IASI-C instrument status and L1 calibration/validation results

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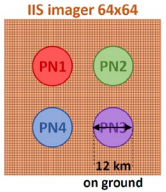
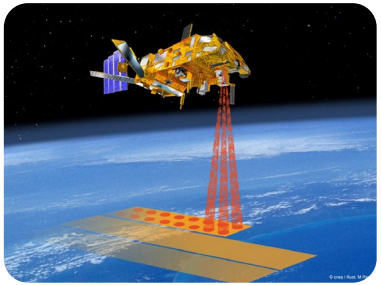
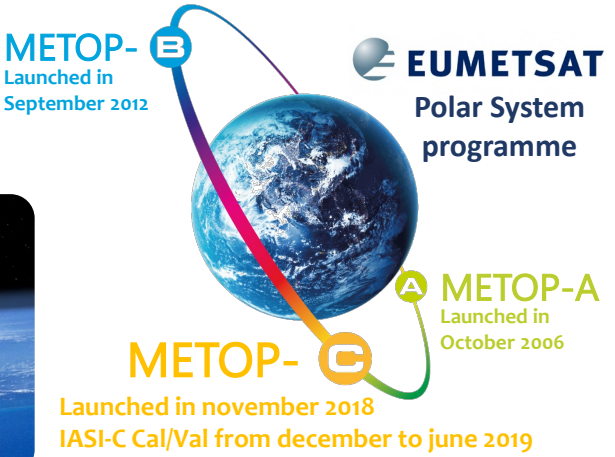
Contents

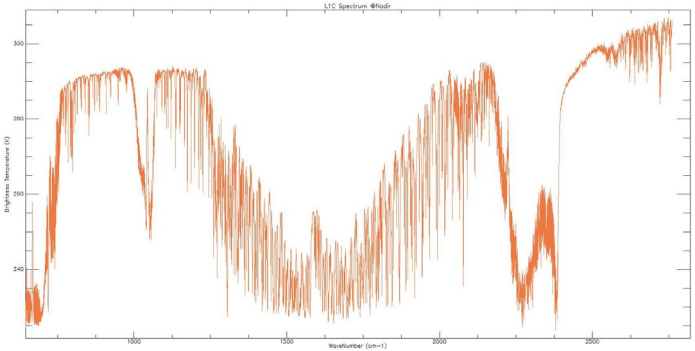
1. IASI instrument on-board METOP

- IASI : Infrared Atmospheric Sounding Interferometer (4 pixels)
  - ⇨ A Fourier transform spectrometer based on a Michelson interferometer + an Integrated Imaging System (IIS)
- CNES IASI Level 1 responsibilities:
  - Perform the L1 Calibration/Validation to ensure that the products are compliant with their specifications;
  - IASI L1 processing chain development & maintenance;
  - Instrument & command/control expertise;
  - Support to EUMETSAT for the operations;





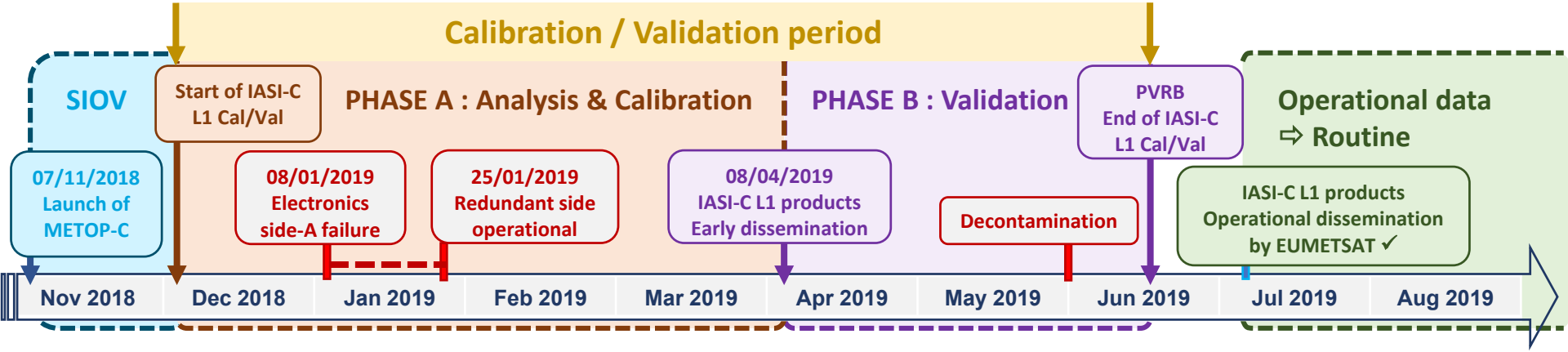




Spectral Band 1 [650 – 1210 cm^{-1}]	Spectral Band 2 [1210 – 1900 cm^{-1}]	Spectral Band 3 [1900 – 2760 cm^{-1}]

Pixel size	12 km @Nadir
Spatial sampling	25 km @Nadir
Radiometric accuracy	< 0,5 K @280 K
Inter-pixel calibration errors	< 0,1 K
Inter-comparison wrt other sounders	< 0,2 K @280 K
Spectral resolution	0,5 cm^{-1}
Sampling step	0,25 cm^{-1} (8461 channels)
Relative spectral calibration errors	< 2.10^{-6}

1. IASI-C Cal/Val – Overview



PHASE A : analysis & calibration

1. Start of the Cal/Val : initialisation of on-board processing chain
2. Start of monitoring : instrument parameters and flags
3. Tuning of on-board and on-ground spectra quality threshold
4. Perform radiometric, spectral & geometric calibration
5. Preliminary data validation before early dissemination to ISSWG members (IASI Sounding Science Working Group)

PHASE B : in-depth validation

1. Inter-comparisons analysis with other sounders
2. Over-time quality and stability data check + fine tuning
3. L1 performance validation ⇨ feedback from ISSWG users
4. Review IASI-C L1 quality ⇨ End of Cal/Val

2. IASI-C on-board performances monitoring

Also performed during all the mission (routine phase)

- **NedT performances : similar to TV (ground) tests = stable**

⇒ Same order of magnitude than IASI-A and IASI-B

- **Ice contamination over-time monitoring :**

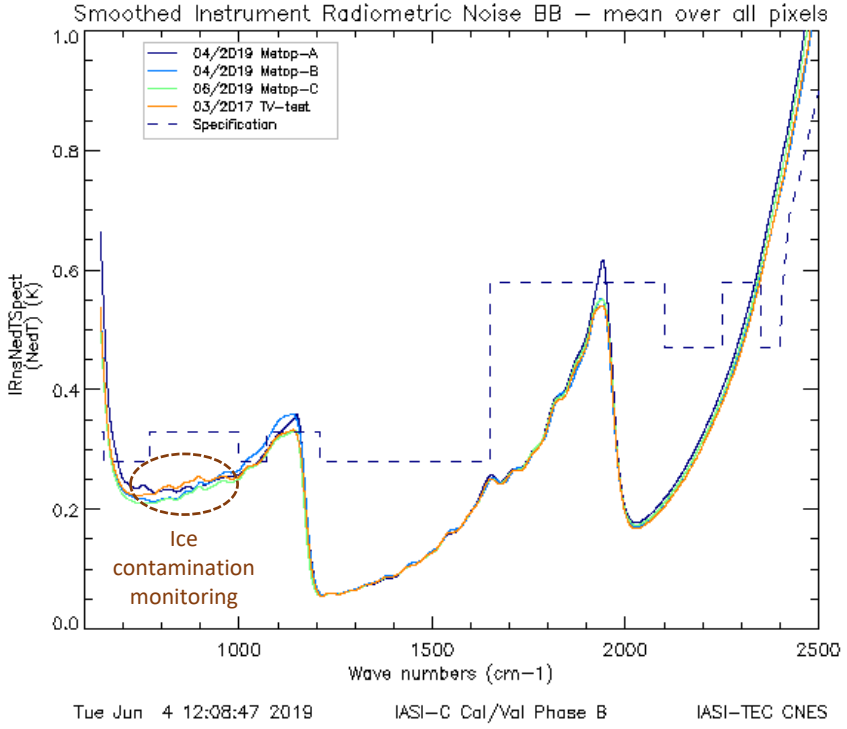
⇒ Transmission loss (in particular around 850 cm^{-1})
if important, a decontamination is programmed

- **On-board detection chain monitoring (gain, offset, delay)**

- **Temperature monitoring**

- **Interferometer system proper functioning and acquired interferograms shape monitoring**

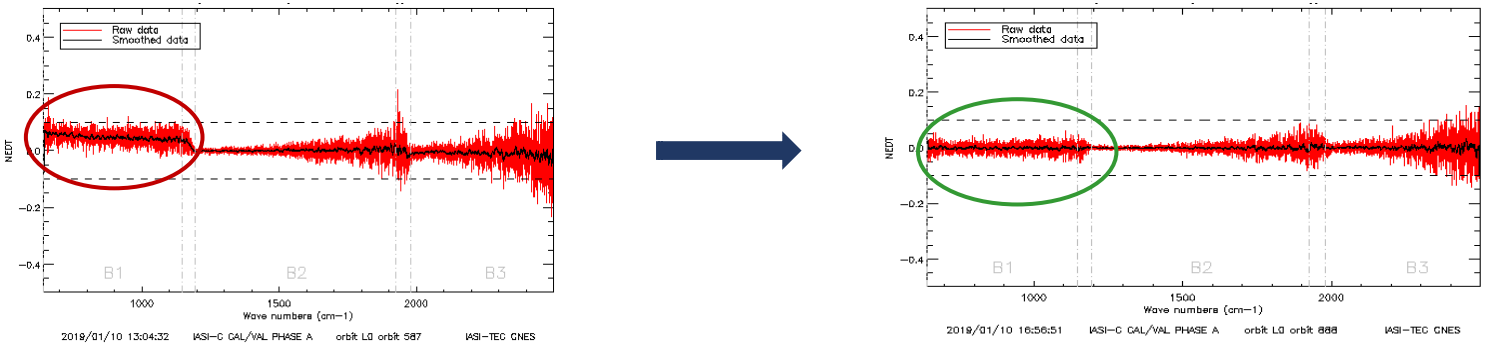
- **On-board radiometric pre-calibration process flag monitoring using Black Body and Cold Space acquisitions**



2. IASI-C on-board radiometric calibration phase

❖ **Non-linearity correction :**

⇒ Non-linearity in SB1 is corrected in the IASI interferograms by on-board processing, with pre-computed correction tables. An improved correction has been applied (same methodology as for IASI-B)
Now all 3 IASI have this non-linearity correction (IASI-A since 30/09/2019)



❖ **Spike detection threshold:**

⇒ Spike in SB3 is one of the main contributors of data rejection mainly in the the South Atlantic Anomaly region

⇒ Determine the thresholds above which the signal in the output spectrum becomes greater than ¼ instrument noise
⇨ statistical analysis

❖ **Band-merging : optimization of spectral band limits**

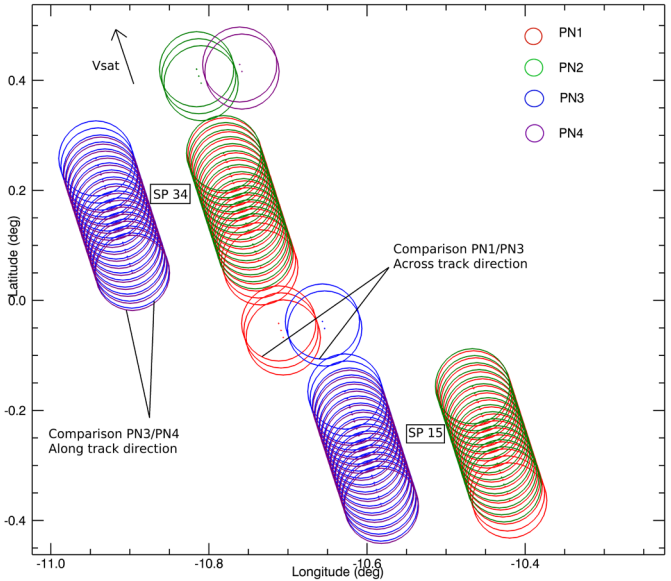
2. IASI-C on-board radiometric calibration phase

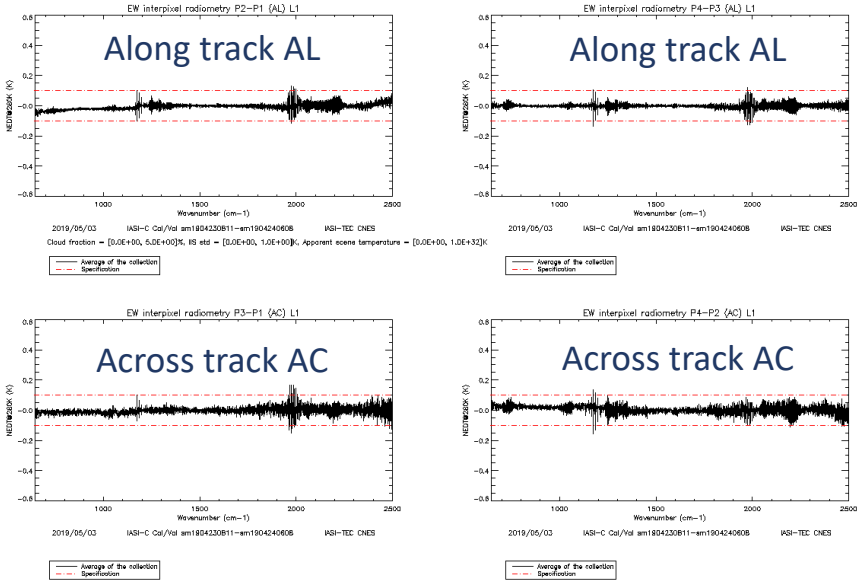
- **Very good inter-pixel radiometry observed : comparing measurements performed by different pixel couples on EW targets**

⇒ Inter-pixel bias on EW < 0.1 K (Along track AL);

⇒ Inter-pixel bias on EW < 0.15 K (Across track AC);

⇒ The observed bias is greater AC due to a worst collocation between PN soundings (6.5 km AC vs 0.3 km AL);





2. IASI-C Noise Covariance Matrix (NCM) delivery

❖ **New methodology for NCM computation since 2018 (the old NCM was overestimated*) :**

⇒ Based on L1C spectra over Black body targets

⇒ Traducing the correlation between channels due to apodisation and micro-vibrations in the interferometer

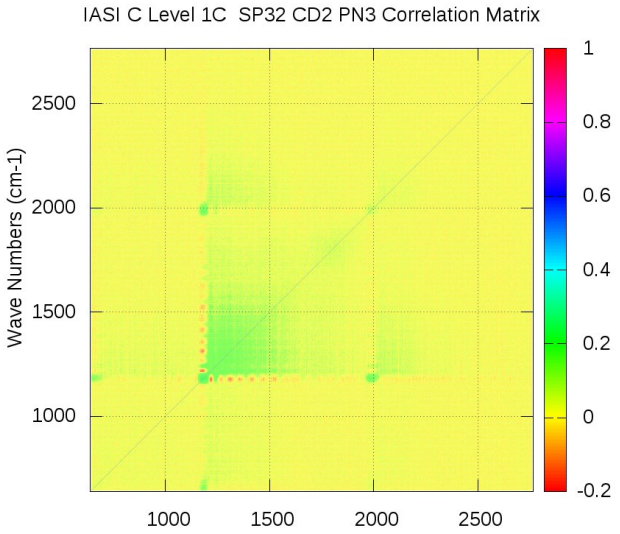
⇒ The full variance-covariance matrix of the normalized BB L1C spectra $S_{norm}(v,N)$ is computed :

$$S_{norm}(v,N) = \frac{Planck(v,T_{Ref})}{Planck(v,T(N))} S(v,N)$$

$$C(i,j) = Covariance\left(S_{norm}(i), S_{norm}(j)\right)$$

$$C(j,i) = C(i,j)$$

- $S_{norm}(v,N)$: the scaled spectrum at the wavenumber v for the scan line LN (N)
- $S(v,N)$: original L1C spectrum
- $T(N)$: Filtered temperature of the BB at the scan line LN(N)
- T_{Ref}: Averaged temperature over the collection
- $Planck(v,T_{Ref})$ and $Planck(v,T(N))$: the Planck function at v corresponding to the temperatures T_{Ref} and $T(N)$ respectively



Reference : PCA determination of the radiometric noise of high spectral resolution infrared observations from spectral residuals : Application to IASI. C. Serio et al, Journal of Quantitative Spectroscopy & Radiative Transfer 206 (2018) 8-21.

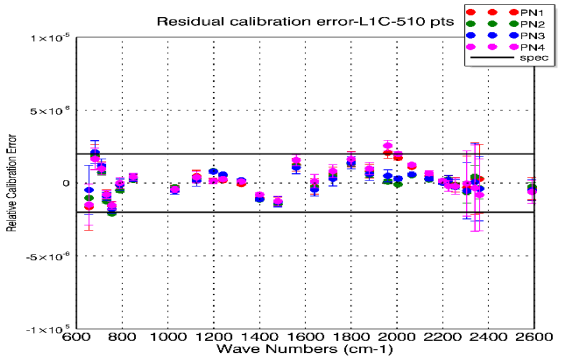
2. IASI-C spectral calibration

- **Correction achieved by comparing IASI spectra with simulated ones (a reference spectrum on the CO2 spectral window 2350-2380 cm^{-1}) on homogeneous scenes. The simulated spectra is obtained from the 4AOP radiative transfer model.**
- **L1C spectral calibration verification after correction**

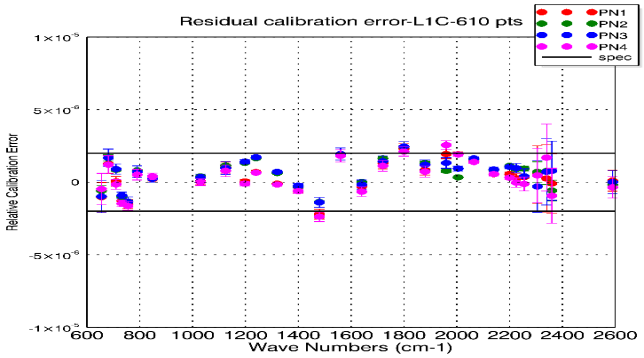
⇒ Same level of performance than on IASI-A and IASI-B (within requirements ≤ 2.10^{-6})

⇒ Residual error = typical snake-like shape (observed on the 3 IASI instruments). It confirms that this shape doesn't come from a methodology error. Attributed to radiative transfer errors (2012 GEISA atlases) + errors on input ECMWF profiles

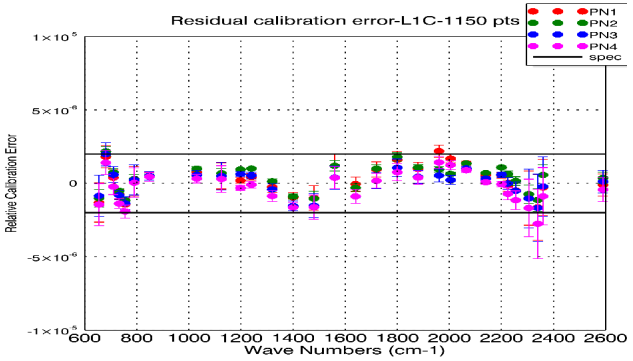
IASI-A



IASI-B



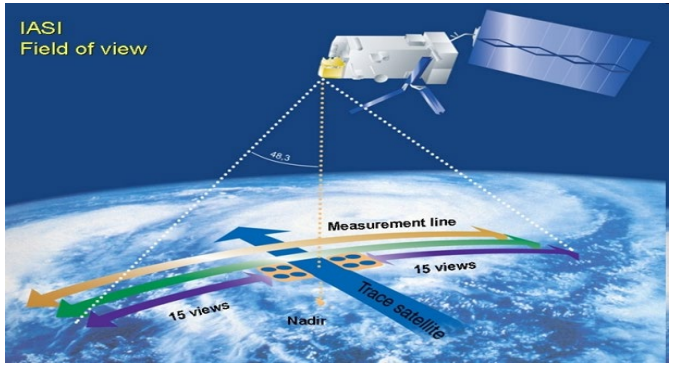
IASI-C

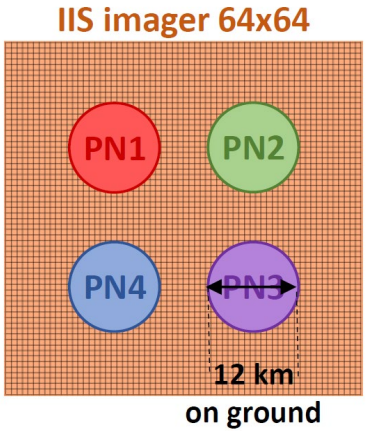


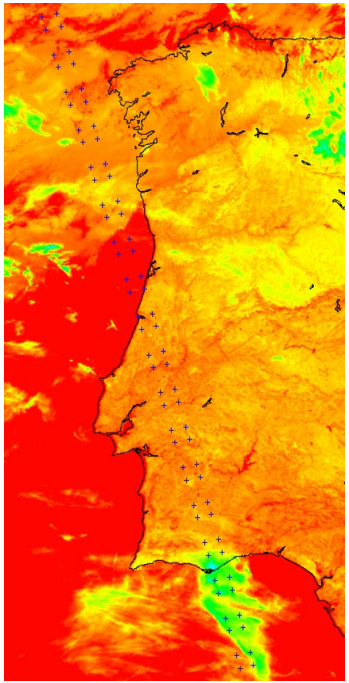
2. IASI-C Geometric calibration

- **Aims of geometric calibration : estimation of the accurate geo-location (longitude and latitude) of IASI pixels on-earth (when acquiring the spectrum) by using both the integrated imager (IIS) and AVHRR imager**

- **Activities performed :**
  - ⇒ **IIS-Sounder coregistration offset and stability over time;**
  - ⇒ **IIS-AVHRR coregistration and stability over time;**
  - ⇒ **Line of sight stability**
  - ⇒ **IIS radiometry analysis (noise, pixel good health)**







3. IASI-C L1 data validation

❖ **End of the calibration phase =**

⇒ ✓ once the spectra quality is good enough and stable over time (only few bad quality spectra are flagged)

⇒ ✓ IASI processing chain behave nominaly;

❖ **Start of the in-depth validation phase =**

⇒ Important feedback from users and EUMETSAT to have a cross validation of the spectra quality
(ECMWF, MetOfficeUK, MeteoFrance, DWD, U. Basilica, IPSL, LMD, LATMOS, U. Wisconsin-Madison, U. Bruxelles)
Times series of OBS-CALC, pixels differences in NedT, feedback on the new NCM delivery

⇒ At CNES :

- radiometric and spectral inter-comparisons with IASI-B and IASI-A
- Inter-comparisons between IASI, CRIS and AIRS
- Massive average analysis

Have a look on the dedicated poster on inter-comparisons performed at CNES :
“IASI-C L1 Validation : radiometric and spectral inter-comparisons between IASI-C and other infrared sounders”

✓ IASI-C vs IASI-B radiometric intercalibration bias < 0.1 K - ✓ Spectral intercalibration bias < 1.10^{-6}

✓ IASI/CrIS-N20 radiometric intercalibration bias < 0.1 K - ✓ IASI/AIRS radiometric intercalibration bias < 0.15 K

❖ **Final Cal/Val review at CNES and at EUMETSAT = L1 data operational dissemination + start of routine**

4. Conclusion

- ✓ **IASI-C switch to the redundant side (January, 25th) :**

⇒ Instrument behavior is nominal at system and equipment levels

- ✓ **IASI-C performances = within requirements and as good as IASI-A and IASI-B**

⇒ Fully operational and stable since July 2019

⇒ Data availability : 98%

- ✓ **IASI-C last decontamination : beginning of June 2019**

- ✓ **IASI-C is very well intercalibrated with IASI-A and IASI-B (cf. dedicated poster):**

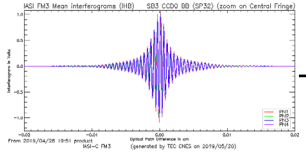
⇒ **New promising method is under analysis: use moon acquisitions as a reference for IASI-A/B/C inter-comparisons**

⇒ **High confidence in the absolute calibration of IASI-C and continuity of IASI-A/IASI-B**

- ✓ **IASI-C is very well intercalibrated with other infrared sounders (cf. dedicated poster):**

Back-up

IASI processing chain



Pre-processing (Non linearity correction & Spike detection)

NZPD determination

FFT

Raw complex spectrum

Calibration target filtering BB,CS

Radiometric calibration

Band Merging

Spectrum coding

Coded & pre-calibrated real spectrum

ON-BOARD

ON-GROUND

Spectrum decoding

Spectral state estimation

Radiometric post-calibration (including Black Body emissivity & scan mirror reflectivity correction)

L1A spectrum

Spectral database

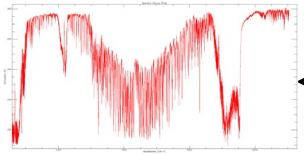
Resampling & Shift removal

L1B spectrum

Apodisation & Shape removal

Geolocation

L1C spectrum



IASI-C product types

⇒ **L0 : On-board processing (DPS) transmitted to the ground**
- pre-calibrated real spectra;
- quality indicators (interferogram acquisition, spectra calculation);
- Only 1 interferogram per scan line (for a chosen PN pixel number and SB spectral band and SP scan position);
- IIS raw images;

⇒ **L1 : on-ground processing (OPS)**
- **L1A** = radiometrically calibrated spectra;
- **L1B** = resampled spectrally calibrated spectra ⇨ archived only
- **L1C** = apodized fully calibrated spectra (instrument line shape removal) ⇨ archived and distributed
- **L1ENG** = on-board + on-ground processing quality indicators + out of useful band data ⇨ archived (for expertise only)
- **L1VER** = verification interferogram ⇨ archived (for expertise only)

⇒ **L1B AVHRR data** used on-ground geometry and sub-pixel classification ⇨ archived