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IDEAS+ Swarm Weekly Report : 22/09/2014 – 28/09/2014

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period 22 to 28 September, 2014.

Author : Igino Coco, on behalf of Swarm IDEAS+ Team

Approval : Lidia Saavedra de Miguel
IDEAS+ Service Manager

Distribution : ESA/ESRIN EOP-GMQ
ESA/ESRIN EOP-GM Swarm MM
IDEAS+ Leadership Team
IDEAS+ subcontractors
ESA/ESTEC Swarm PLSO
ESA/ESOC Swarm FOS

Serco Italia Spa
Via Sciadonna 24/26, 00040, Frascati, Italy
Tel: +39 06 98354400   Fax: +39 06 9419426
www.serco.com

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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	03 Oct 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_20140924_MoM

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

[RD.9] IDEAS+ Swarm Weekly Report: 08/09/2014 – 14/09/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140908_20140914.pdf

[RD.10] IDEAS+ Swarm Weekly Report: 15/09/2014 – 21/09/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140915_20140921_2.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. After a week of operations from the last ready state, the three TIIs have been put in ready state again. Degradation of the images started to appear on S/C A, after 5-6 days of good operations, the new AGC settings and gain maps on S/C B resolved the saturation issue, but the image degradation starts after few days as well. S/C powered on and off on a daily basis did not lead to significant improvements: after few orbits the images are no more usable, especially for the horizontal sensor. Consultations are on-going with industry partners for concerting the next steps.

EFI-LP recent improvements. The LP team at IRF communicated several algorithm improvements aimed at: 1) reducing discrepancies between sweep and normal mode (partially achieved) and 2) removing too large spikes in density and temperature due to electron region current saturation, and smoothing the S/C potential behaviour across the terminators (very good achievements). Implementing the new changes, especially those pertaining to point 2, in a new official version of the EFI prototype will take from 3 to 6 months.

As the release of a stable PLASMA operational processor is delaying and the reference version of the prototype seems to be already obsolete, the user community will be provided with a plasma data set built with prototype data by the EFI scientists. The timeline for this data set delivery is beginning of November.

2.2 Plan for operational processor updates

From the last L1B coordination teleconference the following updates shall be reported [RD.7]:

- GFZ replied to the request of impact assessment of the new RINEX on TEC L2-Cat2 processing. There are differences above expected thresholds between new and old TECs, but this does not mean the new ones are worse than the old ones. In fact, a TEC quality indicator included in the TEC products seems to show better values for the new TECs than for the old ones. The final conclusion is that the corrections on raw RINEX don't give any benefit to the TEC quality, so the recommendation is to use the new RINEX. Therefore, the ORBATT patch can be delivered in the week 6-10/10/2014.

- The PLASMA cross-verification is still delayed because of a misunderstanding about the format of the prototype output. In spite of what written above, that a prototype data set will be produced for the users, the work of operational-prototype processors alignment has not to stop, so measures will be taken in the framework of the ESL contract for assuring this properly.

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 39 (22-28/09/2014)

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

1. **An observation of attitude rejection** occurred on S/C A (4 attitudes rejected the 25/09) caused by simultaneous occurrence of Big Bright Objects on all the three camera units of the S/C. The rejections are nominal, i.e. follow the nominal rules given by processing algorithms and cannot be therefore classified as anomalies. The observation is nonetheless tracked in the IDEAS+ ARTS repository for purposes of monitoring instruments health.

2. **Increase in the time series noise of the ASM-VFM difference** already reported and described past two weeks ([RD.9] and [RD.10]). The observation occurred throughout the week for all S/C, and seems to be an effect of the overall moderate to high geomagnetic activity.

3. **Pulsations observed in the ASM-VFM time series**, with period between 20 and 30 seconds and amplitude up to 500 pT. Trains of such pulsations are observed throughout the week on all S/C, occurring almost simultaneously on S/C A and C and after some delay on S/C B. A full characterisation of this effect is still to be done.

4. **Remarkable decreases in TCF.VFM scale factors** for all S/C during the month of September. The effect seems to be triggered by the geomagnetic storm of 12-13/09, the same event which apparently caused the insurgence of noise in the ASM-VFM time series. Related to this, we also observed a clear amplitude increase of the ASM-VFM time series, especially for S/C A.

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-31	OBS_ROUTINE: 25/09/2014, STR S/C A out of range.	Flags_q, quaternions, B_{NEC}	3.2.1.2	3.2.1.2

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for Week 39: 22/09 - 28/09/2014

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 maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm A, 22-28/09/2014, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard deviation (m)**	**Notes**
22/09	0.08	+/- 9 (Z)	1.6	
23/09	0.25	-15 (Z), 9 (Y)	1.6	
24/09	0.1	-8.6, 7.6 (Z)	1.6	
25/09	0.24	-9.5 (Z), 13 (X)	1.6	
26/09	0.06	-12.5, 10 (Z)	1.8	
27/09	0.08	-9.5, 11 (Z)	1.7	
28/09	0.23	-13.4 (Z), 10.3 (X)	1.5	

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 (22/09, Figure 1), in the middle (25/09, Figure 2) and at the end (28/09, Figure 3). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

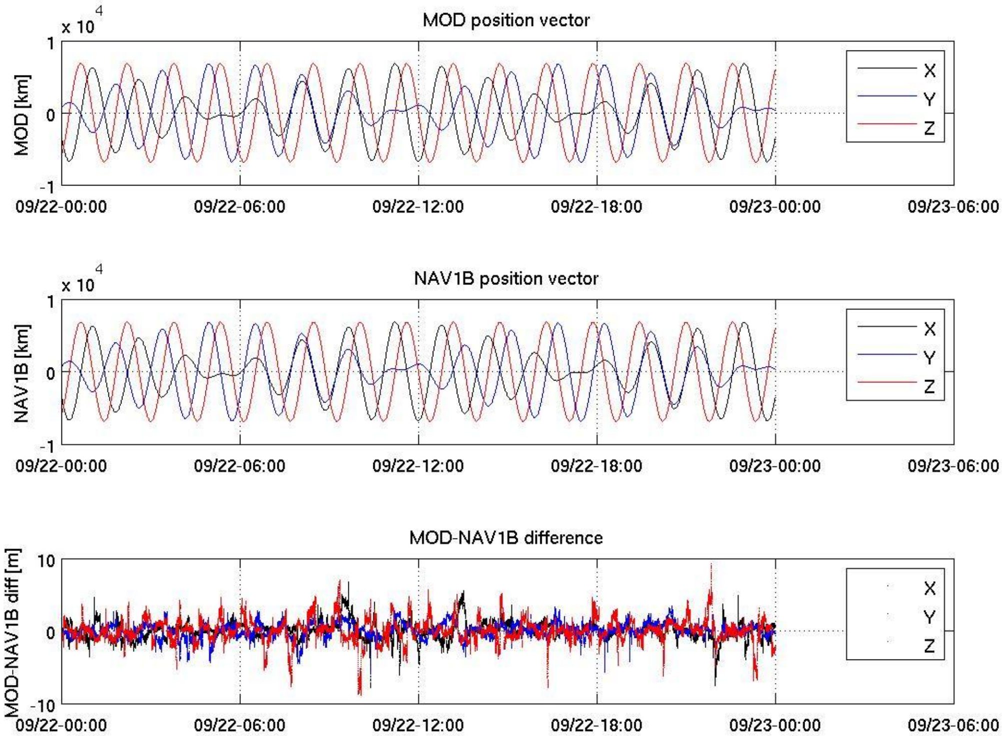

Figure 1: Difference MOD-GPSNAV, sc A, 22/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

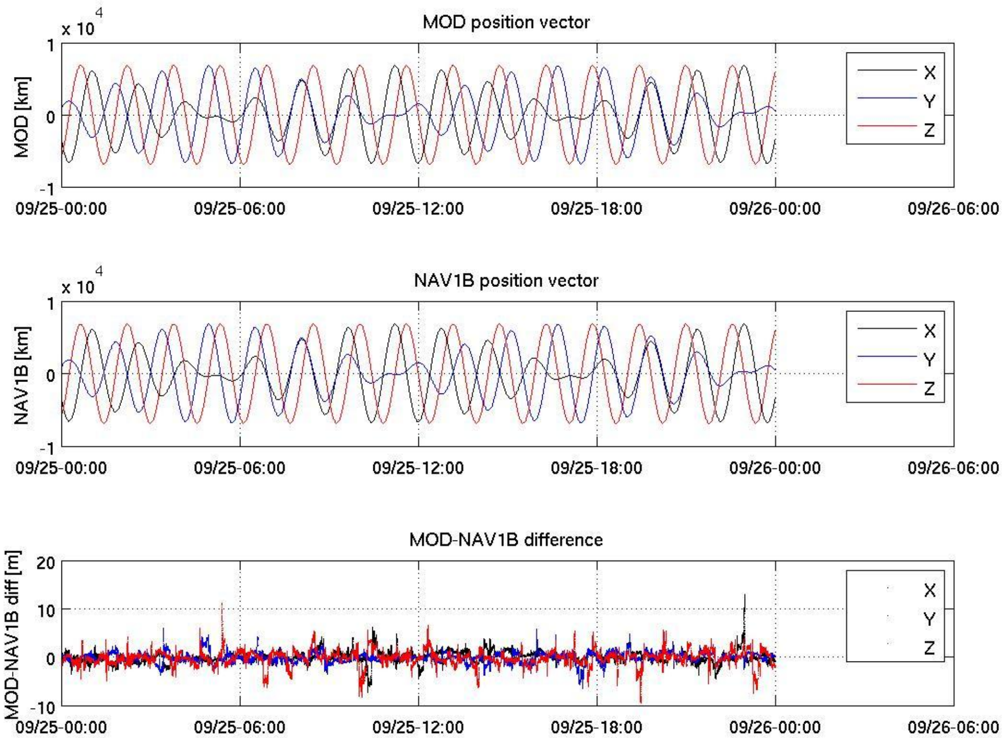

Figure 2: Difference MOD-GPSNAV, sc A, 25/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

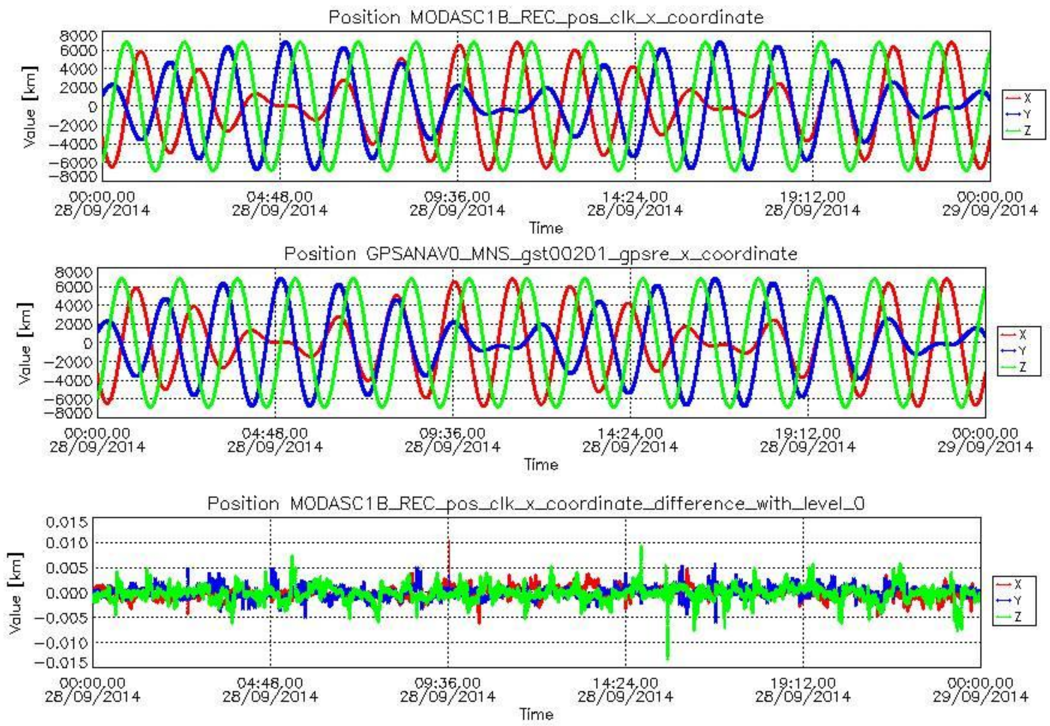

Figure 3: Difference MOD-GPSNAV, sc A, 28/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.1.2 Attitude observations

- **SW-IDEAS-31**
  Affected product:
  SW_OPER_STRAATT_1B_20140925T000000_20140925235959_0301

  4 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
25SEP2014 03:33:21	25SEP2014 03:33:24	4	255

Table 3: Attitudes out-of-range, S/C A, 25/09/2014

The cause of such rejected attitudes is the simultaneous occurrence of BBOs on camera units 1 and 2 and invalid measurements on camera unit 3 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 maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm B, 22-28/09/2014, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
22/09	0.15	-8 (Z), 13.2 (Y)	1.7	
23/09	0.08	-9.4, 10 (Z)	1.6	
24/09	0.1	-8.7, 19.6 (Z)	1.6	One single big spike (about 20 m) on the Z comp.
25/09	0.1	-13.7 (X), 9.7 (Z)	1.6	
26/09	0.17	-8 (X), 9 (Z)	1.5	
27/09	0.11	-9.6, 8 (Z)	1.7	
28/09	0.23	-11, 8.5 (Z)	1.7	

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 (22/09, Figure 4), in the middle (25/09, Figure 5), and at end of the week (28/09, Figure 6). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

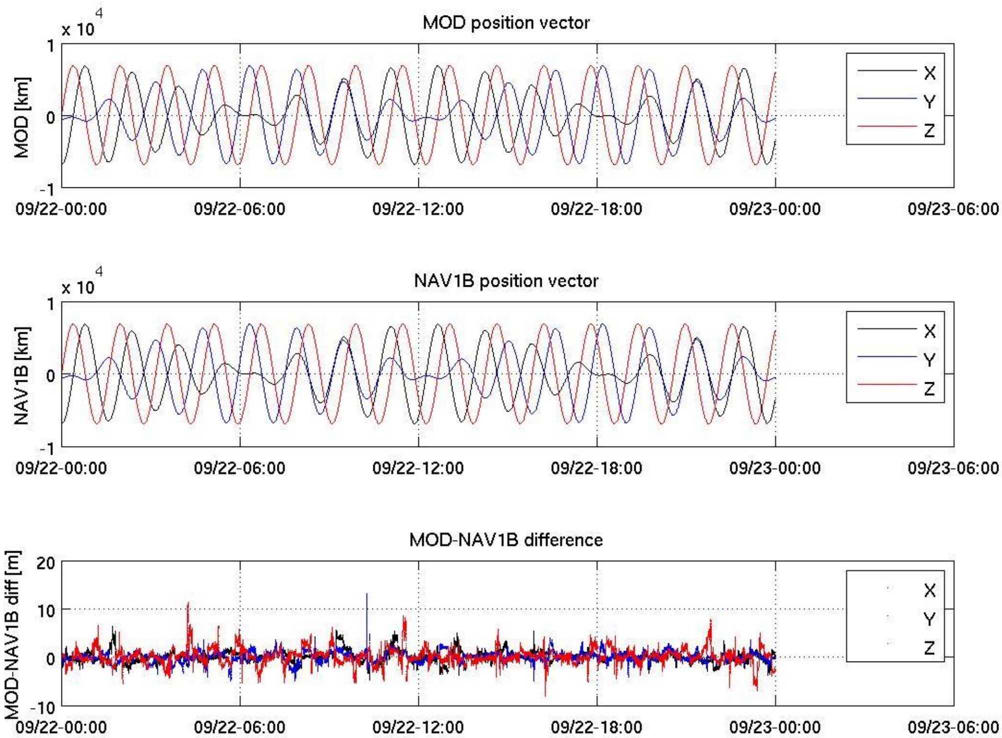

Figure 4: Difference MOD-GPSNAV, sc B, 22/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

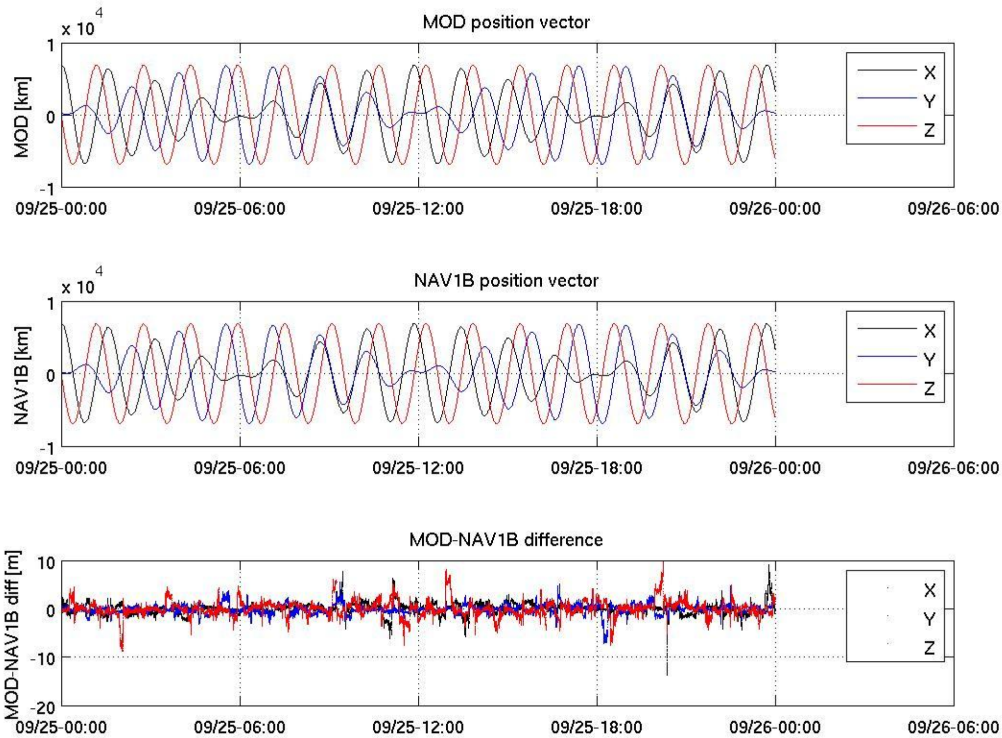

Figure 5: Difference MOD-GPSNAV, sc B, 25/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

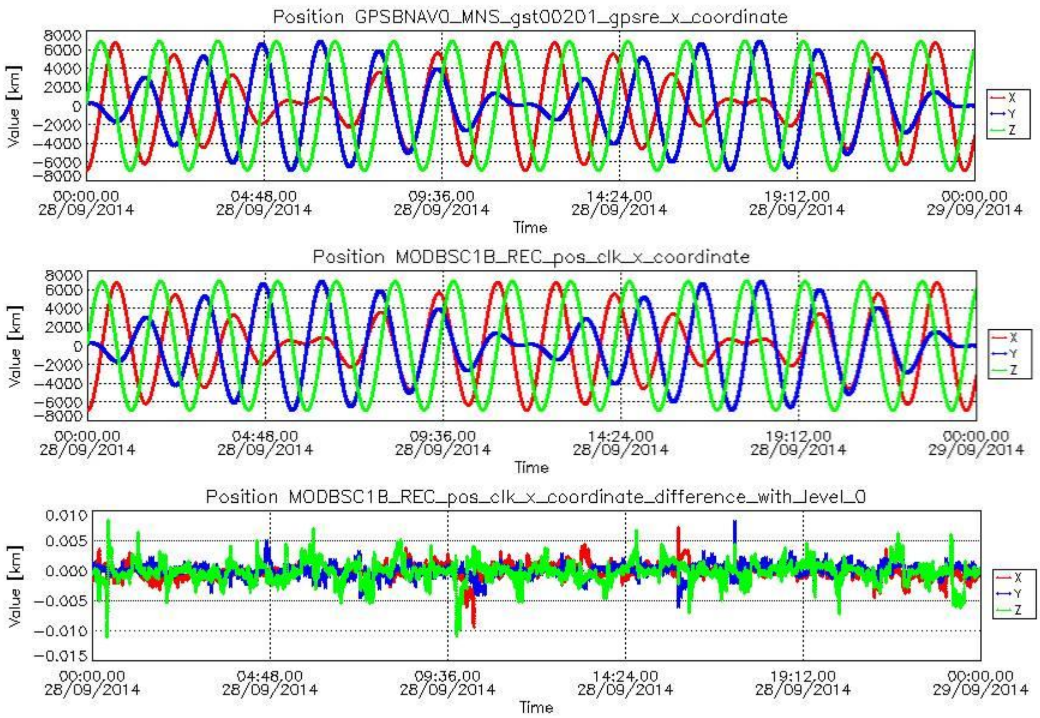

Figure 6: Difference MOD-GPSNAV, sc B, 28/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

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 maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm C, 22-28/09/2014, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
22/09	0.1	-12, 8.3 (Z)	1.6	

Swarm C, 22-28/09/2014, Position difference				
23/09	0.25	-15, 7 (Z)	1.6	
24/09	0.17	+/- 8.5 (Z)	1.6	
25/09	0.16	-8.5, 10 (Z)	1.6	
26/09	0.11	-12.5, 11 (Z)	1.7	
27/09	0.05	-9, 10.5 (Z)	1.7	
28/09	0.23	-12, 9 (Z)	1.4	

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 (22/09, Figure 7), in the middle (25/09, Figure 8) and at the end (28/09, Figure 9). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

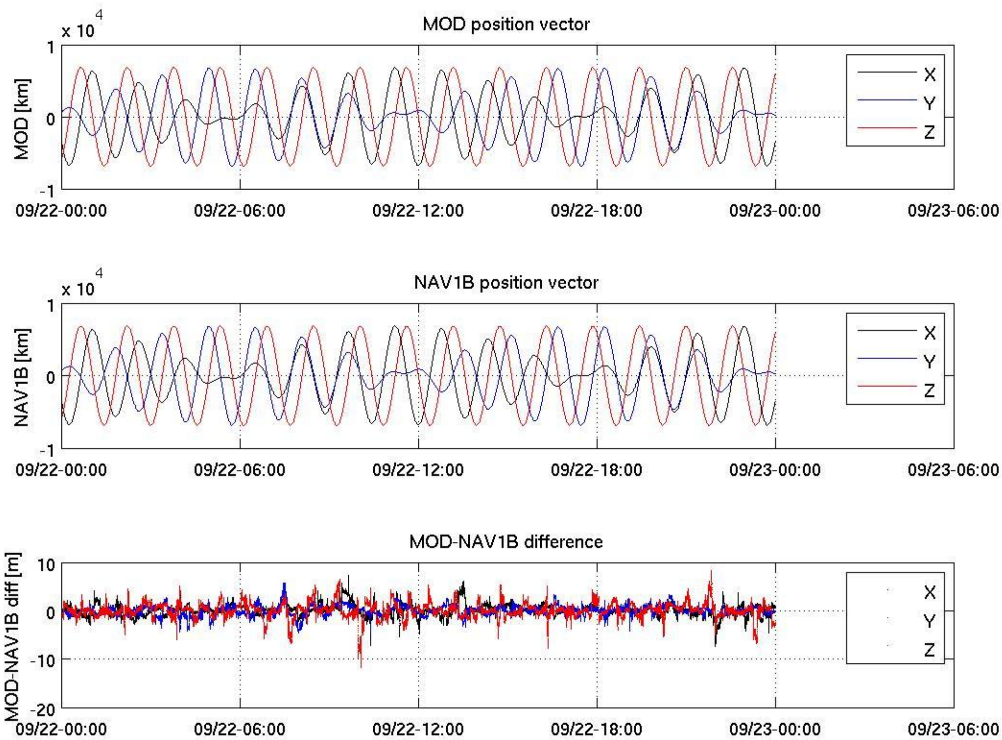

Figure 7: Difference MOD-GPSNAV, sc C, 22/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

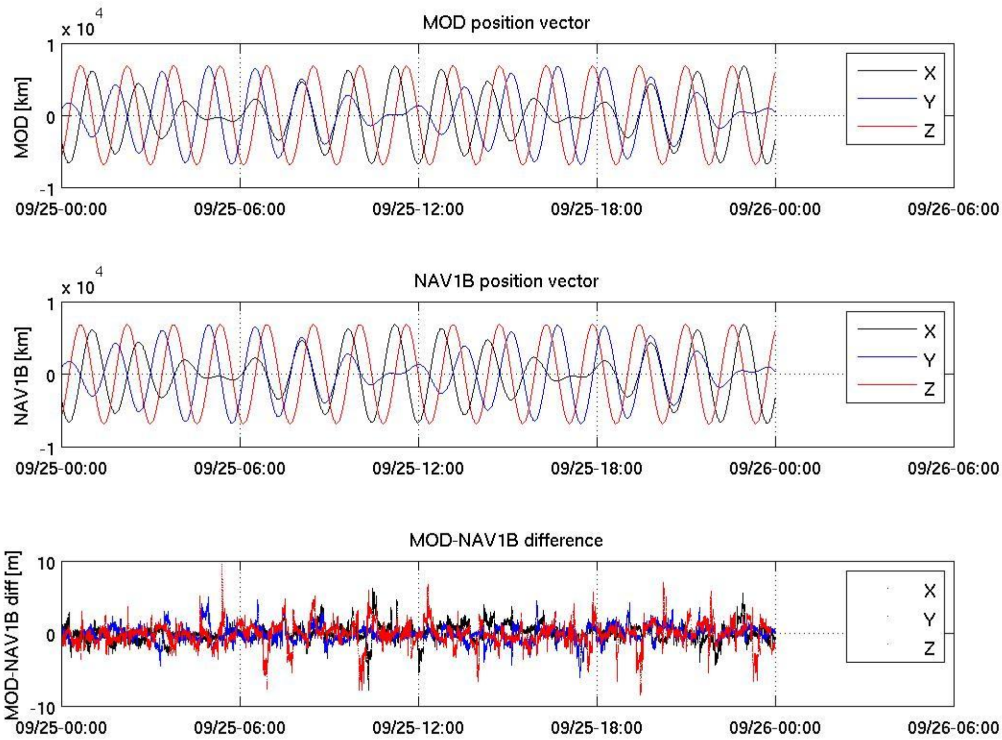

Figure 8: Difference MOD-GPSNAV, sc C, 25/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

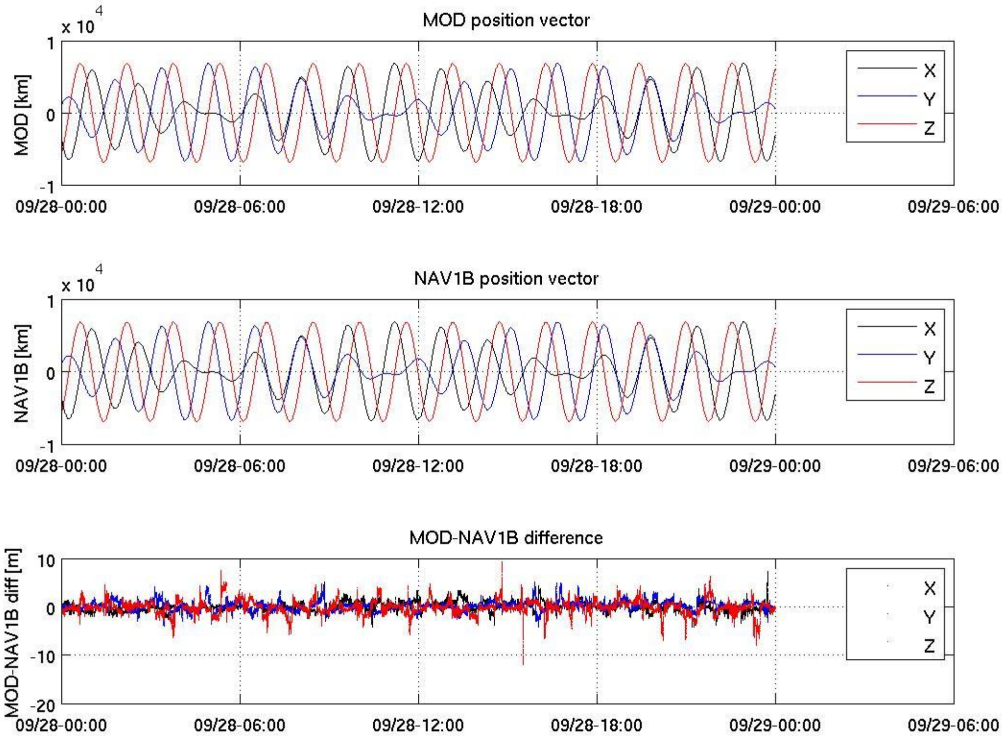

Figure 9: Difference MOD-GPSNAV, sc C, 28/09/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.3.2 Attitude observations

Nothing to report.

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-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	[RD.9],Sect.4.1; [RD.10],Sect. 4.1
SW-IDEAS-32	OBS_ROUTINE: periodic pulsations observed in the	B_{VFM}, F, B_{NEC}		4.2

	ASM-VFM diff			
SW-IDEAS-33	OBS_ROUTINE: remarkable decrease of TCF Scale parameters during September	TCF.VFM	3.3.1.3 3.3.2.3 3.3.3.3 3.3.4	4.3

Table 6: list of events related to magnetic products to be reported in the monitoring for Week 39: 22/09/2014 - 28/09/2014.

For the magnetic products the weekly monitoring consists in:

- Visual inspection of daily time series of magnetic field intensity F, $\mathbf{B}_{\mathbf{NEC}}$ and $\mathbf{B}_{\mathbf{VFM}}$. 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 (27/09/2014):

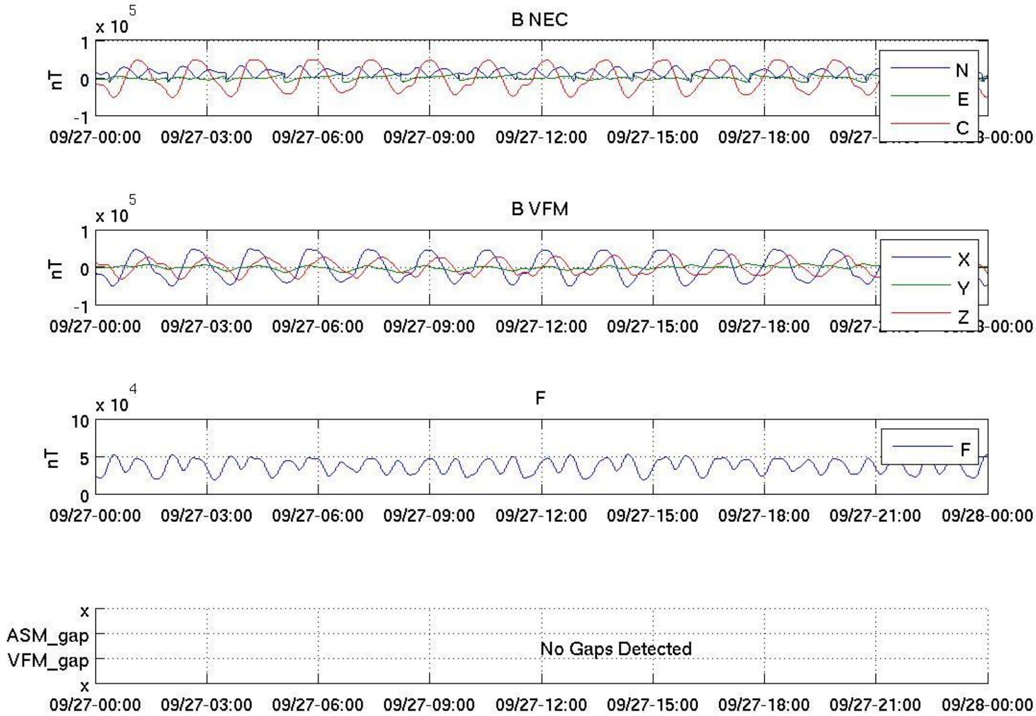

Figure 10: Time series of the geomagnetic field, for 27/09/2014, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.1.2 VFM-ASM anomaly

- **SW-IDEAS-27:** during the whole week, all S/C observe a noise superimposed on the ASM-VFM time series. Detailed descriptions of the effect are reported in [RD.9] and [RD.10]. Throughout the week the geomagnetic activity remains from moderate to high, with Kp between 4 and 5 and AE often above 1000 nT.

The daily peak-to-peak difference around the week is, on average: [-3, 4] nT, with some isolated spike which reaches up to 7.5 nT.

Below some plot example of such differences follows, taken at the beginning of the week (22/9, Figure 11) middle of week (25/09, Figure 12), and end of the week (27/09, Figure 13). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

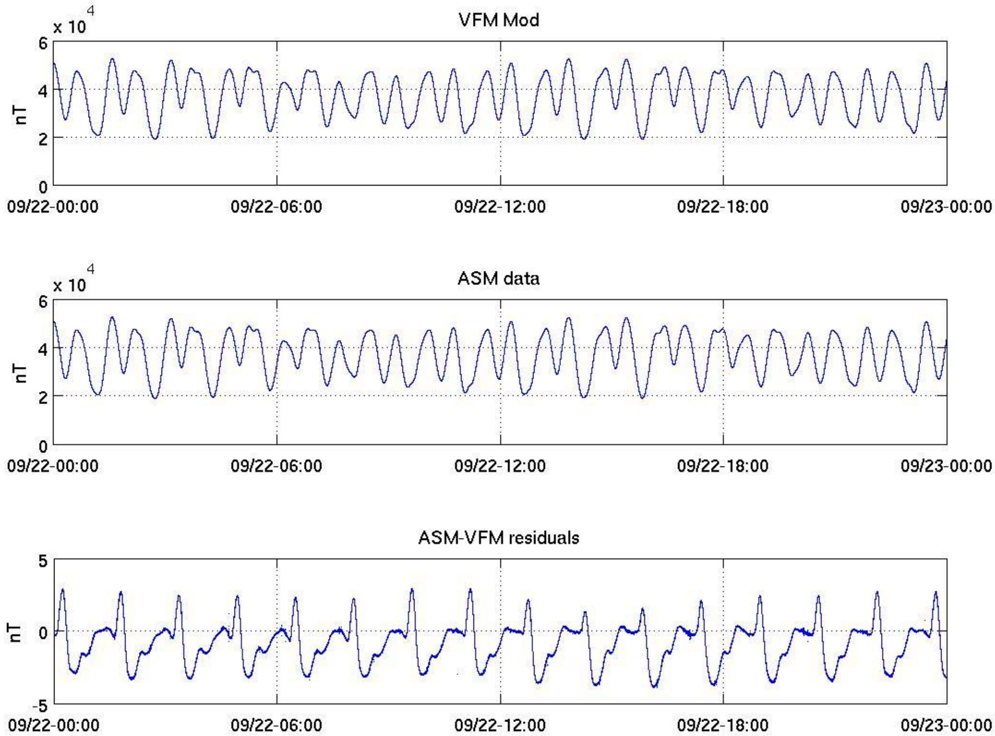

Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 22/09/2014.

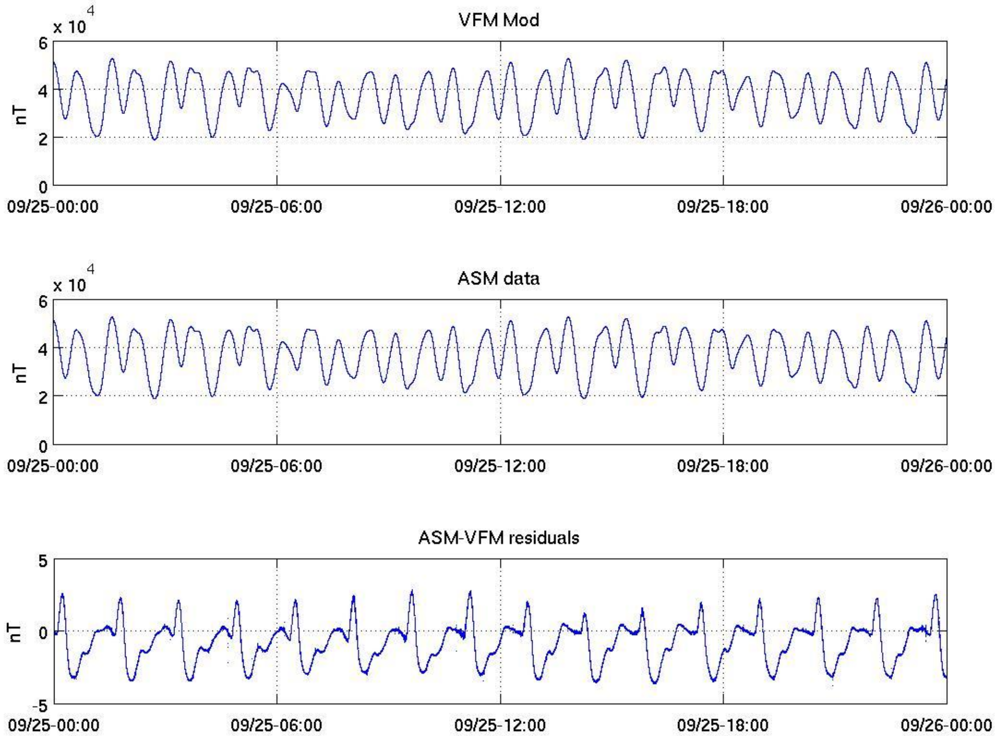

Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 25/09/2014.

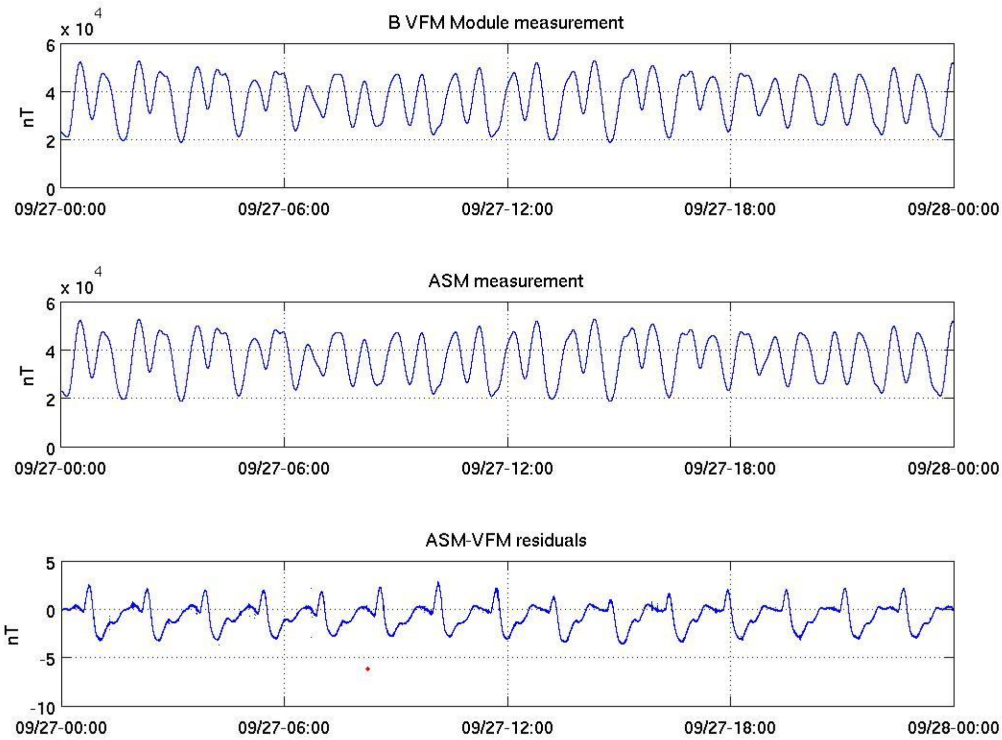

Figure 13: VFM module, ASM module and ASM-VFM residuals for S/C A, 27/09/2014.

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 whole month of September: 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. A remarkable behaviour can be noticed for Scale X component, that shows a strong decreasing trend (of about 0.003%), starting from 12/09 (**SW-IDEAS-33**, for more details see Sect. 4.3).

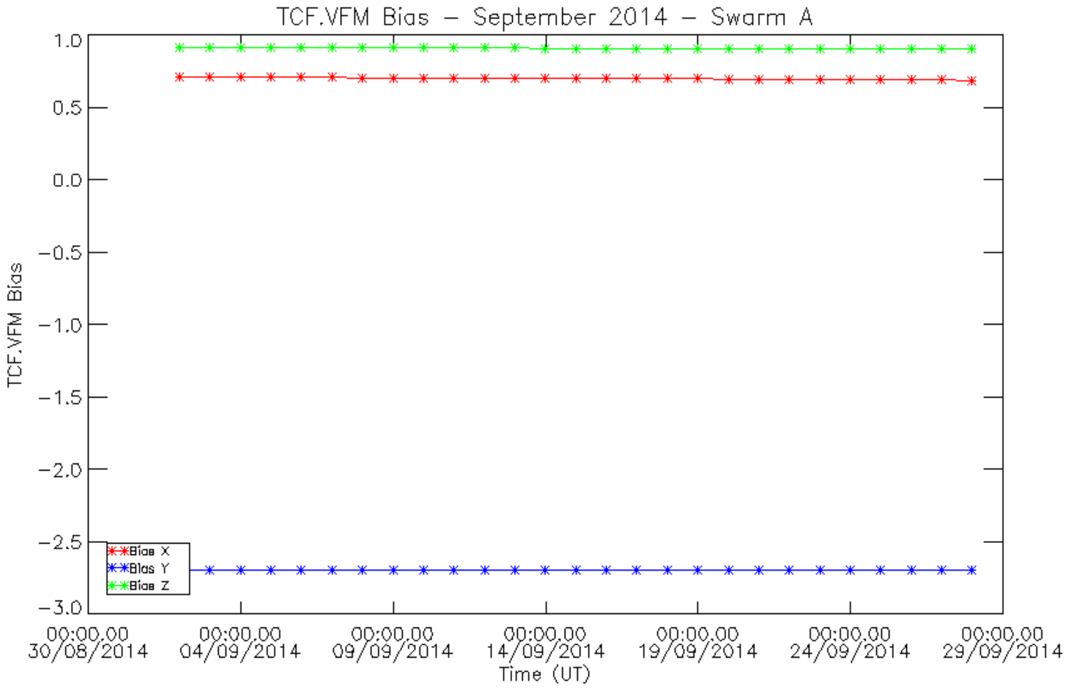

Figure 14: TCF.VFM Biases for S/C A, September 2014.

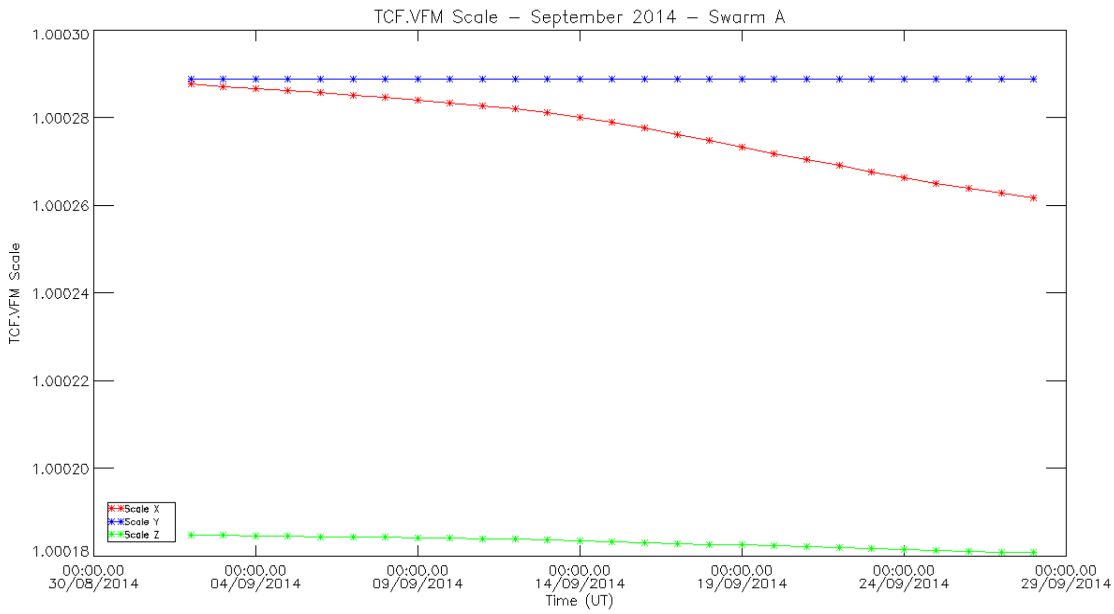

Figure 15: TCF.VFM Scales for S/C A, September 2014.

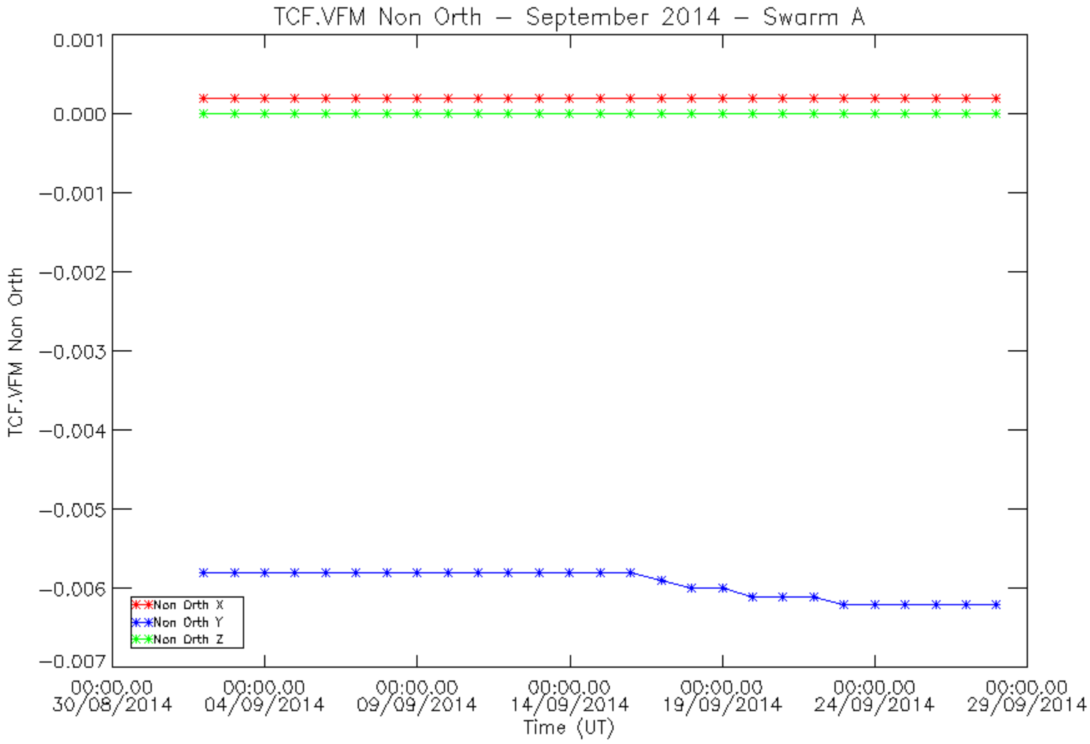

Figure 16: TCF.VFM Non-Orthogonalities for S/C A, September 2014.

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 (28/09/2014) can be seen in Figure 17 below.

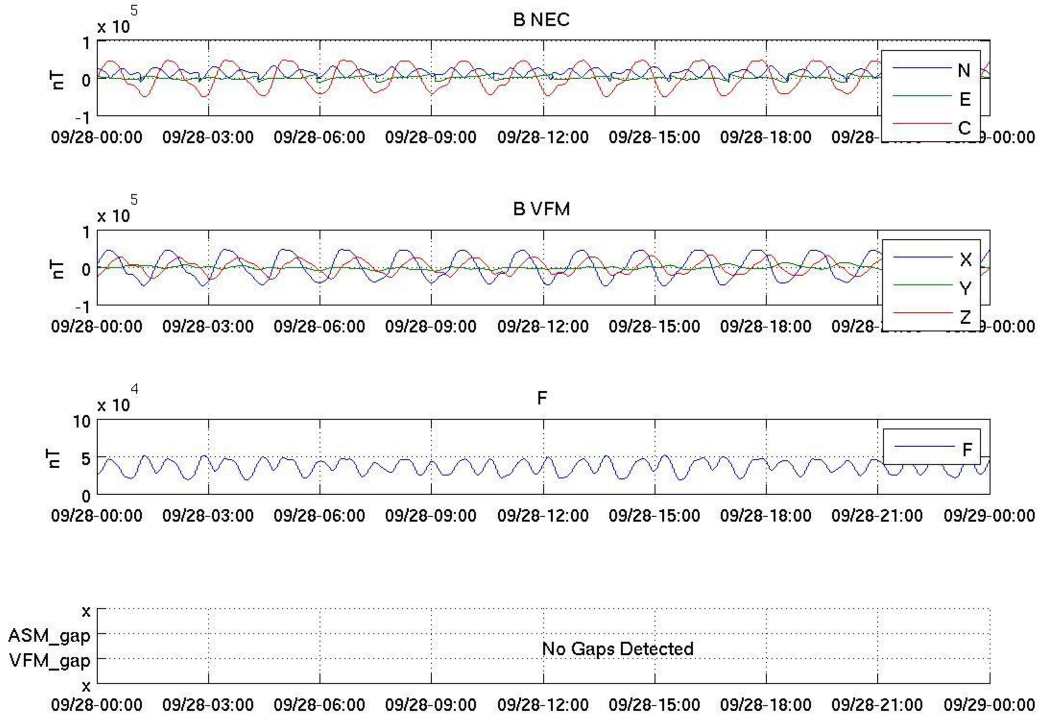

Figure 17: Time series of the geomagnetic field for 28/09/2014, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

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: [-2.5, 1.8] nT, with some small isolated spike which reaches up to 4 nT.

Below some plot example follows of such differences taken at the beginning of the week (22/09, Figure 18), middle of the week (25/09, Figure 19) and at the end of the week (28/09, Figure 20). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

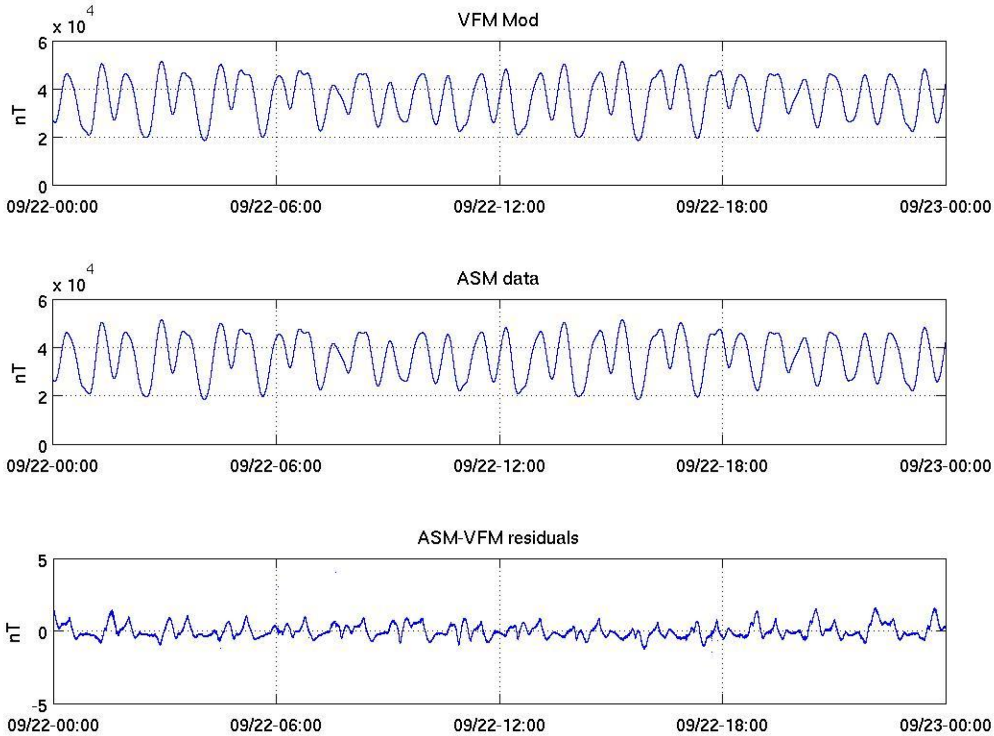

Figure 18: VFM module, ASM module and ASM-VFM residuals for S/C B, 22/09/2014

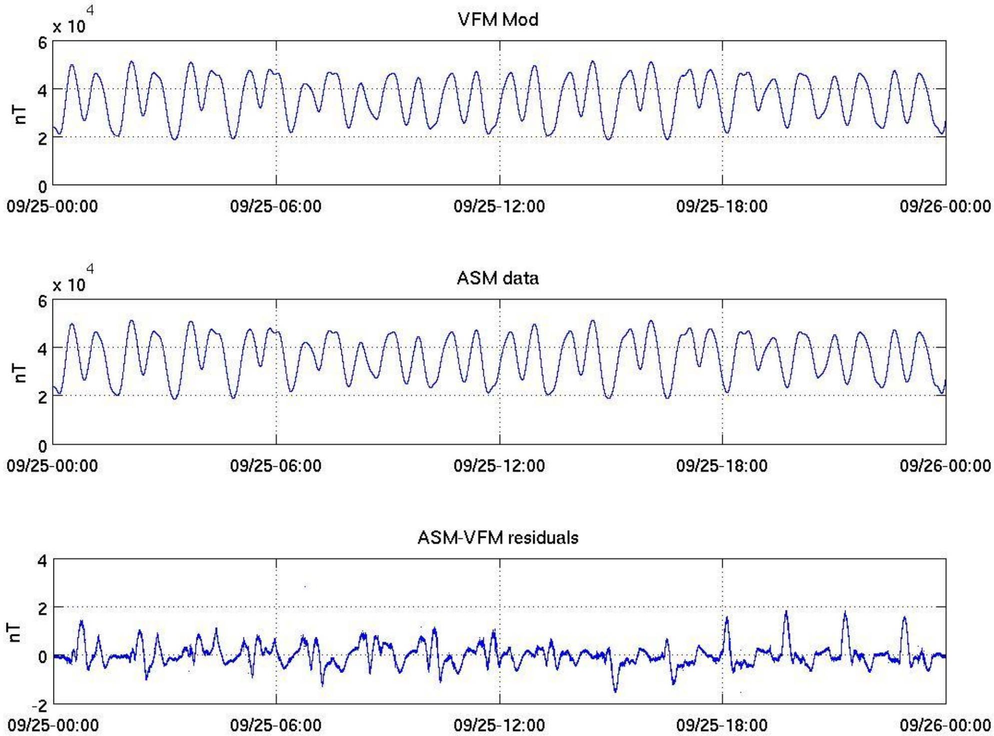

Figure 19: VFM module, ASM module and ASM-VFM residuals for S/C B, 25/09/2014.

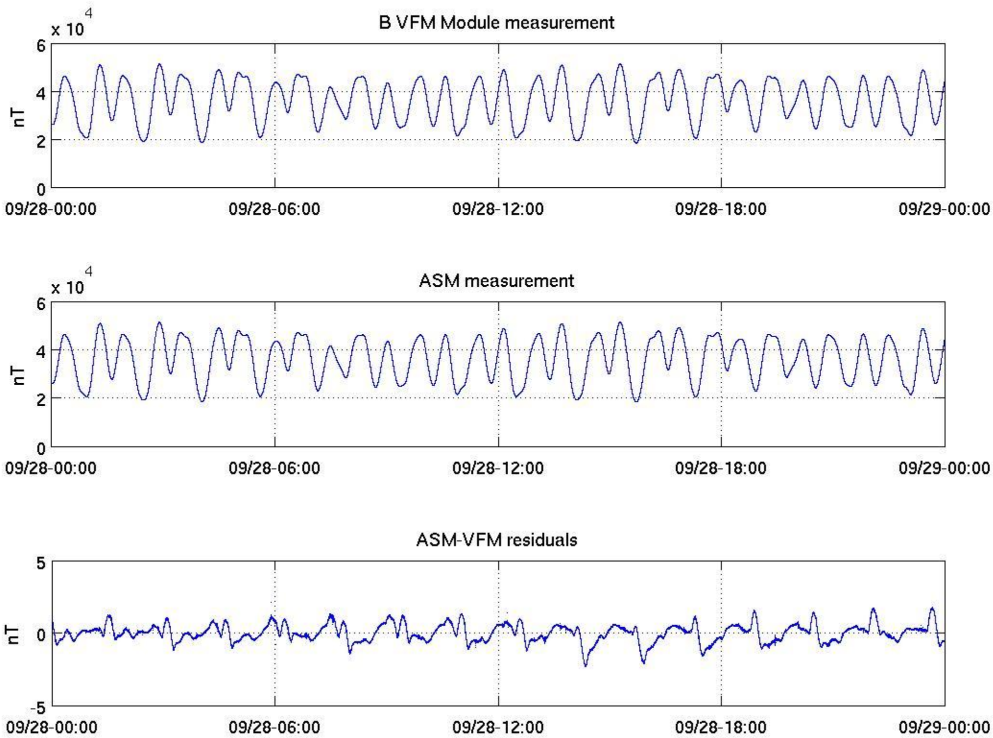

Figure 20: VFM module, ASM module and ASM-VFM residuals for S/C B, 28/09/2014.

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 whole month of September: 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, except for a remarkable decrease of the Scale X component (SW-IDEAS-33, see Sect. 4.3 for more details) of about 0.003%, starting from 18/09.

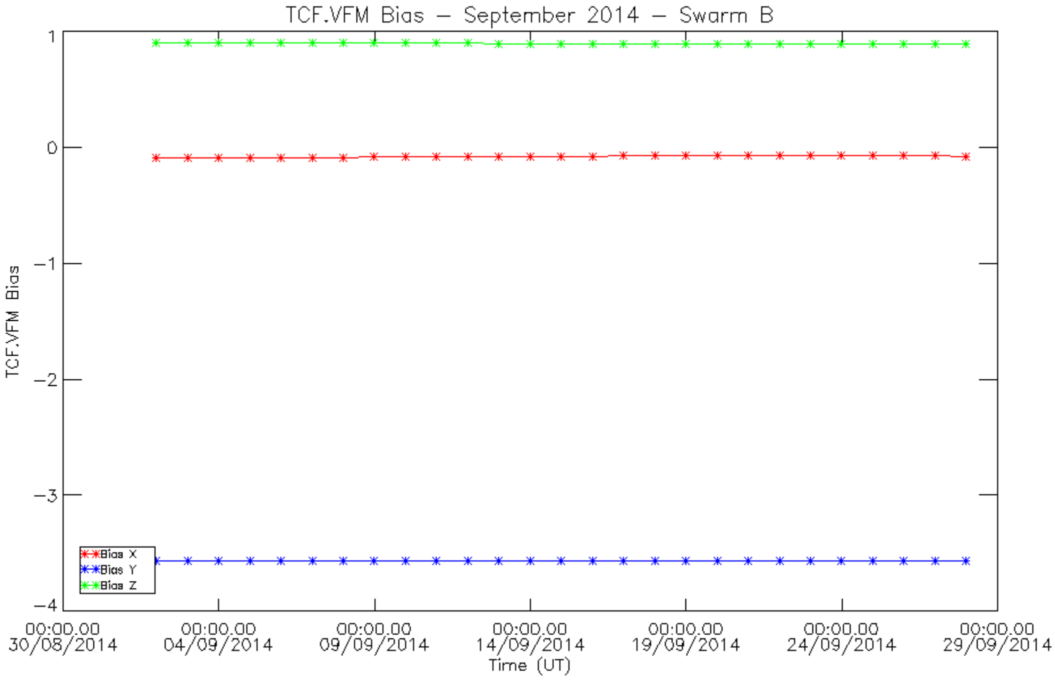

Figure 21: TCF.VFM Biases for S/C B, September 2014.

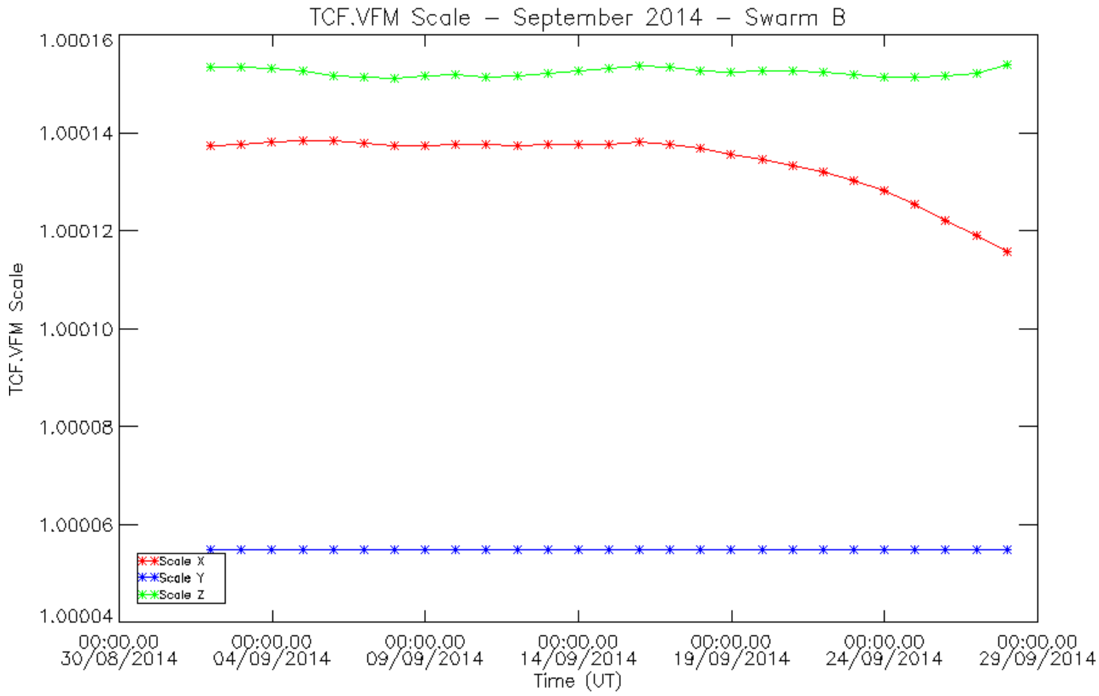

Figure 22: TCF.VFM Scales for S/C B, September 2014.

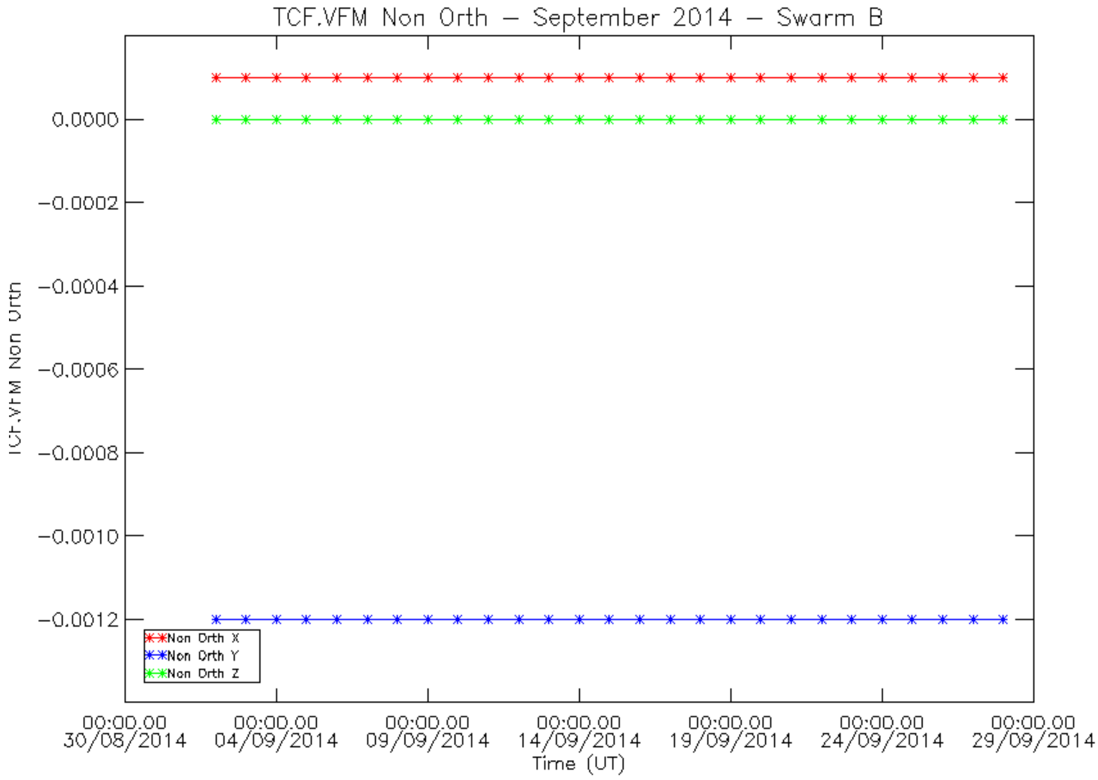

Figure 23: TCF.VFM Non-Orthogonalities for S/C B, September 2014.

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 (28/09/2014) can be seen in Figure 24 below.

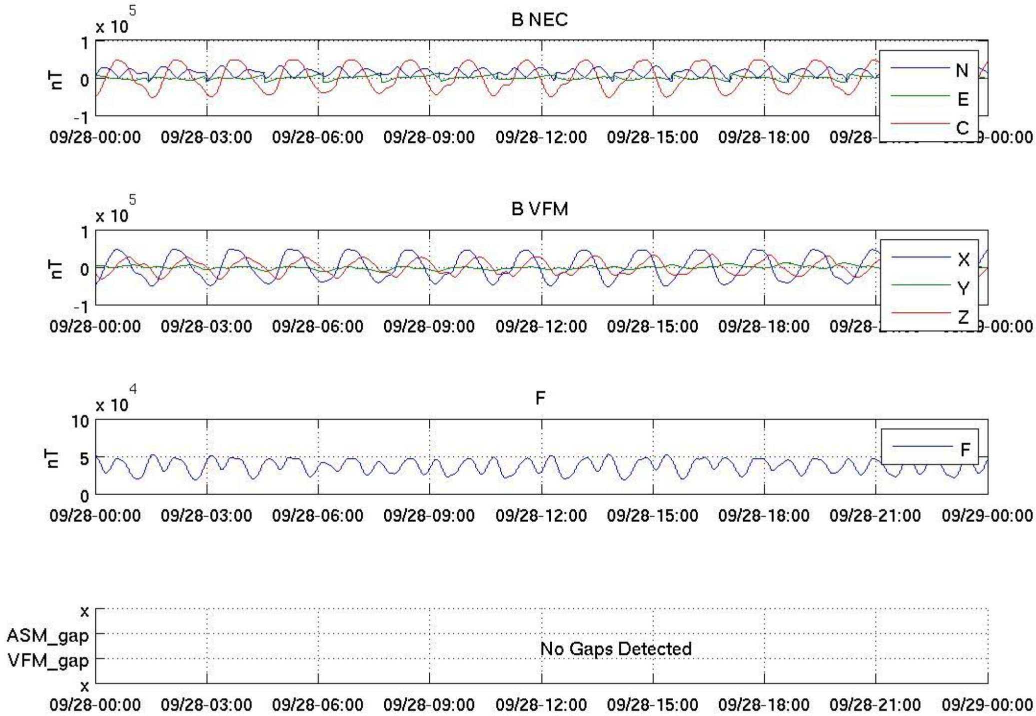

Figure 24: Time series of magnetic field intensity, F, for 28/09/2014, S/C C. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.3.2 VFM-ASM anomaly

- **SW-IDEAS-27:** see Sect. 3.3.1.2. In Figure 26, an example (circled in red) can be seen of a period characterized by higher noise superimposed on the ASM-VFM signal.

The daily peak-to-peak difference around the week is, on average: [-2, 1.5] nT, with isolated spikes which reaches up to 5.5 nT.

Below some plot example follows of such differences taken at the beginning of the week (22/09, Figure 25), at the middle of the week (24/09, Figure 26), and at the end of the week (28/09, Figure 27). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

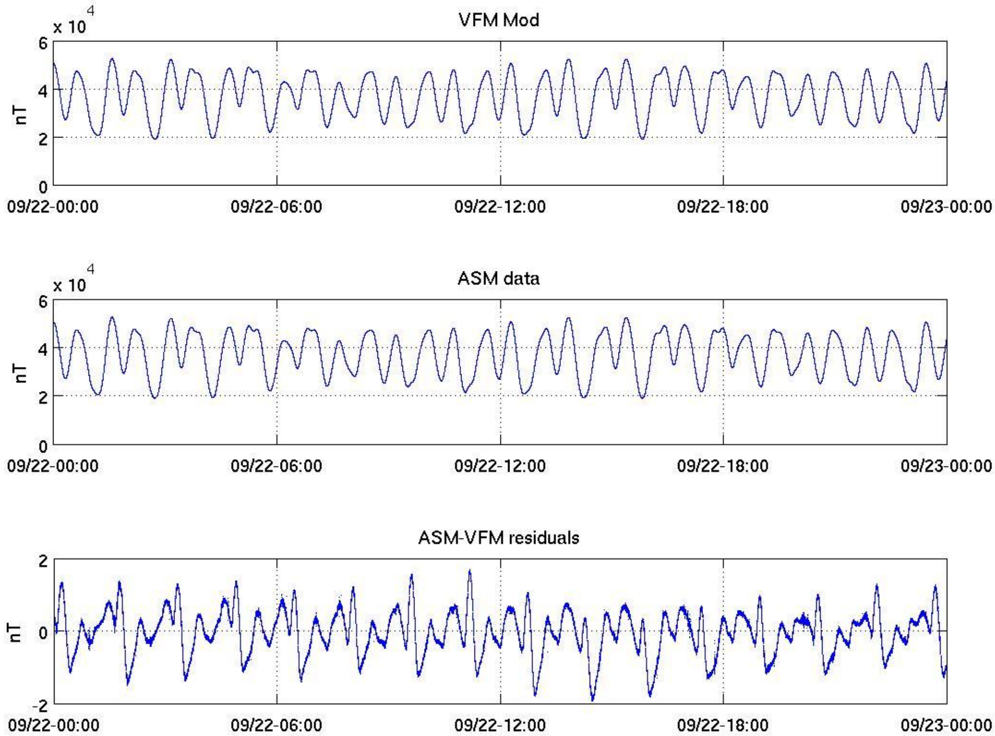

Figure 25: VFM module, ASM module and ASM-VFM residuals for S/C C, 22/09/2014.

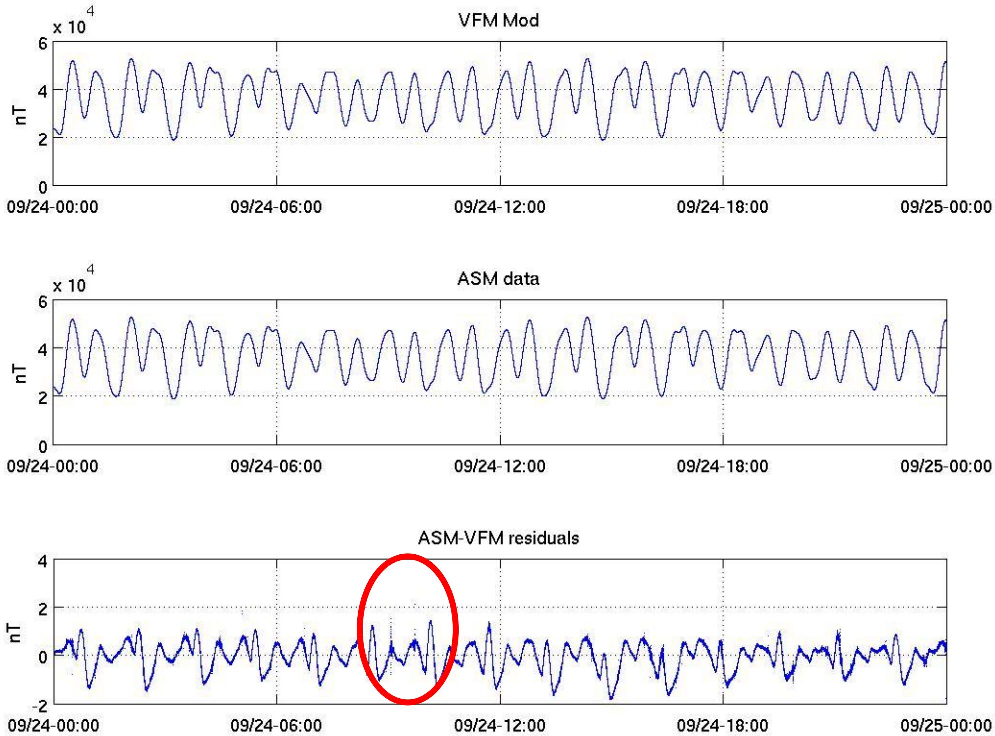

Figure 26: VFM module, ASM module and ASM-VFM residuals for S/C C, 24/09/2014. The red circle highlights a period characterized by noise.

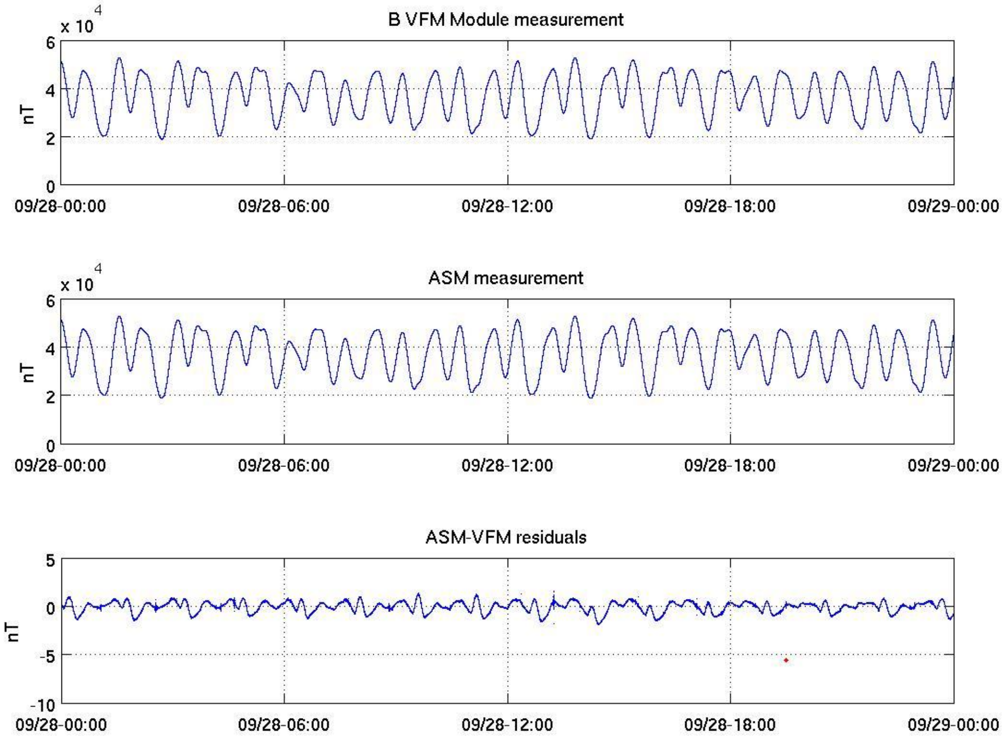

Figure 27: VFM module, ASM module and ASM-VFM residuals for S/C C, 28/09/2014.

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 whole month of September: 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 scale factor, X component, which shows a decrease (of about 0.002%), starting at 12/09/2014 (**SW-IDEAS-33**, see Sect. 4.3 for more details).

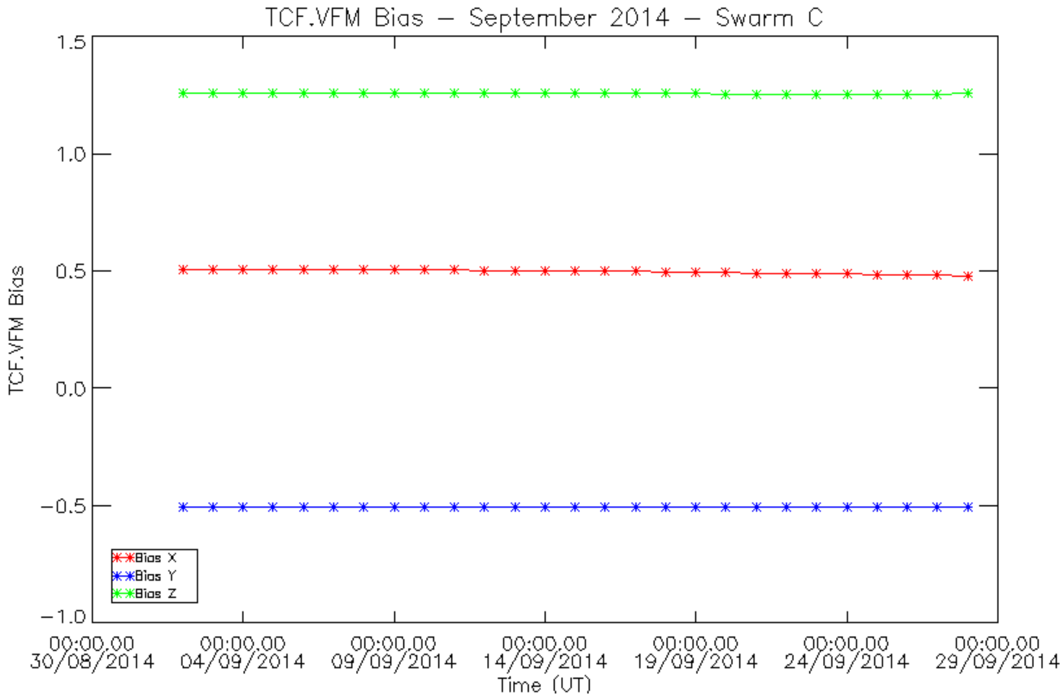

Figure 28: TCF.VFM Biases for S/C C, September 2014.

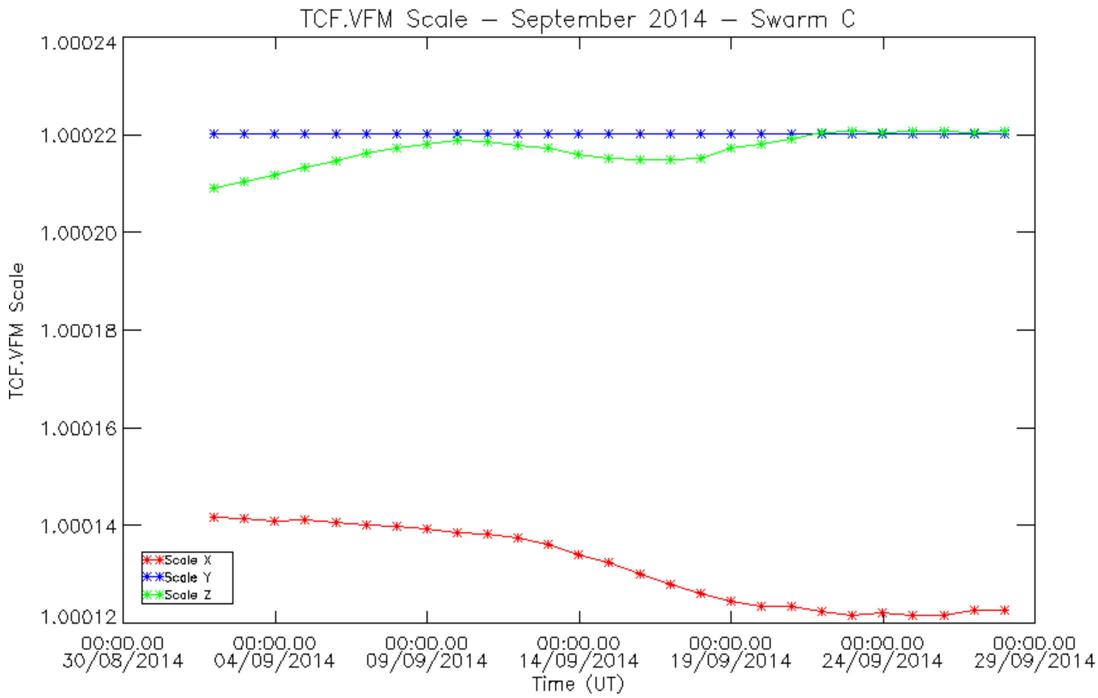

Figure 29: TCF.VFM Scales for S/C C, September 2014.

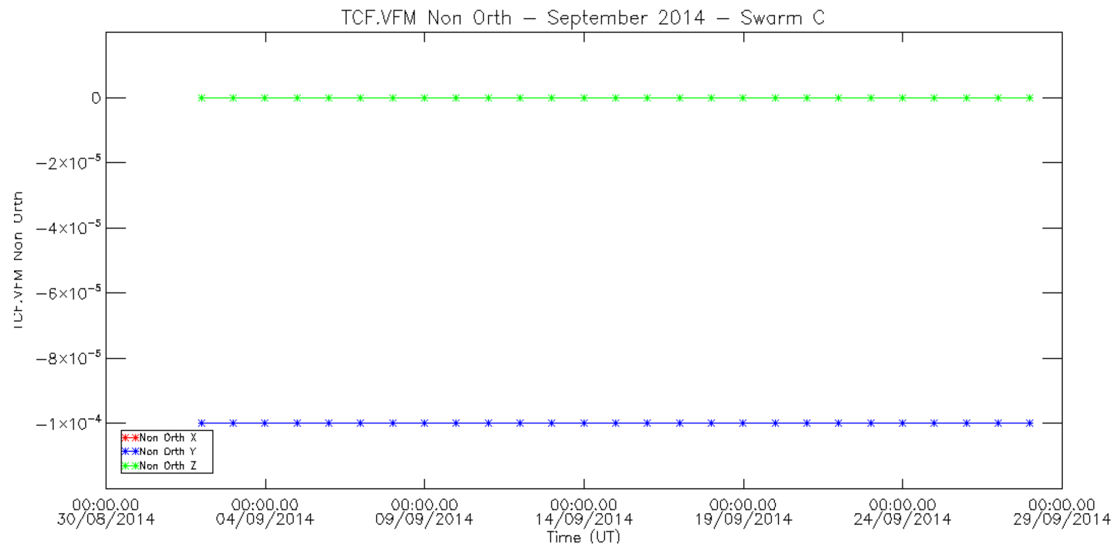

Figure 30: TCF.VFM Non-Orthogonalities for S/C C, September 2014.

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 September 2014 (Red curve = S/C A, blue curve = S/C B, green curve = S/C C). The important observation here is the neat increase of RMS for S/C A, starting at 12/09/2014 (**SW-IDEAS-33**, see Sect. 4.3 for more details).

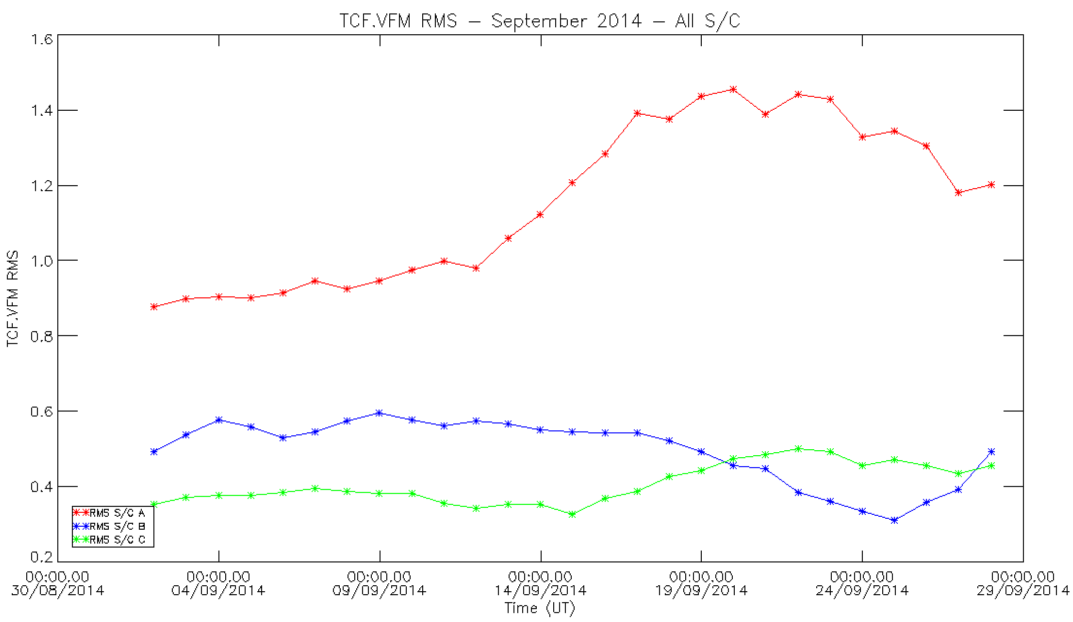

Figure 31: weighted RMS of the residuals after the TCF estimation, all S/C, September 2014.

4. ON-DEMAND ANALYSIS

4.1 SWL1L2DB-9: follow-up of MOD-GPSNAV discrepancies issue.

A preliminary analysis has been done by the Napeos team at GMV.

Mail from Maria Jose Brazal from GMV, 01/10/2014:

“Dear all,

We have investigated the problem you reported (SWL1BL2DB-9), where sometimes the differences between the ORBATT solution (MOD) has large deviation with respect to the navigation solution at the end of the day being processed.

The reason of these big differences was due to a large number of observations being rejected by NAPEOS, mainly in the last part of the day, which cause that the estimation of the parameters (mainly the drag parameters) are not accurate and therefore the errors accumulate, mostly in the last part of the day.

The current configuration of NAPEOS seem to be very demanding in terms of accuracy, so when the real observations does not match with the models assumed, a large amount of data is rejected jeopardizing the accuracy of the orbital product.

We would like to understand the root cause of this mismatch between data and models, so we need to cross-check the location of the centre of gravity and antenna reference point being used right now. The following tables summarize the current set-up:

Centre of Gravity	X (m)	Y (m)	Z (m)	Mass
SWARM-A	-1.94726	-0.00096	0.33386	471.168
SWARM-B	-1.94600	-0.00076	0.33368	471.043
SWARM-C	-1.94418	-0.00103	0.33355	472.117

Antenna Reference Point	X (m)	Y (m)	Z (m)
SWARM-A	-1.6503	-0.0010	0.8059
SWARM-B	-1.6510	-0.0018	0.8057
SWARM-C	-1.6502	-0.0010	0.8056

Besides we would like to confirm that the attitude mode of the satellites is **constantly fix to “Earth pointing mode”**.

We can prepare a set-up of NAPEOS (just a configuration change) to relax the rejection criteria; the current set-up is perhaps too demanding as can be seen with this example. The expected accuracy after this change should be around 0.5 meters (the accuracy of the pseudo-range observations). If at some point we manage to process successfully the phases, you could expect better accuracies (e.g. below 20 cm).

With the current set-up you risk to have this weird behaviour at the end of the day from time to time, but the exact cause of it (why is not happening all the time?) is not clear to me either.

Kind regards,"

We have provided some of the requested information (a document made by Astrium containing the instruments positions on-board the S/C), and we are trying to find out the remaining part.

4.2 SW-IDEAS-32: pulsations observed in the ASM-VFM residuals.

In the past weeks the geomagnetic activity remained moderate to high for most of the time. In Figure 32 one can see the Kp index (from GFZ Potsdam) for September 2014: from 22 September the index was almost always above 3, with peaks of 5/6. Although no geomagnetic storms are reported (Dst index rather steady and quiet, see e.g. Figure 40) after 12-13/09, the AE index is often disturbed, indicating an active auroral region.

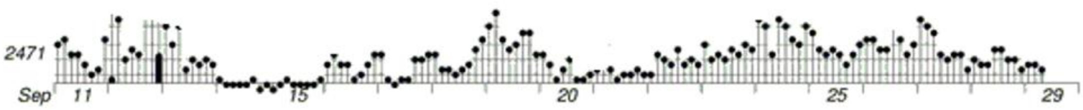

Figure 32: Kp index in September 2014.

In Figure 33 an example of ASM-VFM residual can be seen encompassing few hours across 25/09/2014. The time series of the three S/C are shown together (Red = S/C A, green = S/C B, blue = S/C C). Steep gradients can be observed around the polar regions, especially in the southern hemisphere, and a noise signal is often superimposed on the main signal, as already described in [RD.9] and [RD.10].

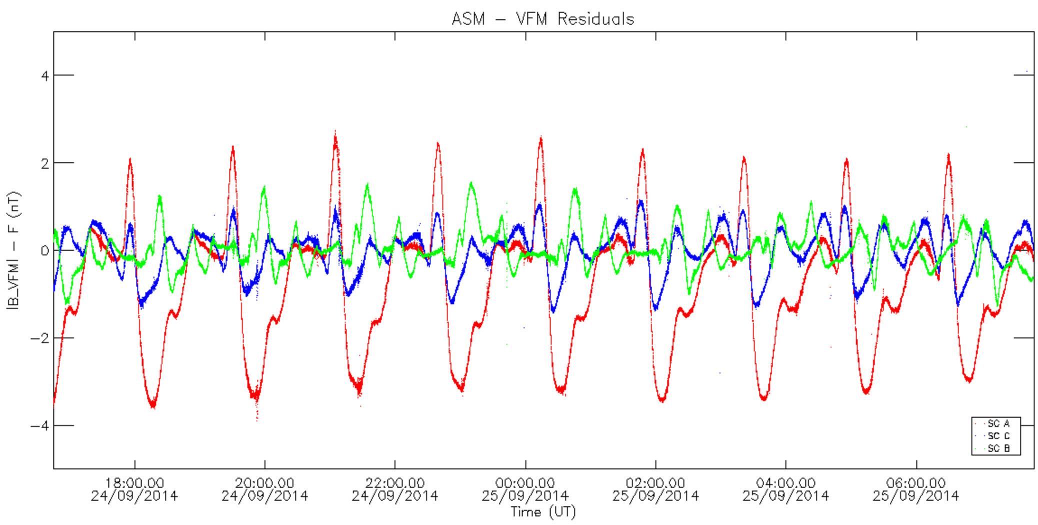

Figure 33: ASM-VFM residuals across 25/09. Red = S/C A, green = S/C B, blue = S/C C.

If we take a look at a magnification of the power spectrum of the signal in the low frequency part, for example in Figure 34 (S/C A, 25/09/2014), such increase of the noise is evident in the frequency band 0.08-0.04 Hz. Another isolated peak in the spectrum is often observed closed to 0.03 Hz (PSD = 0.5 nT/√Hz).

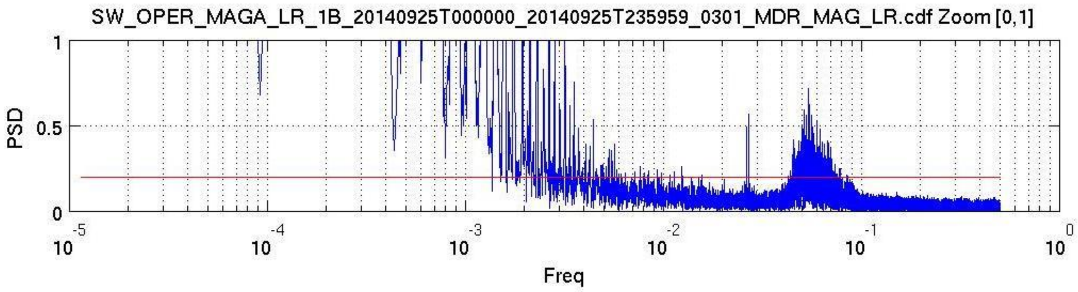

Figure 34: S/C A power spectrum, 25/09/2014. Magnification of the low-frequency portion.

The following two figures show short intervals during 25/9. Figure 35 clearly shows pulsation series occurring almost simultaneously on S/C A (red) and C (blue), between about 00:10 UT and 00:18 UT, apparently at the start of the descending part of the orbit; at that time S/C B (green) does not observe pulsations. These are observed on S/C B about a half an hour later, again at the start of the descending part of the orbit. This is just an example of preliminary observations, but such events are very common during the past two weeks: we still need to characterize such observations against latitude and local time.

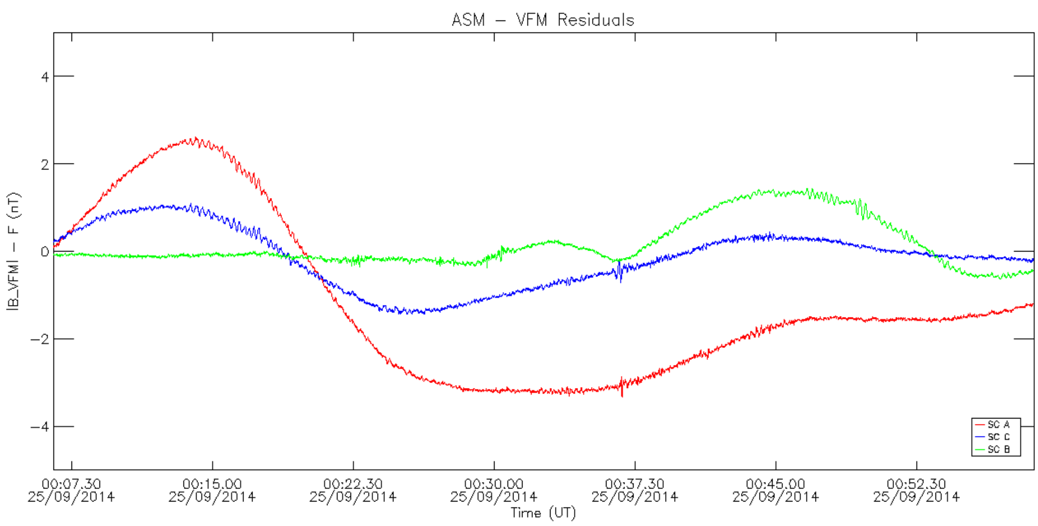

Figure 35: pulsations observed by the three S/C at the beginning of 25/9.

In Figure 36 a detail of such pulsations described in the figure above can be seen. These look like rather regular oscillations with a period between 20 and 30 s, which seems to match the 0.03 Hz peak observed in Figure 34. The peak-to-peak amplitude of such oscillations, for this particular example, is about 200 pT, but we observed cases with amplitudes above 500 pT.

The fact that co-located spacecraft (A and C) observe well correlated features, while S/C B does not observe the pulsations at the same time, could lead to think to a physical effect rather than an instrument effect: the phenomenology is similar to that of Pc3-Pc4 geomagnetic pulsations, which are usually associated to harmonic mode oscillations of the magnetospheric cavity in response to shocks or solar wind discontinuities. Of course further investigations are needed before to draw firm conclusions.

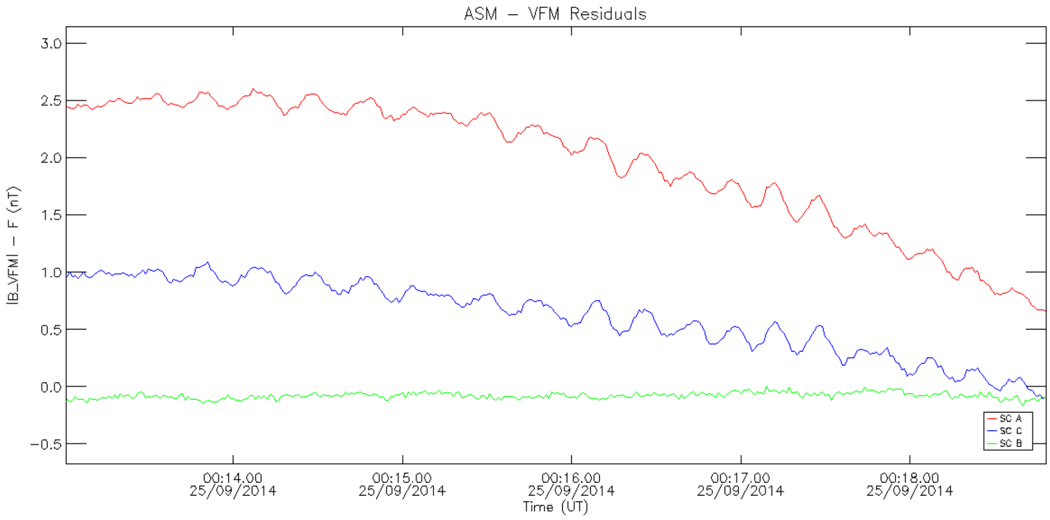

Figure 36: a detail of Figure above.

4.3 SW-IDEAS-33: TCF scale parameters decrease during September, and ASM-VFM residuals increase.

As described in Sects. 3.3.1.3, 3.3.2.3, 3.3.3.3, 3.3.4, during the month of September the X component of the TCF.VFM Scale parameters on all S/C shows a remarkable decrease, starting between 12 and 13/9 for S/C A and C, and between 18 and 19/9 for S/C B. Associated to this behaviour, we report in the three figures below the monthly time series of the ASM-VFM residuals. At the same time of the start of the TCF Scale decrease, a clear increase of the peak-to-peak excursion is observed on S/C A (Figure 37), and a slight increase can be noticed on S/C too (Figure 39); for S/C B we cannot infer any clear behaviour (Figure 38).

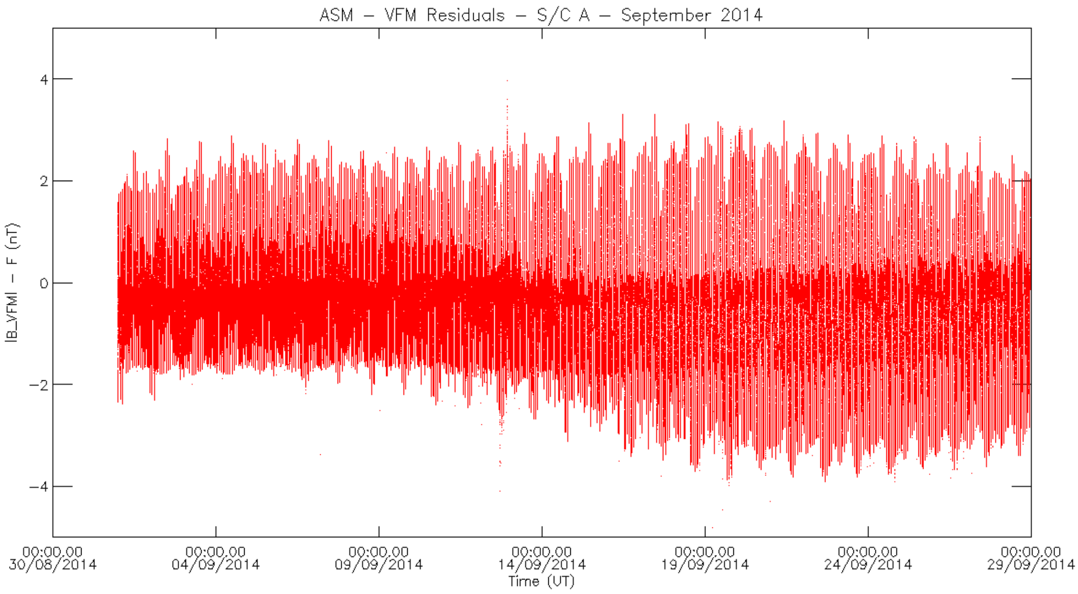

Figure 37: ASM-VFM residuals, S/C A, September 2014.

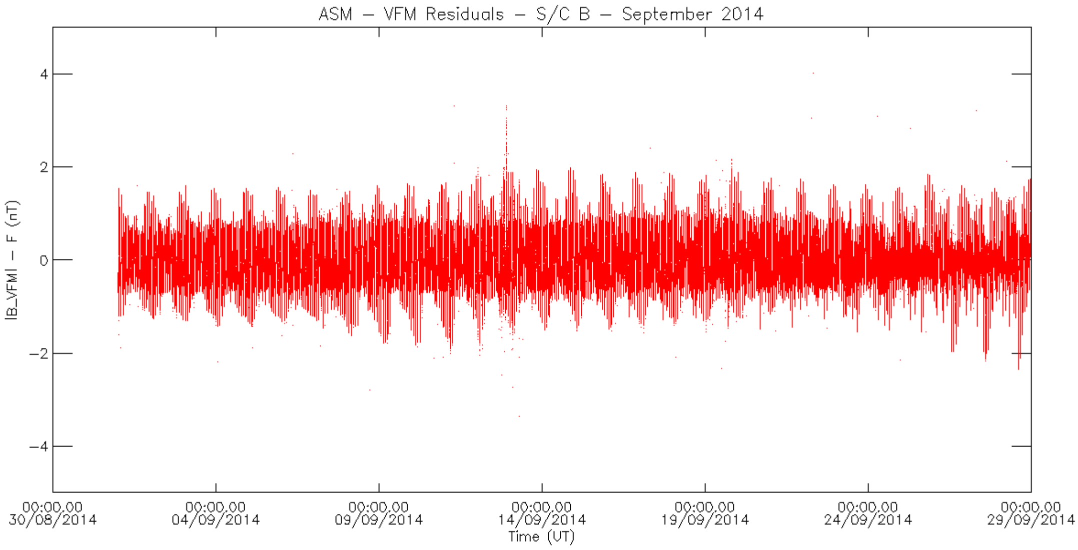

Figure 38: ASM-VFM residuals, S/C B, September 2014.

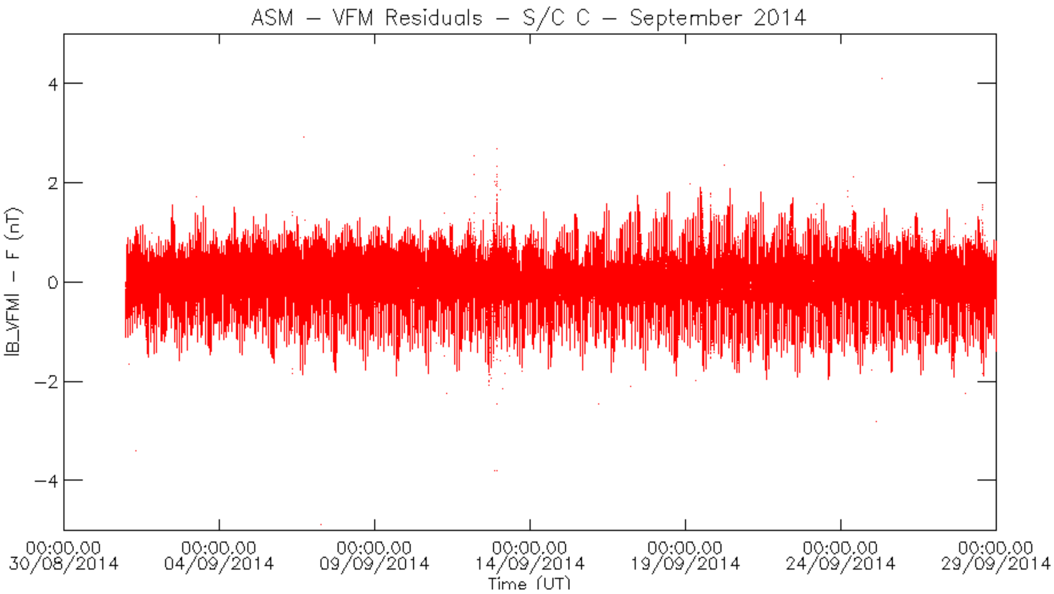

Figure 39: ASM-VFM residuals, S/C C, September 2014.

The event which seems to start this effect is the geomagnetic storm occurred between 12 and 13 September (see Figure 40 below), which is also the trigger for the noise superimposed on the main residual signal that we already described on previous issues of the weekly report (**SW-IDEAS-27**, [RD.9], [RD.10]).

We have reported the observations to the instruments experts and we are waiting for an evaluation.

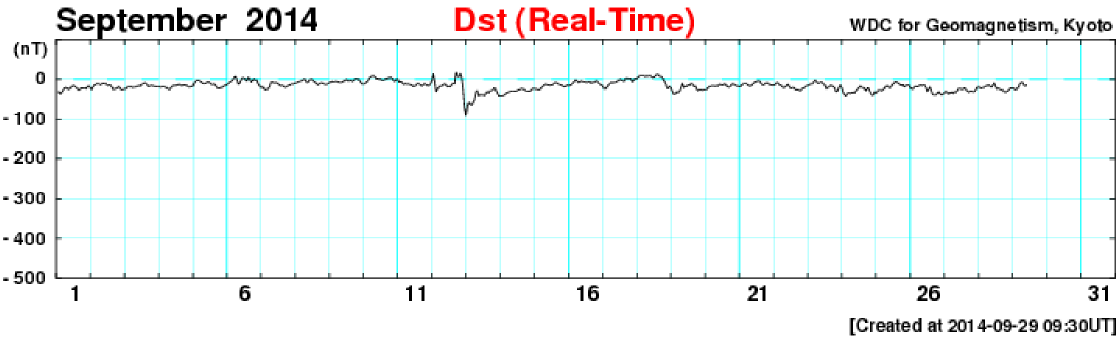

Figure 40: Dst index for September 2014.

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