Infrared Atmospheric Sounding Interferometer

IASI on METOP-A
Radiometric and Spectral Performances measured during commissioning

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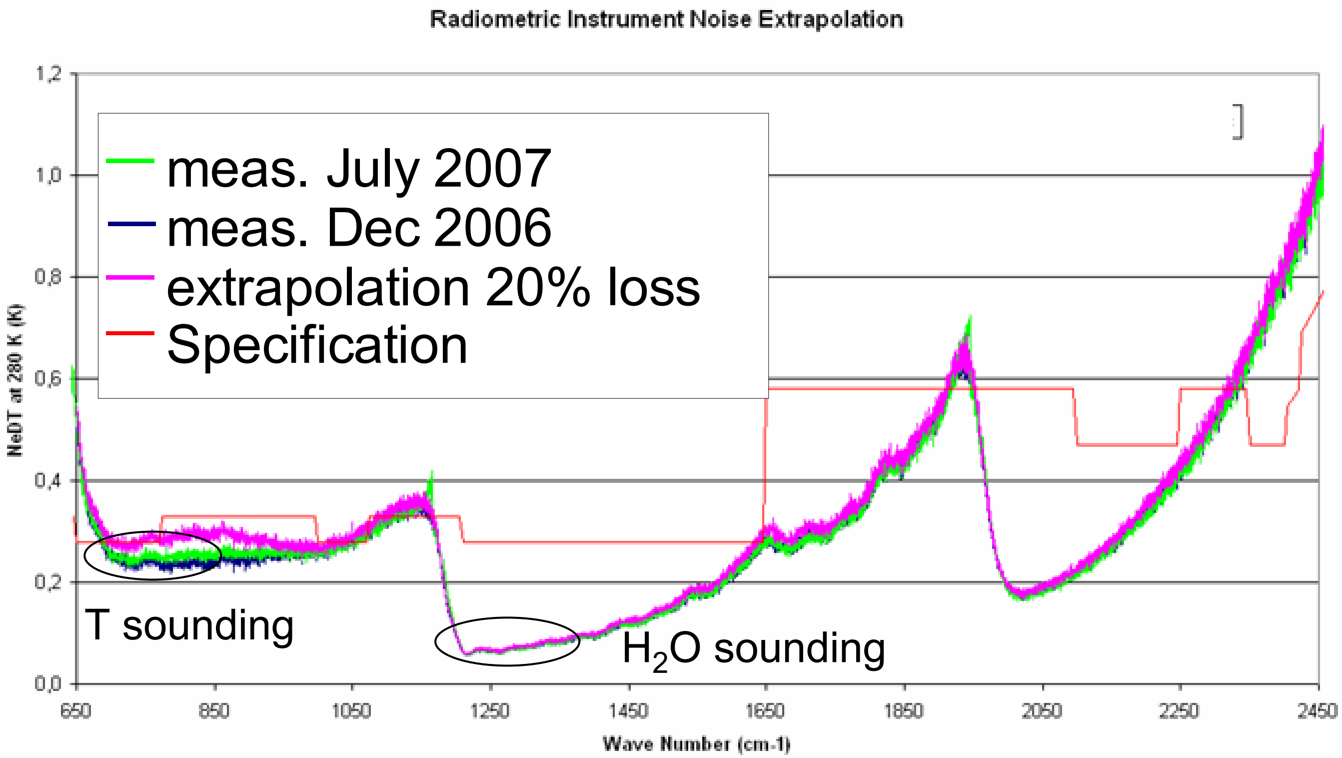
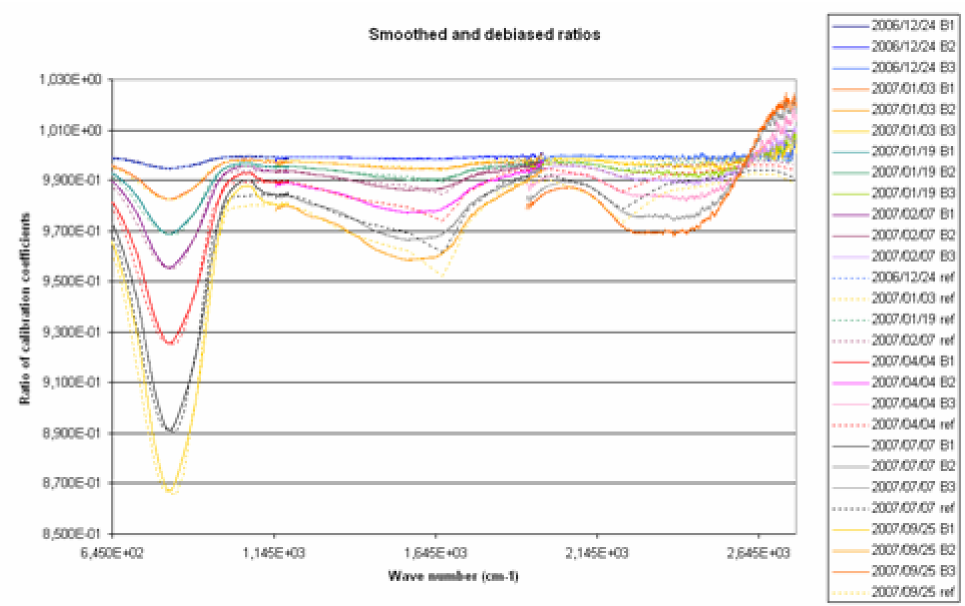
Instrument radiometric Noise (1/2)

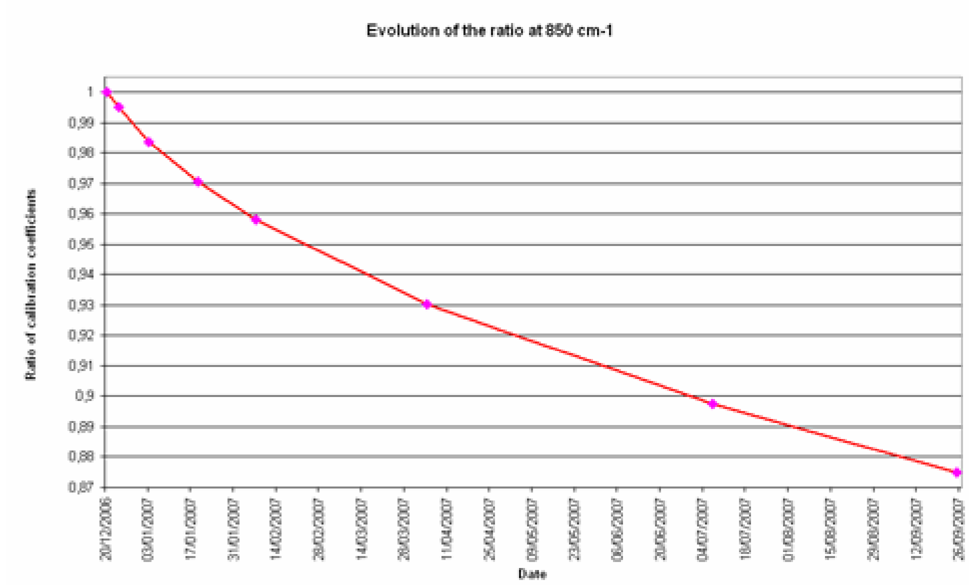
- **Non apodised spectra (L0 product)**
- **Measured on Black Body at 293 K : specified at 280 K**
- **In-flight noise very close to the one measured during on-ground test**



- **Radiometric instrument noise (NeDT at 280 K) measured on 2006/12/04 and 2007/09/25, as well as the predicted noise for a 20 % loss of instrument gain at 850 cm^{-1}.**
- **The radiometric instrument noise is directly related to the instrument gain (the detector temperature is stable).**

Radiometric instrument noise (2/2)

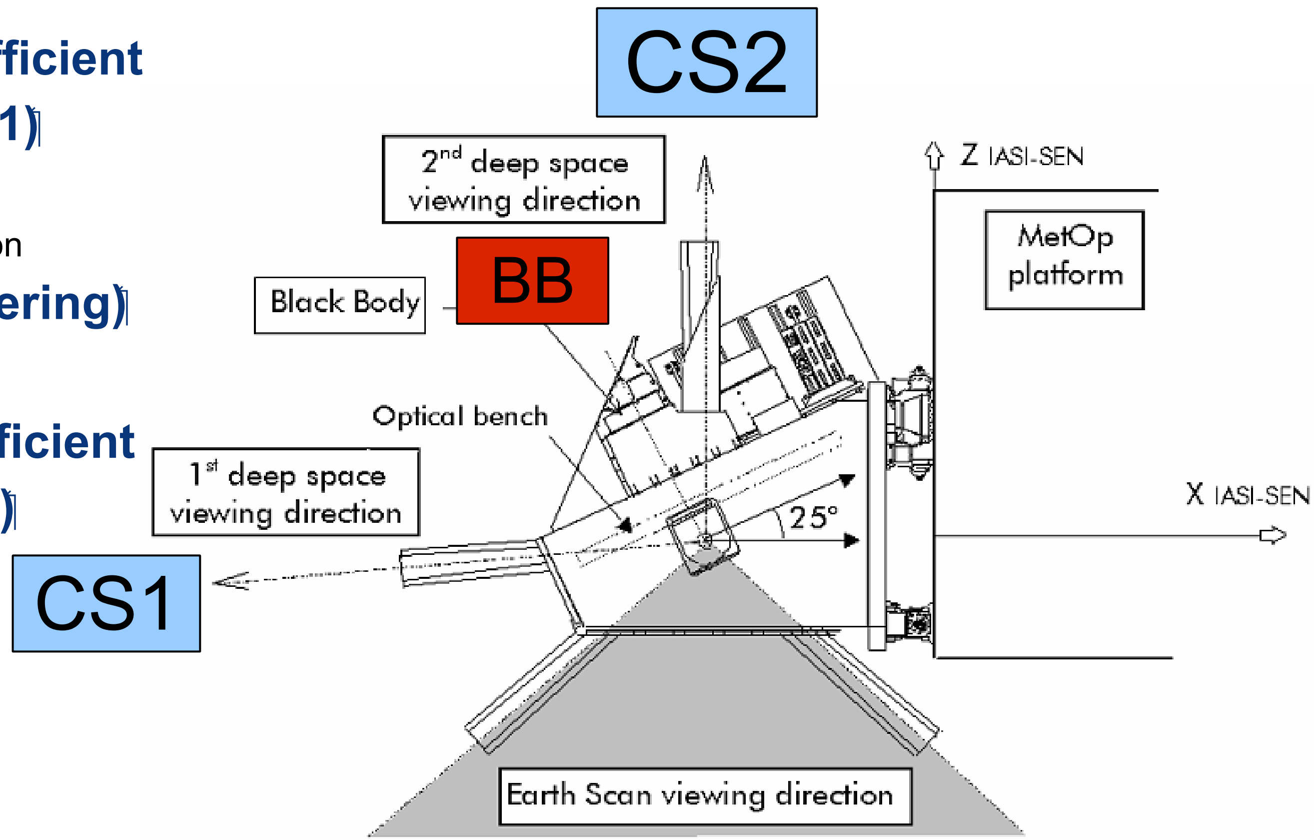




- Monitoring of the evolution of the instrument gain through the ratio of calibration coefficient slopes
- The decrease of the ratio of calibration coefficient slopes at 850 cm^{-1} is proportional to the loss of instrument gain due to ice contamination.
- Loss of gain December 2006 – September 2007: less than 13%
- 20 % loss is expected to be reached in May 2008

Radiometric calibration – orbital stability verification

- First component
  - Offset calibration coefficient
  - Cold Space views (CS1)
  - Lack of parasitic flux
    - CS1 vs CS2 comparison
  - Temporal stability (filtering)
- Second Component
  - Slope calibration coefficient
  - Black Body views (BB)
  - Lack of sensitivity to BB environment
  - Temporal stability (filtering)

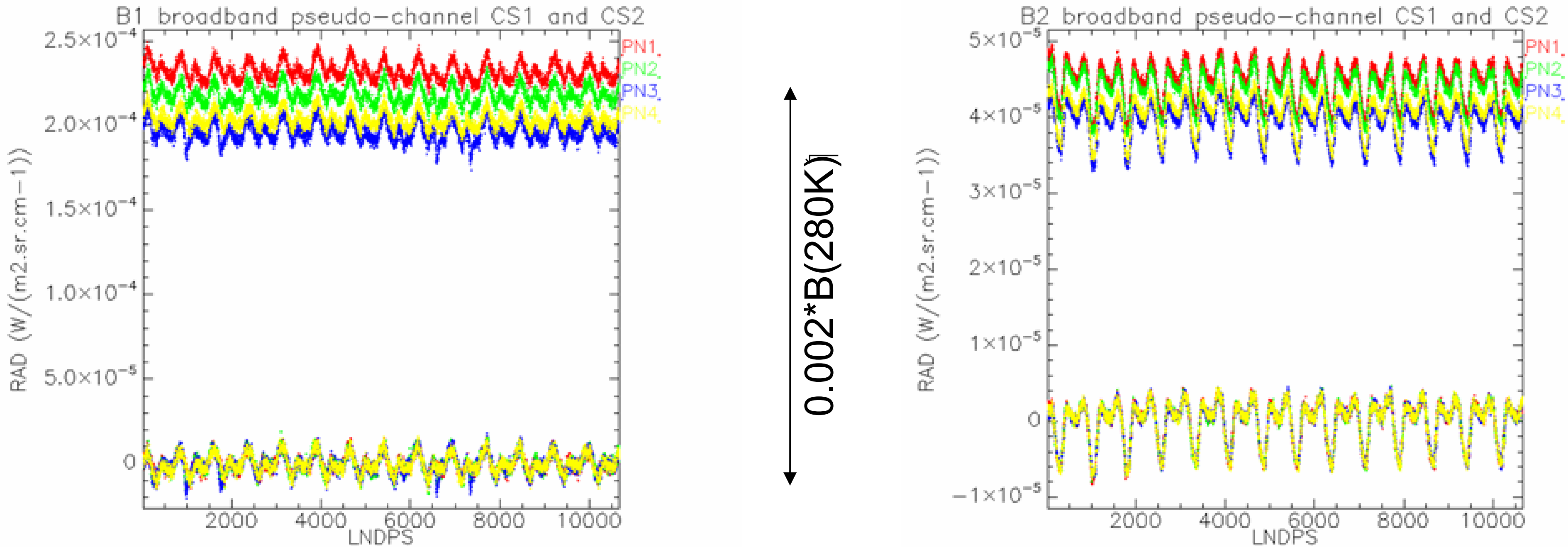


- External Calibration Mode
- Broadband pseudo-channels

Radiometric calibration – orbital stability verification

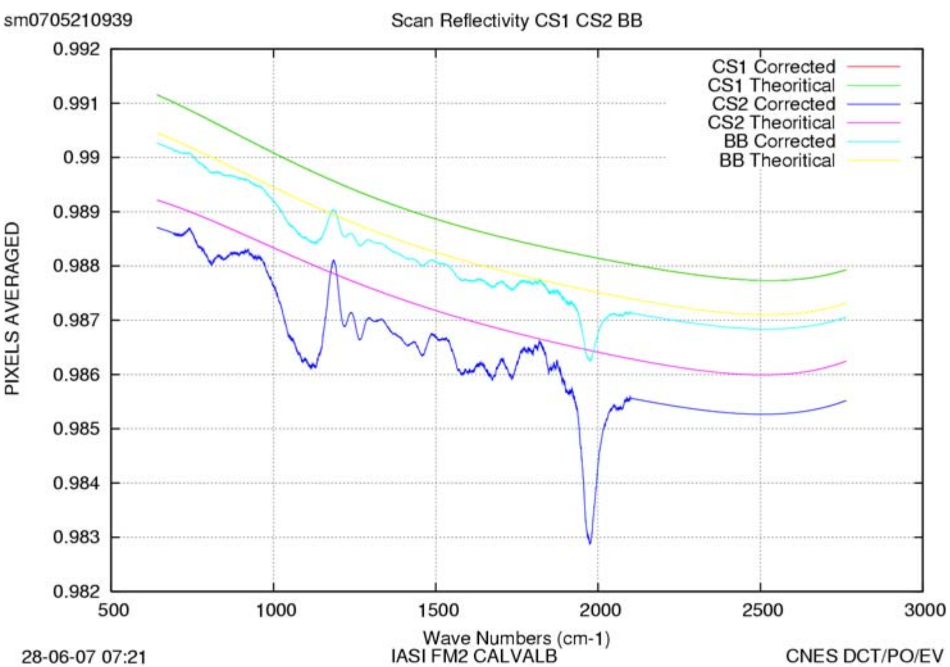
Results on Offset calibration coefficient (14 consecutive orbits)

- **Observation : No Parasitic flux in CS1 or CS2**
- **Orbital fluctuations caused by lag on filtered parameters**
  - **In April/May : 0.02 K (B1), 0.03 K (B2), 0.04 K (B3) peak to peak**
  - **Reduced to : 0.008 K (B1), 0.012 K (B2), 0.016 K (B3) after 27th of June**
- **Reminder : specification +/- 0.15 K (scaled to 280 K)**



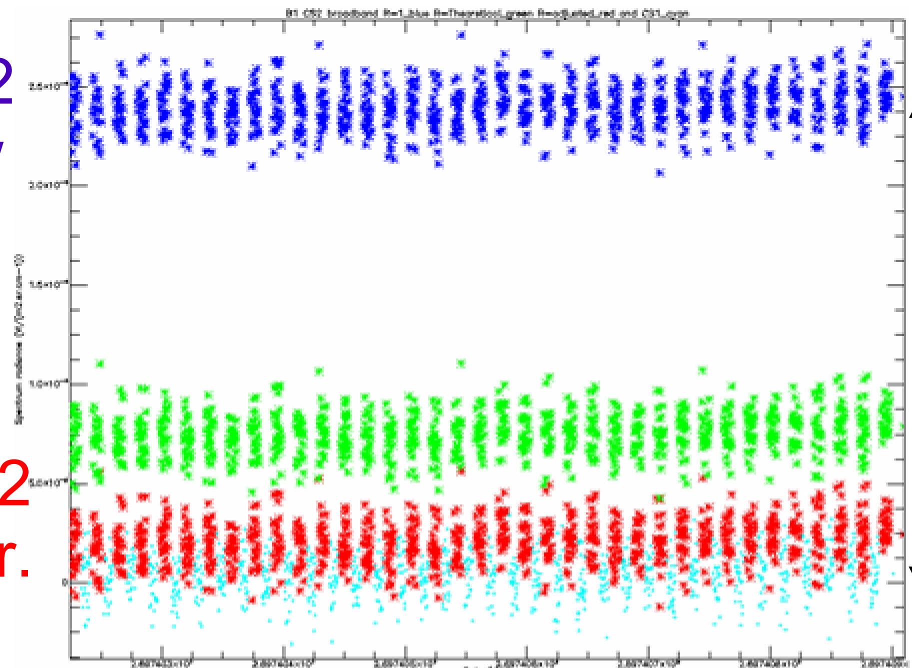
Radiometric Post-Calibration

- **Correction of scan mirror reflectivity variation with incidence angle**
  - **Minor effect (0.07 K at 280 K) but close to the specification (0.1 K)**
  - **Very close to the one observed during ground testing**



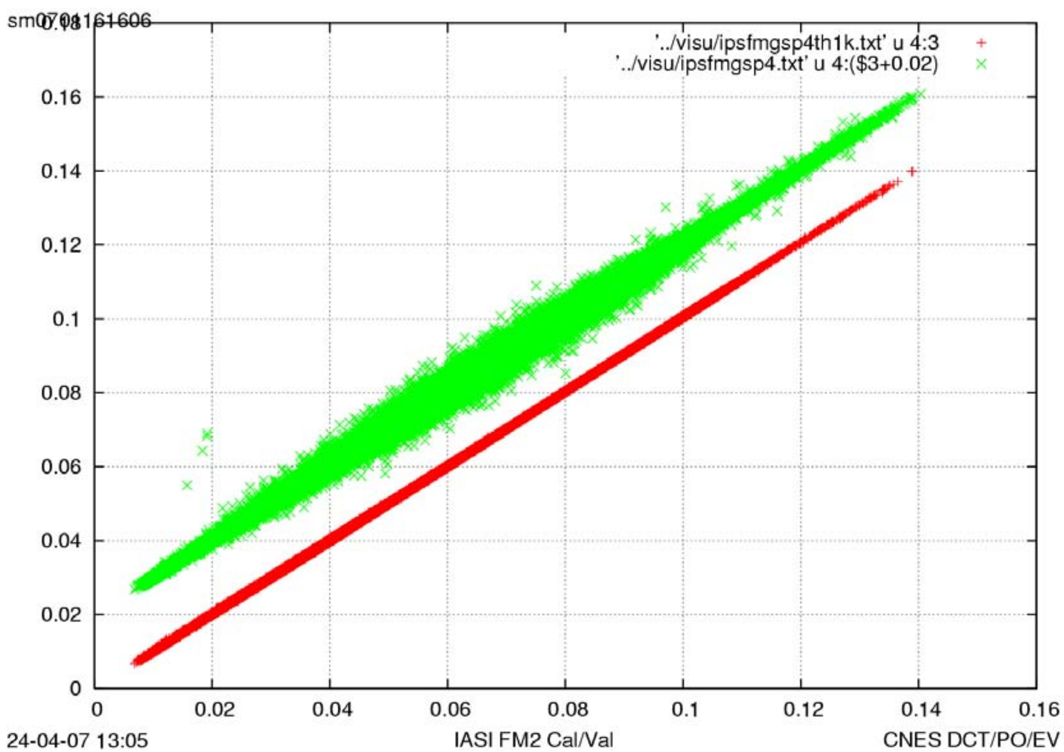
CS2 raw

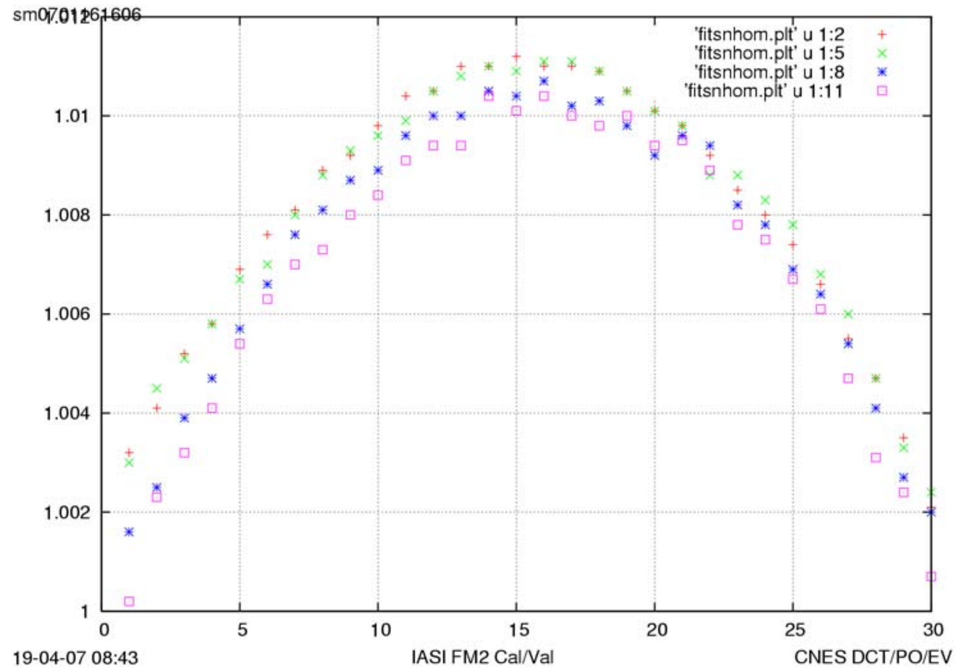
CS2 corr. = CS1



Radiometric calibration — IASI versus AVHRR

- **Method**
  - **Slope of AVHRR (ch4) vs IASI radiances**
  - **Analysis of slopes vs IASI scan angle**



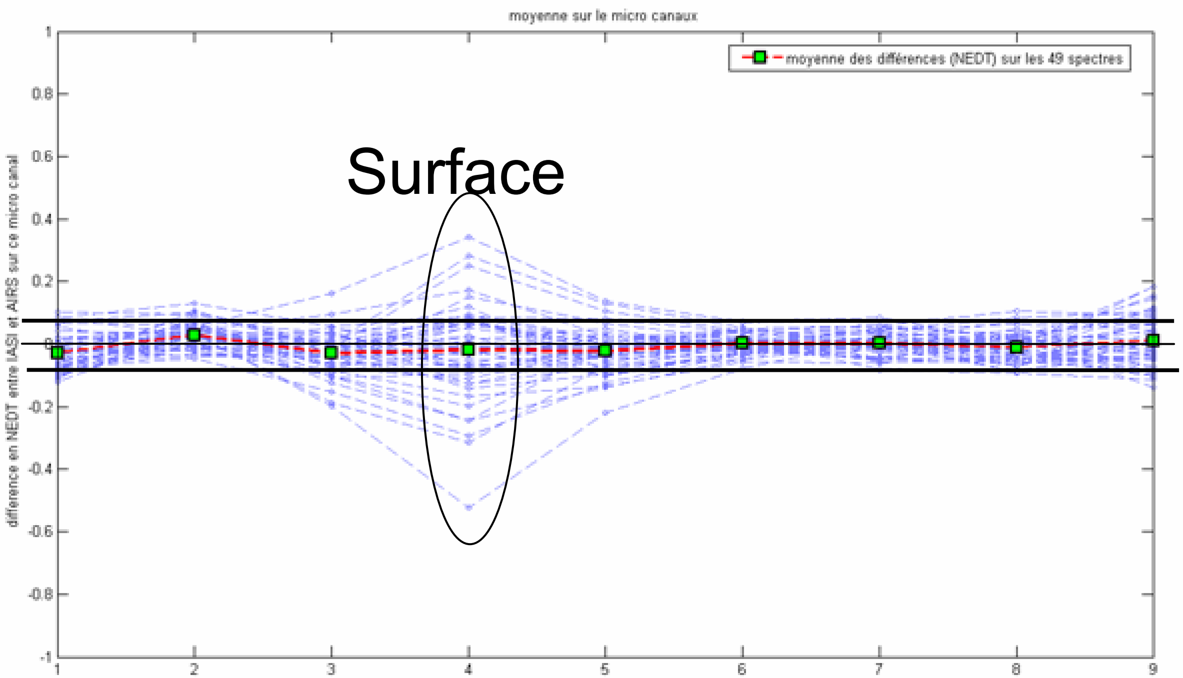


Good fit with cosine of the scan angle
Polarization of AVHRR scanning mirror ?
IASI effect : slight asymmetry

Radiometric calibration — IASI versus AIRS

Summary results (case 16th of April 2007)

- IASI External Calibration Mode. Very uniform situation
- 9 pseudo-channels / 49 soundings / 210 K in atmospheric window
- Differences scaled to 280 K reference temperature



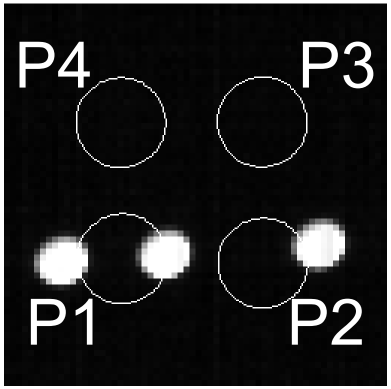
- Intercalibration error << 0.1K (average of the 49 soundings)

Radiometric calibration — Summary

- IASI stability on mid-term temporal range (orbit) very good
  - In particular, no impact of beginning/end of eclipse, terminator crossing, etc.
- IASI interpixel calibration error : **a few 0.01 K (typ. 0.05 K)**
- Intercalibration with AVHRR
  - **Small differences : -0.2 K < DT < 0.4 K (scaled at 280 K), very plausibly attributed to AVHRR (viewing angle dependency)**
  - **IASI spec (absolute) : +/- 0.5 K at 280 K**
- Intercalibration with AIRS
  - **SNO : Simultaneous nadir observations**
  - **Differences measured at 9 positions of the IASI mission band**
  - **3 controls done : differences < 0.1 K at 280 K**
- Long term (over months) stability of the NWP bias monitoring

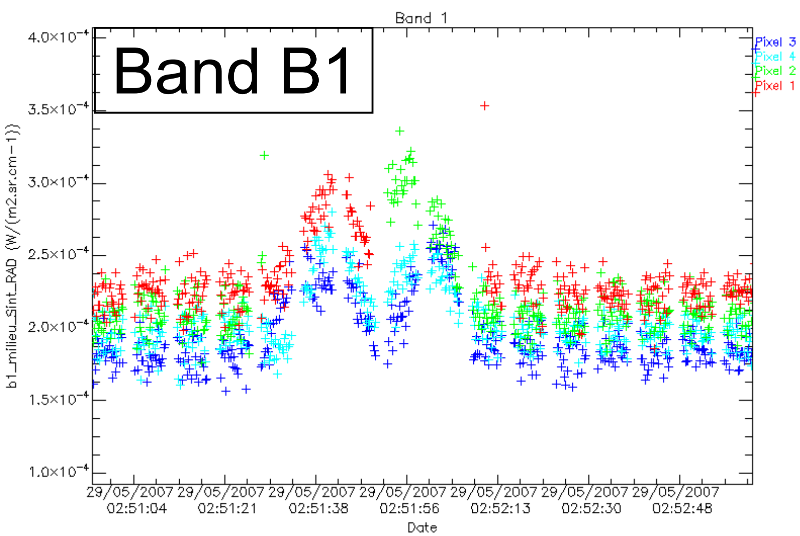
IPSF : In-Flight Straylight analysis

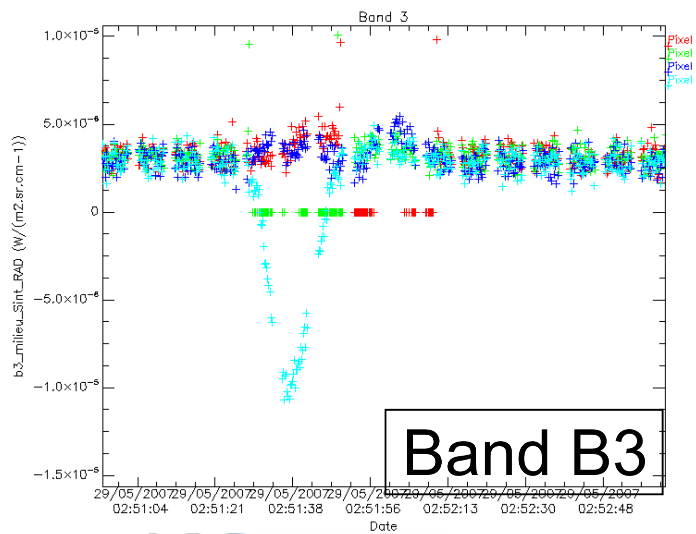
- **Use of moon pass inside Cold Space Field of View (CS2)**



Moon in IIS

- **Level lower than observed during ground testing**
  - **Closer to the predictions performed before the test**
  - **B1 : 0.17 % of input signal**
  - **B2 : 0.11 % of input signal (no measure on ground)**
  - **B3 : 0.3 % of input signal**
  - **Main impact for P4 when the moon is in P2**





Spectral Calibration : Introduction

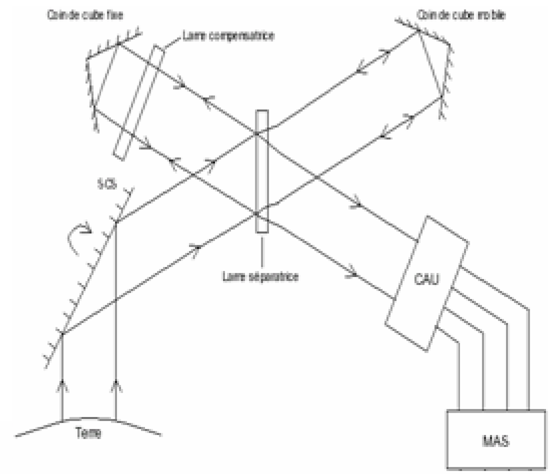
- **The spectral positions of the spectra samples must be known better than 2.10^{-6} i.e. $\Delta\nu/\nu < 2.10^{-6}$**
- **In terms of spectral sample the specification is band dependant :**

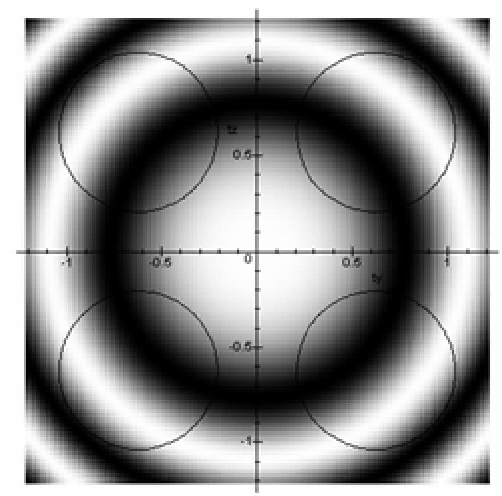
cm-1	cm-1	Sample fraction
650	0.0013	0.0052
1200	0.0024	0.0096
2000	0.0040	0.0160
2500	0.0050	0.0200

- **IASI is a Michelson Interferometer**
  - **No variation of the spectral calibration inside the band is expected**
  - **Off axis detectors induce a high sensitivity of the spectral calibration**
    ⇒ Need for an Instrument Spectral Response Function Estimation Model
    - Parameters are pre flight or in flight characterised and in flight estimated

Spectral calibration : instrument model inputs

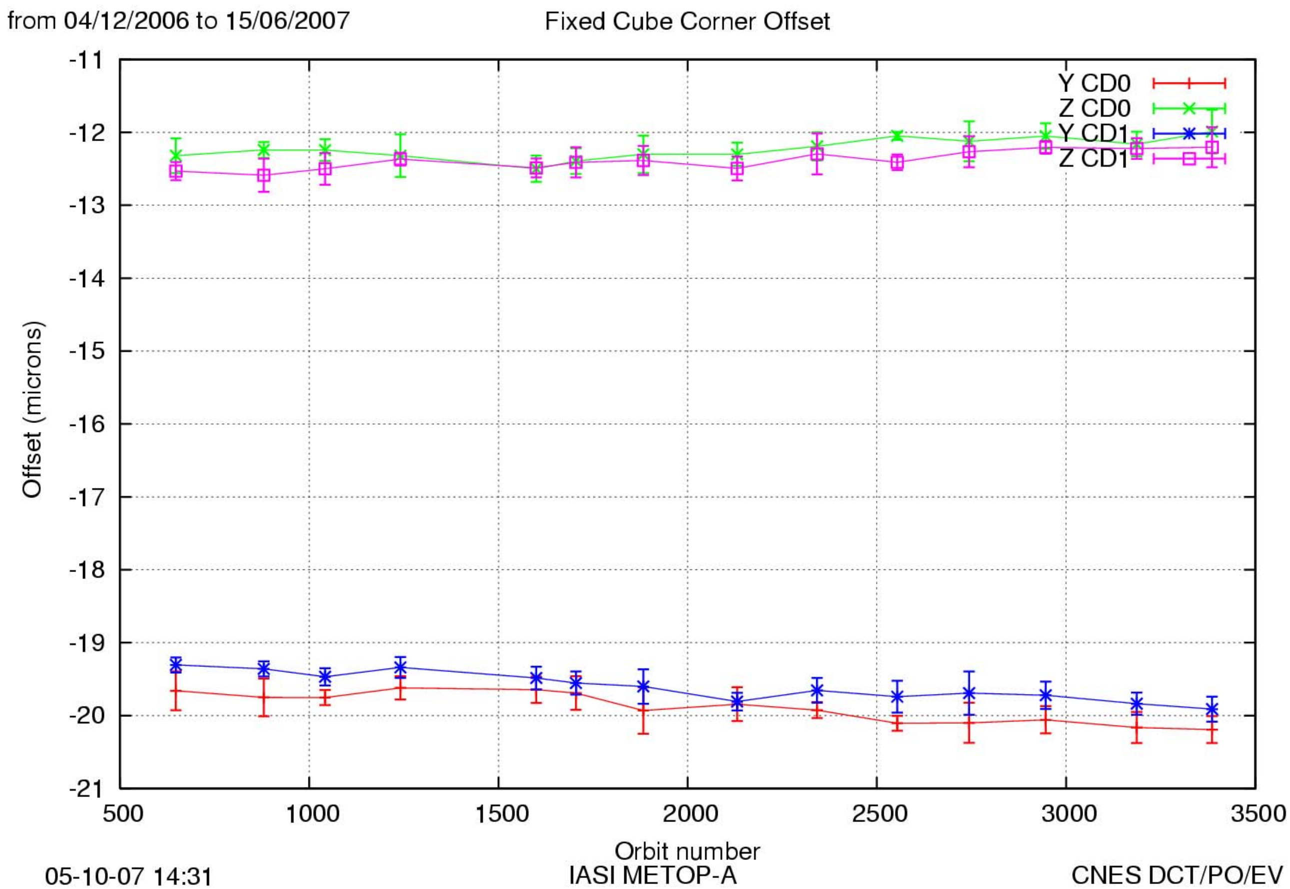
- **Pre-flight characterisation :**
  - **Sampling laser wavelength**
  - **Moving corner cube displacement law (linear)**
  - **Beam splitter and compensator plate (width, angles)**
  - **Instrument Point Spread Functions (one per detector)** Y and Z field angles and weights
- **In flight characterization off line at TEC :**
  - **Fixed cube corner offset (shear)**
  - **Instrument Point Spread Functions (Y and Z field angles)**
- **In flight characterisation near real time :**
  - **Interferometer axis position** (Y and Z coordinates)





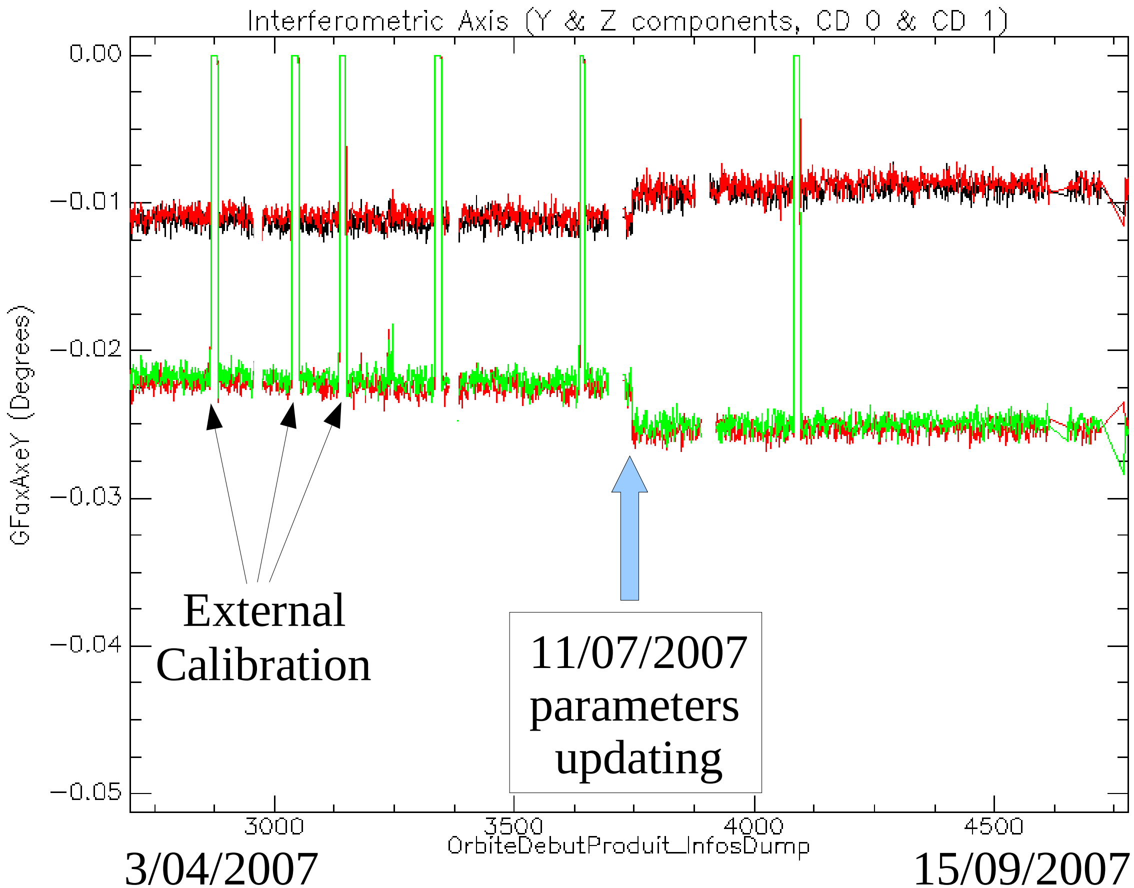
Fixed Cube Corner Offset

- **Accurate determination**
  - **STD < 0.1 µm**
- **Very stable :**
  - **Small drift**
  - **< 0.5 µm**
  - **Over 7 months**



Spectral Calibration

- **Long term stability of the interferometric axis position**
  - **5.5 months period**
    - 3rd of April
    - 15th of September
  - **Average in rad**
    - January
      - Y = -170 10^{-6}
      - Z = -360 10^{-6}
    - April
      - Y = -190 10^{-6}
      - Z = -380 10^{-6}
  - **Small evolution 11th of July**
    - 30 µrad
    - Equivalent to $\Delta\nu/\nu = 5\ 10^{-7}$
    - Spectral Database update



Spectral Calibration : Verification method (1/3)

- **Data set selection**
  - **External calibration mode Nadir viewing**
    - 16/01/2007 9 consecutive orbits
    - 13/04/2007 9 consecutive orbits
    - 04/06/2007 4 consecutive orbits
  - **Homogeneous scenes**
    - IIS Radiances variance < 0.6 Kelvin
  - **Only contiguous scenes are selected**
    - Smaller set = 6 spectra
    - Larger set = 250 spectra
    - Total selected spectra = 6295
    - Number of contiguous sets = 175
  - **For each set of contiguous scenes**
    - Computation of the average spectrum
    - Computation of the corresponding 4AOP (using GEISA spectroscopy) simulated spectrum

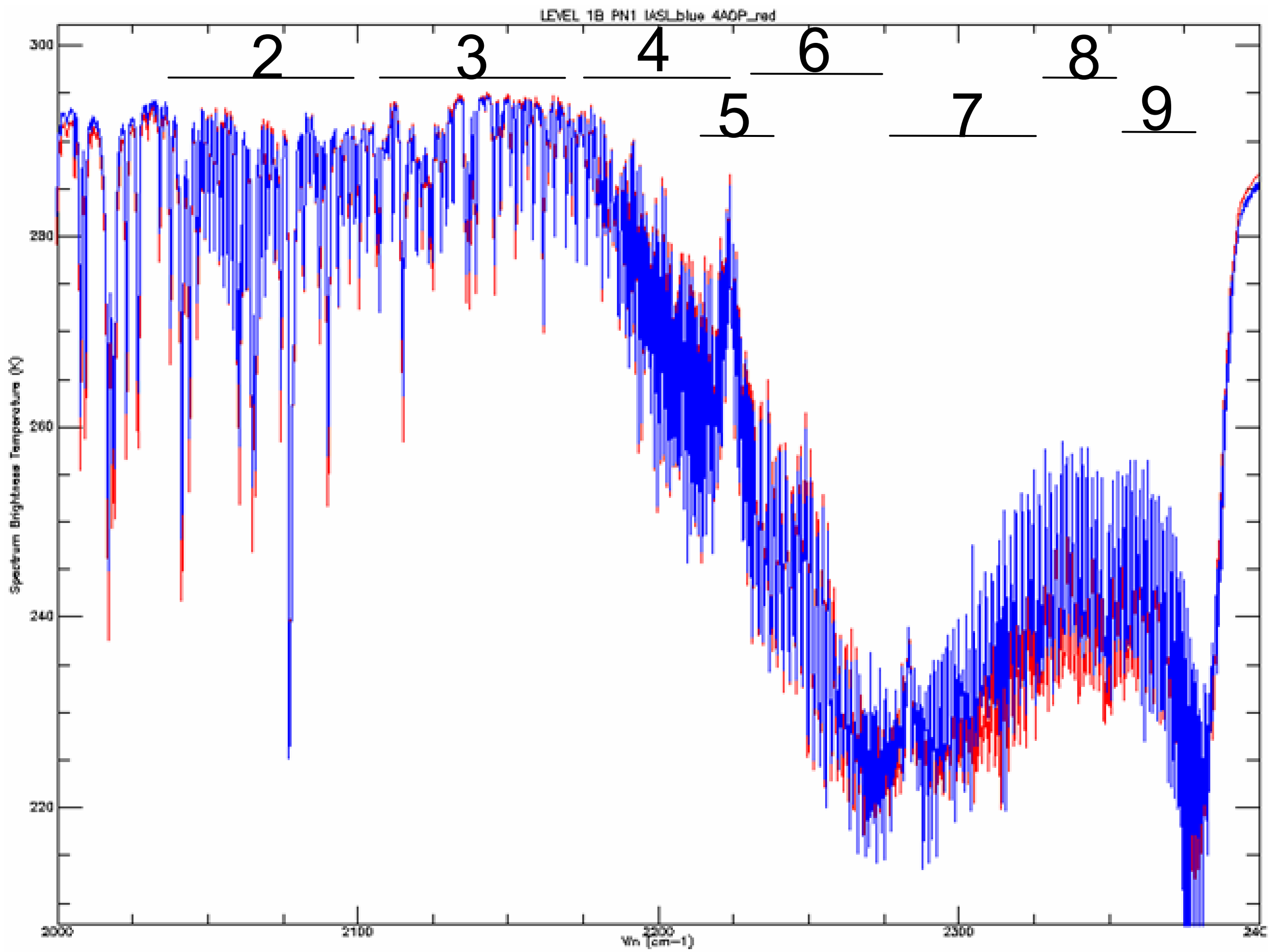
Spectral Calibration : Verification method (2/3)

- 10 spectral windows are selected (8 used)

- For each spectral window
  - Computation of the correlation coefficient between averaged measured spectrum and simulated corresponding spectrum
  - By varying the spectral scaling factor $\Delta\nu/\nu$
  - The position of the maximum of the correlation coefficient gives the relative spectral shift error
  - The value of the maximum gives the quality index of the determination

- The results are filtered using the quality index
  - Quality index > 0.990

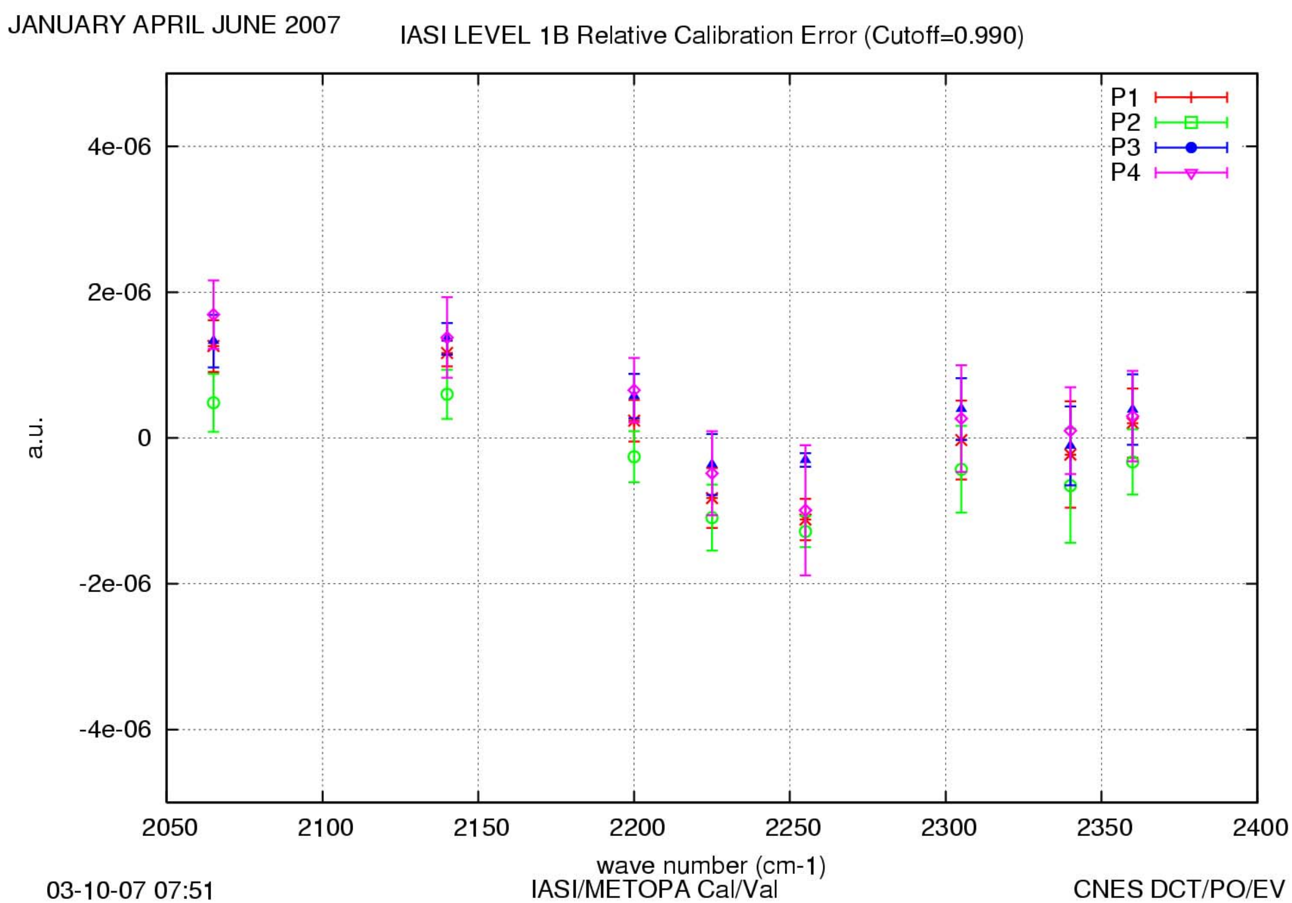
Spectral Calibration : Verification method (3/3)



Spectral Calibration : Results for Level 1B Band 3

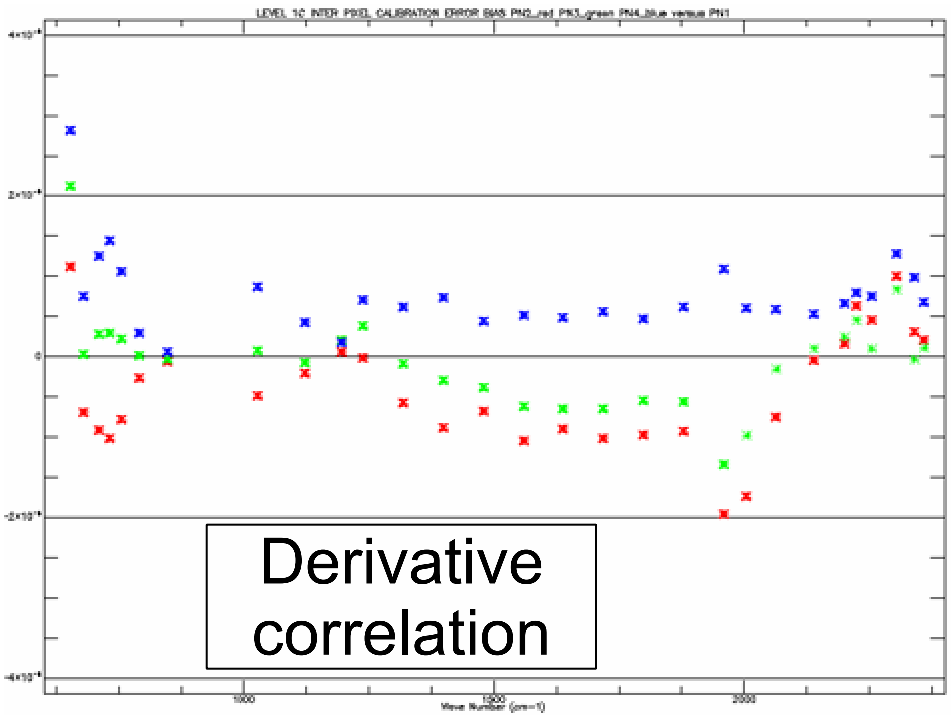
- **Errors bars show the standard deviation of the determinations.**

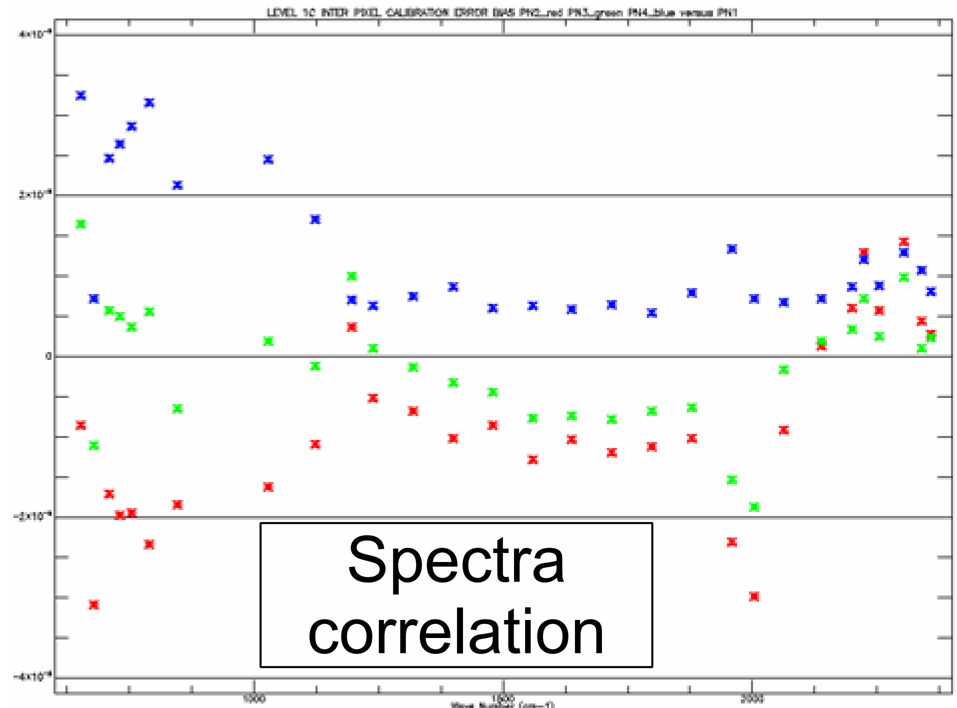
- **Considering the method sensitivity with the atmospheric knowledge the spectral performances are clearly inside the specification.**



Spectral Calibration Verification : Sensitivity to the method

- **2 methods give coherent but different results especially in band B1 (long wave)**
  - **Correlation between derivative of the spectra (best results)**
    - Remove dependency to low frequencies present in the spectra, if any.
  - **Correlation between radiances**





Intercalibration between the 4 IASI pixels (FOV #1 as reference)

Spectral performance : Ghost analysis (1/2)

- **Ghost origin : sampling jitter (harmonic) caused by a micro vibration**
- **Analysis done on BB spectra**
  - **Validation of simple model using ground and flight measurements**
- **Amplitude estimated from real part of BB spectra**

Std Dev	P1 CD0	B2	B3	B3/B2	Flight/ground		Comment
Ground Test	SM0410110948	0.24	0.42	1.74	B2	B3	1000 samples
	SM0612051715	0.25	0.42	1.7	1.02	1	270 samples
	SM0612051854	0.26	0.43	1.67	1.07	1.03	270 samples
	SM0612052036	0.26	0.46	1.73	1.09	1.09	298 samples
	SM0612052218	0.26	0.44	1.72	1.06	1.05	315 samples
IIOV10	SM0612111830	0.26	0.45	1.77	1.05	1.07	270 samples
	SM0612112012	0.25	0.44	1.74	1.04	1.04	270 samples
	SM0612112154	0.25	0.42	1.69	1.01	0.98	281 samples
	SM0612120118	0.24	0.42	1.76	0.99	1	300 samples
	SM0612120300	0.27	0.47	1.75	1.11	1.11	270 samples
	SM0701191003	0.35	0.55	1.58	1.44	1.3	35 samples
Cal/Val A	SM0701191324	0.31	0.52	1.68	1.28	1.23	41 samples
	SM0701191645	0.33	0.6	1.81	1.37	1.42	41 samples
	SM0701200436	0.33	0.59	1.8	1.36	1.4	41 samples
	SM0704041212	0.32	0.56	1.73	1.33	1.32	578 samples
	SM0704041554	0.32	0.54	1.7	1.31	1.28	567 samples
	SM0704041733	0.31	0.54	1.72	1.29	1.27	500 samples
	SM0704050345	0.33	0.56	1.7	1.35	1.32	522 samples
Cal/Val B	SM0705091209	0.33	0.56	1.73	1.34	1.33	553 samples
	SM0705091348	0.32	0.55	1.74	1.31	1.3	589 samples
	SM0705091530	0.31	0.53	1.69	1.29	1.25	520 samples
	SM0705091709	0.32	0.54	1.71	1.31	1.28	520 samples

Spectral performance : Ghost analysis (2/2)

- Use of atmospheric spectra :
  - Analysis of a small number of measurement sessions
  - Concentration on B2 band (H_2O) : very low radiometric noise -> high sensitivity
  - Confirmation of previous preliminary results
    - Noise measured on atmospheric spectra very close to noise measured on Calibration Views (after elimination of atmospheric variability)
    - Estimation of the perturbation close to the noise level (at the minimum)
- Amplitude of the ghost

	Amplitude RMS	Amplitude Max	Shape Error Index 2	
	% of ISRF maximum		Measured	Specified
Band 2	0.32	0.45	0.009	0.026
Band 3	0.54	0.76	0.015	0.042

- No evidence of external contribution to the micro-vibration
- Recommendation
  - No release of LFD (locking and filtering device)

Conclusions

- **After more than 9 months in orbit**
  - **IASI is performing very well**
    - all mission requirements are met
    - both instrument and processing
- **All performances very stable in the long term**
  - **Radiometry, spectral, geometry**
- **L1 commissioning using mainly IASI, AVHRR & HIRS data**
  - **Some verifications done with respect to AIRS and IASI Balloon data**

Routine phase

- During the routine phase, IASI Technical Expertise Center (IASI TEC) located in CNES/Toulouse will take 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
  - Radiances monitoring (wrt Radiative Transfer)

Thank you

- **Visit the CNES IASI Web site**
  - http://smcs.cnes.fr/iasi