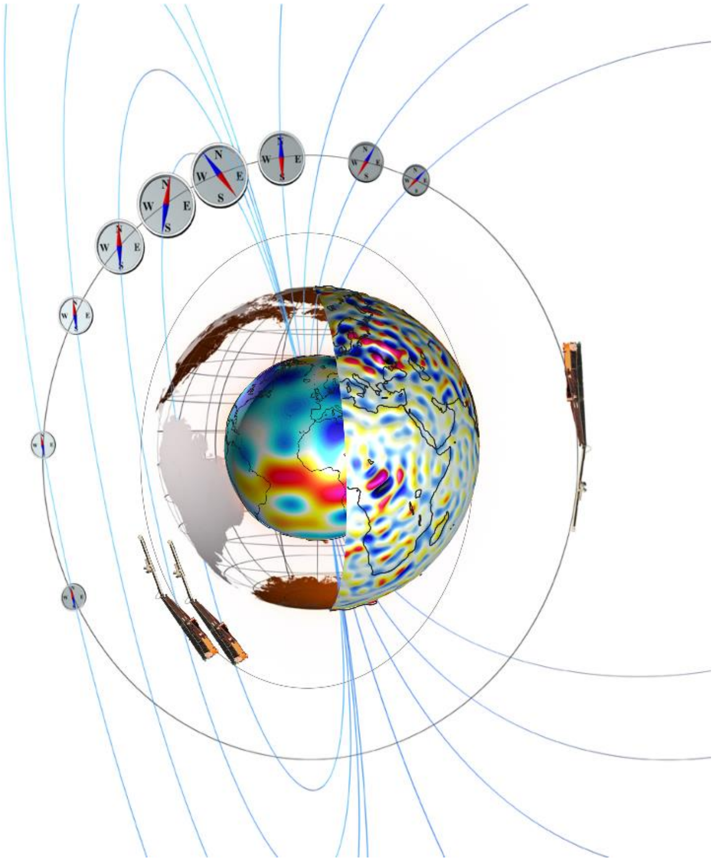
Swarm DISC Weekly Report 2016/41: 2016/10/10 - 2016/10/16



Abstract : This is the **Swarm Data Innovation and Science Cluster** (Swarm DISC) Swarm Weekly report on Swarm products quality, covering the period from 10 October to 16 October 2016.

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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	22 Dec 2016	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 APDF (Archiving Processing Data Facility) 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 2.4.

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 Swarm DISC 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 (Payload Data Ground Segment), FOS (Flight Operations Segment), PLSO (Mission Management, Post-Launch Support Office), ESL (Expert Support Laboratories), QWG (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, for authorised personnel only).

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): Software Problem Report (SPR) on EO ARTS (https://arts.eo.esa.int, for authorised personnel only), 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 Changes in the 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 (v03.19) that will be deployed in operations after the PDGS evolution activities, 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.
- Modification of detections of gaps in HK TM giving rise to among others gaps in MAGx_CA.
- 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.
- Update of the STR data resampling a.o. eliminating recurrent, small jumps in 50 Hz attitude data.
- STR Inter-Boresight Angles correction model.
- An increase of the frequency of the STR L0 product from 1 Hz to 2 Hz
- Changes in the CCDB with inclusion of several new parameters is foreseen for many of the implementations above.

The activity of PLASMA cross-verification has been restarted and hopefully a fully cross-verified PLASMA processor will be included in the next delivery.

L2 Cat-2: Any other delivery of the L2 Cat-2 OP is postponed after the PDGS evolution activity (Jan. 2017).

PDGS evolution related activity: Currently, the deployment in operations of L1BOP 3.18 and L2CAT2OP 1.16, including the update to the full Common Data Format processing schema, is foreseen for beginning of January 2016.

2.3 Quality Working Group and Cal/Val Coordination

Following the decisions of the 6th 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:
    - o in order to de-correlate the VFM T_EU and the Beta angles, it will be investigated the possibility of a 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:
    - o on-ground testing with equipment/spares from development phase

    - o 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:
  - Have to be investigated if the anomaly is caused by something happening inside or outside the instrument/s
  - One hypothesis is: 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:
    - o Understanding the correlation of the electron temperature spikes and the solar illumination on the solar panels.
    - o 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 be published on ESA ftp server. This dataset will contain the following changes:
    - o STR temperature correction and interpolation update.
    - o Updated vector data calibration and disturbance characterization.
  - ASM-V data: IPGP/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 41 (10/10 - 16/10)

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

- Gap in MAG_CA product issue investigated and solved (see Section 4).
- ASM_VFM residuals on SC A violate mean value threshold for whole week (see Section 3.3.1)

3. Routine Quality control

3.1 Gaps analysis

- Several few seconds gaps in MAGx_CA_1B products throughout the week, more details in Section 4.

3.2 Orbit and Attitude Products

In **Table 3-1** are listed events that have to be reported.

Table 3-1: List of events related to attitude and orbit products to be reported in the monitoring for 2016, Week 41: 10/10 - 16/10.

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:
    - 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 = 3m).
    - 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 Position Statistics

In Table 3-2, one can see the statistics of the differences between Medium precision Orbit Determination (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 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 3-1 shows a cumulative trend of the maximum daily standard deviation for the past 30 days of operations of the MOD-NAV difference, while Figure 3-2 shows the daily maximum difference, in absolute value, of the MOD-NAV difference, always for the past 30 days of operations.

Table 3-2: Swarm A, B and C, difference between MOD and on-board solution positions. If not specified maximum difference and standard deviation refers to the Z-axis.

Swarm A, 10/10 - 16/10, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Standard deviation (m)**	**Notes**
10/10	0.15	-6.5	7.1	1.2	
11/10	0.13	-10.3	6.2	1.26	
12/10	0.08	-6.7	6	1.13	
13/10	0.15	-8.9 (X)	6.8	1.22	
14/10	0.13	-6.3	5.5 (X)	1.07	
15/10	0.16	-5.9	6.4 (X)	1.12	
16/10	0.13	-6.9	8.2	1.32	
Swarm B, 10/10 - 16/10, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Standard deviation (m)**	**Notes**
10/10	0.13	-6.8 (Y)	6.5 (Y)	1.08	
11/10	0.13	-7.1	5	1.18	
12/10	0.07	-5.4	8.6	1.16	
13/10	0.13	-8.1	7.6	1.28	
14/10	0.07	-5.8	7.7	1.08	
15/10	0.06	-6.5	6.6	1.35	
16/10	0.05	-8.4	8.3	1.32	
Swarm C, 10/10 - 16/10, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Standard deviation (m)**	**Notes**
10/10	0.13	-5.8	7.2	1.21	
11/10	0.06	-6.6 (Y)	5.9	1.24	
12/10	0.1	-6.3	6.2	1.04	
13/10	0.15	-6.5 (Y)	8.4	1.16	
14/10	0.12	-7	6.6 (X)	1.1	
15/10	0.16	-5.6	5.8	1.12	
16/10	0.16	-6.4	8.3	1.32	

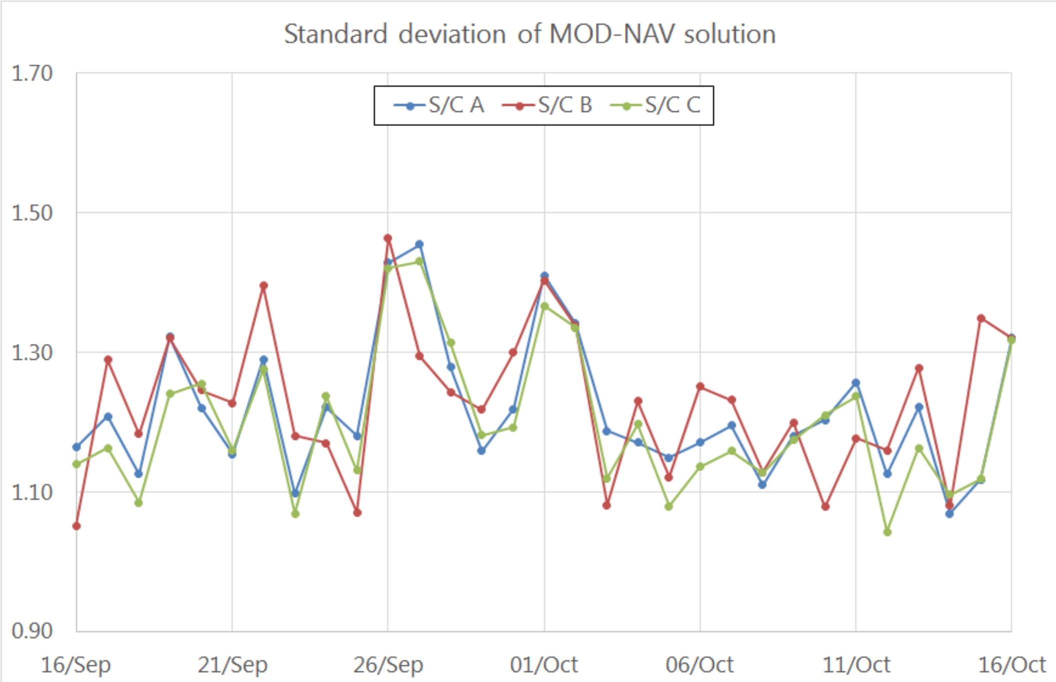


Figure 3-1: Plot of the standard deviation of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

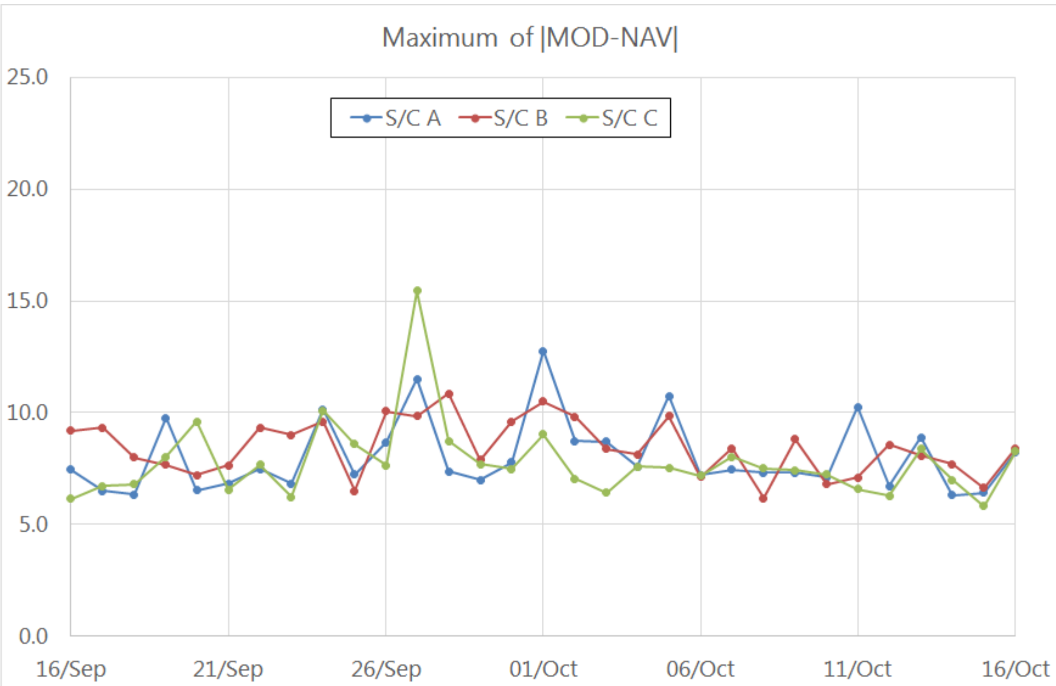


Figure 3-2: Plot of the maximum difference of the absolute value of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

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 (10/10, Figure 3-3). From top to bottom, the plots show of MOD-NAV differences in ITFR reference frame: on X, Y and Z-axis respectively. The differences are given in [m].

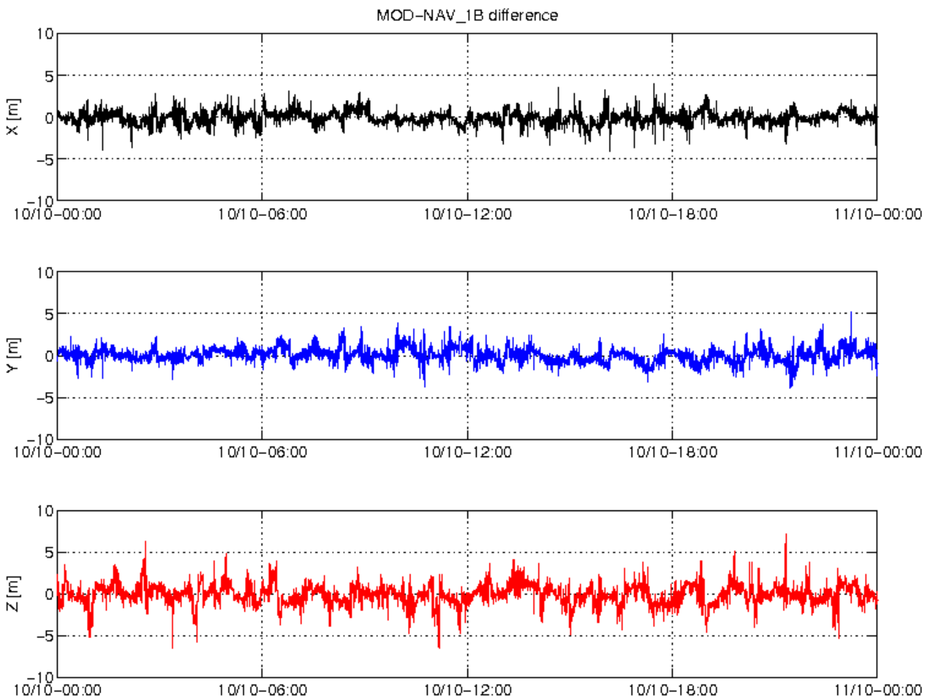


Figure 3-3: Difference MOD-GPSNAV, S/C A, 10/10. From top to bottom: X, Y and Z-axis

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 (10/10, Figure 3-4). From top to bottom, the plots show of MOD-NAV differences in ITFR reference frame: on X, Y and Z-axis respectively. The differences are given in [m].

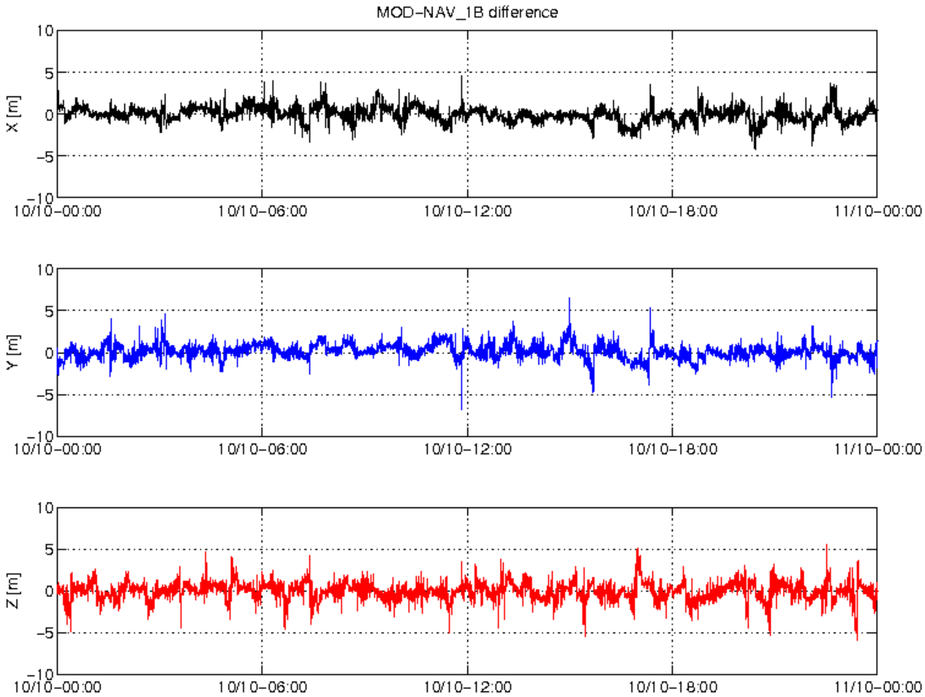


Figure 3-4: Difference MOD-GPSNAV, S/C B, 10/10. From top to bottom: X, Y and Z-axis

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 (10/10, Figure 3-5). From top to bottom, the plots show of MOD-NAV differences in ITFR reference frame: on X, Y and Z-axis respectively. The differences are given in [m].

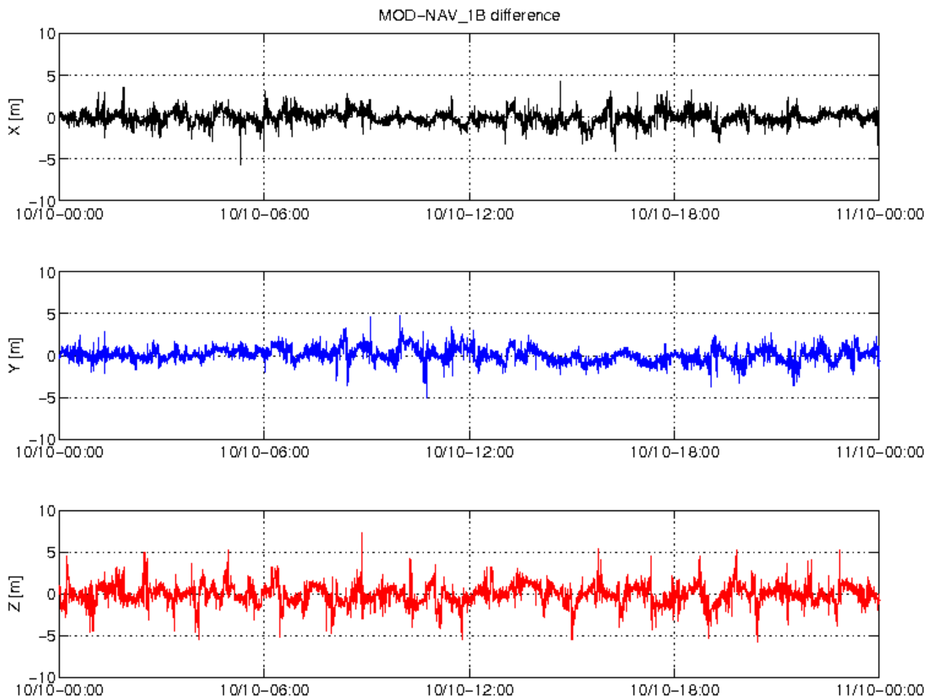


Figure 3-5: Difference MOD-GPSNAV, S/C C, 10/10. From top to bottom: X, Y and Z-axis

3.2.2 Attitude observations

3.2.2.1 Swarm A

Nothing to report.

3.2.2.2 Swarm B

Nothing to report.

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 exceed 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 ±10° latitude are considered, and values above 100 nT/s2 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 3-3** are listed events that have to be reported.

Table 3-3: List of events related to magnetic products to be reported in the monitoring for 2016, Week 41: 10/10 - 16/10.

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:
  - VFM-ASM residuals threshold on 10/10 - 13/10, 15/10, 16/10;
  - mean value of residuals threshold on 10/10 - 16/10;

3.3.1.1 ASM-VFM difference statistics

In Table 3-4, 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 standard deviation is in the fourth column.

The ASM-VFM difference is defined as follow:

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

Figure 3-6 and Figure 3-7 show the daily mean (circles) and standard deviation (crosses) of dF of the last month for Swarm A and Swarm B respectively.

Table 3-4: Swarm A and B, difference between absolute value of magnetic field measured by ASM and by VFM.

Swarm A, 10/10 - 16/10, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
10/10	**1.53**	-0.46	0.26	**0.429**	
11/10	**1.3**	-0.53	0.3	**0.41**	
12/10	**1.27**	-0.48	0.31	**0.428**	
13/10	**1.06**	-0.4	0.27	**0.425**	
14/10	0.99	-0.32	0.24	**0.432**	
15/10	**1.09**	-0.16	0.2	**0.452**	
16/10	**1.01**	0.01	0.17	**0.426**	

Swarm B, 10/10 - 16/10, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
10/10	0.8	-0.9	0.36	0.019	
11/10	0.65	-0.85	0.26	0.026	
12/10	0.63	-0.85	0.27	0.042	
13/10	0.67	-0.83	0.26	0.071	
14/10	0.59	-0.67	0.23	0.091	
15/10	0.7	-0.5	0.22	0.12	
16/10	0.82	-0.42	0.25	0.134	

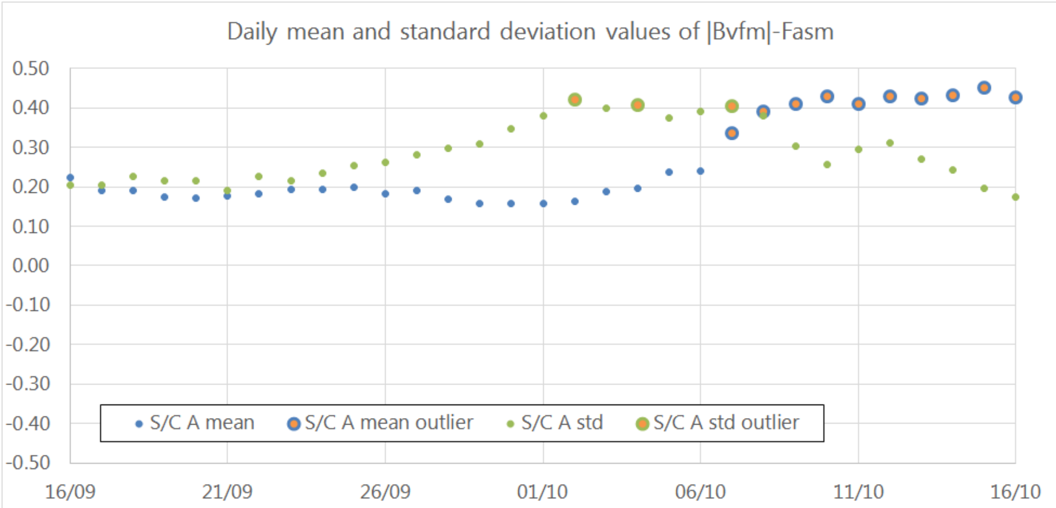


Figure 3-6: Daily mean and standard deviation values of ASM-VFM residuals (defined as dF=|B_{VFM}|-F_{ASM}) for S/C A.

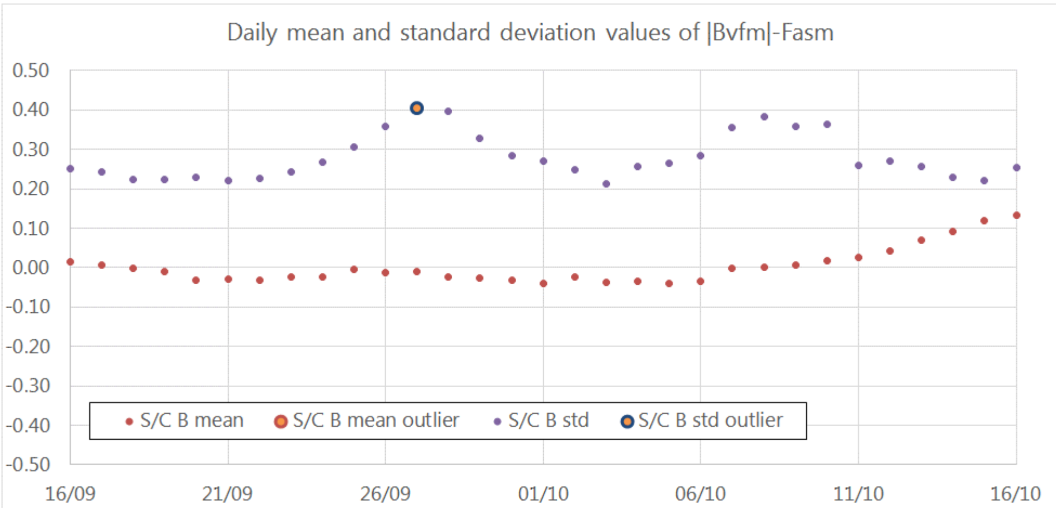


Figure 3-7: Daily mean and standard deviation values of ASM-VFM residuals (defined as dF=|B_{VFM}|-F_{ASM}) for S/C B.

3.3.1.2 Swarm A

The daily peak-to-peak difference around the week stays within [-0.53 - 1.53] nT. Below follow two plots of such differences for current week (Figure 3-8).

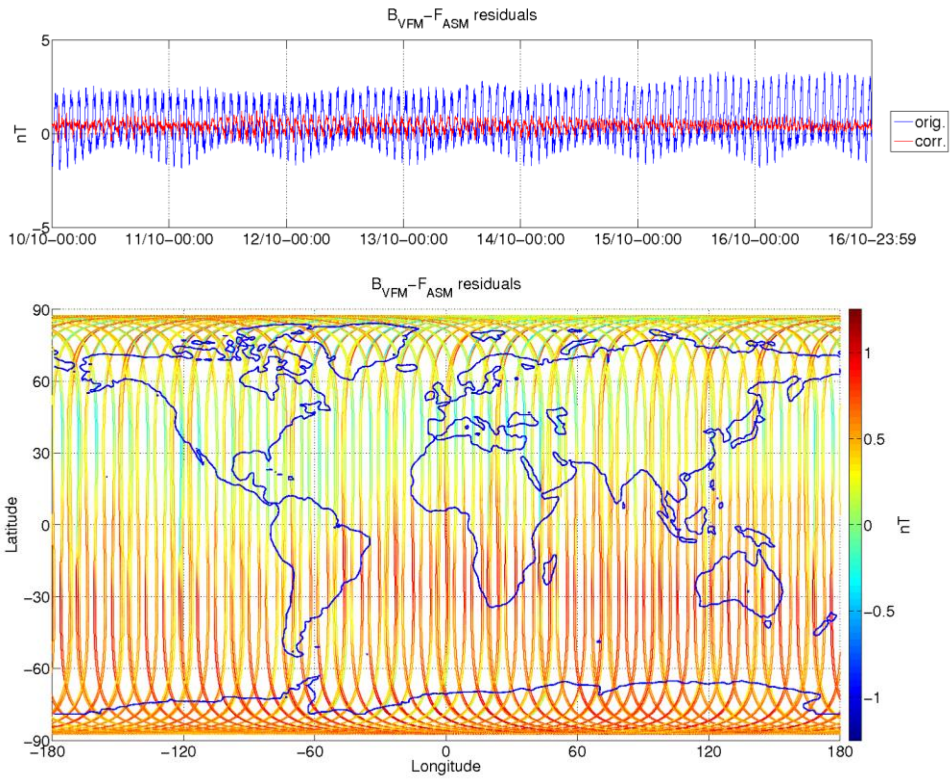


Figure 3-8: ASM-VFM residuals for S/C A, during monitoring period 10/10-16/10. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map.

3.3.1.3 Swarm B

The daily peak-to-peak difference around the week stays within [-0.9 0.82] nT. Below follow two plots of such differences for current week (Figure 3-9).

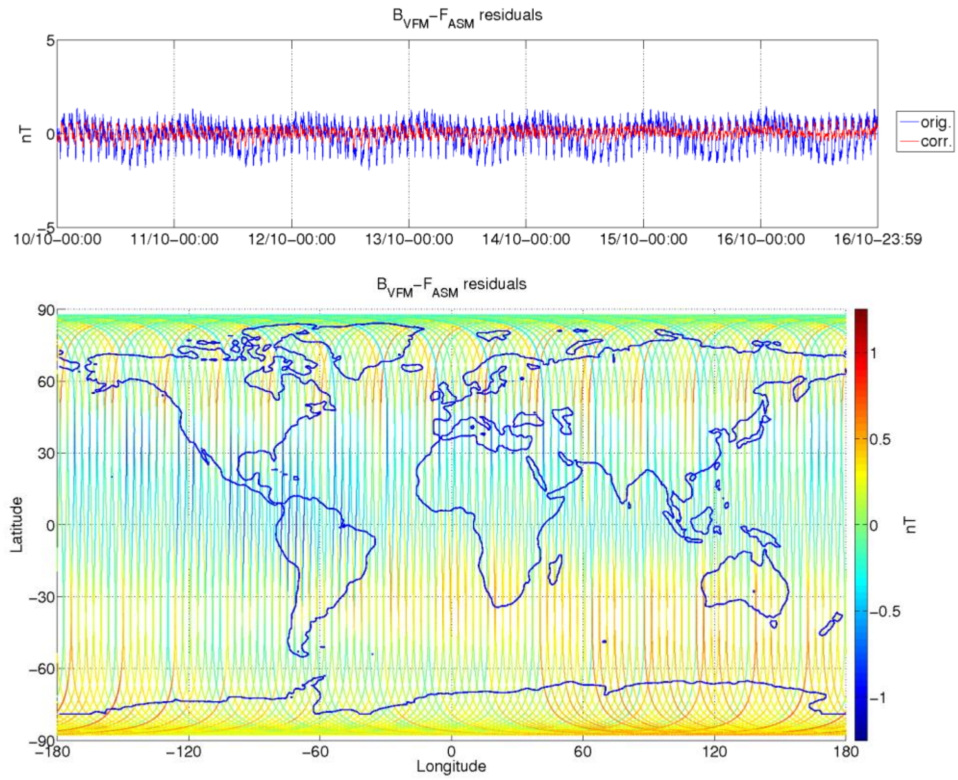


Figure 3-9: ASM-VFM residuals for S/C B, during monitoring period 10/10-16/10. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map.

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)

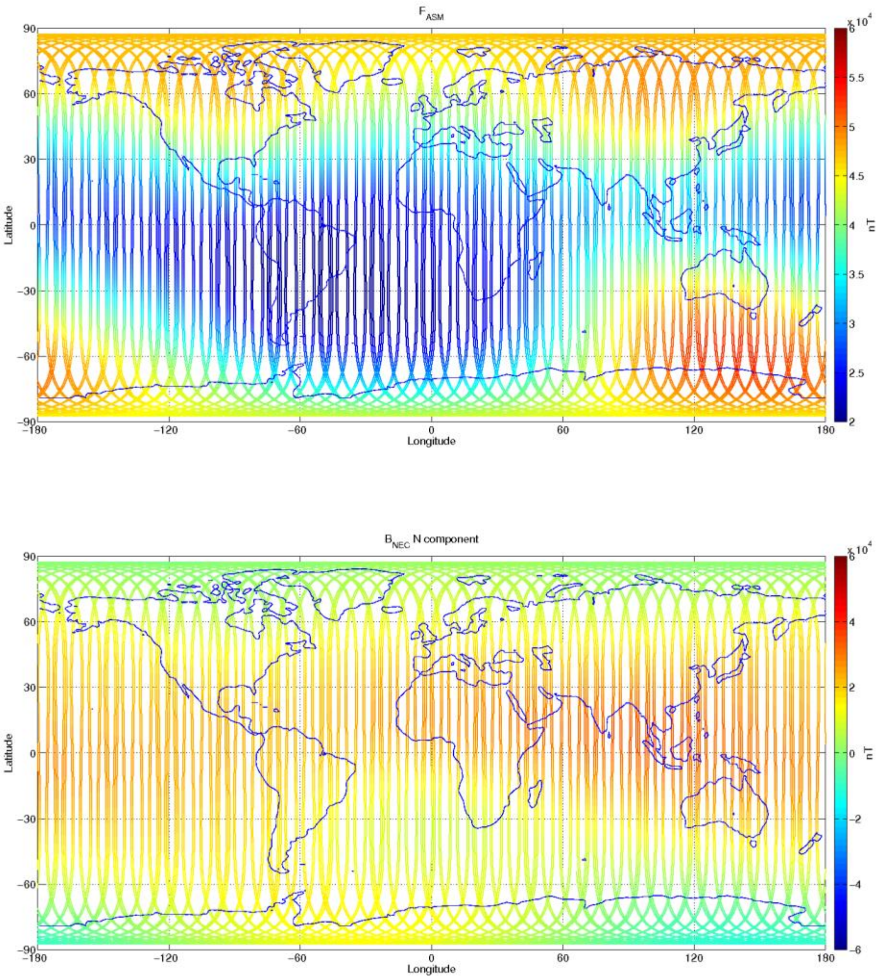
The VFM instrument parameters important for monitoring the instrument health are the VFM sensor temperatures: T_CDC, T_CSC and T_EU.

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 41 for S/C A can be seen in Figure 3-10 below.



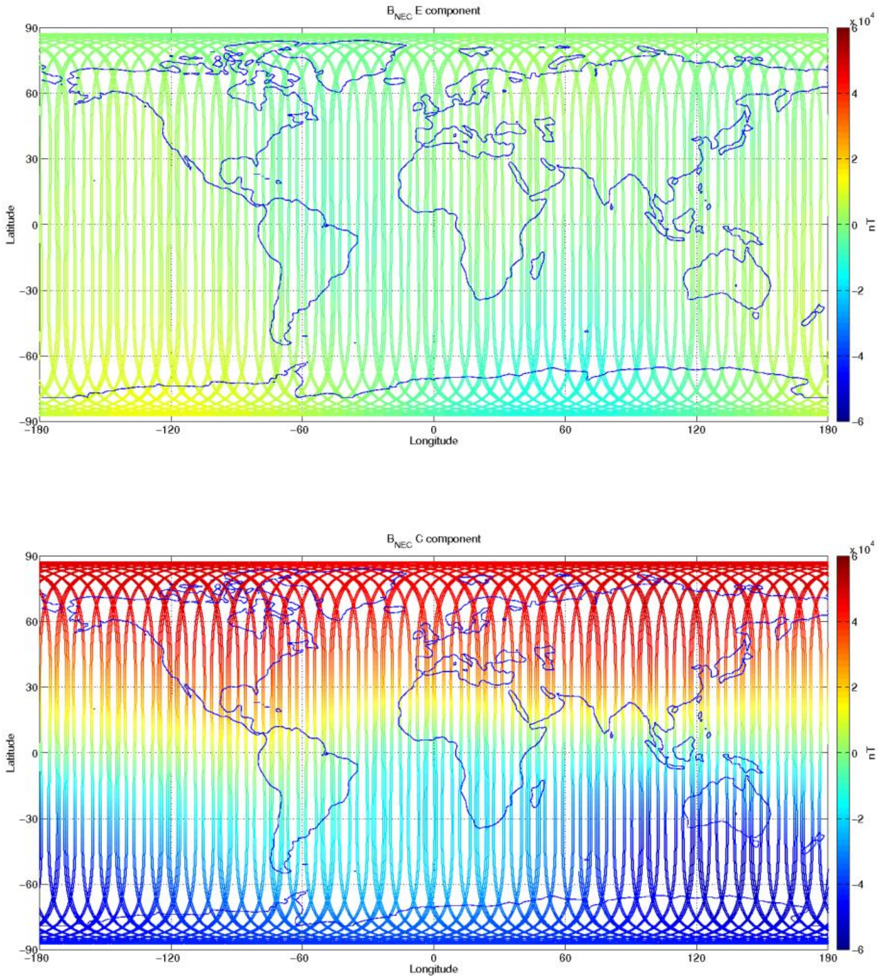
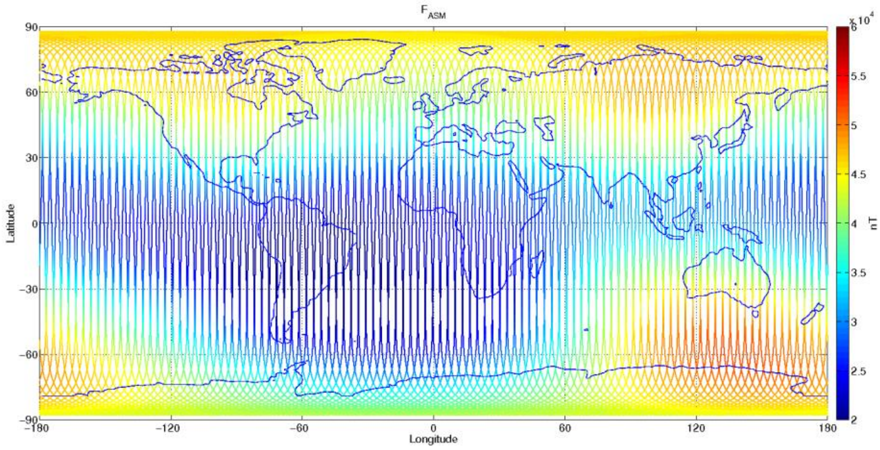
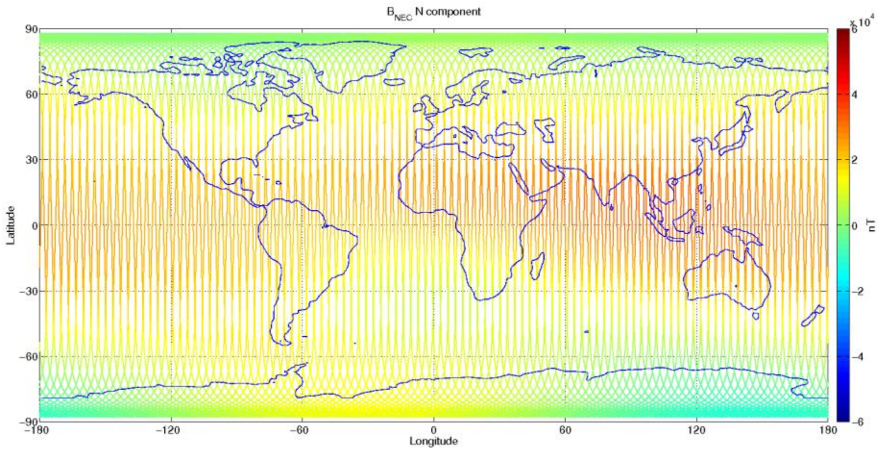


Figure 3-10: S/C A, world map plots of the geomagnetic field and components measured during monitoring period 10/10-16/10. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.2 Swarm B

Map plots of magnetic field measurement for week 41 for S/C B can be seen in Figure 3-11 below.





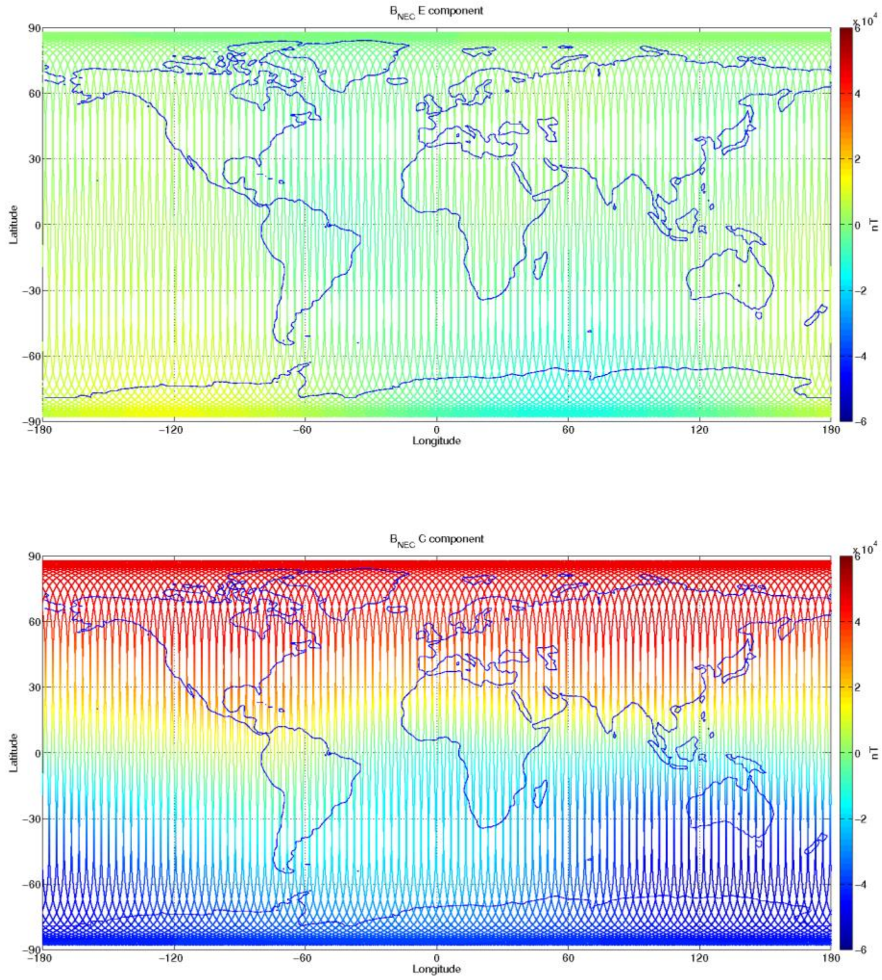


Figure 3-11: S/C B, world map plots of the geomagnetic field and components measured during monitoring period 10/10-16/10. From top to bottom: F-magnetic field from ASM measurement, BNEC components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.3 Swarm C

Map plots of magnetic field measurement for week 41 for S/C C can be seen in Figure 3-12.

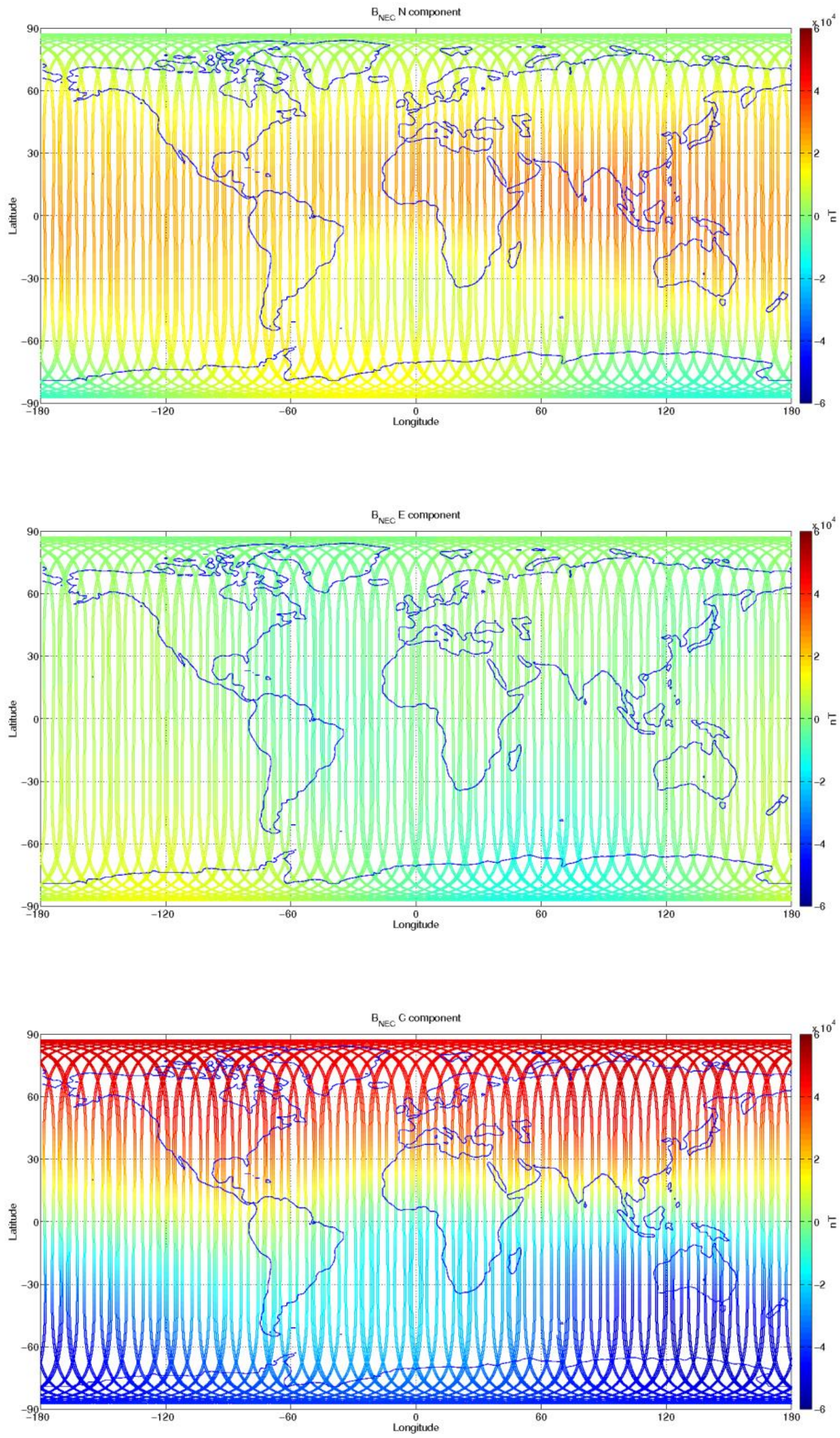


Figure 3-12: S/C C, world map plots of the geomagnetic field and components measured during monitoring period 10/10-16/10. From top to bottom: BNEC components (North, East, and Centre) of magnetic field from VFM measurement.

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_north, B_east, and B_center are the components of the magnetic field vector in NEC frame.

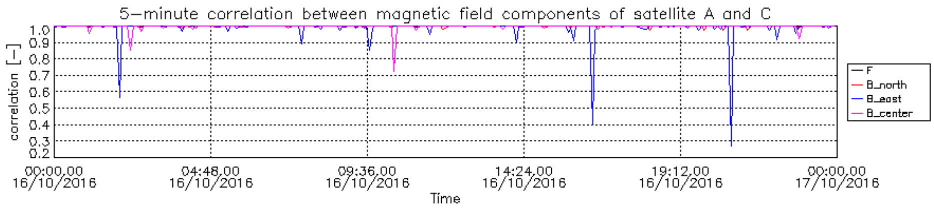


Figure 3-13: Correlation in magnetic data between satellite A and C for B_north, B_east, and B_center components of B_{NEC} are the components of the magnetic field vector in NEC frame

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.

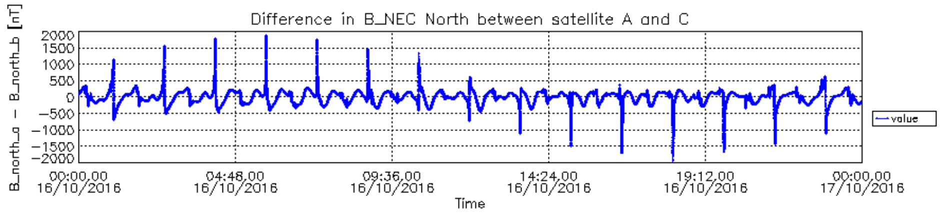


Figure 3-14: Difference in B_{NEC} North component between S/C A and S/C C.

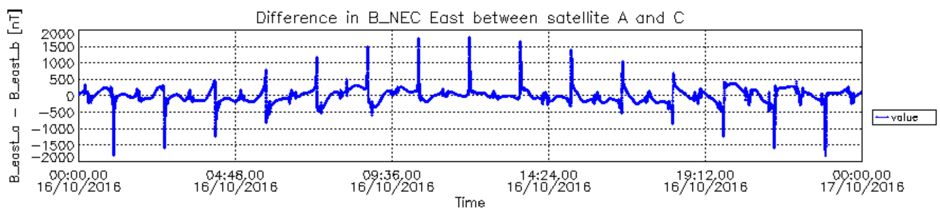


Figure 3-15: Difference in B_{NEC} East component between S/C A and S/C C.

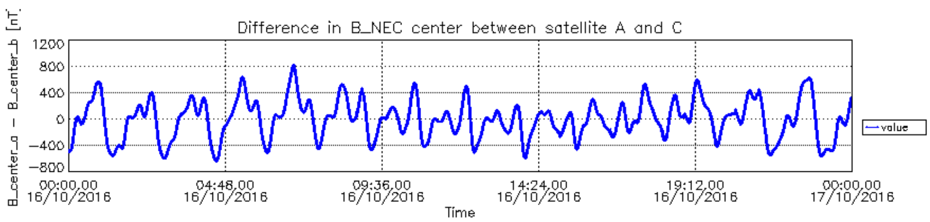


Figure 3-16: Difference in B_{NEC} Center component between S/C A and S/C C.

3.3.7 B_{NEC} 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 3-17, Figure 3-19 and Figure 3-21 show field residuals $dB=B_{NEC} - B_{Chaos}$ (all versus co-latitude in degrees), from top to bottom: 1) Br, 2) Bθ and 3) Bφ.

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 3-18, Figure 3-20 and Figure 3-22 show, from top to bottom, the time series on 10/10 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

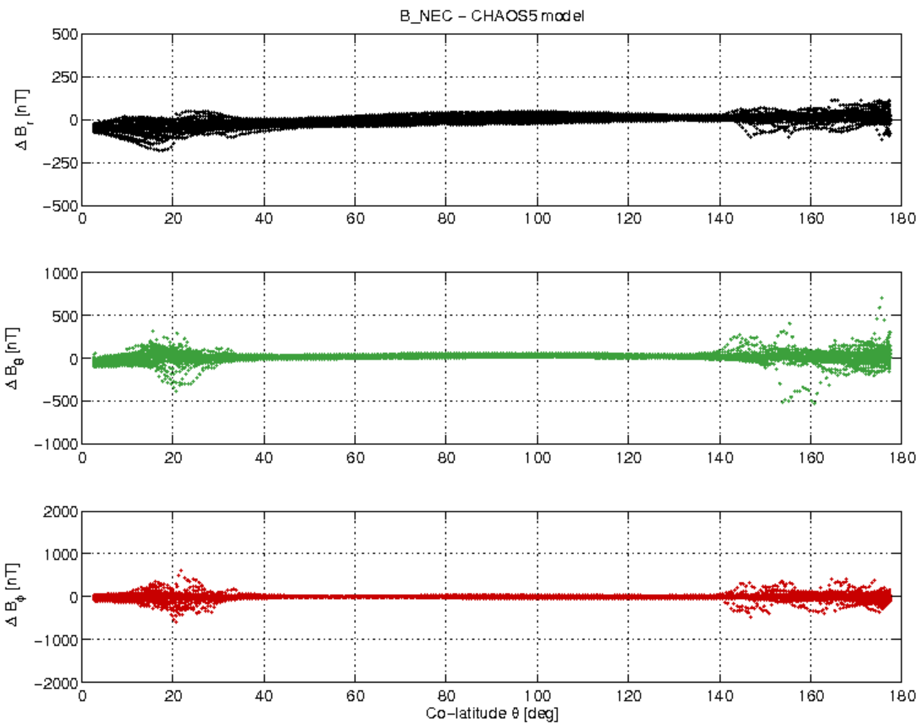


Figure 3-17: S/C A day 10/10 B_{NEC} - B_{Chaos} vs colatitude.

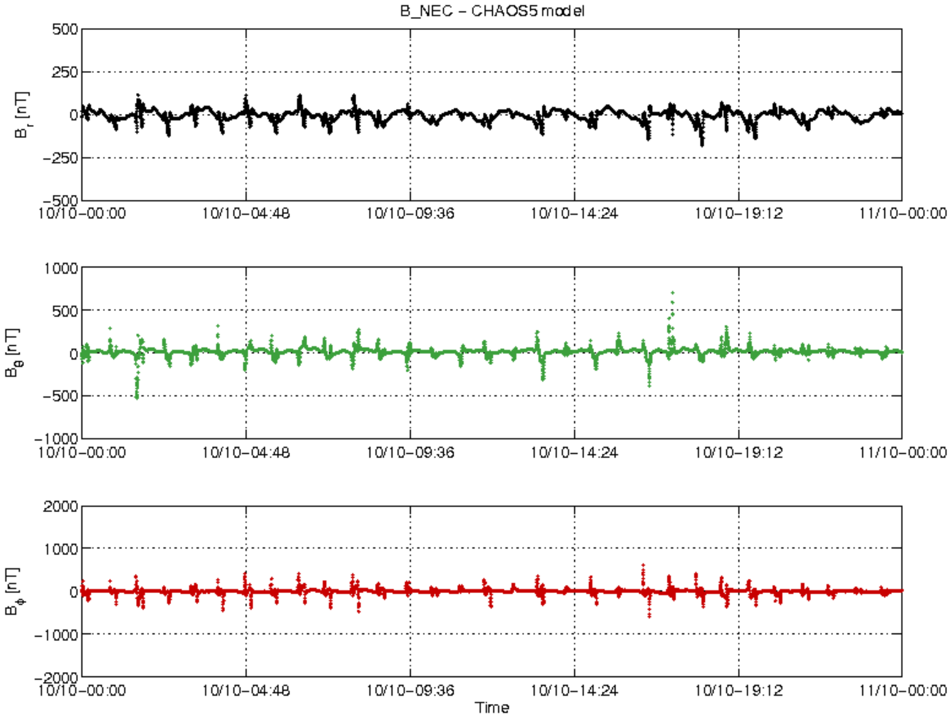


Figure 3-18: S/C A day 10/10: time series of $B_{NEC} - B_{Chaos}$ residuals.

3.3.7.2 Swarm B

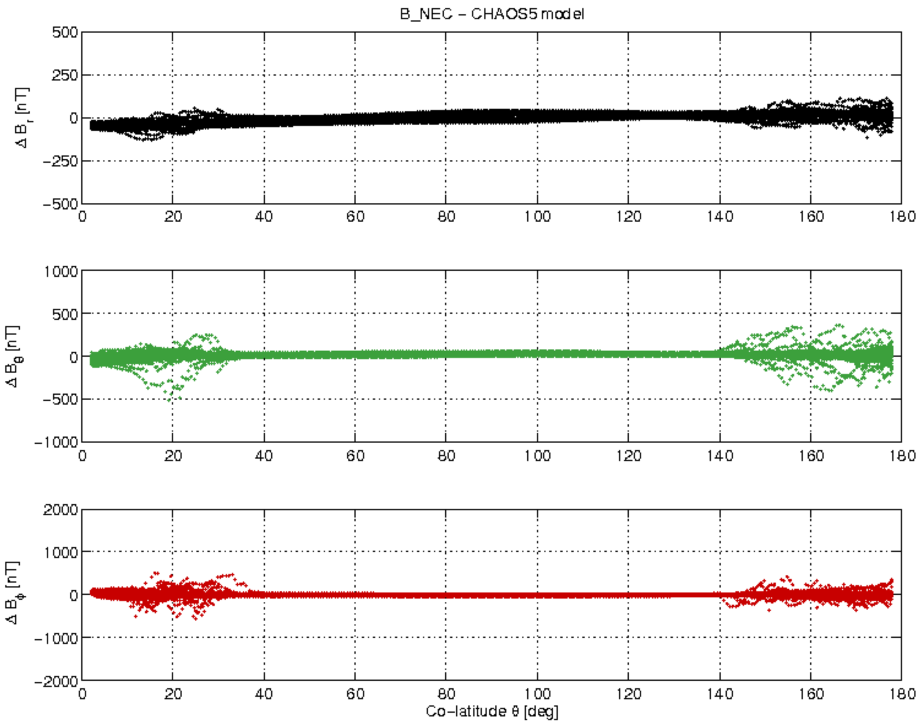


Figure 3-19: S/C B day 10/10 B_{NEC} - B_{Chaos} difference vs colatitude.

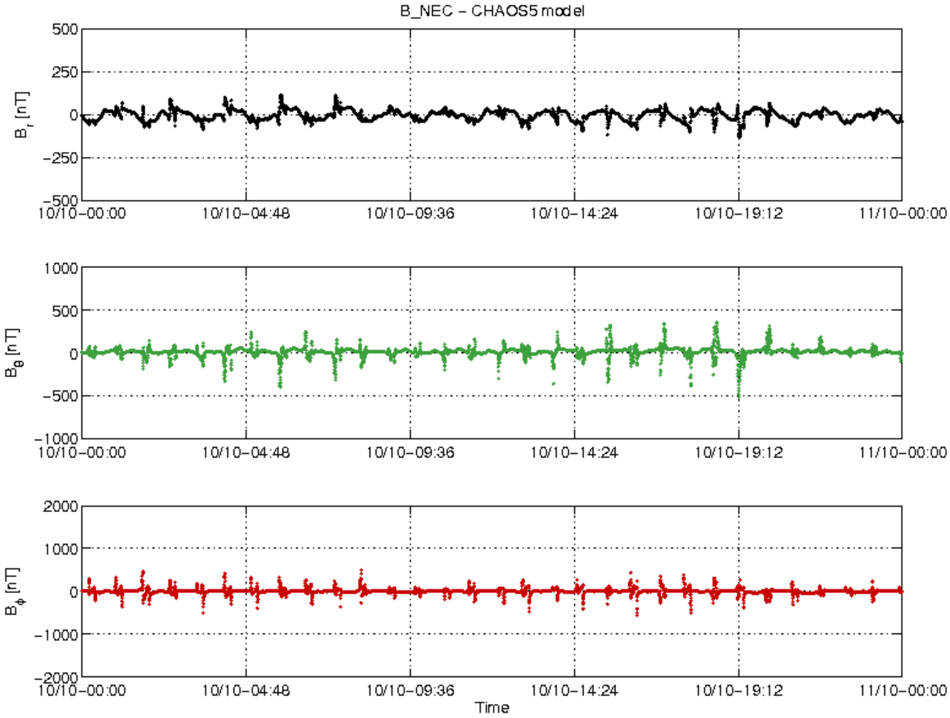


Figure 3-20: S/C B day 10/10 time series of $B_{NEC} - B_{Chaos}$ residuals.

3.3.7.3 Swarm C

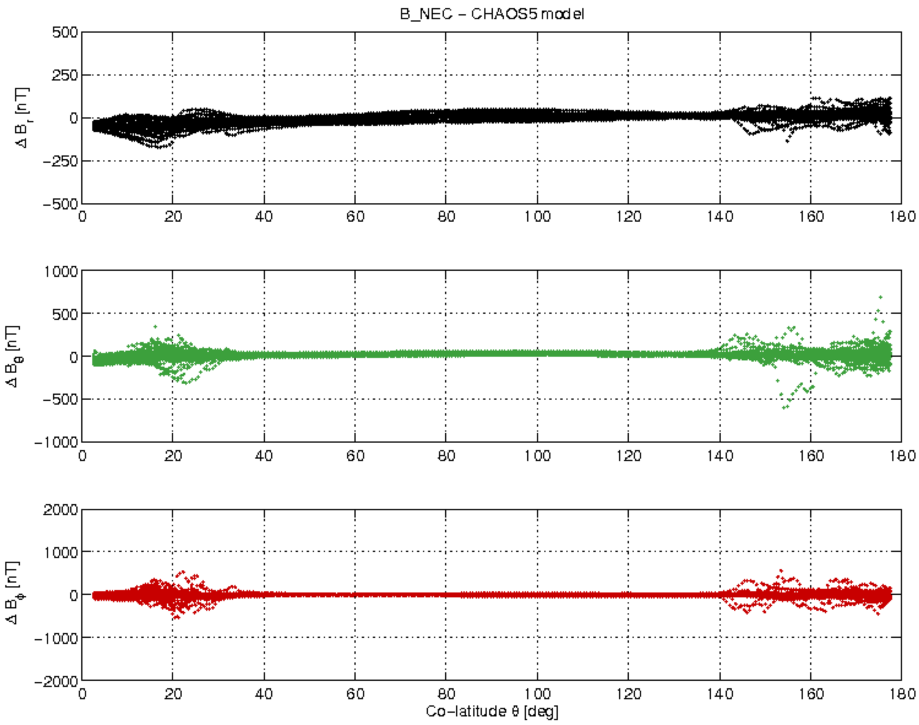


Figure 3-21: S/C C day 10/10 B_{NEC} - B_{Chaos} difference vs colatitude.

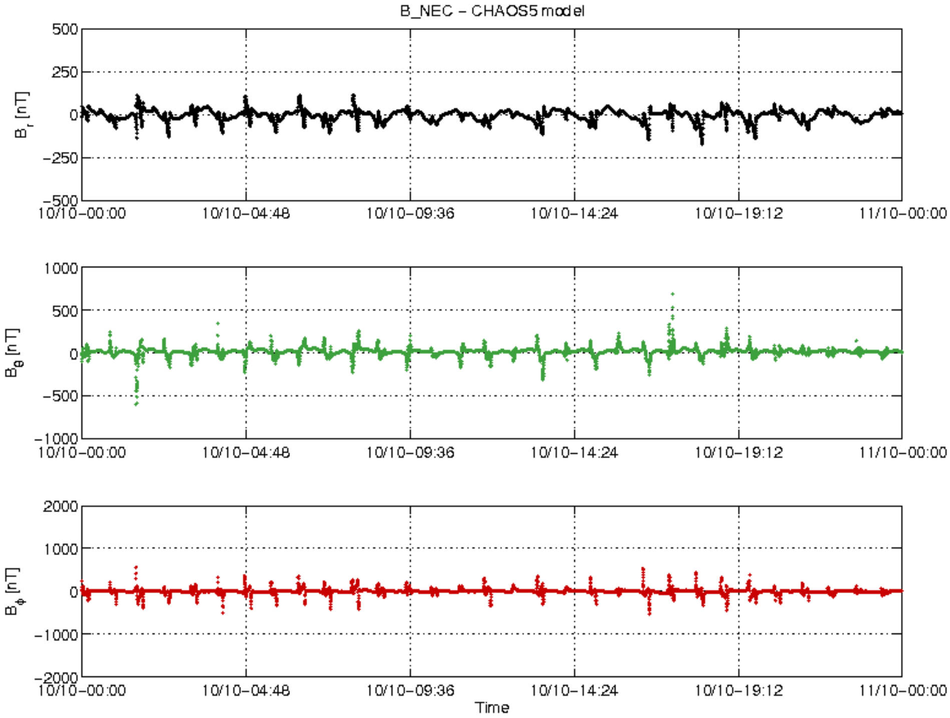


Figure 3-22: S/C C day 10/10 time series of $B_{NEC} - B_{Chaos}$ residuals.

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 ±10° latitude have been considered. Figure 3-23, Figure 3-24 and Figure 3-25 show the daily standard deviation of the second derivative of BVFM 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

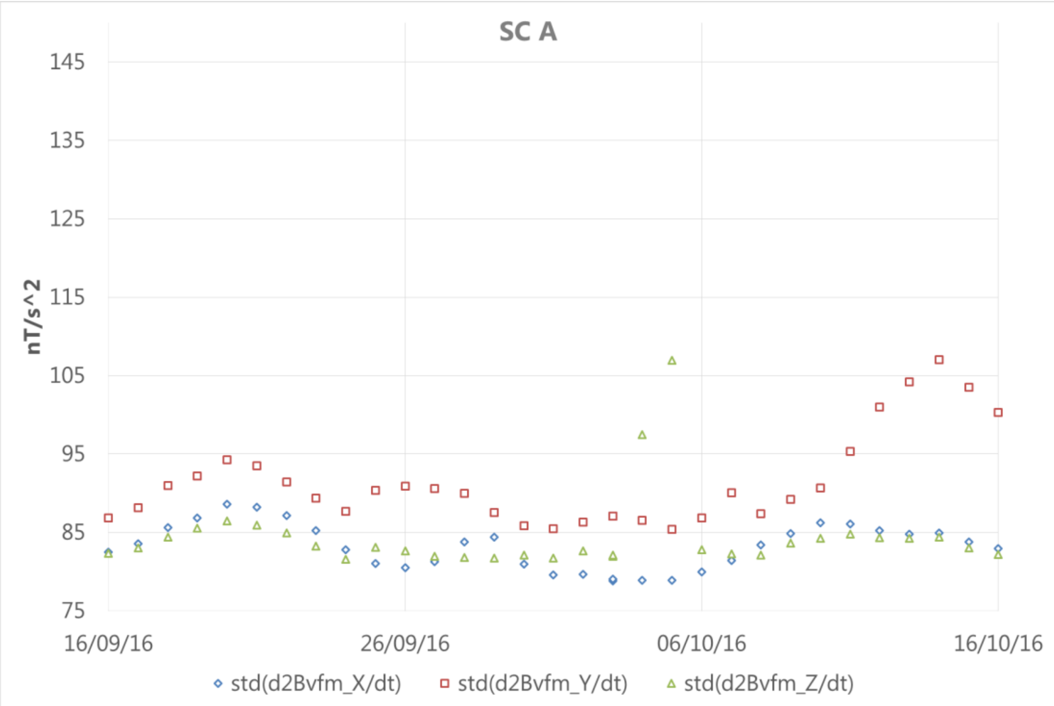


Figure 3-23: Plot of standard deviation of B components in VFM frames.

3.3.8.2 Swarm B

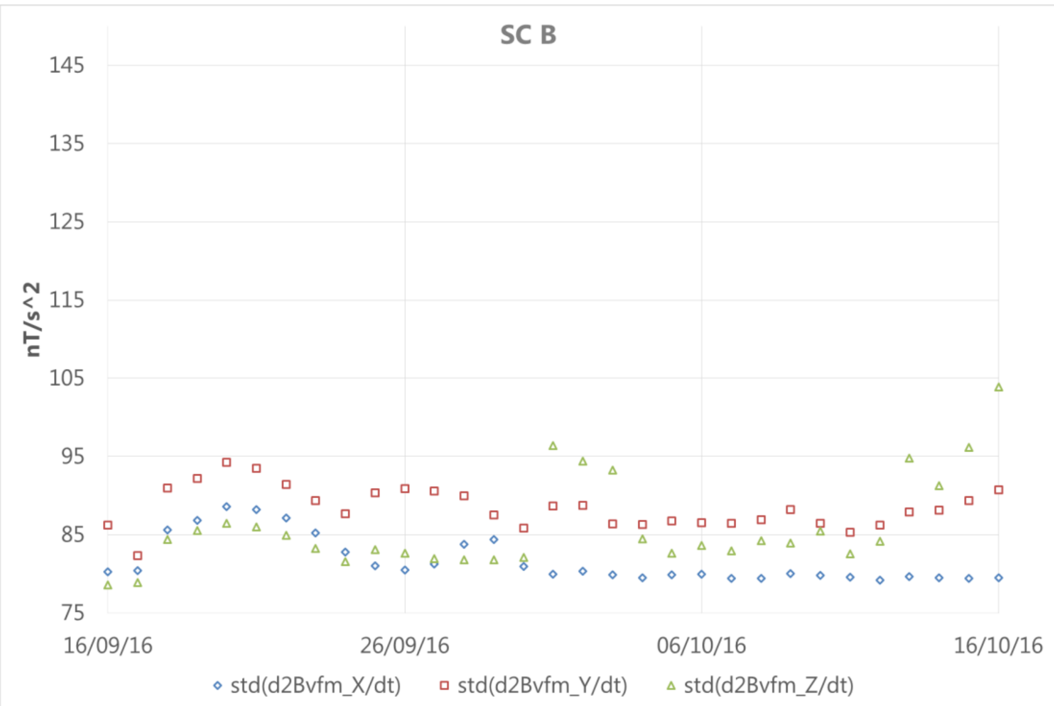


Figure 3-24: Plot of standard deviation of B components in VFM frames.

3.3.8.3 Swarm C

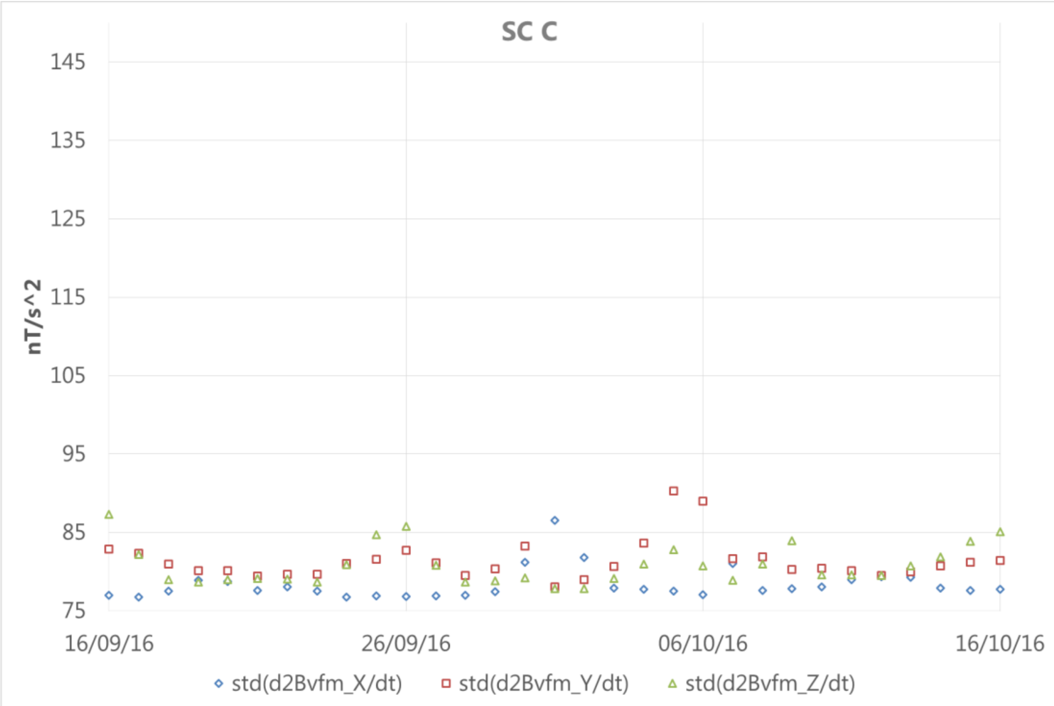


Figure 3-25: Plot of standard deviation of B components in VFM frames.

4. ON-DEMAND analysis

From the beginning of the mission multiple gaps of duration 2 or 9 seconds, or multiple of them, were present in MAGx_CA products. This issue have been investigated. The causes that have been identified are described below:

1. Small time difference between consecutive measurement points was causing data rejection in MAG_CA processing chain. Nominally the frequency of HK AOCS is 1/4Hz. The margin for time variation from 4 seconds between consecutive measurements was set to 0.0001s. For some points the time difference between few consecutive points was slightly higher. Additionally due to different flagging mechanism in MAGx_HR and MAGx_LR products, only in MAG_HR files data was flagged (see Figure 4-27 and Figure 4-29). It was decided with Prototype Processor designer (DTU) to change this threshold to 1% i.e. to 0.04sec and to align fagging mechanisms in MAGx_LR and MAGx_HR products. Preliminary results show that this type of gap disappears.

2. Gaps in MAG_CA products are caused by the rejection of ASM measurements. Following Processor Specification Document, acceleration of F_{ASM} shall not be higher than $2nT/s^2$. In MAG_LR data such rejected points are interpolated. However in MAG_CA data for the purpose of calibration such gaps are not interpolated.

3. Some gaps in MAGx_CA product coincide with flags platform indicating 'gap in AOCS telemetry'. Those flags are present in both products MAGx_HR and MAGx_LR. This type of gap is under investigation by processors provider.

Here below is shown an example of this issue for SC A on day 03 Oct 2016. In Table 4-5 are listed the gaps detected in MAGx_CA product of this day while in Figure 4-26 is shown their time distribution. The gaps number 1 and 4 are caused by gap in L1A bus telemetry (explained above). Gaps number 2 and 5 are caused by gap in AOCS telemetry (issue under investigation). Gap number 3 is caused by ASM measurement rejection, which is flagged (see Figure 4-28) with flagF= 33 (this flag consist of flag 1 and 32, which are 'ASM vector mode' and 'Gap in 4 nearest ASM samples respectively).

Table 4-5: List of gaps in MAGA_CA product on 3 Oct 2016.

Gap No.	Start time gap	Stop time gap	Length gap (s)
1	03/10/16 00:47:25	03/10/16 00:47:34	9
2	03/10/16 10:03:44	03/10/16 10:03:53	9
3	03/10/16 13:35:43	03/10/16 13:35:45	2
4	03/10/16 16:01:13	03/10/16 16:01:22	9
5	03/10/16 19:41:27	03/10/16 19:41:36	9

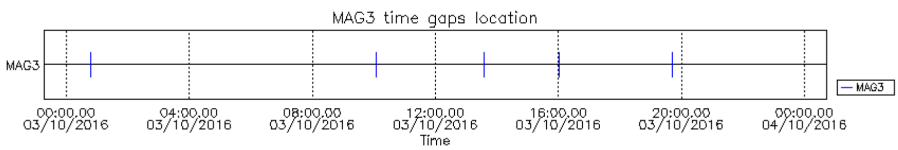


Figure 4-26: Graphical representation of gaps in MAGA_CA product on 3 Oct 2016.

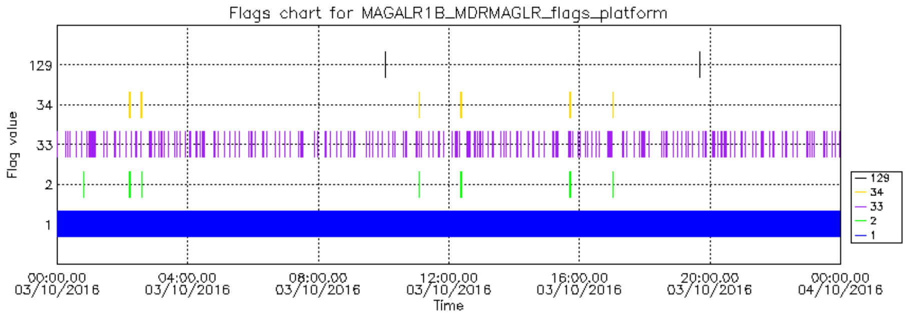


Figure 4-27: Graphical representation of platform flags in MAGA_LR product on 3 Oct 2016 (a detailed description of such flags can be found in [RD.4]).

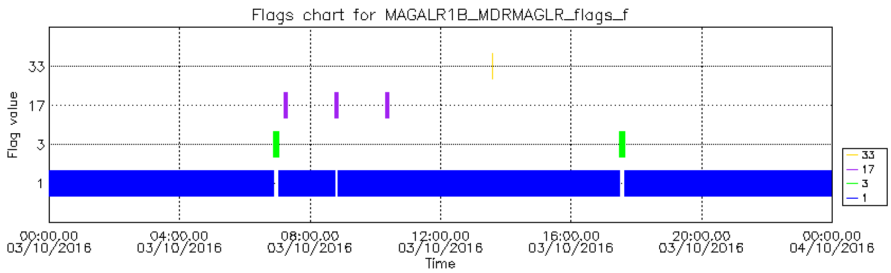


Figure 4-28: Graphical representation of flags F in MAGA_LR product on 3 Oct 2016 (a detailed description of such flags can be found in [RD.4]).

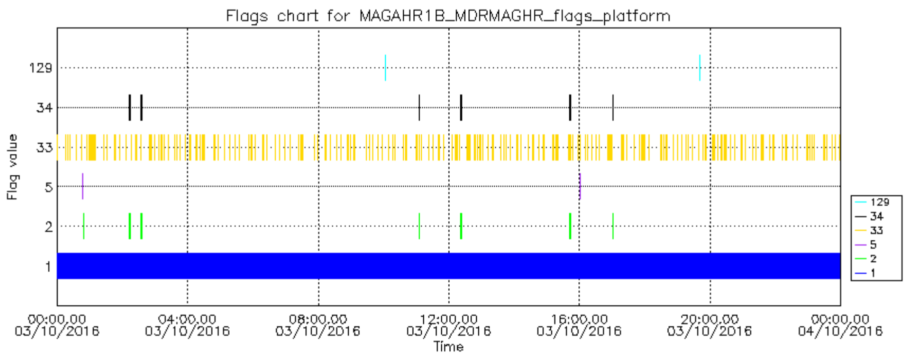


Figure 4-29: Graphical representation of platform flags in MAGA_HR product on 3 Oct 2016 (a detailed description of such flags can be found in [RD.4]).

End of Document