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IDEAS+ Swarm Weekly Report : 08/09/2014 – 14/09/2014

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period 08 to 14 September, 2014.

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TABLE OF CONTENTS

Contents

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	19 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_20140910_MoM

[RD.8] Planned Updates for Level 1b, SW-PL-DTU-GS-008, Rev: 1dC.

[RD.9] IDEAS+ Swarm Weekly Report: 25/08/2014 – 31/08/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140825_20140831.pdf

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:

Status of EFI – TII recent operations. University of Calgary has provided feedback on the image quality after the recent instruments switch-on: S/C A shows good image quality for few days; S/C B is affected by a problem in the Automatic Gain Control which leads to saturation of most part of the images; the improvements in S/C C still last for few orbits after the switch-on.

2.2 Plan for operational processor updates

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]. In the meanwhile (31/08), DTU has released a new version (4.10) of the main prototype processor, containing a number of minor updates in order to be aligned with the operational processor, as described in [RD.8].

With respect to the previous reporting period, the following important update has to be reported:

GMV has tested the operational processor following the recommendations by L2PS community (RINEX produced without antenna pattern corrections and carrier phase filtering) and using the test data set and information provided by C. Siemes. An assessment on the effects on the orbit calculation has been provided by the Napeos team: the impact on the orbital accuracy is small (few cm), so the orbital product of ORBATT is not affected by these modifications (differences of cm), and even it is expected a slight improvement thanks to the removal of the CCDB corrections.

The only step still pending is an evaluation from the POD L2PS team (Univ. of Delft) on the test results provided by GMV.

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 second half 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 at GFZ premises in Potsdam, Germany.

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

2.4 Summary of observations for Week 37 (08-14/09/2014)

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

1. **Two observations of attitude rejection** occurred on S/C A (41 attitudes rejected the 14/09) and S/C C (4 attitudes rejected on 08/09), caused by simultaneous occurrence of Big Bright Objects on all the three camera units of

the S/C, or invalid measurements. 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.

2. **New occurrence of the MOD-NAV anomaly** already reported and described past week (**SWL1L2DB-9**). An error in the MOD determination is observed on S/C C, 11/09/2014, that grows up to about 11 m at the end of the day. The effect seems to be cumulative and starts from about 10 p.m.

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. A new observation has to be reported:

3. **An increase in the time series noise of the ASM-VFM difference** is observed between 12 and 13 September for all S/C. This seems to be an effect of the increases geomagnetic activity.

An observation has been done of few spikes in $|B_{NEC}|$ - F, on all the S/C, apparently related to regions where the vector field is rapidly varying. This kind of events is under monitoring and further analysis will follow in the coming weeks.

3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

No telemetry gaps are reported for the period.

3.2 Orbit and Attitude Products

The following events have to be reported:

Observation ID	Description	Affected parameter	Sect. of Obs. description	Sect. of Obs. analysis
SW-IDEAS-28	OBS_ROUTINE: 08/09/2014, STR S/C C out of range.	Flags_q, quaternions, B_{NEC}	3.2.3.2	3.2.3.2
SW-IDEAS-29	OBS_ROUTINE: 14/09/2014, STR S/C A out of range.	Flags_q, quaternions, B_{NEC}	3.2.1.2	3.2.1.2
SWL1L2DB-9	L1B: MOD - NAV1B discrepancies	S/C position and velocity	3.2.3.1	Sect. 4.3 of [RD.9]

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for Week 37: 08/09 - 14/09/2014

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:
    - 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 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 is, on average, around 1.6 m.

Swarm A, 08-14/09/2014, Position difference			
Day	**Average Difference (m)**	**Maximum difference (m)**	**Notes**
08/09	0.16	-8, 13 (Z)	
09/09	0.07	-9, 8.5 (Z)	
10/09	0.1	-10.5, 9 (Z)	
11/09	0.11	-13, 9 (Z)	
12/09	0.05	+/- 10 (Z)	
13/09	0.2	-12.3, 15.7 (Z)	Few big spikes in the Z comp.
14/09	0.2	-8.5, 10.5 (Z)	

Table 2: 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 (08/09, Figure 1), in the middle (11/09, Figure 2) and at the end (14/09, Figure 3). The values are given in Km.

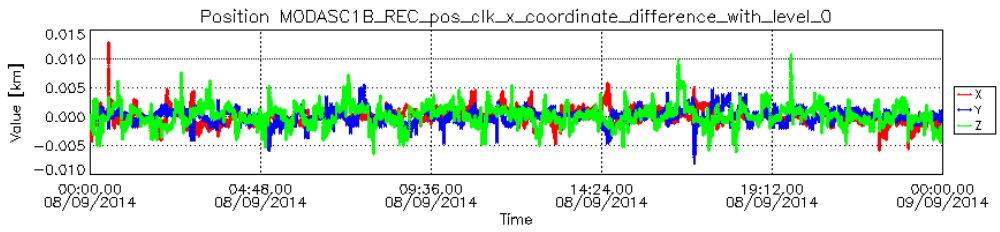

Figure 1: Difference MOD-GPSNAV, sc A, 08/09/2014

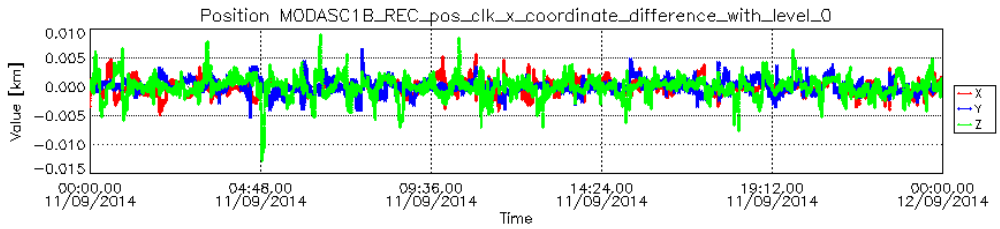

Figure 2: Difference MOD-GPSNAV, sc A, 11/09/2014

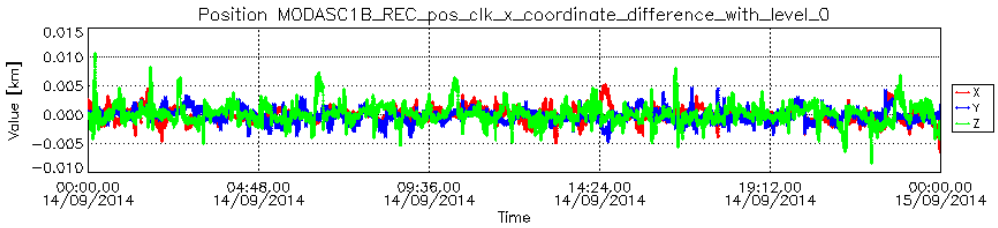

Figure 3: Difference MOD-GPSNAV, sc A, 14/09/2014

3.2.1.2 Attitude observations

- **SW-IDEAS-29**
  Affected product:
  SW_OPER_STRAATT_1B_20140914T000000_20140914T235959_0301

  41 seconds out of range (Flags_q=255, no attitude available).
  See Table 3 for details.

Start Out-of-range	Stop Out-of-range	Duration (s)	Value
14SEP2014 20:08:09	14SEP2014 20:08:49	41	255

Table 3: Attitudes out-of-range, S/C A, 14/09/2014

  The cause of such rejected attitudes is the simultaneous occurrence of invalid measurements and BBOs on the three camera units for the specified interval.

3.2.2 Swarm B

3.2.2.1 Position Statistics

In Table 4 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 1.7 m.

Swarm B, 08-14/09/2014, Position difference			
Day	**Average Difference (m)**	**Maximum difference (m)**	**Notes**
08/09	0.09	-8, 10 (Z)	
09/09	0.13	-12 (Y), 7.5 (Z)	
10/09	0.16	-7.8 (X), 10.3 (Z)	
11/09	0.11	-13.5, 9 (Z)	
12/09	0.07	+/- 7.5 (Z)	
13/09	0.37	-10.3, 18.6 (Z)	Very spiky behaviour, especially in the Z comp., which increases a bit the St. Dev. up to about 1.9
14/09	0.11	-9.6, 18.4 (Z)	

Table 4: Swarm B, difference between MOD and on-board solution positions.

Below some plot example follows of such differences taken at the beginning of the week (08/09, Figure 4), in the middle (11/09, Figure 5), and at end of the week (14/09, Figure 6). Values are given in Km.

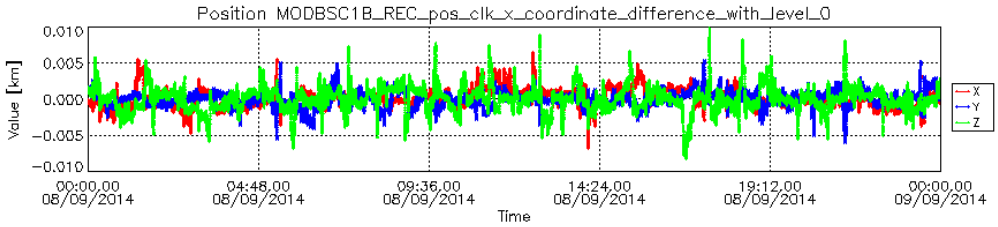

Figure 4: Difference MOD-GPSNAV, sc B, 08/09/2014

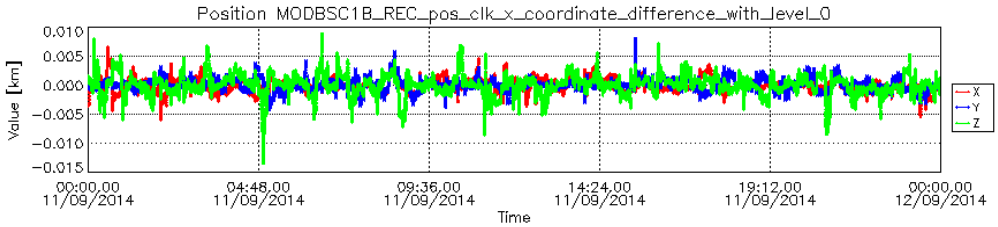

Figure 5: Difference MOD-GPSNAV, sc B, 11/09/2014

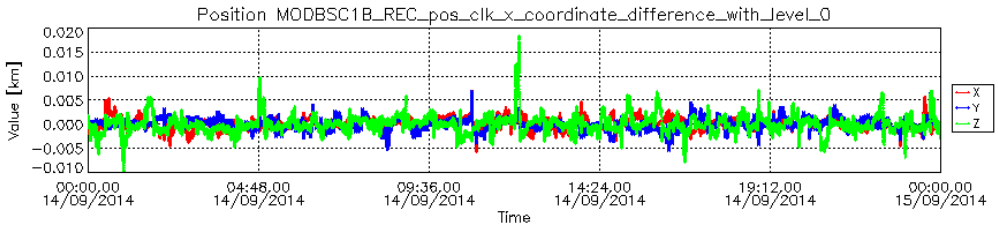

Figure 6: Difference MOD-GPSNAV, sc B, 14/09/2014

3.2.2.2 Attitude observations

Nothing to report.

3.2.3 Swarm C

3.2.3.1 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 1.65 m.

Swarm C, 08-14/09/2014, Position difference			
Day	**Average Difference (m)**	**Maximum difference (m)**	**Notes**
08/09	0.16	-6, 12.5 (Z)	
09/09	0.07	-10 (Y), 8 (Z)	
10/09	0.15	-11, 9.5 (Z)	
11/09	0.18	-12.5, 11 (Z)	Anomaly: the difference between MOD and NAV solution starts to diverge from about 22 UT. St. Dev grows up to 2 (**SWL1L2DB-9**)
12/09	0.07	-10, 8.5 (Z)	
13/09	0.11	-8.5, 12.8 (Z)	
14/09	0.17	-9, 8.3 (Z)	

Table 5: 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 (08/09, Figure 7), in the middle (11/09, Figure 8) and at the end (14/09, Figure 9). The values are given in Km. In particular, in Figure 8 one can observe the occurrence of an already documented anomaly (**SWL1L2DB-9,** [RD.9]): the difference between MOD and NAV solution starts to diverge from about 22 UT.

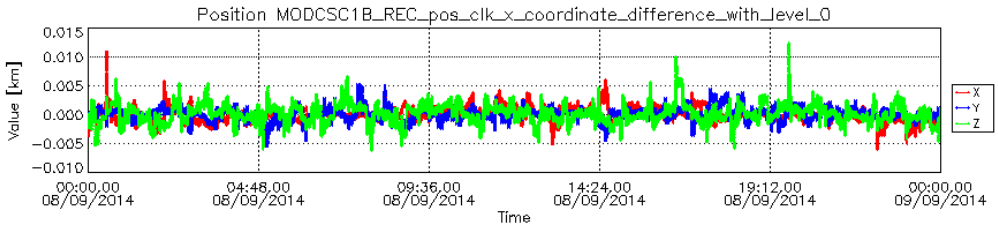

Figure 7: Difference MOD-GPSNAV, sc C, 08/09/2014

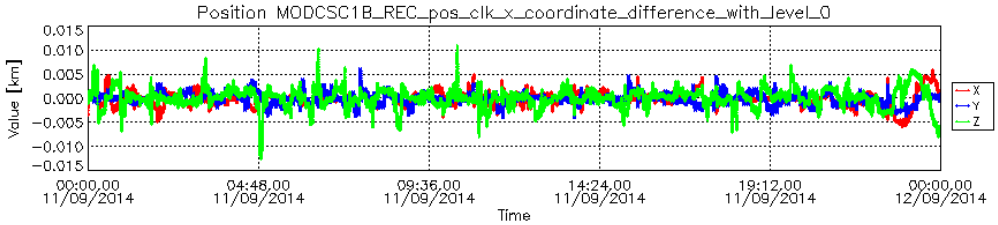

Figure 8: Difference MOD-GPSNAV, sc C, 11/09/2014

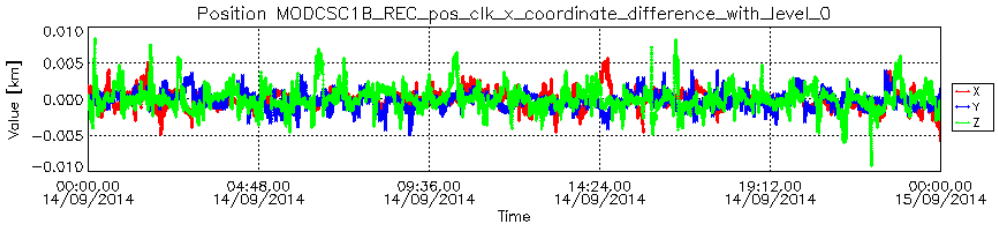

Figure 9: Difference MOD-GPSNAV, sc C, 14/09/2014

3.2.3.2 Attitude observations

- **SW-IDEAS-28**
  Affected product:
  SW_OPER_STRCATT_1B_20140908T000000_20140908T235959_0301

  4 seconds out of range (Flags_q=255, no attitude available).
  See Table 6 for details:

Start Out-of-range	Stop Out-of-range	Duration (s)	Value
08SEP2014 16:47:02	08SEP2014 16:47:05	4	255

Table 6: Attitudes out-of-range, S/C C, 08/09/2014

The cause of such rejected attitudes is the simultaneous occurrence of invalid measurements and BBOs on the three camera units for the specified interval.

3.3 Magnetic Products

The following events have to be reported:

Observation ID	Description	Affected parameter	Sect. of Obs. description	Sect. of Obs. analysis
SW- IDEAS-26	OBS_ROUTINE: ASM-VFM spikes	B_{VFM}, F, B_{NEC}	3.3.1.2, 3.3.2.2, 3.3.3.2	
SW-IDEAS-27	OBS_ROUTINE: increase of noise in VFM-ASM diff	B_{VFM}, F, B_{NEC}	3.3.1.2, 3.3.2.2, 3.3.3.2	4.1

Table 7: list of events related to magnetic products to be reported in the monitoring for Week 37: 08/09 - 14/09/2014

The effects of rejected attitudes (**SW-IDEAS-28, SW-IDEAS-29**) 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 $|B_{NEC}|$ - F and recording of daily maximum variations. If +/- 5 nT are exceed on a given day, an alert is raised.

- 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 magnetic field time series for S/C A can be seen in Figure 10 (14/09/2014):

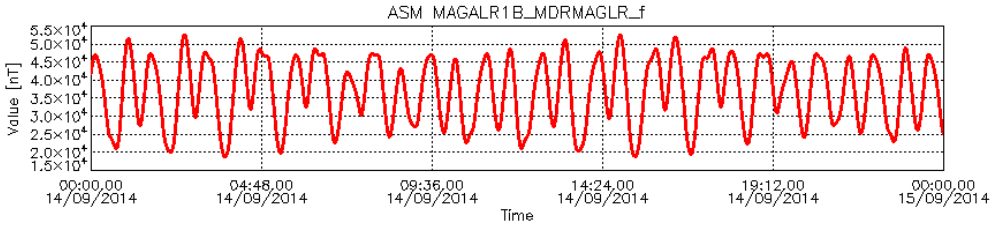

Figure 10: Time series of magnetic field intensity, F, for 14/09/2014, S/C A

3.3.1.2 VFM-ASM anomaly

- **SW-IDEAS-27:** starting from 12/09/2014, 16 UT up to 13/09/2014, 2-3 UT, all S/C observe a noise superimposed on the ASM-VFM time series. The effect seems related with the increased geomagnetic activity and not to an instrument/processing effect. Further analysis is given in Sect. 4.1.

The daily peak-to-peak difference around the week is, on average: [-3, 2.5] nT, with some isolated spike which reaches up to 10 nT (see e.g. Figure 12). Such kind of spikes have been already observed and reported in the previous report (observation_ID: **SW-IDEAS-26**): more detailed analysis will follow as soon as possible.

Below some plot example of such differences follows, taken at the beginning of the week (08/9, Figure 11), and across the **SW-IDEAS-27** event (12/09, Figure 12, and 13/09, Figure 13). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

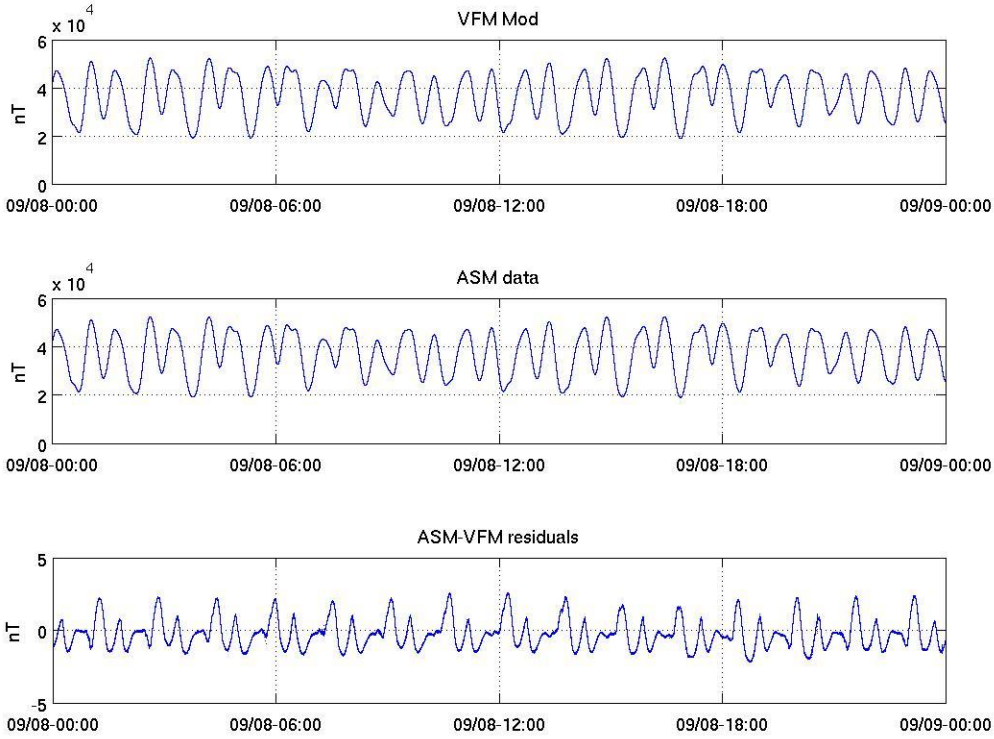

Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 08/09/2014.

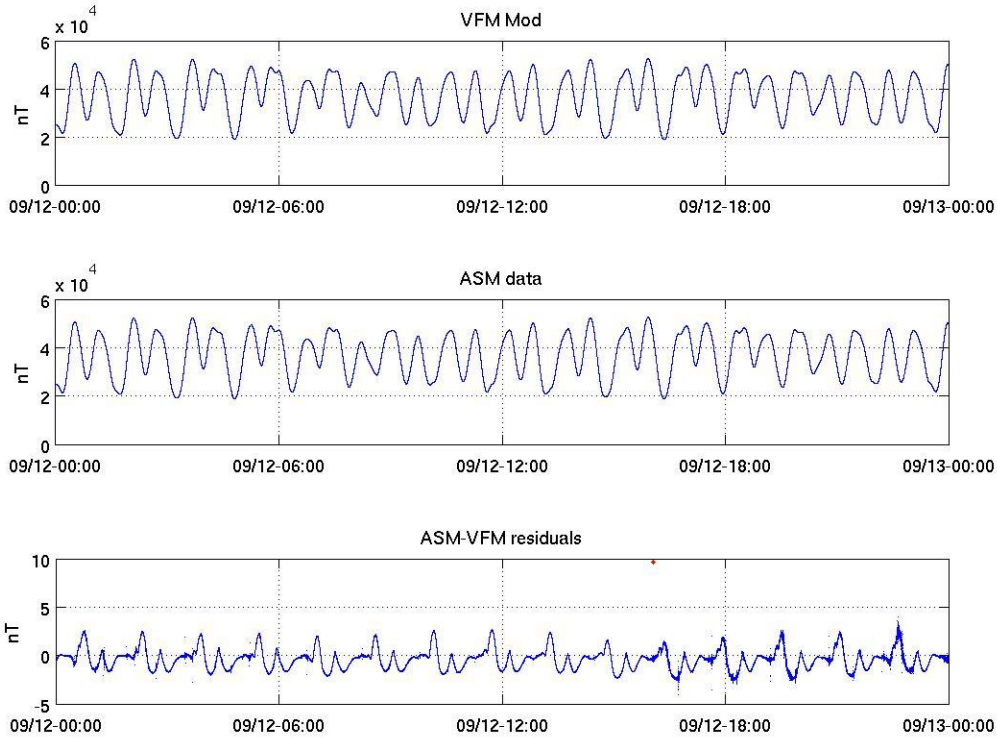

Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 12/09/2014.

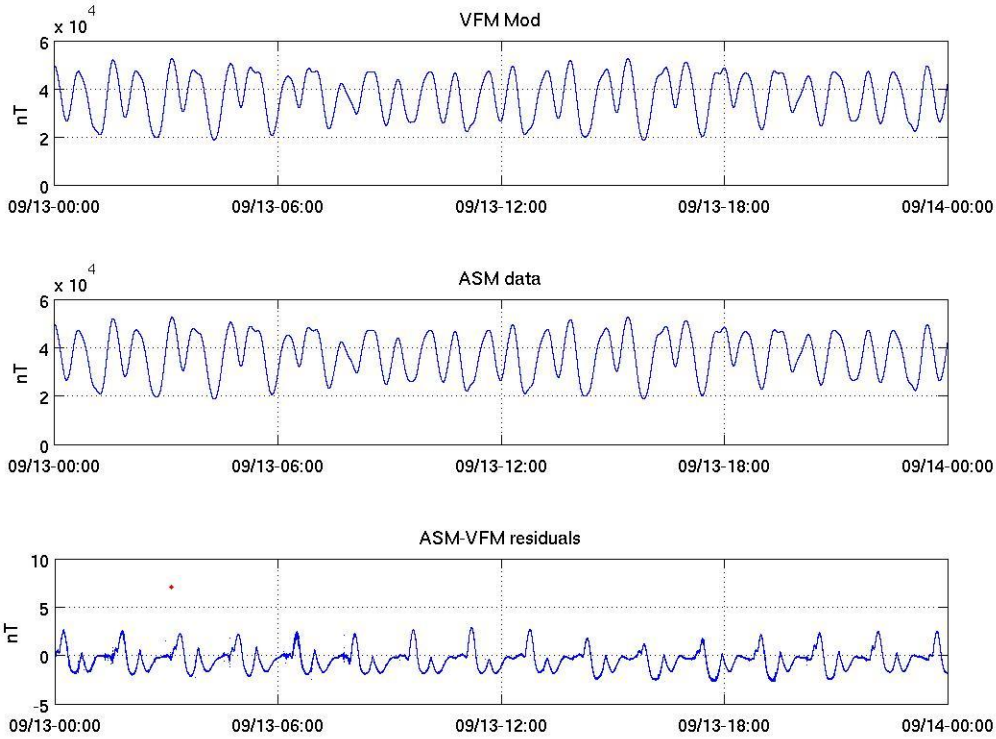

Figure 13: VFM module, ASM module and ASM-VFM residuals for S/C A, 13/09/2014.

3.3.1.3 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm A, for the reported period: Biases (Figure 14), Scales (Figure 15) and Non-orthogonalities (Figure 16). Each group is actually a three-component vector in the compact detector coil frame. The parameters are steady and constant during the week, decreasing trend continues in the X scale components (of about 0.001%).

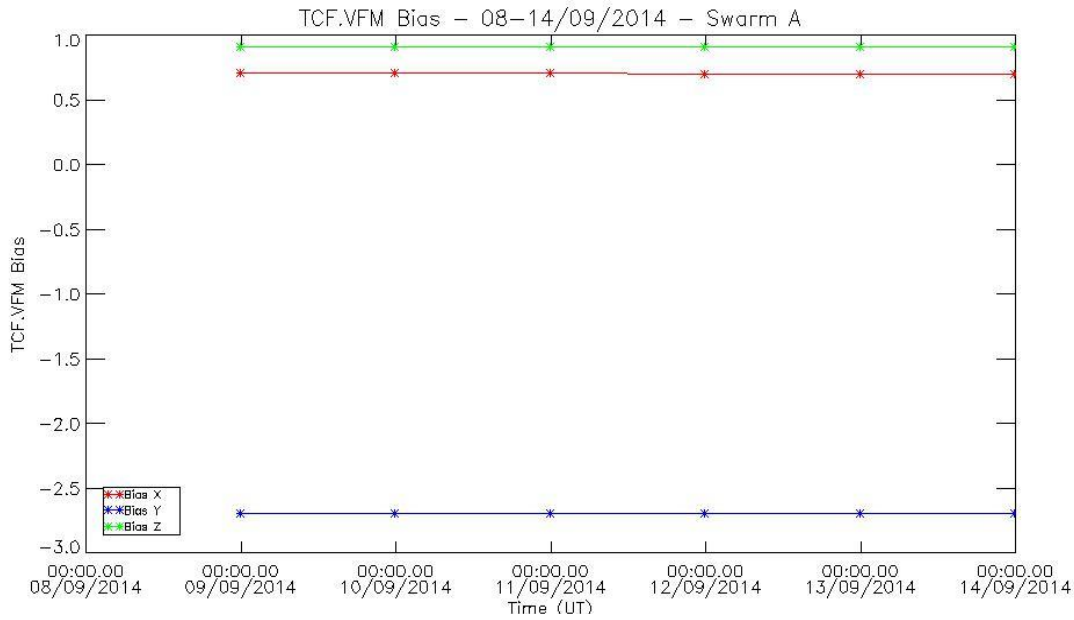

Figure 14: TCF.VFM Biases for S/C A, 08-14/09/2014.

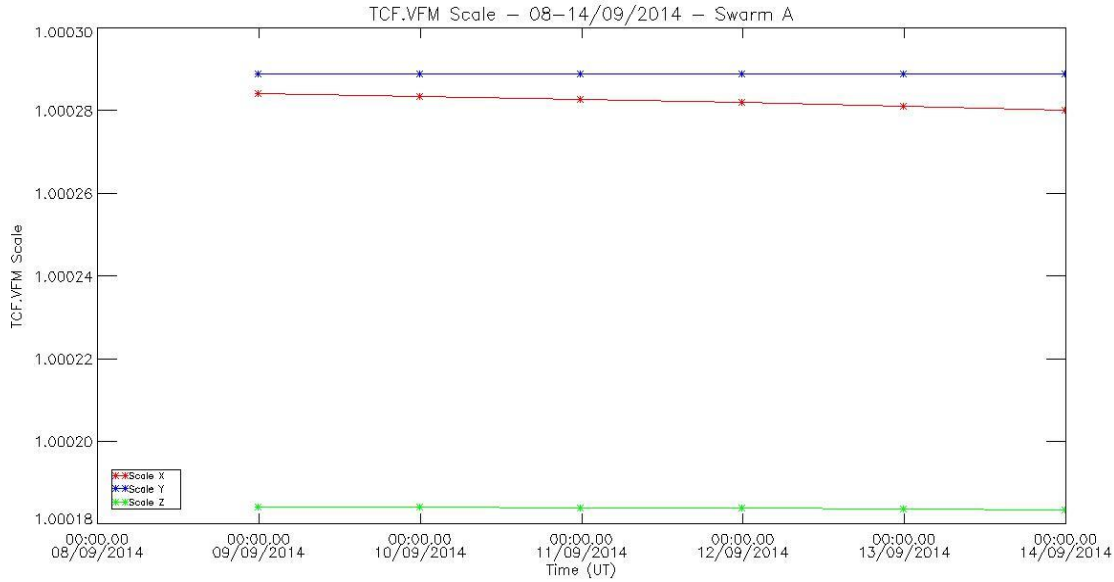

Figure 15: TCF.VFM Scales for S/C A, 08-14/09/2014.

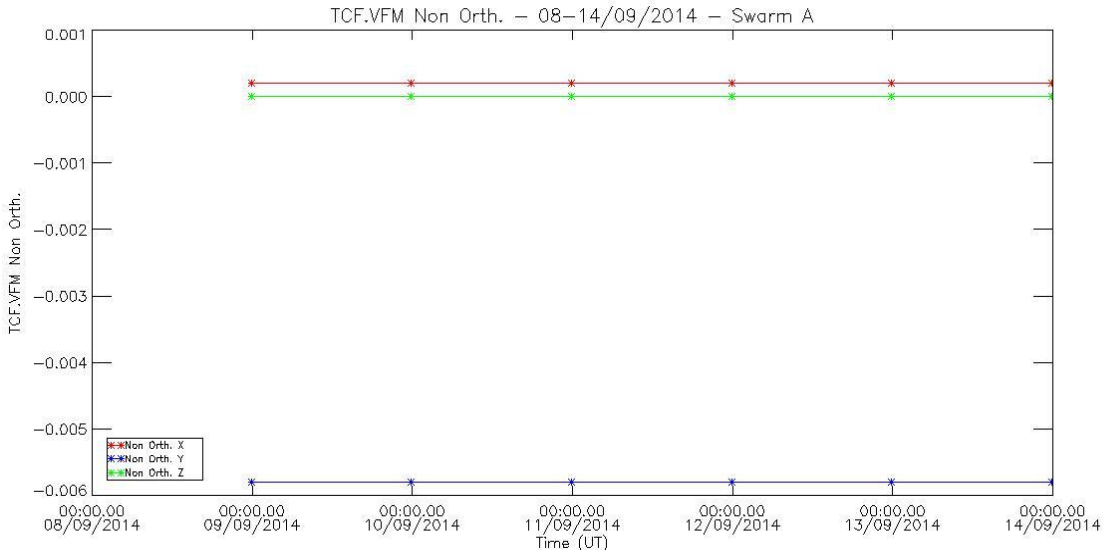

Figure 16: TCF.VFM Non-Orthogonalities for S/C A, 08-14/09/2014.

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 (14/09/2014) can be seen in Figure 17 below.

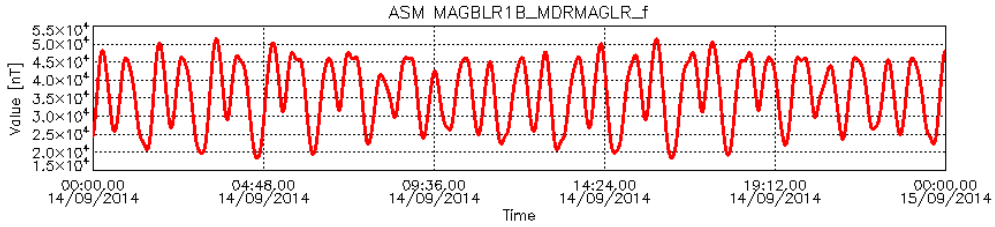

Figure 17: Time series of magnetic field intensity, F, for 14/09/2014, S/C B

3.3.2.2 VFM-ASM anomaly

- **SW-IDEAS-27:** See Sect. 3.3.1.2

The daily peak-to-peak difference around the week is, on average: [-1.5, 2] nT, with some isolated spike which reaches up to 12 nT (see e.g. Figure 19). Such kind of spikes have been already observed and reported in the previous report (observation_ID: **SW-IDEAS-26**): more detailed analysis will follow as soon as possible.

Below some plot example follows of such differences taken at the beginning of the week (08/09, Figure 18), and across the **SW-IDEAS-27** event (12/09, Figure 19, and 13/09, Figure 20). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

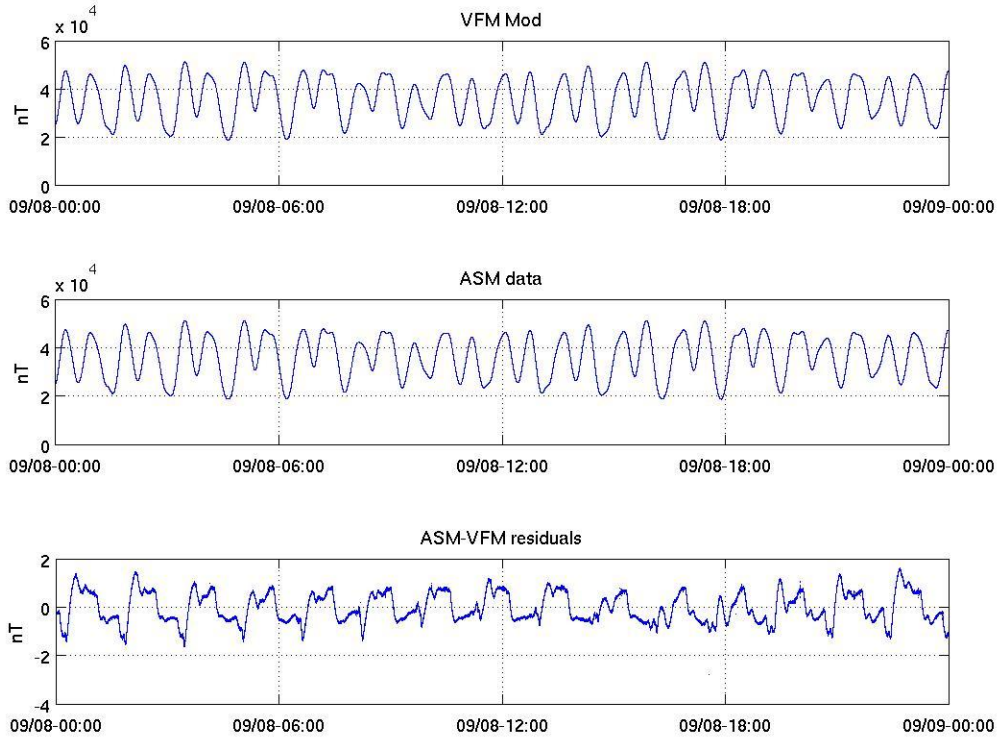

Figure 18: VFM module, ASM module and ASM-VFM residuals for S/C B, 08/09/2014.

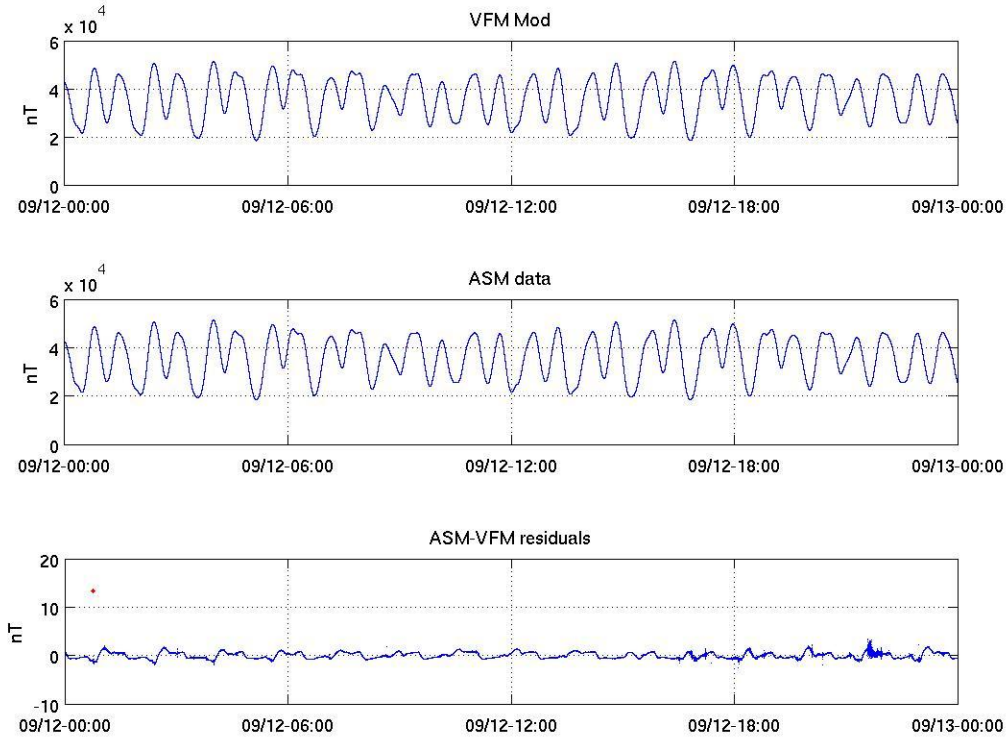

Figure 19: VFM module, ASM module and ASM-VFM residuals for S/C B, 12/09/2014.

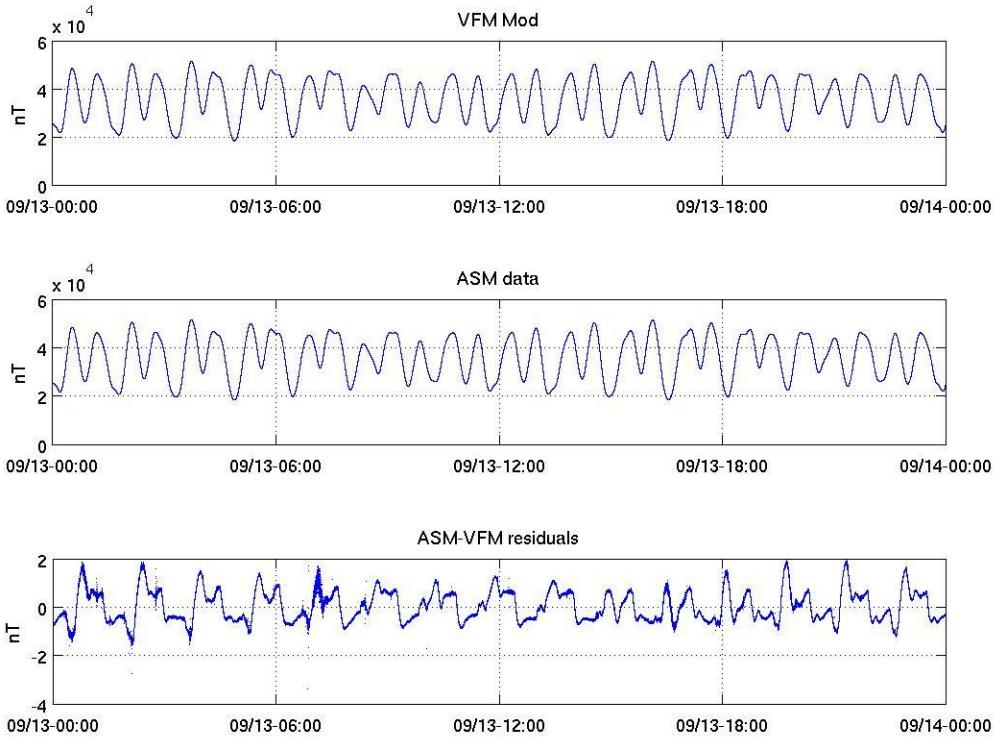

Figure 20: VFM module, ASM module and ASM-VFM residuals for S/C B, 13/09/2014.

3.3.2.3 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm B, for the reported period: 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 period.

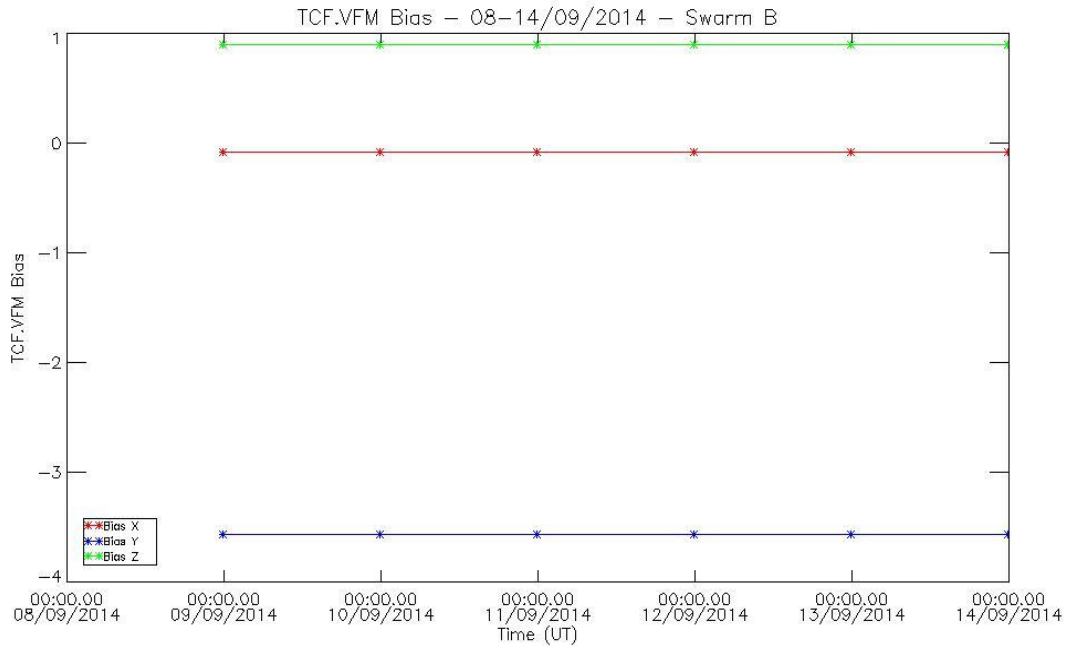

Figure 21: TCF.VFM Biases for S/C B, 08-14/09/2014.

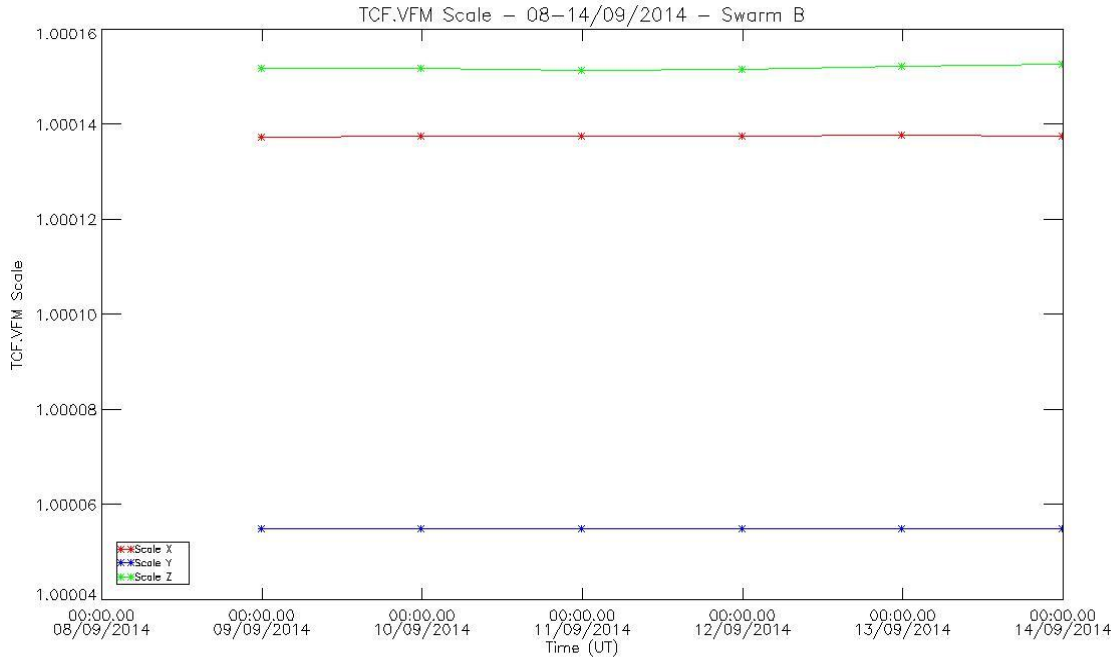

Figure 22: TCF.VFM Scales for S/C B, 08-14/09/2014.

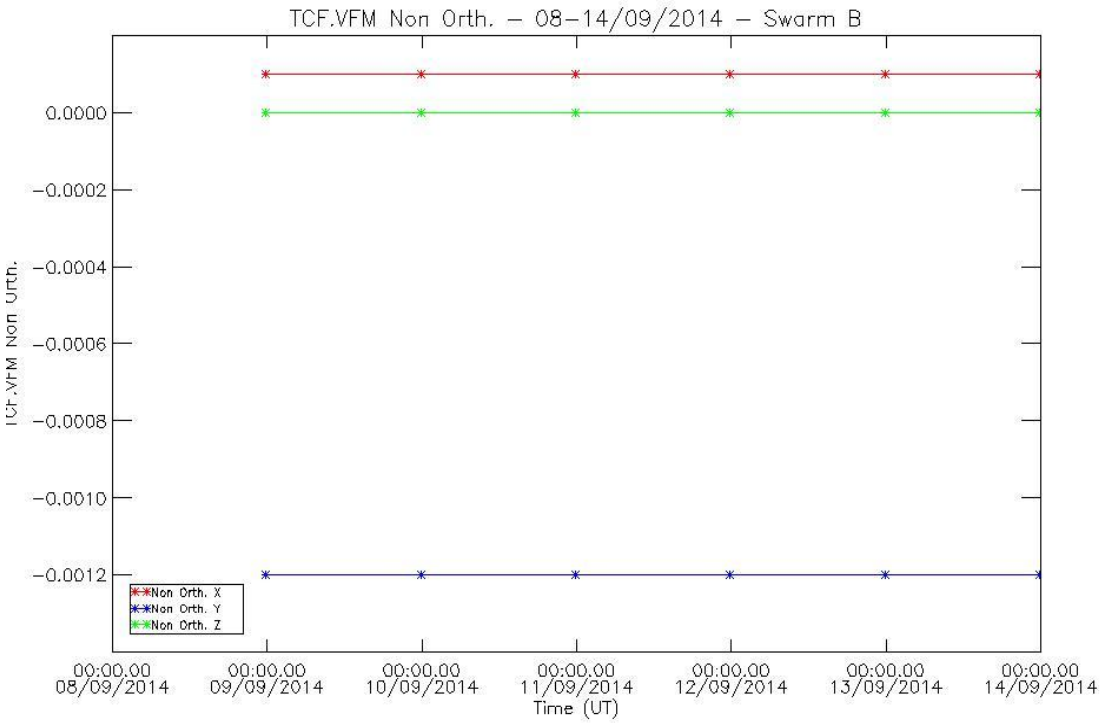

Figure 23: TCF.VFM Non-Orthogonalities for S/C B, 08-14/09/2014.

3.3.3 Swarm C

3.3.3.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative F time series for S/C C (14/09/2014) can be seen in Figure 24 below.

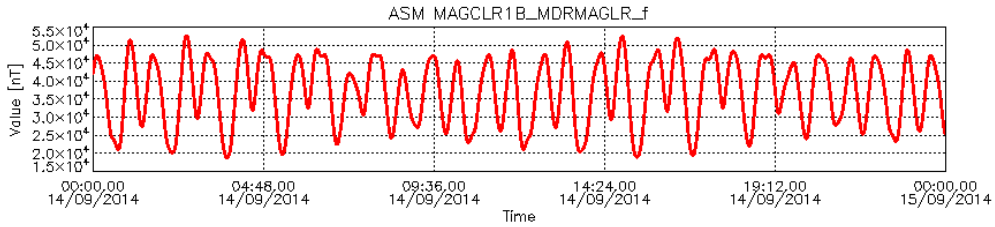

Figure 24: Time series of magnetic field intensity, F, for 14/09/2014, S/C C

3.3.3.2 VFM-ASM anomaly

- **SW-IDEAS-27:** see Sect. 3.3.1.2.

The daily peak-to-peak difference around the week is, on average: [-1.5, 1.5] nT, with some isolated spike which reaches up to 5-6 nT (see e.g. Figure 26). Such kind of spikes have been already observed and reported in the previous report (observation_ID: **SW-IDEAS-26**): more detailed analysis will follow as soon as possible.

Below some plot example follows of such differences taken at the beginning of the week (08/09, Figure 25), and across the **SW-IDEAS-27** event (12/09, Figure 26, and 13/09, Figure 27). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

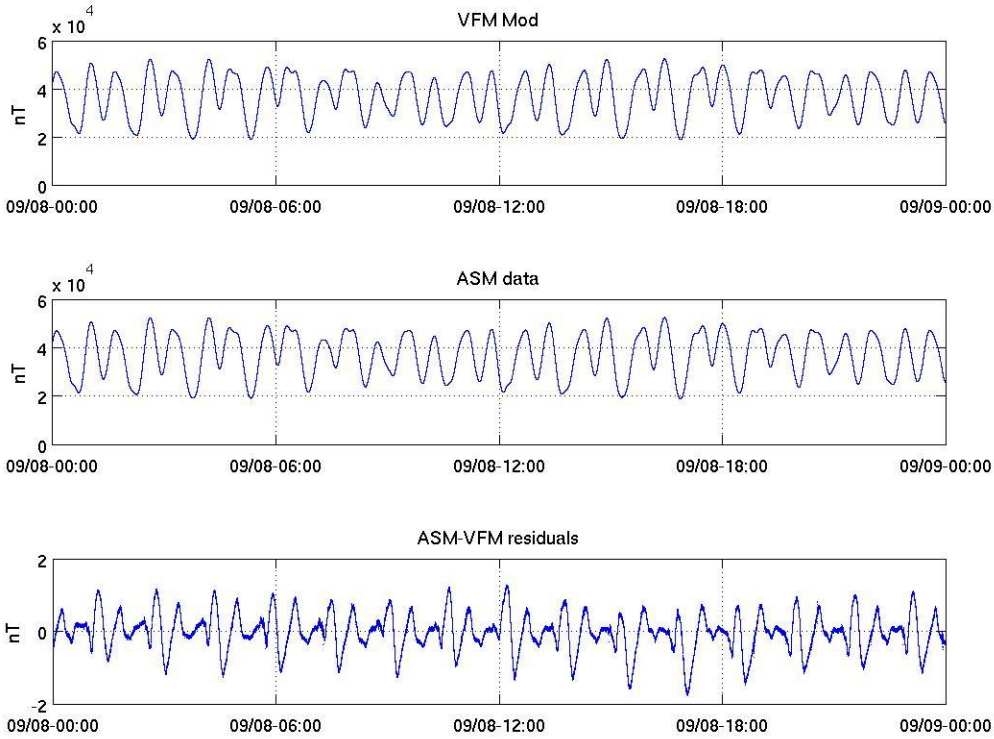

Figure 25: VFM module, ASM module and ASM-VFM residuals for S/C C, 08/09/2014.

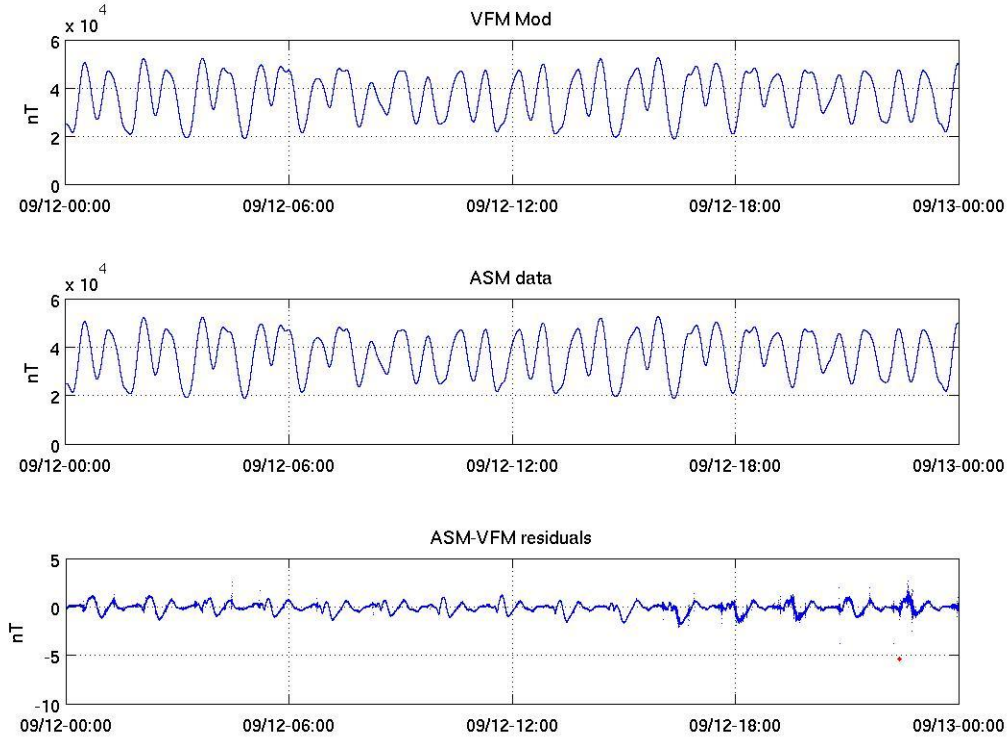

Figure 26: VFM module, ASM module and ASM-VFM residuals for S/C C, 12/09/2014.

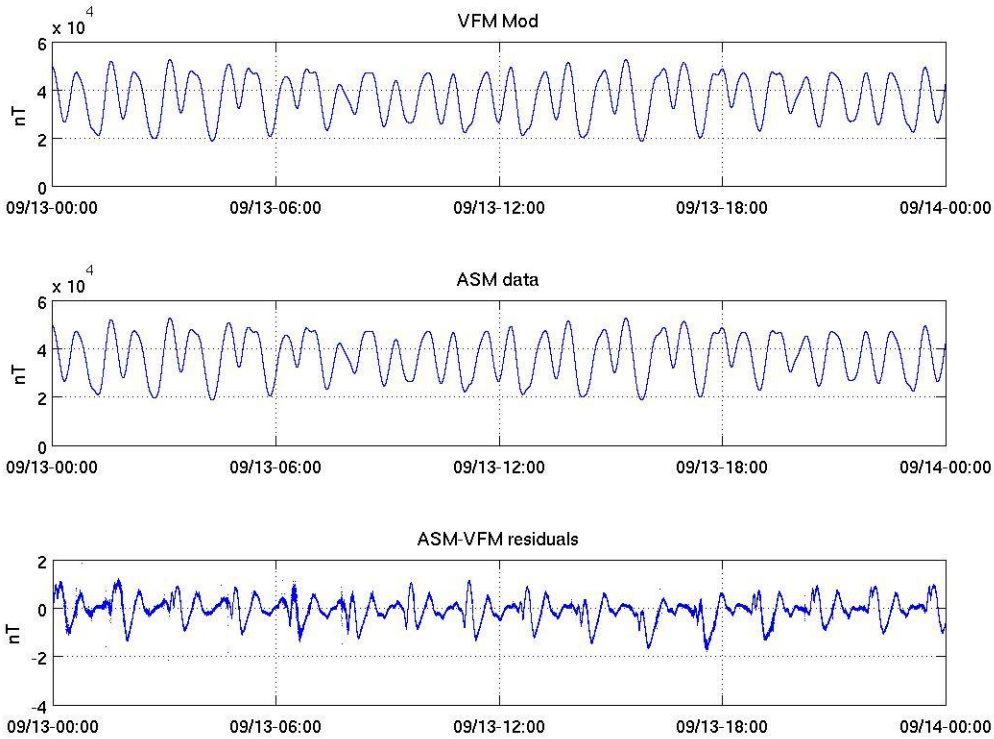

Figure 27: VFM module, ASM module and ASM-VFM residuals for S/C C, 13/09/2014.

3.3.3.3 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm C, during the reporting period: 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 in the X and Z scale components, which show a slow decrease (less than 0.001%).

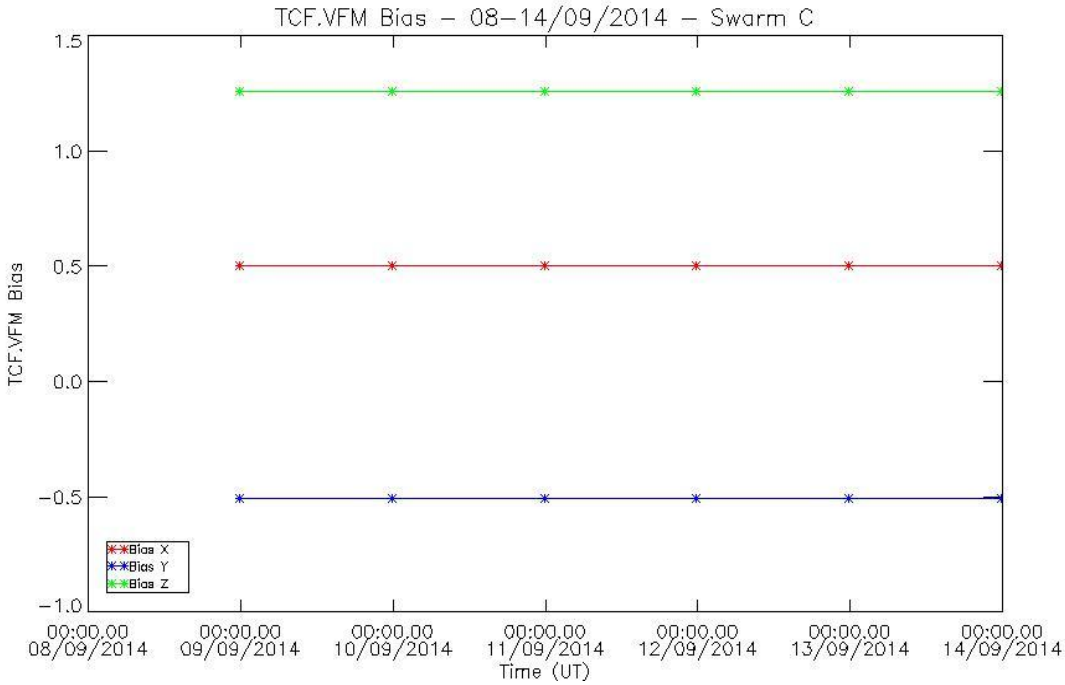

Figure 28: TCF.VFM Biases for S/C C, 08-14/09/2014.

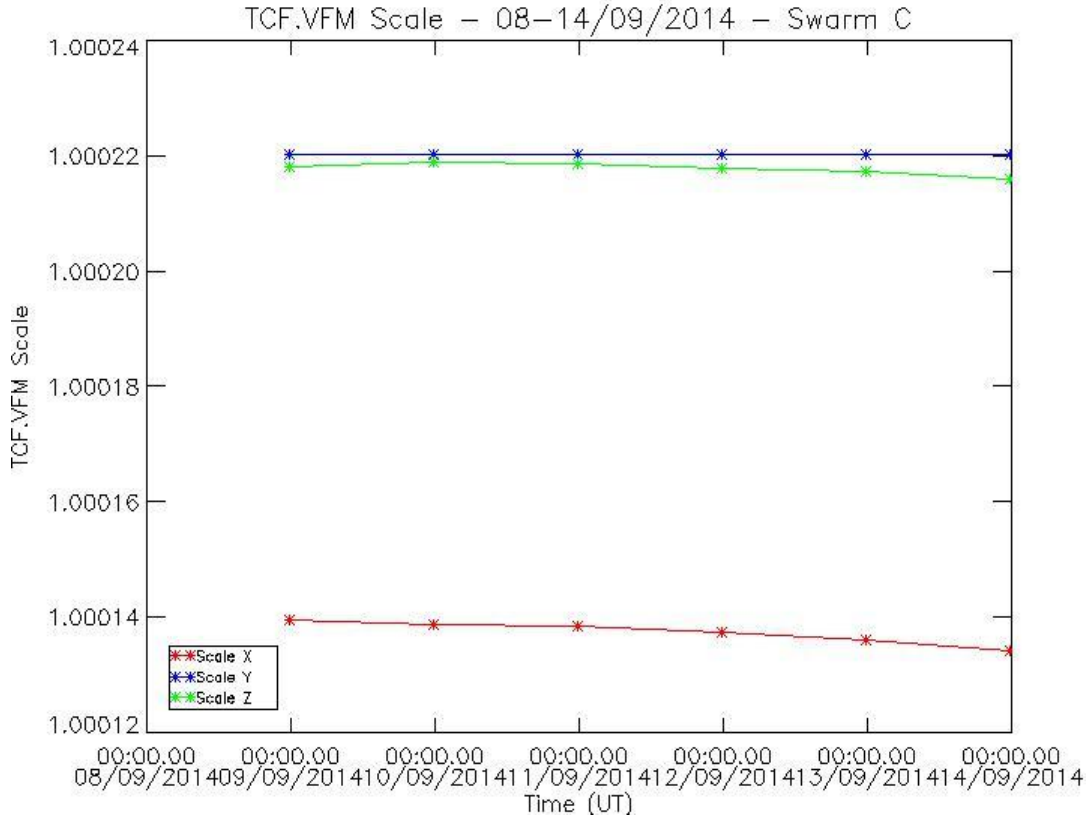

Figure 29: TCF.VFM Scales for S/C C, 08-14/09/2014.

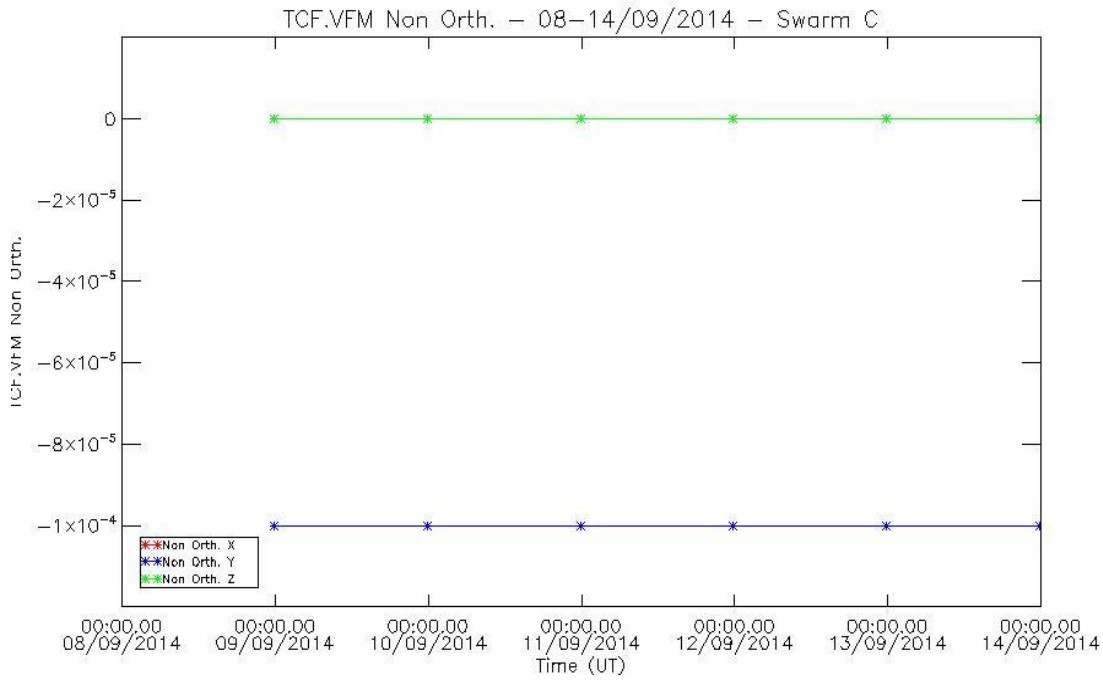

Figure 30: TCF.VFM Non-Orthogonalities for S/C C, 08-14/09/2014.

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. Figure 31 summarizes the RMS behaviour for all S/C during the week 08-14/09/2014 (Red curve = S/C A, blue curve = S/C B, green curve = S/C C).

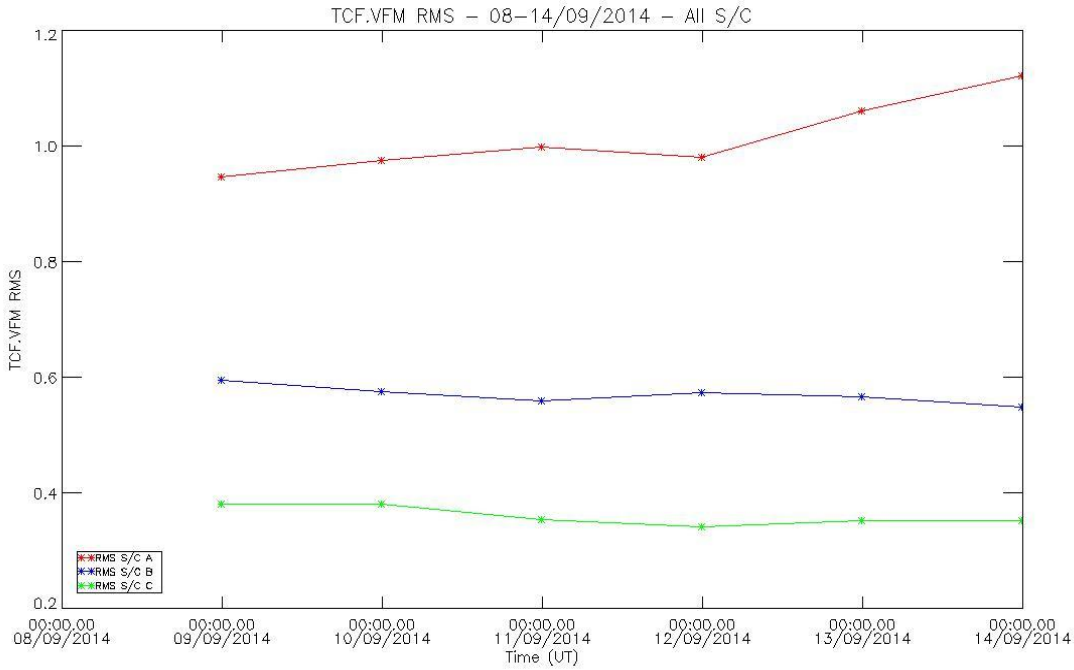

Figure 31: weighted RMS of the residuals after the TCF estimation, all S/C, 08-14/09/2014.

4. ON-DEMAND ANALYSIS

4.1 Increase of noise in VFM-ASM diff (SW-IDEAS-27)

Working on the daily monitoring we have noted a feature of the ASM-VFM residuals time series occurring on 12-13/09/2014 on all S/C (observations shown in Sects. 3.3.1.2, 3.3.2.2 and 3.3.3.2). Figures below refer to S/C A only, for sake of brevity.

Looking to the ASM-VFM residuals it seems that a sort of increase in the "noise" of the signal shows up starting around 16:00 UT of 12/09/2014; the overall behaviour returns to the nominal situation during the day after. The effect is shown in Figure 32; from top to bottom one can see: the first derivative of F field time series (ASM diff), the first derivative of vector field module time series (VFM diff), and the difference F - |B| (the so called ASM-VFM residuals).

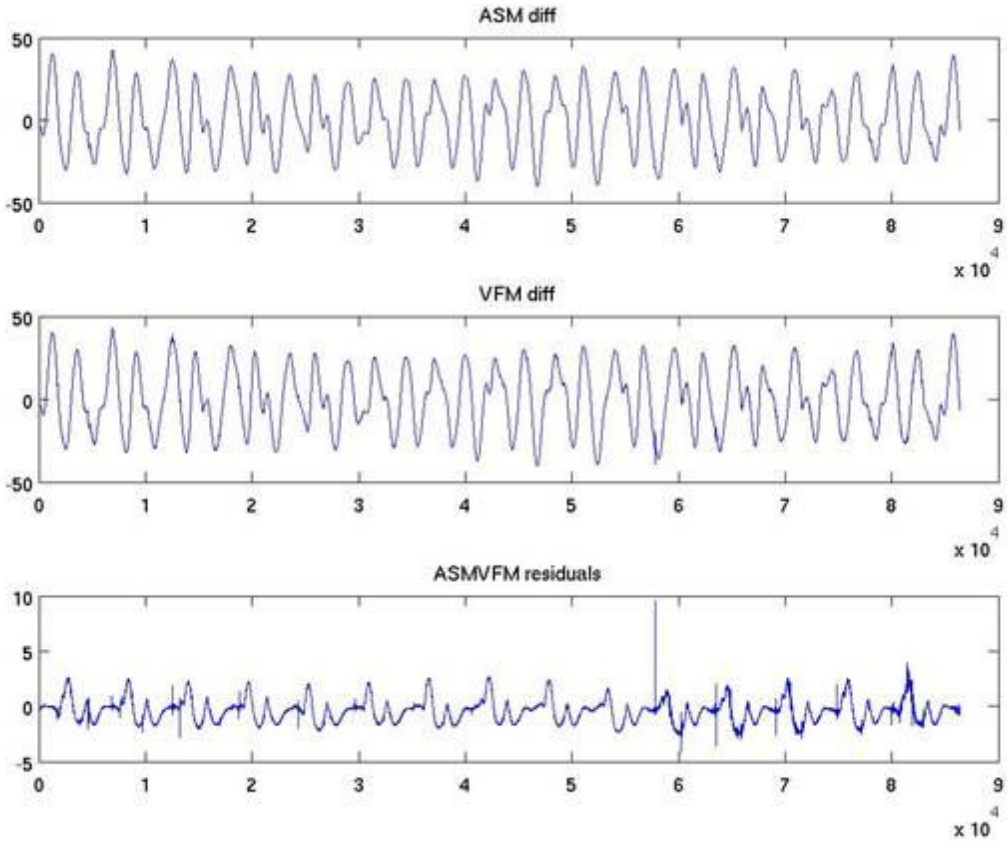

Figure 32. From top to bottom: first derivative of F field time series (ASM diff), the first derivative of vector field module time series (VFM diff), and the difference F - |B|, from S/C A, 12/09/2014.

Due to the similar features observed in all satellites, we have focused our analysis on environmental condition that could have an impact on the magnetometer measurements (ASM or VFM). Figure 33 shows the Real-Time Dst index during September 2014 (upper panel), and the AE index for day 12/09/2014 (lower panel): a moderate geomagnetic storm activity can be seen on day 12/09, reaching the maximum (Dst close to -100 nT) at about 23 UT, while in the Northern hemisphere auroral zones, a substorm activity is present throughout the whole day 12/09, with AE above 1000 nT at the beginning and at

the end of the day. This is in agreement with the space weather alerts of these days, which announced a big solar flare effect should have reached the Earth between 12 and 13/9: in such conditions, it is fully expected a geomagnetic activity starting on the polar regions and, as long as the energy stored in the geomagnetic tail is pushed towards the day side, the ring current intensity increases and a storm is initiated a bit later.

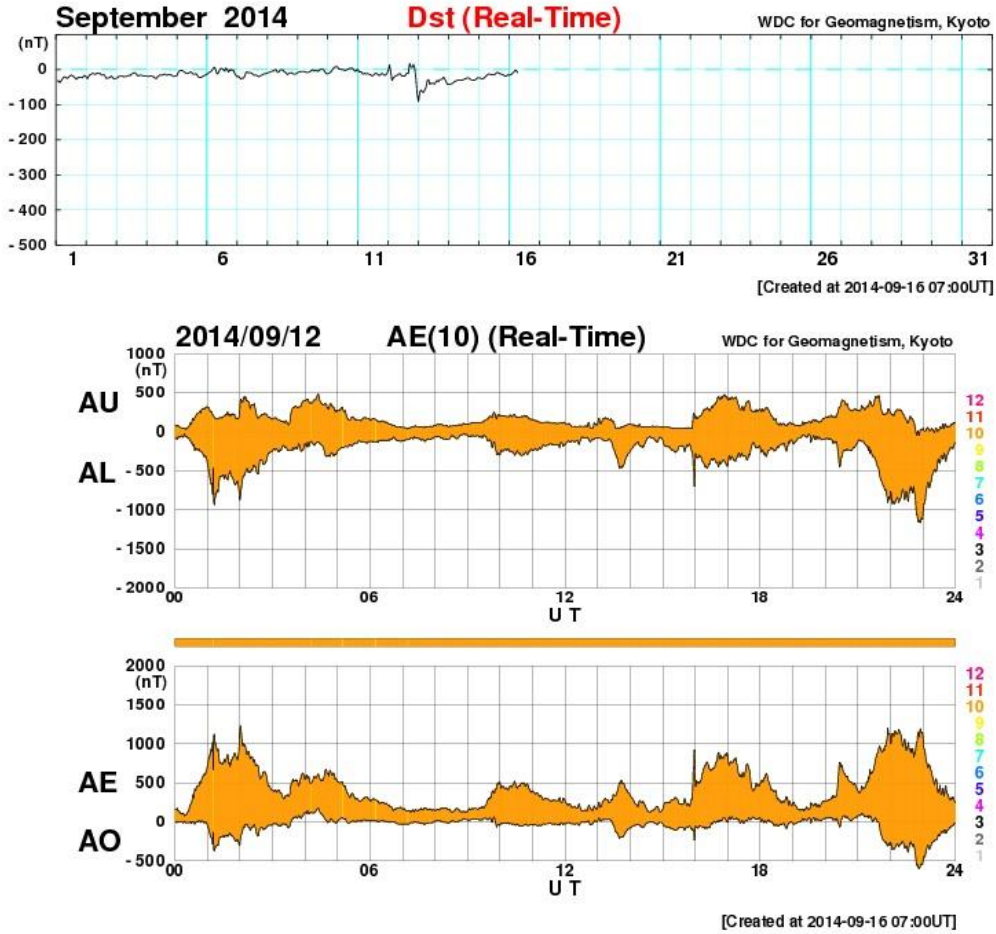

Figure 33: Dst index during September 2014 (upper panel), and the AE index for day 12/09/2014 (lower panel).

Then, observing the ASM-VFM residuals together with the 1st difference field, we have noted that the “noisy time series” seems to be related to the vector measurements processed from VFM; in Figure 34 a zoom of Figure 32 can be seen, taken around the start of the superimposed noise for S/C A: the behaviour is not easy to understand due to the plot resolution, but one can observe single spike in the middle of the figure as a sort of starting point of the more noisy behaviour. The noise intensity is of the order of few pT.

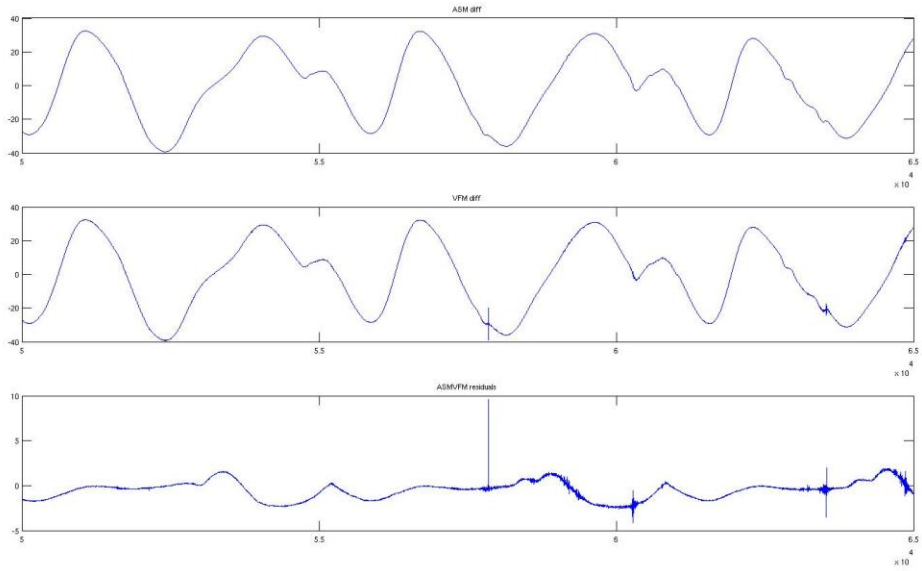

Figure 34: zoom of Figure 32 around the start of the noisy behaviour for S/C A.

We then computed the PSD of the ASM-VFM difference in order to see if it is possible to spot the observed feature in the frequency domain. In Figure 35 one can see, in the upper panel, the PSD calculated for day 12/09, S/C A, and, in the lower panel, the same quantity for day 11/09. A slight increase of the PSD can be observed on day 12/09, in the frequency band between 0.04 and 0.1 Hz (red oval).

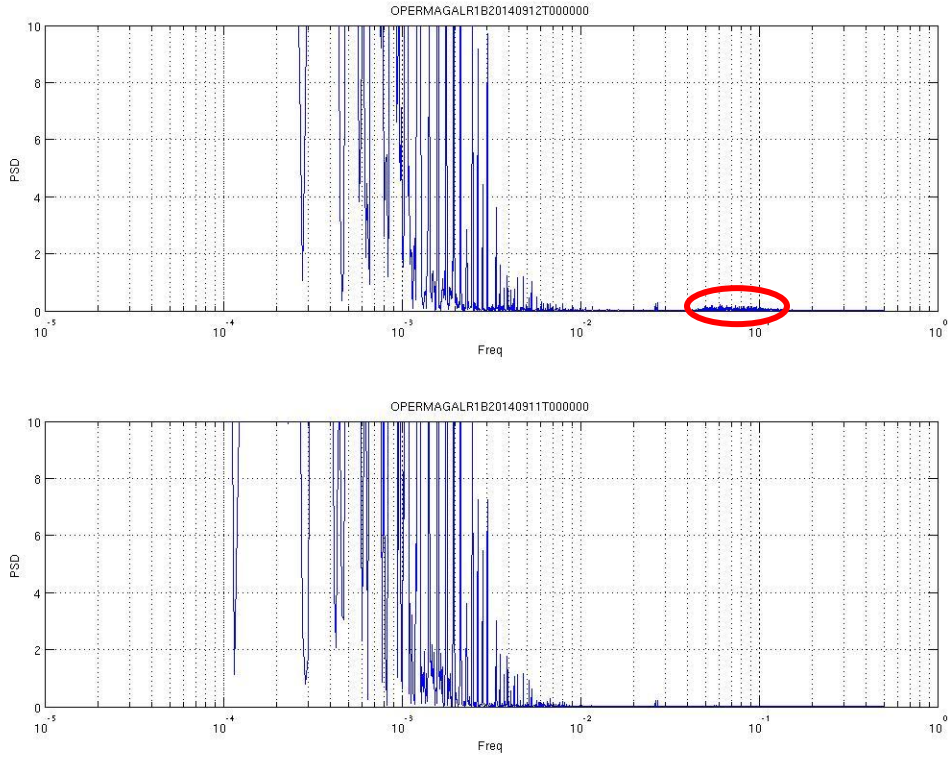

Figure 35: PSD of day 12/09 (upper panel), and 11/09 (lower panel).

We also cross-verified the analysis above on another period during February 2014, when the geomagnetic activity showed similar characteristics as compared to 12-13 September. Again, we saw a similar increase in the VFM noise according to what we have shown in Figure 35 above. So concluding, from our work it seems that the observed feature of the ASM-VFM signal could be correlated with the VFM response to the geomagnetic activity.

We already addressed instruments experts, and they only briefly confirmed an effect of the geomagnetic activity on the VFM signal is expected, but they also clarified that the noise cut-off is different for ASM and VFM, so that it is possible that a similar effect on the ASM is filtered away.

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