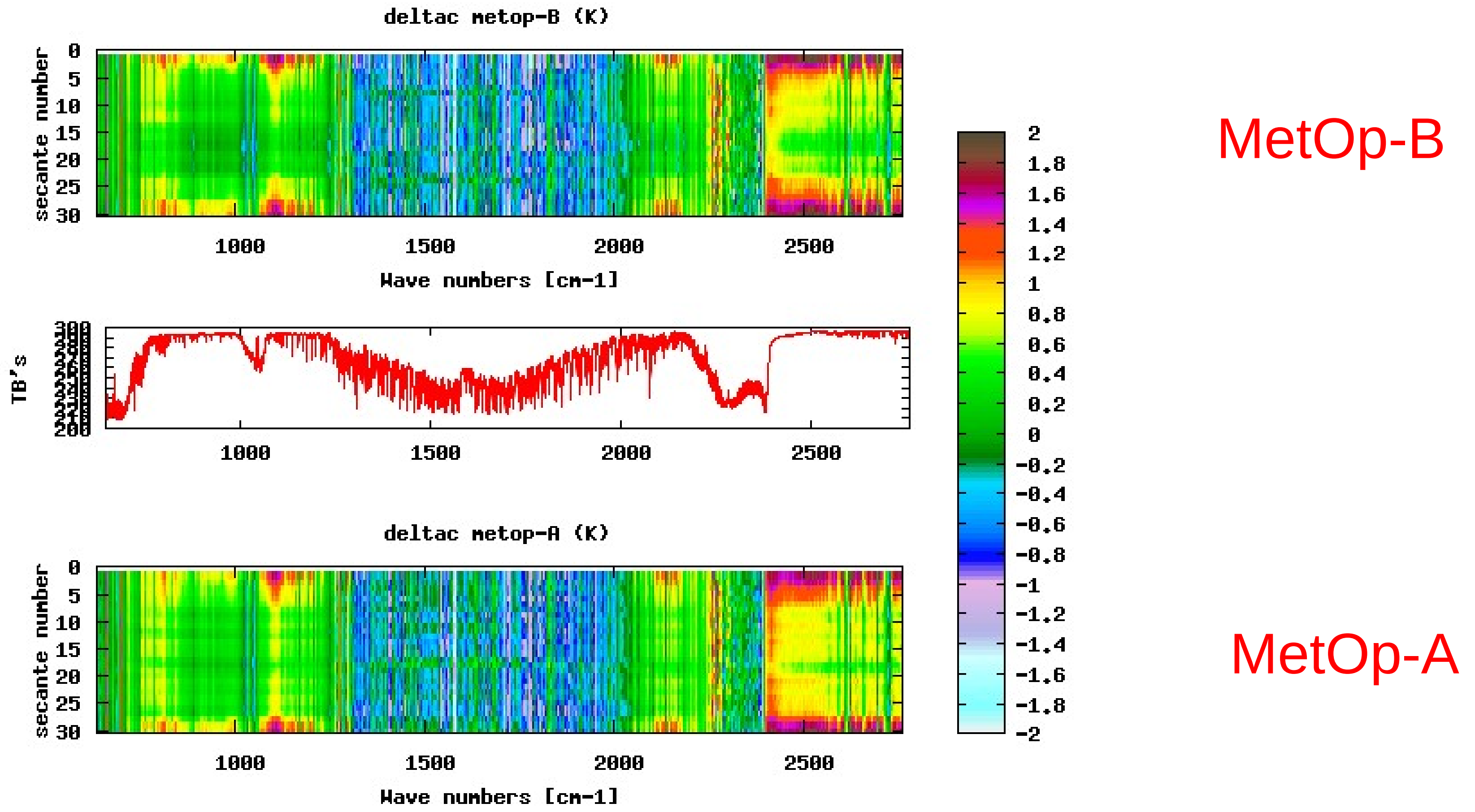
Middle:
Mean BT residuals versus wavenumber

Bottom:
BT residuals (MetOp-A) - BT residuals (MetOp-B)
versus wavenumber

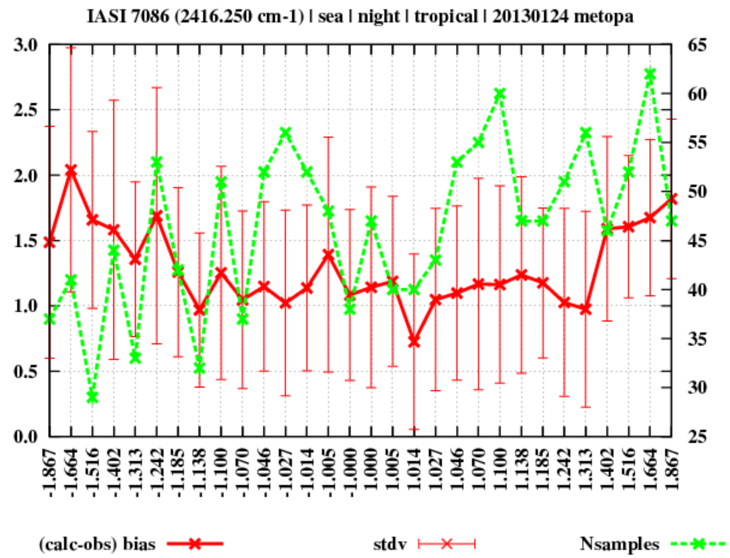
(*) See Pernin et al. Poster Presentation

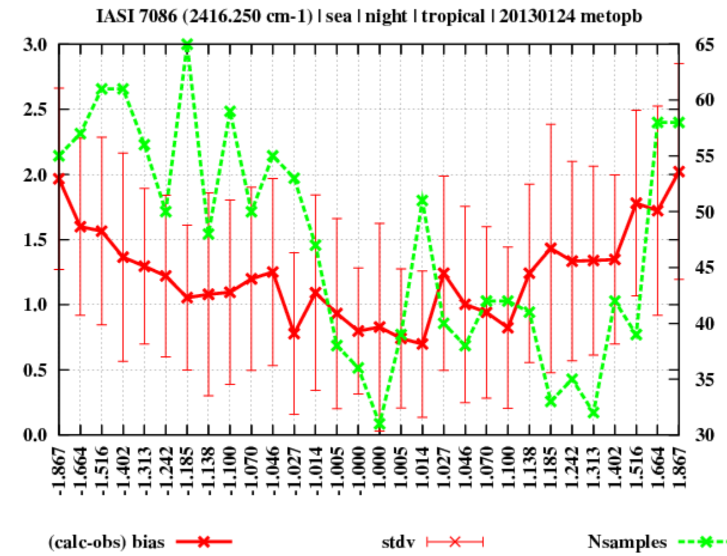
Stand alone aproach : Satellite zenith angle dependence?

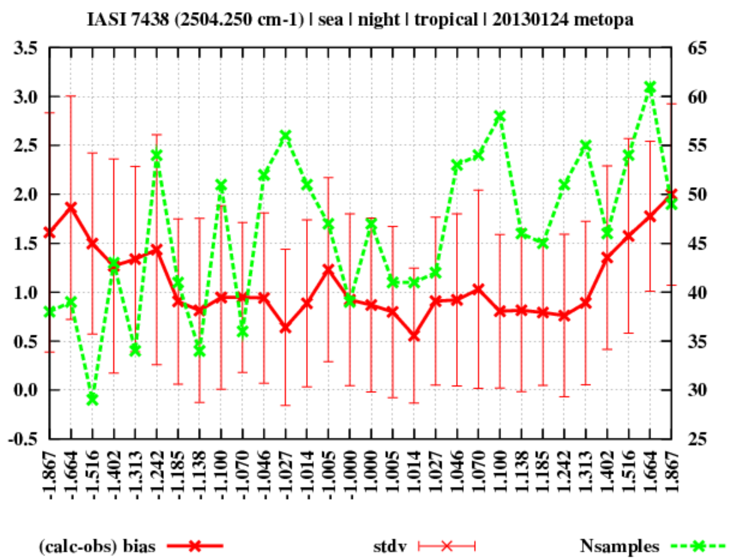
Hovmöller diagram of BT residuals versus position along the scan line
January 2013, 24th
NB: 4A/OP+Ecmwf analysis instead of usual 4A/OP+ARSA

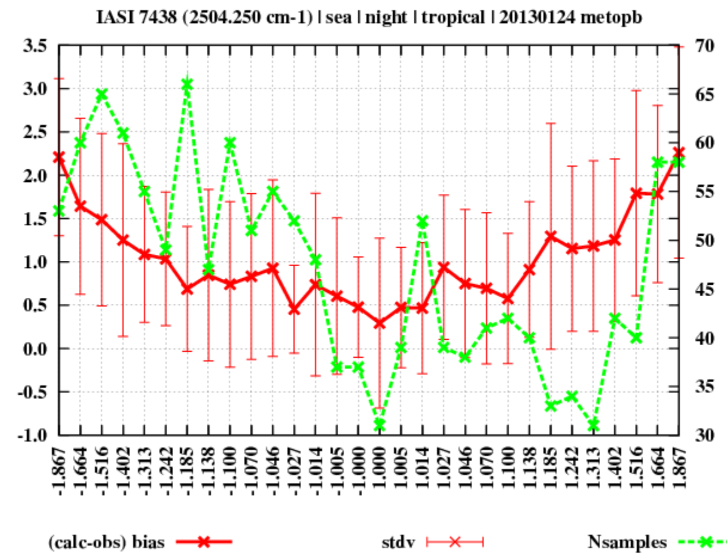


Stand alone aproach : Satellite zenith angle dependence?
BT residuals versus position in the scan line



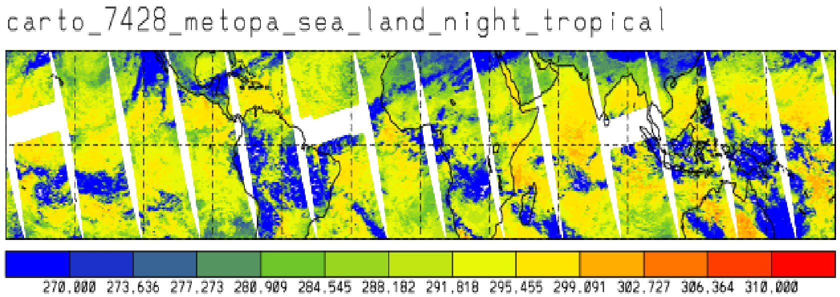






MetOp-A **MetOp-B**

January 2013, 24th

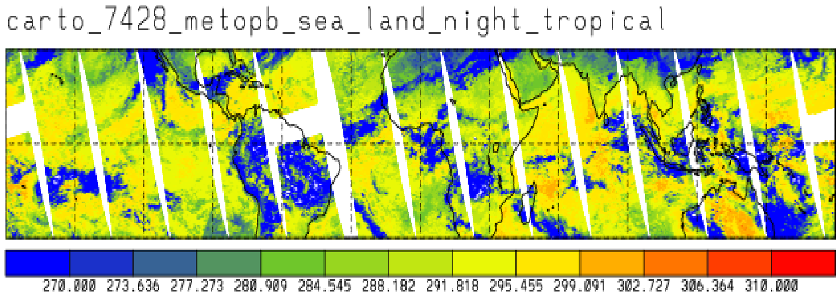


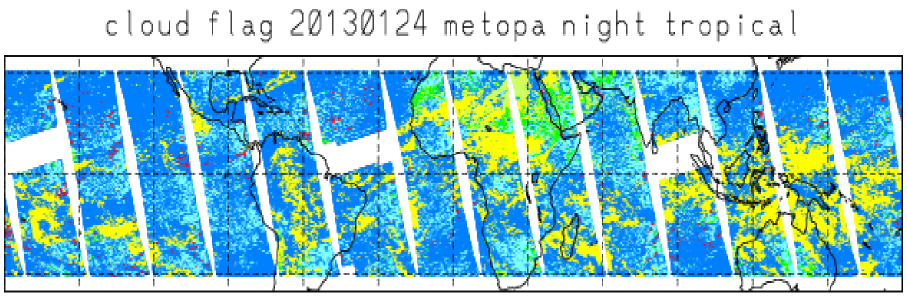
channel 7428

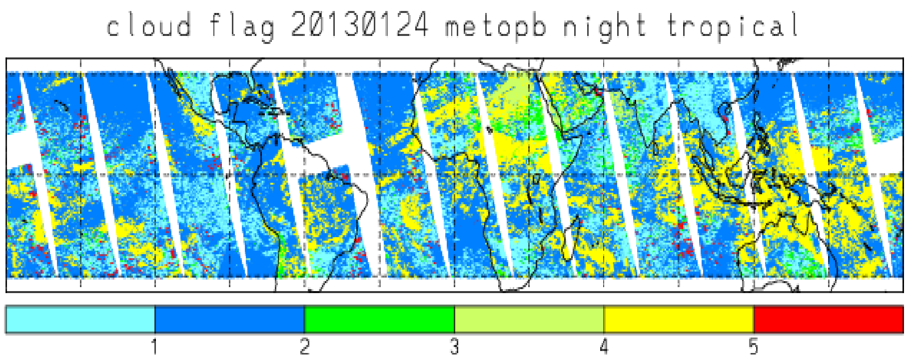
MetOp-A

MetOp-B

(January 24th, 2013)







MetOp-A clear/cloud/aerosol mask applied to MetOp-B

(January 24th, 2013)

This cloud mask relies upon a variety of IASI and AMSU channels

cf. Pernin et al. poster presentation

CONCLUSIONS PERSPECTIVE

- Stand-alone associated to inter-calibration: ➔ powerful procedures to identify unexpected or undesired radiances behaviors
- However: requires permanent validation of all the actors involved in these procedures

- Applications
  - At LMD:
    - BAU for Level1 and Level2 data processing
    - Continue the validation and distribution of ARSA database

  - Within the frame of GSICS: discussion and exchange of results and data with CNES and other international participants

Acknowledgements

- CNES for constant support in ***all*** the phases of this work,
- ECMWF, ACE_Scisat team for making available their archives
- Eumetsat for trial dissemination of MetOp-B
- Ether Thematic Centre for support and MetOp data archiving
- UK MetOff for making available the AAPP

Our very first images and first level2 products ….but requiring further examination

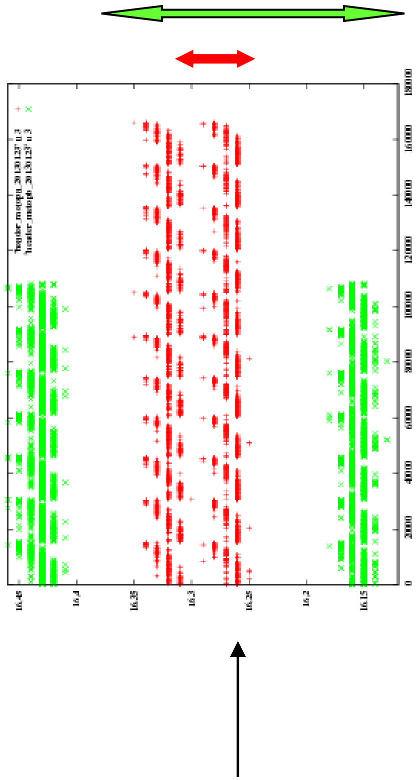
- A few images comparing MetOp-A and MetOp-B observations

- - Cloud mask for January 24^{th}, observations (tropics, night, land+sea)

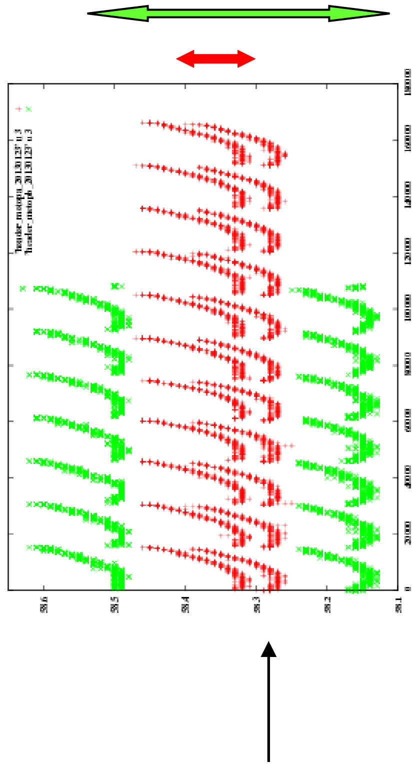
Sequence (all along the orbits) of Satellite Zenith Angles
Day : January 2013, 23rd

Tropics: -30,+30°

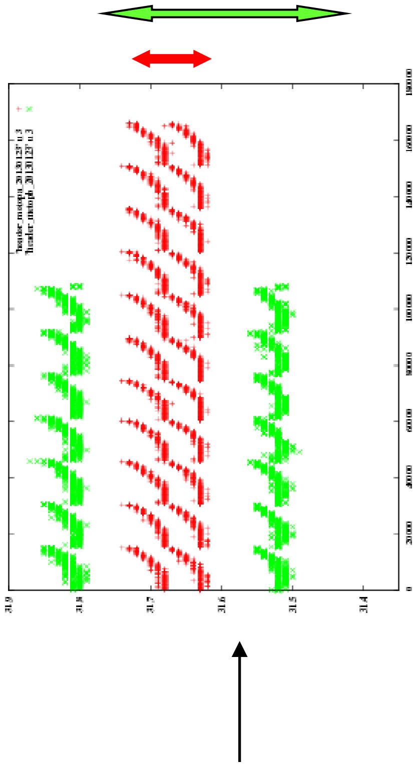
Red : MetOp-A   Green: MetOp-B



SatZenAng ~ 16.3°



SatZenAng ~ 58.35°

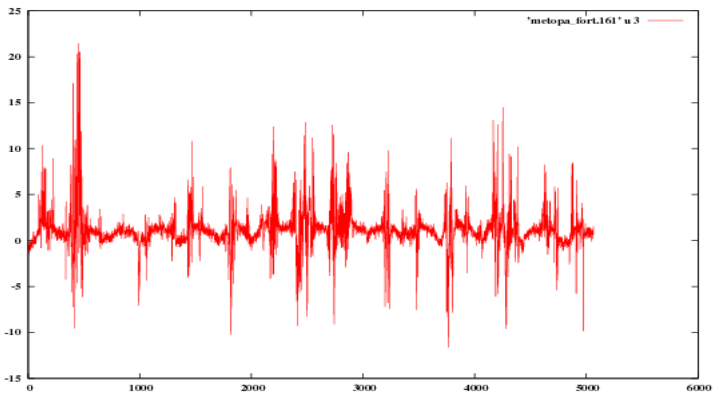


SatZenAng ~ 31.65°

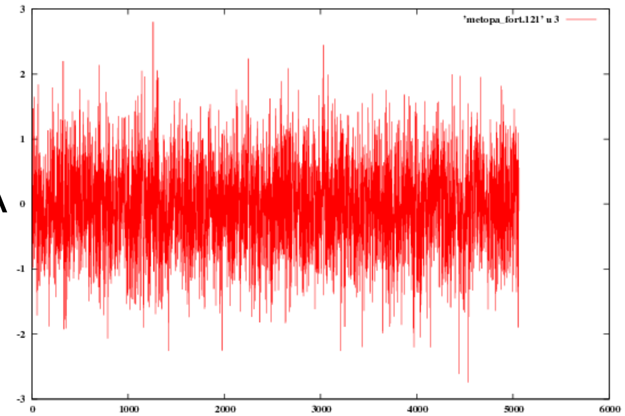
What about the status of HIRS on MetOp-B?
Sequence of IASI_j – HIRS_k for a given secant
Day : January 2013, 24th
I and k : indices of « companion channels » resp IASI and HIRS

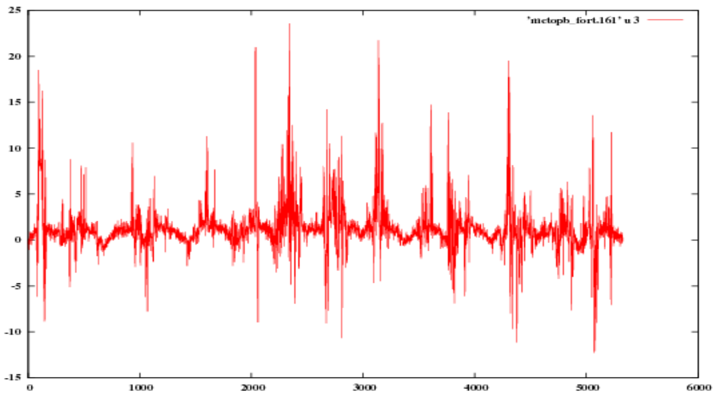
k=4 (HIRS ch4)

k=2 (HIRS ch2)

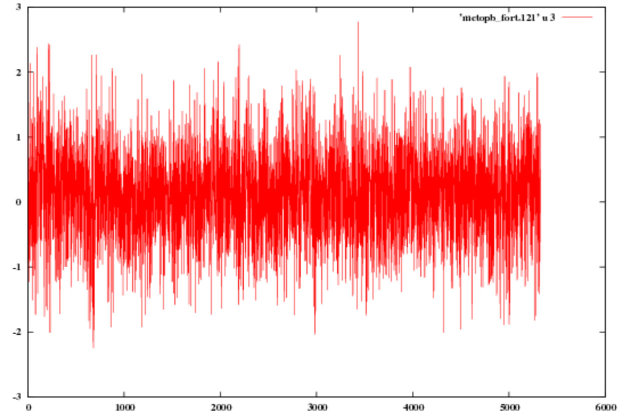


MetOp-A

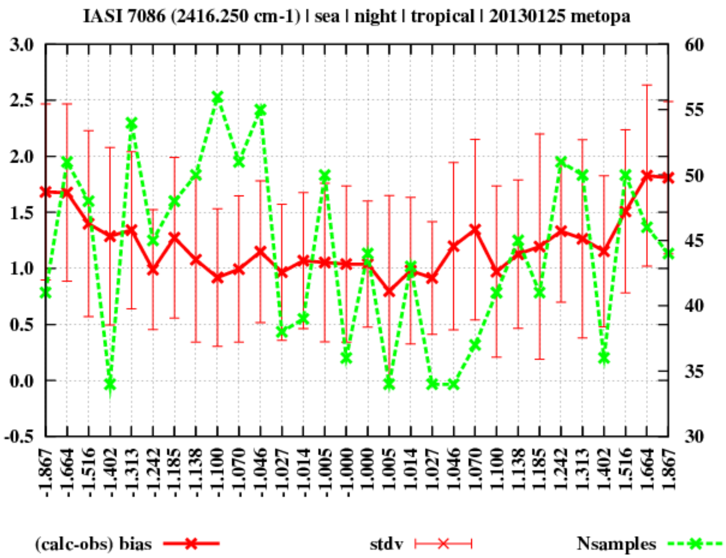


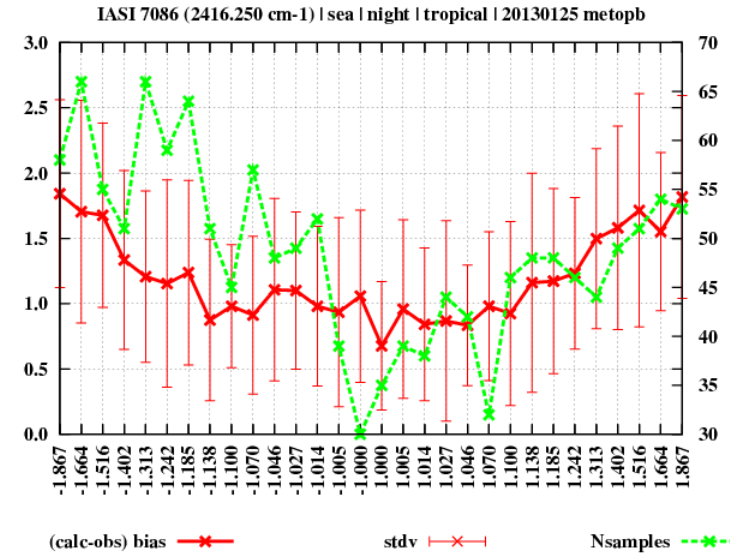


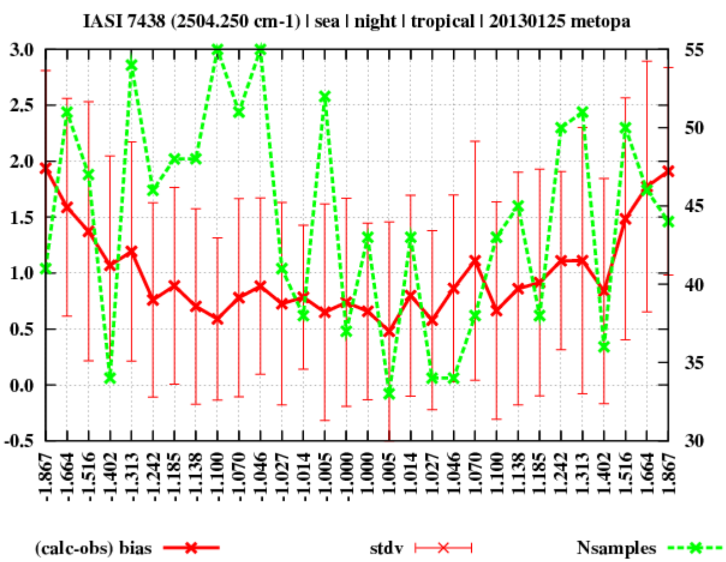
MetOp-B

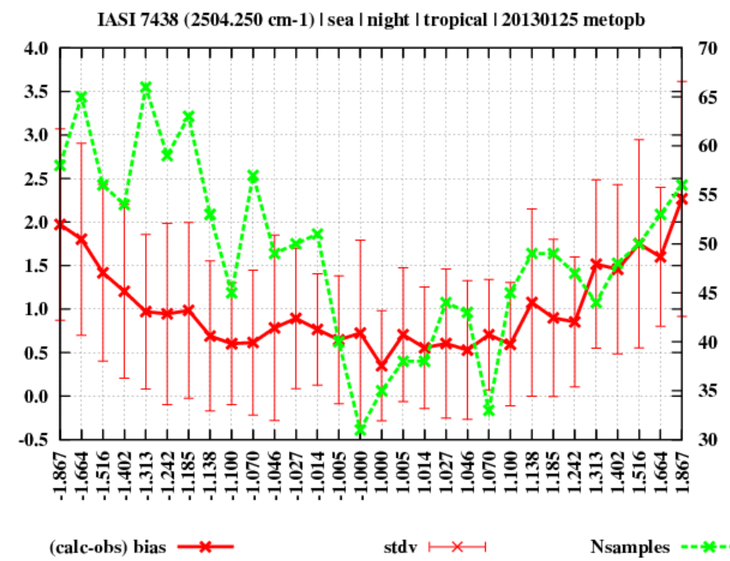


- FIN DE LA PRESENTATION


IASI 7086 (2416.250 cm-1) | sea | night | tropical | 20130125 metopa
(calc-obs) bias
stdv
Nsamples


IASI 7086 (2416.250 cm-1) | sea | night | tropical | 20130125 metopb
(calc-obs) bias
stdv
Nsamples


IASI 7438 (2504.250 cm-1) | sea | night | tropical | 20130125 metopa
(calc-obs) bias
stdv
Nsamples

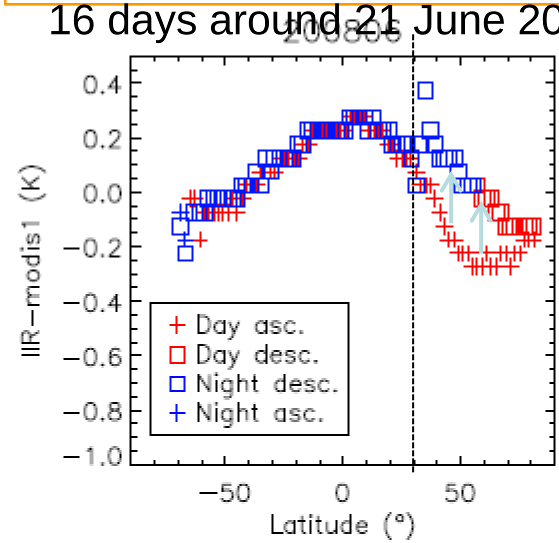

IASI 7438 (2504.250 cm-1) | sea | night | tropical | 20130125 metopb
(calc-obs) bias
stdv
Nsamples

Discussion (2/2)

- Based on these findings, complementary analyses were conducted by plotting IIR-MODIS versus latitude for « short » periods of time.

- Below is an illustration for IIR 8.65 µm-mod29 in June 2008. We observe an hysteris effect between the descending (squares) and ascending (+ signs) portions of the orbit for lat > 30N, which explains the night-day differences observed in the 30N-60N latitude band in summer.

IIR- MODIS vs latitude,
clear sky + non-dust aerosols, sea,
16 days around 21 June 2008



- CNES evidenced a calibration bias related to the elapsed time after the Night to Day transition, therefore at different latitudes according to the season, and expected in the range of latitudes where the IIR-MODIS hysteresis effect is observed.

- Further investigations are on going.

POSITIVE IMPACT OF COMBINATION OF RAOB+ERA_INTERIM+

Water vapor profiles in ARSA: Extension of RAOBs from 350 hPa to 0.1 hPa with ERA_Interim profiles followed by an empirical adjustment of ERA_Interim profiles between 350 and 100 hPa.

WATER VAPOR : 6.3 µm

Blue ➔ ARSA (h2o = RAOB+ERA_INTERIM +ACE_FTS) versus Red ➔ (h2o = RAOB + « OLD » EXTRAPOLATION)