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IDEAS+ Swarm Weekly Report : 18/08/2014 – 24/08/2014

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period 18 to 24 August, 2014.

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AMENDMENT POLICY

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

AMENDMENT RECORD SHEET

ISSUE	DATE	REASON
1.0	29 Aug 2014	First issue

1. INTRODUCTION

This document refers to the activities carried out in the framework of the Sensor Performance, Products and Algorithms (SPPA) Office [RD.1], and as such it reports on work related to:

- Algorithms and Processors Development, Maintenance and Evolution: these include all algorithm and software evolution and maintenance aspects for the different components, for both the Operational processors (OP) and Prototypes processors (PP) of L1 and L2 chains.
- Performance Assessment: these include all Quality Control activities (on-line and offline, systematic or on-demand), for the applicable product levels.
- System Calibration: these include the activities related to calibration, from sensor to system level. They also include aspects like cross calibration and handling of external calibration sources.
- Product validation: these include definition and maintenance of product validation plans.
- End-to-end Sensor Dataset Performance: these include activities related to the organisation and coordination of Quality Working Groups and all aspects of the Experimental platform. It also covers the product baseline, coordination and handling of external communities, and all aspects of ADF handling (both for the operational processors and for the prototypes).

This weekly report constitutes a work in progress throughout the mission life time, and new parts and complements will be added while the consolidation of knowledge on Swarm data and instruments will progress.

Section 2.1 always gives an overview of the general quality status of the mission instruments and products, while the main observations of the week are summarized in Section 2.4.

The document also includes information on data quality for the three Swarm spacecraft, inferred from automated HTML quality reports which are produced on daily basis for each product. Please contact the IDEAS+ Swarm team if interested in accessing the reports via web or FTP (all details about interfaces and folder structure available on [RD.2]). Such quality reports represent the core of the Routine Quality Control (Chapter 3). A description of the implemented quality checks is given in [RD.3], and references therein.

Basing on specific findings of the routine quality control, or on-demand from other entities (i.e. Swarm PDGS, FOS, Mission Management, Post-Launch Support Office, Expert Support Laboratories, Quality Working Groups, user community), anomalies can be triggered and preliminary characterisations and investigations of such anomalies are given in Chapter 4.The anomalies documented in the Weekly Reports are tracked in the IDEAS+ action and ticketing system. Information on Level 1B Swarm products can be found in [RD.4].

1.1 Current configuration of monitored data:

- Processor Version: L1BOP 3.11p2
- L1B baseline: 0301 (for definitions and description of the data baseline concept see https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/swarm/data-access/product-baseline-definition)
- Level 0 input products baseline: 0201
- Input auxiliary files baseline: CCDB 0009, ADF 0101
- MPPF-CVQ v.2.11p2

1.2 Reference documents

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as RD.n, where 'n' is the number in the list below:

[RD.1] Sensor Performance, Products and Algorithms (SPPA), PGSI-GSOP-EOPG-TN-05-0025. Version 2.3.

[RD.2] Swarm PDGS External DMC Interface Control Document, SW-ID-DS-GS-0001, Issue 3.2.

[RD.3] Swarm MPPF-CVQ Monitoring Baseline Document, ST-ESA-SWARM-MBD-0001, Issue 1.7.

[RD.4] Swarm Level 1B Product Definition, SW-RS-DSC-SY-0007, Issue 5.13.

[RD.5] Swarm IDEAS Configuration Management Plan, IDEAS-SER-MGT-PLN-1081 v0.14.

[RD.6] Swarm Quality Control Project Plan, IDEAS-SER-MGT-PLN-1071

[RD.7] SW_L1BOP_status_20140827_MoM

2. SUMMARY OF THE OBSERVATIONS

2.1 General status of Swarm instruments and Level 1B products quality

In future issues, this summary will present only relevant updates.

Overall the mission is successful: all three S/C do not show serious issues from the platform point of view, and the operations are fully nominal. Final constellation orbit has been reached, and a mission lifetime of about ten years is presently foreseen.

The only failure concerned the redundant ASM unit on S/C B, which failed to switch on during the Commissioning Phase and it is considered lost for the mission. Science and housekeeping telemetry is regularly retrieved and the ESA PDGS (Payload Data Ground Segment) is fully in place, processing and distributing data to the users without major issues.

On the quality of data itself, of course the work is in progress also in relation to the knowledge and status of the instrument. Currently, the only datasets with validated scientific value and distributed to the worldwide user community are:

i. Level 1b Orbit and Attitude products,
ii. Level 1B Magnetic products,
iii. Level 2 – Cat2 Field Aligned Currents

As relevant algorithm improvements have been recently done, we plan to distribute the Level 1B Plasma product too in few months. For the acceleration products there are still major issues under investigation and we cannot foresee now a time plan for their distribution.

Below follows a more detailed description of the status by product groups:

1. **Orbit and attitude products.**

    a. The **Medium Accuracy orbit determination** done within the Level 1B processing seems robust and reliable, as it has been verified during the Commissioning Phase by means of comparisons with Laser Retro-Reflectors data.
    b. The **GPS antennae** and related on-board equipments work nominally. Following requests from the Level 2 Precise Orbits determination groups, the GPS Observation dataset has increased its rate (from 0.1 to 1 Hz) in late July 2014 and the Antenna elevation mask is going to be increased up to 83 degrees. Recommendations have been advanced to ESA for producing RINEX L1B products the most “pure” and un-processed as possible, removing the carrier smoothing and the antenna pattern correction.
    c. The **Attitude products** done within the Level 1B processing look nominal and the resulting quaternions are fully within the mission requirements.
    d. The **Star Tracker** instruments, after few initial problems during the Commissioning Phase related to bad calculation of the Center-of-Integration time, promptly fixed by means of a patch on the on-board software, now work nominally. Investigations are on-going concerning unexpected variations of the inter-boresight angles recently detected. Moreover, during the Commissioning Phase the occurrence of unexplained Big Bright Objects in the cameras fields of

view was often reported, but this seems not affect the final attitude determination quality.

2. **Magnetic products.**

   a. The major issue under investigation concerning the quality of magnetic products is **an unexpected residual between the VFM and ASM measurements**. Such residual remains after the VFM-ASM inter-calibration and the subtraction of the stray fields, it appears as a magnetic time series with peak-to-peak variations of the order of few nT and shows a clear dependency on the orbit and instrument attitude. Scientific teams are developing empirical models to describe the observed perturbation. Engineering teams are investigating potential sources of the perturbation. The key possible cause could be thermally induced currents generated on the boom or optical bench sub-components.
   b. Few minor issues concern the integration in the operational processing of the correct calculation of the quality and platform flags and the errors associated with the magnetic measurements. The new release of the operational processor in late September will properly fix the issues.

3. **Plasma products (not distributed yet) and instruments.**

   a. Thermal Ion Imagers: the instruments have been put in Ready state, with all the voltages off, from 6/8/2014 up to 21/8/2014. The reason is the **fast degradation of the raw images** observed during nominal operations which make them completely unusable after few days following an instrument switch-on (or even few orbits in case of Swarm C). The instrument team is hectically investigating on the cause of such degradation and several tests have been planned and about to be executed. A possible explanation might be the Phosphor plate, the phosphor grains of which are not covered by any thin conductive layer (e.g. Aluminium) which would allow all the electrons generated from the MCP to be evacuated without relying exclusively on the Tin layer underneath the phosphor grains. Removing HV power only from the Phosphor plate during 24 hours may be envisaged to identify the element susceptible to degradation. Moreover an update of the gain maps on-board is required for allowing the AGC to correctly tune the MCP gains and avoiding the images to be blurred.
   b. **Langmuir Probes**: the processing algorithms have been recently improved with some bug fixes and also in order to achieve a more stable and smooth transition between LP harmonic mode calculation methods. We now have a safer rejection of the high gain probe overflows in the linear electron region, and data are no more affected by spikes deriving from failures in the determination of the retardation region bias. Still, data records coming from the Sweep mode should be discarded in scientific analyses due to quality issues. The sweep mode data are less than 1% of the total (a Sweep occurs every 128 seconds, lasting 1 second) and are easily identified in the EFIx_PL_1B products by the Flags_LP" parameter taking the values of 9, 10 or 15. One further issue under investigation is the behaviour of the spacecraft potential which shows unexpected increases during night time.

4. **Acceleration products (not distributed yet) and instruments.**

a. The accelerometer data are currently affected by calibration issues under intensive investigation. Main problems are:
   - High number of steps, spikes, pulses observed in linear and angular acceleration
   - Strong dependency on temperature variations.

   Modeling is ongoing for the temperature dependence and filtering algorithms are in preparation for coping with the spike occurrence, but the major concern will be to achieve an absolute and stable calibration of the instrument. No current date is foreseen for the update of the processors and subsequent distribution of the data.

2.2 Plan for processor update

Currently, the L1B processor is being updated with a number of evolutions and fixing various SPRs. A full description of the details of the Prototype Processor and Operational Processor update is provided in [RD.7]. The foreseen delivery date is the 6th of October.

2.3 Quality Working Group and Cal/Val Coordination

The second QWG – Cal/Val meeting took place in Copenhagen on 16-20 June.

The third QWG – Cal/Val meeting is being planned for the 2-5 December 2014 (location TBD).

A number of Task forces, each dedicated to an instrument group, continuously coordinates the investigation of the various anomalies.

2.4 Summary of observations for Week 34 (18-24/08/2014)

The production of the week under monitoring looks nominal. No anomalies encountered.

The variable under specific analysis is the $|B_{NEC}|$ - F parameter, i.e. the residual difference between the VFM and ASM measurements which is still above the accuracy for the mission requirements. The monitoring of this week has evidenced no significant variations with respect to the previous weeks, with peak-to-peak excursions of the order of [-1.5, 1.5] nT. The long-term trend of the past three months seems indeed to suggest that the peak-to-peak variation is decreasing (in late June / beginning of July, we had variations up to [-5, 5] nT).

Also the TCF calibration parameters are affected by the VFM-ASM anomaly, resulting in a slow and constant decrease of the Scales factors (for Swarm C the TCF scales decreased of about 0.0003 % throughout the week): following the algorithms experts, this is expected and does not cause any worry for the time being.

3. ROUTINE QUALITY CONTROL

3.1 Orbit and Attitude Products

The Orbit and Attitude products **look nominal** during the monitored period.

The relevant parameters that have been monitored are:

- Position difference between calculated Medium Accuracy orbits (**MODx_SC_1B**) and on-board solution (**GPSxNAV_0**). Threshold values for such differences have not been assessed yet: we have just monitored the average values and maximum variations around the week, and reported in tables in the sections below, along with some example from the HTML daily reports. For the time being we evaluated an anomaly should be raised if one (or more) of the following conditions occurs:
    - The **average difference** on a given day exceeds the position accuracy requirement for the mission (1.5 m),
    - The variability around the average is quite high: **standard deviation** threshold has been arbitrarily chosen to be twice the position accuracy requirement for the mission (2-sigma = 3 m).
    - At least 4-5 spikes are observed on a given day, exceeding +/- 50 m.
- Visual inspection of Star Tracker characterisation flags (**STRxATT_1B**)
- Deviation of the quaternion norm from unity (deviation threshold = +/- 10^{-9})
- Visual inspection of Euler Angles derived from quaternions.

3.1.1 Swarm A

3.1.1.1 Position statistics

In Table 1 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The standard deviation has not been reported because it is very stable and always below 1 m, with the only exception of day 24/8.

Swarm A, 18-24/08/2014, Position difference			
Day	**Average Difference (m)**	**Maximum difference (m)**	**Notes**
18/08	0.097	+/- 7 (Z)	
19/08	0.092	+/- 10 (Z)	
20/08	0.22	-7.7 (Z), 21 (Z)	Few (2-3) big spikes between 17 and 19 UT
21/08	0.14	-10 (Z), 7 (Z)	
22/08	0.14	-10 (Z), 8.3 (Z)	

Swarm A, 18-24/08/2014, Position difference			
23/08	0.15	-10 (Z), 14 (Z)	
24/08	0.18	-10 (Z), 7.6 (Y)	St. Dev. Around 1.5 m

Table 1: Swarm A, difference between MOD and on-board solution positions.

Below follow some examples plots of such differences taken at the beginning of the week (18/8, Figure 1), in the middle (21/8, Figure 2) and at the end (24/8, Figure 3). The values are given in Km.

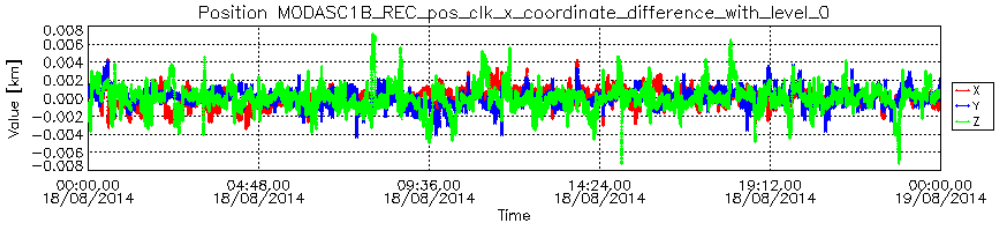

Figure 1: Difference MOD-GPSNAV, sc A, 18/08/2014

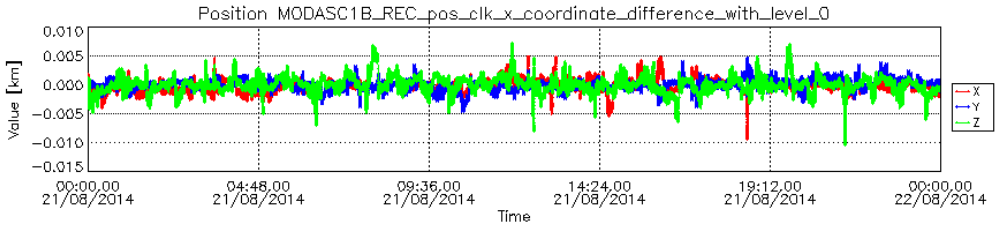

Figure 2: Difference MOD-GPSNAV, sc A, 21/08/2014

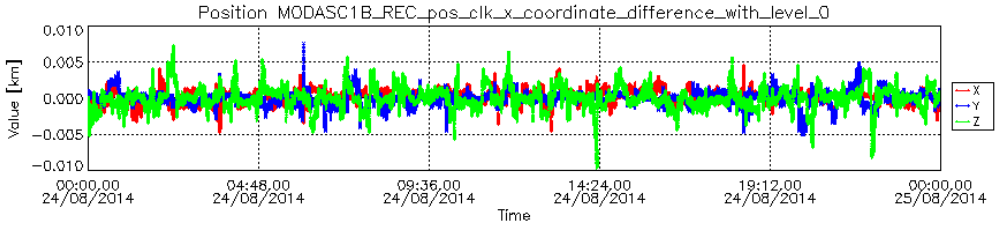

Figure 3: Difference MOD-GPSNAV, sc A, 24/08/2014

3.1.1.2 Attitude observations

Nothing relevant to report.

3.1.2 Swarm B

3.1.2.1 Position Statistics

In Table 2 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The standard deviation has not been reported because it is very stable and always below 1 m.

Swarm B, 18-24/08/2014, Position difference			
Day	**Average Difference (m)**	**Maximum difference (m)**	**Notes**
18/08	0.093	+/- 7 (Z)	
19/08	0.15	+/- 10 (Z)	
20/08	0.21	-24 (Z), 19 (Z)	Few big spikes around 3 and 7 UT
21/08	0.075	-7 (Z), 8 (Z)	
22/08	0.11	-8.3 (Z), 11 (Z)	
23/08	0.19	-11.5 (Z), 23.5 (Z)	Few big spikes between 17 and 19 UT
24/08	0.15	-15 (Z), 7.8 (X, Z)	

Table 2: Swarm B, difference between MOD and on-board solution positions.

Below follow some examples plots of such differences taken at the beginning of the week (18/8,Figure 4), in the middle (21/8,Figure 5) and at the end (24/8,Figure 6). The values are given in Km.

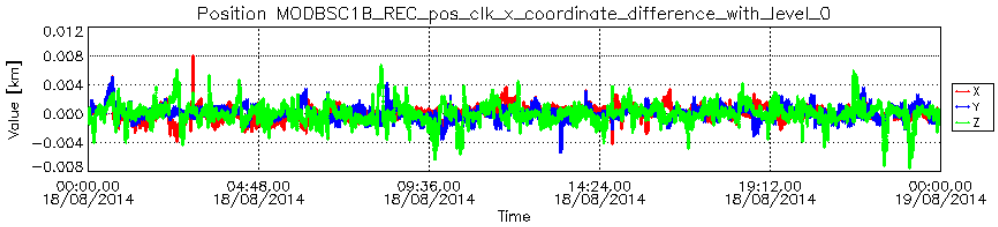

Figure 4: Difference MOD-GPSNAV, sc B, 18/08/2014

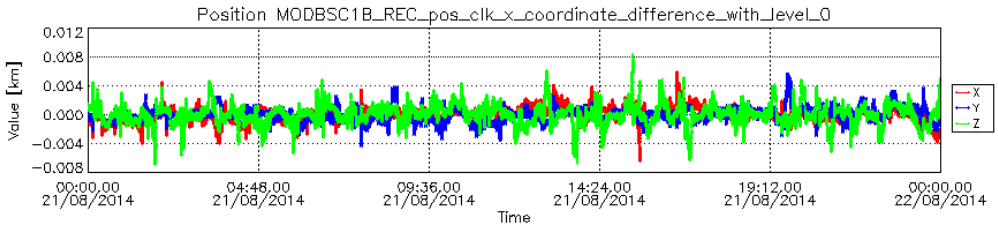

Figure 5: Difference MOD-GPSNAV, sc B, 21/08/2014

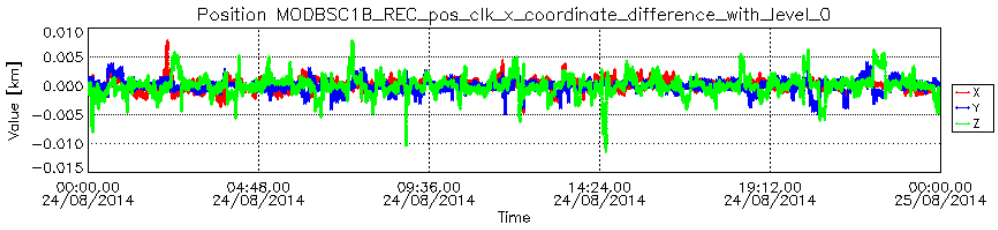

Figure 6: Difference MOD-GPSNAV, sc B, 24/08/2014

3.1.2.2 Attitude observations

Nothing relevant to report.

3.1.3 Swarm C

3.1.3.1 Position Statistics

In Table 3 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The standard deviation has not been reported because it is very stable and always below 1 m.

Swarm C, 18-24/08/2014, Position difference			
Day	**Average Difference (m)**	**Maximum difference (m)**	**Notes**
18/08	0.12	+/- 7 (Z)	
19/08	0.10	+/- 9 (Z)	
20/08	0.24	-8 (Z), 20 (Z)	Few big spikes between 18 UT
21/08	0.12	-11 (Z), 8 (Z)	
22/08	0.18	+/- 9 (Z)	
23/08	0.14	-10 (Z), 29 (Z)	Few (2-3) big spikes between 17 and 19 UT
24/08	0.2	-11.2 (Z), 8 (Y)	

Table 3: Swarm C, difference between MOD and on-board solution positions.

Below follow some examples plots of such differences taken at the beginning of the week (18/8, Figure 7), in the middle (21/8, Figure 8) and at the end (24/8, Figure 9). The values are given in Km.

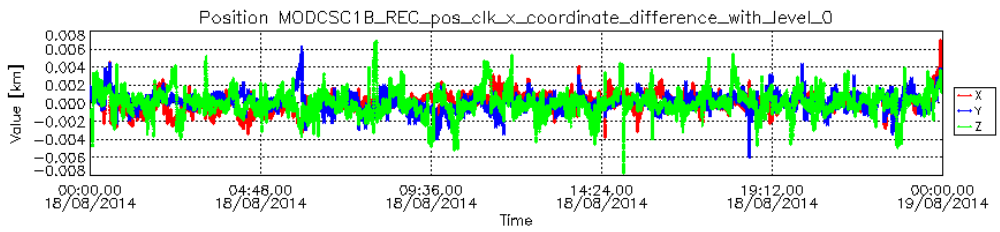

Figure 7: Difference MOD-GPSNAV, sc C, 18/08/2014

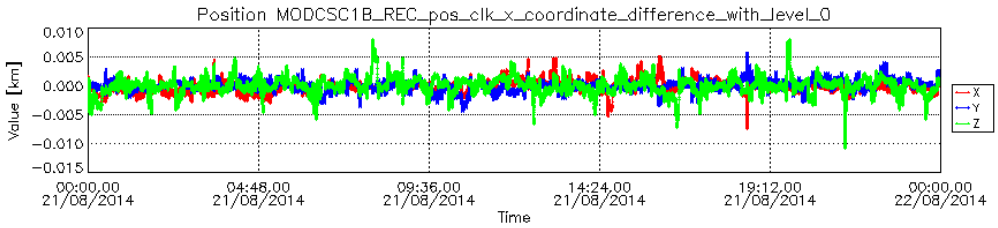

Figure 8: Difference MOD-GPSNAV, sc C, 21/08/2014

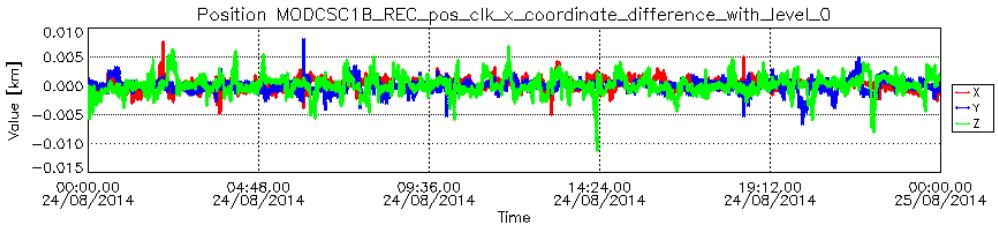

Figure 9: Difference MOD-GPSNAV, sc C, 24/08/2014

3.1.3.2 Attitude observations

Nothing relevant to report.

3.2 Magnetic Products

The magnetic products **look nominal** during the monitored period.

For the magnetic products the weekly monitoring consists in:

- Visual inspection of daily time series of magnetic field intensity F, $\mathbf{B_{NEC}}$ and $\mathbf{B_{VFM}}$. Looking for gaps (or zero values in case of **MAGx_LR_1B** products), out-of-threshold values (i.e. exceeding +/- 60000 nT), and other strange features.

- Monitoring of the **VFM-ASM known anomaly**: visual inspection of $|B_{NEC}|$ - F and recording of daily maximum variations. If +/- 5 nT are exceed on a given day, an alert is raised. Daily PSD analysis and monitoring of the spectrum peaks.

- 2^{nd} difference analysis on F, $\mathbf{B_{NEC}}$ and $\mathbf{B_{VFM}}$. If more than 10% of data of a given day (8640 records) exceeds the threshold (100 nT/s^2) an anomaly is opened.

- TCF.VFM parameters monitoring (VFM calibration parameters): weekly series of biases, scales, non-orthogonality factors and RMS.

3.2.1 Swarm A

3.2.1.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative F time series for S/C A (24/08/2014) can be seen in Figure 10 below.

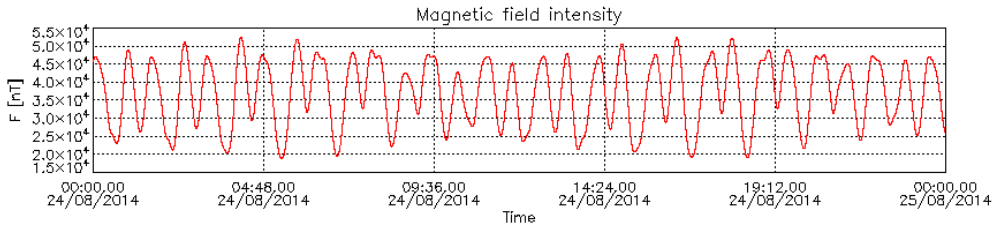

Figure 10: Time series of magnetic field intensity, F, for 24/08/2014, S/C A

3.2.1.2 VFM-ASM anomaly

The differences between the module of $\mathbf{B_{NEC}}$ and F did not show any relevant feature or change with respect to the previous weeks. The daily peak-to-peak difference around the week is, on average: [-2, 1.5] nT.

Below follow some examples plots of such differences taken at the beginning of the week (18/8, Figure 11), in the middle (21/8, Figure 12) and at the end (24/8, Figure 13).

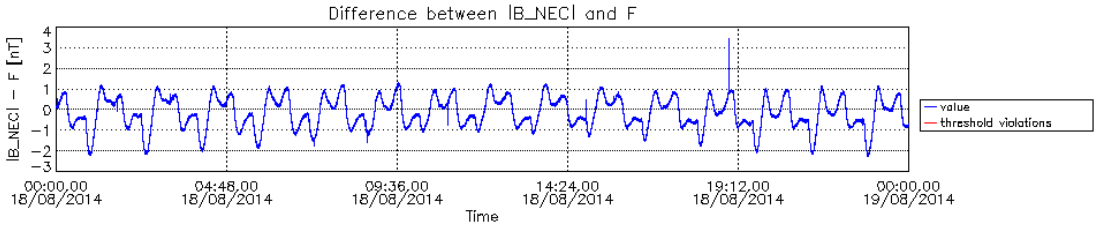

Figure 11: $|B_{NEC}|$ - F for S/C A, 18/08/2014

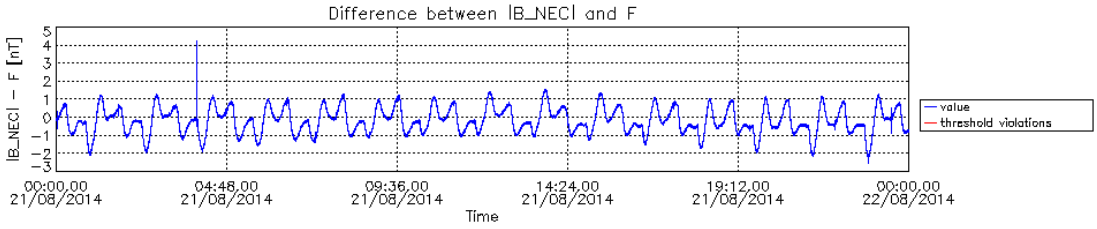

Figure 12: $|B_{NEC}|$ - F for S/C A, 21/08/2014

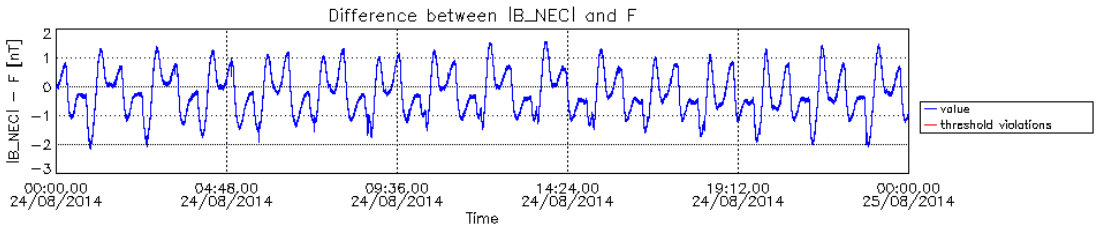

Figure 13: $|B_{NEC}|$ - F for S/C A, 24/08/2014

The Power Spectral Density (PSD) analysis does not evidence variations with respect to the previous weeks. Below (Figure 14) one can see an example of PSD for day 18/8.

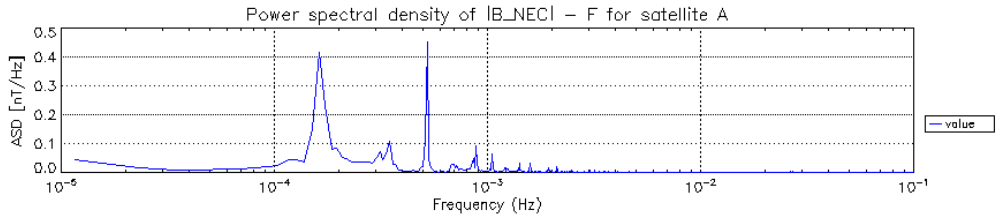

Figure 14: S/C A |B_NEC| - F PSD, 18/08/2014

3.2.1.3 2nd difference analysis

Nothing relevant to report.

3.2.1.4 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm A, from 19 to 24/08: Biases (Figure 15), Scales (Figure 16) and Non-orthogonalities (Figure 17). Each group is actually a three-component vector in the compact detector coil frame. The parameters are steady and constant during the week, only very small decreases observed in the X scale component (less than 0.0001%).

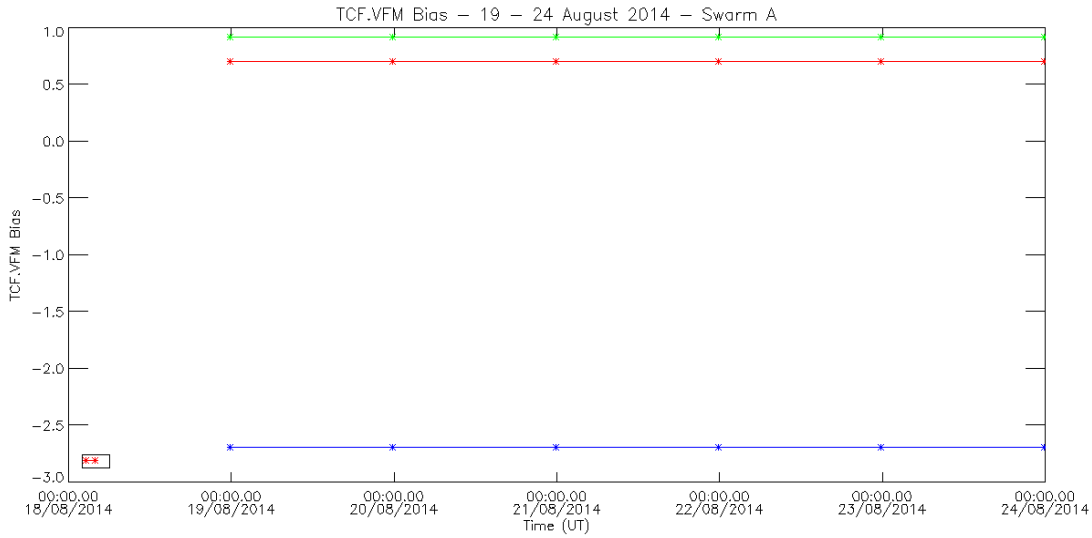

Figure 15: TCF.VFM Biases for S/C A, 19-24/08/2014.

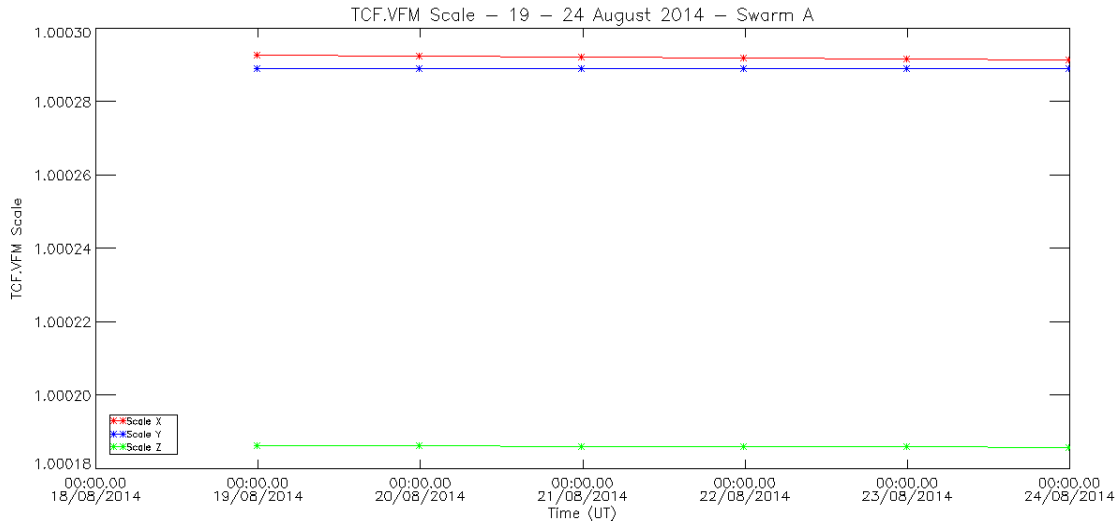

Figure 16: TCF.VFM Scales for S/C A, 19-24/08/2014.

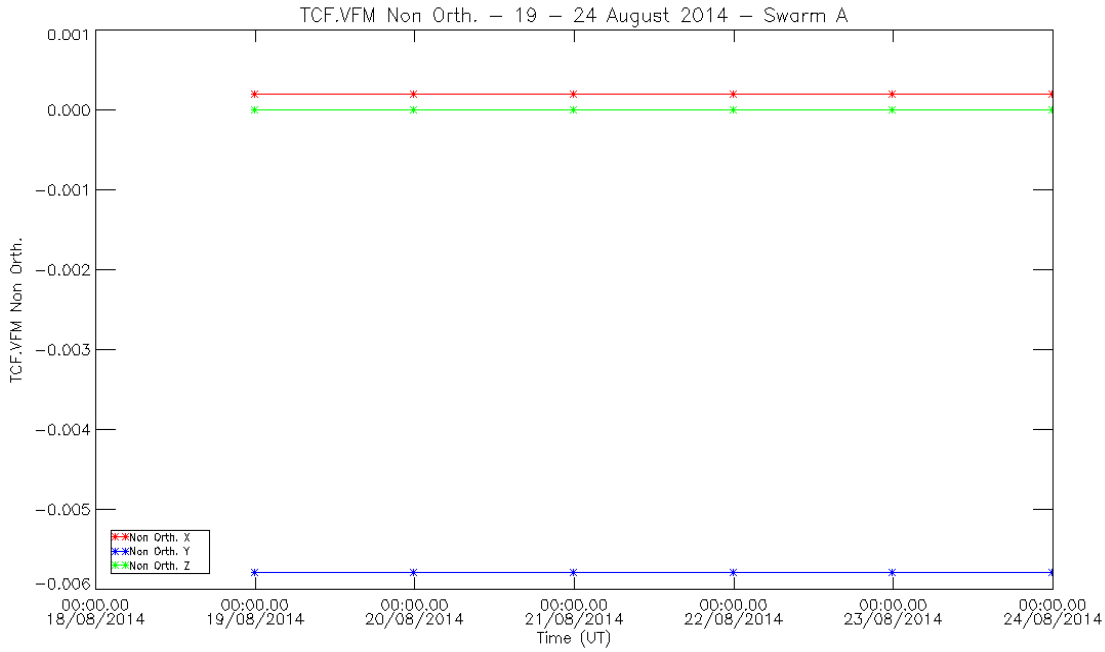

Figure 17: TCF.VFM Non-Orthogonalities for S/C A, 19-24/08/2014.

3.2.2 Swarm B

3.2.2.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative F time series for S/C B (24/08/2014) can be seen in Figure 18 below.

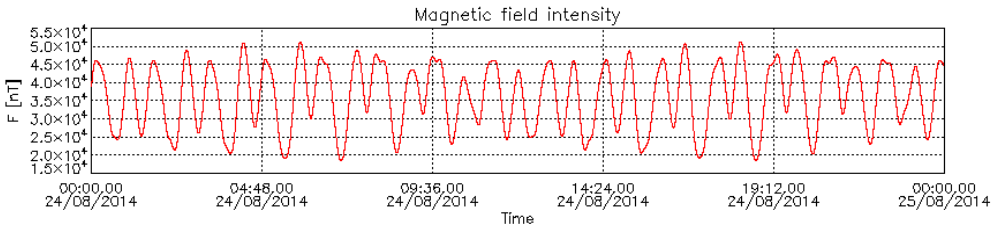

Figure 18: Time series of magnetic field intensity, F, for 24/08/2014, S/C B

3.2.2.2 VFM-ASM anomaly

The differences between the module of $\mathbf{B_{NEC}}$ and F did not show any relevant feature or change with respect to the previous weeks. The daily peak-to-peak difference around the week is, on average: [-2, 1.5] nT.

Below follow some examples plots of such differences taken in the middle of the week (21/8, Figure 19), and at the end (24/8, Figure 20).

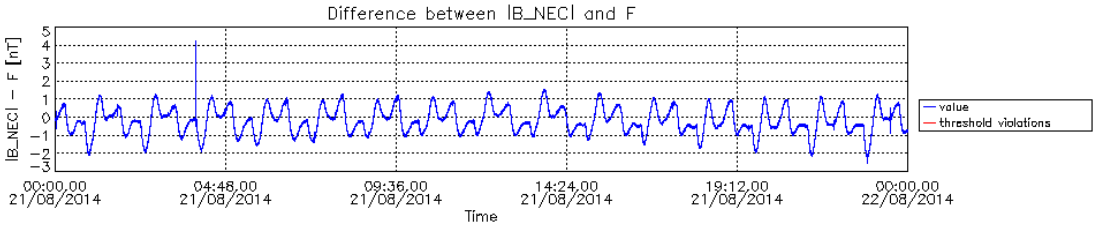

Figure 19: $|B_{NEC}|$ - F for S/C B, 21/08/2014

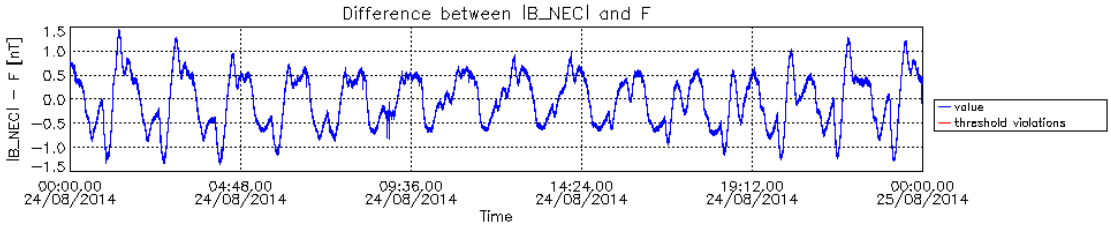

Figure 20: $|B_{NEC}|$ – F for S/C B, 24/08/2014

The Power Spectral Density (PSD) analysis does not evidence variations with respect to the previous weeks.

3.2.2.3 2nd difference analysis

Nothing relevant to report.

3.2.2.4 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm B, from 19 to 24/08: Biases (Figure 21), Scales (Figure 22) and Non-orthogonalities (Figure 23). Each group is actually a three-component vector in the compact detector coil frame. The parameters are steady and constant during the week, only very small decreases observed in the X scale component (less than 0.0001%).

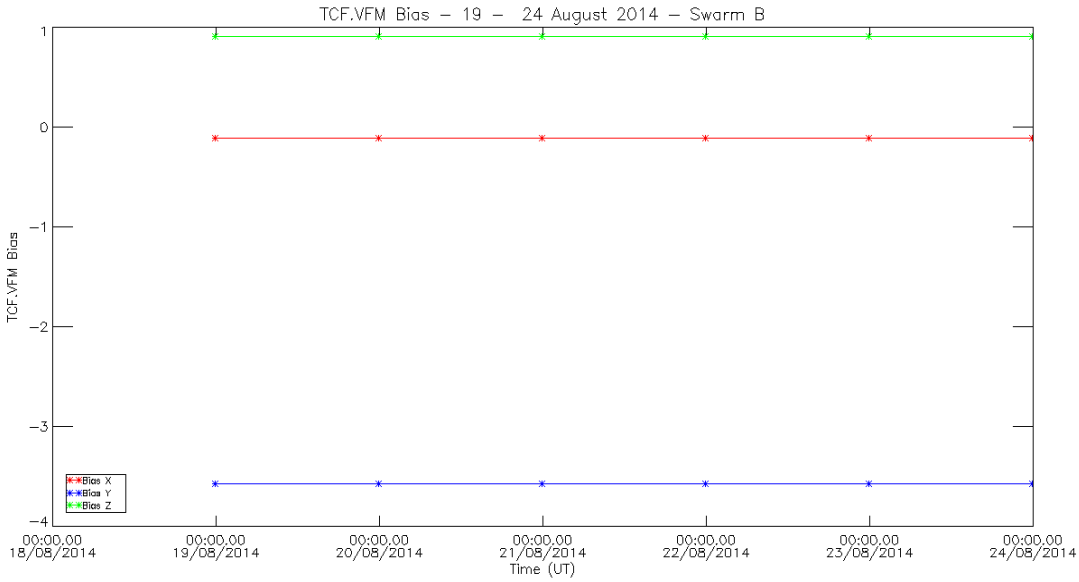

Figure 21: TCF.VFM Biases for S/C B, 19-24/08/2014.

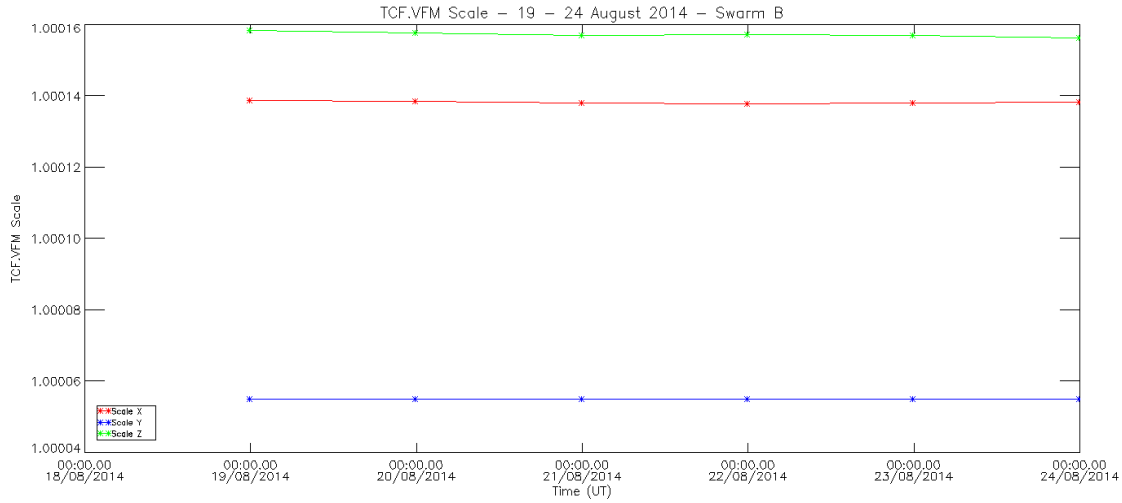

Figure 22: TCF.VFM Scales for S/C B, 19-24/08/2014.

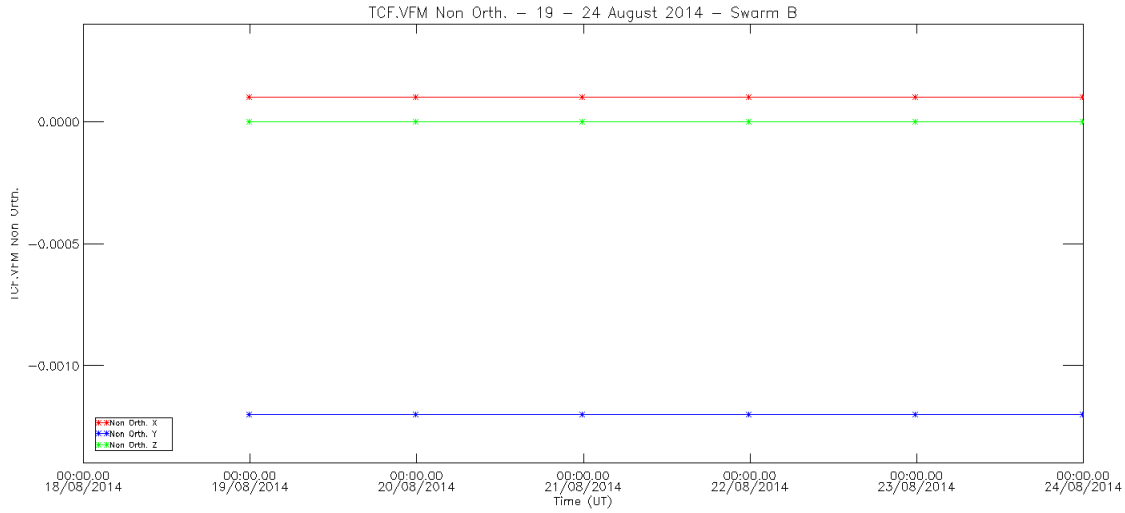

Figure 23: TCF.VFM Non-Orthogonalities for S/C B, 19-24/08/2014.

3.2.3 Swarm C

3.2.3.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative F time series for S/C C (24/08/2014) can be seen in Figure 24 below.

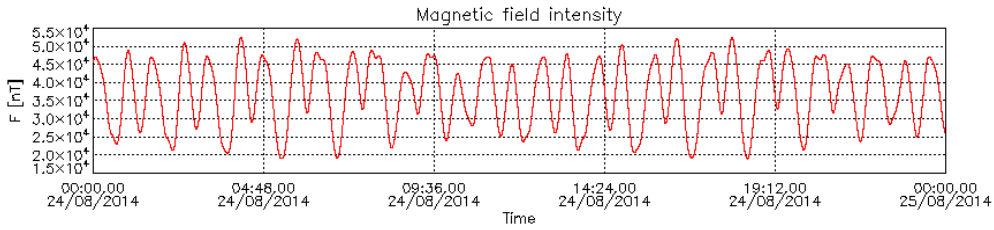

Figure 24: Time series of magnetic field intensity, F, for 24/08/2014, S/C C

3.2.3.2 VFM-ASM anomaly

The differences between the module of $\mathbf{B_{NEC}}$ and F did not show any relevant feature or change with respect to the previous weeks. The daily peak-to-peak difference around the week is, on average: [-1.5, 1.5] nT.

Below follow some examples plots of such differences taken at the beginning of the week (18/8, Figure 25), in the middle (21/8, Figure 26) and at the end (24/8, Figure 27).

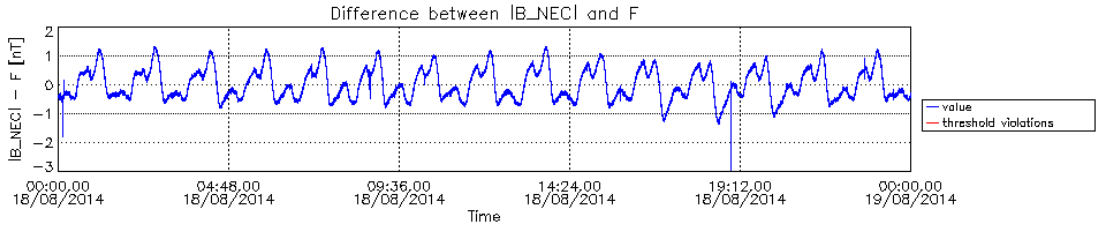

Figure 25: $|B_{NEC}|$ - F for S/C C, 18/08/2014

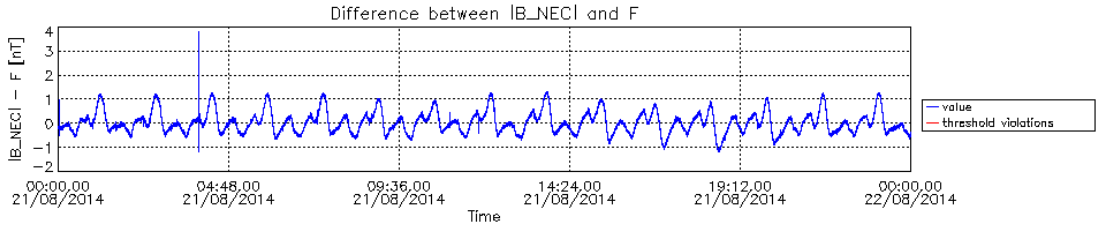

Figure 26: $|B_{NEC}|$ - F for S/C C, 21/08/2014

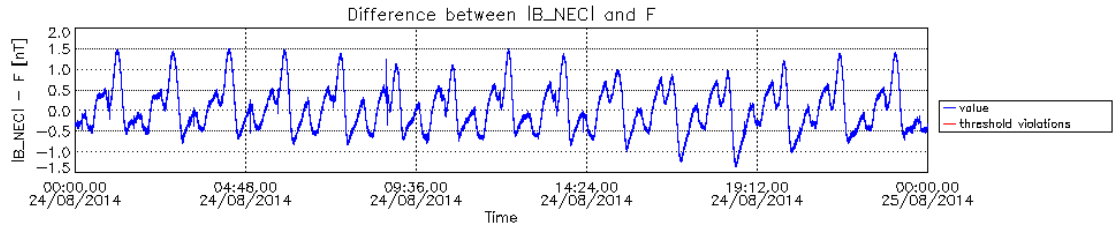

Figure 27: $|B_{NEC}|$ - F for S/C C, 24/08/2014

The Power Spectral Density (PSD) analysis does not evidence variations with respect to the previous weeks.

3.2.3.3 2nd difference analysis

Nothing relevant to report.

3.2.3.4 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm C, from 19 to 24/08: Biases (Figure 28), Scales (Figure 29) and Non-orthogonalities (Figure 30). Each group is actually a three-component vector in the compact detector coil frame. The parameters are steady and constant during the week, with an exception the X scale component, which slowly decreases reaching a level of about 0.0003% lower than at the beginning of the week.

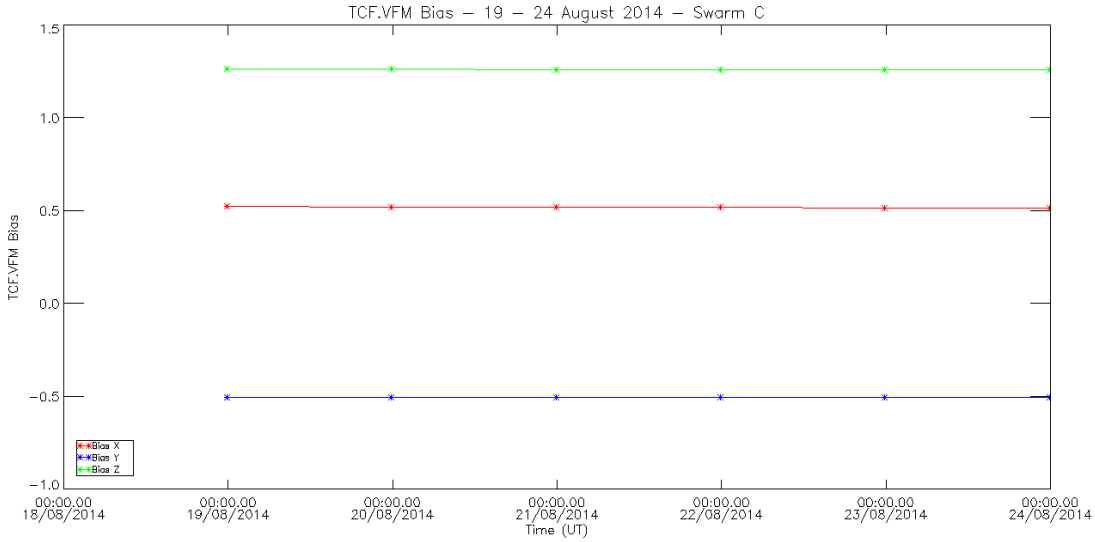

Figure 28: TCF.VFM Biases for S/C C, 19-24/08/2014.

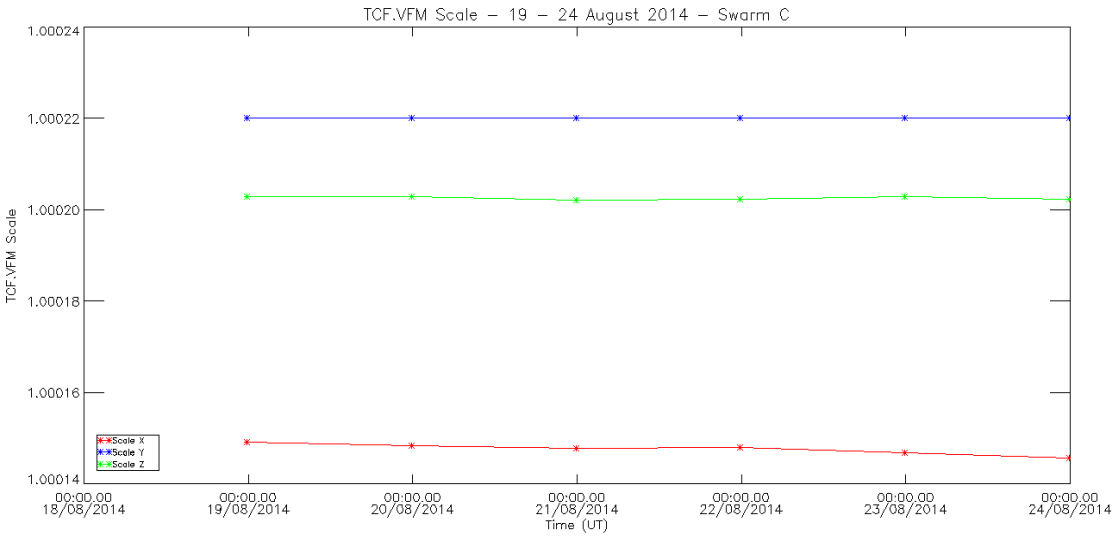

Figure 29: TCF.VFM Scales for S/C C, 19-24/08/2014.

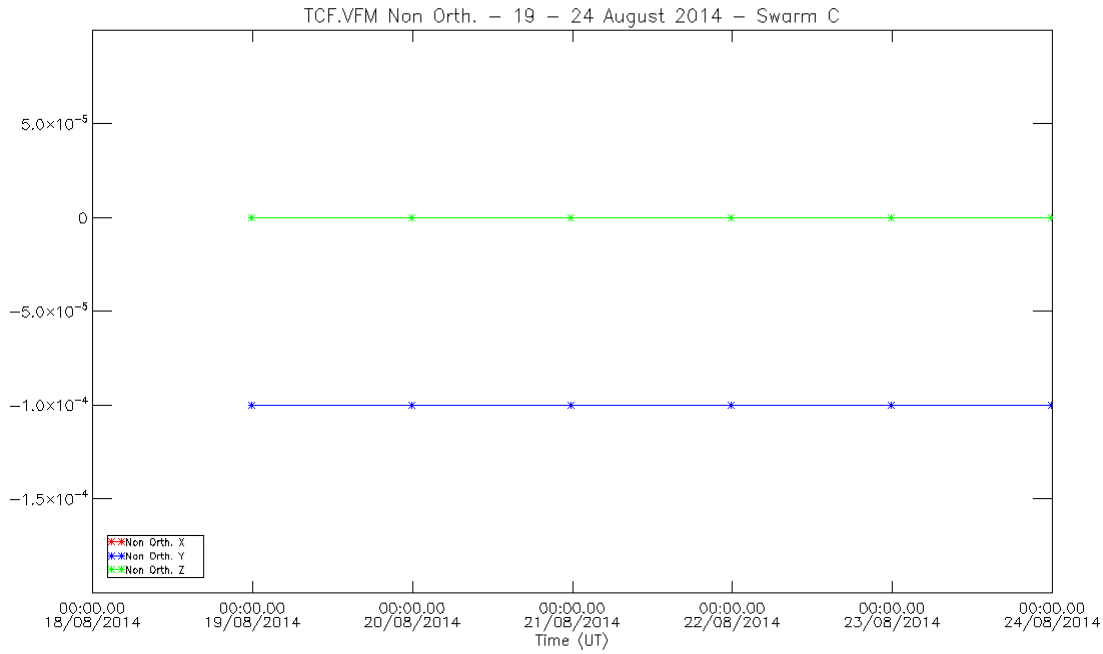

Figure 30: TCF.VFM Non-Orthogonalities for S/C C, 19-24/08/2014.

3.2.4 Summary of TCF behaviour for the three S/C

An important parameter which characterizes the quality of the TCF calculation is the weighted Root Mean Square (RMS) value of the residuals after the estimation. Due to the VFM-ASM anomaly, this value is now relatively high and variable for all S/C (Figure 31).

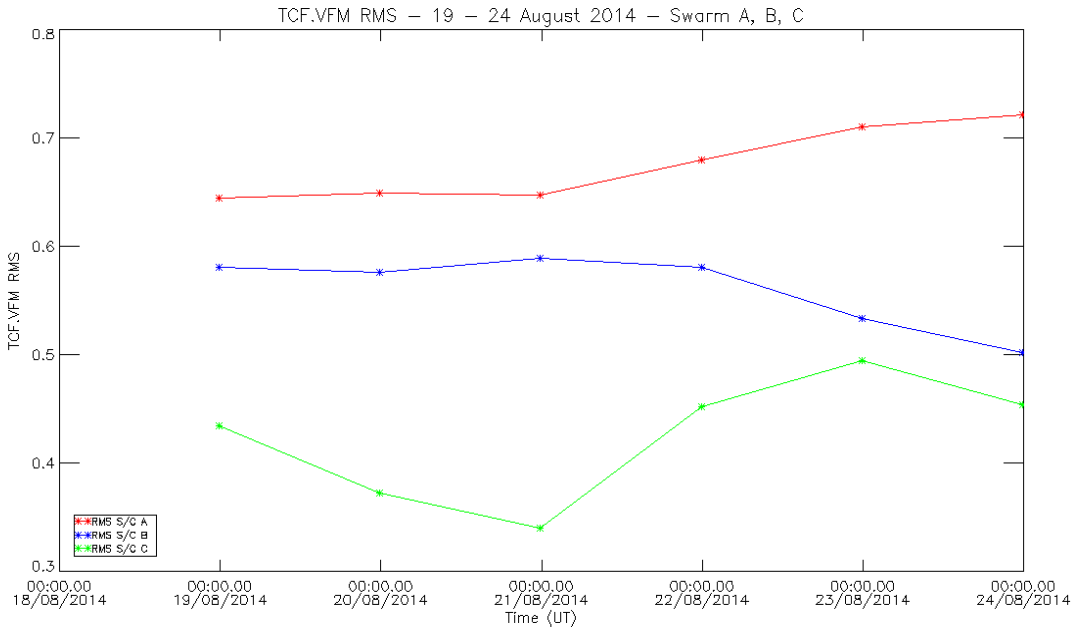

Figure 31: weighted RMS of the residuals after the TCF estimation, all S/C.

4. ON-DEMAND ANALYSIS

In the framework of the TII image anomaly described in Sect. 2.1, we carried out a preliminary analysis on the raw images collected during the period when the instruments were in ready state. The motivation of this analysis is summarized in the e-mail reported below, from I. Coco to the EFI team, the 21/08/2014:

"Dear all,

I apologize since the very beginning as this e-mail will turn to be a bit long, but I really hope to have useful insights on the TII behavior and possible ways to investigate image anomalies.

First of all I ask your advice about an issue that should not be completely new to you (at least I know Rune already talked a bit to David about that).

Because of the fact that, with the new set-up, when the TII is in ready state the Langmuir Probes are usually on and potentially give good data out, the science telemetry is produced and transmitted to ground all the same. At least, this occurs as long as we are in normal mode, because for calibration mode the telemetry is differently packed, as you know. This means that the PDGS receives regular EFIxNOM_0_ products with something inside, the processing is automatically launched and we produce Level 1B products that, in principle, are disseminated to the users. Such products contain a group of parameters from the Langmuir Probes data processing (density, electron temp. and S/c potential) that could (and usually do) have a physical meaning and the users can be interested in having them; but, on the other hand, in these products there are also TII parameters computed which do not make much sense as the instrument is in ready state.

At this point my question is: are the TII data properly flagged for taking into account such situations (TII in ready state)? E.G. I would expect TII_flag > 40 (Not suitable for scientific use) in that case: is it my guess correct? If it is the case, we are pretty safe, because users will clearly know such TII data are not usable; Otherwise we would have to find a way to flag them; we could indeed prevent the production of such data, this is feasible because FOS flagged such periods properly in the housekeeping telemetry and we can force the processor to discard them, but it would be a pity for the LP data that would be lost…

Furthermore, I wonder if one can infer some information from the very outcomes of the TII in ready state. With all the voltages down (so no gain, no phosphor involved), still the CCD experiences a dark current, and this turns out in "images" from the TII that maybe do not have physical meaning but can have an "engineering" meaning. A couple of quick examples can be seen in attachment (very bad in cosmetics, I can do better than that :)): for example one can see that pixels at the borders of the maps (closer to the CCD supporting frame?) seem to be much more excited than the others...I'm maybe telling nonsense, and this is perhaps a well known effect, in line with the CCD characterization properties, but as we have now few days and

several orbits during which all three TIIs were powered down, one can think to analyse the CCD behaviour in "blind" conditions and see whether some sort of degradation is at play, or maybe some other effect. Is it possible, for example, that some light could penetrate directly to the CCD because of a non perfect isolation of the sensor? If so, this effect should be detectable with the high voltages off. Once they are on, the residual light can excite photo-electrons in the MCP and possibly cause the halo that we often observe in the image anomaly, but then all the environment is "contaminated" by several different effects, the sensors get blurred and it becomes very difficult to characterize the problem. In conclusion: is it worth, in your opinion, to study the raw images during this TII ready state time and looking at the counts distributions as a function, e.g., of the zenith angle?

Finally, I want just to report you a strange thing occurring during the TII ready state time on SW B: for this S/C the phosphor and MCP voltage did not go to exactly zero (as for the other two S/C), but the MCP voltage set around 3.5 V (with oscillations of few tenths degrees around that value) and the phosphor set around 11.5 V (with oscillations up to 1.5 deg around that value) for both sensors. I saw this with my monitoring tools and FOS confirmed from their telemetry monitoring. Is this something we have to worry about?”

As a complement to the analysis above, a couple of plots have been sent to the EFI team: A couple of examples of raw images for S/C A during ready state (Figure 32: 2014-08-08 01:45, H sensor; Figure 33: 2014-08-08 01:45, V Sensor), which show the feature explained in the message above.

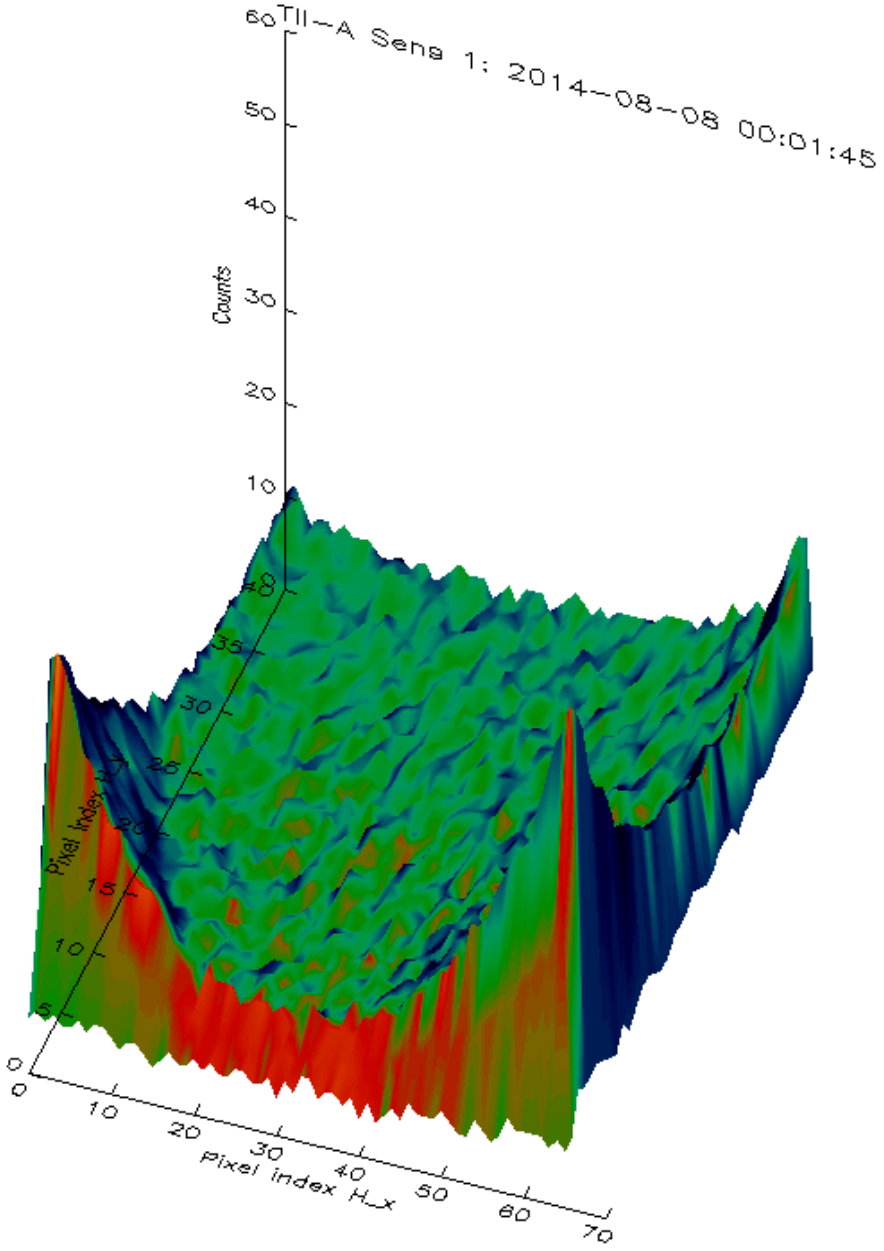

Figure 32: TII raw image example for S/C A, H sensor

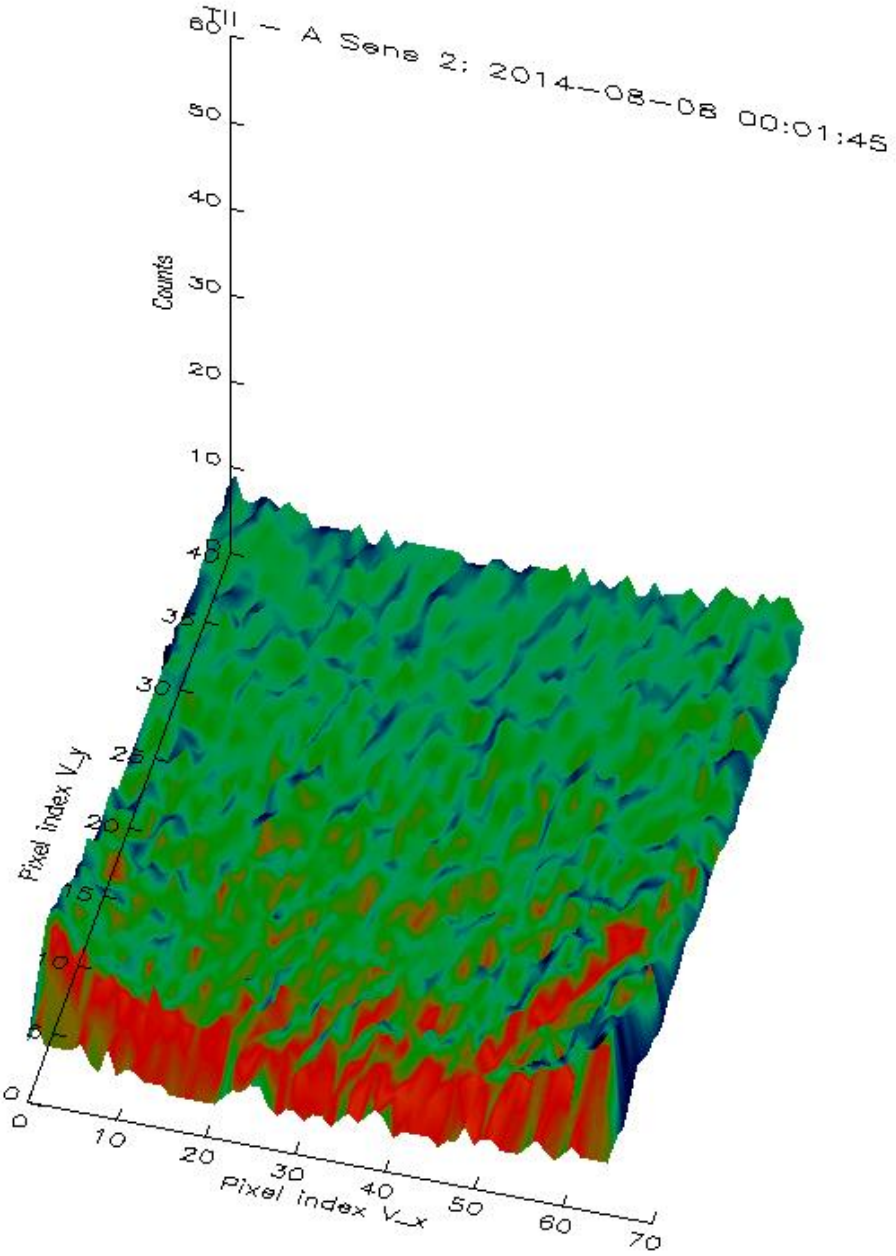

Figure 33: TII raw image example for S/C A, V sensor

We have also checked the TII flag behaviour during the S/C ready state time, and the results can be seen below, in Figure 34: for the whole period, the flag value is above 20, which means "Use with caution, errors may be underestimated", but never reach 40 which would mean "not suitable for scientific use".

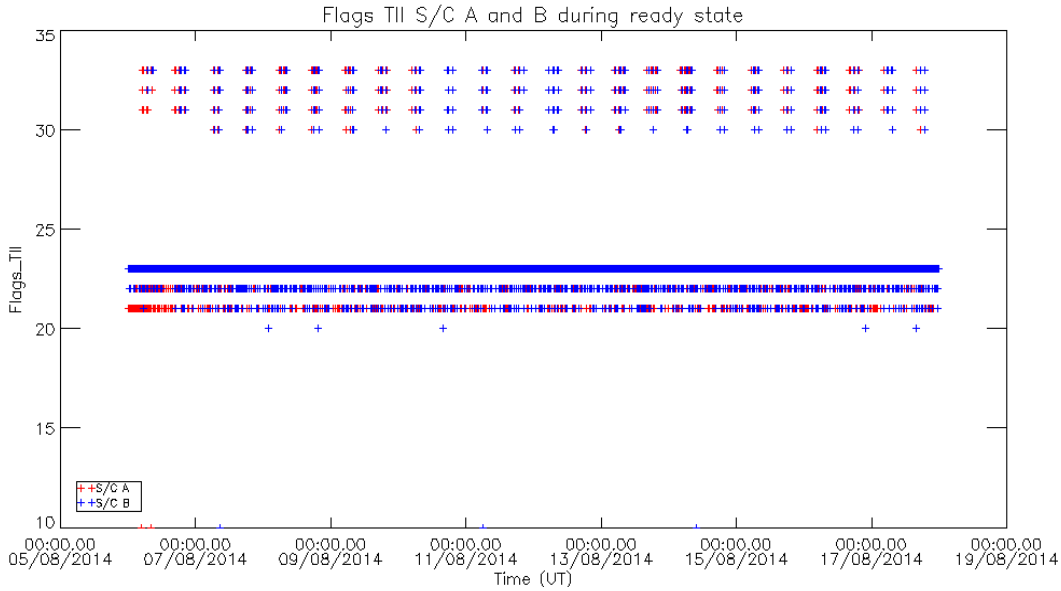

Figure 34: TII quality flags for S/C A and B during ready state

Here follow the replies by Dave Knudsen and Johnathan Burchill, few days later:

1) Dear Gigi,

I'll ask Johnathan to comment on the flag value that results for dark images.

The bright corners are an effect that we saw even before the the first power-up on orbit.

We are pretty sure they are a thermal effect. The circular fiber-optic tapers are glued onto the square FO windows of the CCDs; the tapers have better cooling paths and cool the central portion of the CCD windows, leaving the exposed corners running hotter and leading to more dark signal there. Actually it was Nico Stricker who suggested this explanation during commissioning. These hot areas are masked out of the on-board moment calculations.

> but it would be a pity for the LP data that would be lost…

Under no circumstances should the LP products be suppressed when the TII sensors are in ready state.

The "off" voltage values are not of concern. There was no need and no requirement to set the zero level accurately, so this is in all likelihood just an arbitrary small offset in the monitor circuits, with some thermal fluctuations. I suppose it could also represent small residual charge in the output filter capacitors of the HV supplies following operation, but this also of no concern.

Best regards,

David”

2) Hi Gigi,

Thank you for the email. You are right that the TII quality flag should be 40 when EFI is in ready state.

As a check, I ran the prototype with one minute of Swarm A Level 0 data. I'm getting warnings that the curve fit equation is badly conditioned. Consequently, the prototype writes NaNs for ion velocity, ion temperature, and electric field and their errors. The quality flags, on the other hand, are mostly 10 with a few 30.

The operational processor reproduces neither the NaNs (which would appear as machine max double = 3.40282e38) nor TII flags from the prototype. But the prototype should be revised to give TII quality=40 when in ready state, or rather more generally when Level 0 data derived from dark CCD images are fed to the processor, which can occur also in active state.

I will have to get back to you with a proposal to update the prototype flag calculation.

Best regards,

Johnathan

End of Document