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## IDEAS+ Swarm Weekly Report 2016/40: 2016/10/03 - 2016/10/09

**Abstract** : This is the **Instrument Data Quality Evaluation and Analysis Service Plus (IDEAS+)** Swarm Weekly report on Swarm products quality, covering the period from 03 October to 09 October 2016.

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## TABLE OF CONTENTS

<b>TABLE OF CONTENTS .....</b>	<b>2</b>
<b>1. INTRODUCTION .....</b>	<b>5</b>
1.1 Current Operational configuration of monitored data: .....	5
1.2 Reference documents .....	6
<b>2. SUMMARY OF THE OBSERVATIONS .....</b>	<b>7</b>
2.1 General status of Swarm instruments and Level 1B products quality .....	7
2.2 Plan for operational processor updates .....	7
2.3 Quality Working Group and Cal/Val Coordination .....	7
2.4 Summary of observations for 2016, Week 40 (03/10 - 09/10) .....	8
<b>3. ROUTINE QUALITY CONTROL .....</b>	<b>8</b>
3.1 Gaps analysis .....	9
3.2 Orbit and Attitude Products .....	9
3.2.1 Position Statistics .....	9
3.2.2 Attitude observations .....	14
3.3 Magnetic Products .....	14
3.3.1 VFM-ASM anomaly .....	15
3.3.2 ASM Instrument parameters: quartz frequency and ASM temperature (ASMAVEC_0) .....	18
3.3.3 VFM Instrument parameters: VFM temperatures (MAG_CA) .....	18
3.3.4 Magnetic time series visual inspection .....	19
3.3.5 S/C A and C magnetic correlation .....	24
3.3.6 S/C A and C magnetic difference .....	24
3.3.7 $B_{NEC}$ vs Chaos5 model residuals .....	24
3.3.8 Second derivative of $B_{NEC}$ and $B_{VFM}$ .....	28
<b>4. ON-DEMAND ANALYSIS .....</b>	<b>31</b>



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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**

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## 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 lifetime, 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 2.1.

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 4). 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, and user community), anomalies can be triggered. 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;
  - 2b. if the observation/analysis does not lead to an anomaly or the investigation shall be escalated to other entities (PLSO/industry, ESL, and 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:

- Processors Version: L1BOP 3.17, L2-Cat2 1.15.p5.
- L0 input products baseline: 02



- L1B baseline: MAGNET and PLASMA 04, ORBATT and ACCELE 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: EEF 01, IBI, FAC and TEC 02
- Input auxiliary files baseline: S/C A - CCDB 0012 (13/09/2016), S/C B – CCDB 0012 (16/06/2016), S/C C – CCDB 0012 (13/09/2016), ADF 0101
- MPPF-CVQ v.2.14.01

## 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\_20141124\_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 (ref. for SWL1L2DB-9)
- [RD.10] IDEAS+ Swarm Weekly Report: 29/09/2014 – 05/10/2014, IDEAS+-SER-OQC-REP-2071\_SPPA\_SwarmWeeklyReport\_20140929\_20141005.pdf (ref. for SW-IDEAS-34)
- [RD.11] IDEAS+ Swarm Weekly Report: 06/10/2014 – 12/10/2014, IDEAS+-SER-OQC-REP-2071\_SPPA\_SwarmWeeklyReport\_20141006\_20141012.pdf (ref. for SW-IDEAS-36)
- [RD.12] IDEAS+ Swarm Weekly Report: 20/10/2014 – 26/10/2014, IDEAS+-SER-OQC-REP-2071\_SPPA\_SwarmWeeklyReport\_20141020\_20141026.pdf (ref. for SW-IDEAS-40, GPS sync loss)
- [RD.13] IDEAS+ Swarm Weekly Report: 15/09/2014 – 21/09/2014, IDEAS+-SER-OQC-REP-2071\_SPPA\_SwarmWeeklyReport\_20140915\_20140921.pdf (ref. for SW-IDEAS-27)
- [RD.14] Swarm L1B 03.15 Validation Report, OSMV-OPMT-SRCO-RP-15-3385, Issue 1.3.
- [RD.15] IDEAS+ Swarm Weekly Report: 23/03/2015 – 29/03/2015, IDEAS+-SER-OQC-REP-2071\_SPPA\_SwarmWeeklyReport\_201513\_20150323\_20150329.pdf.
- [RD.16] SWARM Weekly Operations Report #76, SW-RP-ESC-FS-6172
- [RD.17] Olsen, N., H. Luhr, C.C. Finlay, T.J. Sabaka, I. Michaelis, J. Rauberg and L. Tøffner-Clausen, The CHAOS-4 geomagnetic field model, Geophys. J. Int. 197, 815–827, 2014
- [RD.18] IDEAS+-SER-IPF-PLN-2272, Swarm Level 1B Operational Processor Verification Plan, IDEAS+-SER-IPF-PLN-2272\_L1BOP\_316\_v1.5\_final.pdf



## 2. SUMMARY OF THE OBSERVATIONS

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

Nothing to report

### 2.2 Plan for operational processor updates

**L1BOP:** In the next delivery of the L1BOP after the PDGS evolution activities (beginning of Nov. 2016) the following changes will be implemented into the MAGNET and ORBATT processors:

- Change the data resampling used for the interpolation of the ASM measurements to UTC second because the present used in L1B data is removing a significant part of the high frequency content of the ASM data.
- Modification of the F\_error computation.
- More robust handling of the leap second occurrence, and modification in timestamp sorting, in order to make the processor complete the run even in case of VFM on-board anomalies, that could imply a packet frequency greater than 1 Hz.
- STR Inter-Boresight Angles correction model.
- The activity of PLASMA cross-verification has been restarted and hopefully a fully cross-verified PLASMA processor will be included in the next delivery.
- Changes in the CCDB with inclusion of several new parameters is foreseen for many of the implementations above.

For what concern the ORBATT processor, another change to be implemented is under discussion.

- An increase of the frequency of the STR L0 product from 1 Hz to 2 Hz

**L2 Cat-2:** Any other delivery of the L2 Cat-2 OP is postponed after the PDGS evolution activity (Nov. 2016).

**PDGS evolution related activity:** Currently, the deployment in operations of L1BOP 3.18 and L2CAT2OP 1.16, including the update to the full CDF processing schema, is foreseen for mid-November 2016.

### 2.3 Quality Working Group and Cal/Val Coordination

Following the decisions of the 6<sup>th</sup> QWG in Edinburgh, these activities will be carried on in order to better understand:

- ASM-VFM Scalar Residuals:
  - Further work on the improvement of the dB\_sun correction model:
    - in order to de-correlate the VFM T\_EU and the Beta angles, we can investigate the possibility of an eventual test using the VFM Electronic Unit heater.
  - Further work on adjustment of the VFM pre-flight calibration parameter.



- The root cause of the ASM-VFM residuals not yet identified:
  - on-ground testing with equipment/spares from development phase
  - New in orbit heater test: industries and users will be invited to comment the test before its implementation.
- ASM/VFM Inter-comparison analysis: Anomalies detected during the manoeuvres:
  - we don't know whether the anomaly is caused by something happening inside or outside the instrument/s
  - Maybe the ASM-ASM differences are mapped to the VFM during the calibration processing steps
  - More analysis has to be done on the pre-flight characterisation of the ASM after the changes on the bracket and cabling were changed before launch. Maybe a small y-oriented effect has not been fully captured.
  - The Leti team will be involved in order to see if it is possible to perform such test.
- EFI validation and investigations:
  - Validation of electron density and temperature by inter-comparison with ground based (ISR) and space borne (radio-occultation) measurements is at a good stage, with different datasets and approaches giving similar results. What now is needed is a wrap up of the different approaches and a summary work in order to finalize the results. Also very interesting and promising are validation approaches based on comparisons with models (e.g. IRI) and with the same parameters indirectly obtained from other Swarm datasets with some theoretical assumptions (especially electric field).
  - Some investigations are still on-going on Langmuir Probes side:
    - Understanding the correlation of the electron temperature spikes and the solar illumination on the solar panels.
    - S/C potential and el. Temp. hick-ups following a sweep mode activation: good progresses in modelling them, but root cause still unknown.
  - The TII processing has been simplified by the Univ. of Calgary team: only the cross-track flow is determined, which is more stable and reliable. Moreover a robust flagging of data based on the raw images characteristics is in progress.
- Data Distribution:
  - DTU will deliver the Swarm MAGx\_LR\_1B products processed with prototype since BOM for all S/C (0501). This dataset is to be published on ESA ftp server. This dataset will contain the following changes:
    - STR temperature correction and interpolation update.
    - Updated vector data calibration and disturbance characterization.
  - ASM-V data: IGP/LETI will deliver an updated version of the ASM vector data that will be available for all the users.
  - LP Sweep mode dataset will come soon and will be distributed to Mission users only.
  - A TII experimental dataset, based on the new processing scheme, will come soon and will be distributed to Mission users only.

## **2.4 Summary of observations for 2016, Week 40 (03/10 - 09/10)**

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

- Small violations of ASM-VFM residuals thresholds (more in Section 3.3.1)
- Gaps in almost all SwB L1B products caused by 60 sec gap in VC4 telemetry on 03/10/2016.





### 3. ROUTINE QUALITY CONTROL

#### 3.1 Gaps analysis

- SC B – a 60 seconds gap in VC4 telemetry on 3 October at 1:36 have caused gap in the following L0 products: ACCBNOM\_0, GPSBNAV\_0, ASMBVEC\_0, EFIBNOM\_0, HK\_BNOM\_0, STRBNOM\_0, GPSBOBS\_0, VFMBNOM\_0. As consequence, gaps in the following L1B products have been detected: GPSBNAV\_1B, GPSB\_RO\_1B, ACCB\_PR\_1B, MAGB\_CA\_1B, VFMB AUX\_1B, STRBATT\_1B, MAGB\_HR\_1B. While in MAGB\_LR\_1B product, variables F, B\_NEC and B\_VFM have value 0 for this time window.
- Several few seconds gaps in MAGx\_CA\_1B products throughout the week. Some of them seem not to be associated to gaps in telemetry. Monitoring on-going.

#### 3.2 Orbit and Attitude Products

In Table 1 are listed events that have to be reported.

**Table 1:** List of events related to attitude and orbit products to be reported in the monitoring for 2016, Week 40: 03/10 - 09/10.

Observation ID	Description	Affected parameter	Sect. of Obs. Description	Sect. of Obs. Analysis

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. They are reported in tables in the sections below. In addition, some example plots are given 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),
  - o 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).
  - o 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<sup>-9</sup>)
- Visual inspection of Euler Angles derived from quaternions.

##### 3.2.1 Position Statistics

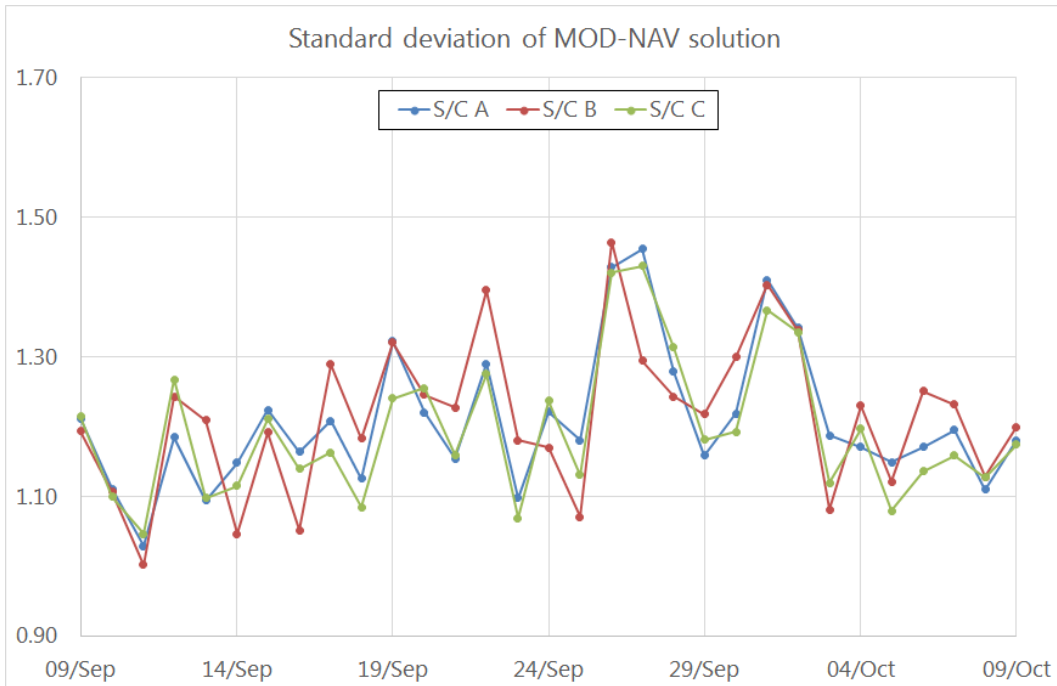
In Table 2, one can see the statistics of the differences between MOD and on-board solution positions for S/C A, B and C respectively. In the third column the maximum differences (maximum negative and maximum positive) are reported. The maximum standard deviation is in the fourth column. Maxima, minima and standard deviations usually refer to the Z component that is often the



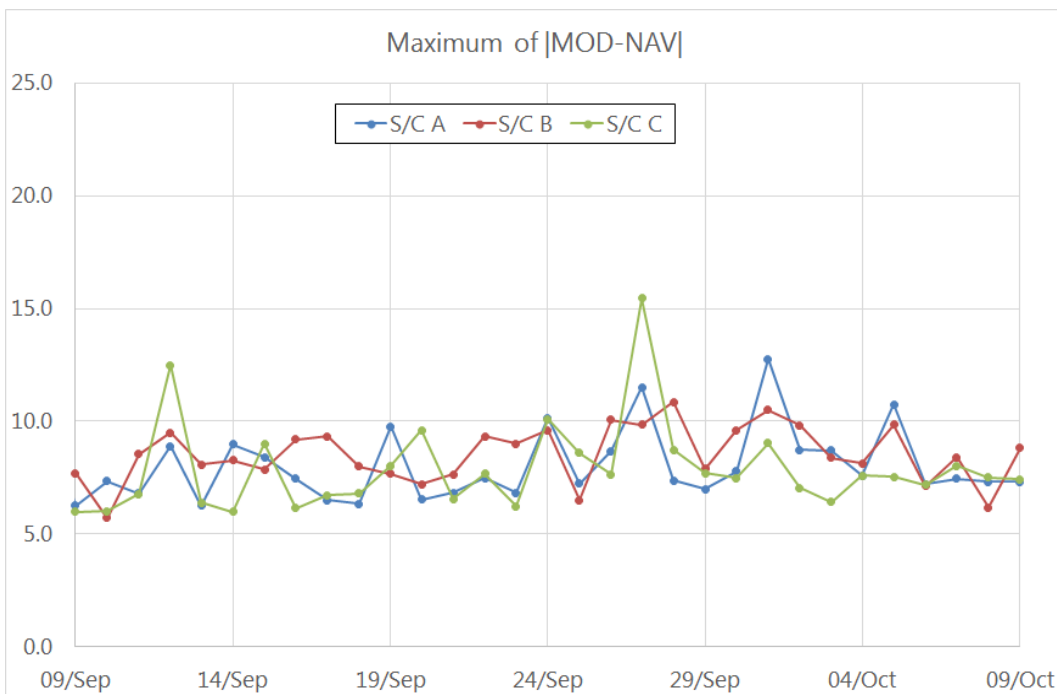
most disturbed; in case another component is most affected, it will be specified in parentheses. Figure 1 shows a cumulative trend of the maximum daily standard deviation for the past 30 days of operations of the MOD-NAV difference, while Figure 2 shows the daily maximum difference, in absolute value, of the MOD-NAV difference, always for the past 30 days of operations.

**Table 2:** Swarm A, B and C, difference between MOD and on-board solution positions. If not specified maximum difference and maximum standard deviation refers to the Z-axis.

<b>Swarm A, 03/10 - 09/10, Position difference</b>					
<b>Day</b>	<b>Average difference (m)</b>	<b>Maximum difference (m)</b>		<b>Maximum standard deviation (m)</b>	<b>Notes</b>
03/10	0.08	-8.7	7	1.19	
04/10	0.05	-7.6	5.6	1.17	
05/10	0.08	-6.1 (X)	10.7	1.15	
06/10	0.1	-6.3 (Y)	7.2	1.17	
07/10	0.05	-7.5	7	1.19	
08/10	0.12	-7.3	5	1.11	
09/10	0.06	-7.3	7.3	1.18	
<b>Swarm B, 03/10 - 09/10, Position difference</b>					
<b>Day</b>	<b>Average difference (m)</b>	<b>Maximum difference (m)</b>		<b>Maximum standard deviation (m)</b>	<b>Notes</b>
03/10	0.13	-5.5	8.4	1.08	
04/10	0.06	-8.1	5.8	1.23	
05/10	0.13	-5.8	9.9	1.12	
06/10	0.06	-5.7	7.1	1.25	
07/10	0.07	-6.9 (X)	8.4 (Y)	1.23	
08/10	0.08	-5.8	6.2	1.13	
09/10	0.08	-7.8	8.8	1.2	
<b>Swarm C, 03/10 - 09/10, Position difference</b>					
<b>Day</b>	<b>Average difference (m)</b>	<b>Maximum difference (m)</b>		<b>Maximum standard deviation (m)</b>	<b>Notes</b>
03/10	0.07	-6.4	5.2	1.12	
04/10	0.04	-7.4	7.6	1.2	
05/10	0.07	-5.5	7.5	1.08	
06/10	0.04	-7.2	6.1	1.14	
07/10	0.05	-8	7.9 (Y)	1.16	
08/10	0.12	-7.5	6.6	1.13	
09/10	0.08	-7.4 (Y)	5	1.17	



**Figure 1:** Plot of the standard deviation of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

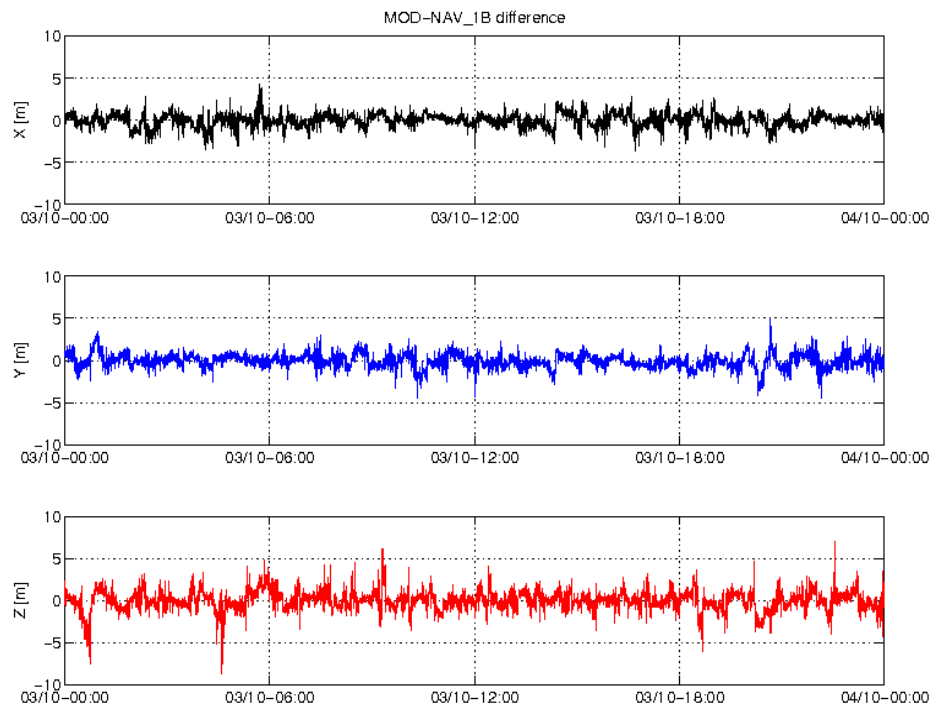


**Figure 2:** Plot of the maximum difference of the absolute value of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.



### 3.2.1.1 Swarm A

Below is presented plot of MOD-NAV differences for S/C A, taken at the beginning of the week (03/10, Figure 3). From top to bottom, the plots show of MOD-NAV differences in ITRF reference frame: on X, Y and Z-axis respectively. The difference between both solutions is given in [m].

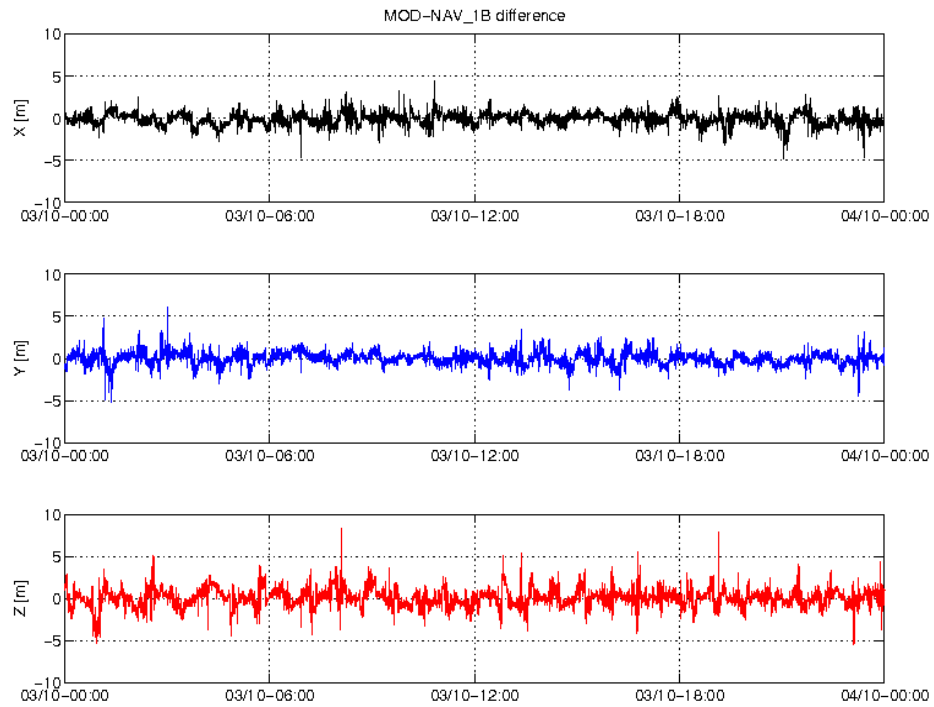


**Figure 3:** Difference MOD-GPSNAV, S/C A, 03/10. From top to bottom: X, Y and Z-axis



### 3.2.1.2 Swarm B

Below is presented plot of MOD-NAV differences for S/C B, taken at the beginning of the week (03/10, Figure 4). From top to bottom, the plots show of MOD-NAV differences in ITRF reference frame: on X, Y and Z-axis respectively. The difference between both solutions is given in [m].

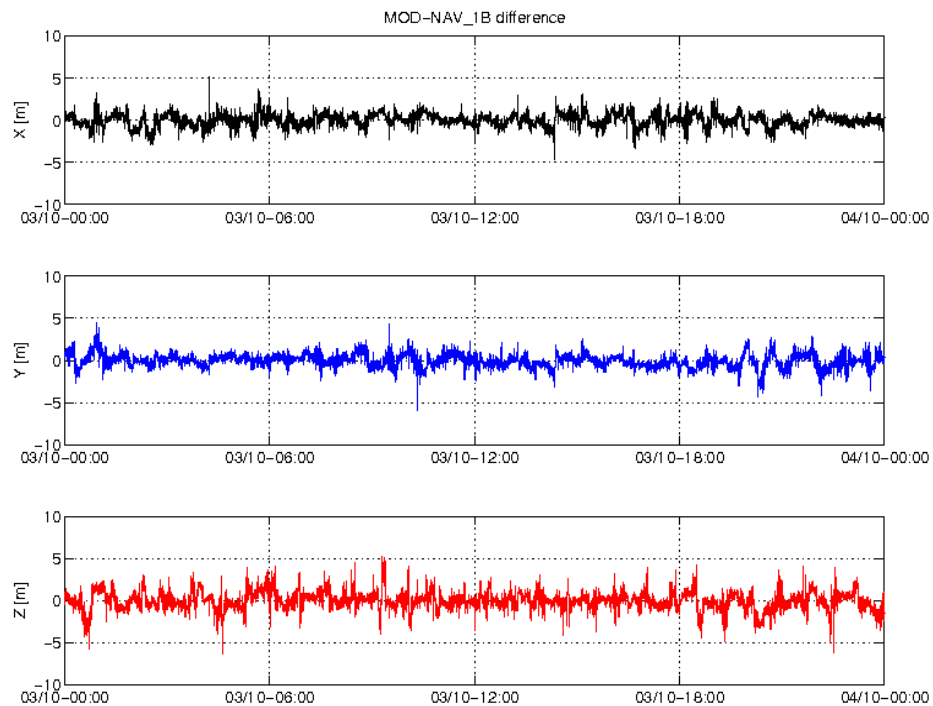


**Figure 4:** Difference MOD-GPSNAV, S/C B, 03/10. From top to bottom: X, Y and Z-axis



### 3.2.1.3 Swarm C

Below is presented plot of MOD-NAV differences for S/C C, taken at the beginning of the week (03/10, Figure 5). From top to bottom, the plots show of MOD-NAV differences in ITRF reference frame: on X, Y and Z-axis respectively. The difference between both solutions is given in [m].



**Figure 5:** Difference MOD-GPSNAV, S/C C, 03/10. From top to bottom: X, Y and Z-axis

## 3.2.2 Attitude observations

### 3.2.2.1 Swarm A

Nothing to report.

### 3.2.2.2 Swarm B

All attitude L0, L1A and L1B data are impacted by the 60 sec gap in VC4 telemetry data 3 Oct at 1:36:07.

### 3.2.2.3 Swarm C

Nothing to report.

## 3.3 Magnetic Products

For the magnetic products, the weekly monitoring consists in:

- ASM instrument monitoring: quartz frequency (nominal range: [2.949E7 – 2.950E7] Hz) and ASM temperature (temperature range shall be: [-30;+50] °C, Rel. Variation shall not exceed: 0.1 °C/sec).



- VFM instrument monitoring: temperatures (Rel. Variation shall not exceed: 0.1 °C/sec).
- Visual inspection of daily time series of magnetic field intensity  $F$ ,  $B_{NEC}$  and  $B_{VFM}$ . 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. Map plots of  $F$  and  $B_{NEC}$  for the whole week are then displayed.
- Monitoring of the ASM-VFM known anomaly: visual inspection of  $|B_{VFM}| - F$  taken from  $MAGx_{CA\_1B}$  products and recording of daily maximum variations and standard deviations. If +/- 1 nT are exceeded on a given day, an alert is raised. Map plots of the residuals are shown along with weekly time series of the residuals with and without the "dB\_Sun" correction: in fact, at least a part of the discrepancies found in the measurements between ASM and VFM are modelled through a stray field (dB\_Sun) that is a function of the orientation of the VFM wrt Sun.
- Comparison of magnetic data ( $B_{NEC}$ ) with a model (Chaos5).
- Second derivative of vector field in VFM and NEC frame. Only measurement points within  $\pm 10^\circ$  latitude are considered, and values above 100 nT/s<sup>2</sup> are considered out of threshold.
- 5-min correlations between S/C A and S/C C  $B_{NEC}$  measurements.
- Differences between S/C A and C,  $B_{NEC}$  measurements. Values above 8000 nT are considered out of threshold.

In Table 3 are listed events that have to be reported.

**Table 3:** List of events related to magnetic products to be reported in the monitoring for 2016, Week 40: 03/10 - 09/10.

Observation ID	Description	Affected parameter	Sect. of Obs. Description	Sect. of Obs. Analysis
SW-IDEAS-63	OBS_ROUTINE: $MAGx_{CA\_1B}$ gaps	$MAGx_{CA\_1B}$	3.1	NA

### 3.3.1 VFM-ASM anomaly

**General observation:**

- S/C A – violation of:
  - o VFM-ASM residuals threshold on 03/10 - 09/10;
  - o mean value of residuals threshold on 07/10 - 09/10;
  - o standard deviation of residuals threshold on 03/10, 04/10, 07/10.

#### 3.3.1.1 ASM-VFM difference statistics

In Table 4, one can see the statistics of the differences between magnetic field absolute value measured by ASM and by VFM. In the second and third column are reported the maximum differences, maximum negative and maximum positive respectively. The maximum standard deviation is in the fourth column.

The ASM-VFM difference is defined as follow:

$$dF = |B_{VFM}| - F_{ASM}$$

Figure 6 and Figure 7 show the daily mean (circles) and standard deviation (crosses) of  $dF$  of the last month for Swarm A and Swarm B respectively.

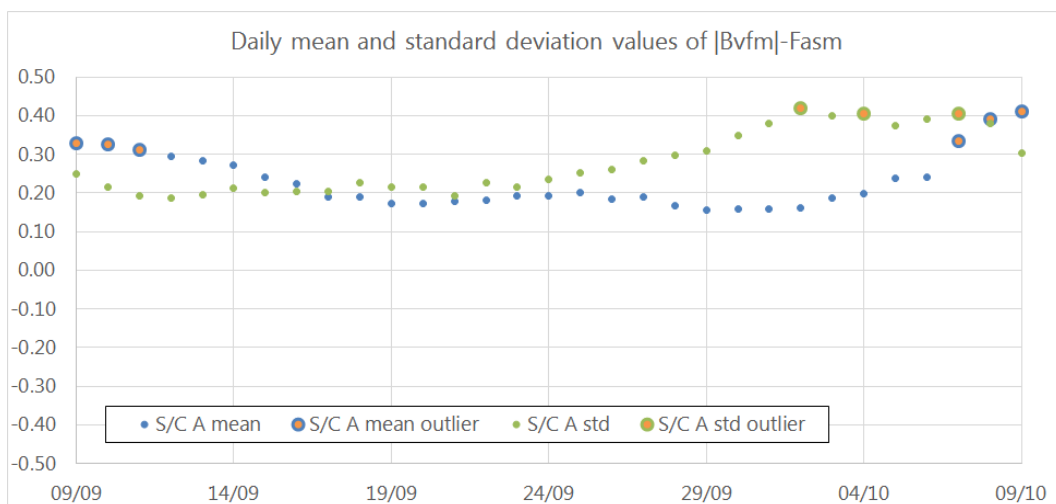


**Table 4:** Swarm A and B, difference between absolute value of magnetic field measured by ASM and by VFM.

Swarm A, 03/10 - 09/10, ASM-VFM difference					
Day	Max (nT)	Min (nT)	Standard deviation (nT)	Mean (nT)	Notes
03/10	0.96	-1.25	0.4	0.188	
04/10	0.92	-1.12	0.41	0.197	
05/10	0.95	-1.14	0.37	0.238	
06/10	1.13	-1.31	0.39	0.241	
07/10	1.34	-1.07	0.41	0.335	
08/10	1.88	-0.78	0.38	0.391	
09/10	1.88	-0.58	0.3	0.41	

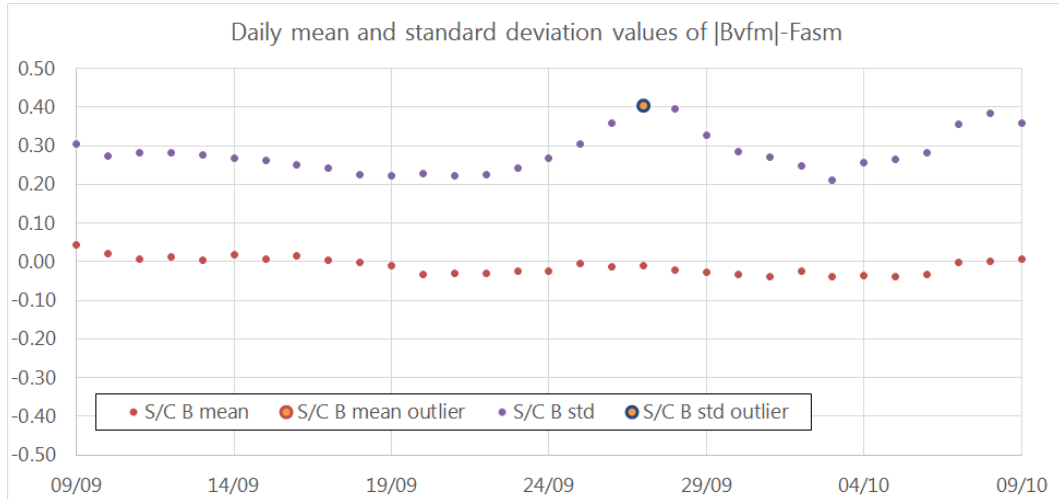
  

Swarm B, 03/10 - 09/10, ASM-VFM difference					
Day	Max (nT)	Min (nT)	Standard deviation (nT)	Mean (nT)	Notes
03/10	0.89	-0.67	0.21	-0.038	
04/10	0.58	-0.75	0.26	-0.035	
05/10	0.51	-0.77	0.27	-0.04	
06/10	0.59	-0.78	0.28	-0.034	
07/10	0.84	-0.91	0.35	-0.003	
08/10	0.78	-0.89	0.38	0.002	
09/10	0.72	-0.92	0.36	0.007	



**Figure 6:** Daily mean and standard deviation values of ASM-VFM residuals (defined as  $dF = |B_{vfm}| - F_{asm}$ ) for S/C A.

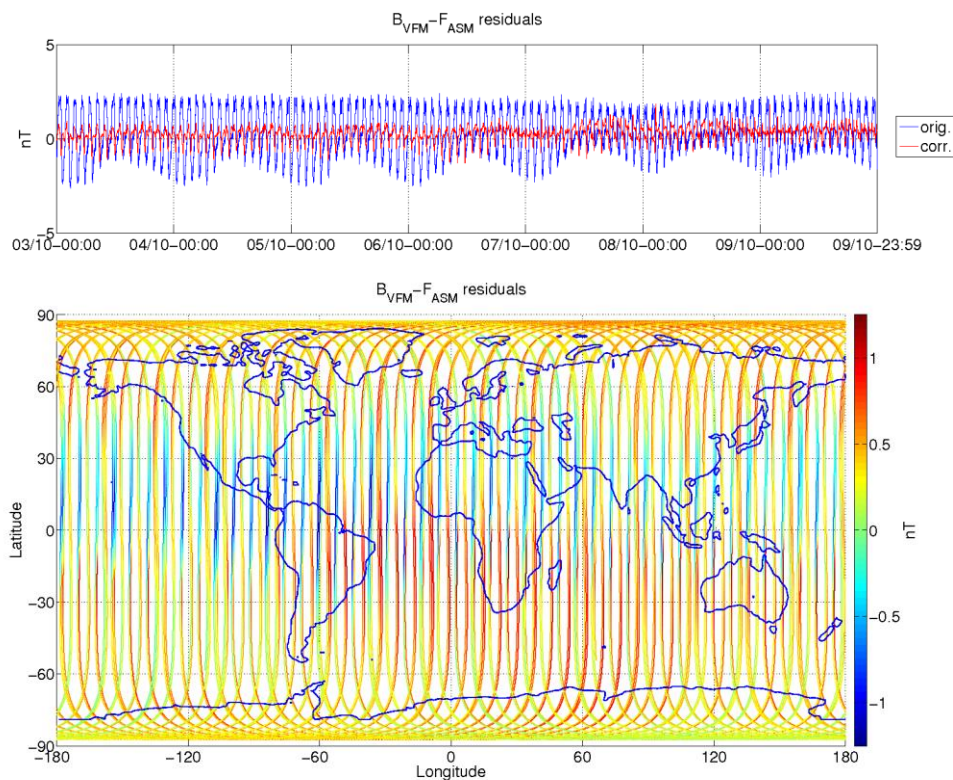




**Figure 7:** Daily mean and standard deviation values of ASM-VFM residuals (defined as  $dF=|B_{VFM}|-F_{ASM}$ ) for S/C B.

### 3.3.1.2 Swarm A

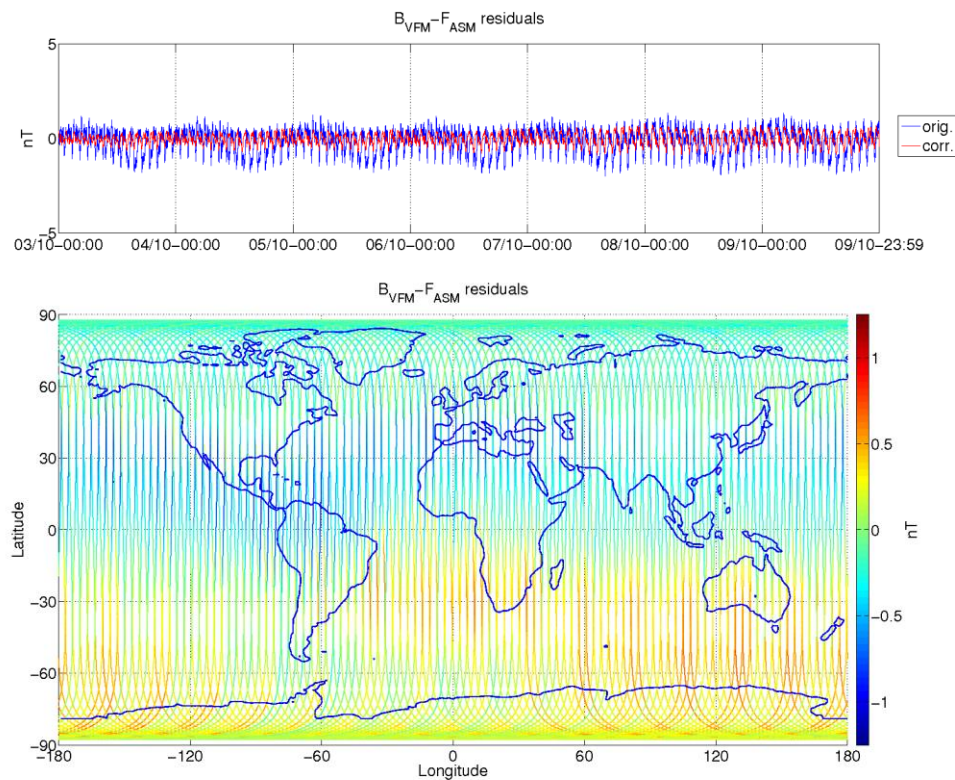
The daily peak-to-peak difference around the week stays within [-1.31 - 1.88] nT. Below follow two plots of such differences for current week (Figure 8).



**Figure 8:** ASM-VFM residuals for S/C A, during monitoring period 03/10-09/10. In top figure are plotted: difference between  $|B_{VFM}|$  and  $F_{ASM}$  (without  $dB_{Sun}$  correction) (blue colour), and the residuals with  $dB_{Sun}$  corrections (red colour). In bottom figure residuals are presented on the world map.

### 3.3.1.3 Swarm B

The daily peak-to-peak difference around the week stays within [-0.92 - 0.89] nT. Below follow two plots of such differences for current week (Figure 9).



**Figure 9:** ASM-VFM residuals for S/C B, during monitoring period 03/10-09/10. In top figure are plotted: difference between  $|B_{VFM}|$  and  $F_{ASM}$  (without  $dB_{Sun}$  correction) (blue colour), and the residuals with  $dB_{Sun}$  corrections (red colour). In bottom figure residuals are presented on the world map.

### 3.3.1.4 Swarm C

No data because ASM is switched off.

### 3.3.2 ASM Instrument parameters: quartz frequency and ASM temperature (ASMAVEC\_0)

For S/C A and B, the temperature and quartz frequency behaved as expected.

### 3.3.3 VFM Instrument parameters: VFM temperatures (MAG\_CA)

The VFM instrument parameters important for monitoring the instrument health are the VFM sensor temperatures:  $T_{CDC}$ ,  $T_{CSC}$  and  $T_{EU}$ .

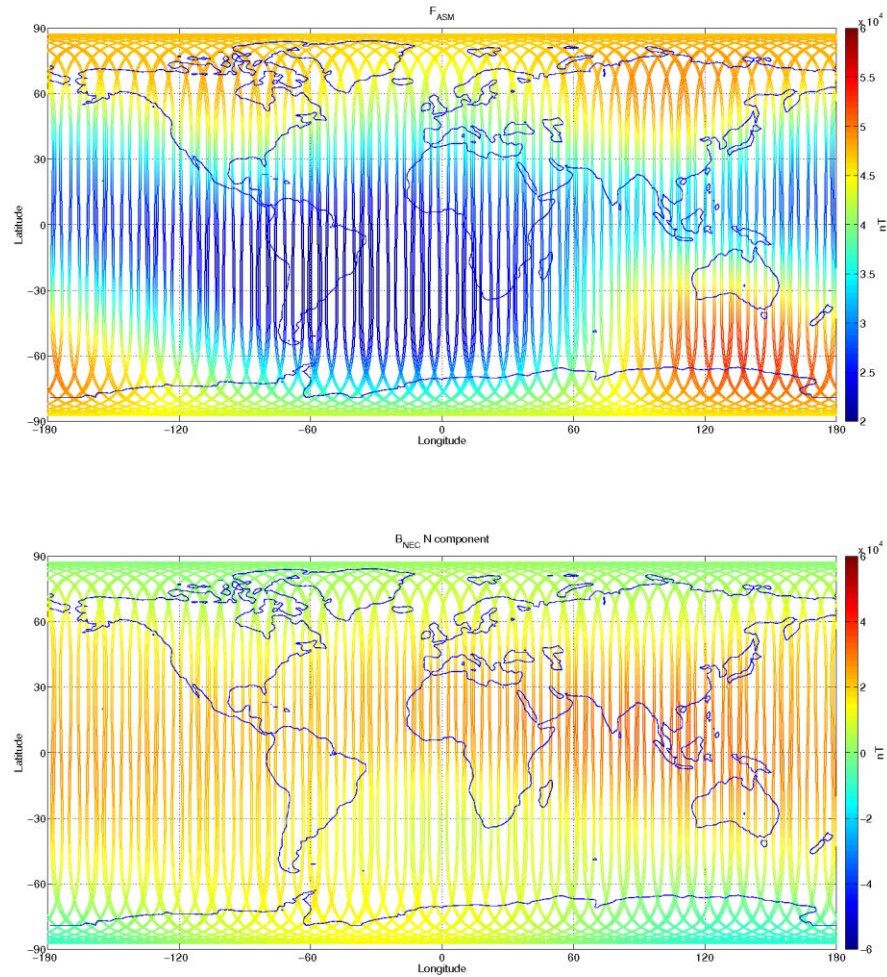
For S/C A, B and C, for reported period, the temperatures behaved as expected.

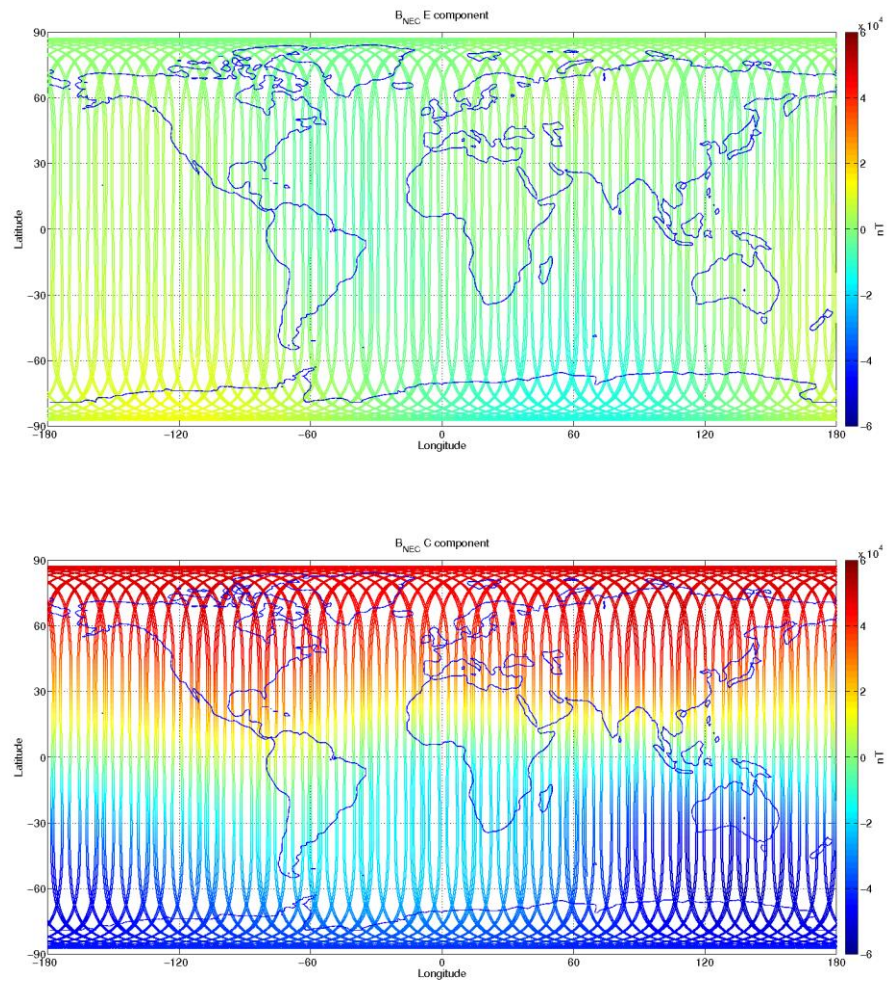


### 3.3.4 Magnetic time series visual inspection

#### 3.3.4.1 Swarm A

Map plots of magnetic field measurement for week 40 for S/C A can be seen in Figure 10 below.



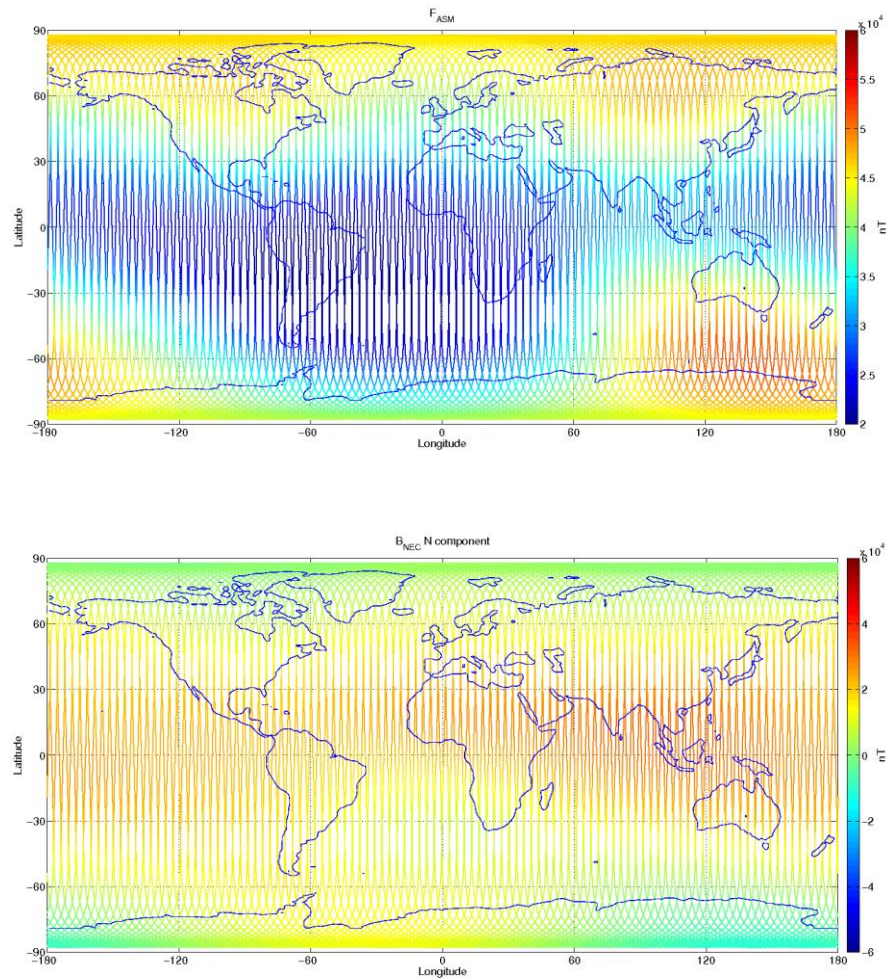


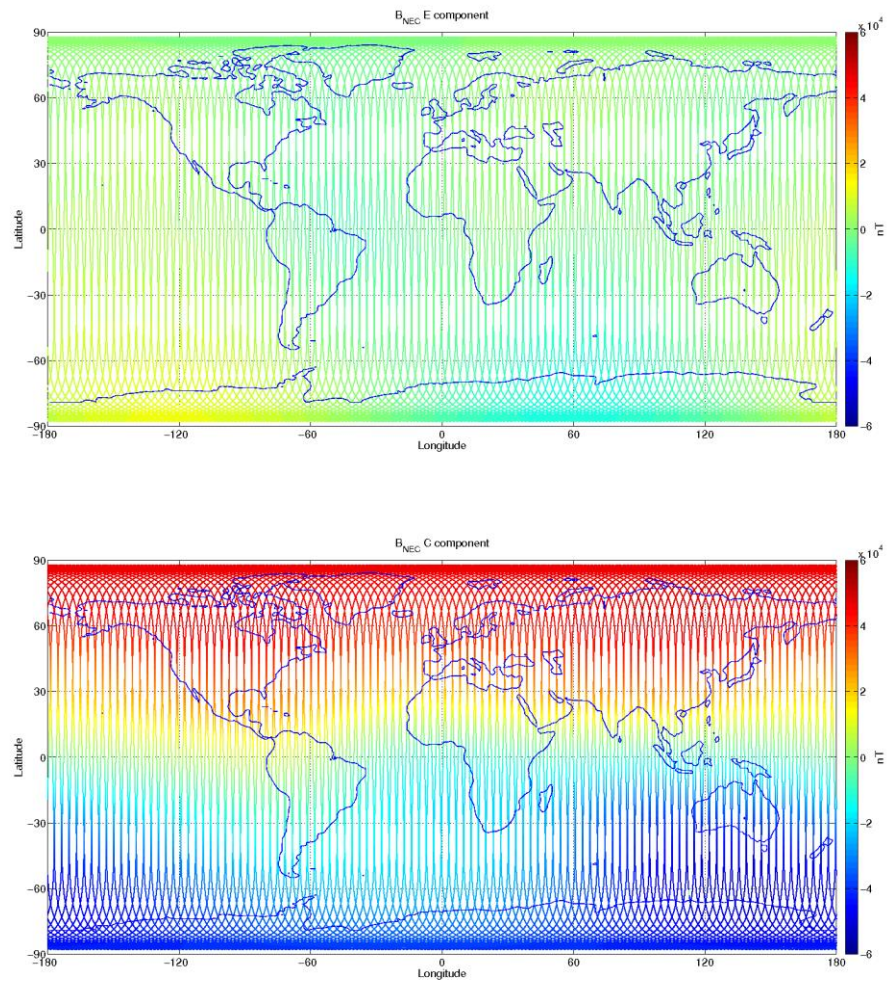
**Figure 10:** S/C A, world map plots of the geomagnetic field and components measured during monitoring period 03/10-09/10. From top to bottom: F-magnetic field from ASM measurement, B<sub>NEC</sub> components (North, East, and Centre) of magnetic field from VFM measurement.



### 3.3.4.2 Swarm B

Map plots of magnetic field measurement for week 40 for S/C B can be seen in Figure 11 below.

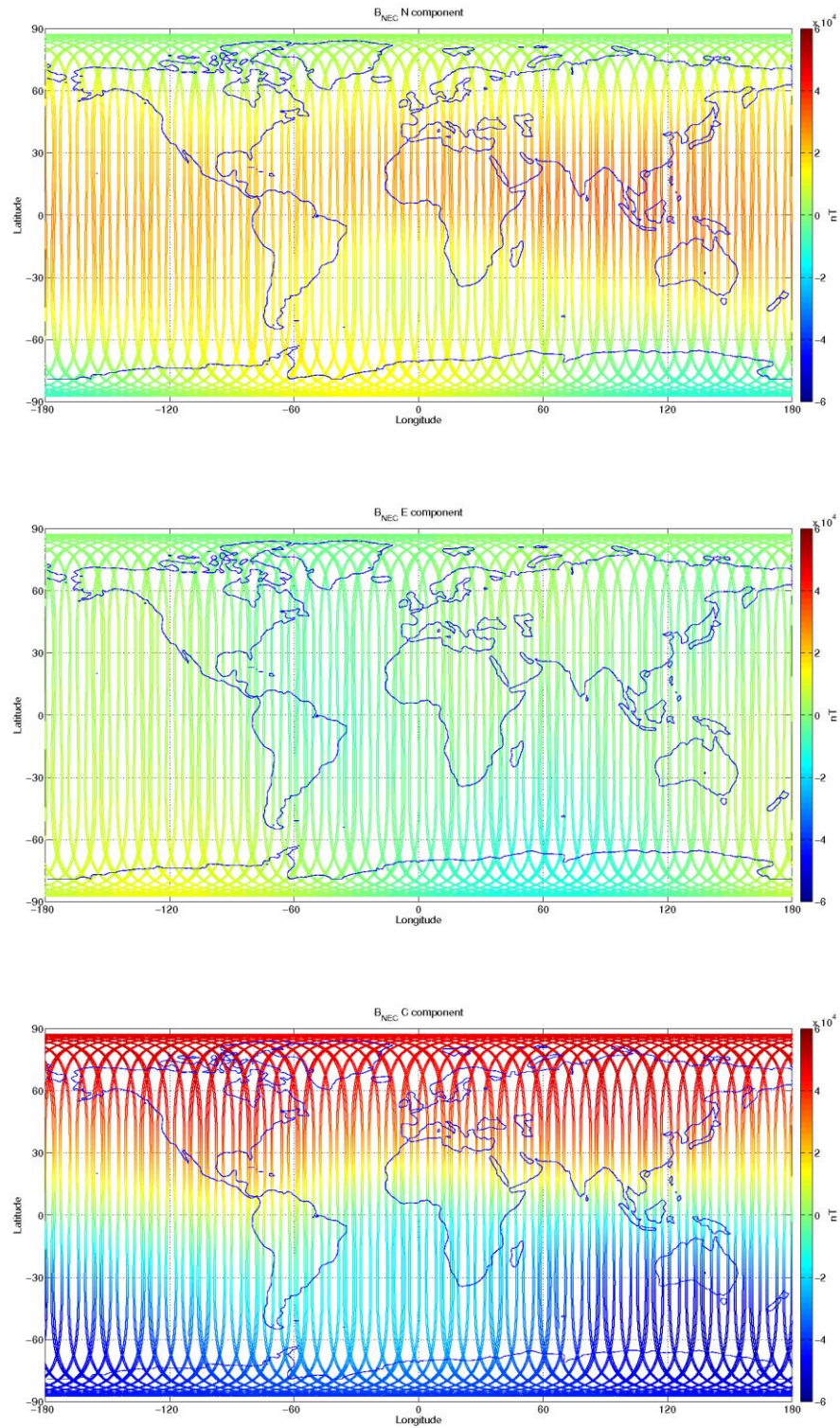




**Figure 11:** S/C B, world map plots of the geomagnetic field and components measured during monitoring period 03/10-09/10. From top to bottom: F-magnetic field from ASM measurement,  $B_{NEC}$  components (North, East, and Centre) of magnetic field from VFM measurement.

### 3.3.4.3 Swarm C

Map plots of magnetic field measurement for week 40 for S/C C can be seen in Figure 12.

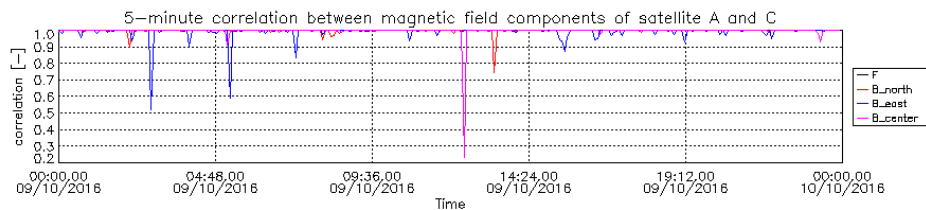


**Figure 12:** S/C C, world map plots of the geomagnetic field and components measured during monitoring period 03/10-09/10. From top to bottom: B<sub>NEC</sub> components (North, East, and Centre) of magnetic field from VFM measurement.



### 3.3.5 S/C A and C magnetic correlation

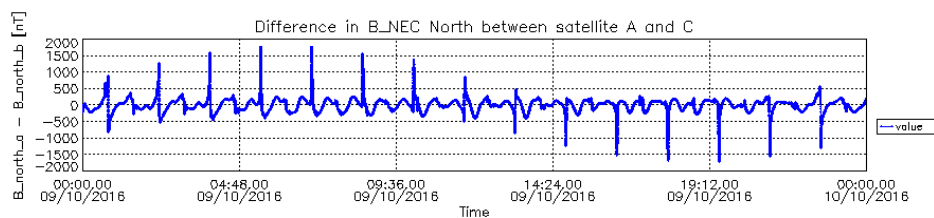
In the plot below is shown the correlation in 5-minutes intervals of magnetic data between satellite A and C. B<sub>north</sub>, B<sub>east</sub>, and B<sub>center</sub> are the components of the magnetic field vector in NEC frame.



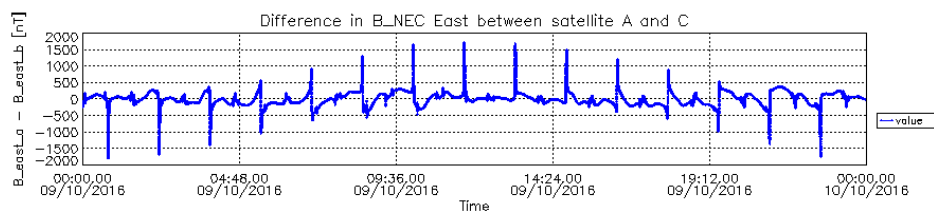
**Figure 13:** Correlation in magnetic data between satellite A and C for B<sub>north</sub>, B<sub>east</sub>, and B<sub>center</sub> components of B<sub>NEC</sub> are the components of the magnetic field vector in NEC frame

### 3.3.6 S/C A and C magnetic difference

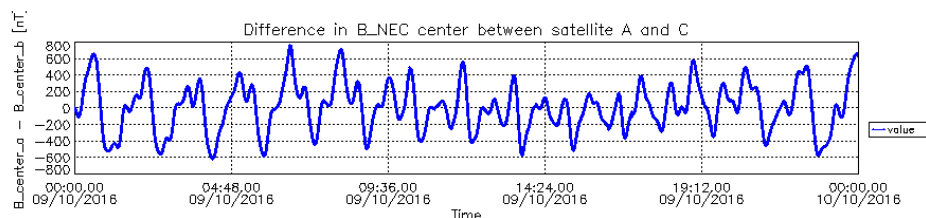
The next three plots show the differences in magnetic data between satellite A and C. Threshold is set to 8 000 nT for each component.



**Figure 14:** Difference in B<sub>NEC</sub> North component between S/C A and S/C C.



**Figure 15:** Difference in B<sub>NEC</sub> East component between S/C A and S/C C.



**Figure 16:** Difference in B<sub>NEC</sub> Center component between S/C A and S/C C.

### 3.3.7 B<sub>NEC</sub> vs Chaos5 model residuals

The magnetic field measurement is compared to magnetic field estimated from the Chaos5 global geomagnetic field model (only Core and Crustal contributions). Currently in the monitoring routines the external contribution based on Dst index is not taken into account.



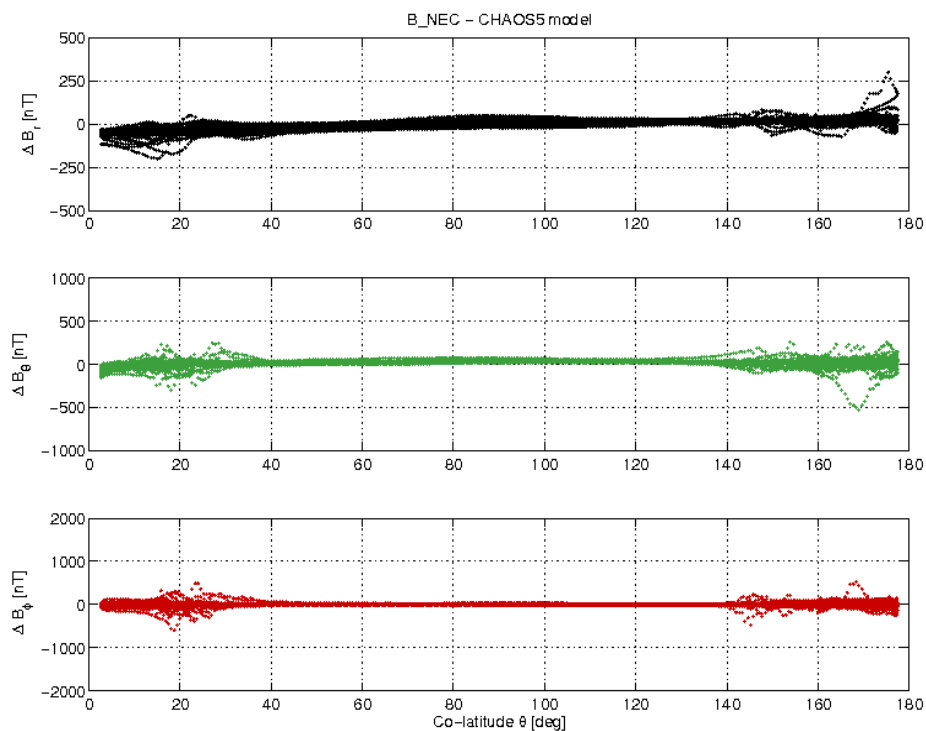
Figure 17, Figure 19 and Figure 21 show field residuals  $\Delta B = B_{NEC} - B_{Chaos}$  (all versus co-latitude in degrees), from top to bottom: 1)  $B_r$ , 2)  $B_\theta$  and 3)  $B_\phi$ .

As a general feature one can see the field residuals to be steady and usually below 50 nT at low and middle latitudes, up to [55] - [60] degrees; then the residual increases at high latitudes because the Chaos model does not take into account the contribution from the external field ([RD.17]).

Figure 18, Figure 20 and Figure 22 show, from top to bottom, the time series on 03/10 of: (1-2-3) residuals of  $B_{NEC} - B_{Chaos}$  by components, related to S/C A, B and C respectively.

The component most affected by residual spikes and variations is  $B_{\theta_{NEC}}$ , i.e. the component that shows the variations of the field wrt to co-latitude. At high latitudes, the order of magnitude of the variability is about +/- 200 nT.

### 3.3.7.1 Swarm A



**Figure 17:** S/C A day 03/10  $B_{NEC} - B_{Chaos}$  vs colatitude.

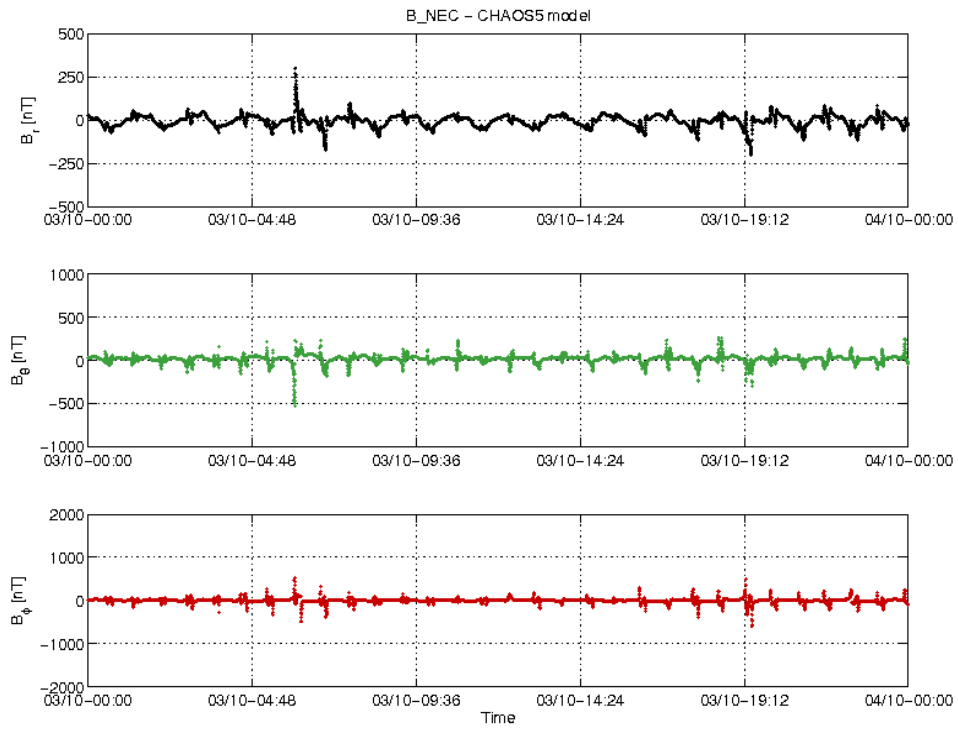


Figure 18: S/C A day 03/10: time series of  $B_{NEC} - B_{Chaos}$  residuals.

### 3.3.7.2 Swarm B

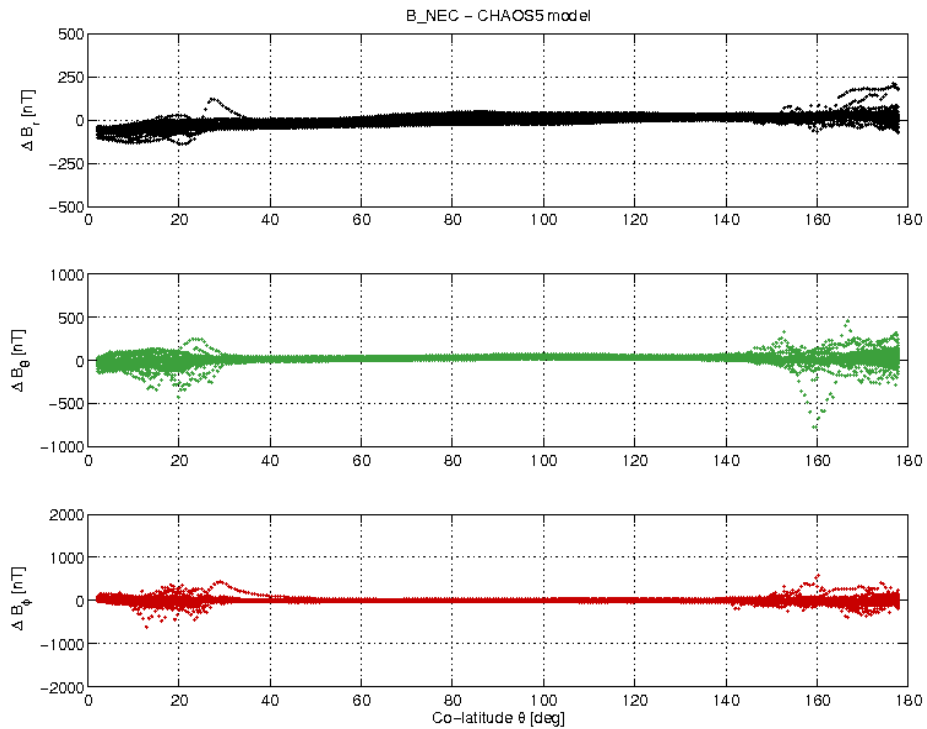


Figure 19: S/C B day 03/10  $B_{NEC} - B_{Chaos}$  difference vs colatitude.

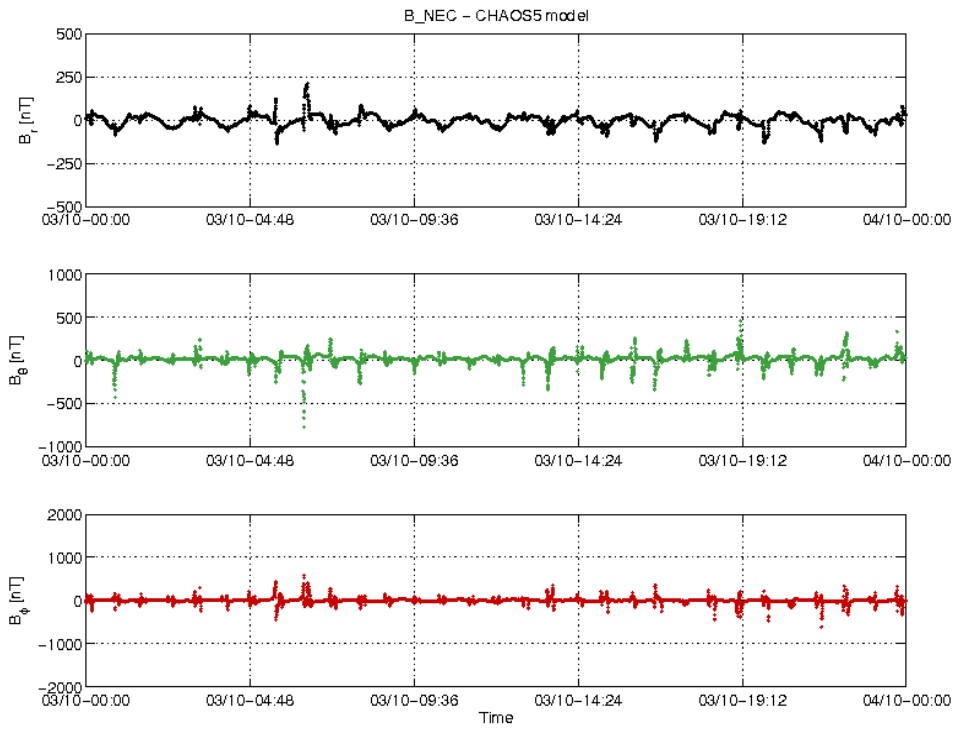


Figure 20: S/C B day 03/10 time series of  $B_{NEC} - B_{Chaos}$  residuals.

### 3.3.7.3 Swarm C

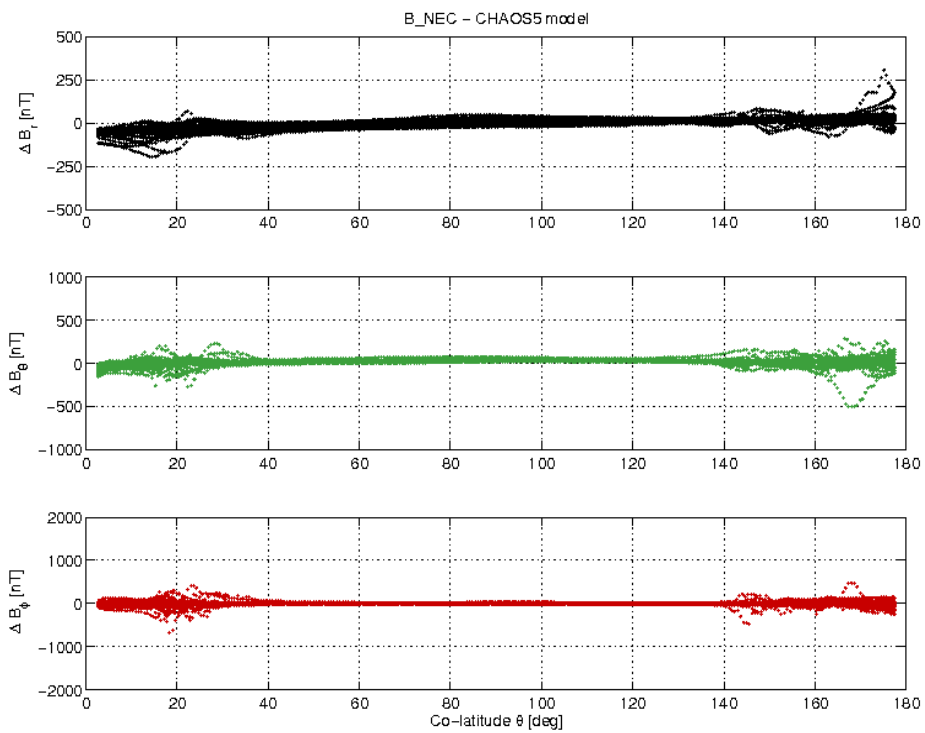


Figure 21: S/C C day 03/10  $B_{NEC} - B_{Chaos}$  difference vs colatitude.

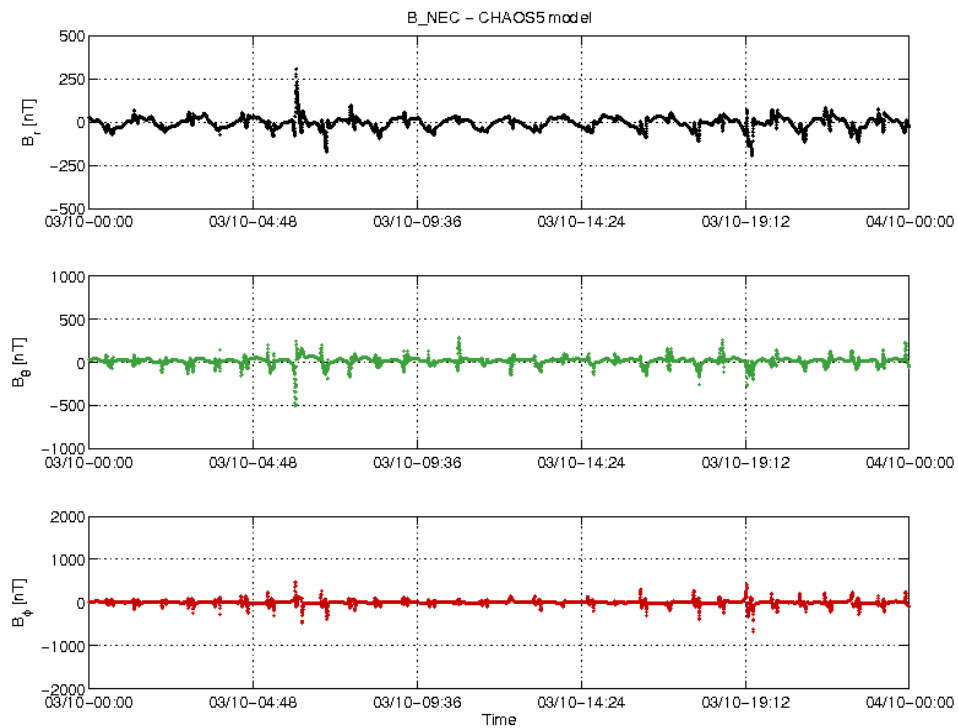


Figure 22: S/C C day 03/10 time series of  $B_{NEC} - B_{Chaos}$  residuals.

### 3.3.8 Second derivative of $B_{NEC}$ and $B_{VFM}$

The second derivative of the vector magnetic field measurements in both VFM and NEC frame has been performed on 50Hz data (MAGx\_HR\_1B). In this analysis only measurement points within  $\pm 10^\circ$  latitude have been considered. Figure 23, Figure 24 and Figure 25 show the daily standard deviation of the second derivative of  $B_{VFM}$  of the last month for S/C A, B, and C respectively. Second derivative of  $B_{NEC}$  is not shown due to artificial spikes introduced during quaternions interpolation from 1Hz to 50Hz.



3.3.8.1 Swarm A

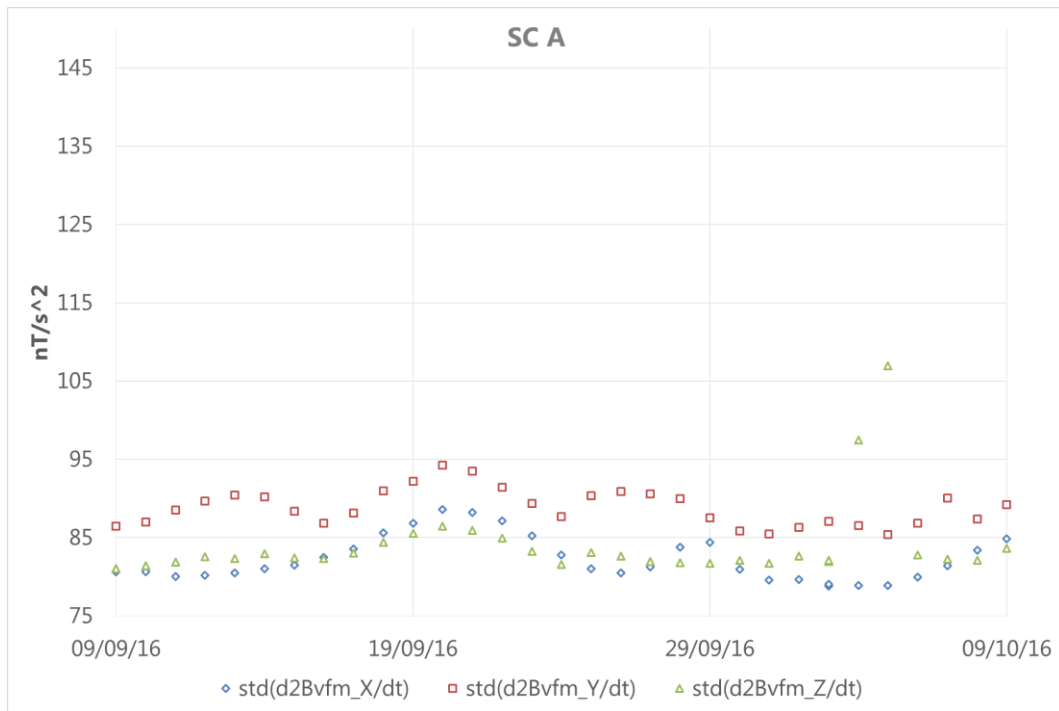


Figure 23: Plot of standard deviation of B components in VFM frames.

3.3.8.2 Swarm B

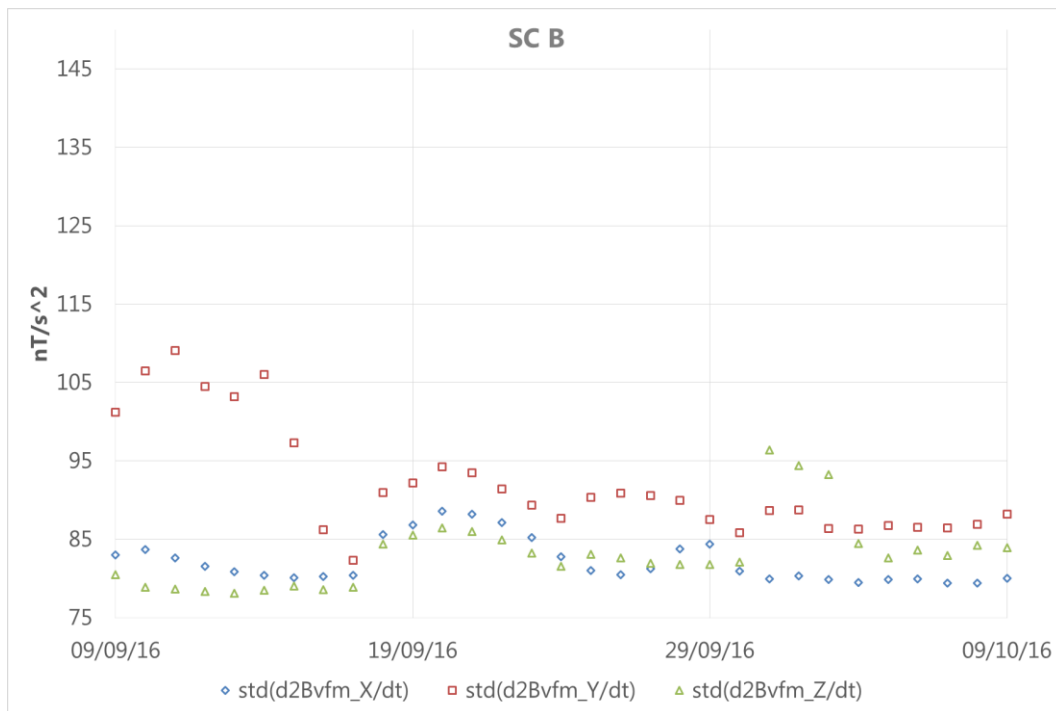


Figure 24: Plot of standard deviation of B components in VFM frames.



### 3.3.8.3 Swarm C

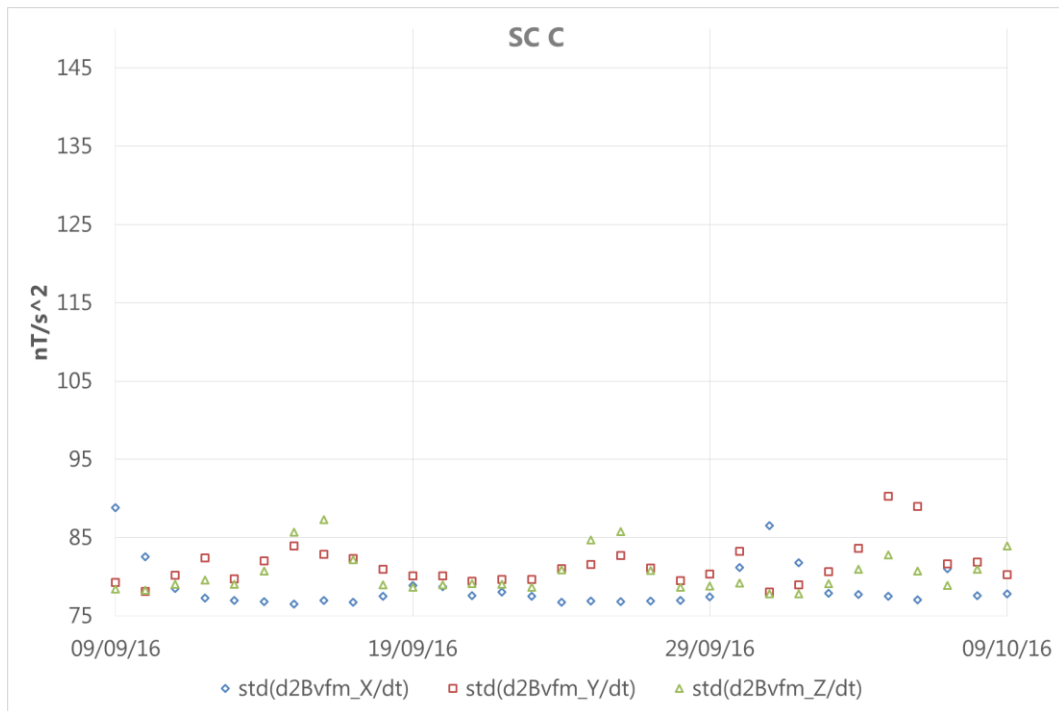


Figure 25: Plot of standard deviation of B components in VFM frames.



#### **4. ON-DEMAND ANALYSIS**

Nothing to report.



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