IASI spectral calibration monitoring on MetOp-A and MetOp-B

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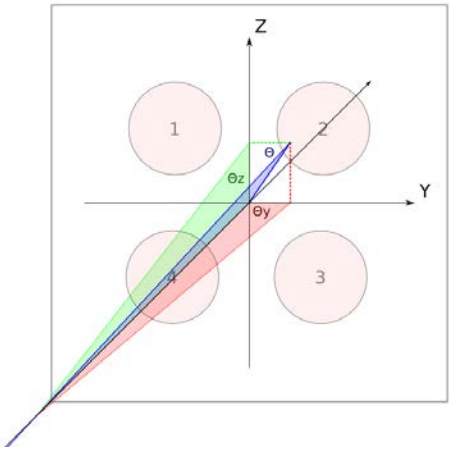
OUTLINE

- 1 - Introduction to spectral calibration
- 2 - Inputs of ISRF model
- 3 - Measured spectral shifts and interferometric axis
- 4 - Spectral calibration assessment
- 5 - Spectral intercalibration between IASI-A and IASI-B
- 6 - Conclusion

1 - Introduction to spectral calibration

IASI is a Michelson interferometer, with 4 off-axis pixels



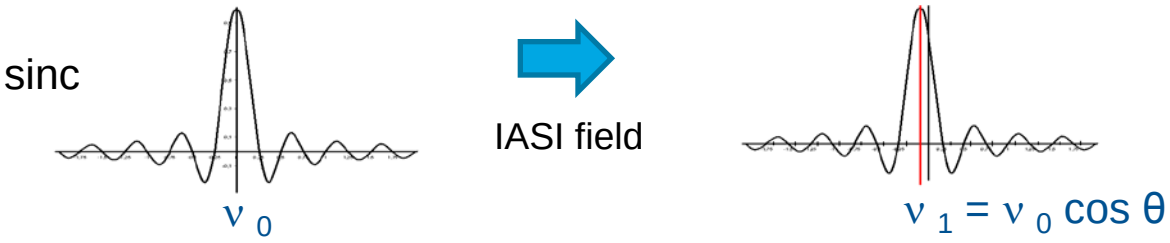
- Effect of limited cube corner course (+/- 2 cm) :
  Interferogram truncation

In the spectrum domain, a Dirac at ν_0 become a cardinal sine centered on ν_0

- Effect of IASI field on a monochromatic wave @ ν_0 :

For a pixel located at the angle θ, the wavenumber is

$\nu_1 = \nu_0 \cos\theta$ Spectral shift : $\Delta\nu = \nu_1 - \nu_0 = \nu_0 (1 - \cos\theta)$



- Effect of extended pixel : energy spreading around θ (from θ_{min} to θ_{max})

1 - Introduction to spectral calibration

- The spectral positions of the spectra samples must be known better than 2.10^{-6}

$$\Delta \nu / \nu < 2.10^{-6}$$

In terms of spectral sampling,
the accuracy of 2 ppm is equivalent to:

Wavenumber	Wn	% of spectral sampling (0.25 cm^{-1})
@645 cm^{-1}	0.00129 cm^{-1}	0.52 %
@1500 cm^{-1}	0.0030 cm^{-1}	1.2 %
@2200 cm^{-1}	0.0044 cm^{-1}	1.76 %

Spectral calibration goals:

- Correction of the spectral shift effect ($\Delta \nu = \nu_1 - \nu_0 = \nu_0 (1 - \cos \theta)$)

- Removal of the Instrument Spectral Response Function ISRF, wavenumber and pixel dependent, with a constant ISRF at L1C for all pixels and channels: Gaussian function with FWHM = 0.5 cm^{-1} (spectral resolution)

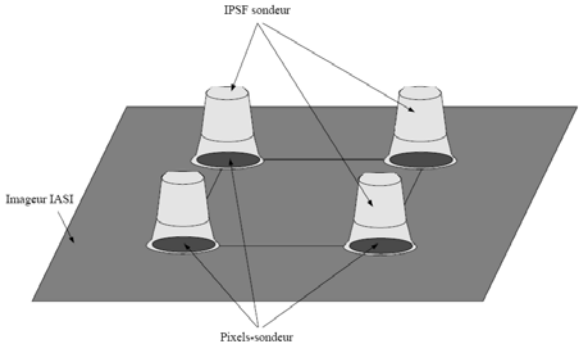
- To do this, we need an accurate model of the ISRF.

The input parameters of the ISRF model have to be well known and monitored.

2 - Inputs of ISRF model

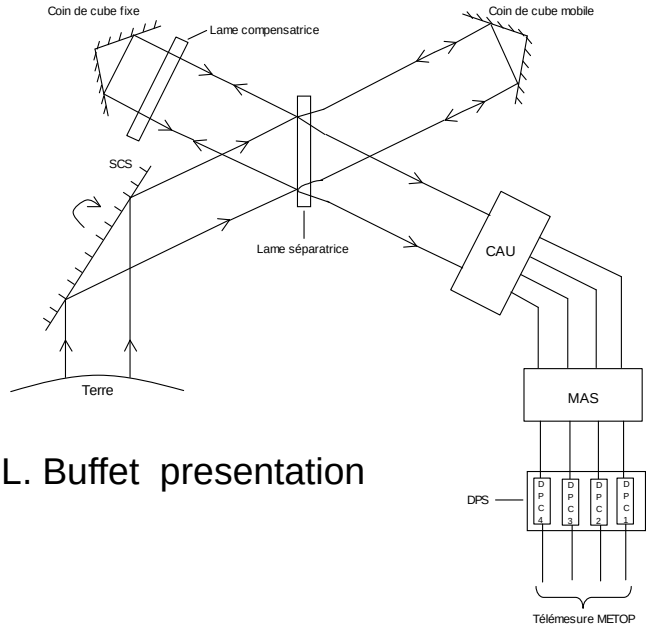
- Laser alignment => sampling laser wavelength
  -> Ground characterized

- Instrument Point Spread Functions IPSF (Y and Z field angles and weights for each pixel)
  -> Ground characterized
  + position and shape adjustment in flight



- Beam splitter and compensator plate (width, angles)
  -> Ground characterized

- Cube corner trajectory :
  - Moving corner cube displacement law (linear)
    -> Ground characterized + characterized in flight
  - Fixed cube corner offset -> characterized in flight
  - Parabolic -> Ground characterized
  - Interferometric axis -> computed in real time



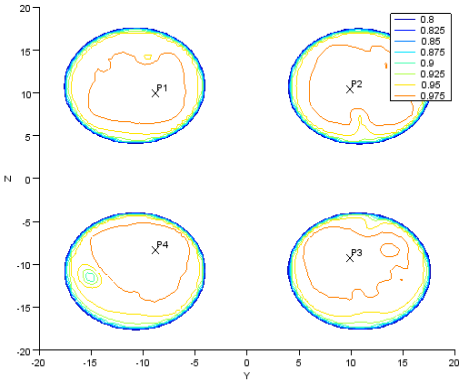
} see L. Buffet presentation

- Ghost effect -> characterized in flight, not taken into account in the operational ISRF model

2 - Inputs of ISRF model

Instrument Point Spread Functions IPSF

It is the Y and Z field angles and weights for each IASI pixel, it describes the non uniformity of the detectors response in the field.



Ground characterized + position and shape adjustment in flight

- Method of the adjustment in flight:
  - ✦ IASI IPSF position are tuned to maximize the correlation of pseudo-channels IASI-AVHRR like (spectral integration over AVHRR-5 filter) and AVHRR-IASI like (spatial integration of AVHRR-5 pixels over the IPSF)
  - ✦ On Earth view near nadir (always SP 15 in external calibration mode)

2 - Inputs of ISRF model

Instrument Point Spread Functions IPSF

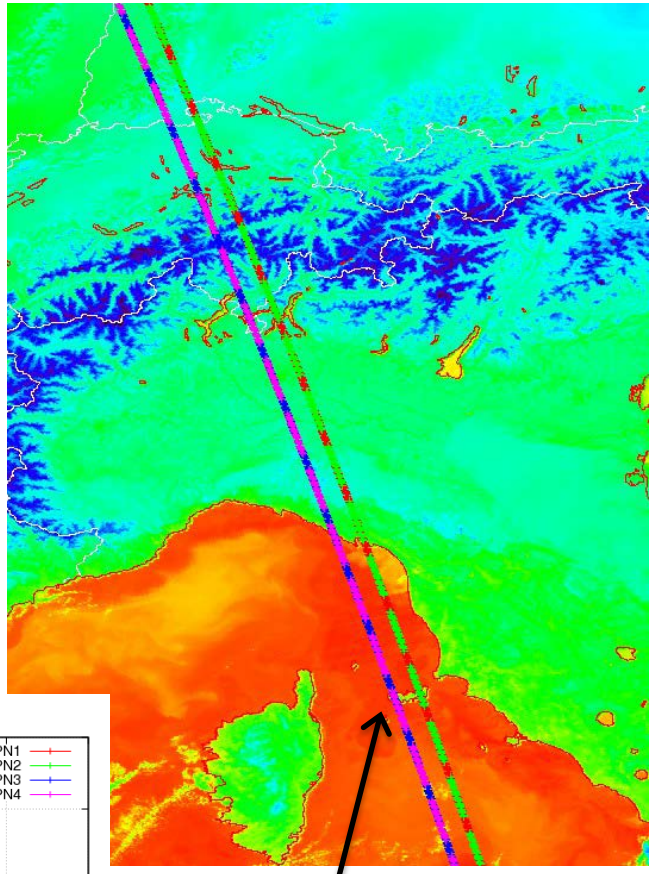
Zone selection:

- Coastlines with a sharp radiometric gradient (high temperature contrast) between land and sea.
- Various cost orientations are needed to adjust the IPSF position in all directions.

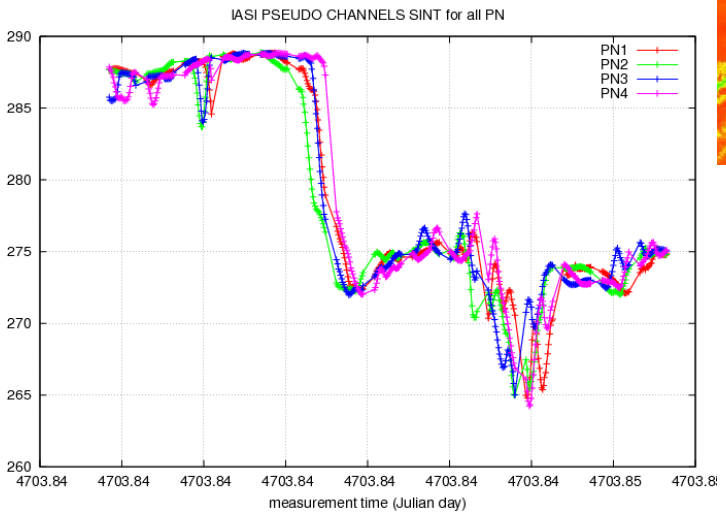
- Results for IASI-B, last configuration:

	Offset Y (rad)	Offset Z (rad)
PN1	1.053e-03	3.29e-04
PN2	9.27e-04	4.13e-04
PN3	9.19e-04	4.80e-04
PN4	1.048e-03	4.23e-04

Scale = 0.9705



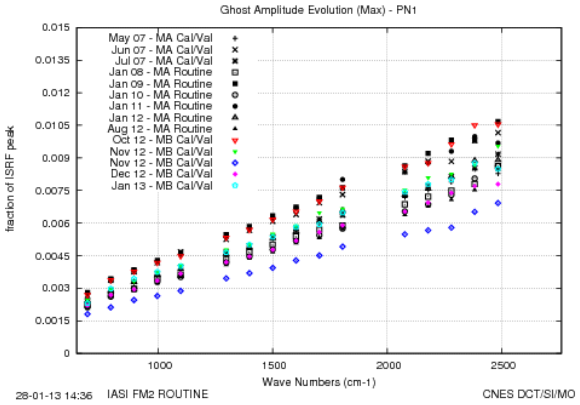
IASI-B track, nadir

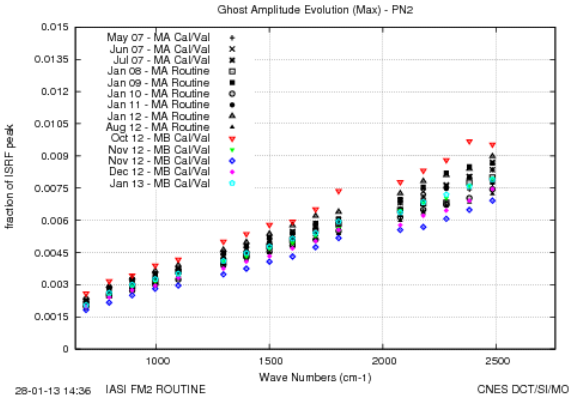


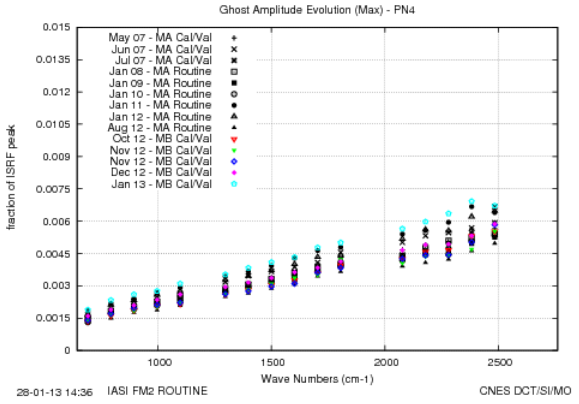
2 - Inputs of ISRF model

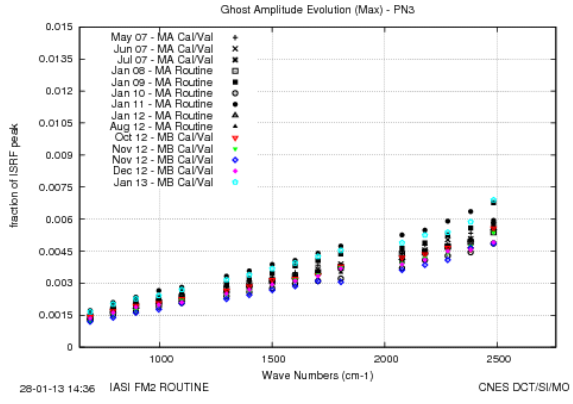
Ghost effect

- Origin: sampling jitter (harmonic) caused by micro vibrations of the beamsplitter
- Analysis done on BB spectra





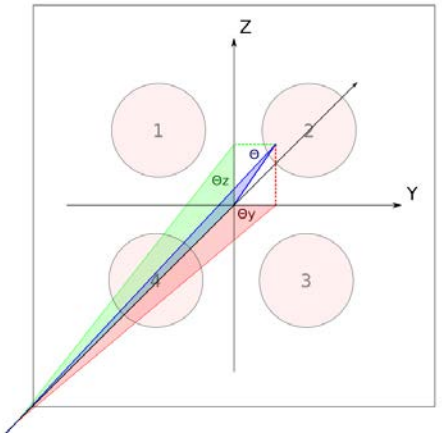




- IASI-B has the same behavior as IASI-A
- Amplitude slightly higher for P1&P2 compared to IASI-A, but no significant impact on radiometric and spectral performances

3 - Measured spectral shifts and interferometric axis

Interferometric axis



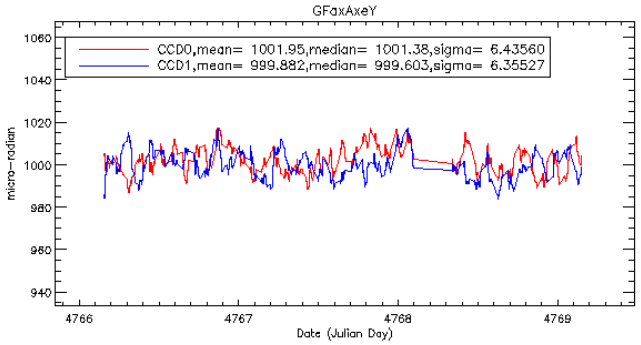
- It is the cube corner displacement direction

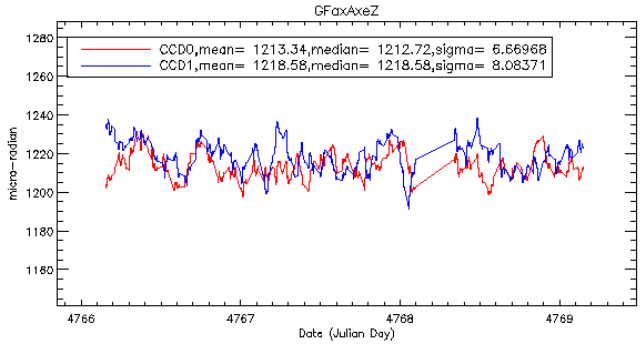
Spectral calibration in the ground processing

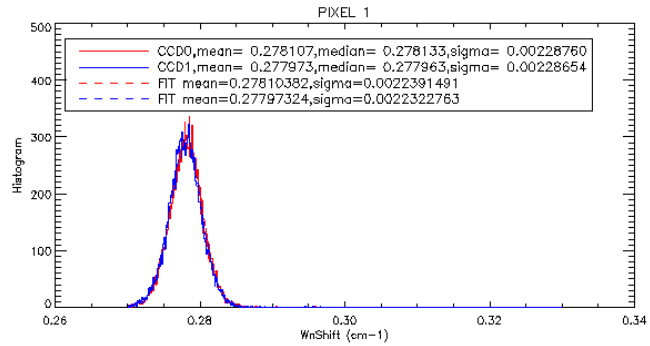
- Determination of the interferometric axis position by minimization of the spectral shifts (WnShift) between each pixel and a reference spectrum (calibrated)

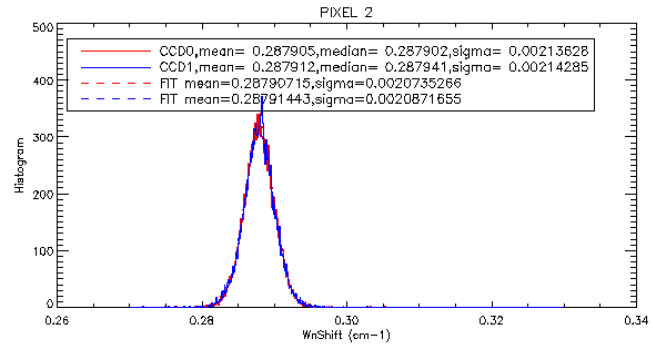
- Application of the spectral calibration function in BSO corresponding to this interferometric axis (computed with modeled ISRF), to correct the spectral shift of each pixel

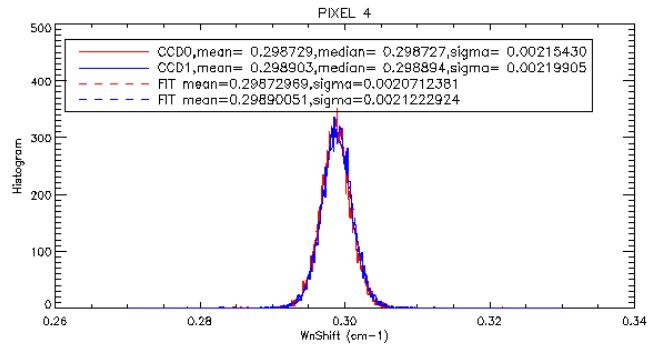
3 - Measured spectral shifts and interferometric axis

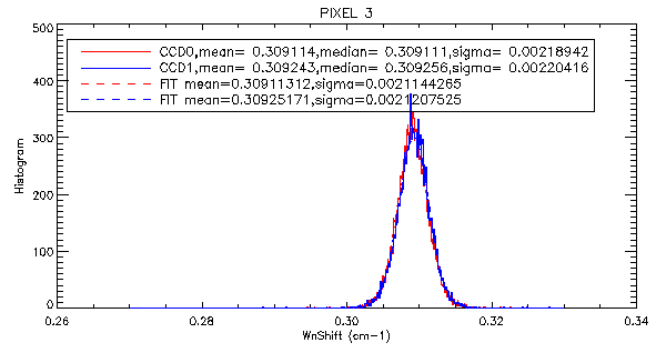












- For the last configuration:
- Interferometric axis converges properly around Y = 1000 µrad Z = 1215 µrad
- Gaussian distribution of filtered WnShift: only the instrument noise effect

4 - Spectral calibration assessment

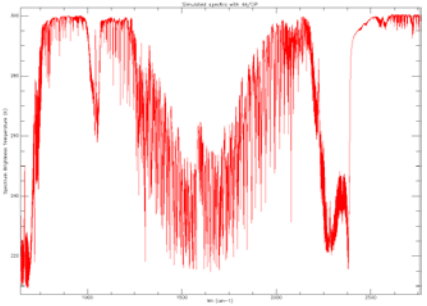
Spectral calibration: verification method

- Comparison between IASI spectra with simulated spectra on homogeneous scenes in external calibration mode nadir viewing
  + interpixel comparison

- Selection on homogeneous scenes, warm and clear
  - ✦IIS radiance variance < 0.65 K , IIS BT > 286 K, collocated (20 lines maximum)

- Correlation method in spectral windows => relative spectral shift error

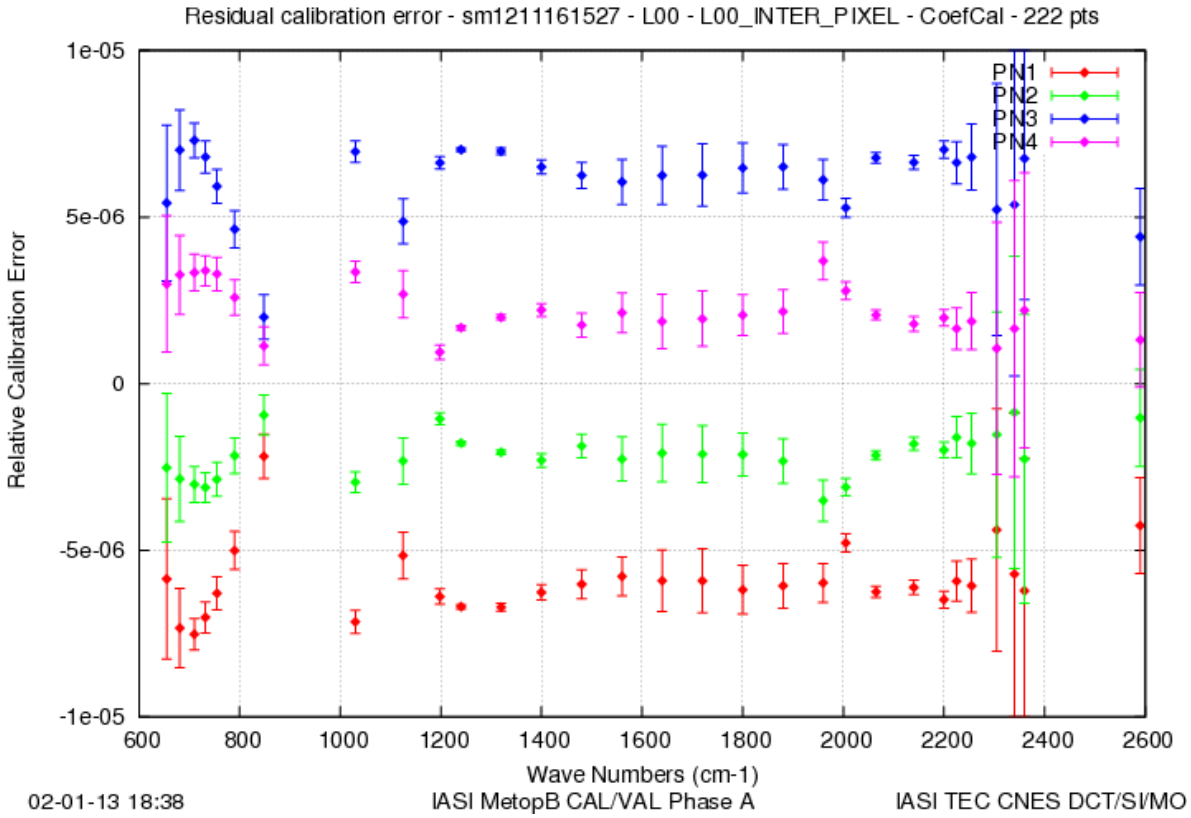
- Simulate spectra with:
  - ✦ Radiative transfer model 4A/OP
  - ✦ + ECMWF analysis fields: temperature + H_2O profiles



4 - Spectral calibration assessment

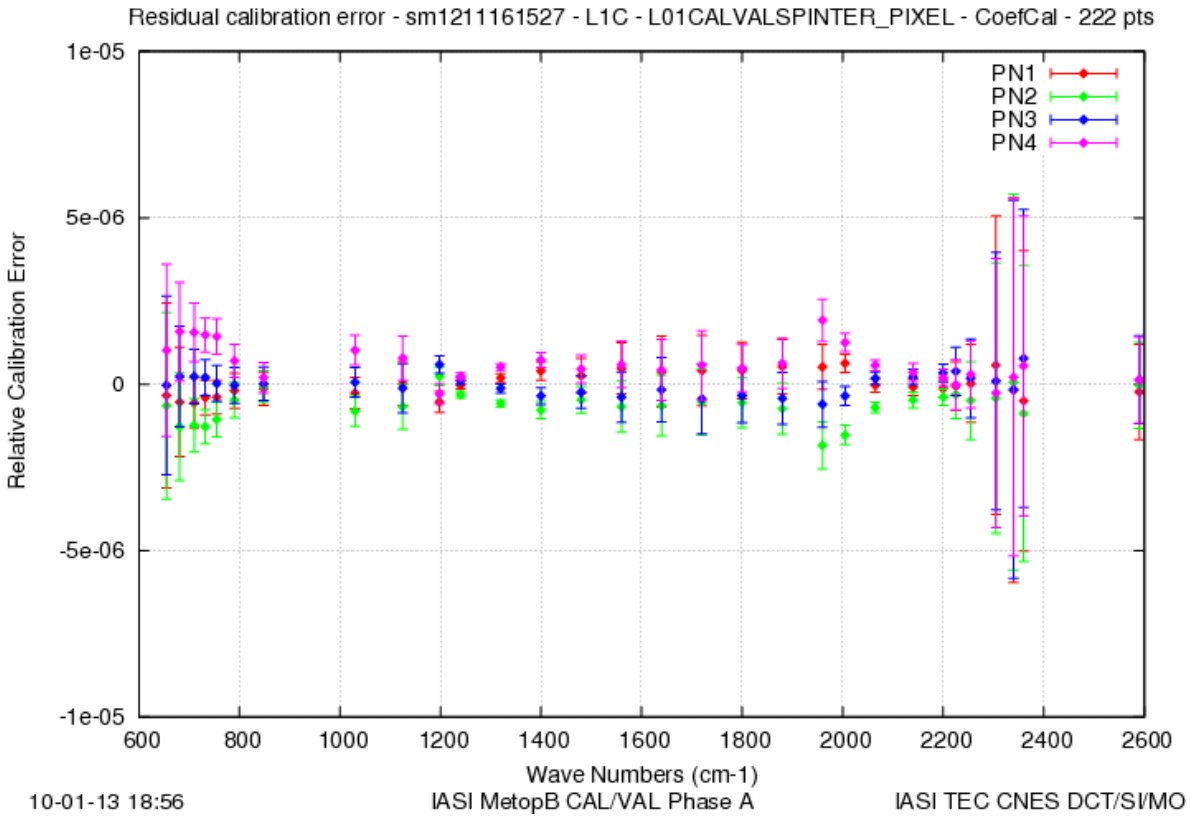
Without spectral calibration: inter pixel spectral shift error on L0 product

=> Need of correction !



4 - Spectral calibration assessment

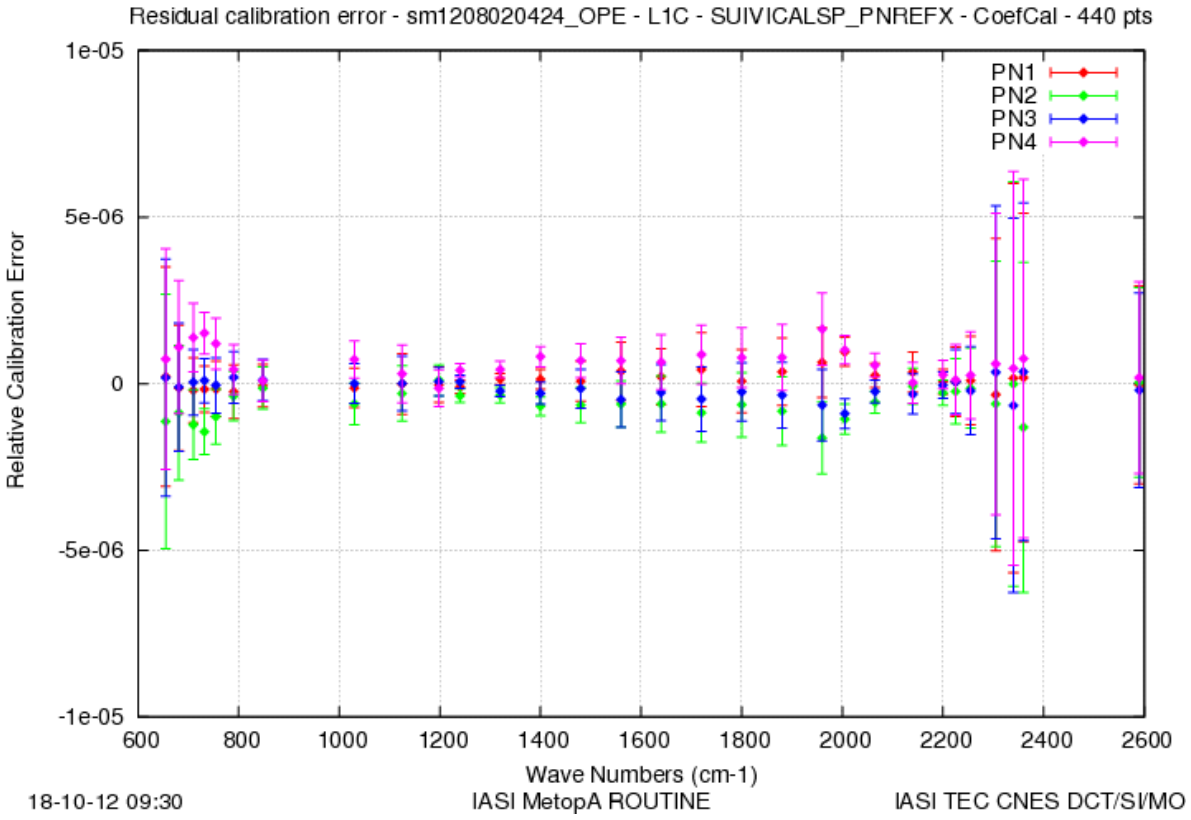
Interpixel spectral shift on L1C products, **IASI-B**



- Interpixel at L1C is < 2 ppm, all pixels are independent
- L1B (spectral shift correction) & L1C (SRF removal) processing work perfectly

4 - Spectral calibration assessment

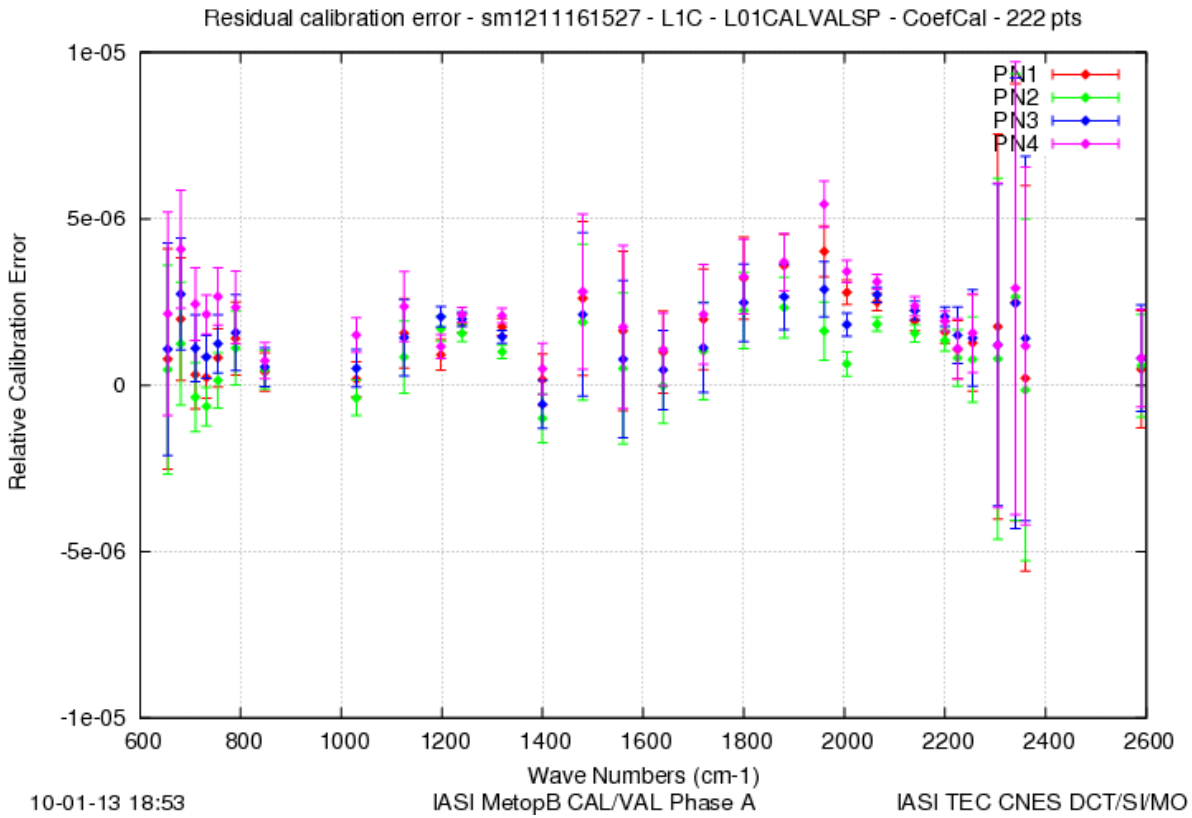
Interpixel spectral shift on L1C products, **IASI-A**



- IASI-B interpixel spectral calibration is very good wrt IASI-A

4 - Spectral calibration assessment

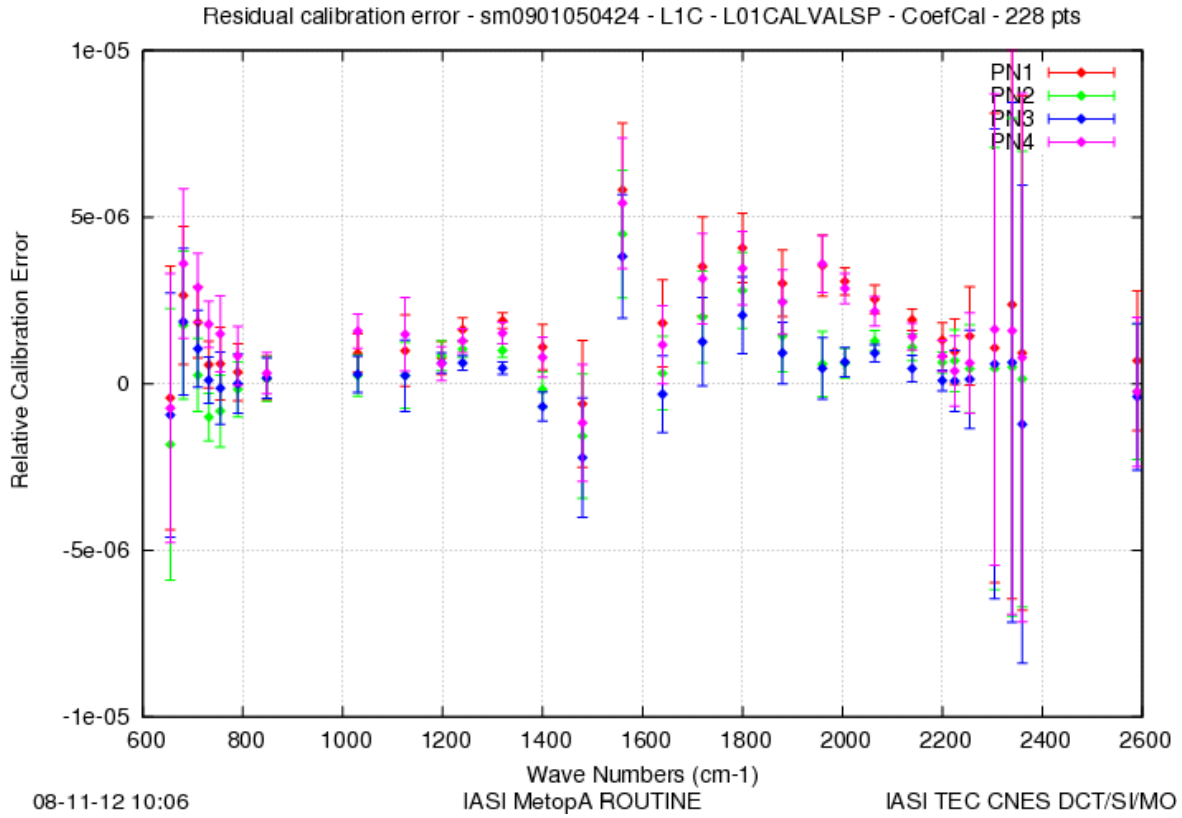
Absolute spectral calibration on L1C, **IASI-B** (Obs-Calc)



- Difficult to give an interpretation. It depends on scene selection, radiative transfer (spectroscopy, line-mixing, pressure shift), atmospheric profile used, algorithm (correlation, difference, peak finding), spectral line shape, instrument noise, laser misalignment

4 - Spectral calibration assessment

Absolute spectral calibration on L1C, **IASI-A** (Obs-Calc)

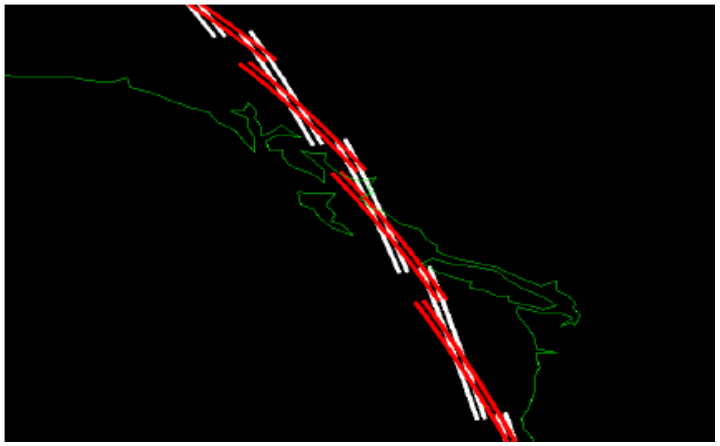


- Shape close to IASI-A
- Further investigation on Cal/Val phase B

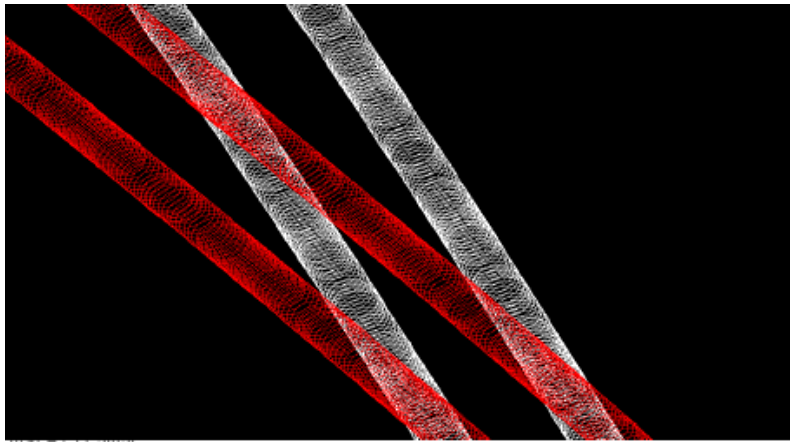
5 - Spectral intercalibration between IASI-A and IASI-B

IASI-A/IASI-B intercalibration on specific external calibration mode

- Scan Position programmed in order to maximize the overlap on ground between MetOp-A and MetOp-B (50 min delay).



White = MetOp-A , Red = MetOp-B

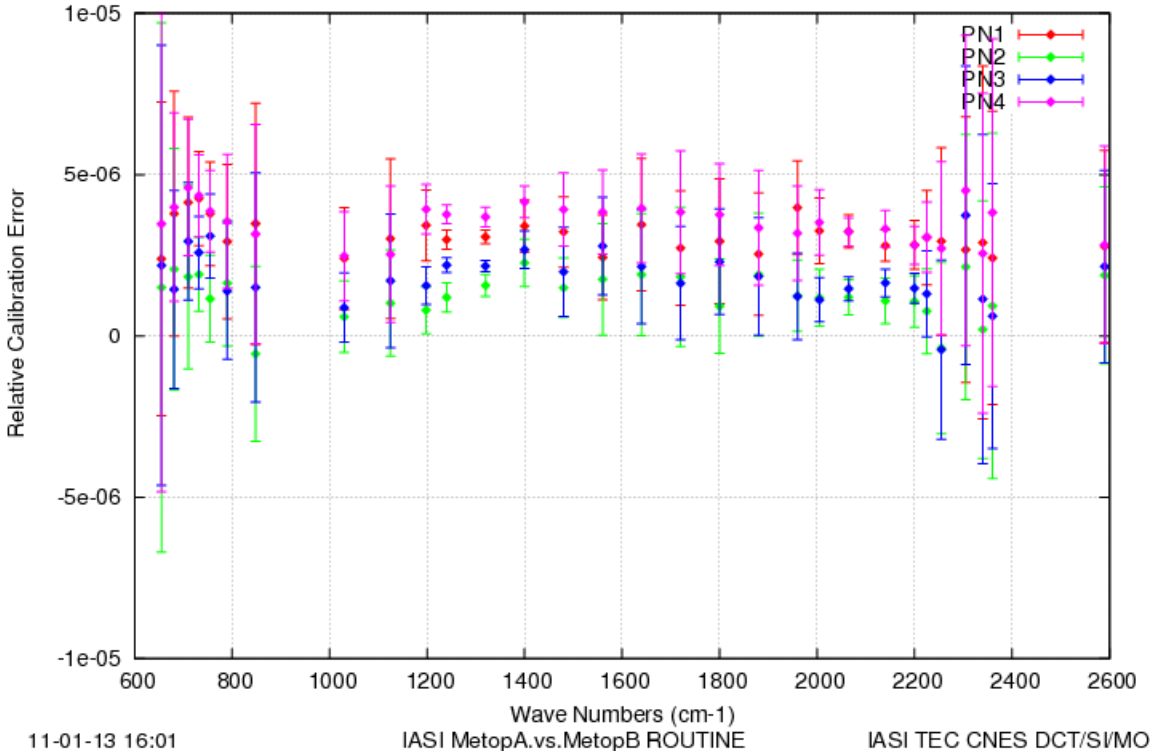


Zoom

- Selection on stable and homogeneous scenes
- + Best matching scenes selected with 3 criteria: co-registration, narrow scan angle, narrow brightness temperature (BT) @ 2616.5 cm^{-1} (window)

5 - Spectral intercalibration between IASI-A and IASI-B

IASI-A/IASI-B spectral intercalibration on L1C



- With the last configuration, ~ 50 scenes
- Interpixel at L1C display a bias of 2.5 ppm. A part of this bias may be attributed to IASI-B laser misalignment. It will be improved in phase B.

6 - Conclusion

After 3 months of IASI-B Cal/Val:

- IASI-B spectral performances are similar to IASI-A
- Good working of ground processing
- Stable behavior of ISRF parameters
- The IASI-B interpixel spectral calibration is fully satisfactory, it is in the specification of 2ppm, the pixels are independent.
- Work in Cal/Val phase B: tune the absolute spectral calibration