CENTRE NATIONAL D'ÉTUDES SPATIALES

Status of IASI performances after 3 years in orbit

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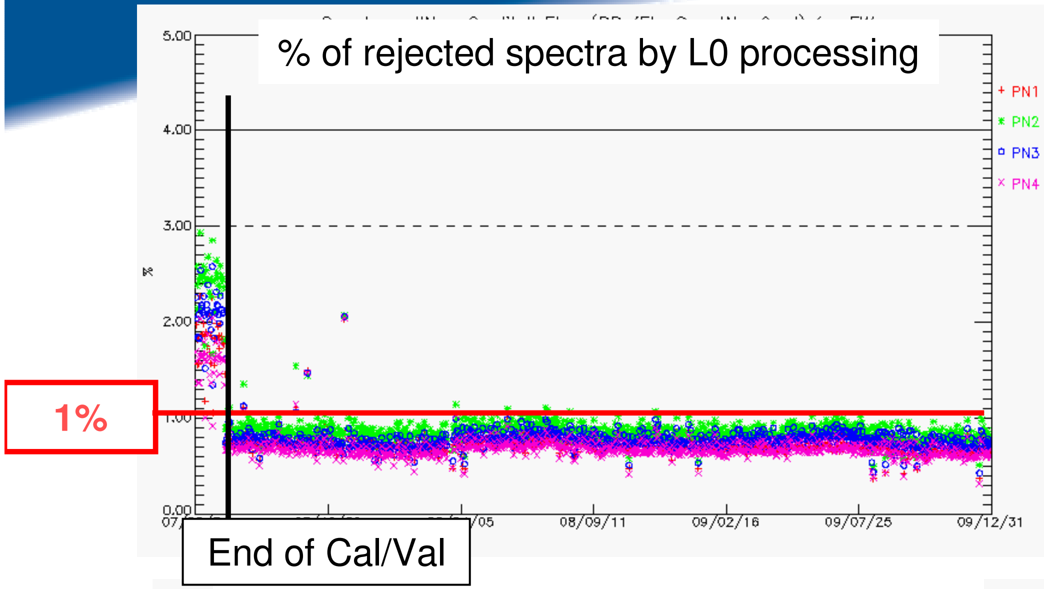
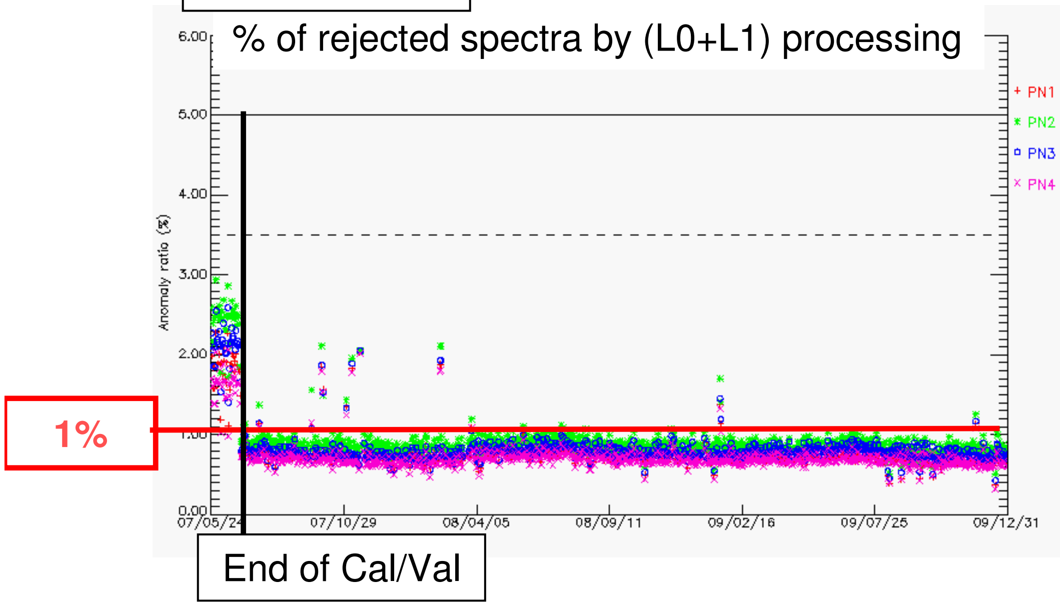
Outline

- 1. L0/L1 Data quality
- 2. Radiometric performances
- 3. Spectral performances
- 4. Geometric performances
- 5. Ghost effect
- 6. Gibbs effect
- 7. Moon intrusion in CS1
- 8. Compression

Overall quality of L0/L1 data





	PN 1	PN 2	PN 3	PN 4
Total % of rejected spectra	**0.83**	**1.01**	**0.88**	**0.77**
% of rejected spectra by L0 processing (on-board)	**0.81**	**0.99**	**0.86**	**0.75**

- Main contributors : spikes in B3 (0.55%), NZPD detection failure (0.15), Radiometric calibration failure (0.02%), Over/Underflows (0.02%)
- In NOp, 99% of good quality spectra
- Ground segment is very reliable

Stable since end of Cal/Val

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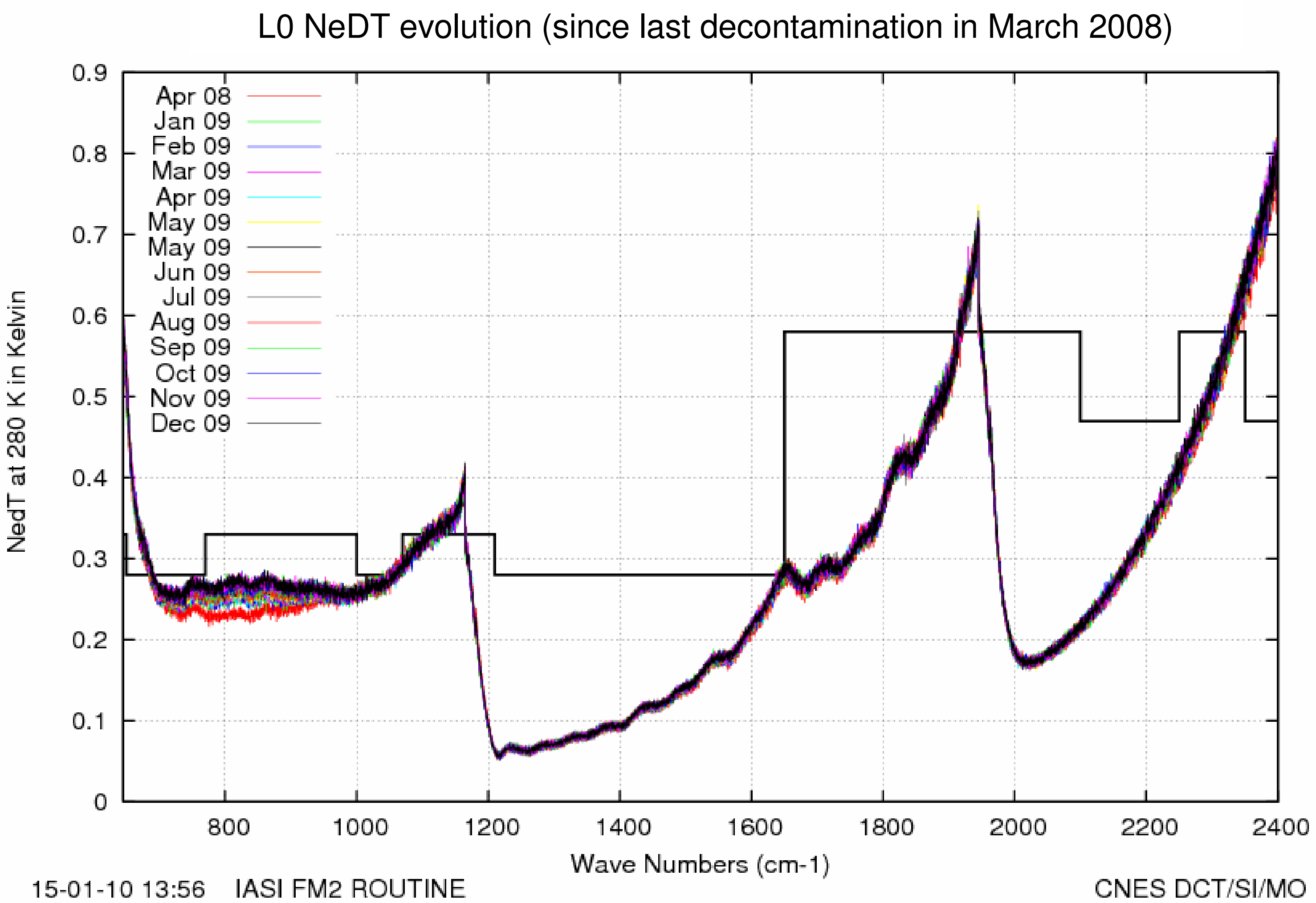
Radiometric noise

Monthly Estimation (Ext.Cal.) by using Hot Black Body target



Stable since last decontamination, except ice effect between 750 et 900 cm^{-1}

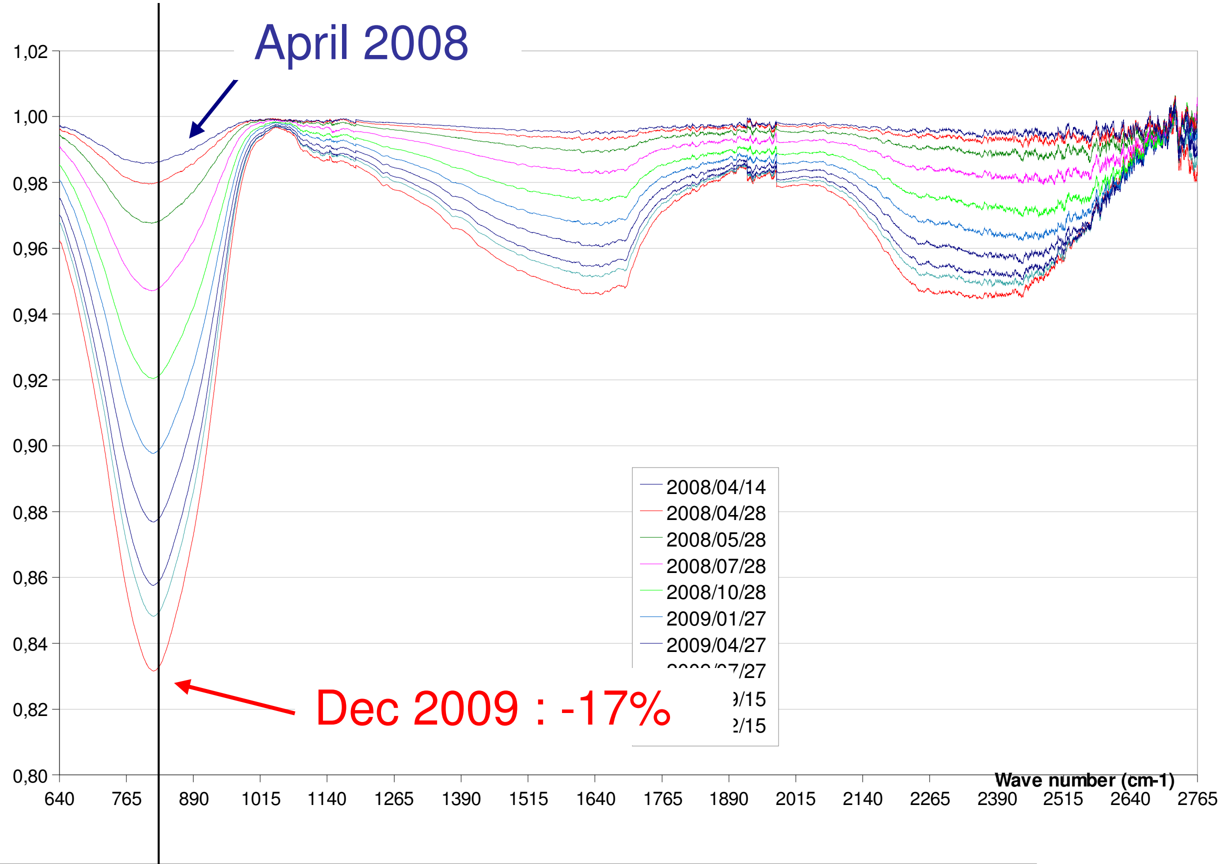
Instrument transmission since last decontamination (March 2008)

Estimation by using radiometric calibration coefficient (slope)

Physical phenomenon : water released by materials at 300K (MLI, electronics)

- → **condensation on field lens at 100K (entrance of Cold Box Subsystem)**
- → **formation of ice**
- → **instrument transmission decreases**
- → **less signal**
- → **SNR decreases**
- → **NeDT increases**

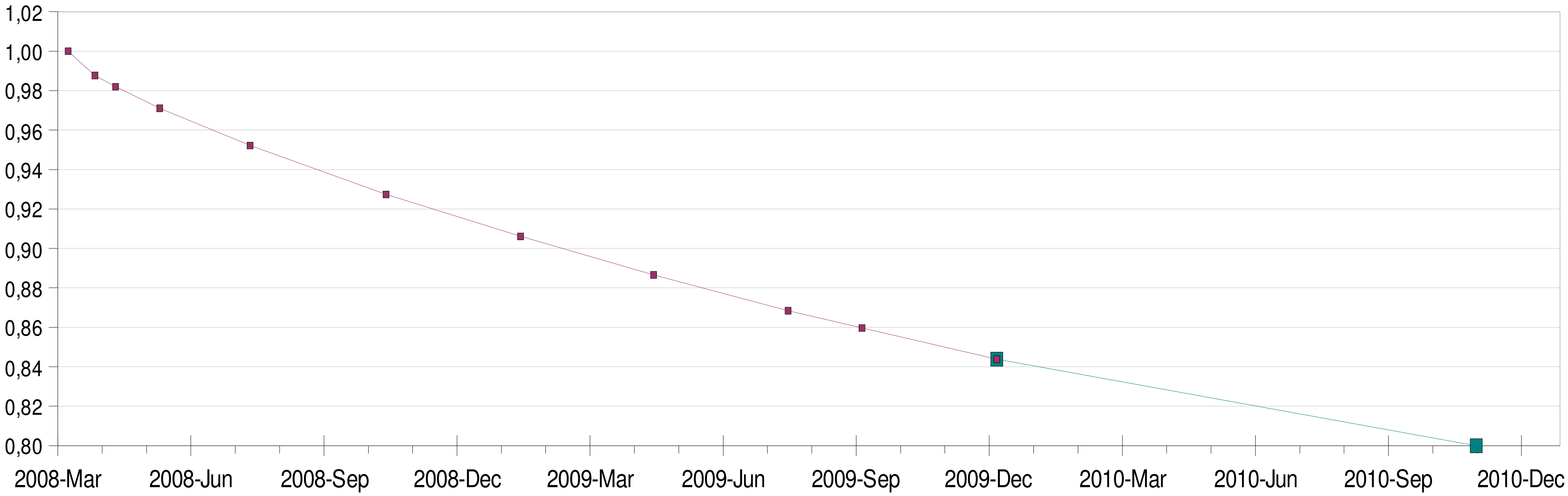
Instrument transmission evolution



Maximum loss due to water ice at 812 cm^{-1}

Next decontamination

Evolution of instrument transmission at 850 cm^{-1} since last decontamination

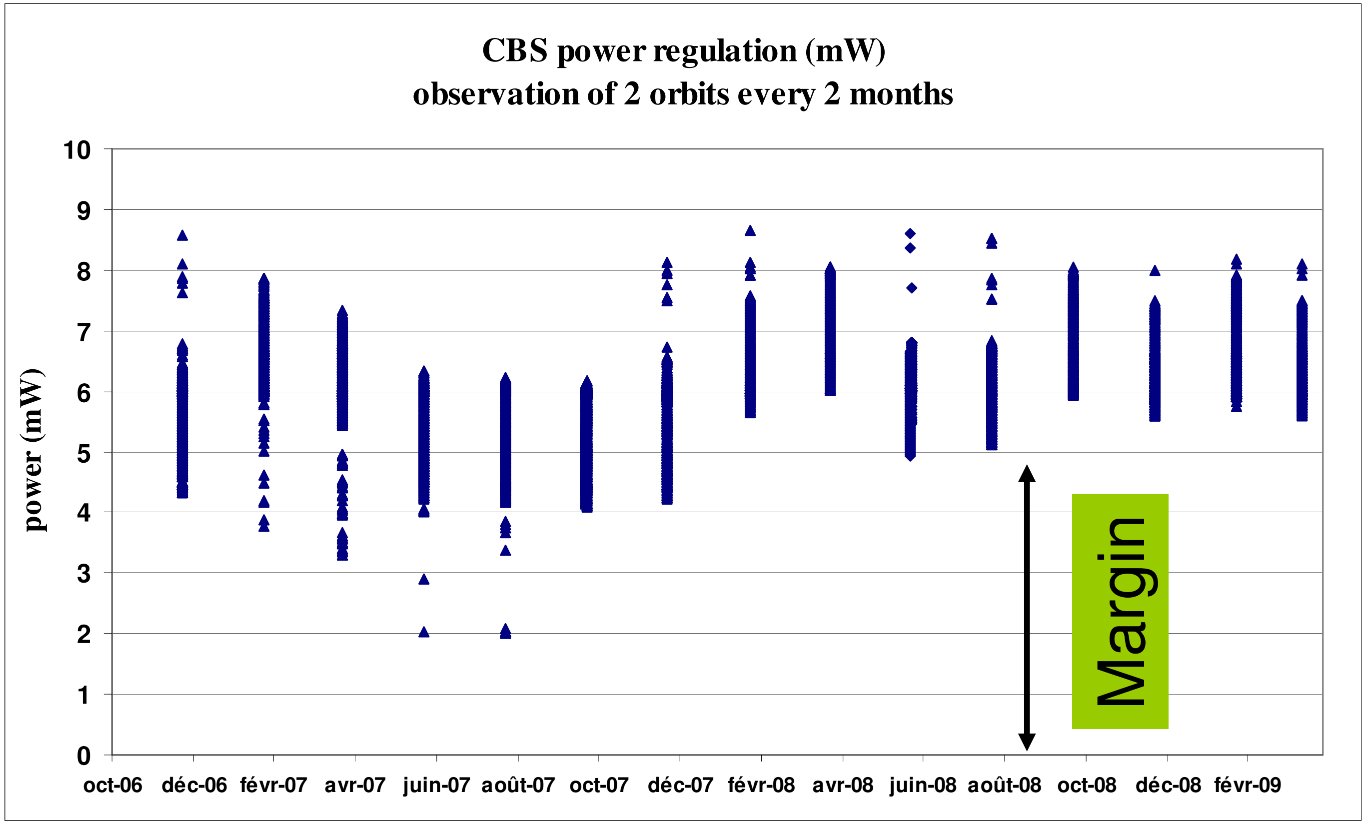


- **Criteria :** **maximum noise increase of 20-25% @ 850cm^{-1} (= transmission loss of about 20-25%)**
- **Last IASI decontamination :** **21-24th March 2008 (1.5 year after launch)**
- **Next one :** **October/November 2010 (2.5 year after the last one)**

Stability of detector temperature

- **Focal plane temperature regulated at 91.7 K**

- **Power regulation**
  - **Stable (No trend towards 0)**
  - **Seasonal effect**

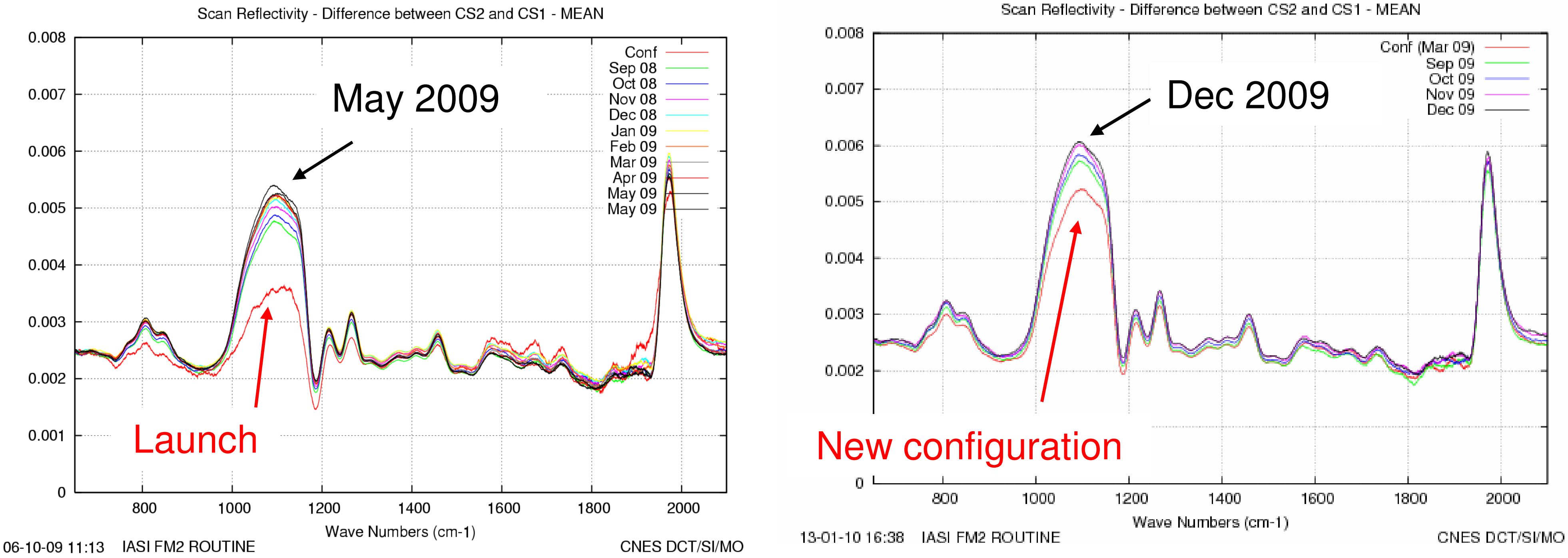


- **Conclusions**
  - **Contamination of the sun shield is low, radiators still working nominally**
  - **Margin sufficient : No need to increase focal plane temperature target**

→ Stability of the radiometric noise expected in the next years

Scan mirror reflectivity : variation with incidence

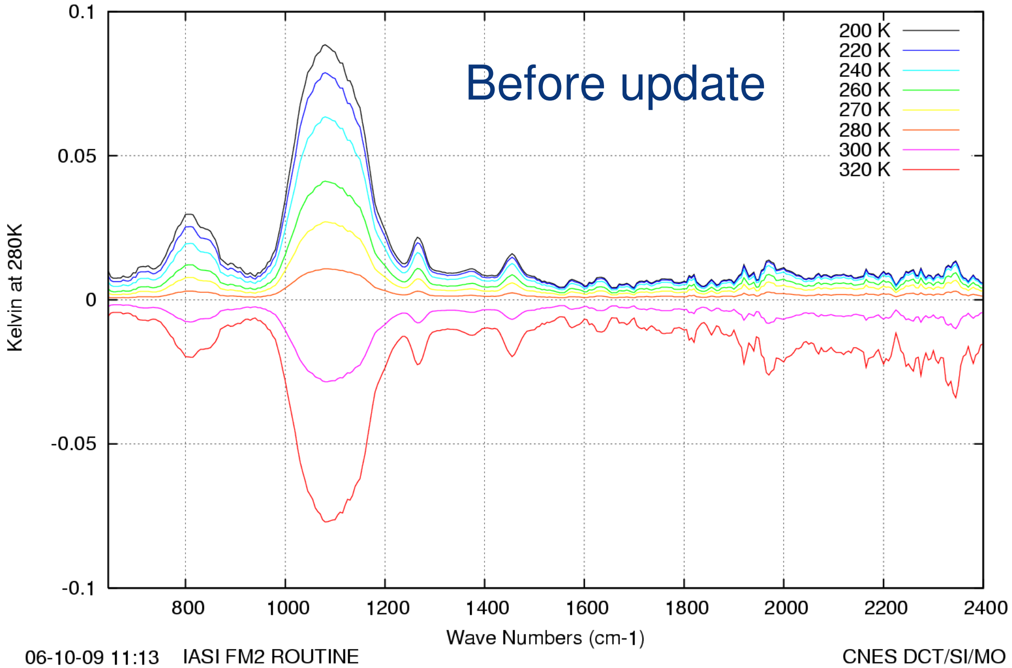
Monthly Estimation (Ext.Cal.) by using L0 spectra from CS1 (10°) and CS2 (60°) targets

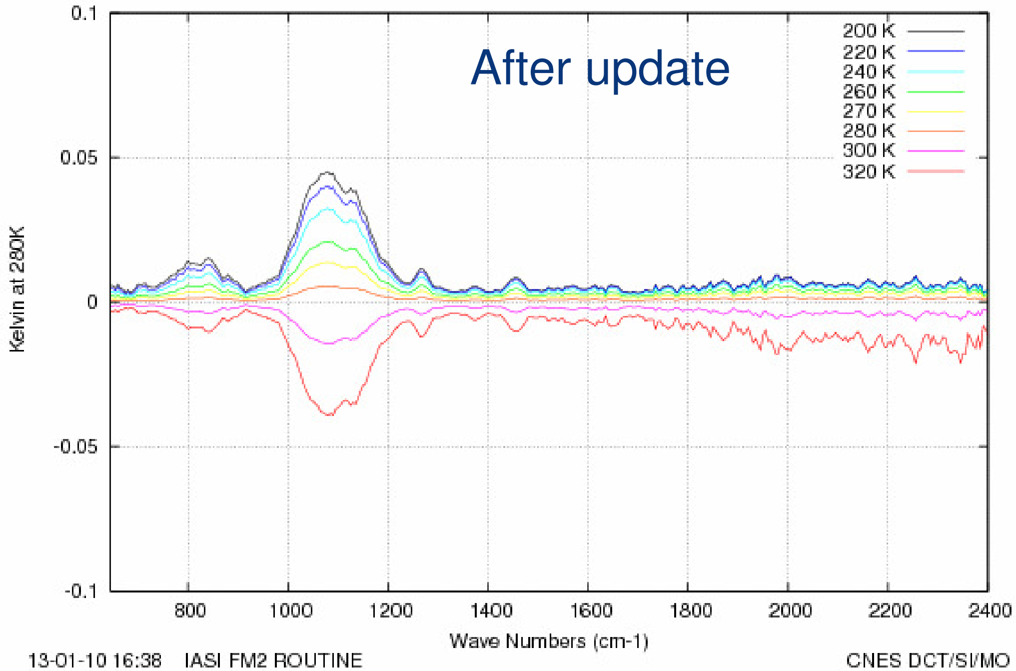


- Update of scan reflectivity in May 2009 (ground segment configuration file)
- Used in L1 processing to correct for this effect (radiometric post-calibration)

Scan mirror reflectivity : radiometric impact

Maximum impact of scan reflectivity variation on radiometric calibration within a scan line for different scene temperature





- specification = 0.1K

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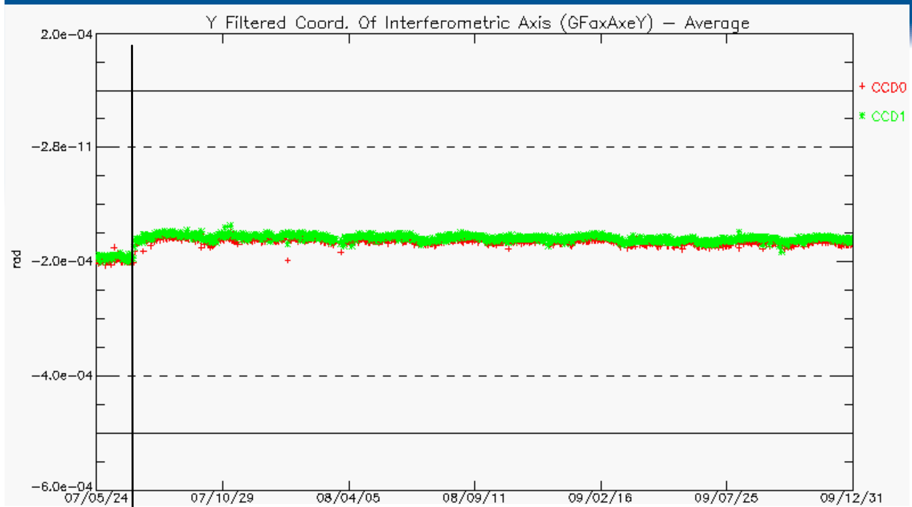
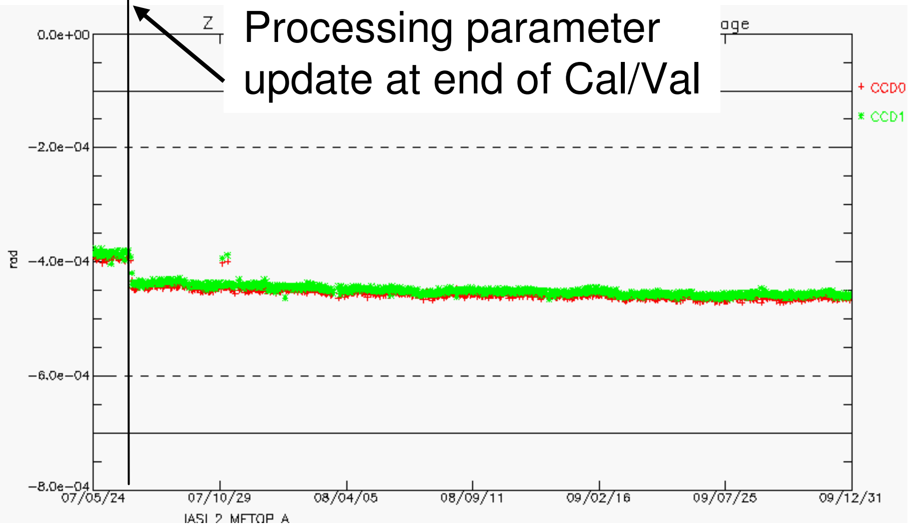
Interferometric Axis



Y position of IA at the end of Cal/Val : Y0 = -159 µrad

Long term drift: $Y-Y_0$= - 8 µrad

Seasonal cycle amplitude: 15 µrad



Z position of IA at the end of Cal/Val : Z0 = -443 µrad

Long term drift: $Z-Z_0$ = - 25 µrad

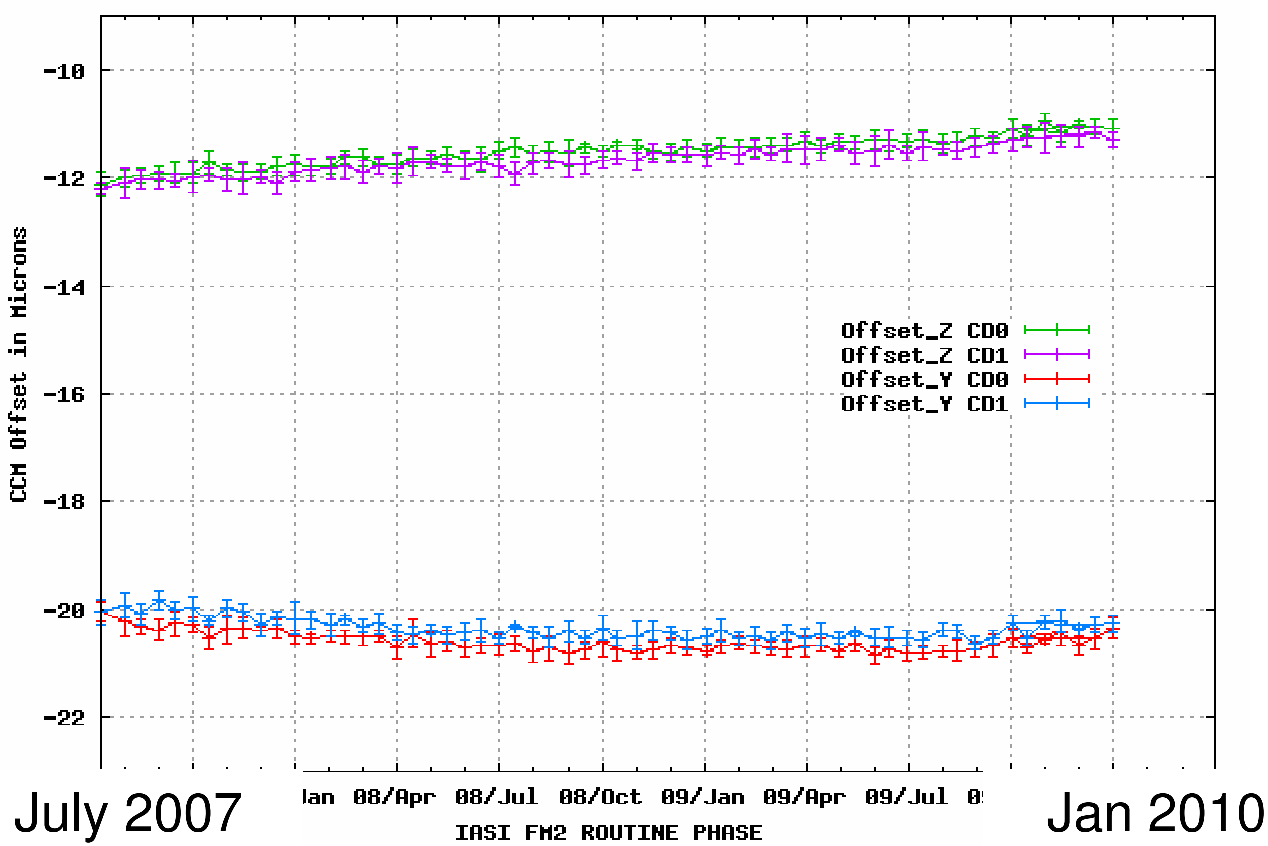
Seasonnal cycle amplitude: 20 µrad

- Total drift with respect to reference position in the spectral database: (+40 µrad,-60 µrad)
- As soon as |Total Drift| < 300 µrad => No spectral database configuration update needed

Cube corner Motion

Velocity : continuous on-board monitoring
+ regular in-depth checks (no evolution)

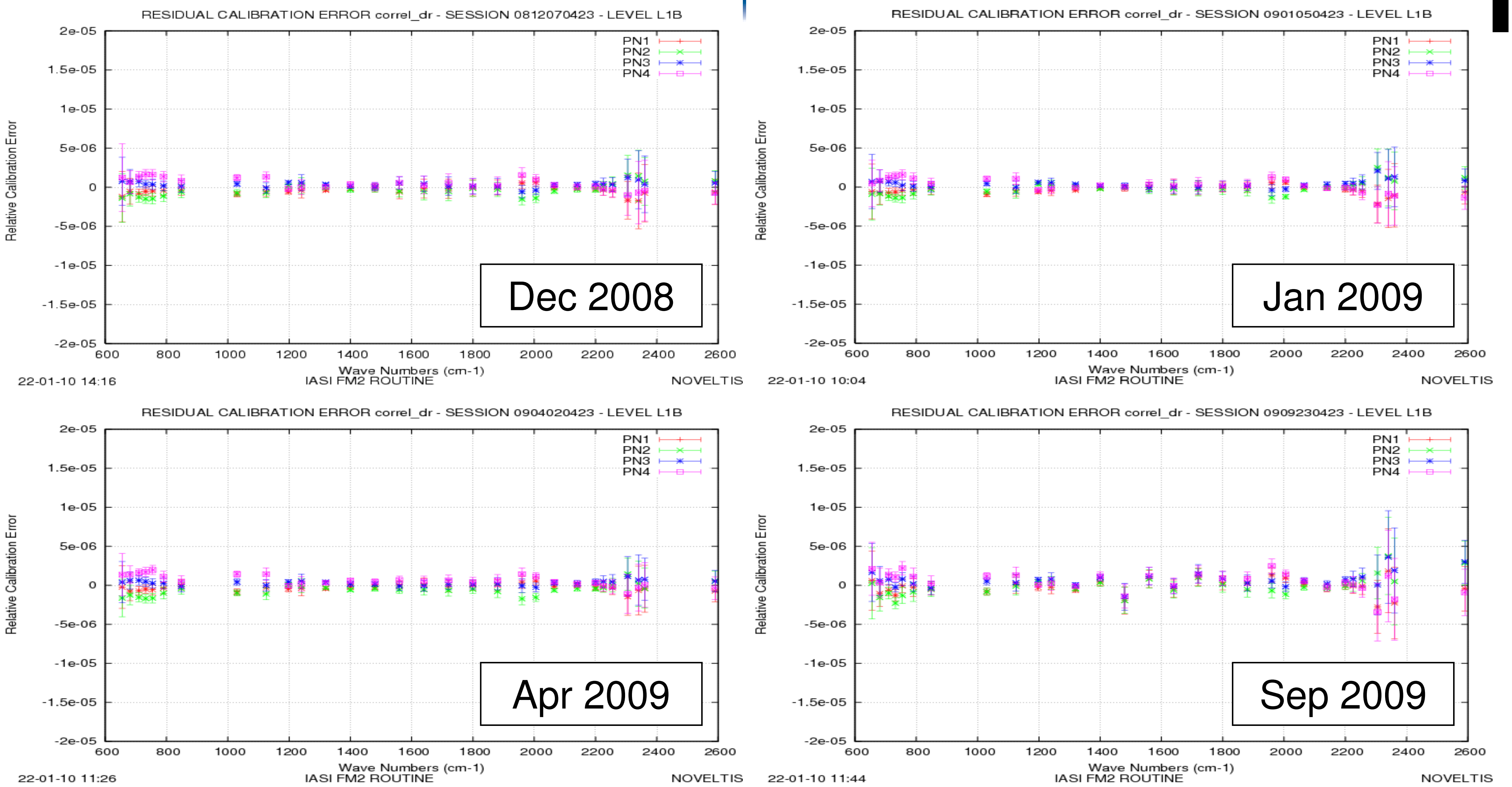
Position : cube corner offset (shear)



July 2007 Jan 2010

Drift < 1 µm in 2.5 years
=> No spectral database configuration update needed (up to 4 µm)

Spectral calibration monitoring : L1B interpixel homogeneous scenes (night/sea) in EC



- Stable since the end of Cal/Val and < 2.10^{-6}

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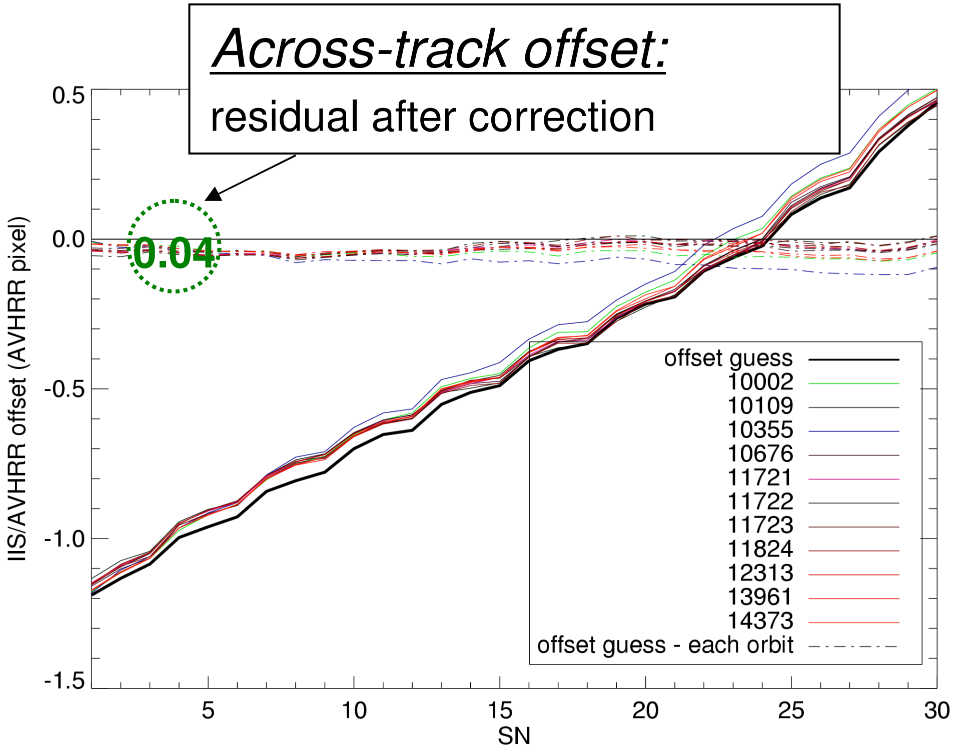
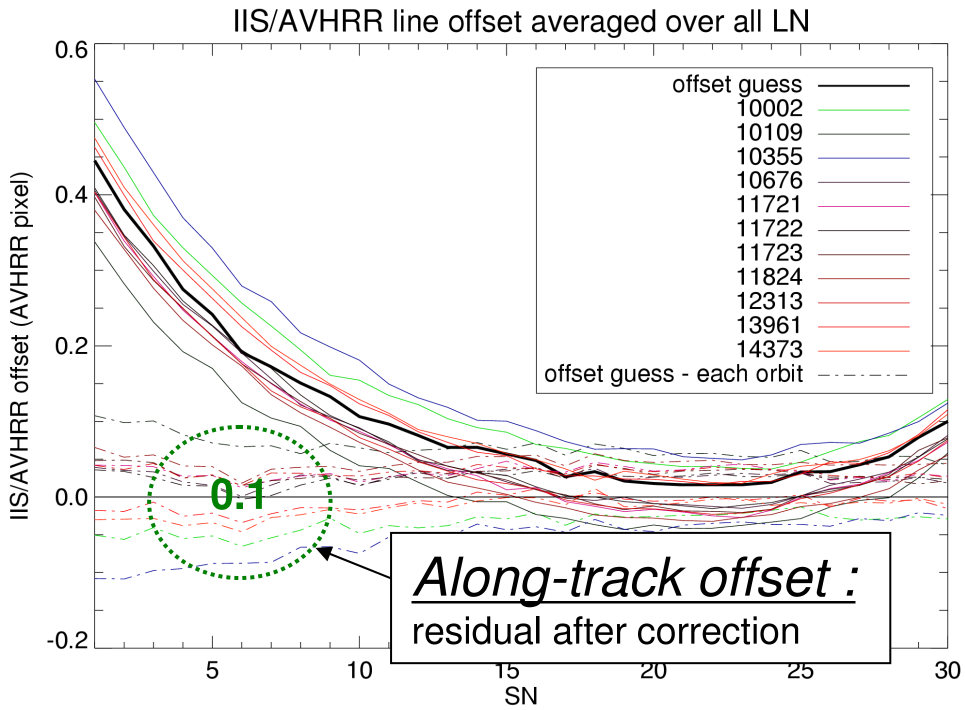
IIS/AVHRR Coregistration

- IIS offset in AVHRR raster : along-track (0.1 AVHRR pixel), across-track (0.04 AVHRR pixel)
- IASI pixel centre localisation accuracy in AVHRR raster ~ 100m



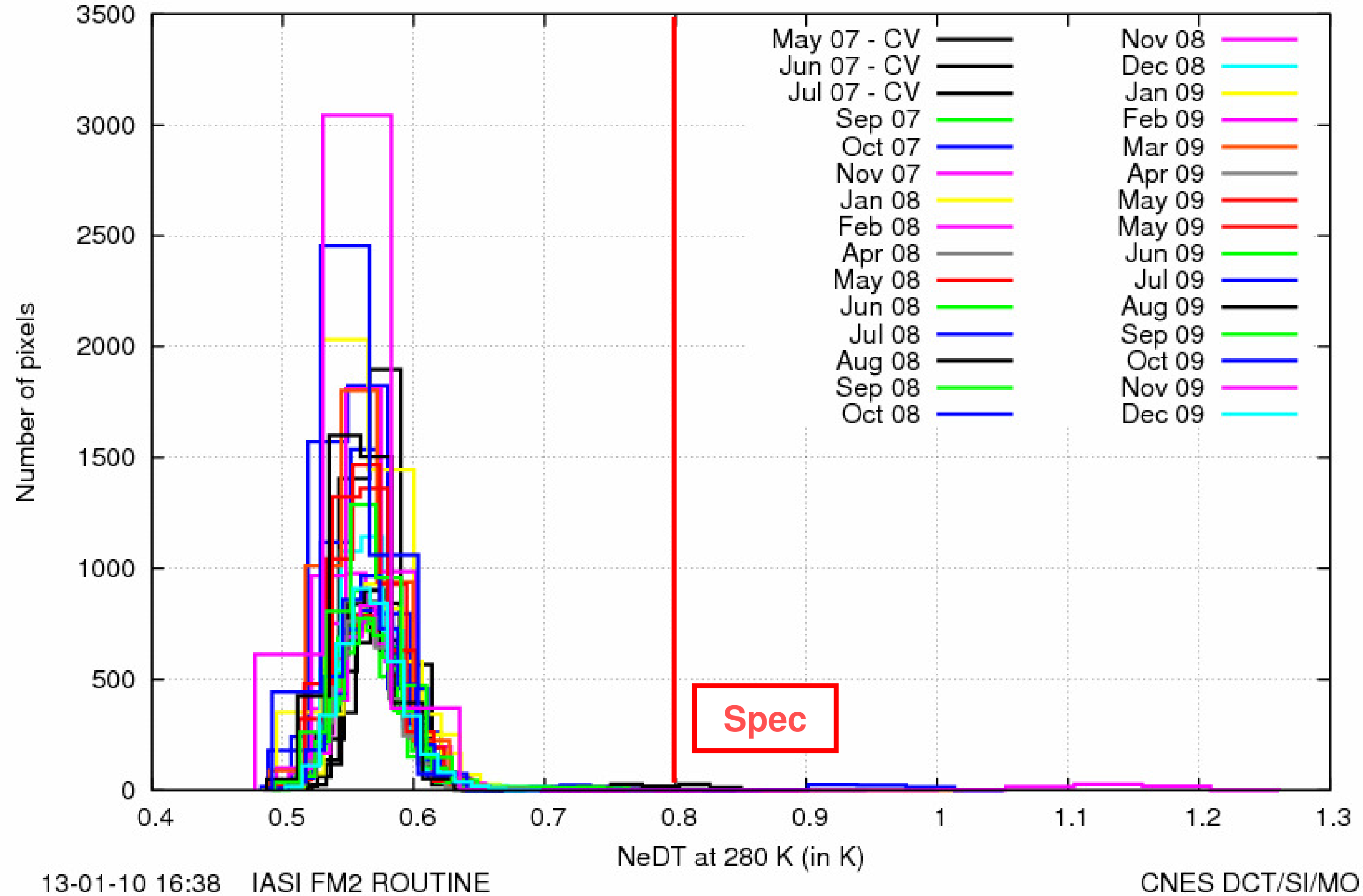


Within the specification (0.3) and very good stability since the end of the Cal/Val

→ Health check for scanning mirror mechanism

IIS noise

Temporal evolution of IIS noise (histogram with all the pixels)



• Stable (0.57K) and widely within the specification (0.8K)

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Origin : beam-splitter micro-vibration at 380Hz

Impact on Instrument Spectral Response Function (ISRF) :

- Replication of ISRF
- The spectral position and the amplitude of the replicated ISRF depends on : cube corner velocity, micro-vibration mechanical amplitude and frequency, field angle, orientation wrt focal plan and wavenumber

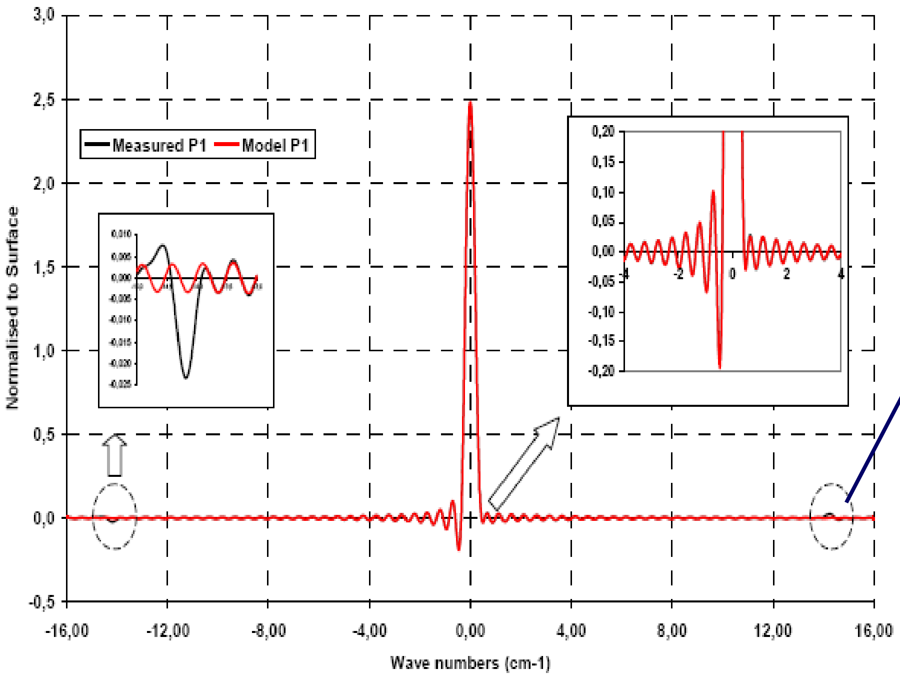
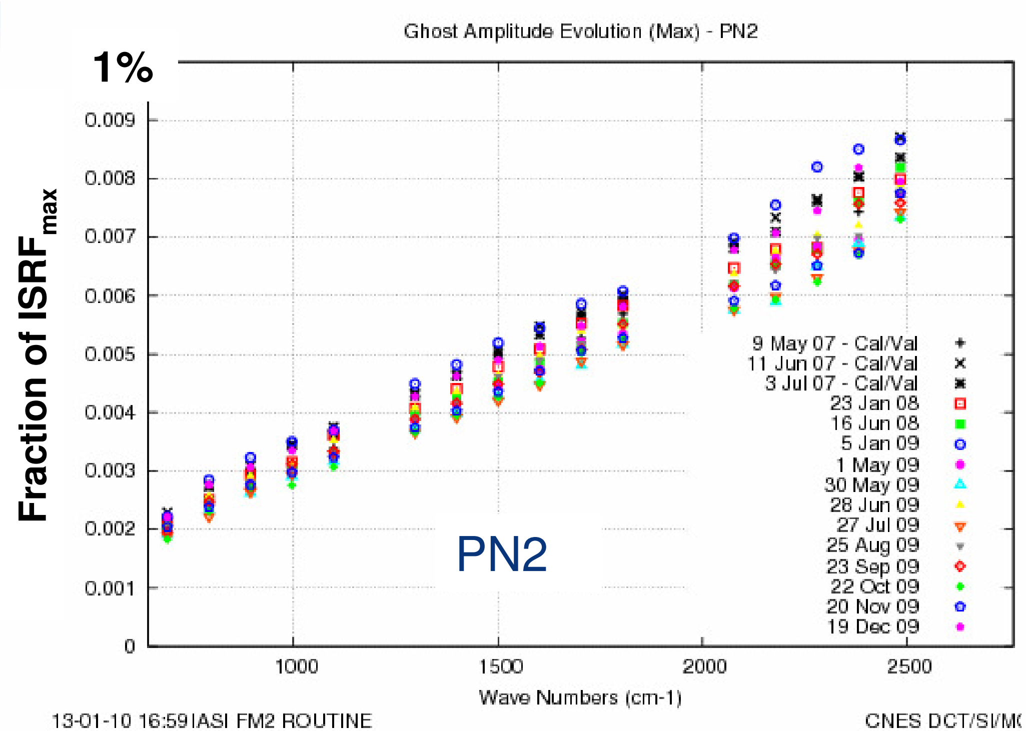


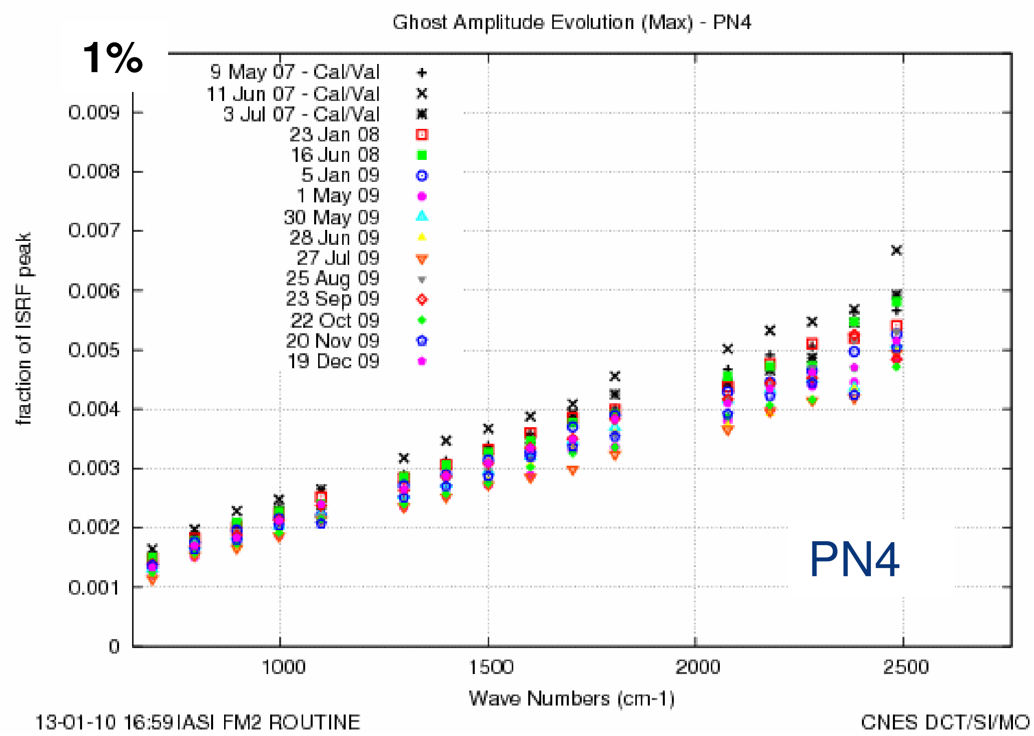
Fig 11b – ISRF in band B3 (2655.9 cm^{-1})

- Ghost effect is very small with respect of $ISRF_{max}$
- The position w.r.t the center of the ISRF gives us the frequency

Ghost : in-flight monitoring

In-flight monitoring : by using imaginary residuals of radiometric calibration on BB target





Maximum effect w.r.t $ISRF_{max}$

- PN1 & PN2 : 0.9%@2500cm^{-1} (stable since end of cal/val) => amplitude ~ 0,72 µm
- PN3 & PN4 : 0.6%@2500cm^{-1} (stable since end of cal/val) => amplitude ~ 0,45 µm
- Vibration around the vertical axis of the beam splitter

Parameterization of ghost effect :

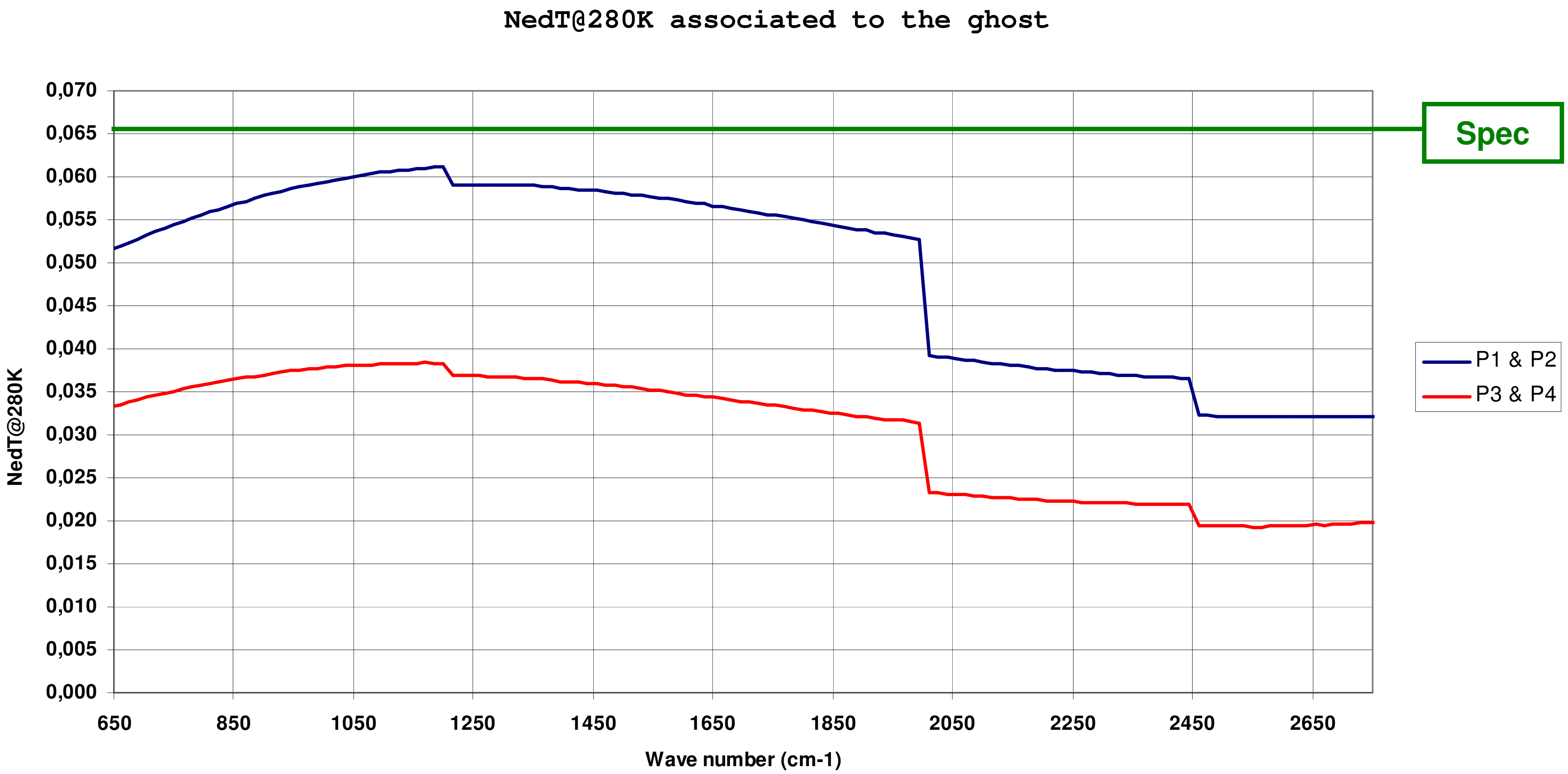
- The effect depends on the cube corner motion, field angle, vibration frequency, amplitude, orientation wrt focal plan and wavenumber. All of these parameters are known or measurable (on-ground TV test / in-flight) and stable with time.
- However, the phase of the ghost is pseudo-periodically changing with time and not accurately measurable => its projection on the real part of the ISRF is varying pseudo-randomly with time => ghost impact on ISRF is randomly sampled with time over a scan line

Impact on radiometric performances :

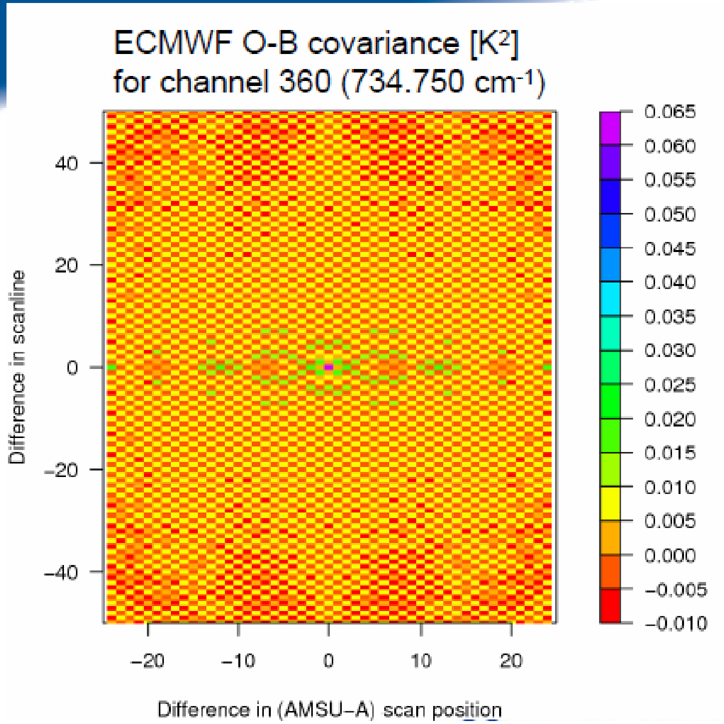
- Ghost has a direct impact on the ISRF by modifying its shape.
  - ⇒ Error between the simulated ISRF and real one
- Because ghost impact on ISRF is randomly sampled with time over a scan line, its effect on IASI spectra cannot be accurately simulated and then corrected. Its effect is then assimilated to a random pseudo-noise.
  - o Pseudo-noise associated to the maximum ghost effect is within the specification of 0.066K
  - o No radiometric impact on Climatological Data Records

Ghost : maximum radiometric impact

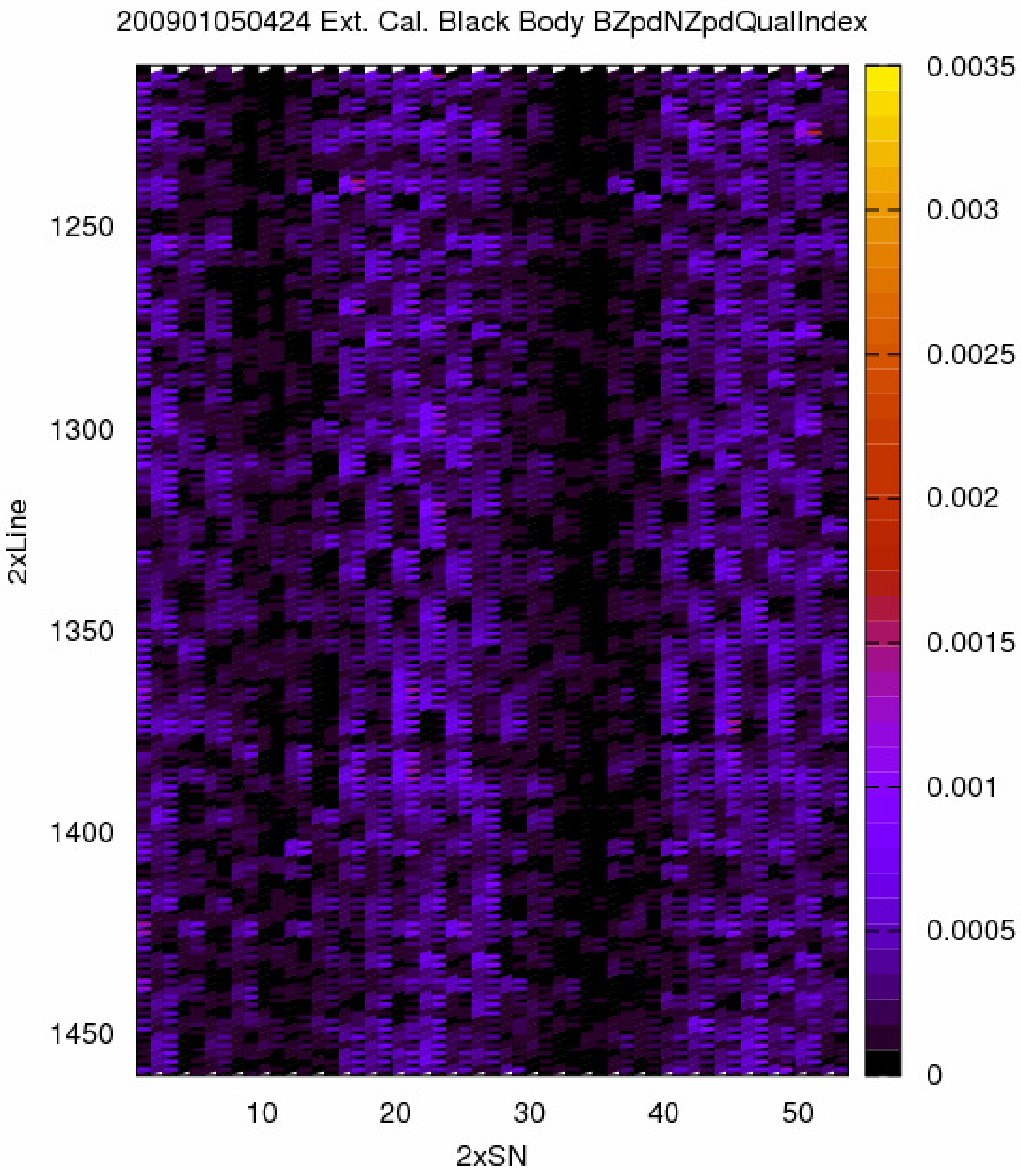
Pseudo-noise associated to the ghost impact : based on isrf simulations with current cube corner offset, interferometric axis and ghost amplitude/orientation measured in flight



Ghost : chessboard pattern on zpd



Niels B. & Fiona H., ISSWG October 2009

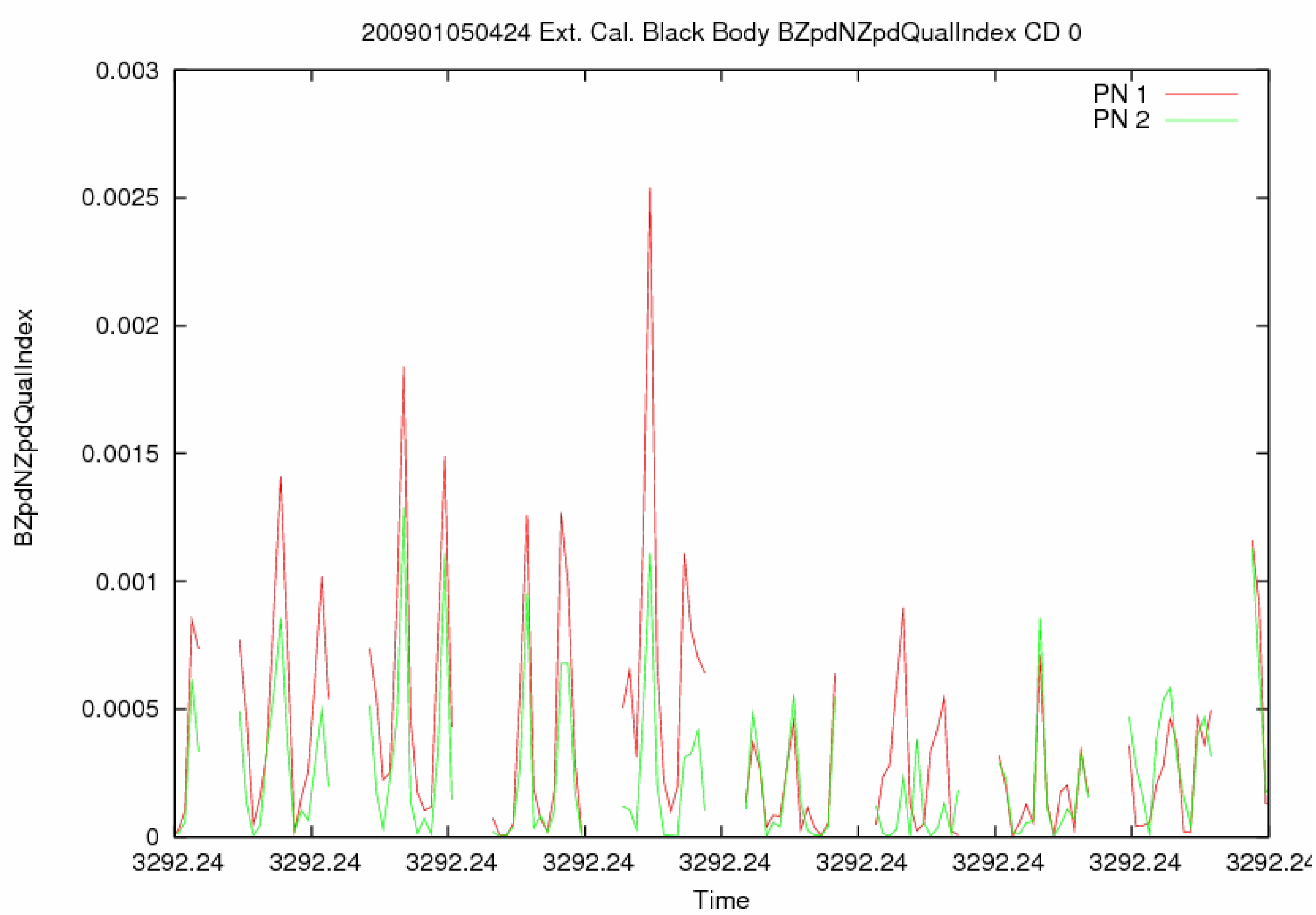


Signature of beam splitter micro-vibration at 380 Hz (ghost)

=> Confirmed on Zpd quality control indicator (forward/backward cube corner motion)

Ghost : phase random sampling effect

Example of ghost phase random sampling effect with time over scan lines (on zpd determination quality control indicator)



Uncertainty on zpd calculation is proportional to the projection of the ghost amplitude in the real plane

Ghost : conclusions and future work

- Ghost radiometric impact is within the specification and is greater for pixels 1&2 than for pixels 3&4
- No evolution of ghost amplitude since launch (monthly monitoring)
- Its is an instrumental effect (vibration of the beam-splitter at 380 Hz of less than 1 µm). Because of the random sampling of the ghost phase with time over a scan line there is no possible accurate correction by software. Only the maximum radiometric impact can be estimated.
- Good indicator of the stability of spectral and radiometric calibrations, otherwise it would have been drown into noise and we would not even have been able to see it !
- To come : list of the most affected channels by the ghost effect in some typical atmospheric conditions

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Gibbs effect : origin

- <u>Origin:</u>

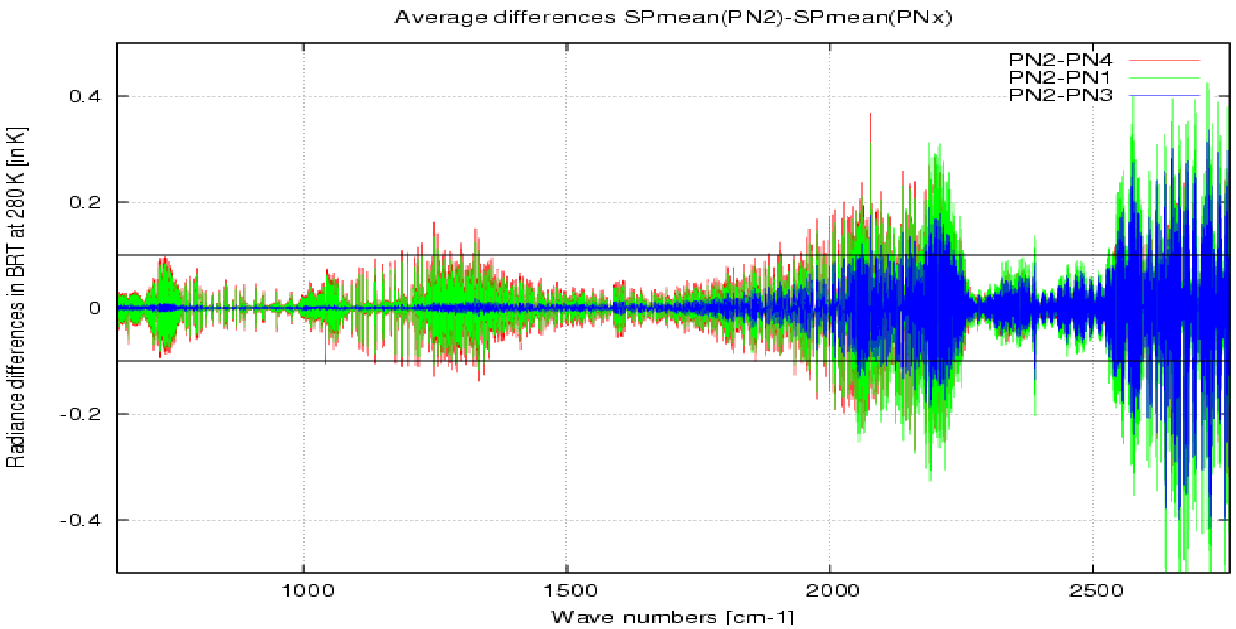
  - ➢ When using a truncated interferogram, if values at the edges of the interferogram are not the same, its transformation into spectrum (FFT) causes overshoot and ringing known as the Gibbs effect

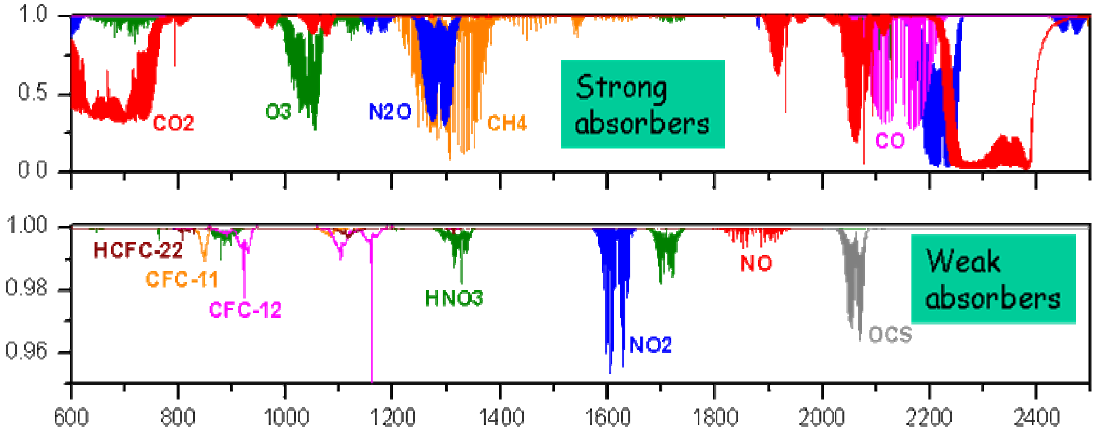
  - ➢ Its is a processing artefact when we go from L1A to L1B spectra (over-sampling and re-sampling)

- <u>Impact of the Gibbs on atmospheric spectra:</u> we have performed radiative transfer simulations (4A) on a set of TIGR atmospheric profiles with the average interferometric axis position

Gibbs effect : impact on atmospheric spectra

- No noise, interferometric axis perfectly known (=> no residual spectral calibration errors)
- Interpixel differences (P2 = reference pixel)

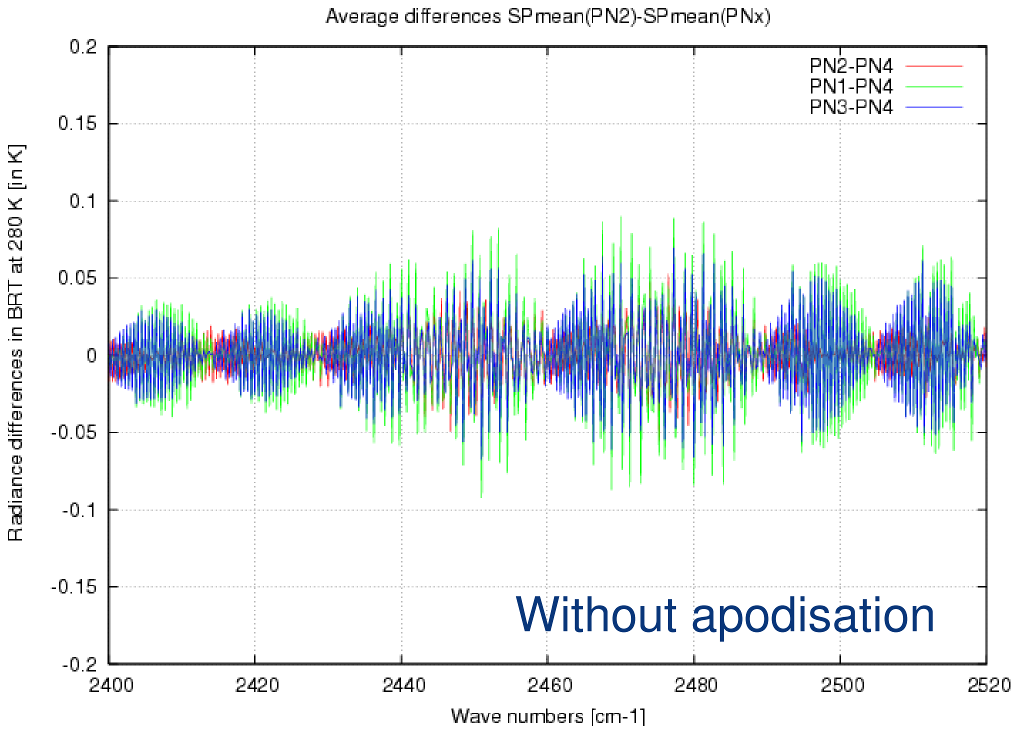


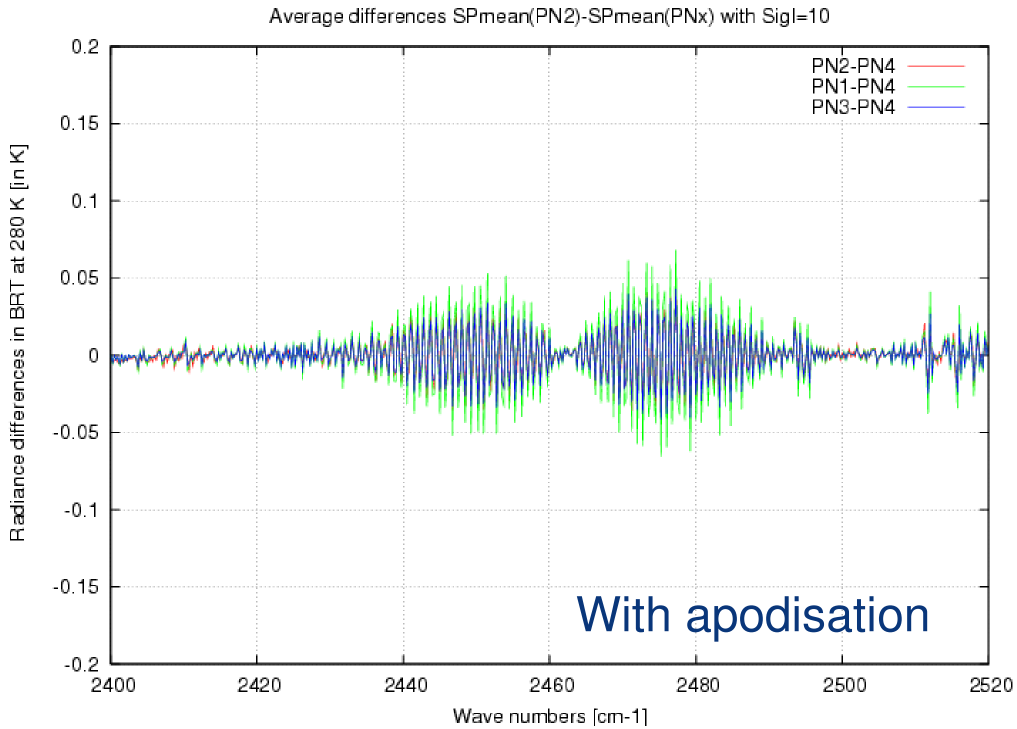


- On atmospheric spectra there is an interaction between gibbs ringing and absorption lines
- Impact is greater for strong absorption lines with a pseudo-period close to the gibbs one => amplification
- Differential effect from one pixel to another comes from differential interferometric axis relative position from one pixel to another
- See Lars study on interpixel using observed data

Gibbs effect : correction

- Apodisation of L1A interferogram (typically 10-20 samples)





- Gibbs effect is partially corrected
- Still some effects in absorption lines (under investigation at CNES and EUMETSAT)
- On-ground processing configuration file will be updated for DAY-2

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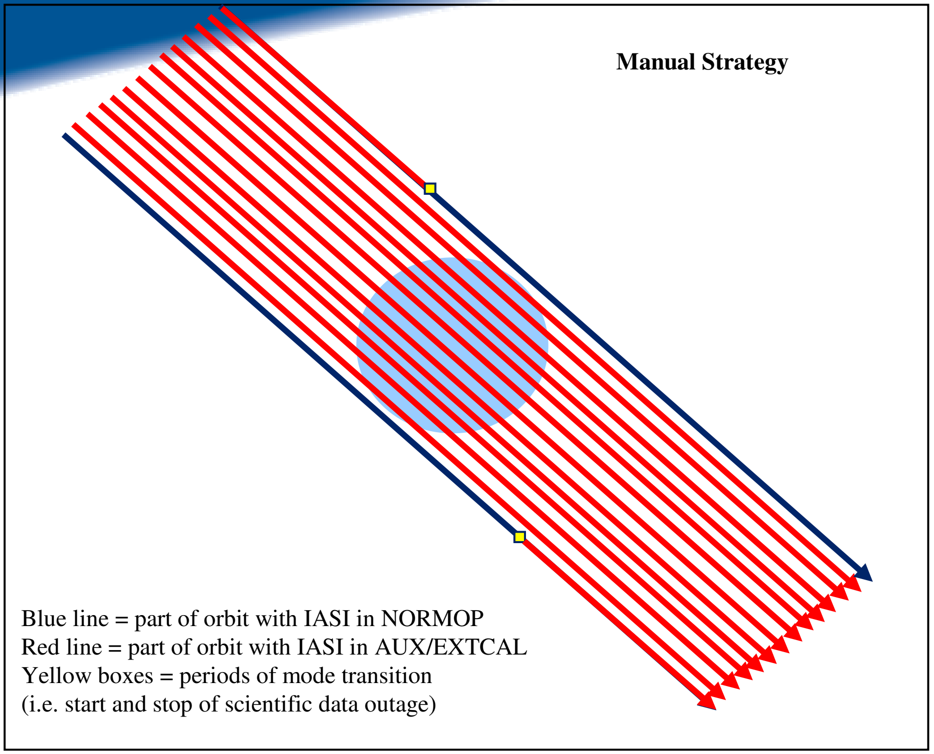
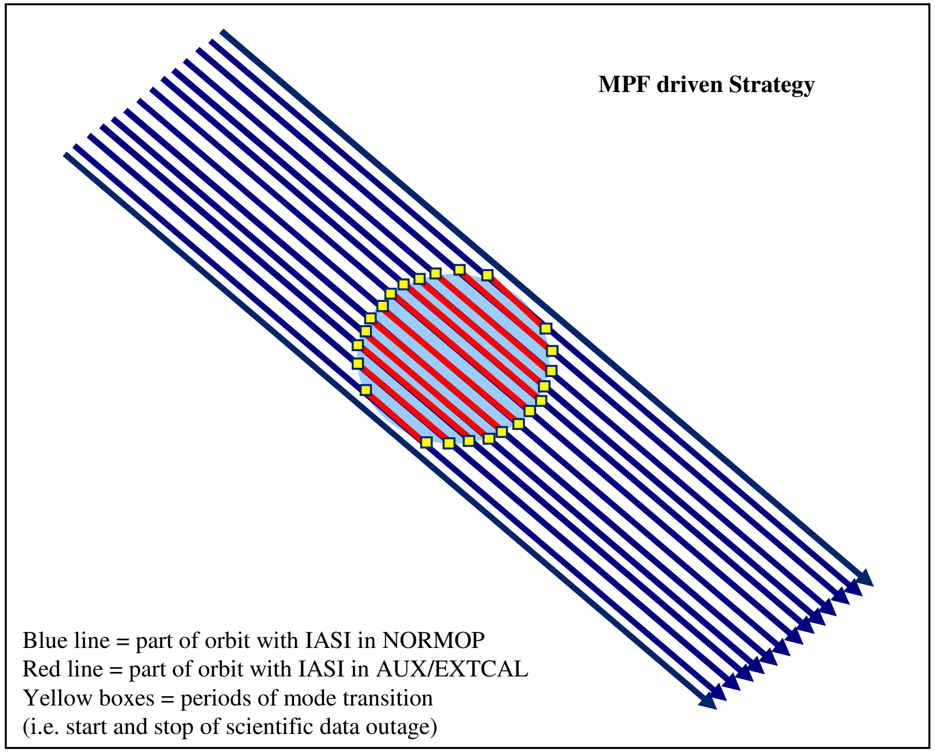
Moon intrusion in CS1 : A new strategy to decrease mission outages



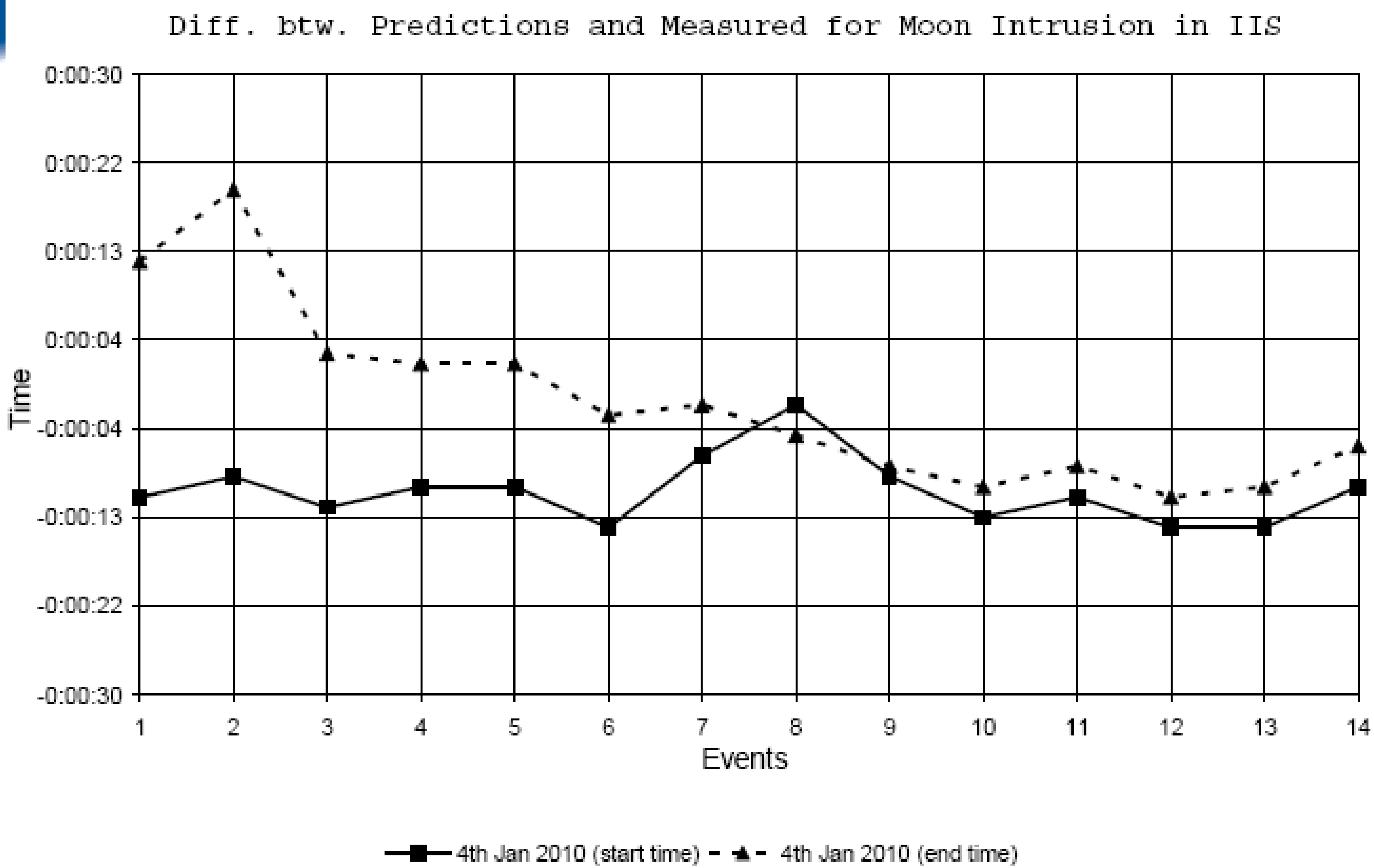
Moon intrusion manual commanding strategy
(24 h in External Calibration => data outage)



Moon intrusion MPF driven commanding strategy

Data outage reduction between 60% and 75% <u>but</u> we need an accurate and reliable prediction model (implemented at Eumetsat MPF)

Moon intrusion in CS1 :
A reliable prediction model of moon intrusion



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Compression of L1C : motivation

"data providers should not used compression methods that introduce cross-correlation between channels" (ECMWF workshop, May 2009)

PCs compression

- Advantages generally outlined : it decreases diagonal noise, data compression factor of 15-30 (depending on the number of PCs)
- **Price to pay for it** :

1) How to deal with geophysical situations that are not represented in the PC learning database ?

2) Introduction of an additional and non negligible cross-correlation between channels (non-localized jacobians, off diagonal terms of O covariance matrix have higher amplitude wrt diagonal,…). *See, in particular, A. Collard presentation at the ECMWF workshop in May 2009.*

Inversion

- Atmospheric variables are **correlated** through the radiative transfer equation
- The purpose of inversion is precisely to **decorrelate** atmospheric variables from the radiative transfer equation (the only thing we can observed)
- By increasing IR-sounders spectral resolving power we are able to select suitable channels that are sensitive to some atmospheric variables you may be interested in and not sensitive (or the least) to other atmospheric variables (NWP : T and Q at different atmospheric levels, Chemistry : signature of a particular trace gas)

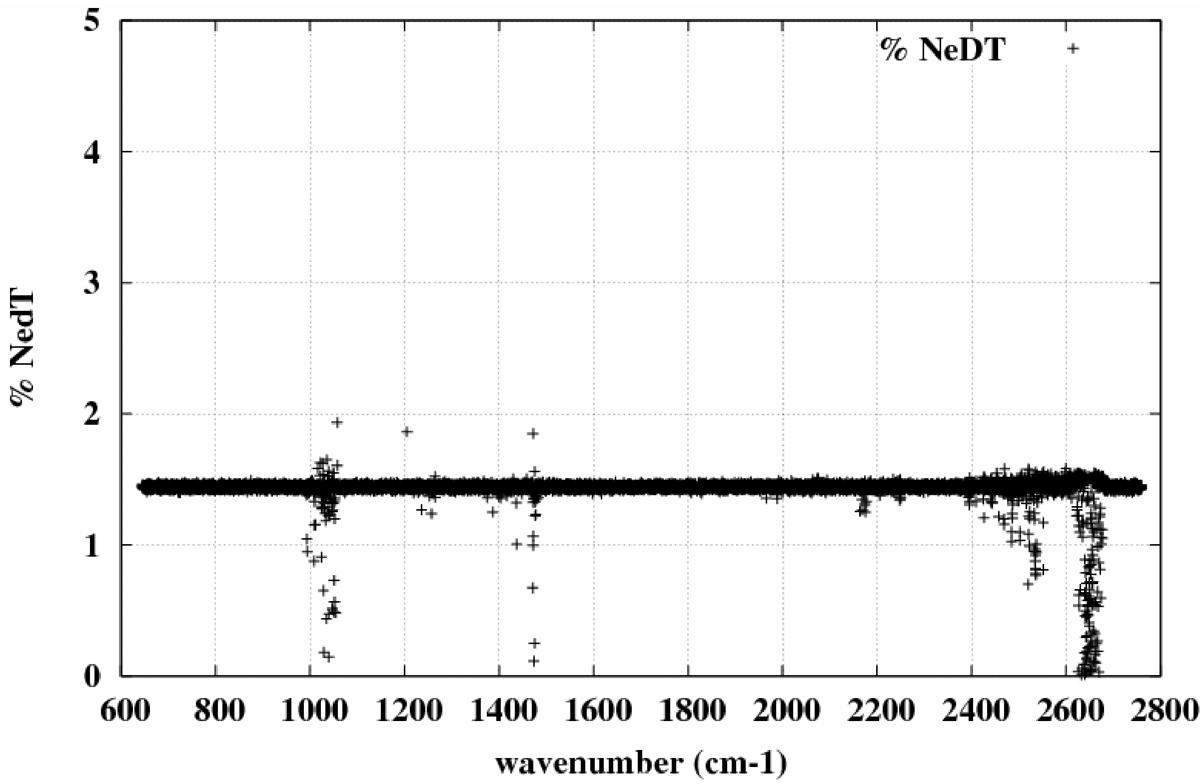
Conclusion : It's going in the wrong direction

Compression : first results on 4 L1C granules

- We are studying an alternative almost lossless compression scheme of L1C spectra that do not introduce cross-correlation between channels

<u>Step 1 : quantization</u>

- For the moment, each L1C spectrum samples are encoded on 16 bit (signed)
- Bit-trimming with an adaptative quantization step w.r.t L1C noise : 16 bpp => 14 bpp
- L1C additional noise is less than 2%



Compression : first results on 4 L1C granules

Step 2 : 2D vs 3D lossless compression

- CCSDS 2D lossless compressor. Compression factor ~ 1.3
- FLOSS 3D lossless compressor (Klimesh, JPL). Compression factor ~ 2

  ⇒ 3D compression is useful !
- Overall compression : 16 bbp => 8 bbp

Step 3 (to come) : 3D optimal compression

- FLOSS 3D lossless compressor with an optimal spectral re-organization of IASI channels by putting “correlated” channels close to eachother w.r.t to geophysical state of the atmosphere
- We expect an overall compression factor between 2 and 3
- We are also checking that compression/decompression times are compatible with NRT needs.

cnes

Conclusions

IASI

- ✓ After 39 months in orbit
  - IASI is performing very well
    - no redundancy used
    - all mission requirements are met : both instrument and processing
    - the instrument is extremely stable : radiometry, spectral, geometry
    - mechanisms (Cube Corner, Scan) show no evolution in orbit
    - radiator (passive cooling) show no evolution in orbit
  - There is still a lot of science to be done with IASI data (meteorology, climatology, atmospheric chemistry)
- ✓ During the routine phase, IASI Technical Expertise Center (IASI TEC in CNES premises in Toulouse) takes care of :
    - In-depth Performance monitoring, processing parameters updating
- ✓ In parallel with the operational monitoring performed by the EUMETSAT EPS/CGS teams :
    - Near Real Time PDU analyses, Radiance monitoring
- ✓ DAY-2 evolution of ground-processing and product format deliver to Eumetsat in September 2009
- ✓ Metop-B TV test in June 2010 at ESTEC (good health check)