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IDEAS+ Swarm Weekly Report : 25/08/2014 – 31/08/2014

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period 25 to 31 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	08 Sep 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 following way:

1. If triggered by ESA Eohelp or within the Service: IDEAS+ action and ticketing system (<http://requests-sppa.serco.it/RT3/index.html>).
2. If triggered by IDEAS+ Swarm team or other entities:
 - 2a. If the observation/analysis leads to an anomaly to be addressed to the processor provider (GMV): SPR on EO ARTS (<https://arts.eo.esa.int>), **SWL1L2DB** project.



2.b. If the observation/analysis does not lead to an anomaly or the investigation shall be escalated to other entities (PLSO/industry, ESL, PDGS): Action tracked on EO ARTS, **SW-IDEAS** project, then addressed to the proper tracking system if needed (e.g. JIRA for ESLs, SW-CP-AR project on EO ARTS for PDGS)

Information on Level 1B Swarm products can be found in [RD.4].

1.1 Current Operational configuration of monitored data:

- Processor Version: L1BOP 3.11p2
- L0 input products baseline: 02
- L1B baseline: 03 (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 2 – Cat 2 baseline: 01
- 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
- [RD.8] Planned Updates for Level 1b, SW-PL-DTU-GS-008, Rev: 1dC.



2. SUMMARY OF THE OBSERVATIONS

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

With respect to the previous reporting period, the following updates have to be reported:

1. VFM S/C C switched off between 25/8 and 26/8 2014

The Vector Field Magnetometer on the Swarm C satellite was temporarily switched off from 05:52 UTC on 25 August 2014, until 11:25 UTC on 26 August 2014.

On 25 August, the VFM stopped producing telemetry and the On-board Computer automatically triggered the the instrument switch-off at 05:52 UTC.

The spacecraft was near the North Pole and Space Weather did not report any special event. A careful verification of the instrument and platform house-keeping parameters and science data just before the anomaly did not highlight any significant event or conditions. The VFM instrument team at DTU (i.e. the instrument manufacturers) explained that the most probable cause is the FPGA being hit by a particle and the watchdog being directly affected by a single event without the capacity to automatically recover. This scenario is actually not unexpected, and its probability of occurrence is very low (i.e. around once per year).

The investigation team concluded that the instrument could safely be powered on again and this has been performed on 26 August 2014, at 11:25 UTC.

The instrument operation is now nominal.

2. Status of EFI – TII recent operations after switching in Active State.

On August 21, the TII on all the three S/C have been put in Active State. On Swarm C the phosphor voltage has been risen up to 5000 V. A gain map calibration has been executed on all three S/C, and new gain maps have to be delivered in the future by UoC., which should improve the images background and allowing a better investigation of the image anomaly in a cleaner environment. The next TII Anomaly Review Board is scheduled for September 11th, 2014.

3. Status of EFI – Langmuir Probes: recent updates.

S. Buchert from IRF reported on the quality of the Langmuir Probes observations during July and August 2014:

"Dear all,

just FYI, LPs on all satellites seem to be ok, please see attached plots.

On this overview level Ne and Te look more or less as expected.

Swarm C has over large periods a much more positive Vs than A and B.

Jumps in V_s , probably at sunset/rise, are still obvious. A more systematic investigation of these issues is in work.

Best regards,

Stephan"

See an example of the mentioned plots in Figure 1 below:

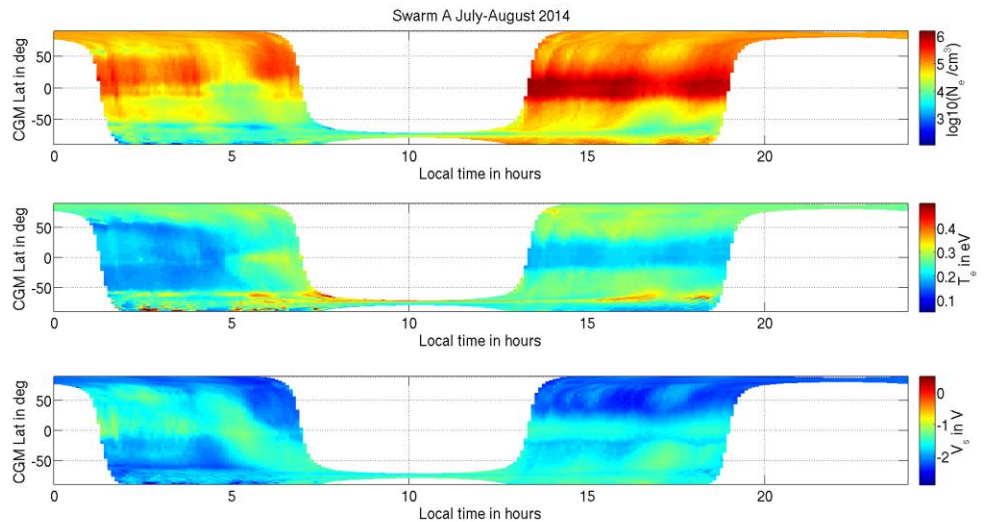


Figure 1: Swarm A Langmuir Probe measurements during July-August 2014

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].

With respect to the previous reporting period, the following update has to be reported: It has been suggested by the STR instrument group to include additional CHU attitude samples in the combination of attitude solutions; this possibly requires the introduction of a new CCDB parameter as described in [RD.8], and investigations are ongoing for evaluating the impacts of including these change in the next L1BOP delivery. Moreover, ESA wants a clear and full alignment between the envisaged evolutions of the L1B prototype processors and the operational implementations.

An update of [RD.8] has been requested by ESA to the ESL, and the foreseen final delivery of the Operational Processor by GMV date is therefore postponed to the 13th of October.

2.3 Quality Working Group and Cal/Val Coordination

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 35 (25-31/08/2014)

During the monitored week the following events have been found and investigated:

1. **A telemetry gap for S/C B on day 30/08** caused the loss of about 1 minute of data on all the instruments dataset. The effect on the Level 1B products has been the loss of some attitudes (26 values flagged as 255) and consequent failures in the B_{NEC} computation ($B_{NEC} = \text{exactly } 0$ for such records).
2. **Two observations of attitude rejection** occurred on S/C A (20 attitudes rejected) and S/C C (82 attitudes rejected) the 31/08/2014, caused by simultaneous occurrence of Big Bright Objects on all the three camera units of the S/C, or invalid measurements, or attitude computed with insufficient accuracy. The rejections are nominal, i.e. follow the nominal rules given by processing algorithms and cannot be therefore classified as anomalies. The observations are nonetheless tracked in the IDEAS+ ARTS repository for purposes of monitoring instruments health.
3. **An anomaly in the MOD orbits and GPS on-board solution difference has been found for S/C B, 28/08:** an error in the MOD determination is observed, that grows close to 18 m at the end of the day. The effect seems to be cumulative and starts from about 8 p.m. This has been tracked through SWL1L2DB-9.

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.

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 0.002 % throughout the month of August): following the algorithms experts, this is expected and does not cause any worry for the time being.



3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

SW-IDEAS-21: OBS_ROUTINE: 30/08/2014, S/C B telemetry gaps between 3:52 UT and 5:24 UT.

156 telemetry gaps are present in:

SW_OPER_TMB_VC4KIR_20140830T110032_20140830T111802_0001

telemetry file, affecting the following Level 0 products:

SW_OPER_ACCBNOM_0_20140829T161008_20140830T110707_0201
 SW_OPER_ASMBVEC_0_20140829T161009_20140830T110708_0201
 SW_OPER_EFIBNOM_0_20140829T161008_20140830T110707_0201
 SW_OPER_GPSBGPS_0_20140829T161302_20140830T110202_0201
 SW_OPER_GPSBNV_0_20140829T161010_20140830T110709_0201
 SW_OPER_GPSBOBS_0_20140829T161010_20140830T110709_0201
 SW_OPER_HK_BNOM_0_20140829T161010_20140830T110710_0201
 SW_OPER_STRBNOM_0_20140829T161009_20140830T110708_0201
 SW_OPER_VFMBNOM_0_20140829T161008_20140830T110707_0201

Gaps are present in the products above between 3:52 and 5:24 UT whose maximum overall duration is about 60 seconds. An example of gaps locations is shown in Figure 2, for the STR L0 product, and in Table 1 one can see the list of such gaps.

As a consequence, spikes, out-of-range/invalid values and gaps are observed in the derived L1B products.

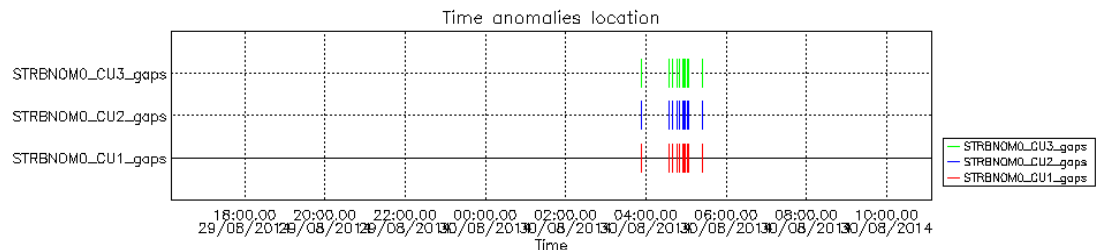


Figure 2: telemetry gap locations for S/C B, August 30. Example showing gaps in STRBNOM_0 product, Camera Unit 1.

Start Gap	End Gap	Duration (s)
30AUG2014 03:52:16	30AUG2014 03:52:27	11.000000
30AUG2014 04:34:49	30AUG2014 04:34:51	2.000000
30AUG2014 04:38:53	30AUG2014 04:38:55	2.000000
30AUG2014 04:46:34	30AUG2014 04:46:37	3.000000
30AUG2014 04:49:32	30AUG2014 04:49:38	6.000000
30AUG2014 04:50:31	30AUG2014 04:50:33	2.000000



30AUG2014 04:55:09	30AUG2014 04:55:11	2.0000000
30AUG2014 04:56:50	30AUG2014 04:56:59	9.0000000
30AUG2014 04:58:08	30AUG2014 04:58:10	2.0000000
30AUG2014 05:02:39	30AUG2014 05:02:41	2.0000000
30AUG2014 05:02:45	30AUG2014 05:02:47	2.0000001
30AUG2014 05:03:30	30AUG2014 05:03:32	2.0000000
30AUG2014 05:04:29	30AUG2014 05:04:31	2.0000000
30AUG2014 05:23:58	30AUG2014 05:24:00	2.0000000

Table 1 : list of telemetry gaps for STRBNOM_0_, CHU1, 30/08/2014.

3.2 Orbit and Attitude Products

The following events have to be reported:

Observation ID	Description	Affected parameters	Sect. of Obs. description	Sect. of Obs. analysis
SW-IDEAS-20	OBS_ROUTINE: 31/08/2014, STR S/C A out of range	Flags_q, quaternions, B _{NEC}	3.2.1.2	4.2
SWL1L2DB-9	L1B: MOD - NAV1B discrepancies on day 20140827- SAT B-0301	MOD position and velocity	3.2.2.1	4.3
SW-IDEAS-23	OBS_ROUTINE: 31/08/2014, STR S/C C out of range	Flags_q, quaternions, B _{NEC}	3.2.3.2	3.2.3.2

Table 2: list of events to be reported in the monitoring for Week 35: 25/8 - 31/08/2014

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:
 - o 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.

3.2.1 Swarm A

3.2.1.1 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 is, on average, around 1.5 m.

Swarm A, 25-31/08/2014, Position difference			
Day	Average Difference (m)	Maximum difference (m)	Notes
25/08	0.11	- 8.4 (Z), 7.5 (Z)	
26/08	0.09	+/- 7 (Z)	
27/08	0.13	-9.6 (Z), 10.2 (Z)	
28/08	0.1	-9 (Z), 12 (Z)	
29/08	0.13	-6.3 (Z), 7.5 (X)	
30/08	0.37	-15 (Z), 9 (X)	
31/08	0.07	+/- 8 (Z and X)	

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

Below some plot example follows of such differences taken at the beginning of the week (25/8, Figure 3), in the middle (28/8, Figure 4) and at the end (31/8, Figure 5). The values are given in Km.

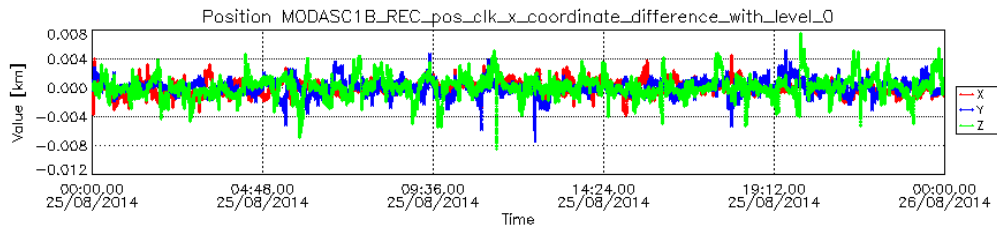


Figure 3: Difference MOD-GPSNAV, sc A, 25/08/2014

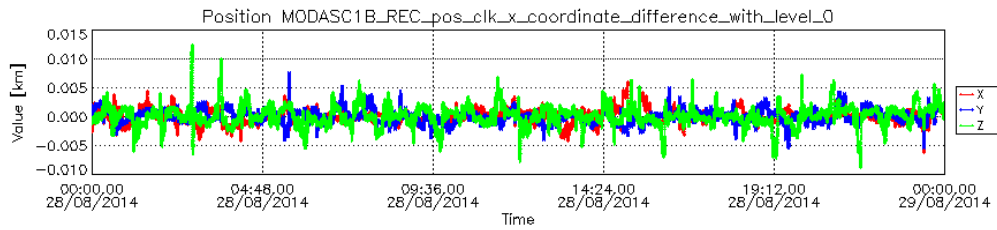


Figure 4: Difference MOD-GPSNAV, sc A, 28/08/2014

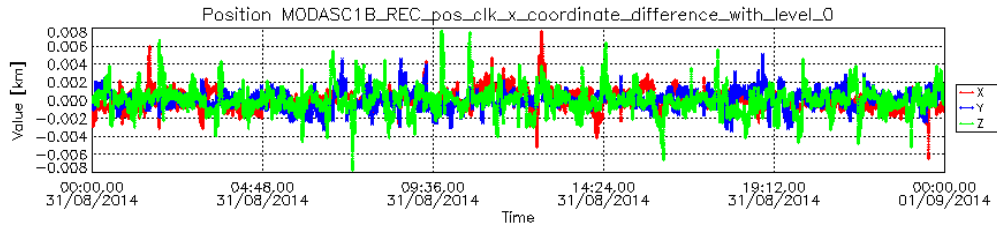


Figure 5: Difference MOD-GPSNAV, sc A, 31/08/2014

3.2.1.2 Attitude observations

- **SW-IDEAS-20**

Affected product:

SW_OPER_STRAATT_1B_20140831T000000_20140831T235959_0301

20 seconds out of range (Flags_q=255, no attitude available).

See Table 4 for details.

Start Out-of-range	Stop Out-of-range	Duration (s)	Value
31AUG2014 06:43:05	31AUG2014 06:43:15	11	255
31AUG2014 14:33:22	31AUG2014 14:33:30	9	255

Table 4: Attitudes out-of-range, S/C A, 31/08/2014

3.2.2 Swarm B

3.2.2.1 Position Statistics

In Table 5 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 is, on average, around 1.5 m (with the exception of day 27/8 because of the anomaly described below).



Swarm B, 25-31/08/2014, Position difference			
Day	Average Difference (m)	Maximum difference (m)	Notes
25/08	0.085	-9.4 (Z), 7.5 (Z)	
26/08	0.11	-9 (Z), 7 (Z)	
27/08	0.3	-14 (Z), 21 (Z)	Anomaly. Max St. Dev. = 3.9 m on Z comp.
28/08	0.15	-8.4 (Z), 10.5 (Z)	Anomaly no more present: only few spikes as usual
29/08	0.14	+/- 7 (Z)	
30/08	0.11	-57 (Z), 102.3 (X)	A couple of big spikes show up, corresponding to telemetry gaps in GPSNAV_0_data (Obs. SW-IDEAS-21 , see Sect. 3.1)
31/08	0.09	+/- 8 (Z)	

Table 5: Swarm B, difference between MOD and on-board solution positions.

SPR SWL1L2DB-9: Anomaly found in day 27/8: starting from 19 UT the solution difference oscillates in quasi-sinusoidal way, reaching +/- 20 m peak to peak. This causes the standard deviation to increase above 3.5 m on all components with a maximum on the Z component.

Below follow some examples plots of such differences taken at the beginning of the week (25/8, Figure 6), **the day of the anomaly reported above (27/8, Figure 7)**, and the day after (28/8, Figure 8), and at end of the week (31/8, Figure 9). Values are given in Km.

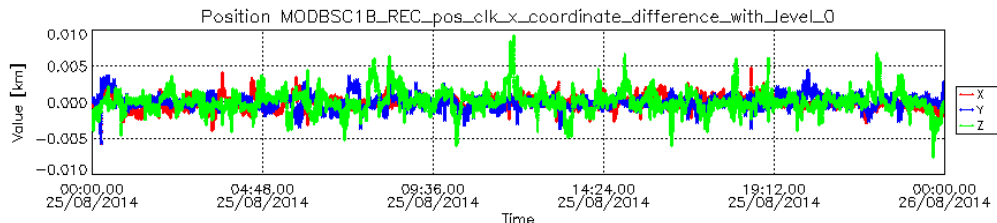


Figure 6: Difference MOD-GPSNAV, sc B, 25/08/2014

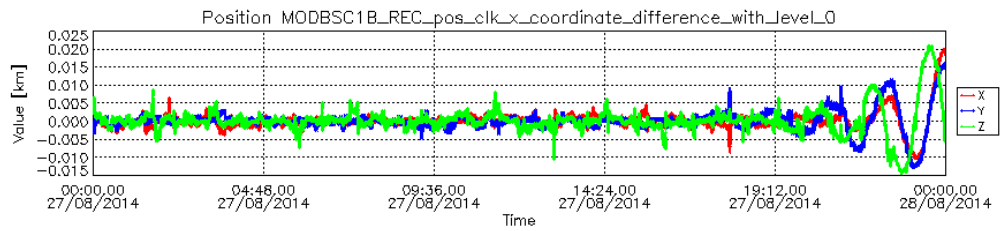


Figure 7: Difference MOD-GPSNAV, sc B, 27/08/2014. The anomalous behaviour can be seen starting from 19 UT.

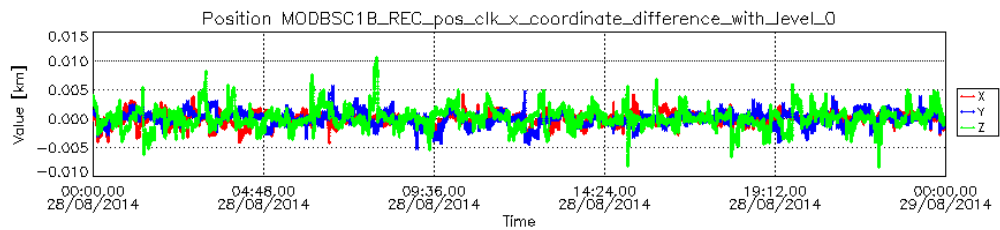


Figure 8: Difference MOD-GPSNAV, sc B, 28/08/2014

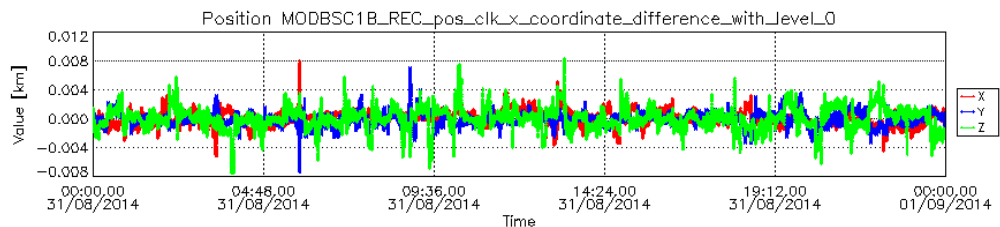


Figure 9: Difference MOD-GPSNAV, sc B, 31/08/2014

3.2.2.2 Attitude observations

The observation **SW-IDEAS-21** about telemetry gaps (Sect. 3.1) on day 30/08 affects the STR data: few out-of-range Flags_q (255) are observed corresponding to such gaps.

3.2.3 Swarm C

3.2.3.1 Position Statistics

In Table 6 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 is, on average, around 1.5 m.

Swarm C, 25-31/08/2014, Position difference			
Day	Average Difference (m)	Maximum difference (m)	Notes
25/08	0.14	+/- 11 (Z)	



Swarm C, 25-31/08/2014, Position difference			
26/08	0.13	-8 (Z), 7.4 (Z)	
27/08	0.09	-9 (Z), 11 (Z)	
28/08	0.032	-9 (Y), 11.5 (Z)	
29/08	0.13	-7 (Z), 8.4 (Z)	
30/08	0.13	-7 (Z), 8.4 (Z)	
31/08	0.08	+/- 8 (Z)	

Table 6: Swarm C, difference between MOD and on-board solution positions.

Below some plot example of such differences follows, taken at the beginning of the week (25/8, Figure 10), in the middle (28/8, Figure 11) and at the end (31/8, Figure 12). The values are given in Km.

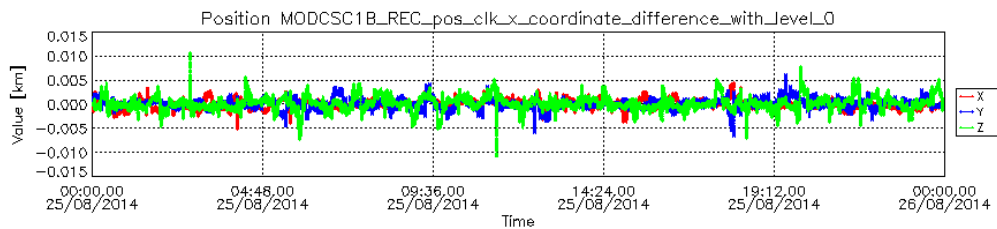


Figure 10: Difference MOD-GPSNAV, sc C, 25/08/2014

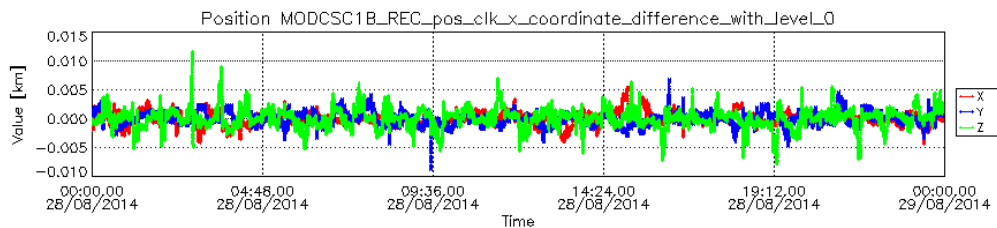


Figure 11: Difference MOD-GPSNAV, sc C, 28/08/2014

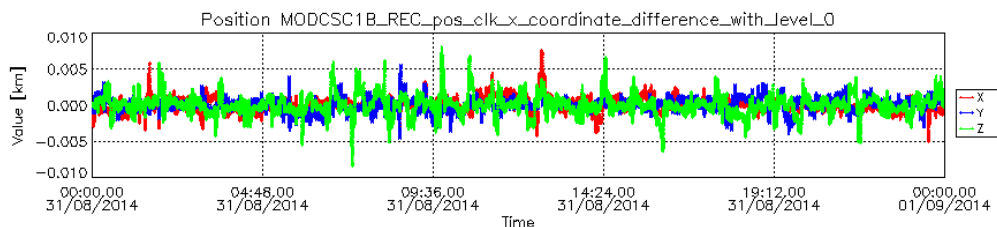


Figure 12: Difference MOD-GPSNAV, sc C, 31/08/2014

3.2.3.2 Attitude observations

- **SW-IDEAS-23**

Affected product:

SW_OPER_STRCATT_1B_20140831T000000_20140831T235959_0301

82 seconds out of range (Flags_q=255, no attitude available).



See Table 7 for details:

Start Out-of-range	Stop Out-of-range	Duration (s)	Value
31AUG2014 14:41:04	31AUG2014 14:41:29	26	255
31AUG2014 16:15:08	31AUG2014 16:15:14	7	255
31AUG2014 17:49:11	31AUG2014 17:49:21	11	255
31AUG2014 19:23:04	31AUG2014 19:23:19	16	255
31AUG2014 20:57:13	31AUG2014 20:57:21	9	255
31AUG2014 22:30:51	31AUG2014 22:30:57	7	255
31AUG2014 22:31:40	31AUG2014 22:31:45	6	255

Table 7: Attitudes out-of-range, S/C C, 31/08/2014

As for Observation **SW-IDEAS-20**, we performed further analysis and verified that: 1) No telemetry gaps corresponded to such out-of-range values, 2) the non calculated attitudes are due to a combination of BBO occurrences, invalid measurements and quaternions calculated with insufficient accuracy. As for the event described within **SW-IDEAS-20**, **the observation is therefore not an anomaly and the attitude rejections are expected.**

3.3 Magnetic Products

The magnetic products **look nominal** during the monitored period. The effects of data gaps and rejected attitudes (**SW-IDEAS-20**, **SW-IDEAS-21** and **SW-IDEAS-23**) are observed in magnetic data as “zero” values in the vector field time series and few isolated spikes in the ASM-VFM differences.

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 $|\mathbf{B}_{NEC}| - F$ and recording of daily maximum variations. If +/- 5 nT are exceeded on a given day, an alert is raised. Daily PSD analysis and monitoring of the spectrum peaks.
- 2nd 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/s²) an anomaly is opened.
- TCF.VFM parameters monitoring (VFM calibration parameters): weekly series of biases, scales, non-orthogonality factors and RMS.

3.3.1 Swarm A

3.3.1.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative F time series for S/C A (31/08/2014) can be seen in Figure 13 below.

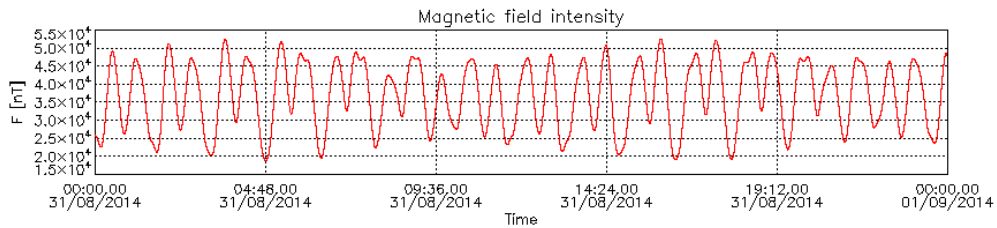


Figure 13: Time series of magnetic field intensity, F, for 31/08/2014, S/C A

3.3.1.2 VFM-ASM anomaly

The differences between the module of 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 some plot example of such differences follows, taken at the beginning of the week (25/8, Figure 14), in the middle (28/8, Figure 15) and at the end (31/8, Figure 16).

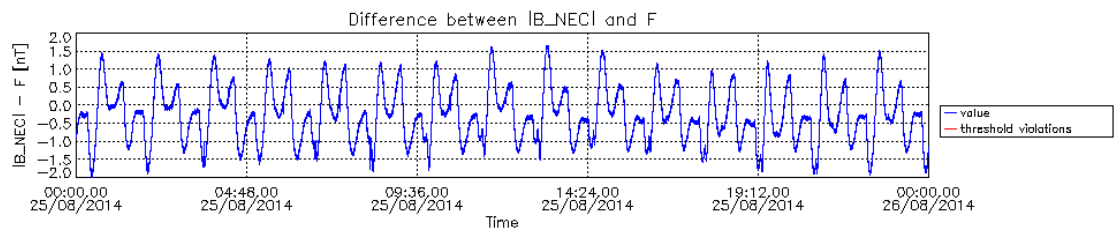


Figure 14: $|B_{NEC}| - F$ for S/C A, 25/08/2014

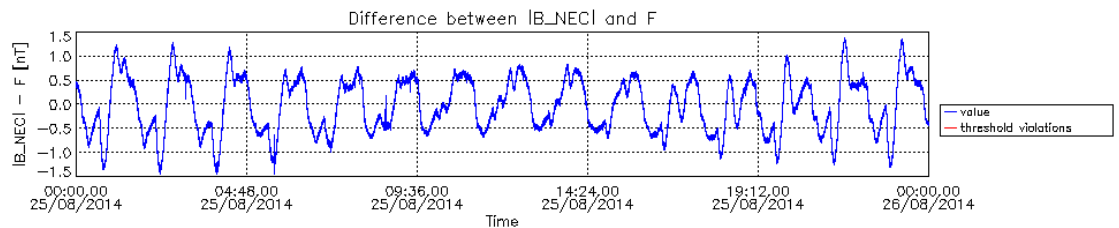


Figure 15: $|B_{NEC}| - F$ for S/C A, 28/08/2014

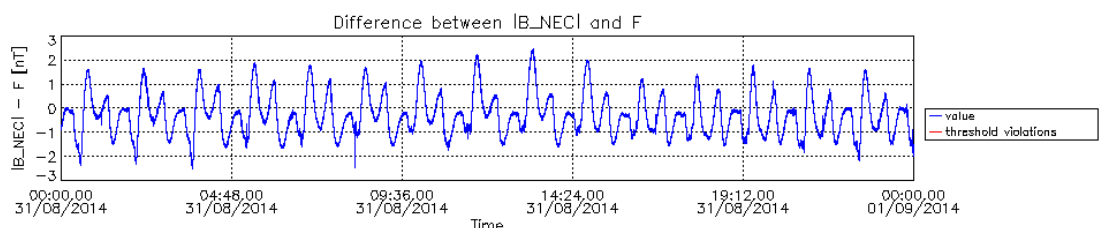


Figure 16: $|B_{NEC}| - F$ for S/C A, 31/08/2014

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

3.3.1.3 2nd difference analysis

Nothing relevant to report.



3.3.1.4 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm A, for the whole month of August 2014: Biases (Figure 17), Scales (Figure 18) and Non-orthogonalities (Figure 19). Each group is actually a three-component vector in the compact detector coil frame. The parameters are steady and constant during the month, only small decreases observed in the X and Z scale components (of about 0.001%).

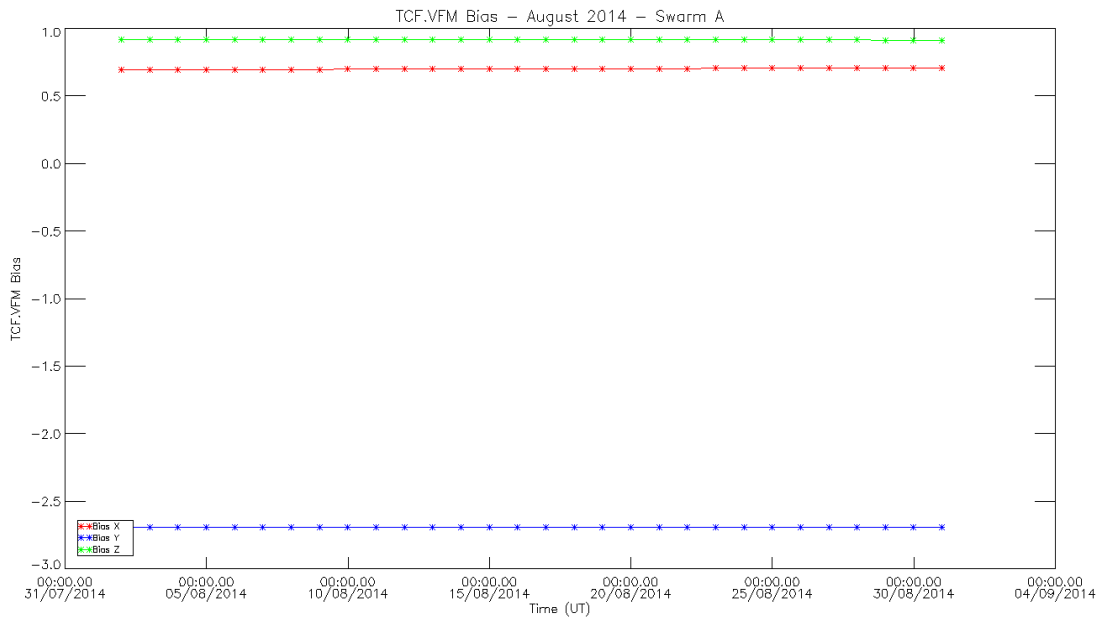


Figure 17: TCF.VFM Biases for S/C A, August 2014.

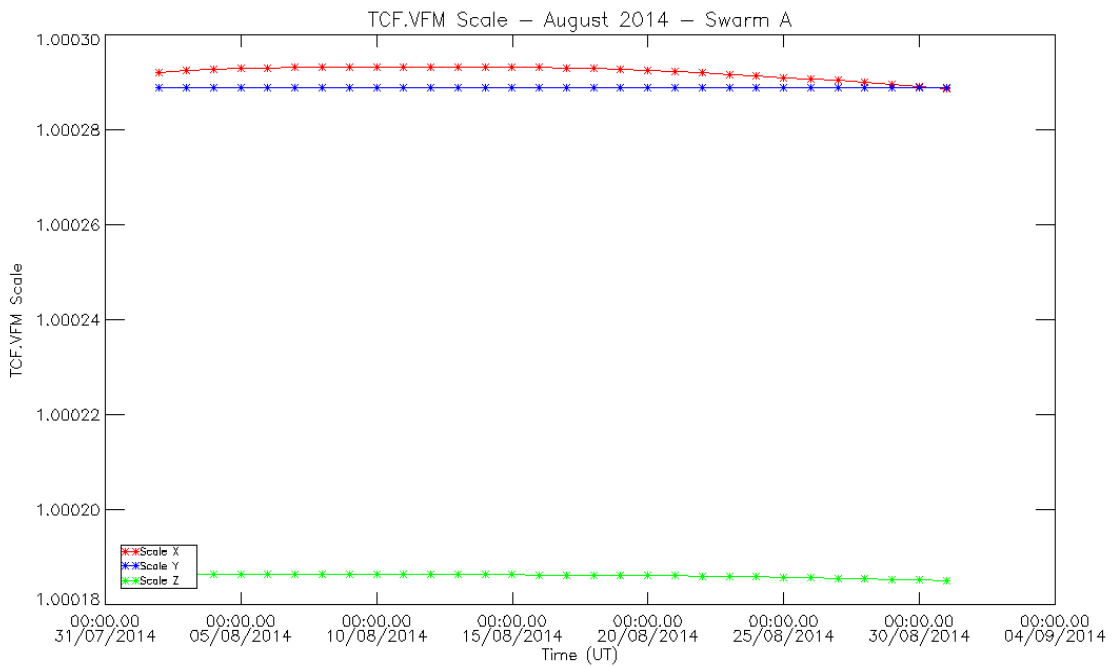


Figure 18: TCF.VFM Scales for S/C A, August 2014.

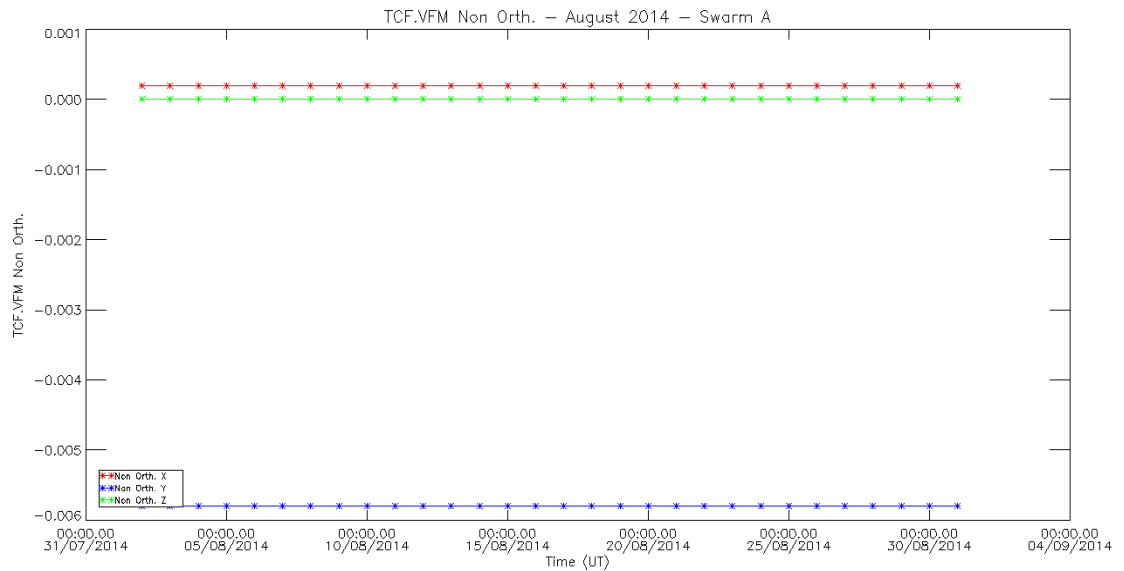


Figure 19: TCF.VFM Non-Orthogonalities for S/C A, August 2014.

3.3.2 Swarm B

3.3.2.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative F time series for S/C B (31/08/2014) can be seen in Figure 20 below.

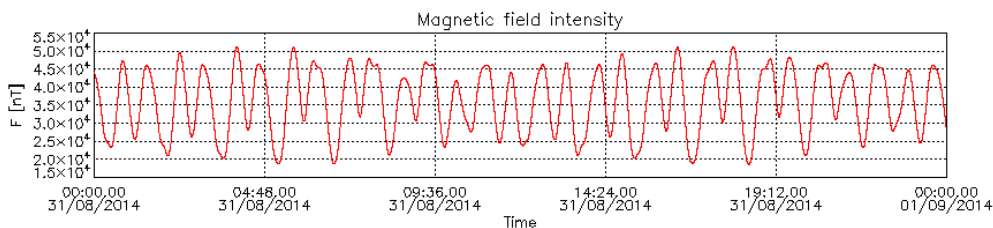


Figure 20: Time series of magnetic field intensity, F, for 31/08/2014, S/C B

3.3.2.2 VFM-ASM anomaly

The differences between the module of 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 some plot example follows of such differences taken in the middle of the week (25/8, Figure 21), at the middle (28/8, Figure 22), and at the end (31/8, Figure 23).

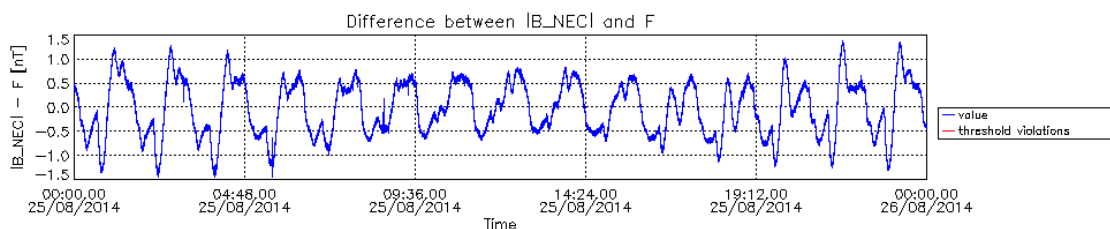


Figure 21: $|B_{NEC}| - F$ for S/C B, 25/08/2014

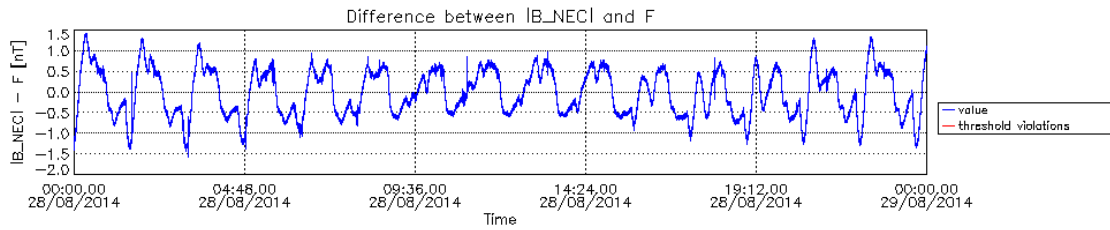


Figure 22: $|B_{NEC}| - F$ for S/C B, 28/08/2014

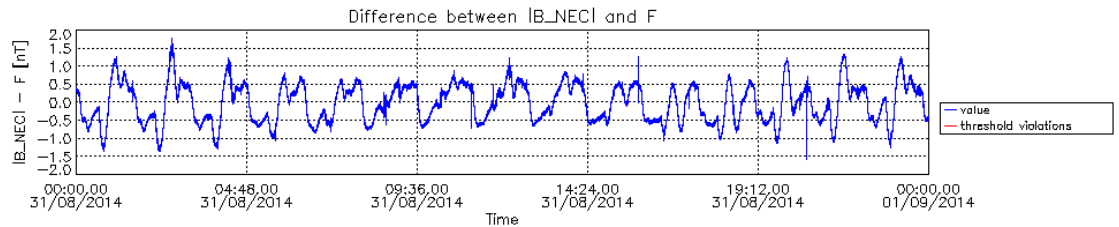


Figure 23: $|B_{NEC}| - F$ for S/C B, 31/08/2014

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

3.3.2.3 2nd difference analysis

Nothing relevant to report.

3.3.2.4 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm B, for August 2014: Biases (Figure 24), Scales (Figure 25) and Non-orthogonalities (Figure 26). Each group is actually a three-component vector in the compact detector coil frame. The parameters are steady and constant during the month, only small decreases observed in the X scale component (about 0.002%).

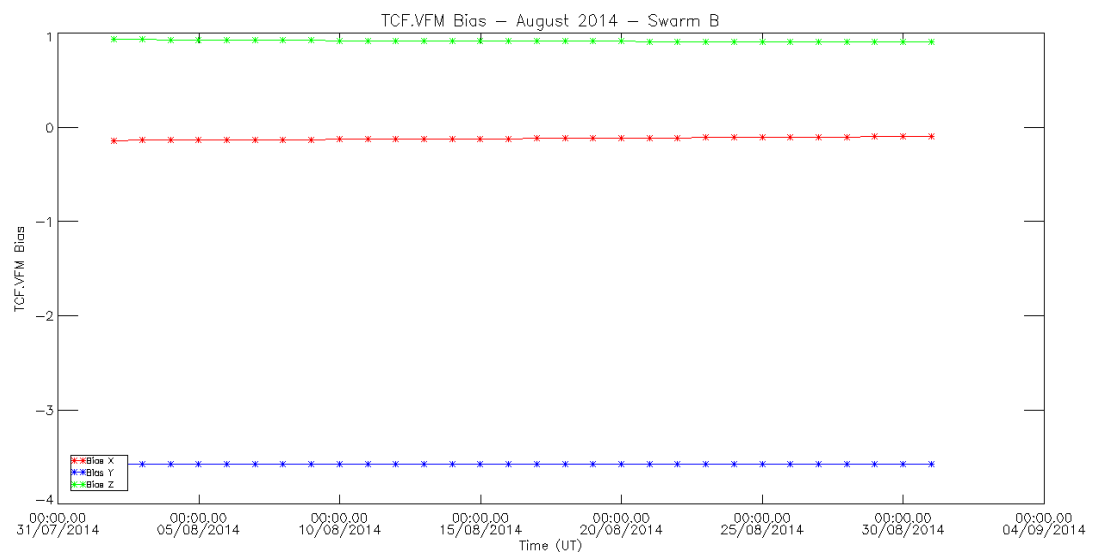


Figure 24: TCF.VFM Biases for S/C B, August 2014.

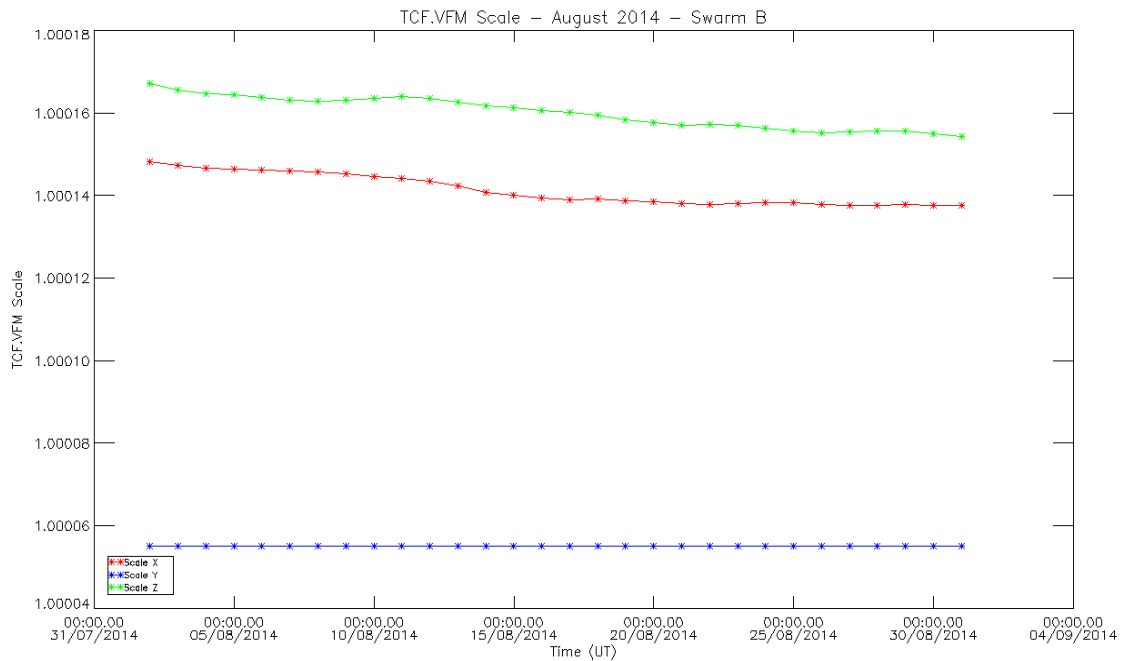


Figure 25: TCF.VFM Scales for S/C B, August 2014.

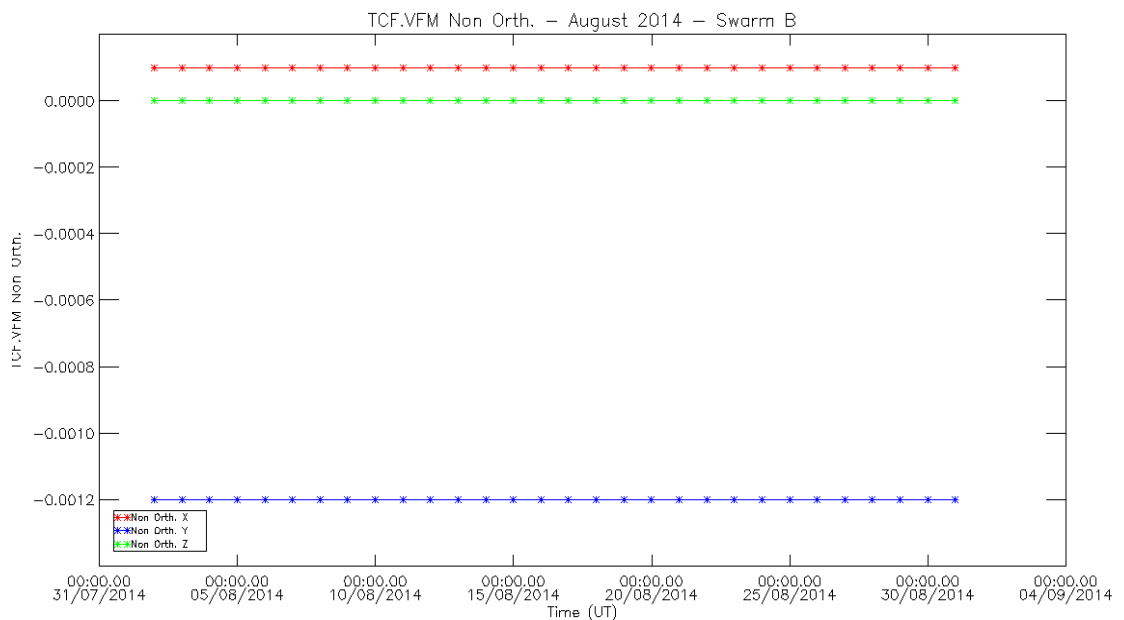


Figure 26: TCF.VFM Non-Orthogonalities for S/C B, August 2014.

3.3.3 Swarm C

3.3.3.1 Magnetic time series visual inspection

From 25/08 05:54 to 26/08 11:30 UT the VFM data for Swarm C was not available because of the instrument switch-off anomaly described in Sect. 2.1. An example of representative F time series for S/C C (31/08/2014) can be seen in Figure 27 below.

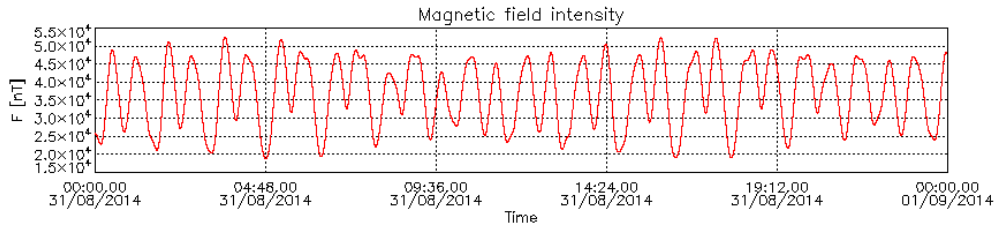


Figure 27: Time series of magnetic field intensity, F, for 31/08/2014, S/C C

3.3.3.2 VFM-ASM anomaly

The differences between the module of 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 some plot example follows of such differences taken at middle of the week (28/8, Figure 28), and at the end (31/8, Figure 29).

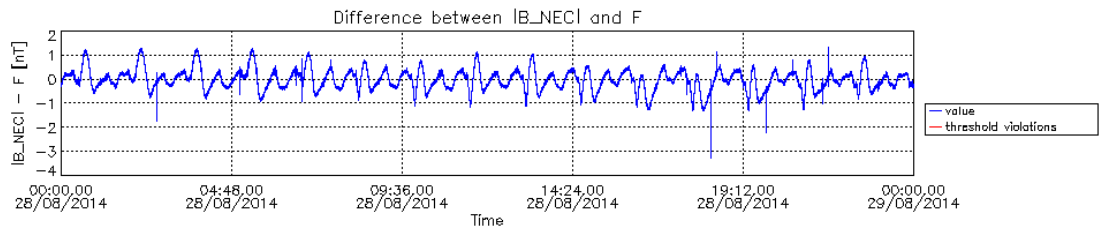


Figure 28: $|B_{NEC}| - F$ for S/C C, 28/08/2014

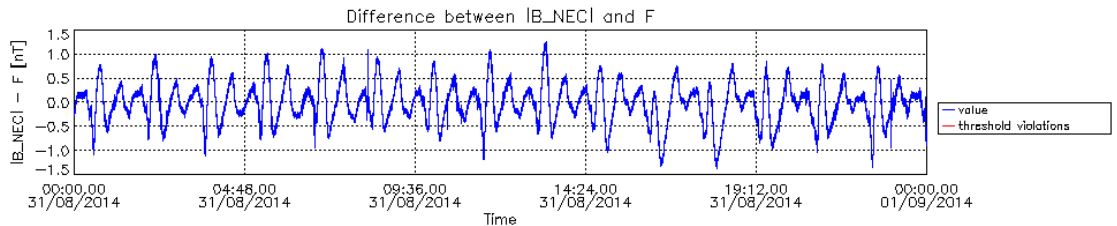


Figure 29: $|B_{NEC}| - F$ for S/C C, 31/08/2014

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

3.3.3.3 2nd difference analysis

Nothing relevant to report.

3.3.3.4 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm C, during August 2014: Biases (Figure 30), Scales (Figure 31) and Non-orthogonalities (Figure 32). Each group is actually a three-component vector in the compact detector coil frame. The parameters are steady and constant during the month, with an exception in the X scale component, which slowly decreases reaching a level of about 0.002% lower than at the beginning of the month.

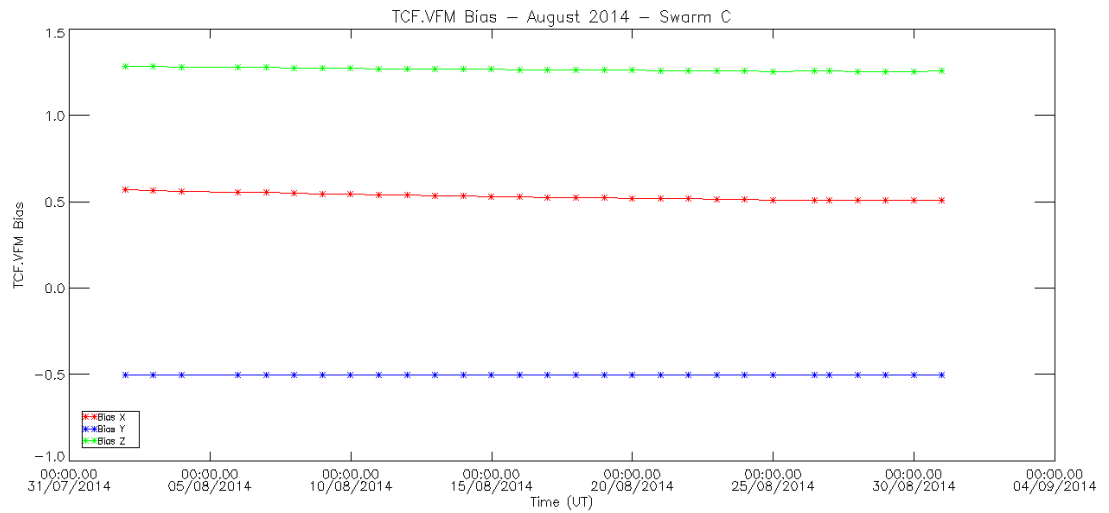


Figure 30: TCF.VFM Biases for S/C C, August 2014.

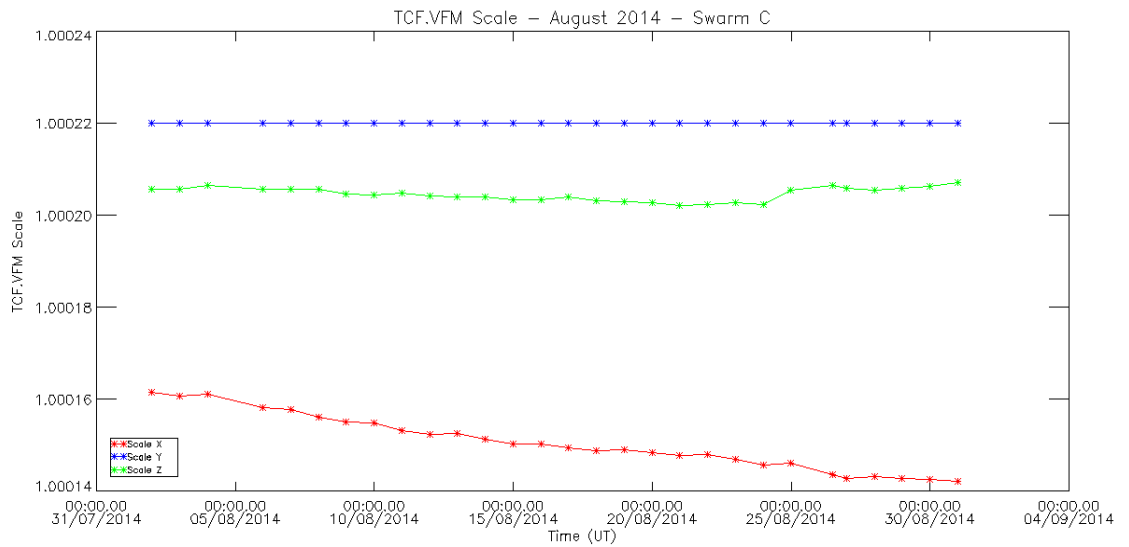


Figure 31: TCF.VFM Scales for S/C C, August 2014.

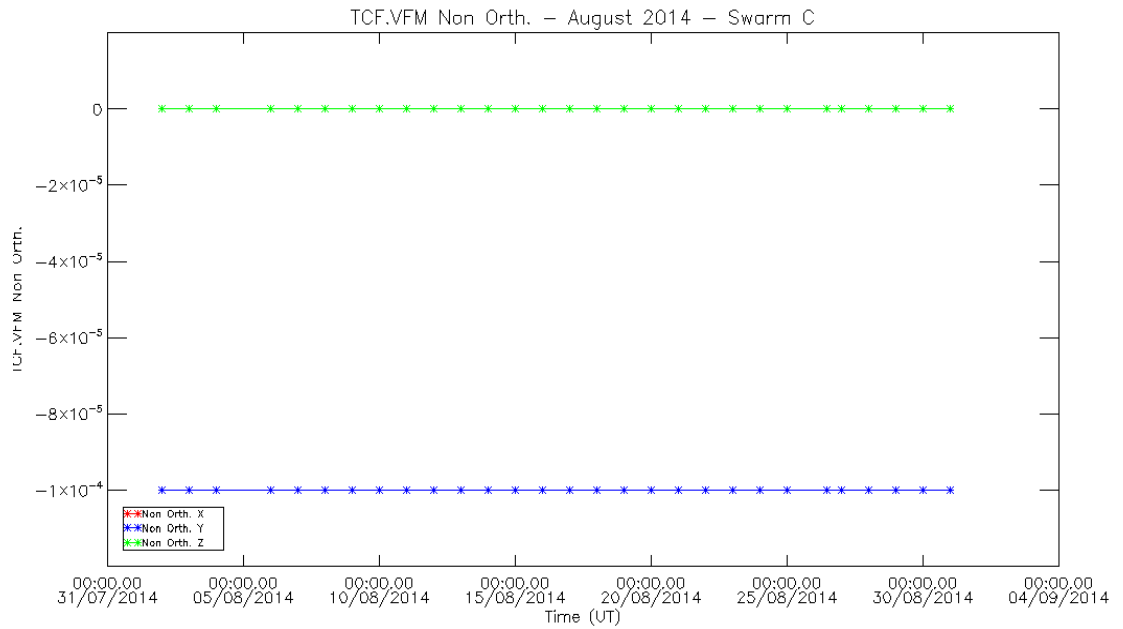


Figure 32: TCF.VFM Non-Orthogonalities for S/C C, August 2014.

3.3.4 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 33 summarizes the RMS behaviour for all S/C during August 2014.

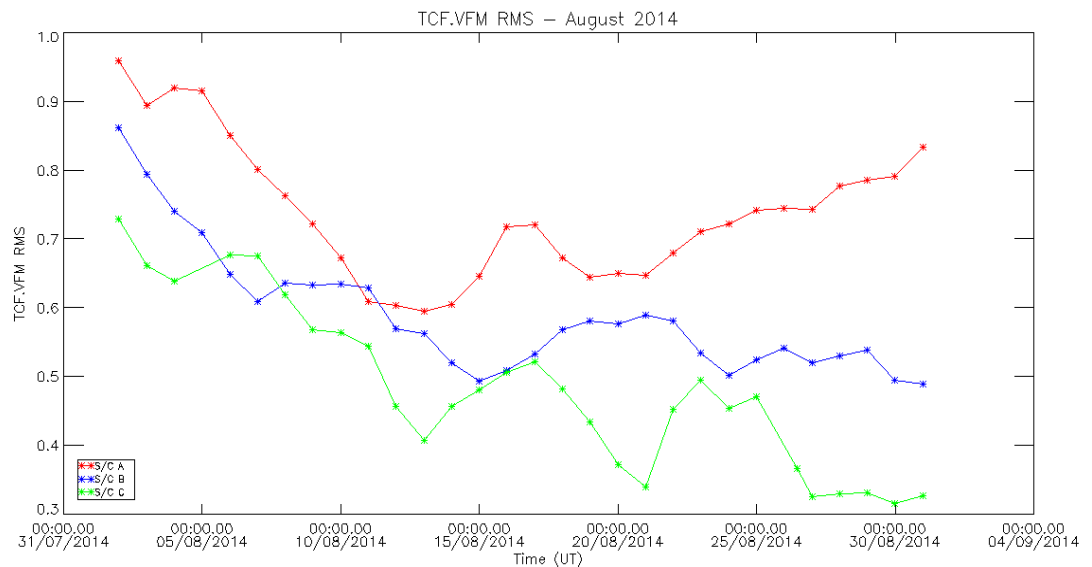


Figure 33: weighted RMS of the residuals after the TCF estimation, all S/C, August 2014.

4. ON-DEMAND ANALYSIS

4.1 VFM S/C C switched off between 25/8 and 26/8 2014

As described in Sect. 2.1, the Vector Field Magnetometer on the Swarm C satellite was temporarily switched off from 05:52 UTC on 25 August 2014, until 11:25 UTC on 26 August 2014.

In support to the investigations we have checked the raw VFM B values and the sensor temperatures just before the switch-off and we did not find any issue. Below you can see the plot of such values: in order to speed up the analysis, the raw data comes from VFMCNOM_0 products, using only the CMP (SID 11) dataset at 1 Hz rate; for that reason, some gaps appear in the figures below corresponding to the missing UCM (SID 14) dataset records, which are a small fraction of the overall data for the period and do not affect the analysis.

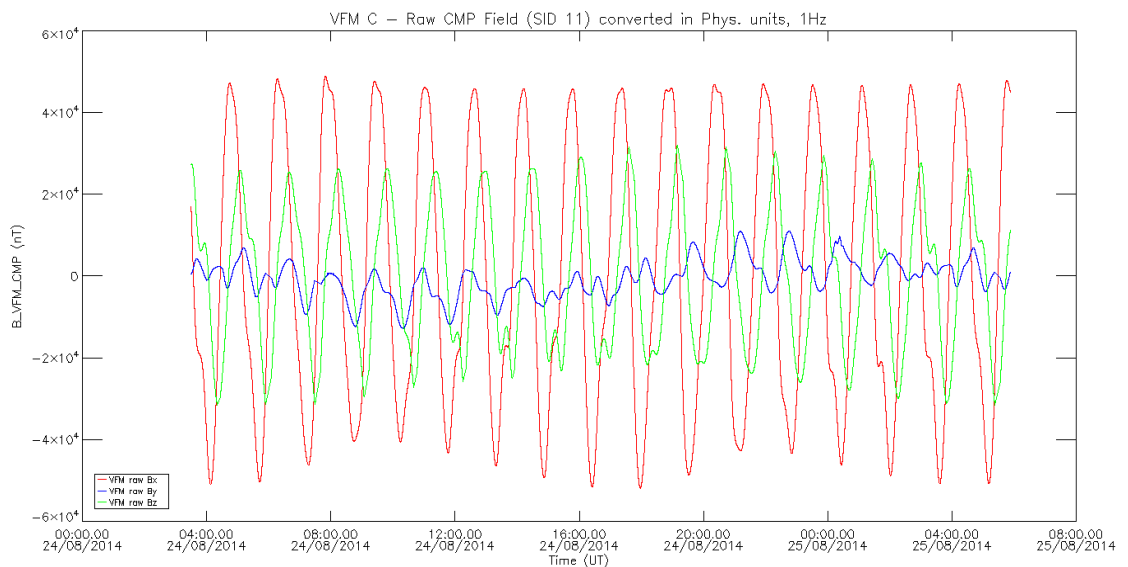


Figure 34: Raw CMP Field (SID 11) converted in physical units, just before the VFM C switch-off.

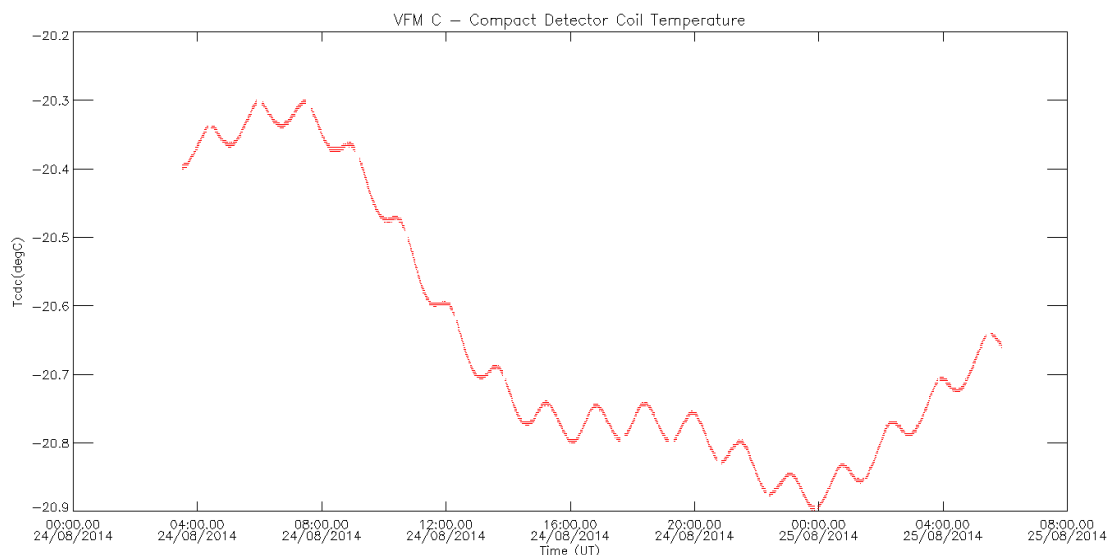


Figure 35: Compact Detector Coil temperature, Swarm C

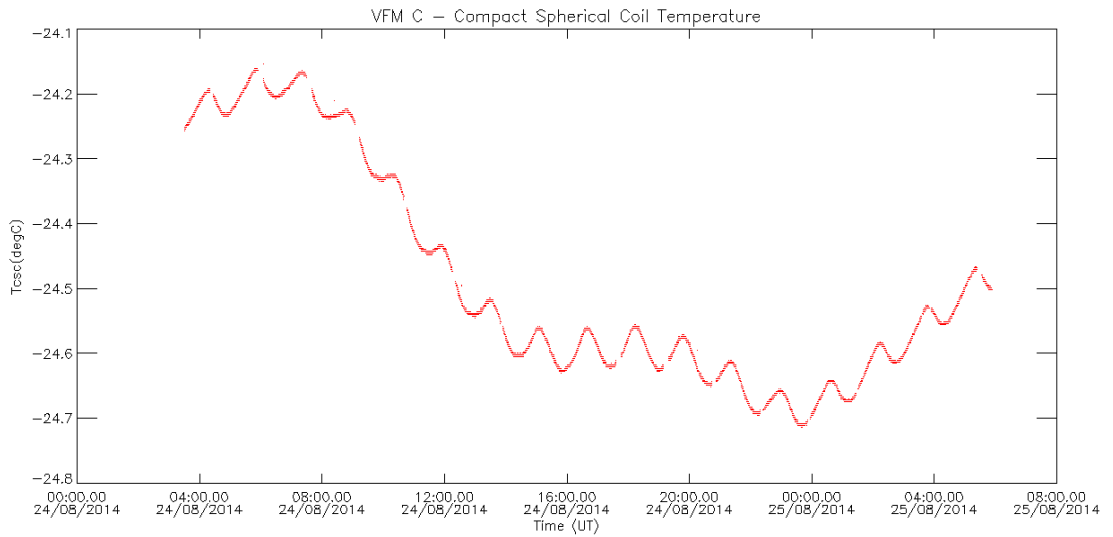


Figure 36: Compact Spherical Coil temperature, Swarm C

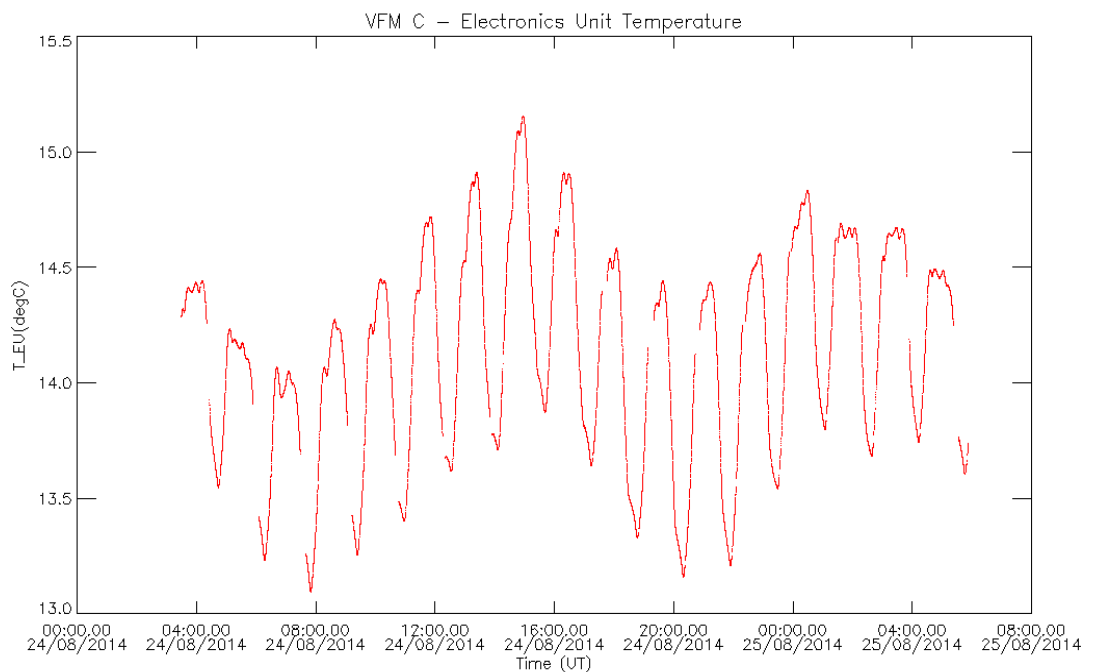


Figure 37: VFM C electronics unit temperature

4.2 SW-IDEAS-20: 31/08/2014, STR S/C A out of range

Concerning the observations shown in Sect. 3.2.1.2, further analysis has been done investigating the behaviour of the following Level 0/Level 1A parameters: Validity, Sequence, BBO (Big Bright Object). Such parameters are in fact checked before to compute the STR attitude combined solution, and values of the single cameras measurements are discarded basing on the parameters above.



It was found that, for the two out-of-range intervals listed in Table 4, no attitude could be selected, because of the simultaneous occurrence of BBOs on the three cameras. See, for example, in Figure 38, a snapshot of the BBO flag for the three camera head units of S/C A, around 6:43 UT (from SW_OPER_STRANOM_0_20140831T051652_20140831T150951_0201): the first Flags_q out-of-range interval listed in Table 4 is enclosed between the two red lines, and one can see that BBOs occurred for the three cameras simultaneously. **The observation is therefore not an anomaly and the attitude rejections are expected.**

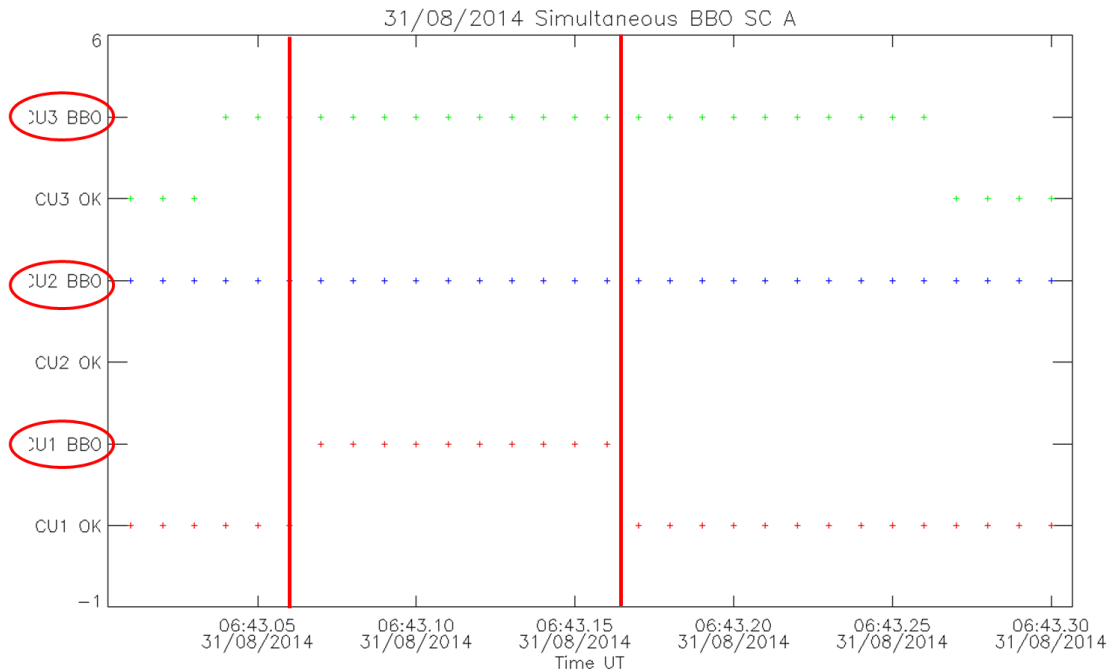


Figure 38: Example of BBO occurrence for SC A, 31/08/2014

4.3 SWL1L2DB-9: Anomaly MOD-GPS on-board, S/C B, 27/08/2014

What shown in Sect. 3.2.2.1, Figure 7 (27/08/2014, S/C B) is repeated, for sake of clarity, also in Figure 39: the difference between the MOD and NAV1B solution for S/C position (first panel from the top), and the first derivative of the such difference (X, Y and Z components, second, third and fourth panels from the top).

The plots show an error that grows close to 18 m at the end of the day. The effect seems to be cumulative and starts from about 8 p.m.

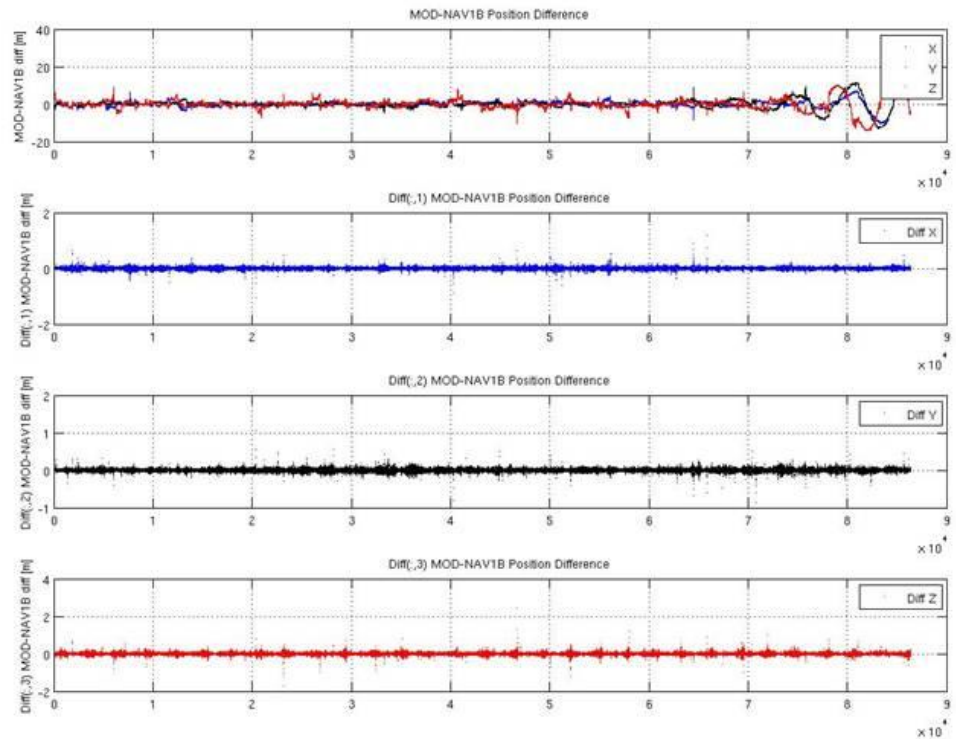


Figure 39: First panel from top: MOD-NAV1B positions plot for S/C B 27/08/2014. Three panels below: first derivative of the difference shown in the first panel (X, Y and Z components).

A similar effect can be noted also on the velocity (Figure 40) Moreover, on a 3-D representation (Figure 41) one can clearly see the difference vector departing from the centre along a spiral for a portion of the computations of the day.

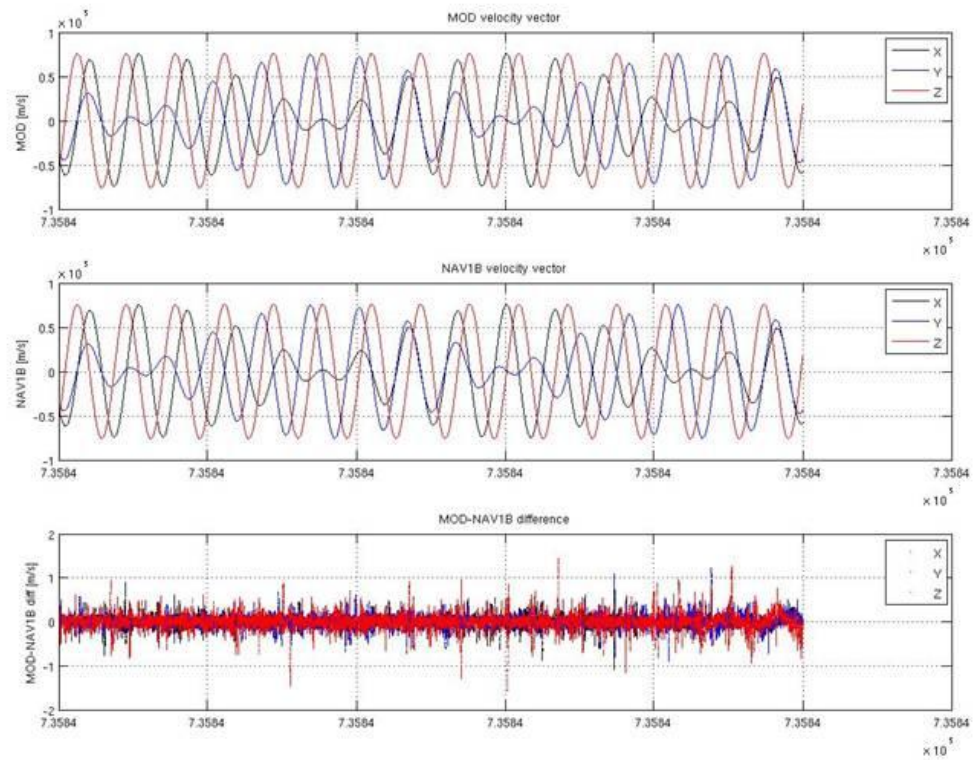


Figure 40: MOD velocity for S/C B, 27/08/2014 (upper panel); GPSNAV1B velocity for S/C B, 27/08/2014 (middle panel); difference between the two above (lower panel).

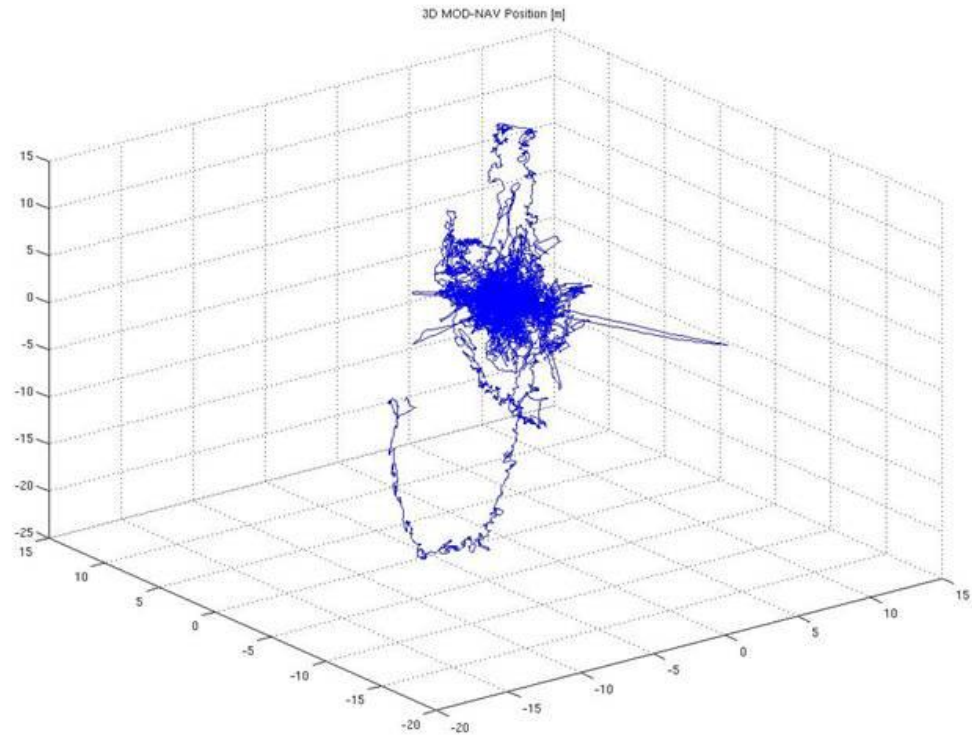


Figure 41: MOD-NAV1B position vector for S/C B 27/08/2014.

Looking at the same parameters for the day after (28/08/2014, see e.g. Figure 8) we do not observe a continuation of the effect, and all seems to restart from a nominal condition.

We recall something similar happened during the commissioning phase: see for example, in Figure 42 the MOD-NAV0 position plot for S/C B, 31/12/2013, before corrections to Napeos were applied and a reprocessing done. Such issue was fixed with the L1BOP 3.8 delivery (SPR-218,220,221 on GMV Symphony tracking tool).

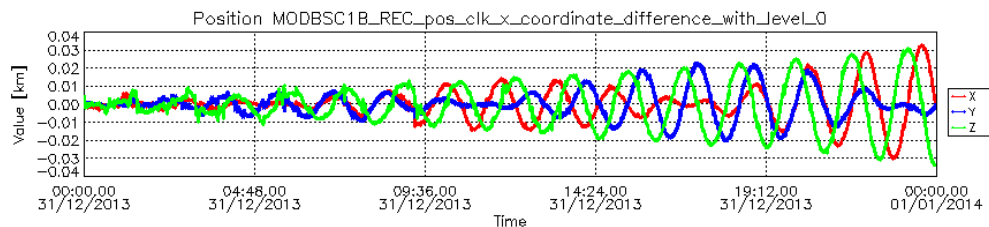


Figure 42: MOD-NAV0 position plot for S/C B, 31/12/2013, baseline 01.

The MOD clock solution shows a behavior that seems to be in a way correlated with the start of the anomaly (Figure 43): a modification of the clock drifts behaviour with respect to the same day values seems to show up at about the same time of error accumulation of position and velocity.

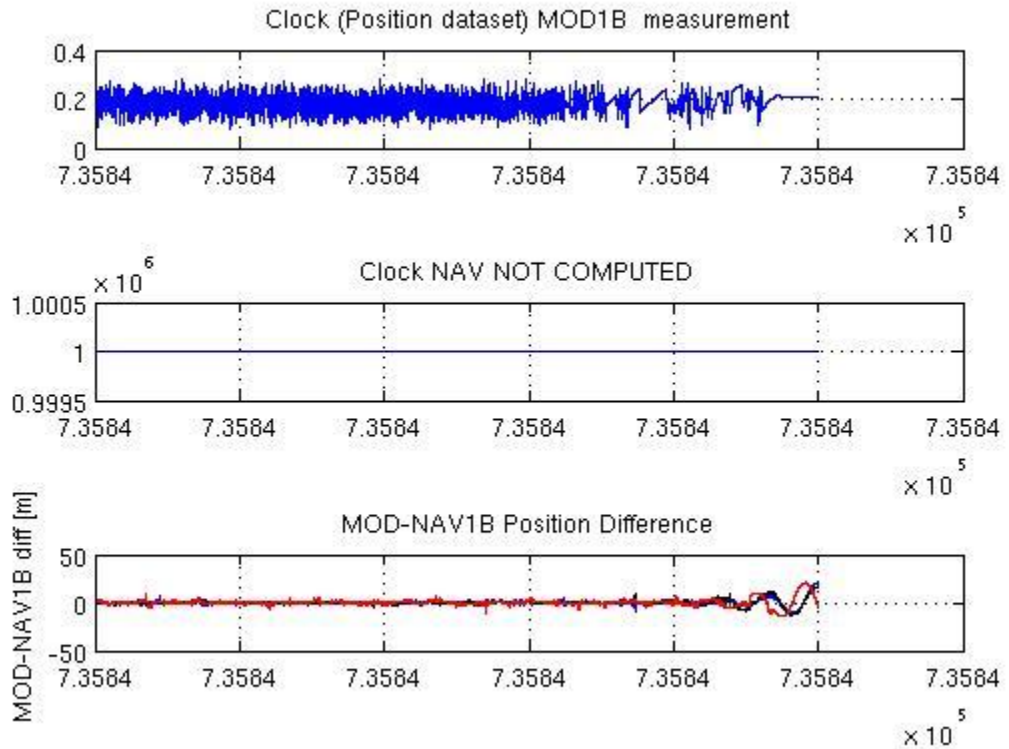


Figure 43: GPS clock computation for S/C B, 27/08/2014

The GPSNAV0 data shows the receiver was in NavMode for the entire duration of the anomaly and that the TDOP (Time Dilution of Precision) and GDOP (Geometric Dilution of precision) did not show particular feature. In addition the GPSNAV0 Minimum Navigation Solution is marked as valid.

The anomaly has been reported to the processor manufacturer for further investigations, tracked through SPR **SWL1L2DB-9**.



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