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IASI QUARTERLY PERFORMANCE REPORT

FROM 2019/07/01 TO 2019/08/31

BY IASI TEC (TECHNICAL EXPERTISE CENTER)

FOR IASI FM3-R ON METOP C

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Auteur(s) :

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RESUME :

Quarterly report issued by the IASI TEC team to show trends and layout from the "long term synthesis" TEC function for flags and observables quality indicators

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Instrument characteristics / In-orbit performances monitoring

DOCUMENT MODEL CHANGE RECORD

Version	Date	Paragraphs	Description
1.0	01/09/2019		Creation of the model (from Metop-B)

DOCUMENT CHANGE RECORD

Version	Date	Paragraphs	Description
1.0	01/09/2019		Creation of the document

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Figures and tables

LIST OF ACRONYMS

4A/OP	Automatized Atmospheric Absorptions Atlas/ Operational
APO	Other Parameters OPS
AR	Anomaly Report
ASE	Acquisition Start End
AVHRR	Advanced Very High Resolution Radiometer
BB	Black Body
BRD	BoaRD configuration
CCFD	Cube Corner Functional Device
CCD	Cube Corner Direction
CCM	Cube Corner Mechanism
CD	Cube corner Compensation Device
CHART	Component Health Assessment and Reporting Tool
CGS	Core Ground Segment at EUMETSAT
CNES	Centre National d'Etudes Spatiales
CS	Cold Space
DA	Applicable document
DPS	Data Processing Subsystem
ECMWF	European Centre for Medium Range Weather Forecasts
EM	Engineering Model
EPS	EUMETSAT Polar System
EUMETSAT	European organisation for exploitation of METeorological SATellites
FM2 / FM3	Flight Model n°2 or 3
FOV	Field Of View
GRD	GRounD configuration
IASI	Infrared Atmospheric Sounding Interferometer
IIS	Integrated Imaging Subsystem
IPSF	Instrument Point Spread Function
ISRF	Instrument Spectral Response Function
LFD	Locking Filtering Device
LN	Line Number
LSB	Least Significant Bit
METOP	METeorological OPerational satellite
MPF	Mission Planning Facility
NedT	Noise equivalent difference Temperature
NDVI	Normalized Difference Vegetation Index
NZPD	Number of Zero Path Difference
ODB	Operational Data Base
OPS	Operational Software
PC	Principal Component
PDD	Position Data Diagnostic

PDU	Product Dissemination Unit
PL SOL	PayLoad Switch Off-Line
PN	Pixel Number
PTSI	Parameter Table Status Identifier
RMS	Root Mean Square
RD	Reference Document
SAA	South Atlantic Anomaly
SEU	Single Event Upset
TEC	IASI Technical Centre of Expertise (located in CNES, Toulouse)
TIGR	Thermodynamic Initial Guess Retrieval data set
VDS	Verification Data Selection
ZPD	Zero Path Difference

1 INTRODUCTION

The IASI TEC is based at CNES Toulouse and is responsible for the monitoring of the IASI system performances, covering both instrument and level 1 processing sub-system.

This document describes the activities and results obtained at the IASI TEC for instrument FM3 on METOP-C during the following period:

- Start Time: 2019/07/01 Orbit: 3353
- End Time: 2019/08/31 Orbit: 4233
- Duration:3 months

Note that IASI-C ended the Calibration / Validation (commissioning) phase on June 2019.

2 RELATED DOCUMENTS

2.1 APPLICABLE DOCUMENTS

N°	Reference	Titre
DA.1	IA-SP-0000-3242-CNE	Spécification de suivi de la performance en vol de IASI sur METOP-A
DA.2	IA-SP-1000-3650-CNE	Spécification de suivi par la TEC des paramètres fonctionnels de IASI en vol

2.2 REFERENCE DOCUMENTS

N°	Reference	Titre
RD.1	EUM/OPS-EPS/REP/	

3 SIGNIFICANT EVENTS

The following tables present a timeline of the various requests sent by TEC and the external IASI activities.

Those events are typically the configuration changes, programming requests, software update, but also any external operation or activity such as mission interruption, manoeuvre, dissemination problem, ...

3.1 EXTERNAL CALIBRATION

Table 1 shows the External Calibration within the time period reported here. Note that the VDS files that come with each request are not described here.

Execution	TEC ref.(1)	Description	Activities
From 13/07/2019 21h25 to 04h33 orb. 3535 to 3539	CE-CS2	Moon acquisition MPF(2) Targets: 2nd Deep Space	Acquisition of moon data in CS2 FOV
25/07/2019 from 05h15 to 09h11 orb. 3696 to 3698	RM-04	Monthly_MPF(2) Targets: Earth 15, Blackbody, 2nd Deep Space, Mirror Backside	For routine monitoring (IIS and IASI NeDT, scan mirror reflectivity, ghost,…)
From 12/08/2019 07h12 to 14h10 orb. 3953 to 3957	CE-CS2	Moon acquisition MPF(2) Targets: 2nd Deep Space	Acquisition of moon data in CS2 FOV
From 20/08/2019 06h51 to 21/08/2019 01h40 orb.4066 to 4077	RL-02	Moon avoidance MPF(2) Targets: 1st Deep Space	Monitoring of moon intrusion in CS1 FOV
23/08/2019 from 05h15 to 09h11 orb. 4108 to 4110	RM-05	Monthly_MPF(2) Targets: Earth 15, Blackbody, 2nd Deep Space, Mirror Backside	For routine monitoring (IIS and IASI NeDT, scan mirror reflectivity, ghost,…)

Table 1: External Calibration TEC Requests

(1) TEC convention: R for Routine, M for Monthly and L for moon avoidance, followed by a chronological number

(2) An external calibration could be the result of:

- a TEC request or
- a "MPF" uploaded directly by EUMETSAT in full accordance with TEC.

Moon external calibration RL-02 detail:

External Calibration	
From	to
2019/08/20 06:51:25	2019/08/20 07:14:20
2019/08/20 08:31:41	2019/08/20 09:00:12
2019/08/20 10:11:41	2019/08/20 10:40:28
2019/08/20 11:51:41	2019/08/20 12:20:44
2019/08/20 13:31:41	2019/08/20 14:00:44
2019/08/20 15:11:25	2019/08/20 15:40:44
2019/08/20 16:51:24	2019/08/20 17:20:44

External Calibration	
From	to
2019/08/20 18:31:08	2019/08/20 19:00:44
2019/08/20 20:11:08	2019/08/20 20:40:28
2019/08/20 21:51:08	2019/08/20 22:20:28
2019/08/20 23:33:00	2019/08/21 00:00:12
2019/08/21 01:15:56	2019/08/21 01:40:12

3.2 ON BOARD CONFIGURATION

On-board processing configuration updates that had been made within the time period reported here:

PTSI	IASI on board parameter files	Delivery by TEC	activated on	TEC ref.	affected parameters of a DPS TOP configuration update
14 1.0	IDPS_OBP_xx_M03_20190830000000Z_20200229000000Z_20190829125337Z_IAST_DPSPARAMOD.tar	29/08/19			CTC for SMA monitoring (CS)

Table 2: DPS and MAS configuration TEC Requests

Delivery applicable at the beginning of the period:

PTSI	IASI on board parameter files	Delivery by TEC	activated on	TEC ref.	affected parameters of a DPS TOP configuration update
13 1.0	IDPS_OBP_xx_M03_20190507120000Z_20191107120000Z_20190507081517Z_IAST_DPSPARAMOD.tar	07/05/19	15/05/2019, orbit 2692	cvb14	CTC for moon (CS)

Table 3: DPS and MAS previous configuration

The associated ground configuration table (BRD file), necessary to handle coherent configuration at system level, is presented in the next section. These associated configuration table are necessary for L1 processing.

3.3 GROUND CONFIGURATIONS UPDATES FOR LEVEL 1 PROCESSING

On-ground processing configuration updates that had been made within the time period reported here:

IDef	IASI L1 auxiliary files	Delivery by TEC	Upload on GS1	Content
17	IASI_BRD_xx_M03_20190830000000Z_xxxxxxxxxxxxxxZ_20190829125233Z_IAST_0000000014(IDefIDConf = 17)	29/08/19		CTC for SMA monitoring (CS)

Table 4: IASI L1 Auxiliary File Configuration on the Operational EPS Ground Segment

Delivery applicable at the beginning of the period:

IDef	IASI L1 auxiliary files	Delivery by TEC	Upload on GS1	Content
15	IASI_BRD_xx_M03_20190529120000Z_xxxxxxxxxxxxxxZ_20190529080235Z_IAST_0000000013 (IDefIDConf = 15)	29/05/19	BRD activated on 06/06/2019 11:23, orbit 3004	CTC for moon decoding (on ground)
4	IASI_GRD_xx_M03_20190326000000Z_xxxxxxxxxxxxxxZ_20190325144039Z_IAST_0000000004 (IDefStableParamID = 4)	25/03/19	GRD activated on 28/03/2019 12:53, orbit 2010	
4	IASI_ODB_xx_M03_20190326000000Z_xxxxxxxxxxxxxxZ_20190325143708Z_IAST_0000000004 (IDefSDB = 4)	25/03/19	ODB activated on 28/03/2019 12:53, orbit 2010	

Table 5: IASI L1 auxiliary file previous configuration

3.4 DATA BASES UPDATE FOR THE USERS

The Noise Covariance Matrix (NCM) and Spectral data base (SDB) are specific data bases for the users. They are updated according to the main ground level 1 evolutions.

Updates of the NCM and SDB that had been made within the time period reported here:

IDef	Users Data-Base	Delivery by TEC	TEC ref.	Comments

Table 6: IASI Data Bases for the users

Delivery applicable at the beginning of the period:

IDef	Users Data-Base	Delivery by TEC	TEC ref.	Comments
	IASI_NCM_xx_M03_20190404000000Z_20190404000000Z_20190403092554Z_IAST_SPECTRESPO	03/04/19		Update of NCM
	IASI_SDB_xx_M01_20130123150000Z_20130123150000Z_20130123142336Z_IAST_IASISPECDB	03/04/19		User database associated to ODB

Table 7: previous IASI Data Bases

3.5 ON GROUND HW/SW EVOLUTION

Updates of PPF L1 software within the time period reported here:

IASI L1 PPF software version	Delivery by TEC	**Date introduced on GS1**	**Comments**

Table 8: IASI L1 PPF Configuration on the Operational EPS Ground Segment

Software version applicable at the beginning of the period:

IASI L1 PPF software version	Delivery by TEC	**Date introduced on GS1**	**Comments**
8.0	07/07/2017	13/09/2017	AIX 7.1 and Linux 6.5 upgrade, LMA_SIMU and PGE_SIMU update, processing of big orbits in 32 bits

Table 9: Previous IASI L1 PPF

3.6 DECONTAMINATION

Decontaminations that have been made or requested within the time period reported here:

Last due date	Date of decontamination	Description

Table 10: Decontamination TEC Requests

Previous decontamination:

Last due date	Date of decontamination	Description
	From May 27th to June 3rd (Orbits 2861 to 2960)	Decontamination 200K

Table 11: Previous decontamination

3.7 INSTRUMENT

3.7.1 External events

This category is for those activities/events that are external to IASI but still have an impact. It is broken down into classes of *PL-SOL* and *OOP* manoeuvre.

3.7.1.1 Manoeuvres

Date	Type(*)	Description	IP flag	OoP mission Outage
10/07/2019	IP	IP manoeuvre #5 (orbit 3487)	Y	

Table 12: Overview of METOP manoeuvres in the reporting period

(*): IP for In-Plane manoeuvres (IASI stays in NOp) and OoP for Out of plane manoeuvres (IASI is put in Heater 2)

3.7.1.2 PL-SOL

PL-SOL events that have occurred within the time period reported here:

Dates	Orbits	Description

Table 13: PL-SOL

3.7.2 Operation leading to mission outage

This chapter presents the intervention on IASI needing routine interruption that have occurred within the time period reported here.

Dates	Orbits	type	IASI mode	Description

Table 14: Scheduled interruptions

3.7.3 Anomaly leading to mission outage

Tables 15 and 16 present the major and minor anomalies internal to IASI that have occurred within the time period reported here.

Note that in this section minor anomalies are all identified and without any impact on the mission, and major anomalies only affect IASI instrument, and no other sub-systems of the spacecraft.

Dates	Orbits	Anomaly type (*)	IASI mode	Description

Table 15: Major anomalies

(*): SEU (LAS, CCM or DPS) anomalies or SET anomalies

Day	Orbits	error n°	Severity	Anomaly type	LN	SN	Description
28/07/2019 23:02	3749	6	1	CSQ	38632	32	CCD=0 (backward)

Table 16: Minor anomalies

4 PERFORMANCE MONITORING

4.1 PERFORMANCE MONITORING

In order to ensure that the IASI system is permanently running in good conditions, the CNES (IASI TEC) and EUMETSAT (CGS) are monitoring products at various temporal levels : at line, PDUs and DUMP (full orbit).

The on-board and ground processing performance algorithms issue more than one hundred quality indicators, called flags and simple parameters. Those are alarms for any bad functioning or local performance degradation.

According to the results, the TEC is also in charge of delivering new on-board or ground parameters to EUMETSAT when it is necessary. EUMETSAT is then in charge of uploading them on-board or as an input of the level 1 processing chain. During the whole instrument life, these parameter adjustments are necessary in order to take into account instrument evolution in the processing and finally to maintain a good data quality.

Colour code used for the status report.

Status Colour	Meaning
GREEN	≥ 95% of good spectra
YELLOW	< 95% of good spectra
RED	Production interrupted
BLANK	No Status Reported

Table 17: Functional status legend

4.2 PERFORMANCE SYNOPSIS

Synthetic view of all the indicators evaluated for L0/L1 data and their current status.

Section	Component	Description	Status	Comments
4.3	**L0**	**Level-0 Data Quality** • Overall quality • Main flag and quality indicator parameters - Spikes monitoring - ZPD monitoring - Overflows/Underflows monitoring - Reduced Spectra monitoring • Second level flag and quality indicators	GREEN	On-board processing
4.4	**L1**	**Level-1 Data Quality** • Overall quality • Main flag and quality indicator parameters	GREEN	On ground processing
4.5	**L1**	**Sounder radiometric performances** • Radiometric noise • Radiometric calibration • Acquisition chain delay • Optical transmission - Ice - Prediction of decontamination date • Interferometric contrast • Interferogram Baseline • Detection chain	GREEN	
4.6	**L1**	**Sounder spectral performances** • Dimensional stability - Position of axis - Cube Corner constant offset - Cube Corner velocity - Optical bench temperature • Spectral calibration	GREEN	
4.7	**L1**	**Geometric performances** • Sounder/IIS co-registration • IIS/AVHRR co registration	GREEN	
4.8	**L1**	**IIS radiometric performances**	GREEN	

Table 18: IASI product components functional status

4.3 *LEVEL 0 DATA QUALITY (L0)*

4.3.1 Overall quality

The IASI L0 data quality (orbit average) through IASI engineering products is shown in Figure 1.

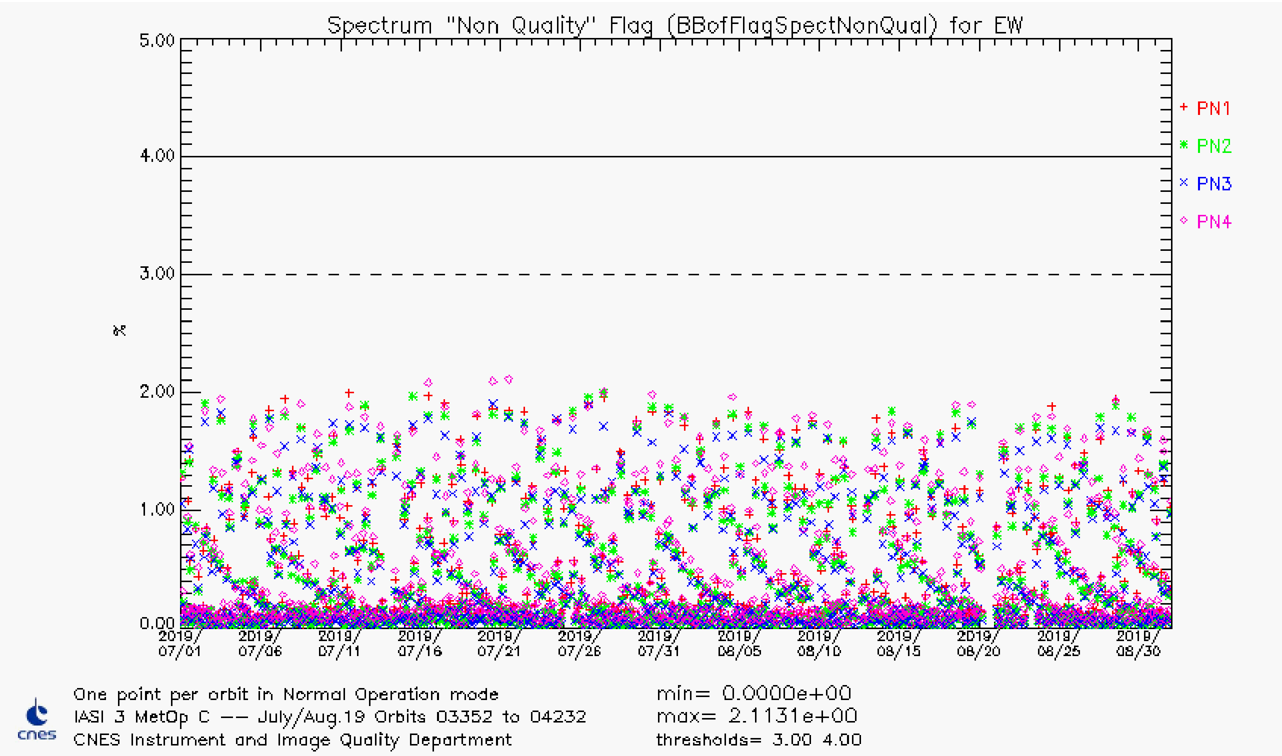
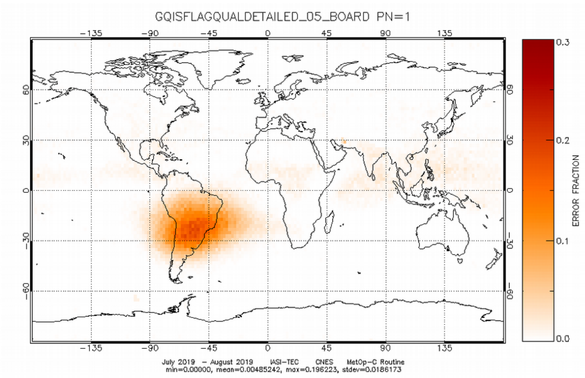


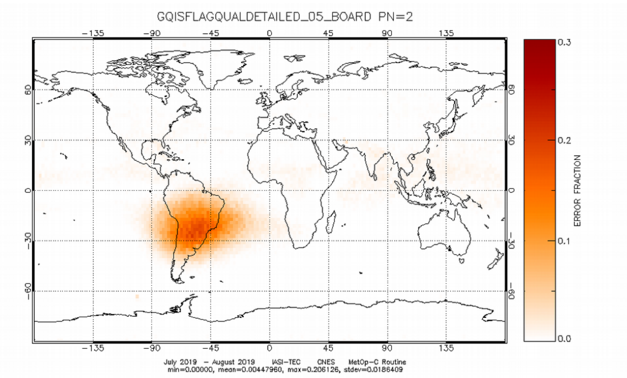
Figure 1 : IASI L0 data quality orbit average (per pixel and CCD)

The geographical distribution of the overall L0 (board) quality flag for the 4 pixels is shown in Figure 2.

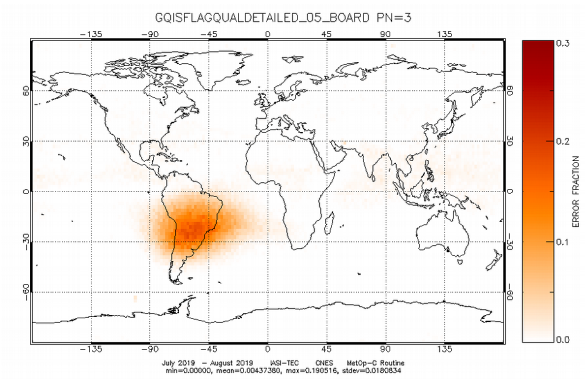
PN1



PN2



PN3



PN4

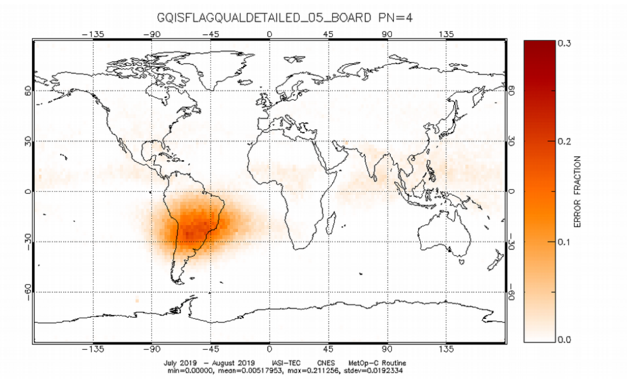


Figure 2 : IASI L0 data quality spatial distribution (per pixel)

The IASI L0 quality and on-board processing are nominal.

4.3.2 Main flag and quality indicator parameters

The main contributors to the rejected spectra by on-board processing are: spikes (proton interaction on detectors), failure of NZPD algorithm determination and over/underflows (measured data exceeding on-board coding tables capacity). They are analysed in details hereafter.

4.3.2.1 Spikes monitoring

Spikes occur when a proton hits a detector. This very high energetic particle disrupts the measure of the interferogram and then corrupts the spectrum.

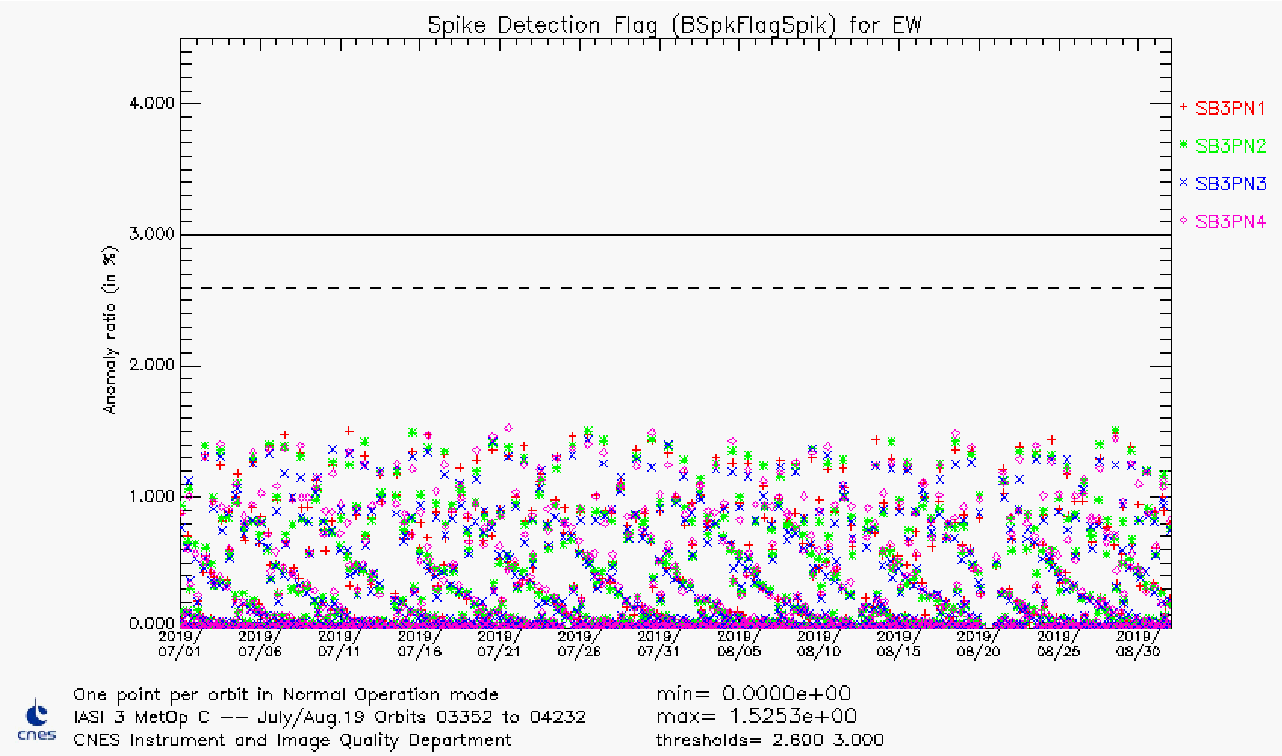


Figure 3 : Temporal evolution of spikes anomaly ratio in % for all pixels (orbit average)

An example of the geographical distribution of spikes occurrences on band 3 for the 4 pixels is shown in Figure 4.

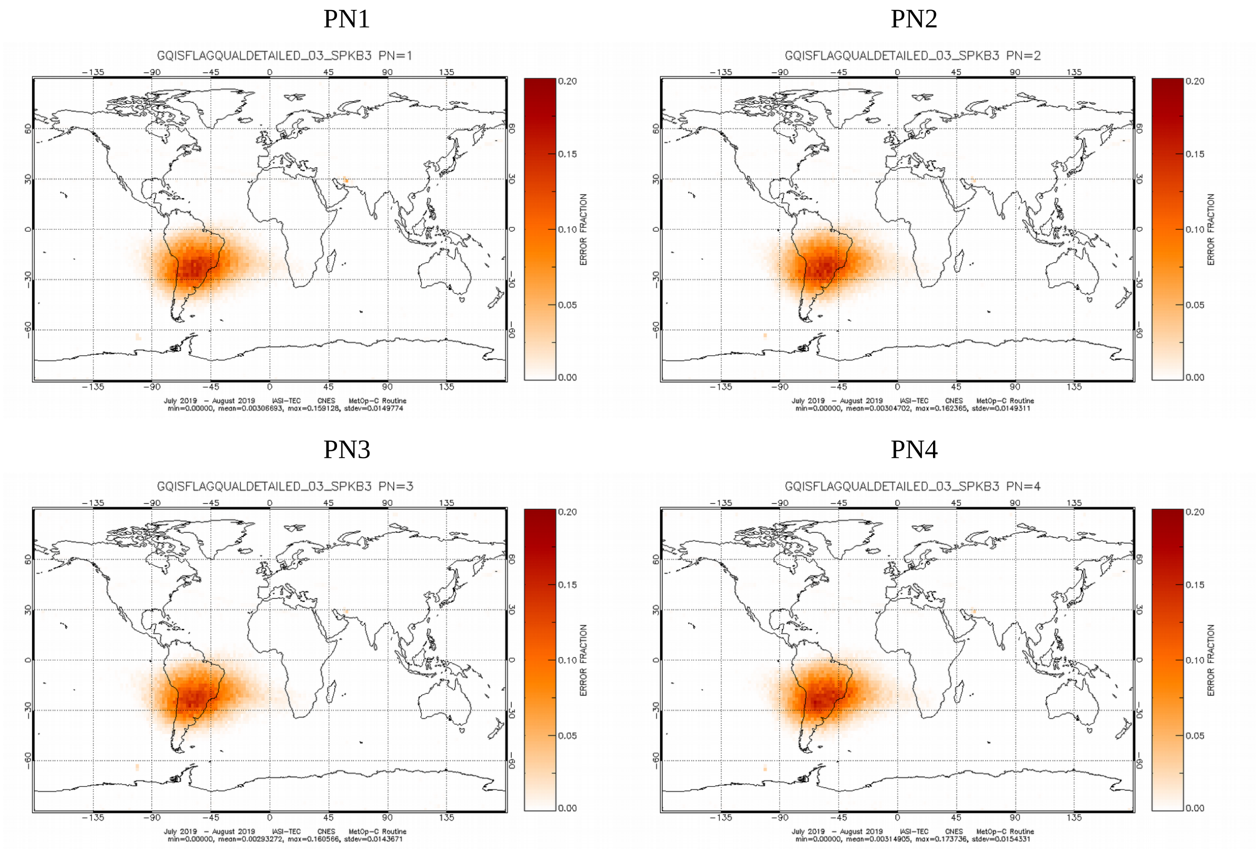


Figure 4 : Geographical distribution of spikes occurrences in % for band 3 and all pixels

Spikes are mainly located in the regions of Earth where the magnetic field doesn't protect the satellite from the energetic particles: the poles and the SAA (South Atlantic anomaly).

Spike anomaly ratio is nominal for the reported period.

4.3.2.2 ZPD monitoring

The ZPD ("Zero Path Difference") is the position of the central fringe of the interferogram. The NZPD is the number of the sample detected as the ZPD. On IASI, it is determined by a software. This is a special feature of IASI in comparison to other instruments for which NZPD determination is done by hardware.

NZPD variations are governed by two phenomenons:

1. ASE fluctuations which have the same effect on each pixel and can produce NZPD variation of 30-40 samples over month. This is the first order phenomena.
2. Mechanical deformation of the interferometer or evolution of detection chain delays. These phenomenons affect the 4 pixels in different way. However this phenomenon has a second order effect in comparison to the first one.

We monitor both NZPD determination quality flag and interpixel homogeneity. We expect stability.

<u>BZPDFlagNZPDNonQualEW:</u> Temporal evolution of NZPD determination quality flag for earth view

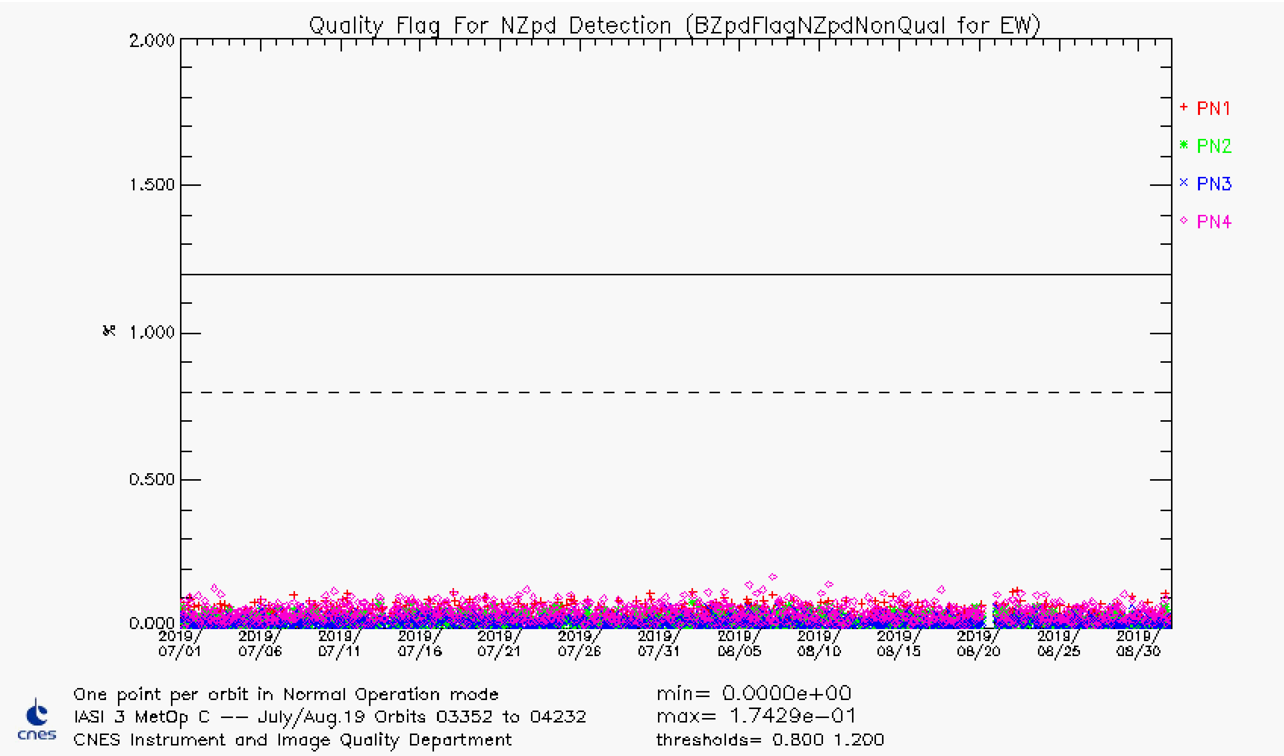
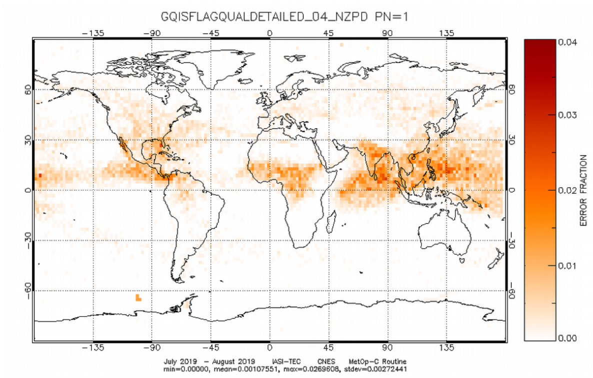


Figure 5 : Temporal evolution of NZPD determination anomaly ratio in % for all pixels (orbit average)

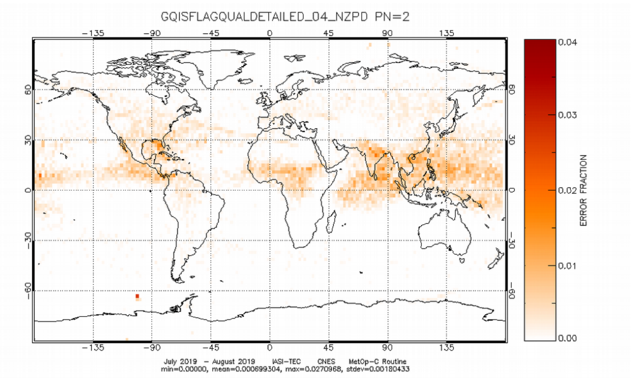
NZPD determination anomaly ratio is nominal for the reported period.

The geographical distribution of the NZPD determination quality flag for the 4 pixels is shown in Figure 6.

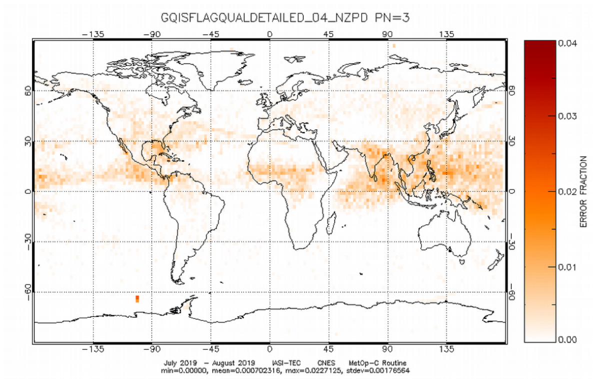
PN1



PN2



PN3



PN4

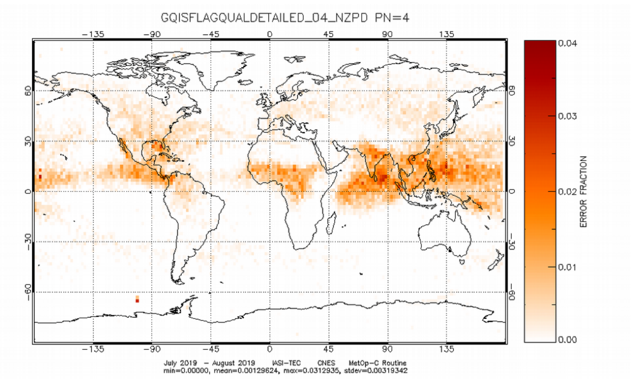


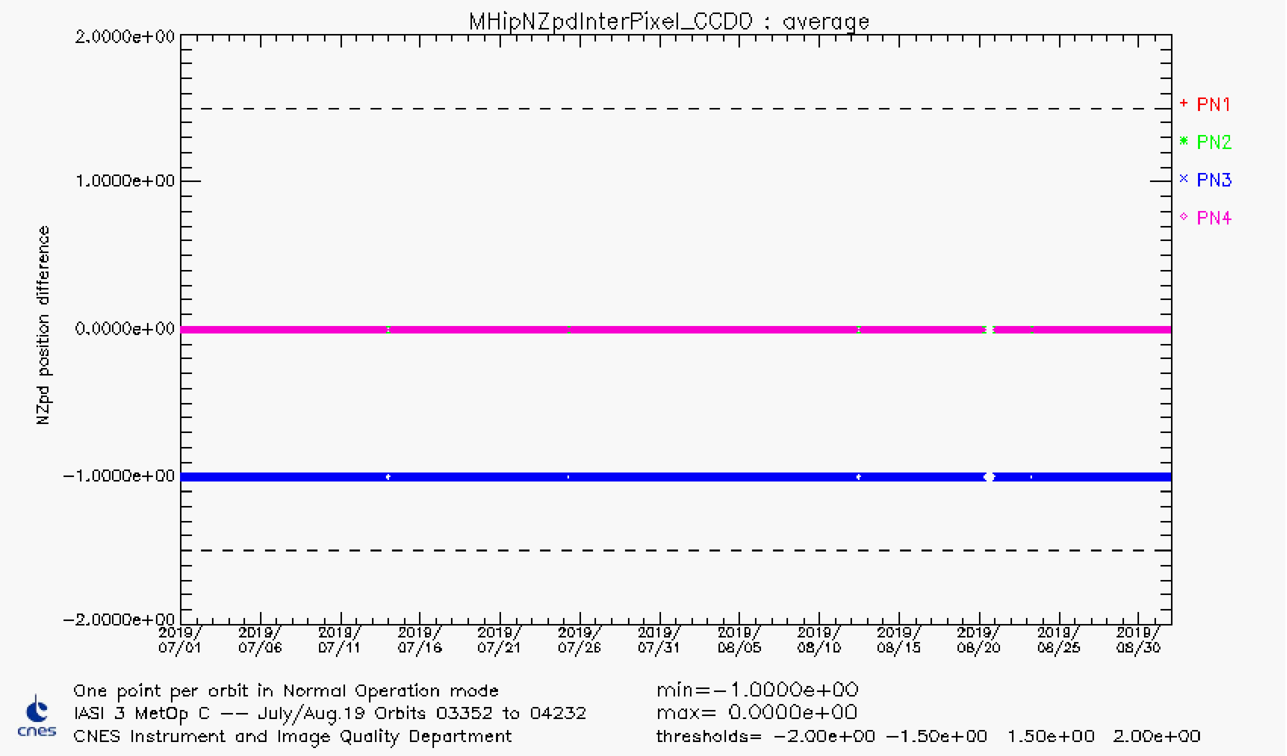
Figure 6 : IASI NZPD determination quality flag spatial distribution (per pixel)

The NZPD determination fails over some clouds that have a temperature that induces no energy in the central fringe of the interferogram.

<u>NZPD inter-pixel homogeneity monitoring</u>

This monitoring is necessary in order to follow potential deformation of the interferometer or evolution of detection chain delay.

The NZPD inter-pixel homogeneity is nominal over the reported period. Consequently, these parameters are perfectively stable and in-line with the specification.



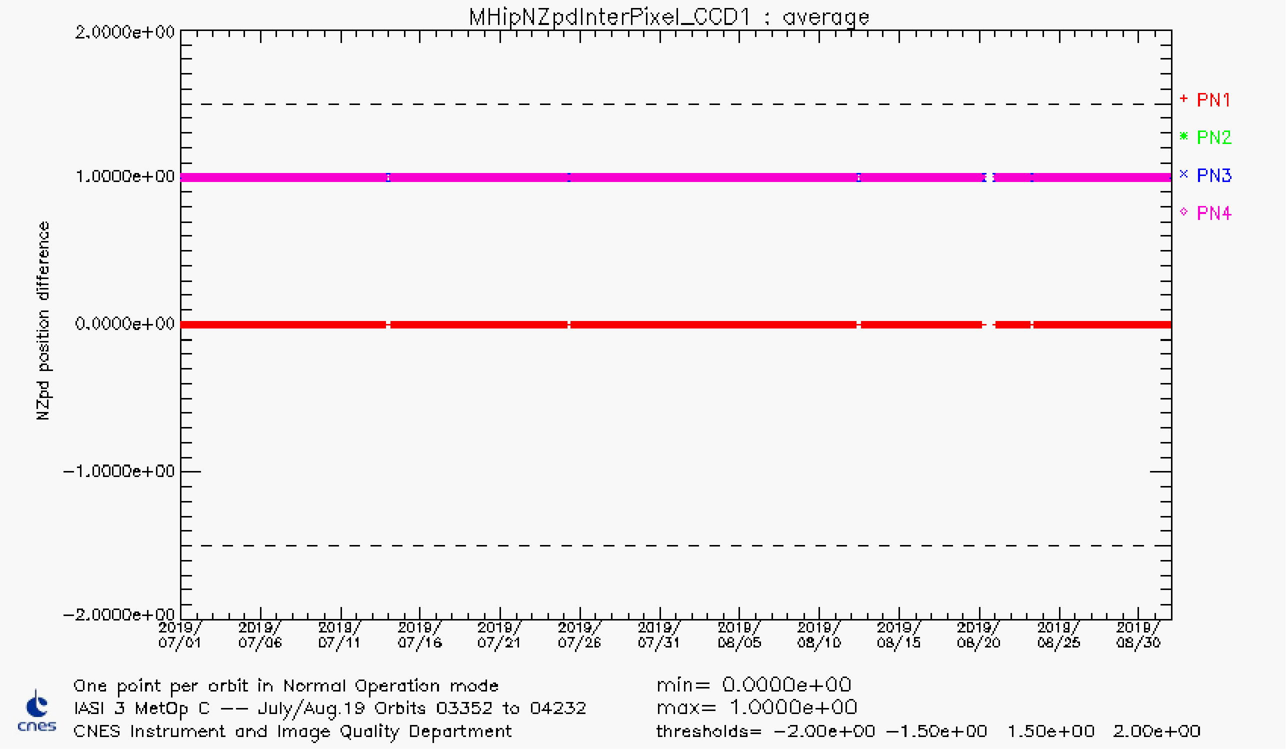


Figure 7 : NZPD inter-pixel for all pixels and CCD calculated with respect to pixel 1 (orbit average)

4.3.2.3 Overflows / Underflows monitoring

The total number of bits available for a spectrum to be transmitted to the ground is limited. For that reason, we have defined coding tables to encode each measured spectrum. These tables have been designed by using “extreme spectrum” corresponding to known drastic atmospheric conditions. The coding step is also set to not introduce additional noise into the spectrum. However for very extreme atmospheric conditions (sunglint in B3, very high stratospheric temperature…) a measurement can exceed on-board coding tables’ capacity and causes an over/underflow.

Over/underflows occurrences are monitored and stability is expected. As long as they remain to low levels, the coding table is not changed. Note that changing the coding tables requires compromises. Indeed, increasing the encoding capacity can be achieved by two different ways. A first solution consists in an increase of the coding step without changing the number of bits. However, that leads to an increase of the digitalization noise. Then, a second solution consists in keeping the coding step constant while increasing the number of bits available for a particular band. But, the total amount of bits available for the entire spectrum is limited and constant. So, that requires to decrease the encoding capacity in another spectral band.

Time series of Overflows and Underflows (orbit average) are shown in following figure for all pixels.

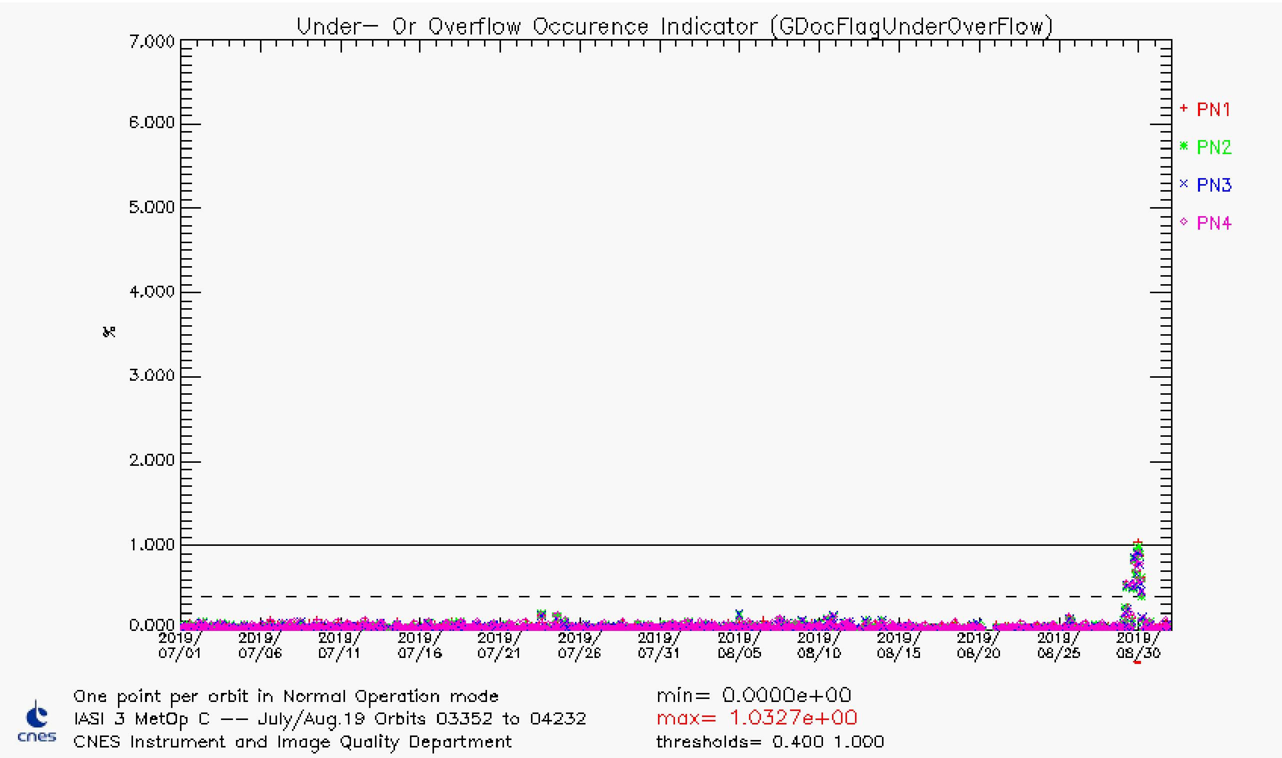


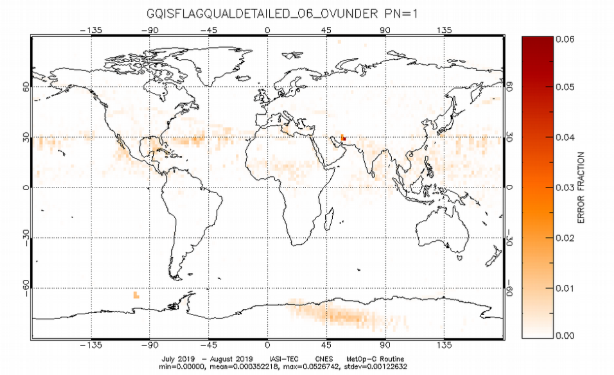
Figure 8 : IASI L0 over/under-flows orbit average of all pixels

Over/underflows ratio is nominal for the reported period.

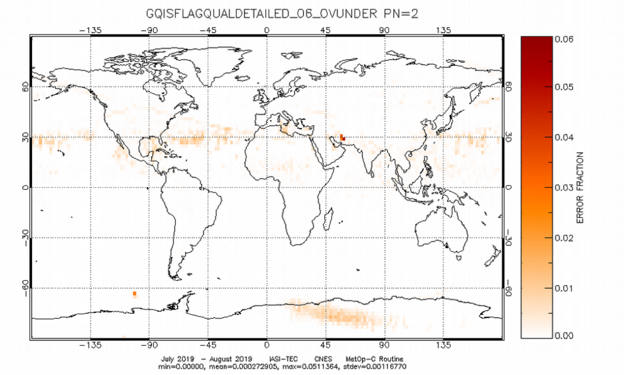
Note: the peak observed on the figure is due to high stratospheric temperature. This phenomenon is related to the polar vortex collapse (rapid increase of the temperature in the stratosphere). When it happens over Antarctica, it is known as the Sudden Stratospheric Warming (SSW). The consequence for IASI system is that the on-board coding tables are not able to encode this type of exceptional event around 2350-2400 cm^{-1} (CO_2 band).

The geographical distribution of the Overflows and Underflows for the 4 pixels shown in Figure 9 clearly indicates the polar vortex collapse.

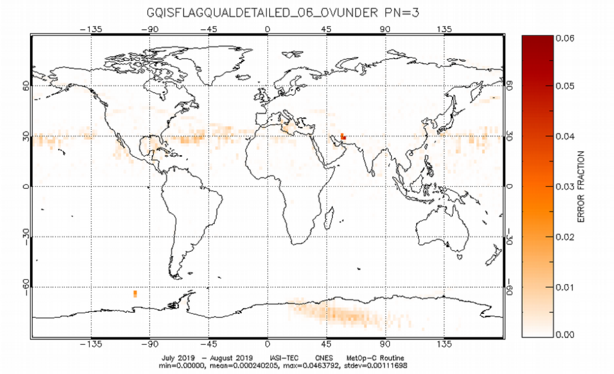
PN1



PN2



PN3



PN4

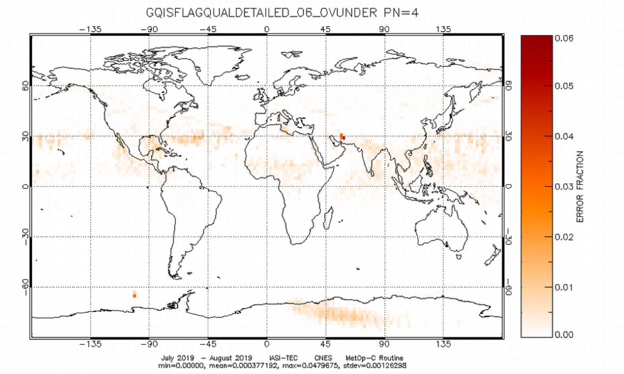


Figure 9 : IASI Overflows and Underflows spatial distribution (per pixel)

4.3.2.4 Reduced Spectra monitoring

On-board Reduced Spectra is one of the most important parameter to monitor. It ensures that on-board spectra still have a good radiometric calibration when on-board configuration reduced spectra are reloaded. This is the case, for instance, after an instrument mode change.

Reduced spectra are slightly evolving with respect to potential deformation of the interferometer (optical bench).

In order to prevent from a large difference between current and on-board configuration reduced spectra, we apply the DPS processing on the verification interferograms using the reduced spectra from the on-board configuration (TOP) instead of the filtered reduced spectra computed on-board with the current calibration views. These reduced spectra from the on-board configuration are used as initialisation each time there is mode change. If they are too far from the reality, no spectra can be computed on-board after a mode change. We monitor the evolution of ZPD determination quality index for calibration views (BZpdNzpdQualIndexBB and CS) obtained by this DPS processing at TEC, results of this monitoring are given hereafter.

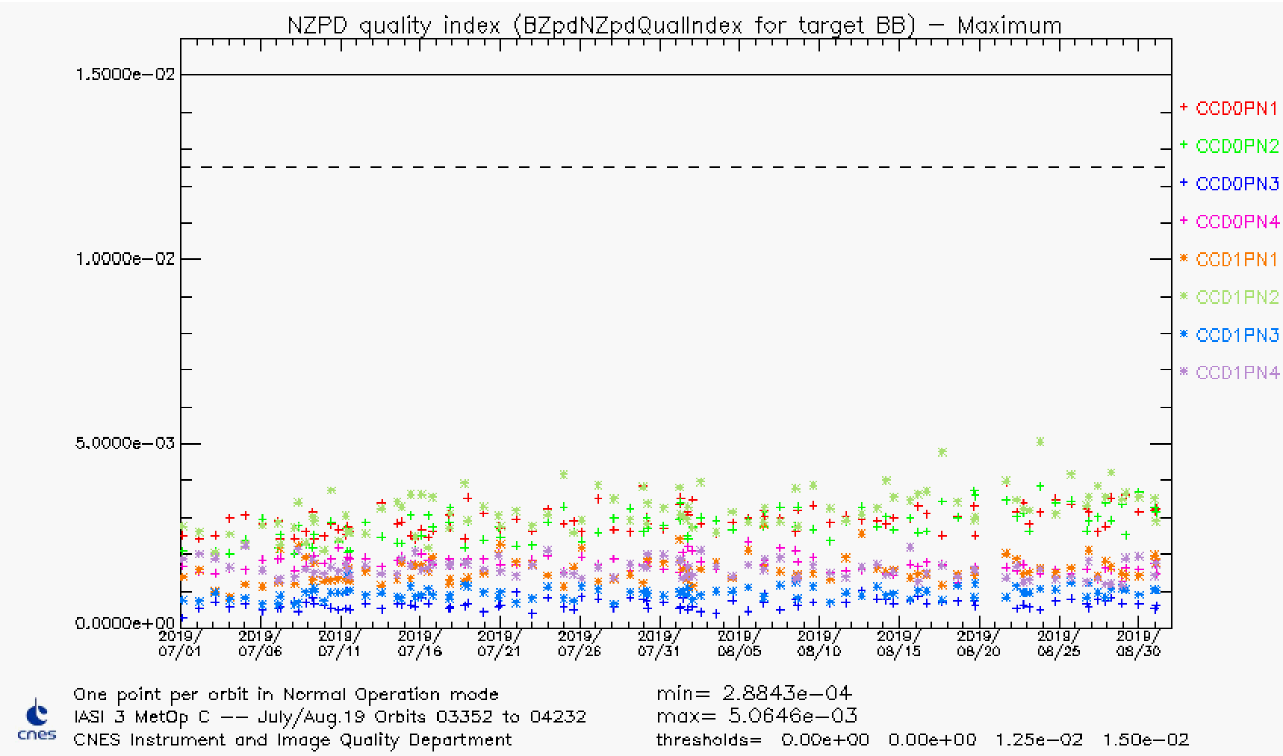


Figure 10 : Max of NZPD quality index for all pixels and CCD - BB

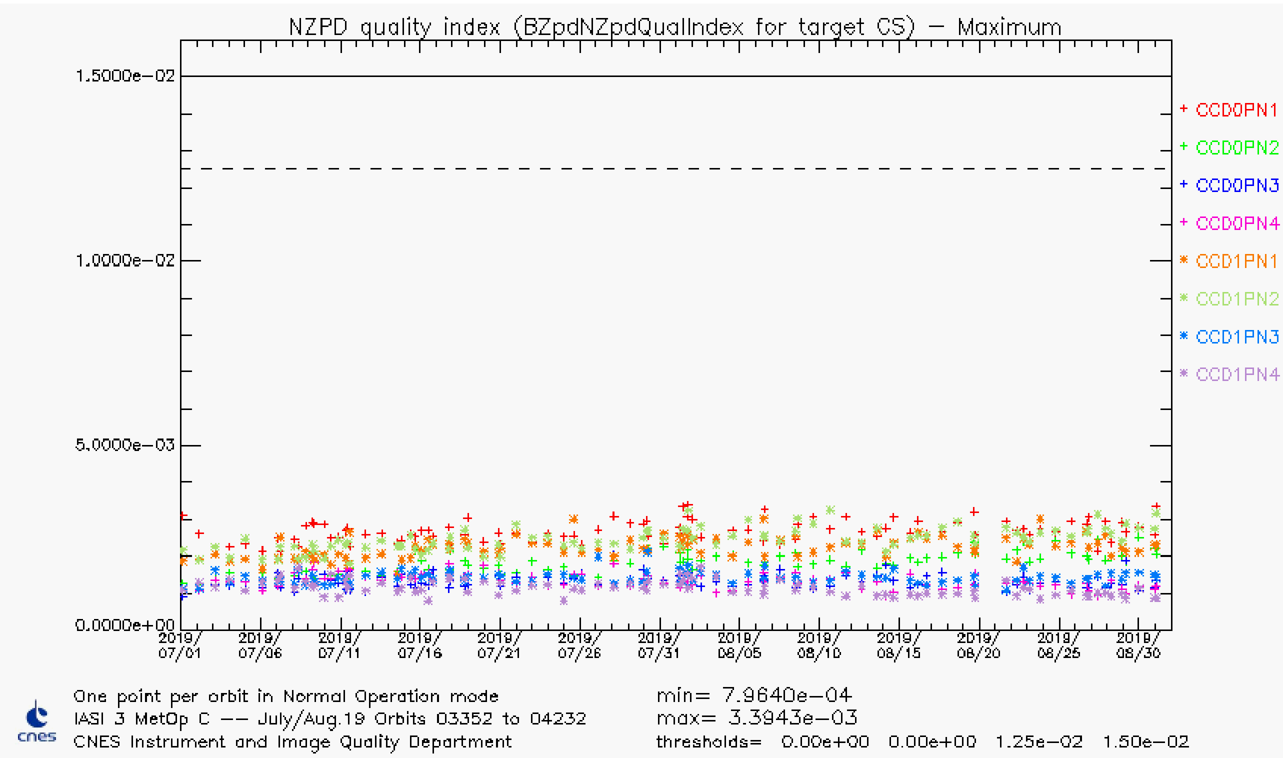
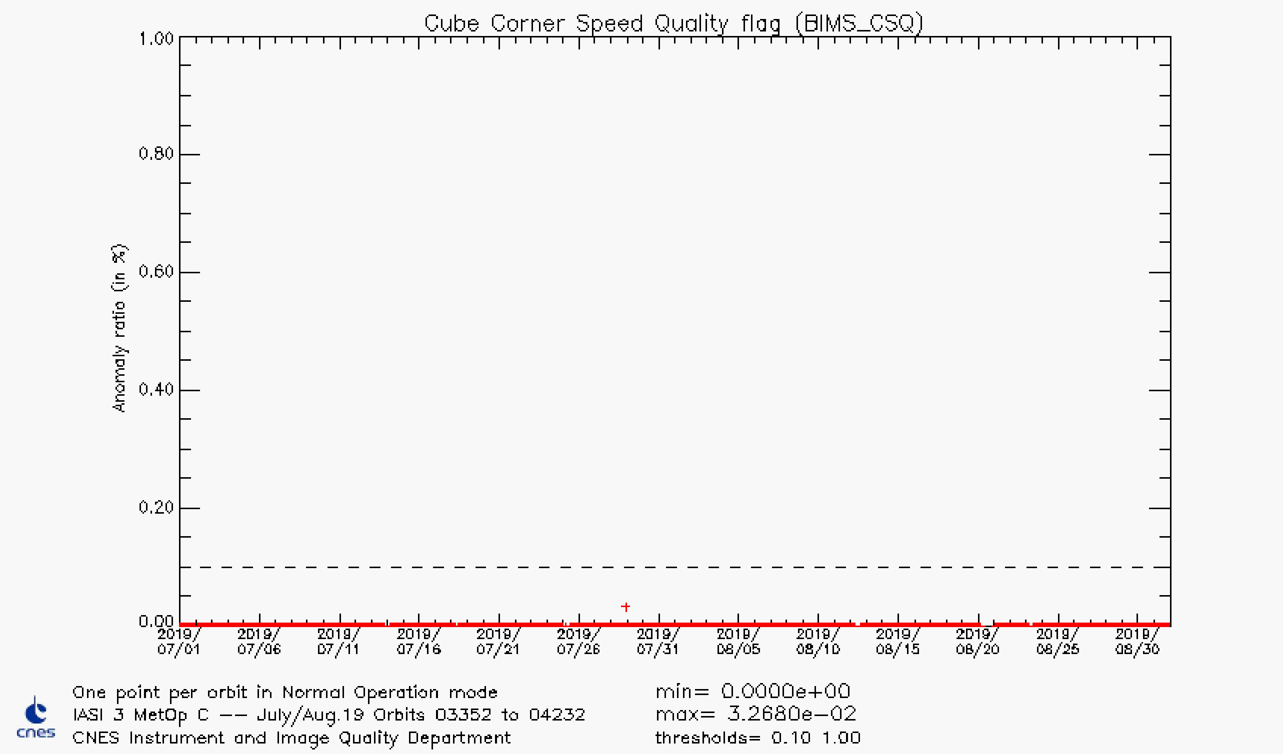


Figure 11 : Max of NZPD quality index for all pixels and CCD - CS

As soon as BZPDNZPDQualIndexBB and CS remain below 0.02 on-board reduced spectra are robust to an instrument mode change. The reduced spectra quality is well within specification since the last update of the on-board reduced spectra performed in March 2019.

4.3.2.5 Cube corner Speed Quality (CSQ) monitoring

From verification products (BB & CS):



From engineering products (EW):

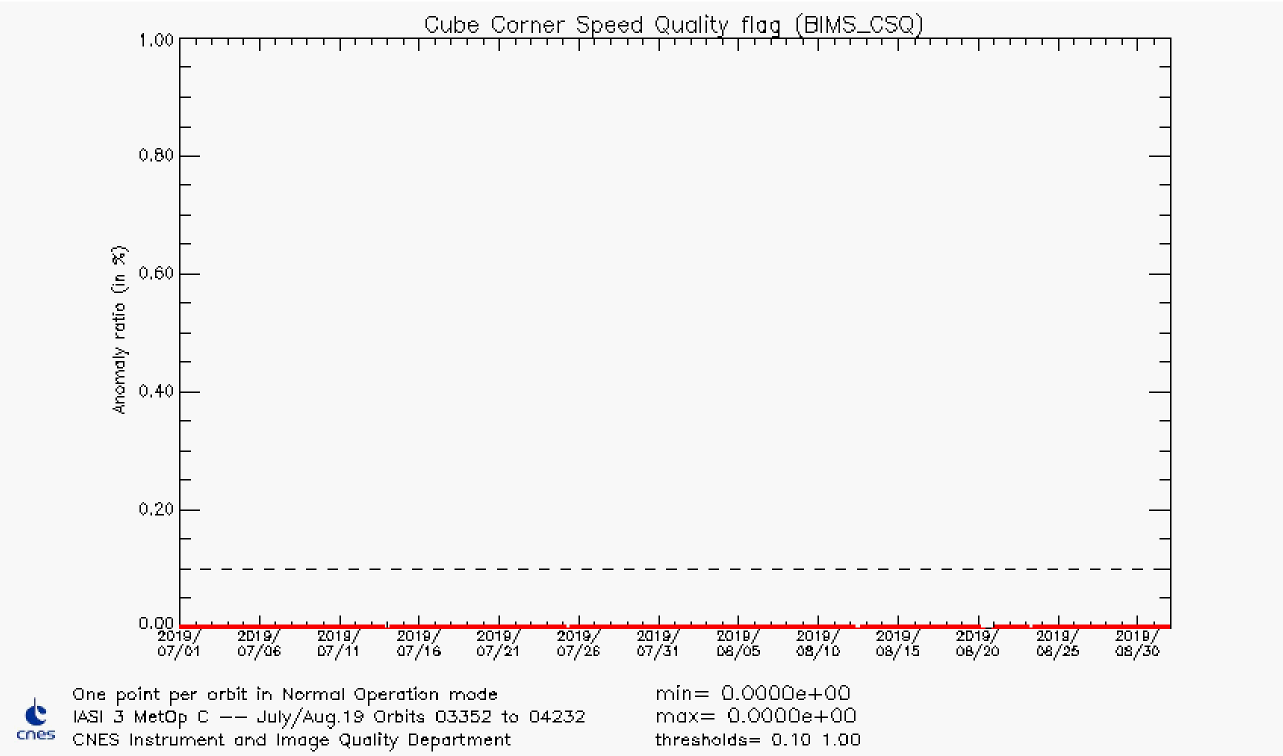


Figure 12 : Number of CSQ

Only 1 CSQ occurred during the period, not visible on the graph due to the very small proportion of data that 1 event represents.

4.3.3 Second level flags and quality indicators

All second level flags and indicators are stable and nominal.

4.3.4 Conclusion

L0 Flag and quality indicators are stable.

4.4 LEVEL 1 DATA QUALITY (L1)

4.4.1 Overall quality

The IASI overall quality is shown as the orbit averages of the quality indicator for the individual pixels in the next figure.

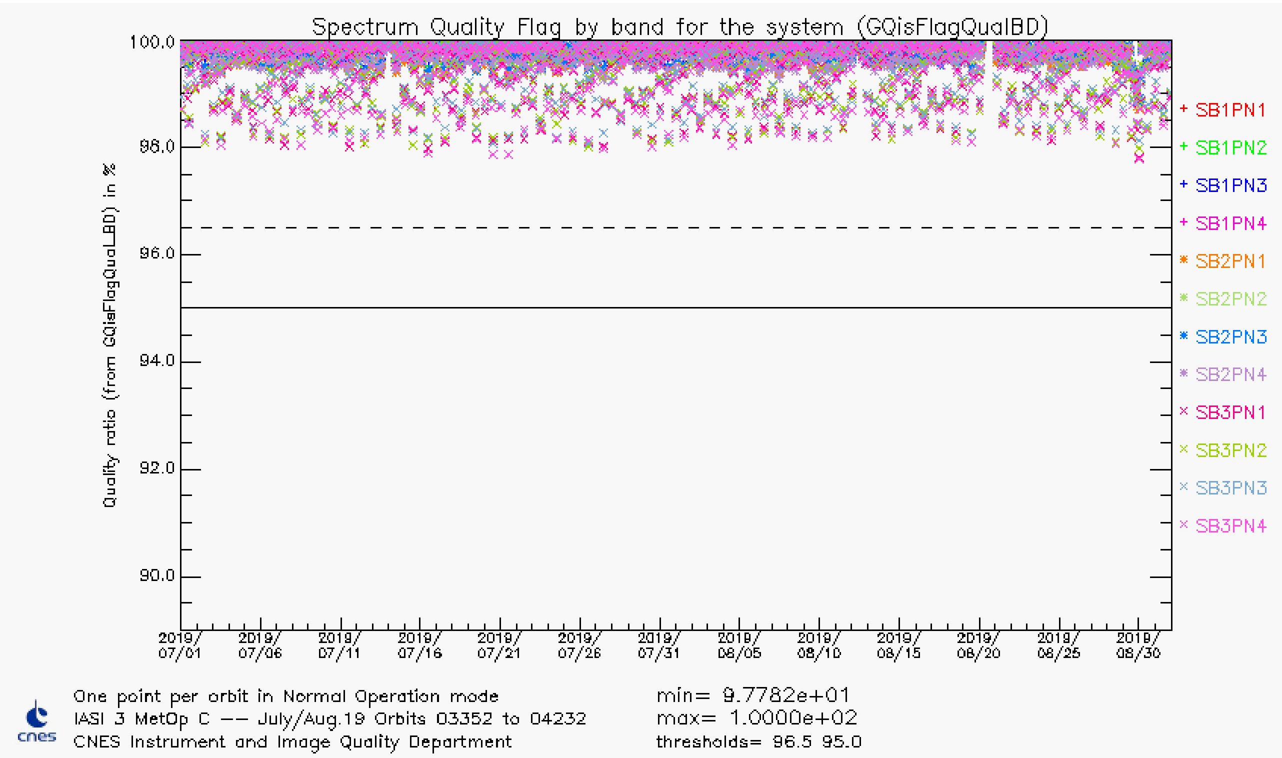


Figure 13 : IASI L1 data quality orbit average (% of good by PN and SB)

One should note that, over the period covered by the present document, the averaged data rejection ratio is less than 1%.We clearly see that data quality is better on the bands B1 and B2 in comparison to band B3 (which is the most affected by spikes).

The geographical distribution of the IASI product overall quality for the 4 pixels is shown in Figure 14.

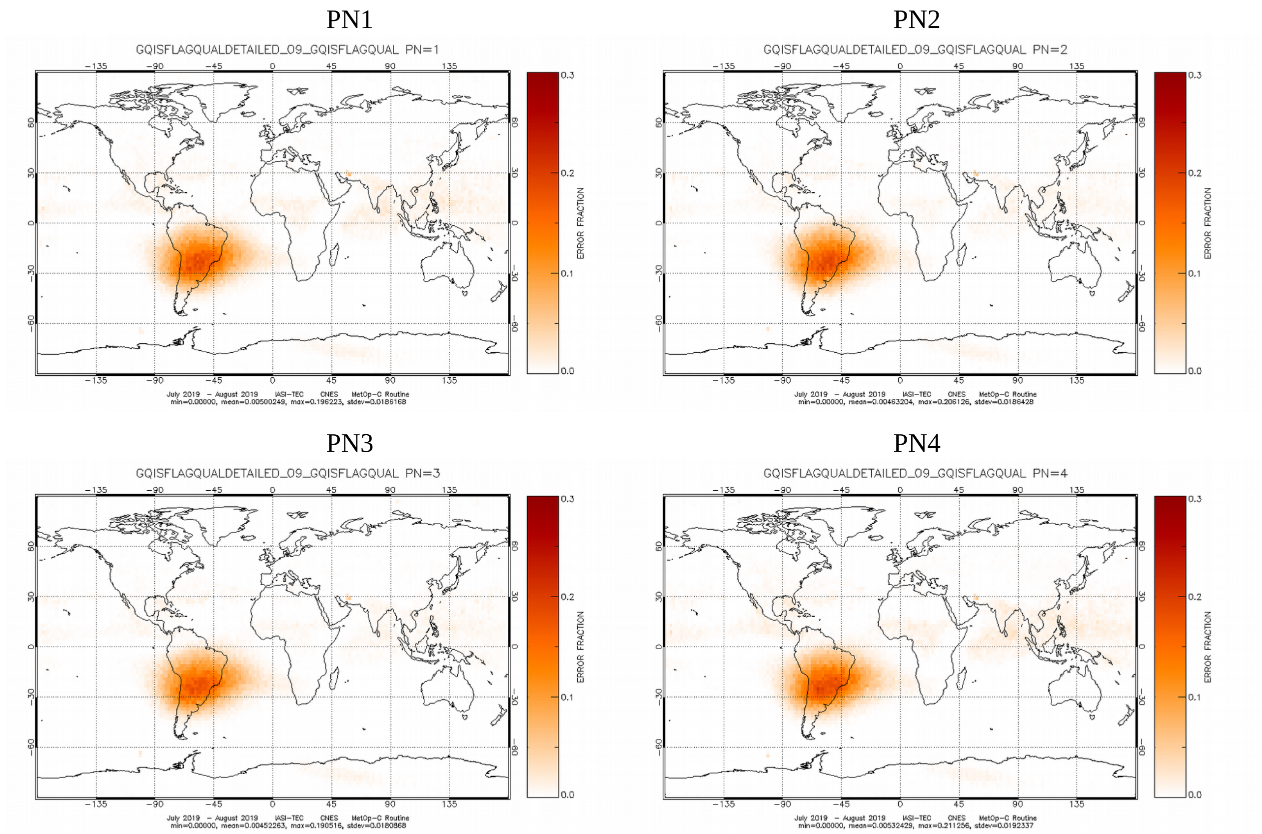


Figure 14 : IASI product overall quality spatial distribution (per pixel)

The main contributors are the spikes (mainly in band 3, which is the band the most sensitive to the spikes).

4.4.2 Main flag and quality indicator parameters

All the quality indexes that follow are general L1 quality indexes of sounder products.

GQisQualIndex – average – is the average general quality index of the sounder products.

GQisQualIndexIIS is the IASI integrated imager (IIS) images quality index.

GQisQualIndexSpect is the spectral quality index of the sounder products.

GQisQualIndexRad is the radiometric quality index of the sounder products.

GqisQualIndexLoc is the ground localisation quality index of the sounder products.

MDptPixQual is a quality index for IASI integrated imager (IIS) that represents a fraction of not dead pixels.

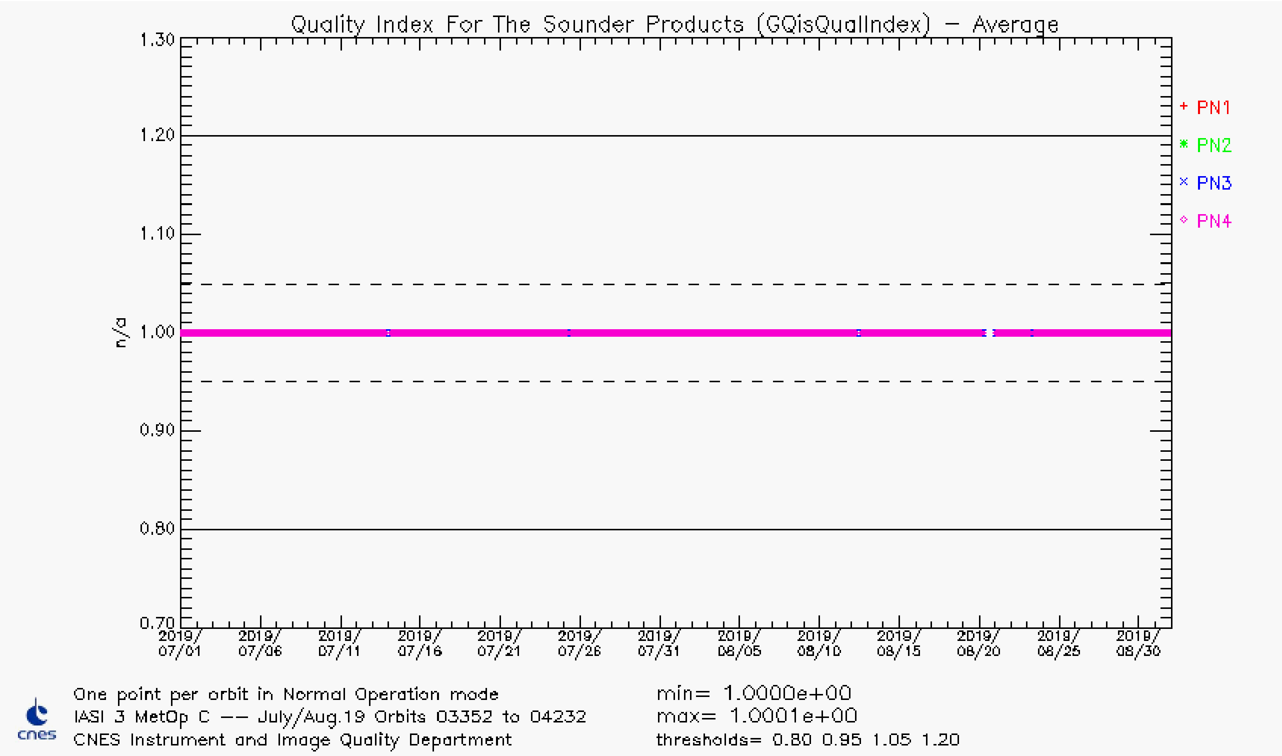


Figure 15 : GQisQualIndex average (L1 data quality index for IASI sounder)

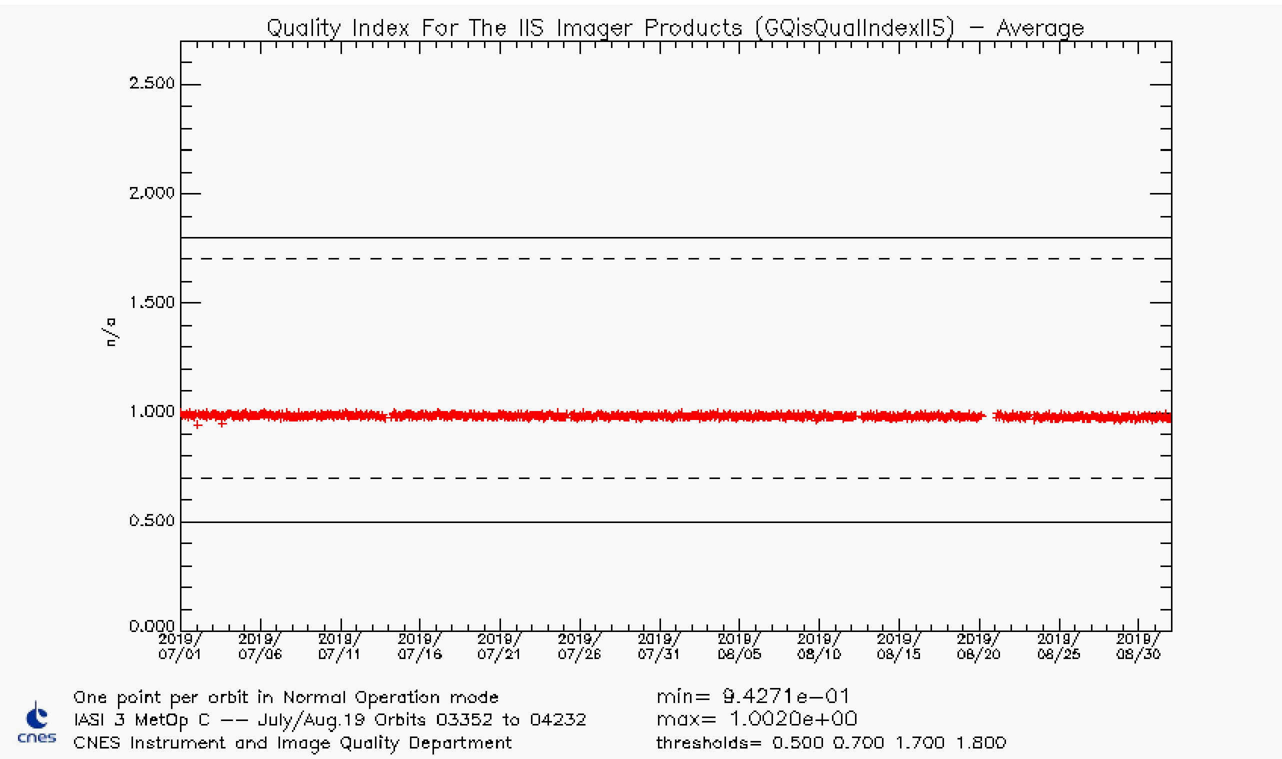


Figure 16 : GQisQualIndexIIS average (L1 data quality index for IASI Integrated Imager)

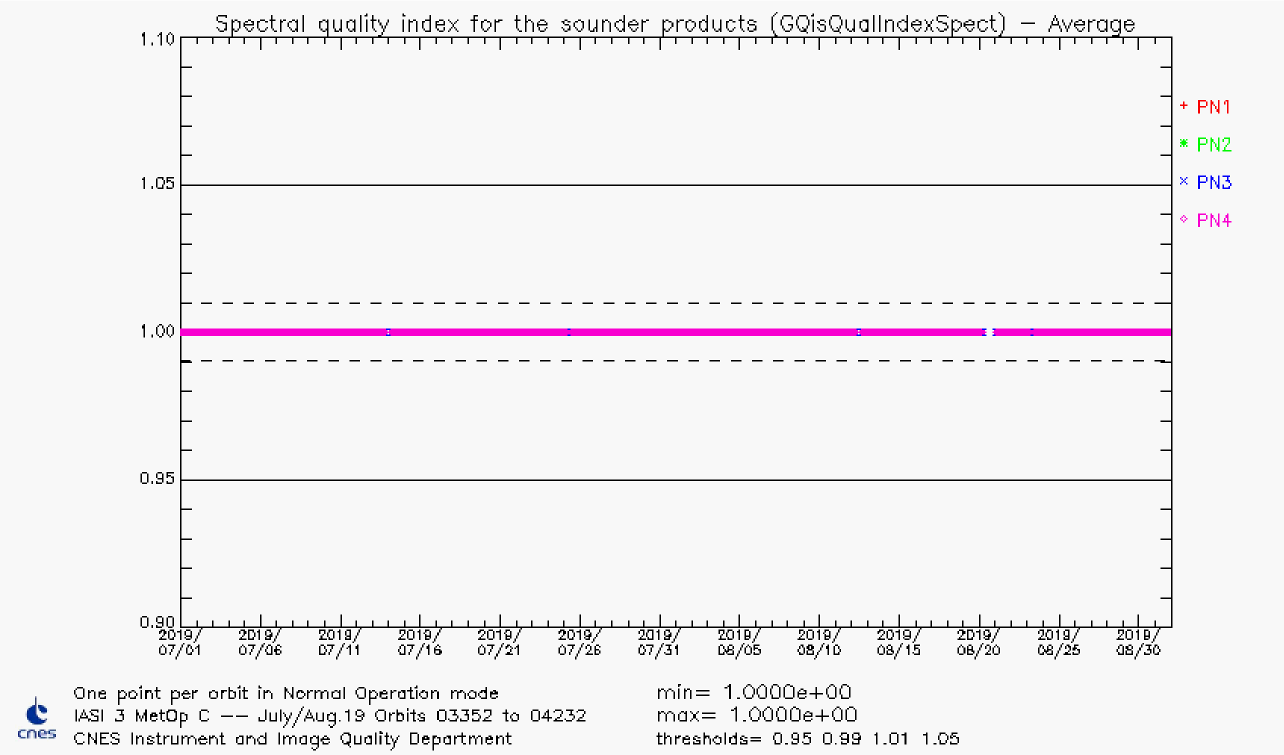


Figure 17 : GQisQualIndexSpect average (L1 data index for spectral calibration quality)

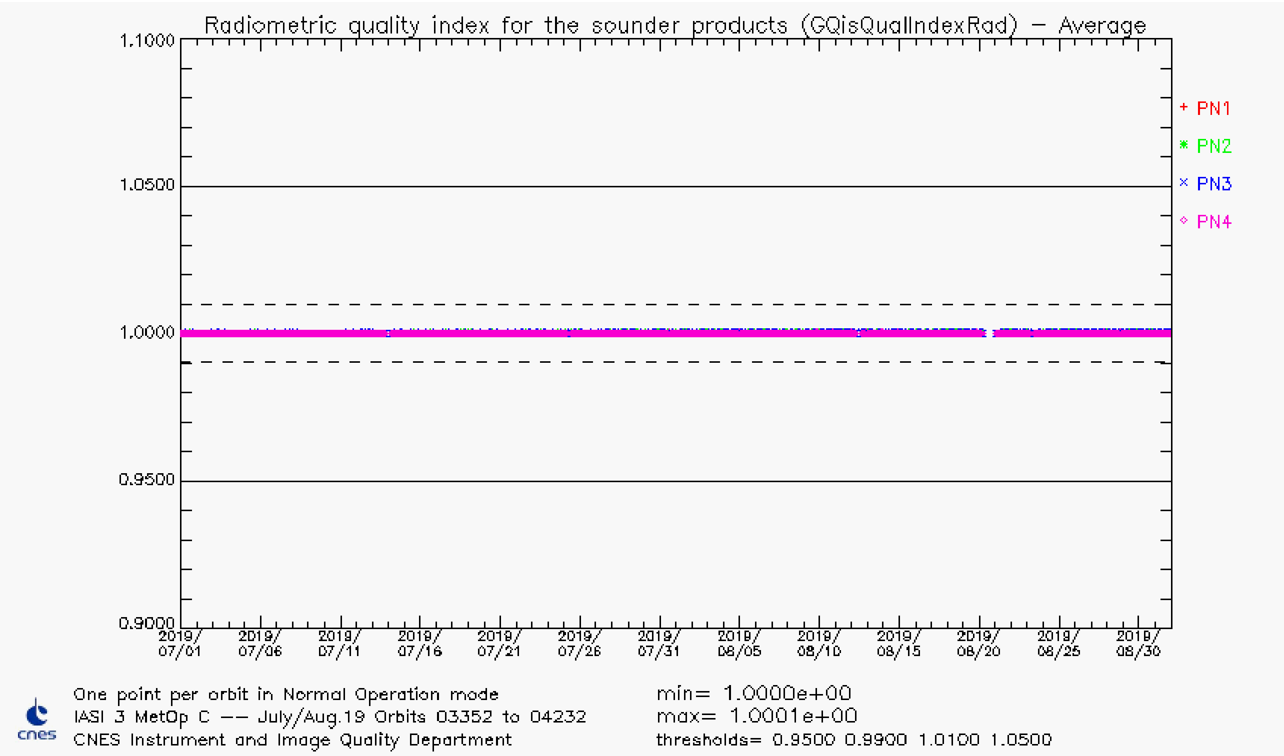


Figure 18 : GQisQualIndexRad average (L1 data index for radiometric calibration quality)

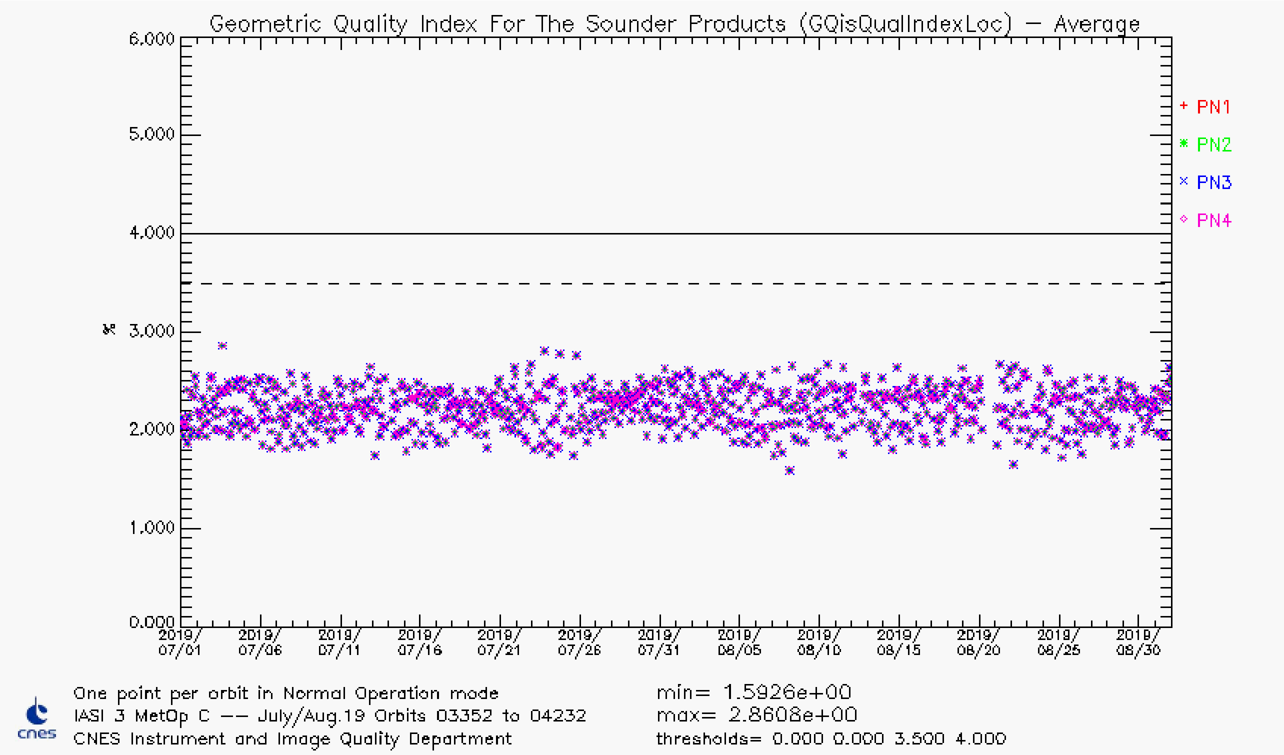


Figure 19 : GQisQualIndexLoc average (L1 data index for ground localisation quality)

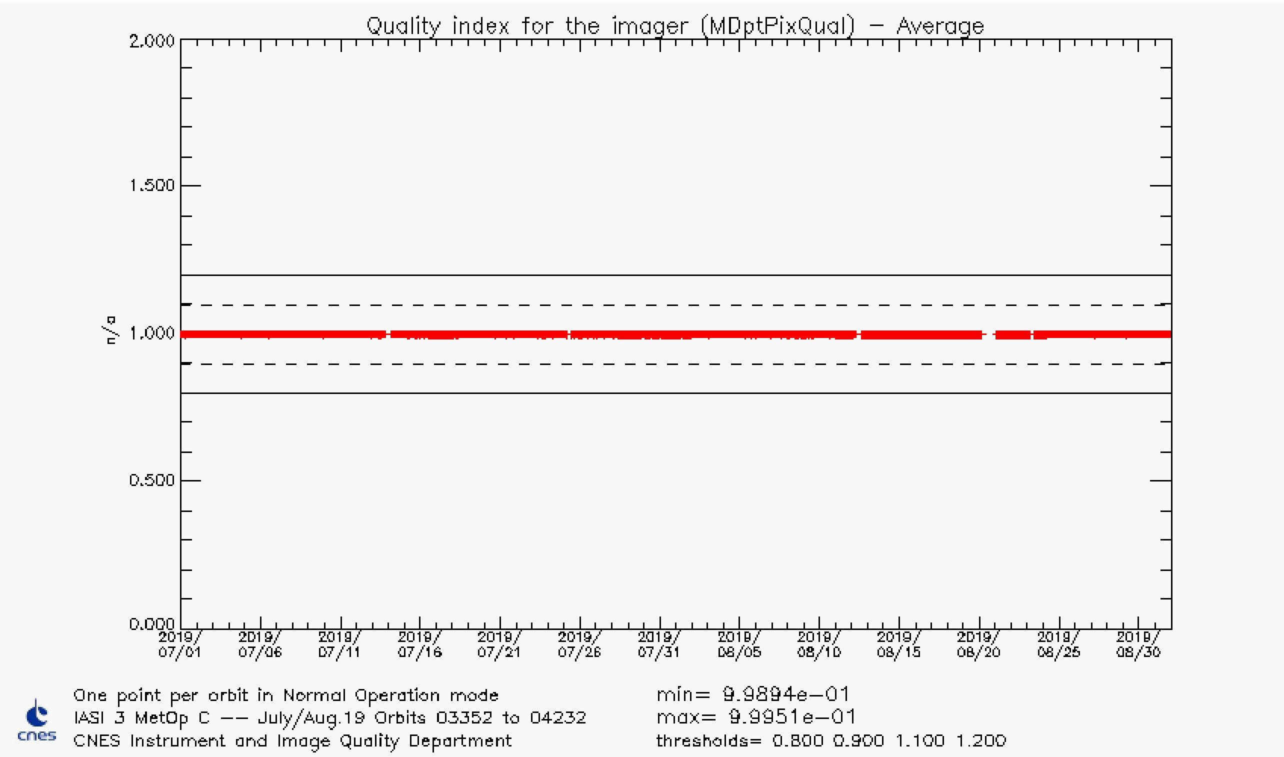


Figure 20 : MDptPixQual average (L1 quality index for IASI integrated imager, fraction of not dead pixels)

4.4.3 Conclusion

L1 Flag and quality indicators are stable and meet the specifications.

4.5 SOUNDER RADIOMETRIC PERFORMANCES

4.5.1 Radiometric Noise

Monitoring the radiometric noise allows to monitor the long term degradation of the instrument as well as to look for punctual anomaly of IASI or other component of METOP.

Monthly L0 noise estimation (CE)

This monthly estimation is performed during routine External Calibration on BB views.

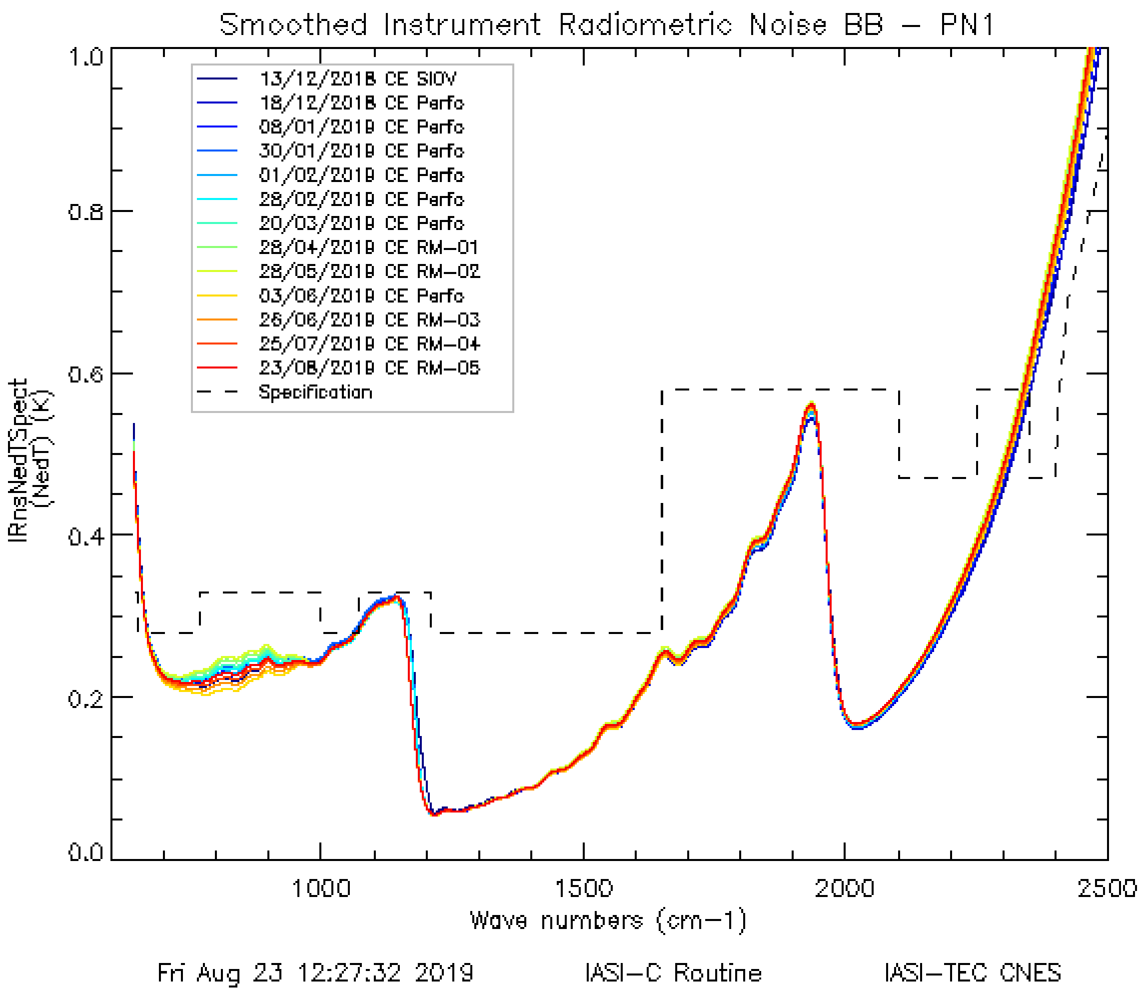


Figure 21 : Instrument noise evolution between start and end of the period

The instrument noise has decreased after the decontamination performed in June 2019, especially between 700 and 1000 cm^{-1}. This point will be developed in section 4.5.4.1.

4.5.2 Radiometric Calibration

The radiometric calibration allows to convert an instrumental measurement into a physical value. The radiometric calibration is used to convert an interferogram into an absolute energy flux by taking into account instrument discrepancies. Even if the calibration has been studied on ground, it has to be continuously monitored in-flight in order to follow any potential degradation of the instrument (optics, detectors …).

Approach: Radiometric fine characterization has been done during on-ground testing and Cal/Val. All parameters likely to cause a failure in radiometric calibration process have been identified and are continuously monitored. As long as they remain stable, there is no problem with radiometric calibration.

Evolution of scanning mirror reflectivity

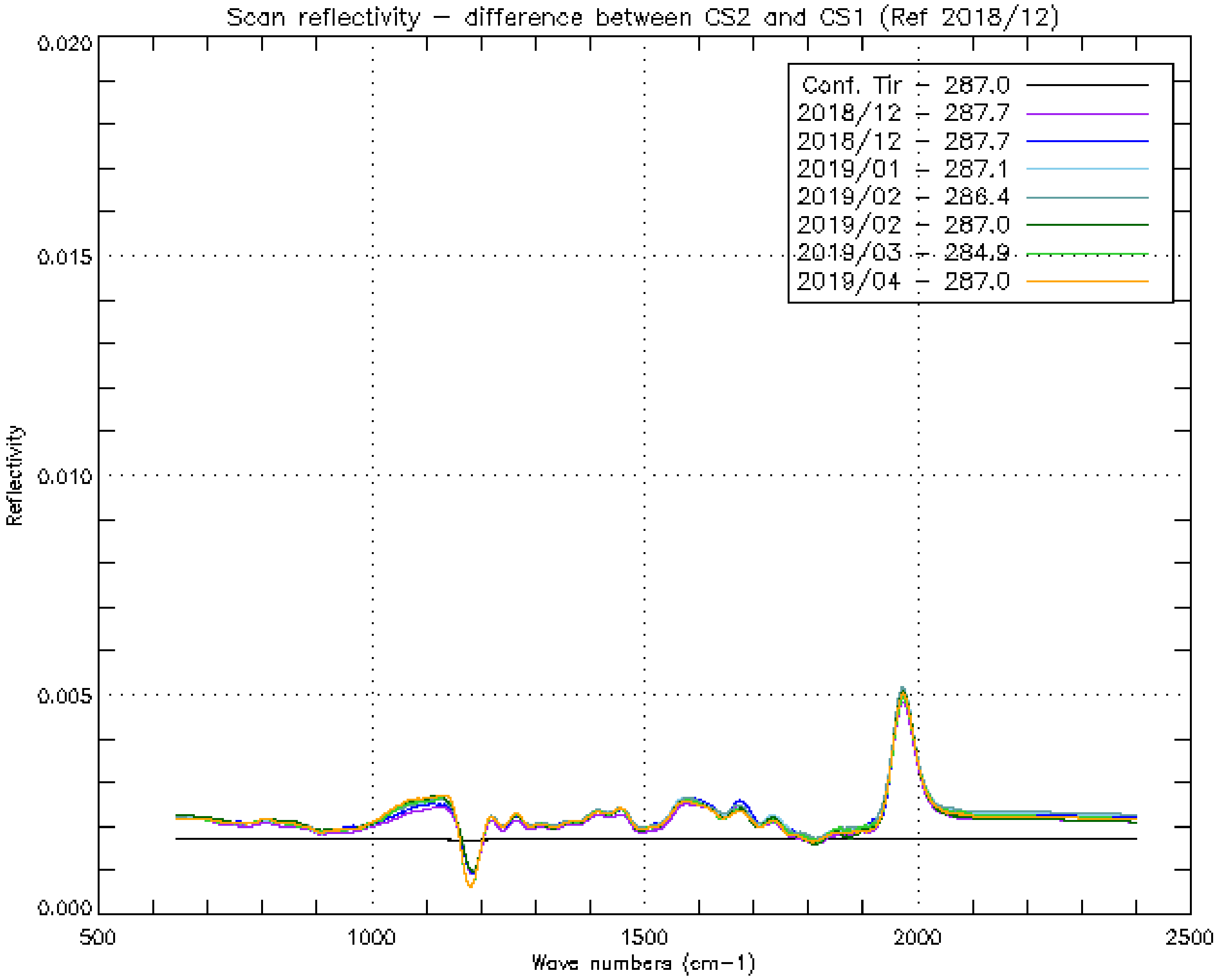


Figure 22 : Scan mirror reflectivity evolution

The reference reflexivity (in black) is the one computed on external calibration data from January 8th 2019. We see a slight evolution within [1000-1100 cm^{-1}] band. Values for wavenumbers greater than 2400 cm^{-1} are not significant because of instrument noise.

The next figure shows the translation of scan mirror reflectivity in terms of maximum radiometric calibration error for different scene temperatures.

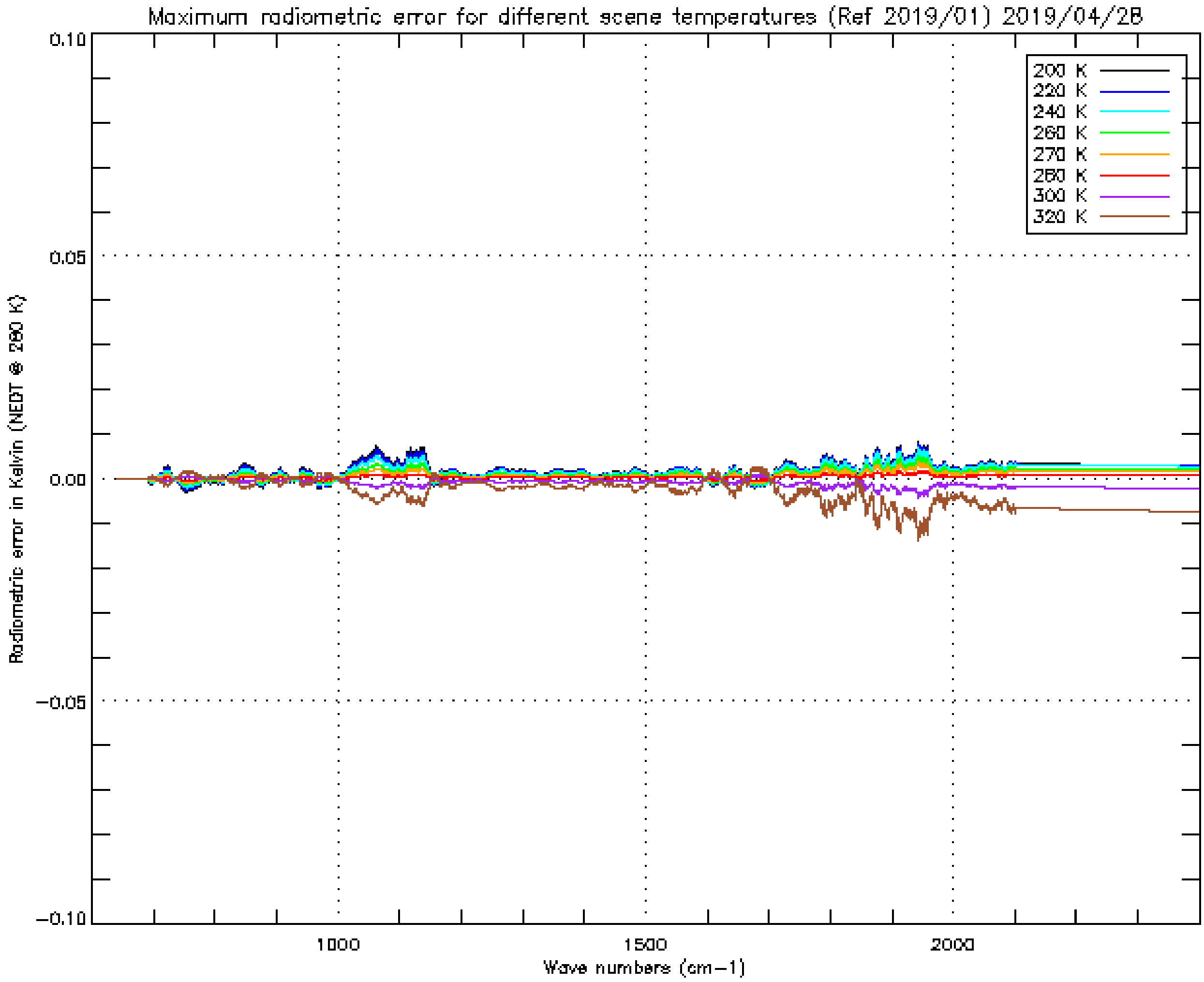


Figure 23 : Radiometric calibration error due to scan mirror reflectivity dependency with viewing angle Maximum effect on SN1 for different scene temperature. Done with the period February 19 / April 19

In any cases radiometric calibration maximum error is lower than the specification (0.1K). The scan mirror reflectivity law (on ground configuration), prepared with January 8th routine External Calibration data, has been updated in the operational ground segment on February 1st 2019.

Remark: The last monitoring was done with April 28th external calibration data. Since May, on-board cold space coding tables are optimized for Moon acquisition and make scan mirror reflectivity monitoring no more feasible. These coding tables will be changed again to the nominal ones at least at the end of the year to perform a new verification of scan mirror reflectivity evolution.

Internal black body

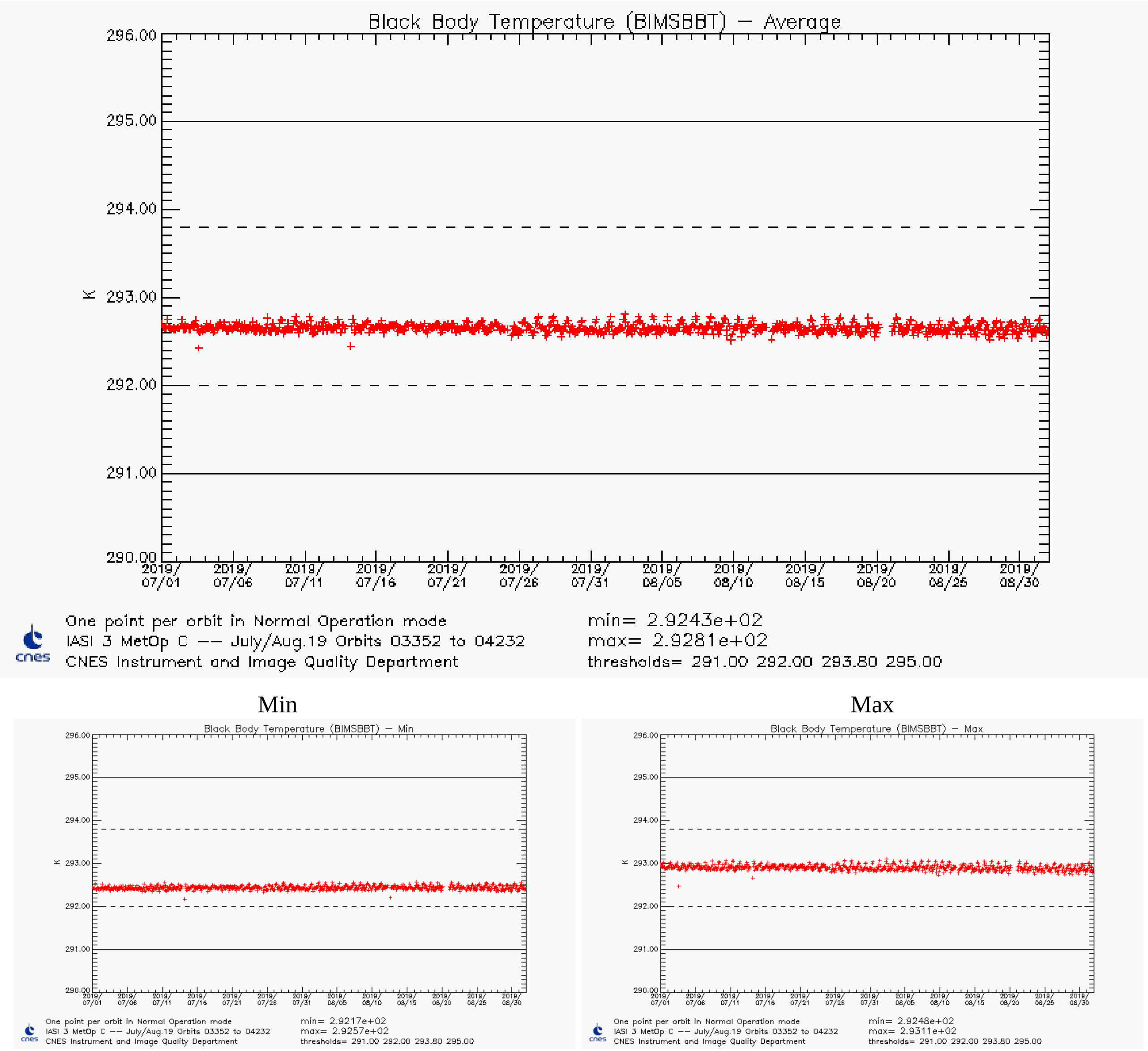


Figure 24 : Black Body Temperature

The black body temperature is stable.

<u>*Non linearity of the detection chains*</u>

Non-linearity tables of the detection chains are still nominal as long as sounder focal plane temperature variation amplitude is lower than 1K.

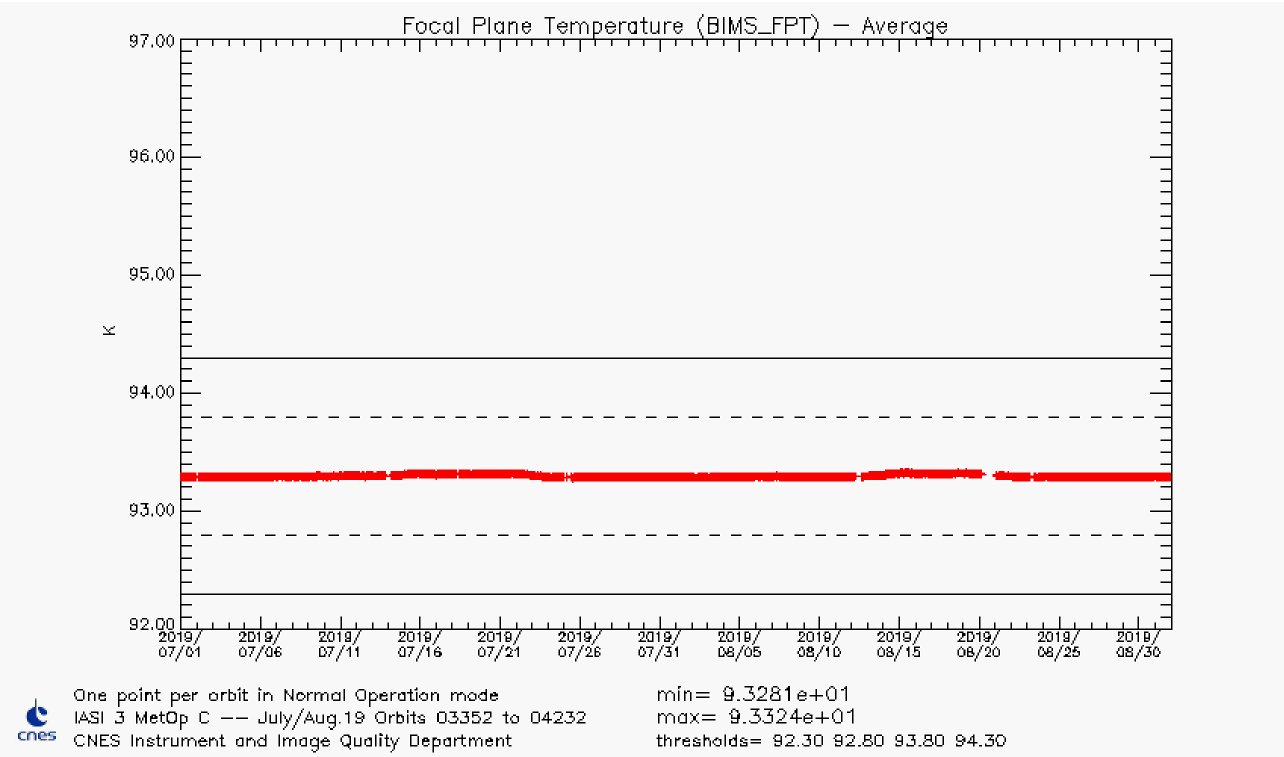
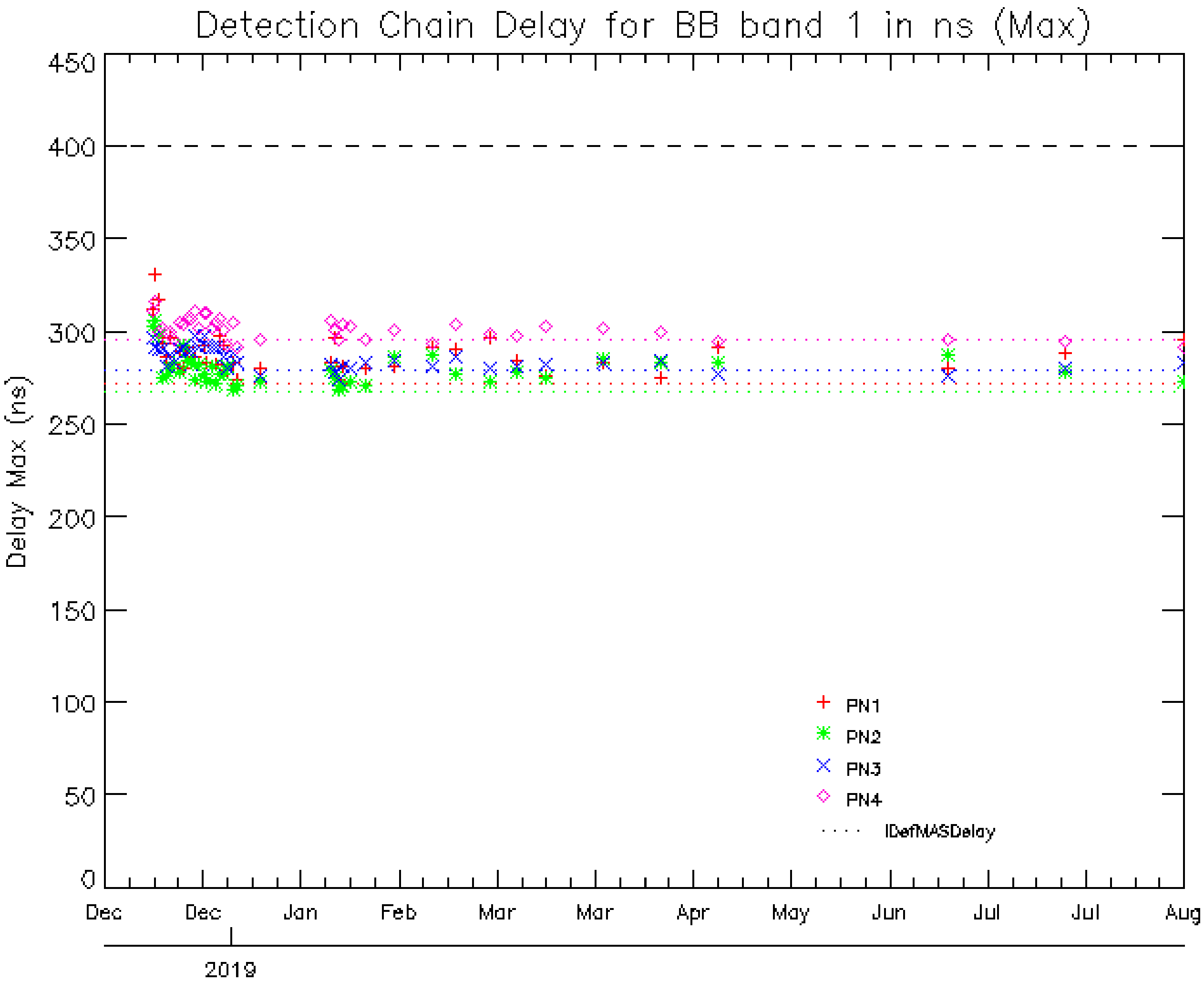


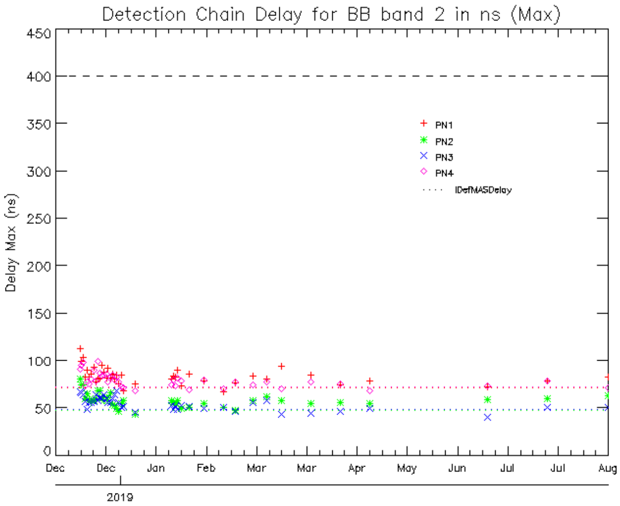
Figure 25 : Focal Plane Temperature

4.5.3 Delay of Detection Chains

Long term stability and values lower than 400 ns are required in order to properly take into account cube corner velocity fluctuations.



SB2



SB3

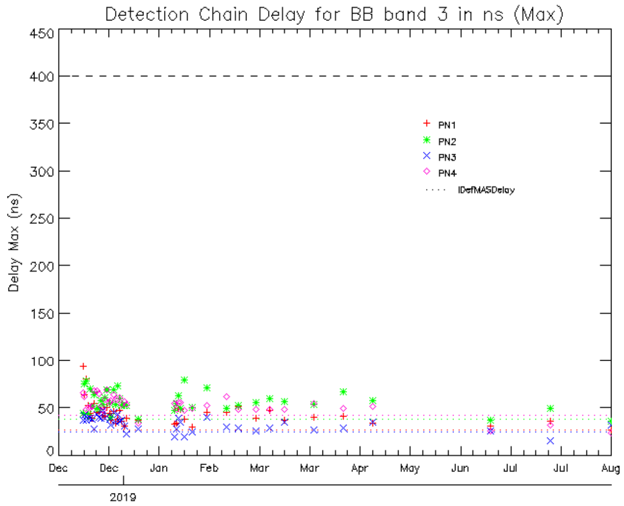


Figure 26 : Monitoring of detection chain maximum delays for all bands

4.5.4 Optical Transmission

4.5.4.1 Ice

The IASI interferometer and optical bench are regulated at 20°C temperature, while the cold box containing cold optics and detection subsystem is at about -180°C. Water desorption from the instrument causes ice formation on the field lens at the entrance of IASI cold box. This desorption phenomenon is particularly important at the beginning of the instrument in-orbit life. That's why one of the very first activities of IASI in-orbit commissioning was an outgasing phase consisting in heating the cold box up to 300 K during 21 days (from November 12th until December 3rd 2018). This operation allows removing most of the initial contaminants coming from IASI and other MetOp instruments. A routine outgasing is then needed from time to time to remove ice contamination, but less and less frequently as the desorption process becomes slower.

The first routine outgassing procedure (shorter duration and at 200K) was done from May 27th to June 3rd 2019.

The maximum acceptable degradation of transmission is about 20% loss at 850 cm^{-1} (which corresponds to an ice deposit thickness of about 0.5 µm).

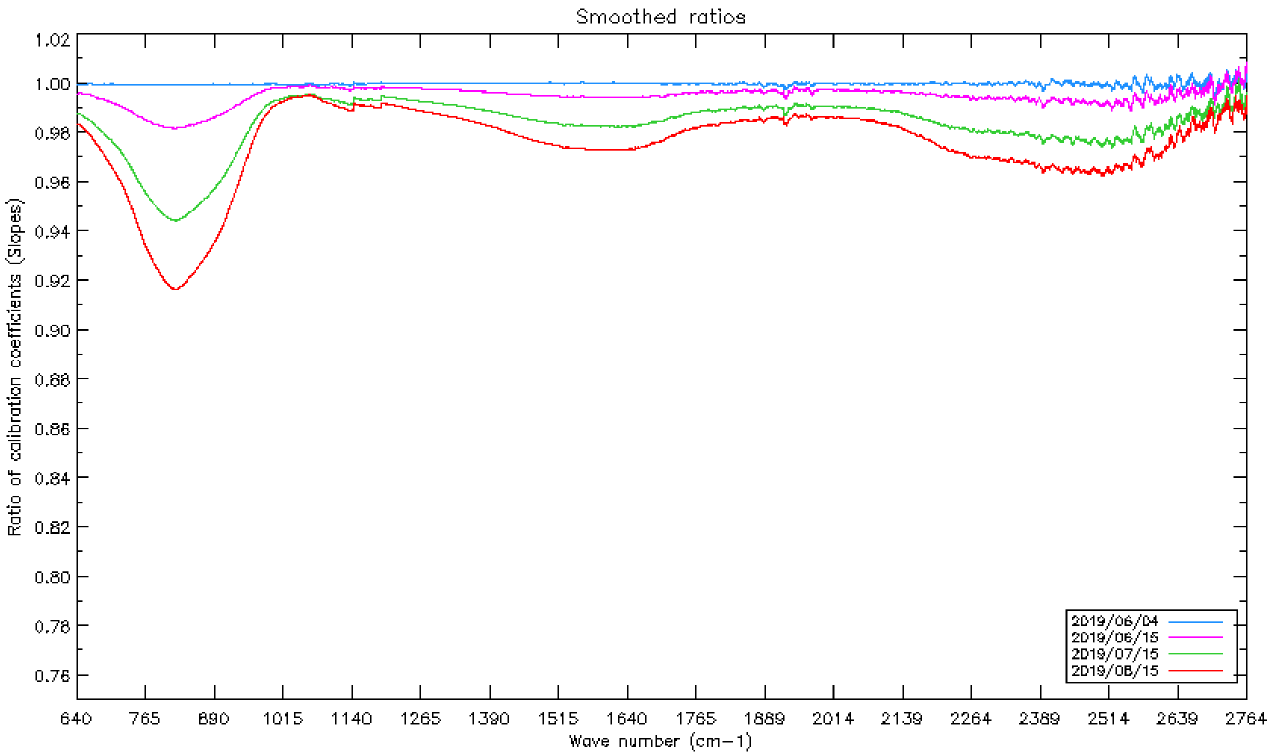


Figure 27 : Ratio of calibration coefficient slopes as a function of wave number and time after the last decontamination

4.5.4.2 Prediction of decontamination date

The transmission degradation rate is regularly monitored by CNES TEC through gain measurements given by calibration coefficients ratios.

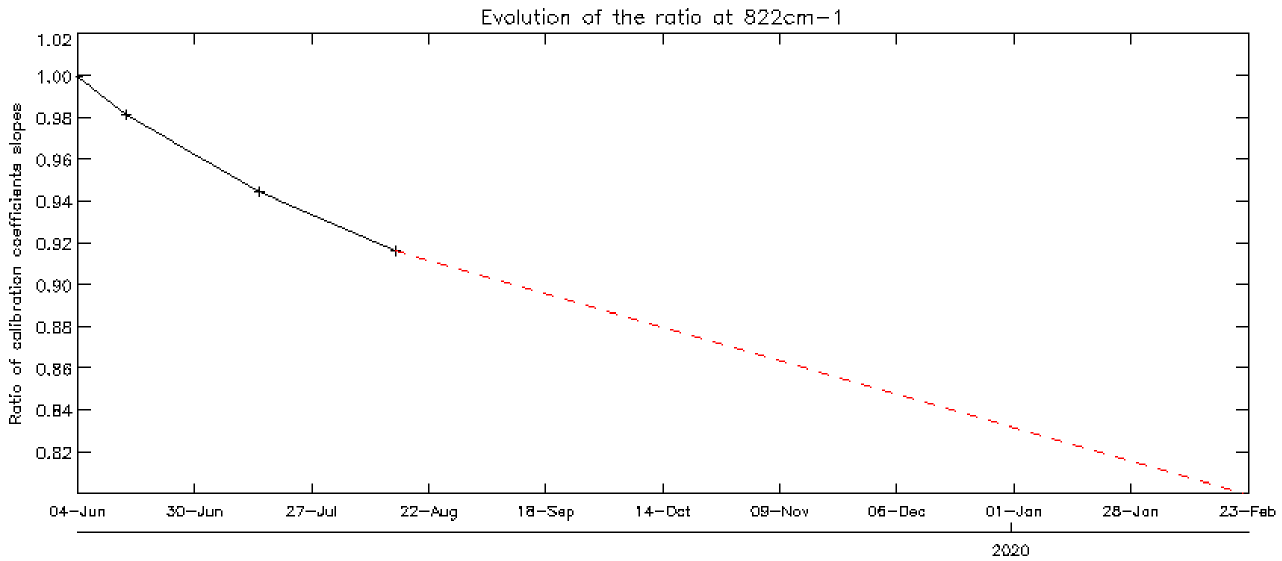
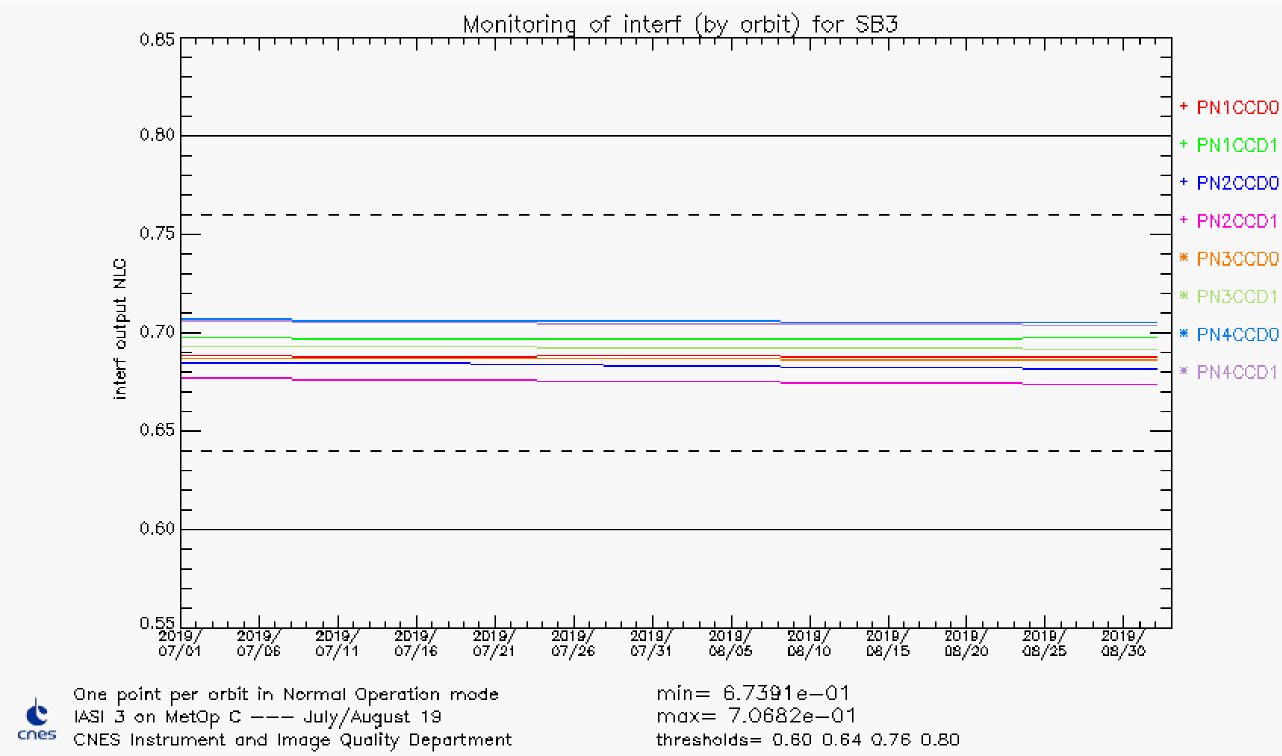


Figure 28 : Temporal evolution of calibration ratio coefficient slopes since the last decontamination. The curve was fitted with a decreasing exponential function to determine a rough date for the next decontamination (relative gain evolution of 0.8)

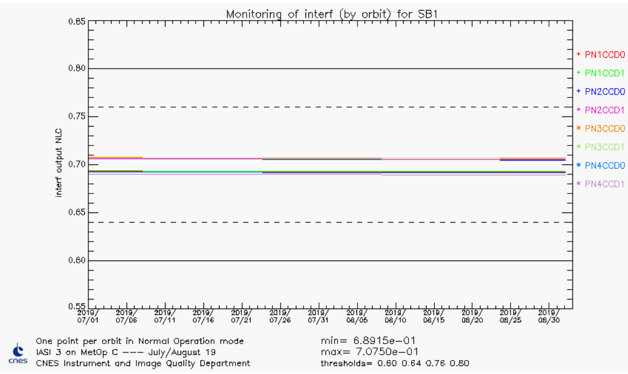
The loss of instrument gain due to ice contamination is, as expected, decreasing over time.
The next decontamination is not expected before beginning of 2020.

4.5.5 Interferometric Contrast

The interferometric contrast is defined as the interferogram fringe discrimination power. Figure 29 shows temporal evolution of instrument contrast since the beginning of IASI life in orbit for all pixels and all CCD.



SB1



SB2

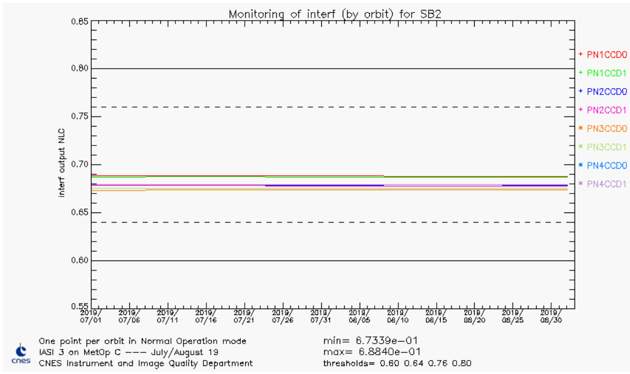


Figure 29 : Contrast Monitoring

4.5.6 Interferogram Baseline

The interferogram baseline is the mean value of the interferogram. Figure 30 shows temporal evolution of the baseline of the raw interferograms on calibration targets (BB and CS). The values are raw values, they are not physical, but the evolution is interesting: as the values are proportional to the energy received from a target and calibration targets are stable, the evolution can show the decrease of instrument transmission or events due to energetic particles.

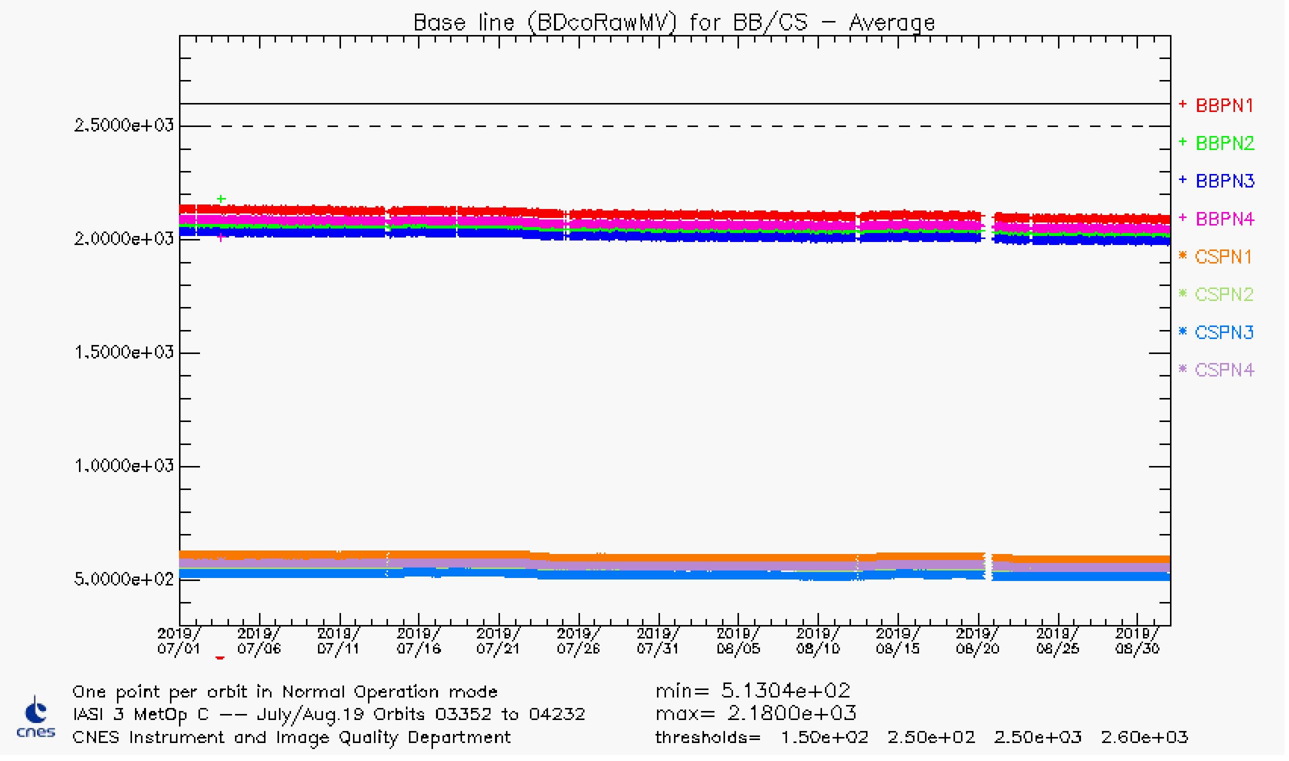


Figure 30 : Monitoring of interferogram baseline

4.5.7 Detection Chain

Detection chains are tuned in gain and offset via telecommand. The goal is to avoid saturation while conserving the maximum dynamic to limit digitalization noise.

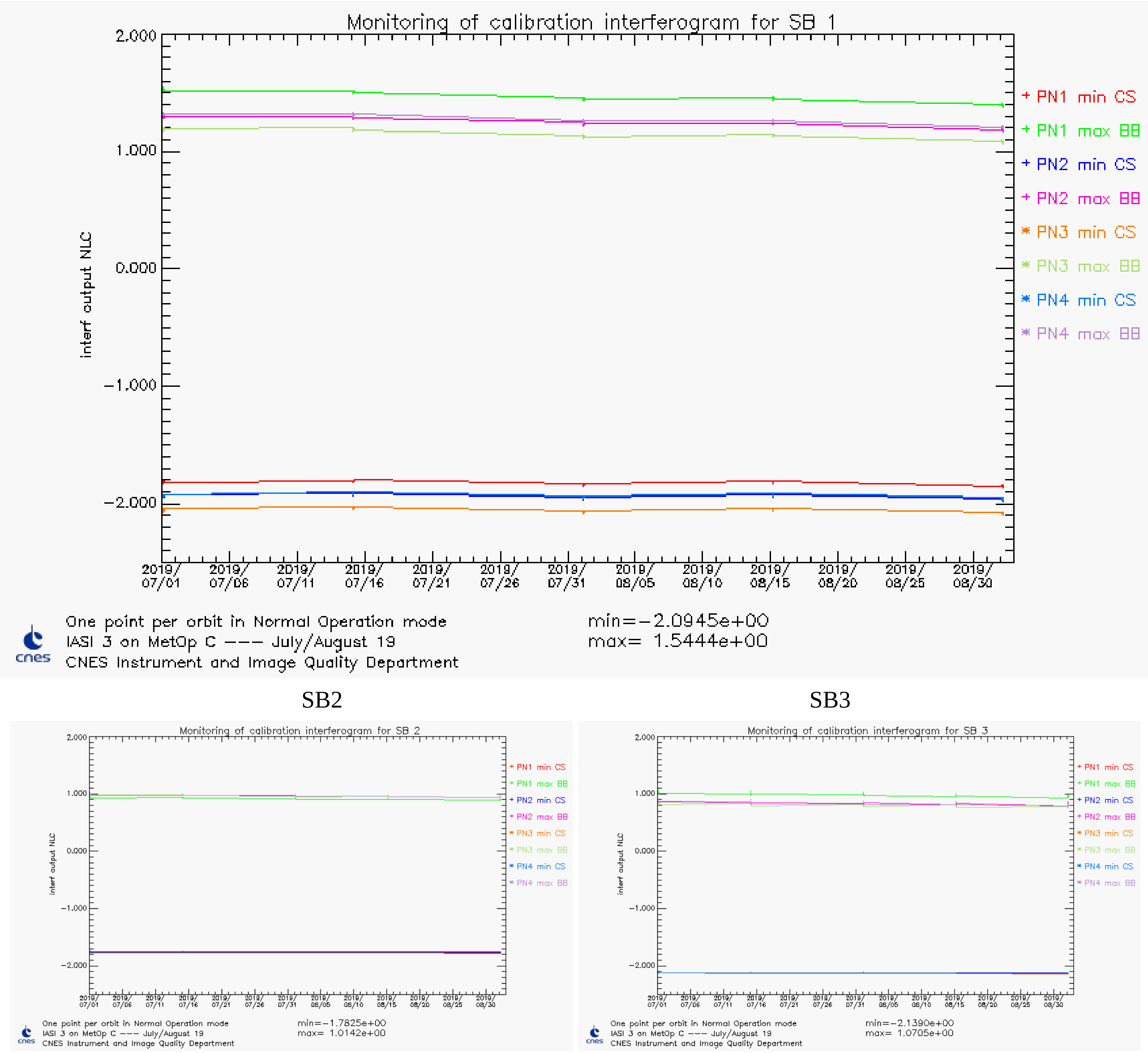


Figure 31 : Monitoring of detection chain margins

Margins are sufficient for the moment. The slight decreasing slope in SB1 (BB) for all pixels is linked to the instrument transmission evolution already mentioned in §4.5.4.1.

4.5.8 Conclusion

The radiometric performances of IASI are nominal and stable. An extrapolation of the current calibration ratio leads to a rough date for the next decontamination at the beginning of 2020. Scan mirror reflectivity was updated in February 2019. The next update is not foreseen before mid 2020.

4.6 SOUNDER SPECTRAL PERFORMANCES

The goal of the spectral calibration is to provide the best estimates of spectral position of the 8461 IASI channels.

The large sensitivity of infrared spectrum to spectral calibration errors has led to stringent specifications:

• A prior knowledge of spectral position better than of 2.10^{-4} (design)

• A posterior maximum spectral calibration relative error of 2.10^{-6} (after calibration by OPS)

In order to reach the specification of 2.10^{-6}, we need an accurate Instrument Spectral Response Function (ISRF) model. This model have been done and validated in the early time of IASI development.

For sake of operational time constrain, complete ISRF calculation is not done in real-time by OPS software but pre-calculated and stored in a database called “spectral database”. OPS processing determine on-line the most relevant instrument function to be used by OPS with respect to current values of a set of parameters (interferometric axis, cube corner offset…).

The approach to monitor IASI spectral performances is very similar to the one used for radiometric calibration. Spectral calibration fine characterization has been done during ground testing and Cal/Val. All parameters likely to cause a failure in spectral calibration process have been identified and are continuously monitored. As long as they remain stable, there is no problem with IASI spectral calibration.

In addition, a spectral calibration assessment is done over homogeneous scenes when IASI is in external calibration, nadir view.

4.6.1 Monitoring of the ISRF inputs

4.6.1.1 Position of the interferometric axis

The interferometric axis is the cube corner displacement direction. Its value has changed several times during CalVal due to the various configurations used. Since the end of CalVal, its value is now stable around (Y = 935µrad; Z = 2640µrad). The central position used in the “spectral database” generation, are 909µrad and 2621µrad, respectively for Y and Z axis.

Since the drift of the interferometer axis is lower than 300 µrad, there is no need to update the “spectral database”.

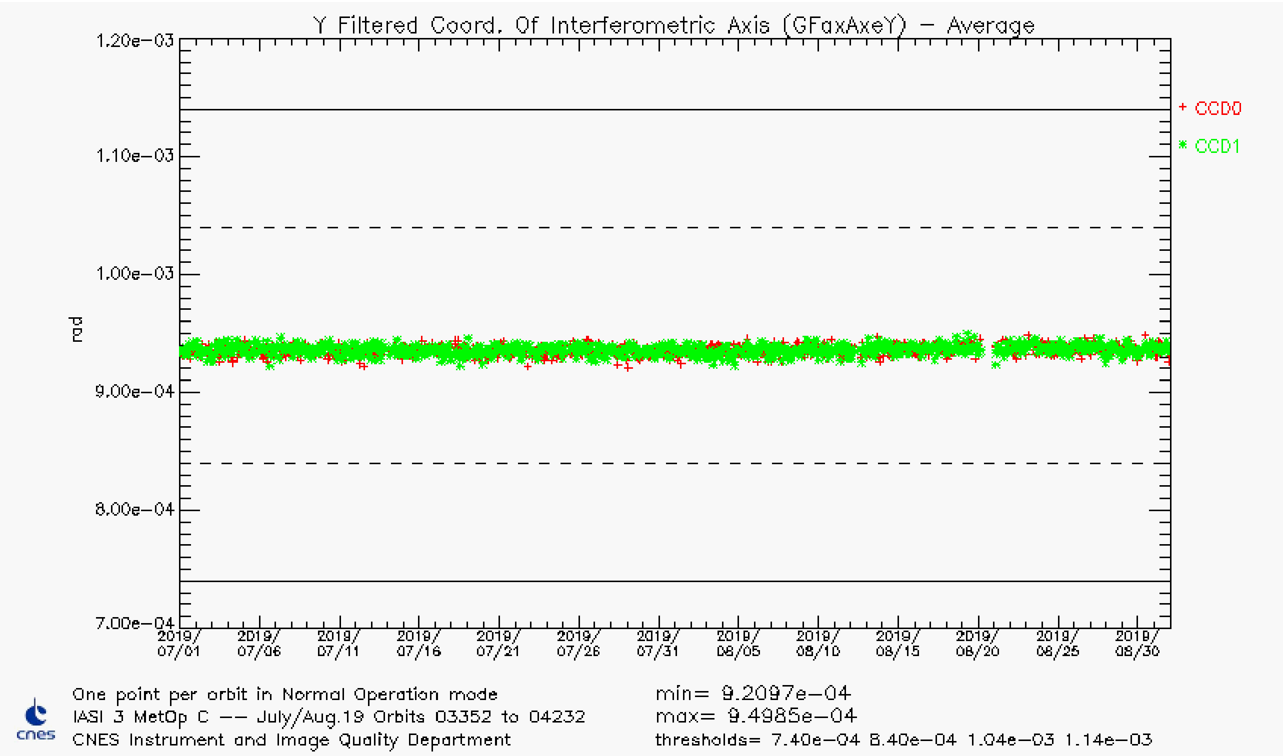


Figure 32 : GFaxAxeY average (Y filtered coordinates of sounder interferometric axis)

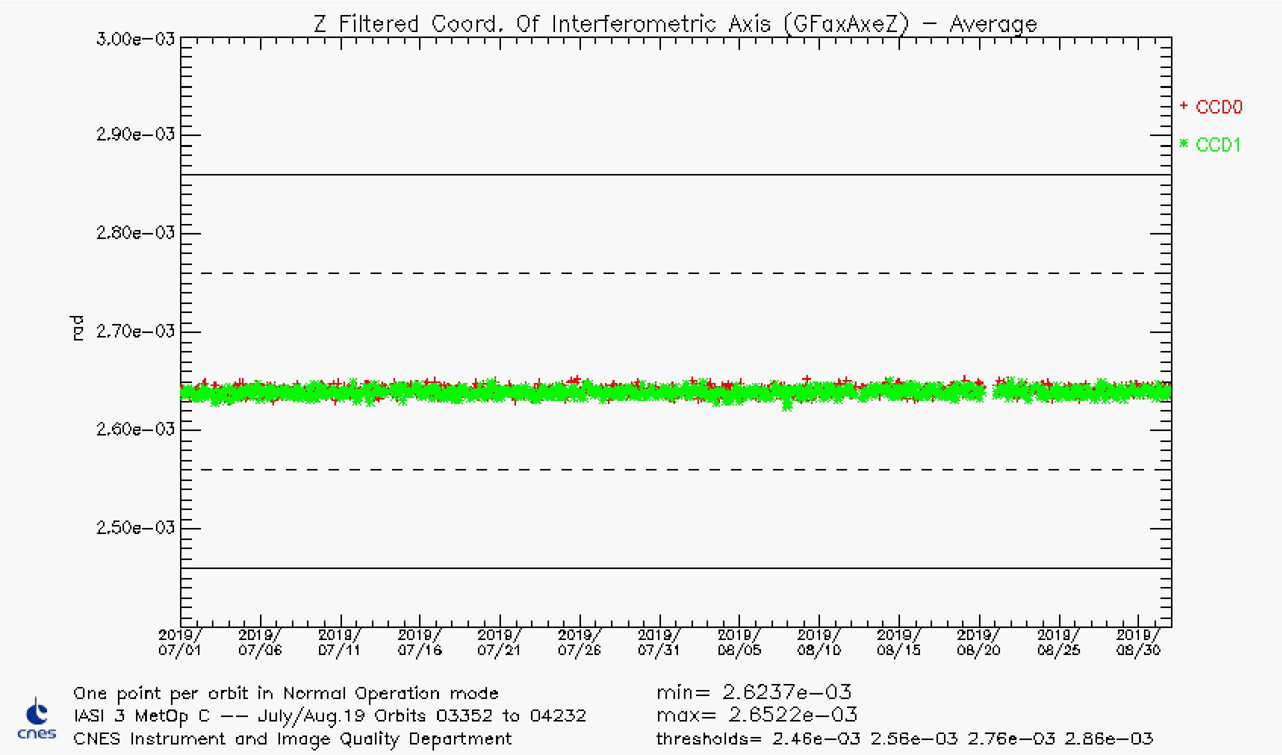


Figure 33 : GFaxAxeZ average (Z filtered coordinates of sounder interferometric axis)

4.6.1.2 Cube Corner constant offset

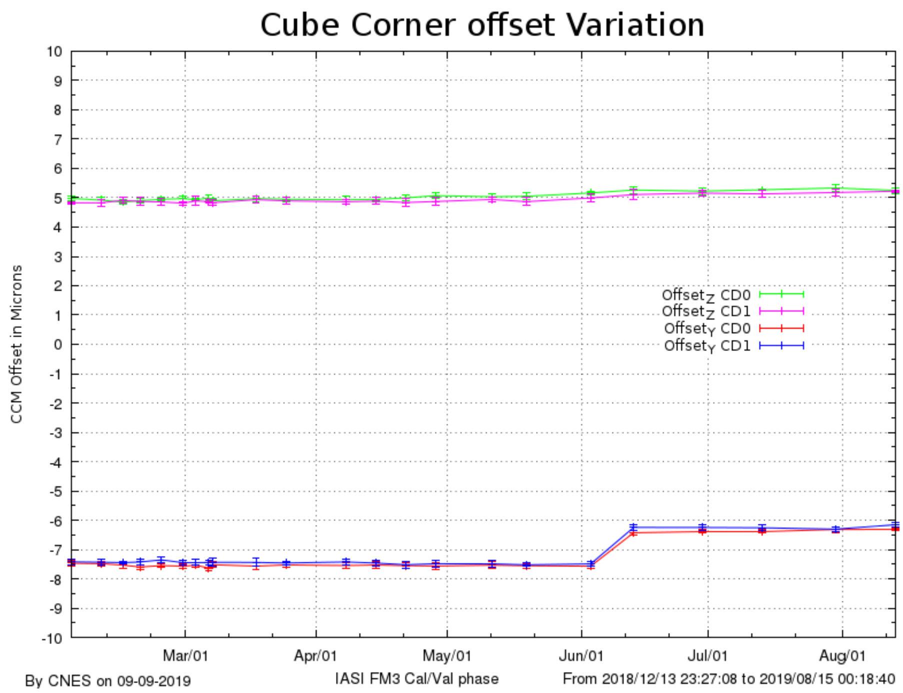


Figure 34 : Cube Corner offset variation

Reference cube corner offsets, used in the spectral database of the period (ODB 4), are -7.45 µm, -7.51 µm, +4.85 µm and +4.77 µm, respectively for Y CD0, Y CD1, Z CD0 and Z CD1. Since the drift of cube corner offset is lower than 4 µm, there is no need to update the spectral database.

4.6.1.3 Cube corner velocity

Refer to REVEX, paragraph 5.5.

4.6.1.4 Interferometer optical bench temperature

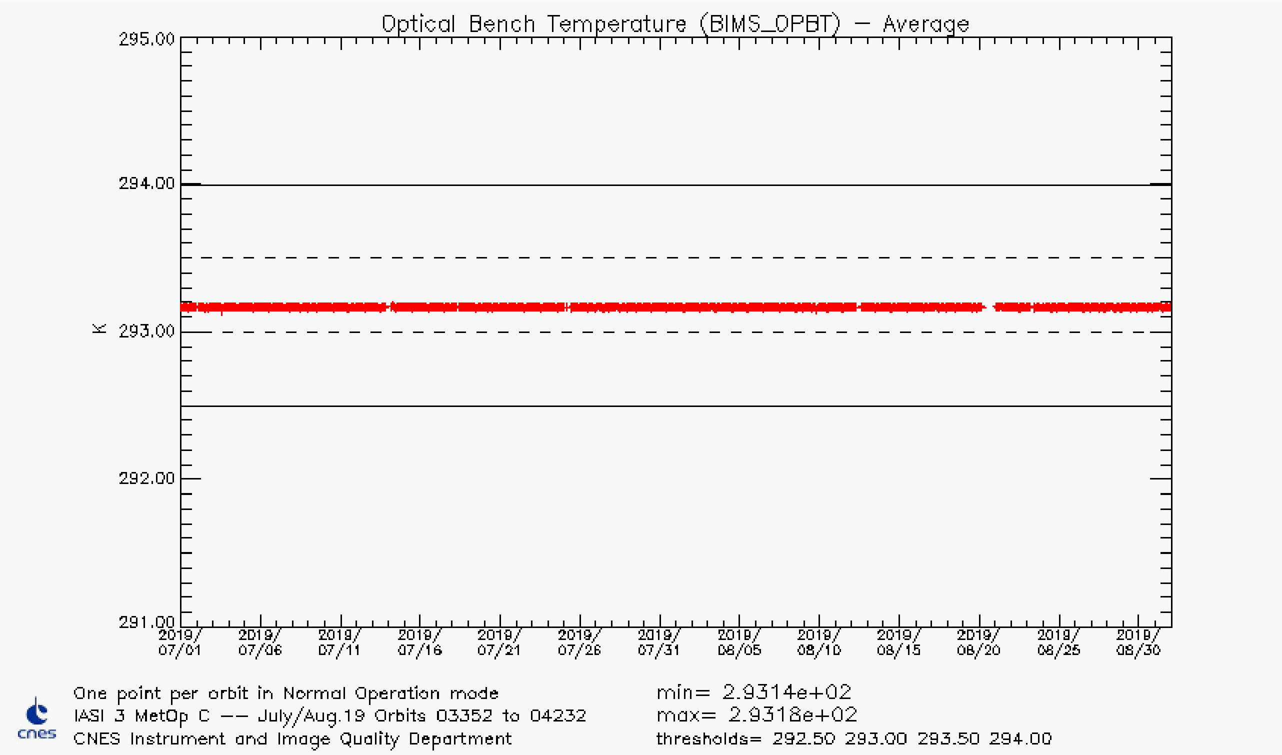


Figure 35 : Optical bench Temperature

4.6.2 Spectral calibration assessment

Absolute spectral calibration assessment and Interpixel spectral calibration assessment are performed during routine External Calibration on Earth views at nadir (SP 15) and synthesized once a year.

Refer to REVEX, paragraph 6.6.2.

4.6.3 Conclusion

All parameters impacting IASI spectral calibration are stable and within specifications.

4.7 GEOMETRIC PERFORMANCES

The geometric calibration is performed on ground (level 1 processing). Most of the analyses of geometric performances require being in external calibration mode.

Specifications are the following: the IIS/AVHRR co-registration has to be better than 0.3AVHRR pixel while the IIS/sounder co-registration has to be better than 0.8mrad.

4.7.1 Sounder / IIS co-registration monitoring

This monitoring is performed one time a year for REVEX.

The sonder/IIS coregistration error is lower than 100µrad (eq. 100m on ground).

4.7.2 IIS / AVHRR co-registration

The IIS/AVHRR co-registration is permanently estimated by the L1 processing chain.

Note that AVHRR channels 4 and 5 are within the IIS spectral filter. The spatial resolution of the IIS (0,7km) is close to AVHRR (1km).

The IIS/AVHRR offset guess in the ground segment configuration is used when the algorithm of correlation between IIS and AVHRR does not converge (typically over homogeneous scenes).

The following figures show a comparison of IIS-AVHRR offsets (GIacOffsetIISAvhrr) mean profiles.

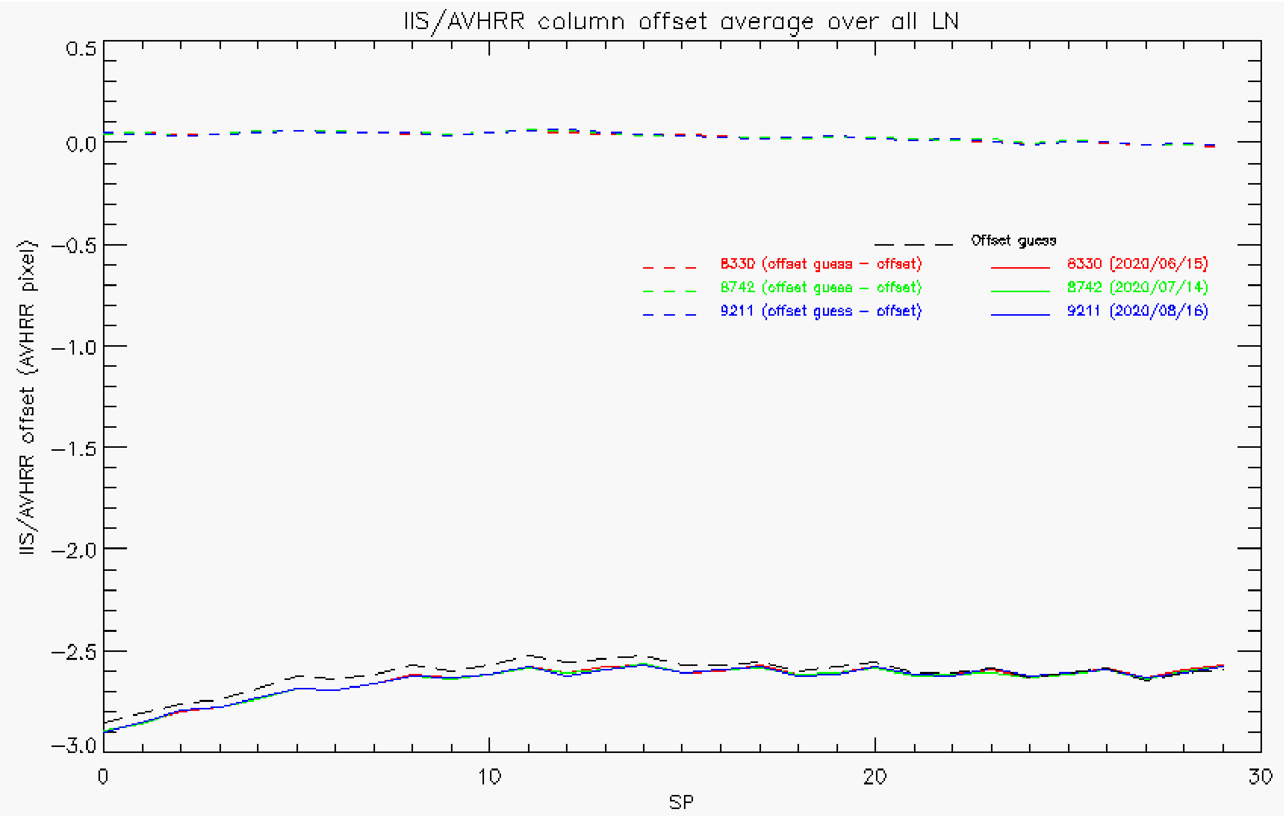


Figure 36 : Column offset (black) guess vs. column offset averaged over all lines (LN) as a function of the scan position (SP=SN), and orbit number (along track IIS/AVHRR offset)

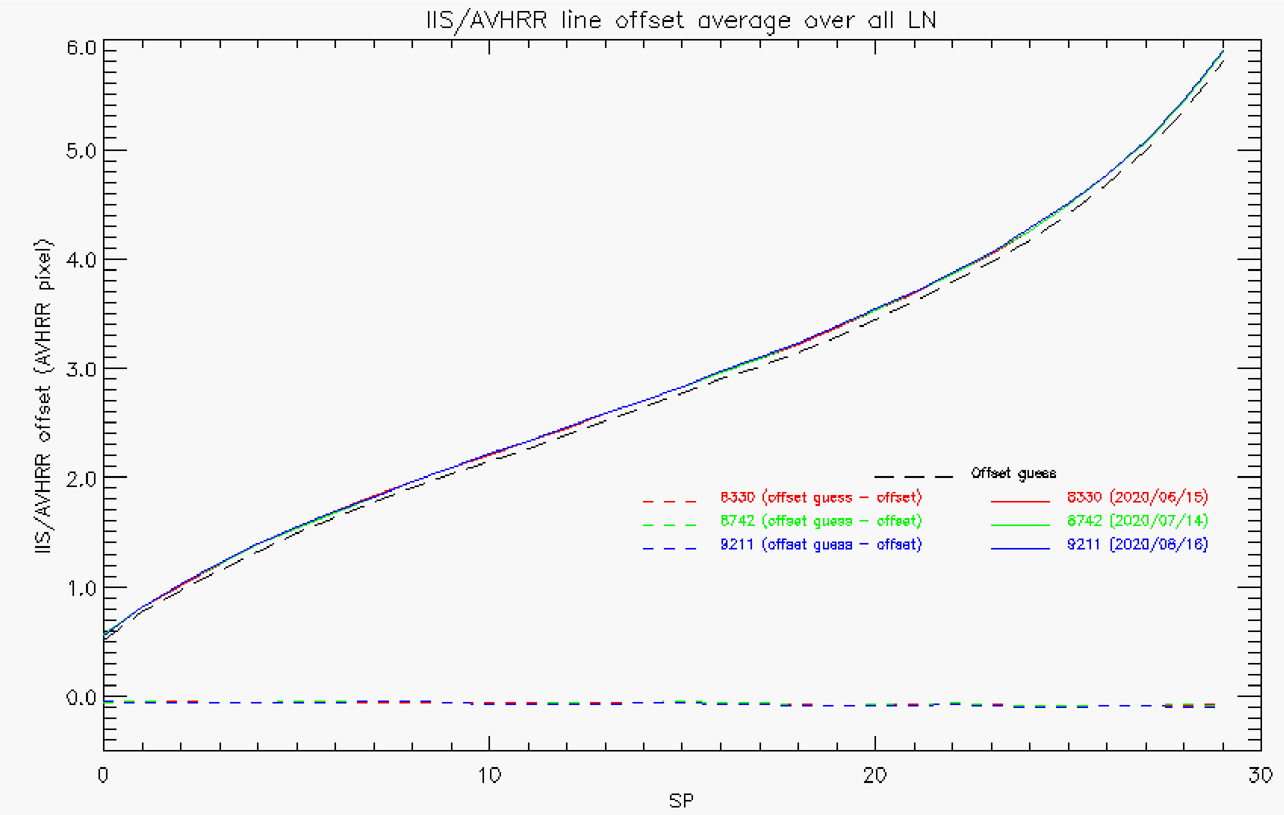


Figure 37 : Line offset guess (black) vs. line offset averaged over all lines (LN) as a function of the scan position (SP=SN), and the orbit number (across track IIS/AVHRR offset)

For both across track and along track, the residuals between measured and IIS/AVHRR offset guess in the ground segment configuration are lower than 0.1 AVHRR pixel for all viewing angles, that is equivalent to 100m on ground.

The values are stable.

4.7.3 Conclusion

The positions of IASI pixel are considered stable and well within specification.

IIS-sounder co-registration is stable at about 100µrad which is equivalent to 100m on ground (specification : < 0.8 mrad).

IIS-AVHRR offset is lower than two pixels and stable over time: less than 0.1 AVHRR pixels over three months (specification: < 0.3 AVHRR pixel).

IASI pixel centre location accuracy in AVHRR raster is around 200m. The geolocation of IASI pixels are thus considered stable and well within specification (5 km).

4.8 IIS RADIOMETRIC PERFORMANCES

The main task of IIS is to insure a good relative positioning of IASI sounder pixels with respect to AVHRR. Its performances are studied on one monthly external calibration in three and the monitoring is performed one time a year for REVEX.

4.8.1 IIS Radiometric Noise Monitoring

Refer to REVEX, paragraph 6.9.1.

4.8.2 IIS Radiometric Calibration Monitoring

Refer to REVEX, paragraph 6.9.2.

5 IASI TEC SOFTWARE AND INTERFACES

5.1 IASI TEC EVOLUTION

No evolution within the period.

Previous software evolutions :

IASI TEC software version	implementation	Comments
9.3	October 2018	

Table 19: IASI TEC at CNES Toulouse

5.2 EUMETCAST INTERFACE

EUMETCast dissemination is used for Near Real Time data reception by IASI TEC at CNES, Toulouse.

Each orbit, L1 ENG, L1 VER, and AVHRR 1B products are received under continuous series of 3 minutes PDU. Full dumps are reconstructed by the EUMETCAST terminal and pushed to a IASI TEC server.

In case of failure of the prime EUMETCAST station, products remain available several days on a redundant station.

The behaviour of the EUMETCAST reception is nominal.

No modification in the EUMETCAST configuration during the period.

5.3 FTP INTERFACE

IASI L0 full dumps are available in Near Real Time on a EUMETSAT FTP server. The IASI TEC software automatically downloads products from the EUMETSAT FTP server.

The reception of L0 products at IASI TEC is nominal.

6 CONCLUSION AND OPERATIONS FORESEEN

Please visit https://iasi.cnes.fr to get IASI news.

6.1 SUMMARY

The IASI FM3 instrument is fully operational.

The instrument configuration is the nominal one.

The main events are :

- Moon acquisition on 13 July and 12 August 2019
- Moon avoidance on 20-21 August 2019
- In Plane manoeuvre on 10 July 2019

- CSQ on 28 July 2019

6.2 SHORT-TERM EVENTS

- Moon avoidance (CS1) on 18-19 September 2019
- Moon acquisition (CS2) on 10 October 2019
- Out of Plane manoeuvre on 4 December 2019

- New GRD configuration R16 on 17 October 2019 (CTC CS routine coding tables for SMA monitoring)

6.3 OPERATIONS FORESEEN

- Next decontamination should happen in 2020
- Update of Scan mirror reflectivity coefficients mid 2020

End of document