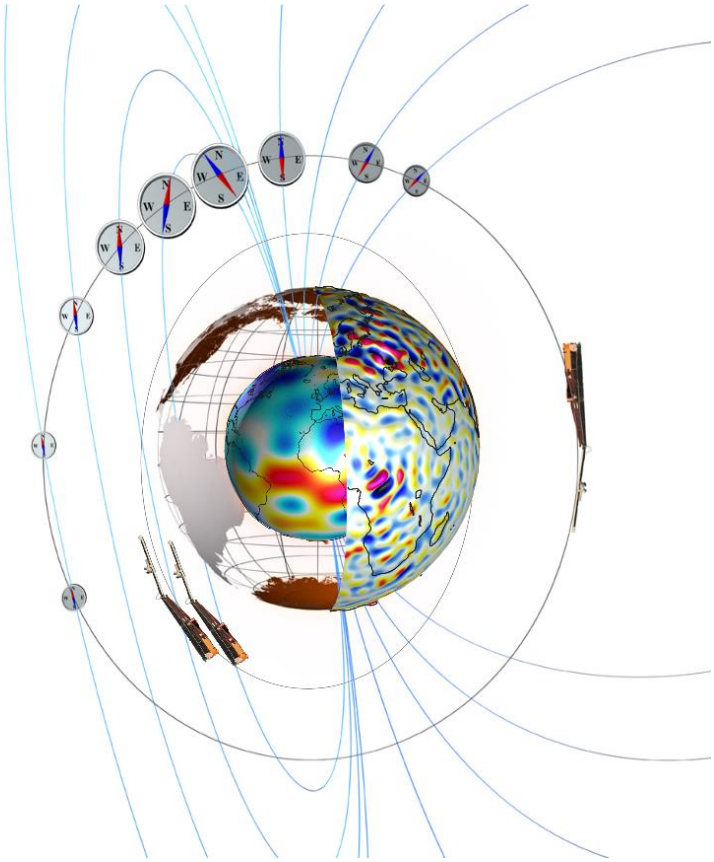
Swarm DISC Weekly Report 2018/33: 2018/08/13 - 2018/08/19



Abstract : This is the **Swarm Data Innovation and Science Cluster** (Swarm DISC) Weekly report on Swarm products quality, covering the period from 13 August to 19 August 2018.

Doc. No : SW-RP-SER-GS-010

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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	25 Jan 2019	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 (Archive and 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 2.2.

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 Payload Data Ground Segment (PDGS), Flight Operation Segment (FOS), Mission Management, Post-Launch Support Office (PLSO), Expert Support Laboratories (ESL), Quality Working Groups (QWG), 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: DISC action and ticketing system (http://requests-sppa.serco.it/RT3/index.html, for authorised personnel only).

2. If triggered by Swarm Disc 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, 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 3.18p2, L2-Cat2 1.16p2.

- 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 0016 (01/03/2018), S/C B – CCDB 0017 (01/05/2018), S/C C – CCDB 0017 (01/03/2018), ADF 0101
- MPPF-CVQ v.03.04.01

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

[RD.19] SW-RP-SER-GS-010_SPPA_SwarmWeeklyReport_201641_20161010_20161016.pdf

2. Summary of the observations

2.1 Changes in the general status of Swarm instruments and Level 1B products quality

Due to a science packet corruption which occurred on the VFM (Vector Field Magnetometer) on board Swarm Bravo, the VFM science data (at 50 Hz rate) were not received from 19 August at 10:03 UTC to 28 August at 07:06 UTC. As a consequence, no L1B Magnetic and Plasma and Level 2 – Cat-2 FAC, IBI and EEF data are available during this time window.

2.2 Plan for operational processor updates

L1B v03.20 / L2 Cat-2 v01.18: The PDGS team have completed the execution of all the tests (Cross-verification, Anomalous scenarios and Interface tests). The output data have been provided to the Swarm DISC team for final validation. No discrepancies was detected during the comparison between PDGS outputs and GMV outputs. Validation considered completed.
Once confirmed the correct implementation of the different evolutions / fixes in the above mentioned deliveries, it was agreed to transfer into operations (only in the reprocessing chain) the L1B v03.20 and L2 Cat-2 v01.18 deliveries (done on 21/05/2018). A full Swarm L1B/L2 Cat-2 data reprocessing was performed. The datasets concern the 3 Swarm spacecraft, cover the period from the BoM (Beginning of Mission) until 30 April 2018 and include the following improvements:

ORBATT: Change in ORBATT of carrier phase observation to get full-cycle ambiguities / Align data in RINEX files to GPS time (GPS_RO clock offset and drift) / Reduction of receiver clock noise / STR Inter-Boresight Angles correction model.

MAGNET: Separation of pre-flight from the in-flight VFM calibration parameters / Update of vector data calibration and disturbance characterization / Change the data resampling used for the interpolation of the ASM measurements to UTC second / Fixes in the computation of ASM stray fields.

PLASMA: New LP product at LP timestamp (EFIx_LP_1B) / New LP product interpolated at exact UTC (EFIxLPI_1B) / Modification on the computation of the Te by using mainly the high gain probe / Improvement in flagging in LP new data products

ACCELE: New ACC product (SC_xDYN_1B) containing a subset of parameters of the current ACCx_PR_1B

L2 Cat-2: Minor improvements introduced in L2 chain.

An important effort has been made in the quality-assessment of the reprocessed data, which has allowed Swarm Cal/Val experts to detect 3 minor and non-blocking issues described here below:

ORBATT: The RINEX observation files (GPSx_RO_1B) systematically miss one epoch in each file for the period 01/07/2015 - 01/01/2017. No impact on the other Level 1b data is expected. The Level 2 precise orbits, non-gravitational acceleration and TEC estimates instead are marginally affected by the missing epoch.

MAGNET: in some cases when the B_VFM == 0, the corresponding flag, i.e., Flags_B, is not set to 255 (i.e., not enough VFM samples to generate B_VFM and B_NEC). In such conditions the Flags_B is not correctly set to 16 which indicates gaps in VFM data, but enough data to generate the 1 Hz sample.

PLASMA : LP products (EFIx_LP_1B and EFIxLPI_1B) do not contain reliable errors. Therefore all the error parameters (Ne_error, Te_error, Vs_error) are still set to fixed values as in the previous

version but are wrongly set to negative values. In this release, Ne_error changed from 4.29497E+8 to -0.1; Te_error changed from 4.29497E+7 to -0.01, while Vs_error is unchanged and set to 32.767 as in the previous version.

A new delivery of the L1BOP containing the fixes of the above described issues was delivered on 11/07/2018.

2.3 Quality Working Group and Cal/Val Coordination

Following the decisions of the 7th QWG in Delft, the following activities will be carried on for a better understanding of some open issues:

- On the ASM-VFM Scalar Residuals further work will be done on the improvement of the correction model that consists in:
  - Short term :
    - Update of the vector data calibration and disturbance characterization currently in operation in the L1B chain
    - If needed, further adjustment of the VFM pre-flight calibration parameter
    - Investigation on the dependency of the VFM scaling with beta-angle or with T_EU
    - Separation of the pre-flight and in-flight calibration parameters with B_pre parameter in MAGx_CA_1B product as a source of "original residuals"
  - Long term :
    - Make use of the findings that came out from the thermos-electric investigations performed by DTU-MI on ground (thermoelectric currents in the pigtail wires responsible of the disturbance).
    - A preliminary thermodynamic model of the temperature of the rivets on the blanket is set up The disturbance vector varies from one spacecraft to the others. Probably caused by differences in the contact resistance of the rivets to the MLI layers.
    - Further analysis are needed to correctly model each component of the disturbance on each spacecraft.
    - The effect on the ASM location has been also modelled since the beta cloth blanket around the AMS sensor has a configuration that suggest a y-axis disturbance (this could explain the discrepancy between the ASM-A and ASM-C during maneuvers).
    - DTU proposed :
      - to use the models (one for ASM and one for VFM) of P. Brauer as basis-functions
      - co-estimate the scales of these basis functions together with current spherical harmonic & scaling model
      - Analyse resulting spherical harmonic models – which will contain small scale details – and iterate P. Brauer model
      - Apply $dB_{Sun,ASM}$ correction to ASM measurements and generate version 0601 L1b data for modelling and Euler angle investigations
- EFI validation and investigations:
  - Validation of LP data: electron density and temperature by inter-comparison with ground based (ISR), ionosondes and space borne (radio-occultation) measurements has been performed, with different datasets and approaches giving similar results. Also validation 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). In particular electron density has been compared also with faceplate measurements.
  - Validation of TII data: in particular E field data by using the method of SECS (Spherical Elementary Current System); studying plasma depletions events characterized by a correlation between E field and B; also comparison of Swarm cross-track ion drifts and SUPERDARN line-of-sight velocities.

- Some investigations are still on-going on LP side:
  - Understanding the correlation of the electron temperature spikes and the solar illumination on the solar panels.
  - S/C potential and electron temperature hick-ups following a sweep mode activation: good progresses in modelling them, but root cause still unknown.
  - Differences between sweep mode and harmonic mode
  - Estimation of real ion mass composition since the assumption of pure O^+ ion plasma should be reconsidered.
- 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:
  - ASM-V data: IPGP/LETI will deliver an updated version of the ASM vector data that will be available for all the users.

2.4 Summary of observations for 2018, Week 33 (13/08 - 19/08)

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

- There is no VFM and ASM data for SC B from 19.08 till 28.08.2018, due to error in VFM L0 products.
- Very weak geomagnetic activity appeared on days 15-18/08/2018. It caused anomalies on B_NEC - CHAOS5 model plots on S/C A, B and C.

3. Routine Quality control

3.1 Gaps analysis

- Several short duration time gaps (duration 1 to 4 s) found in HK_ANOM_0_ from 14:30:36 till 14:31:50 on day 17/08/2018. It only effects MAGA_CA product.
- Several short duration time gaps (duration 1 to 4s) found in HK_BNOM_0_ from 07:23:51 till 07:25:59 on day 17/08/2018. 30s time gap duration found in HKBNOM0TNK STARTING FROM 07:25:22. It only effects MAGB_CA_1B product.
- Several short duration time gaps (duration 1to 4s) found in HK_CNOM from 06:36:44 till 06:38:31 on day 17/08/2018. It only effects MAGB_CA_1B product.
- Several few seconds gaps in MAGx_CA_1B products throughout the week (gaps result from bug in the OP implementation, for details please see [RD.19]).
- Two time gaps observed for S/C A on 12/08/2018 for MAGA_CA_1B, with a duration of 105s starting from 01:44:19 and of 9s starting from 14:36:20.

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 2018, Week 33: 13/08 - 19/08.

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 = 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 Position Statistics

In Table 3-2, 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 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. Spikes observed on 26/07/2018 for S/C A in Figures 3-1 and 3-2 are possibly due to a test performed on the ASM (Absolute Scalar Magnetometer).

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, 13/08 - 19/08, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Standard deviation (m)**	**Notes**
13/08	0,14	-8,5 (X)	6,9	1,34	
14/08	0,13	-5,7 (Y)	8,5	1,29	
15/08	0,16	-6,5	7,3 (Y)	1,12	
16/08	0,15	-11,1	8,1	1,2	
17/08	0,15	-7	7,9 (Y)	1,14	
18/08	0,09	-6,5	5,7 (Y)	1,17	
19/08	0,21	-5,1	8,8	1,15	
Swarm B, 13/08 - 19/08, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Standard deviation (m)**	**Notes**
13/08	0,23	-9,2 (X)	9	1,32	
14/08	0,15	-7,4	9,4	1,38	
15/08	0,16	-8,1	8,7	1,22	
16/08	0,2	-5,2 (X)	10,6	1,17	
17/08	0,11	-10,4	5,6 (X)	1,19	
18/08	0,09	-7,1 (Y)	6,4	1,24	
19/08	0,17	-6,6	7,6	1,17	
Swarm C, 13/08 - 19/08, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Standard deviation (m)**	**Notes**
13/08	0,12	-7,1 (X)	10,4	1,3	
14/08	0,05	-9,2	8	1,3	
15/08	0,16	-4,8	5,6	1,1	
16/08	0,19	-7,6	8,7	1,19	
17/08	0,13	-6,8	5,4	1,12	
18/08	0,07	-6,3 (Y)	6,9 (Y)	1,17	
19/08	0,18	-7,3	9,2	1,13	

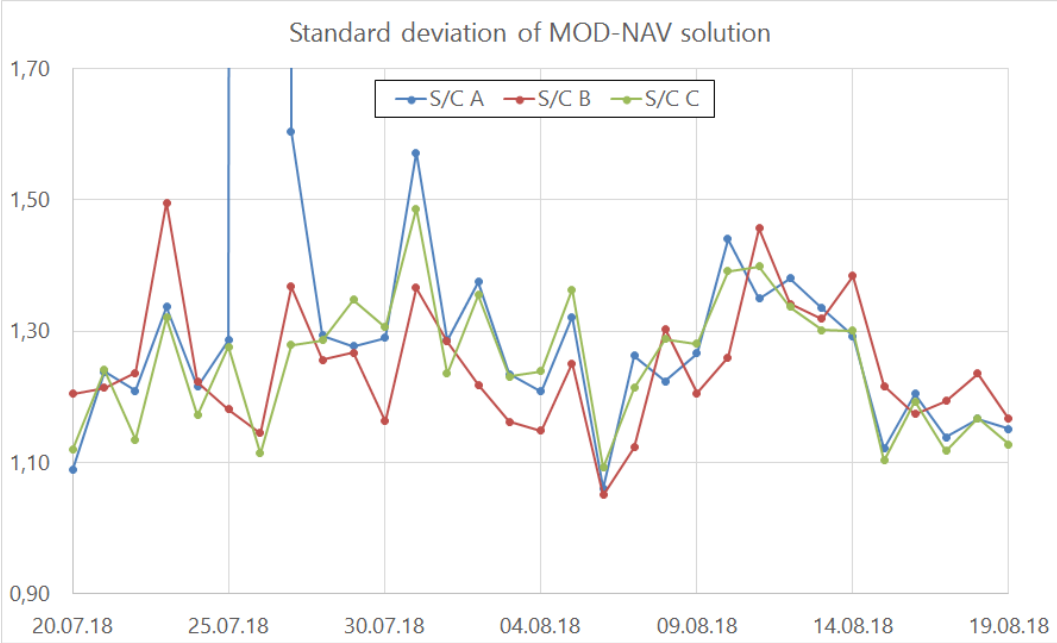


Figure 3-1: Plot of the standard deviation of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

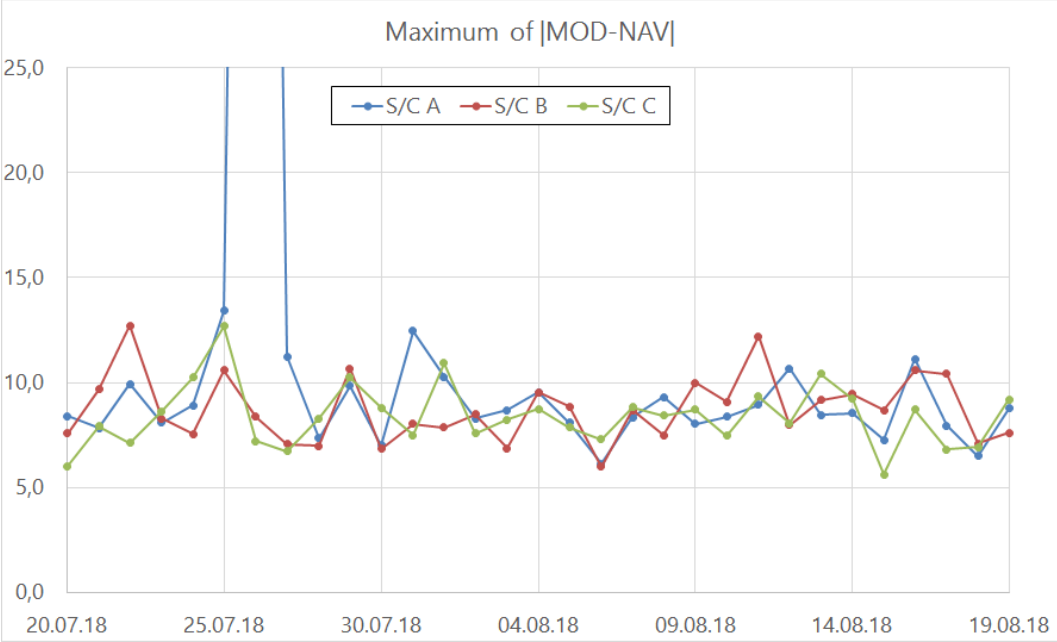


Figure 3-2: Plot of the maximum difference of the absolute value of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

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 (13.08, 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, differences are given in [m].

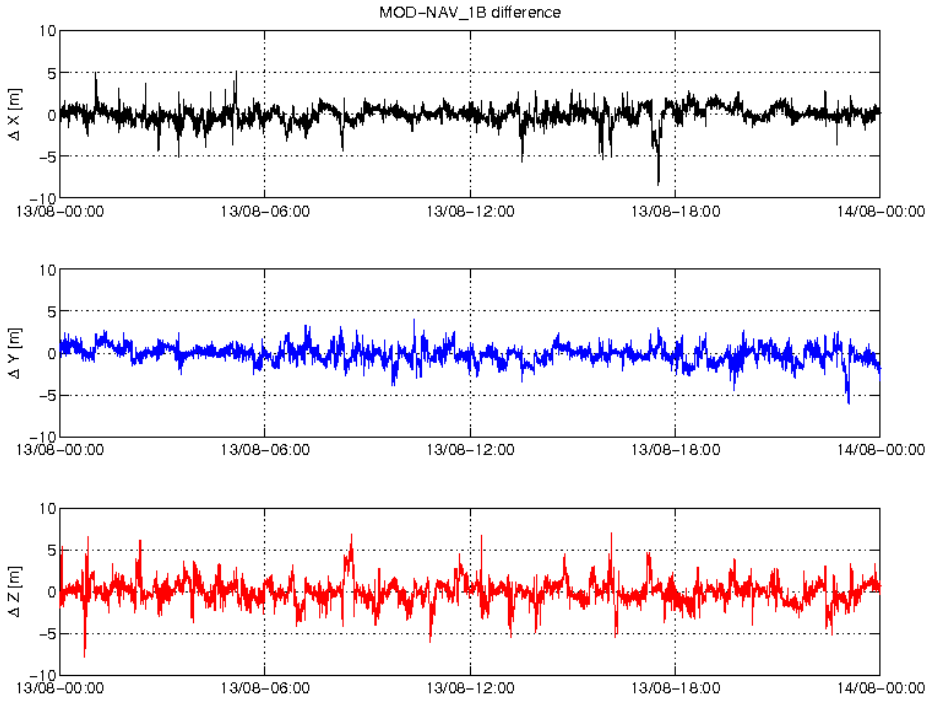


Figure 3-3: Difference MOD-GPSNAV, S/C A, 13.08. From top to bottom: X, Y and Z-axis

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 (13.08, 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, differences are given in [m].

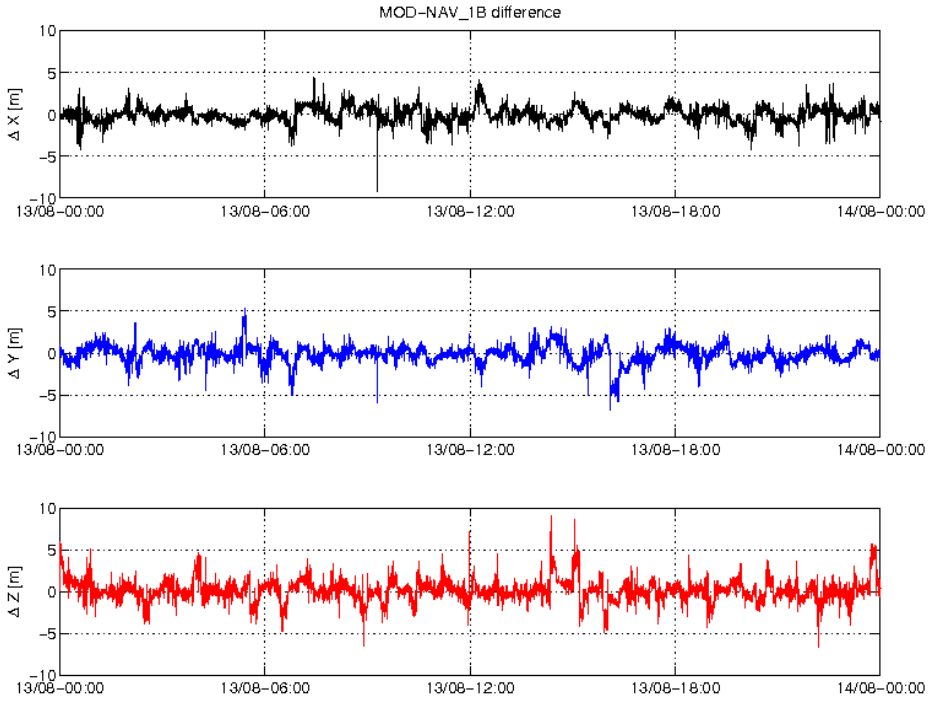


Figure 3-4: Difference MOD-GPSNAV, S/C B, 13.08. From top to bottom: X, Y and Z-axis

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 (13.08, 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, differences are given in [m].

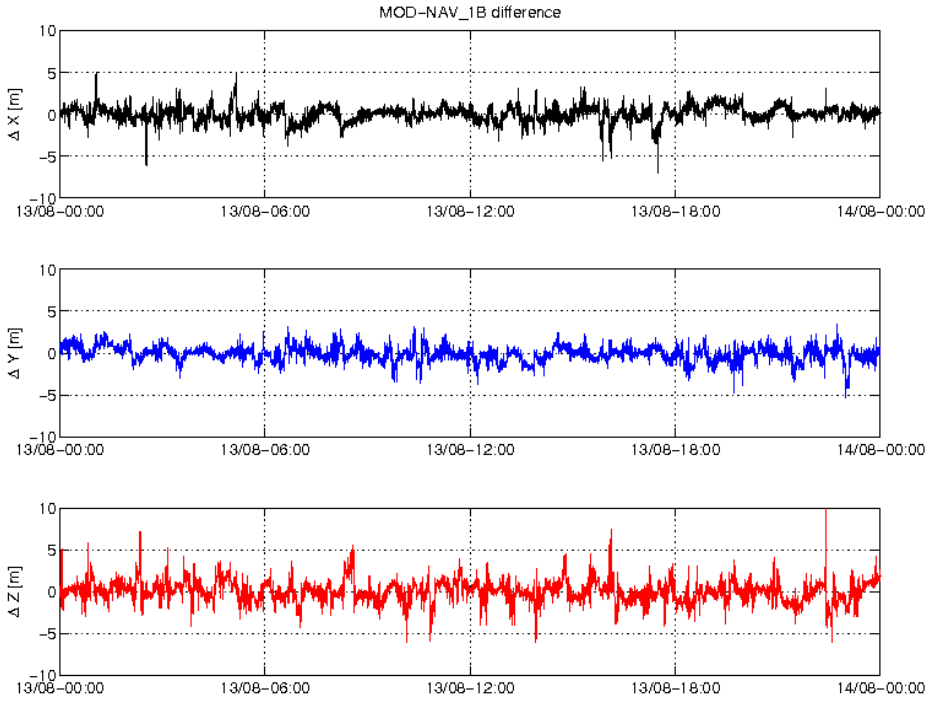


Figure 3-5: Difference MOD-GPSNAV, S/C C, 13.08. From top to bottom: X, Y and Z-axis

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 2018, Week 33: 13/08 - 19/08.

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

3.3.1 VFM-ASM anomaly

- S/C A – violation of:
  - VFM-ASM residuals threshold on 13/08, 14/08, 15/08, 16/08, 17/08, 18/08, 19/08;
  - mean value of residuals threshold on 13/08, 14/08, 15/08, 16/08, 17/08, 18/08, 19/08;
  - standard deviation of residuals threshold on 13/08, 14/08, 15/08, 16/08, 17/08, 18/08, 19/08.
- S/C B – violation of:
  - VFM-ASM residuals threshold on 13/08, 14/08, 15/08, 16/08, 17/08;
  - standard deviation of residuals threshold on 13/08, 14/08, 15/08, 16/08, 17/08, 18/08.

For SC B day 19.08.2018 no data available.

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.
Data gaps for S/C A observed in 24-27/07/2018 are due to a test performed on the ASM (Absolute Scalar Magnetometer) commanded in burst mode. The magnetic field intensity derived from the ASM in the MAGA_LR_1B and MAGA_CA_1B products is set to zero from 24 July 2018 at 14:44 UTC to 26 July 2018 at 07:00 UTC.

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

Swarm A, 13/08 - 19/08, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
13/08	**1,85**	-0,29	**0,46**	**0,809**	
14/08	**1,85**	-0,37	**0,48**	**0,821**	
15/08	**1,81**	-0,36	**0,47**	**0,829**	
16/08	**1,87**	-0,39	**0,47**	**0,823**	
17/08	**1,87**	-0,37	**0,5**	**0,839**	
18/08	**1,82**	-0,3	**0,48**	**0,81**	
19/08	**1,75**	-0,34	**0,46**	**0,831**	
Swarm B, 13/08 - 19/08, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
13/08	**1,09**	-0,91	**0,44**	0,229	
14/08	**1,12**	-0,91	**0,44**	0,209	
15/08	**1,09**	-0,9	**0,45**	0,222	
16/08	**1**	-0,93	**0,45**	0,208	
17/08	**1**	-0,89	**0,44**	0,196	
18/08	0,99	-0,83	**0,45**	0,208	
19/08	0	0	0	0	

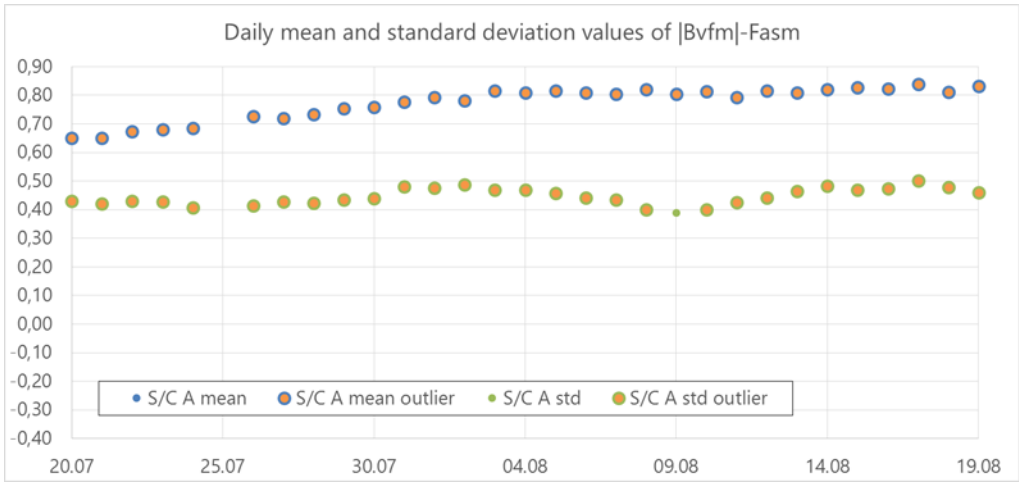


Figure 3-6: Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C A.

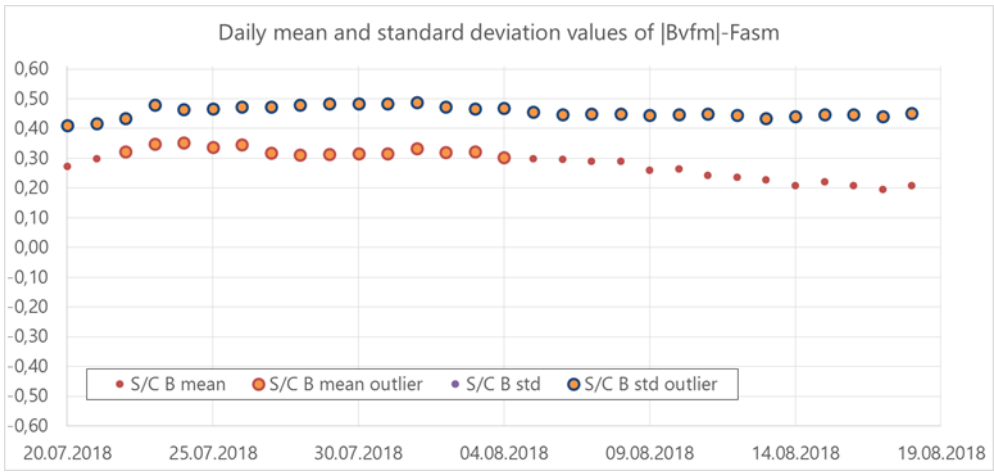


Figure 3-7: Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C B.

3.3.1.2 Swarm A

The daily peak-to-peak difference around the week stays within [-0,39 - 1,87] nT. Below follow two plots of such differences for current week (Figure 3-8).

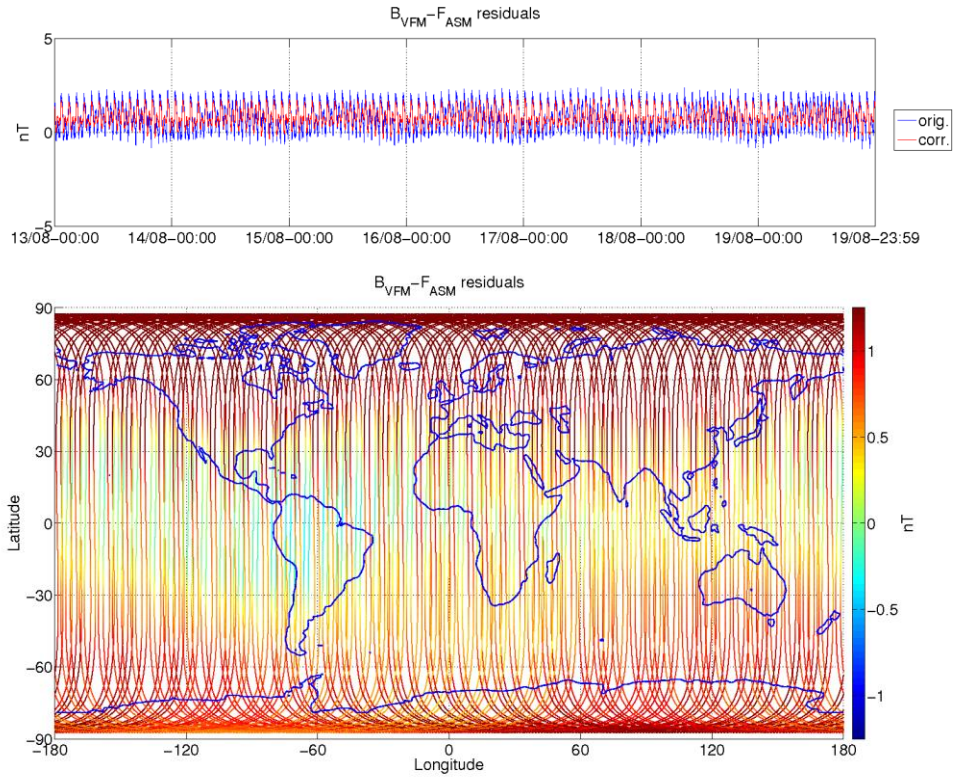


Figure 3-8: ASM-VFM residuals for S/C A, during monitoring period 13/08-19/08. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map.

3.3.1.3 Swarm B

The daily peak-to-peak difference around the week stays within [-0,93 - 1,12] nT. Below follow two plots of such differences for current week (Figure 3-9).

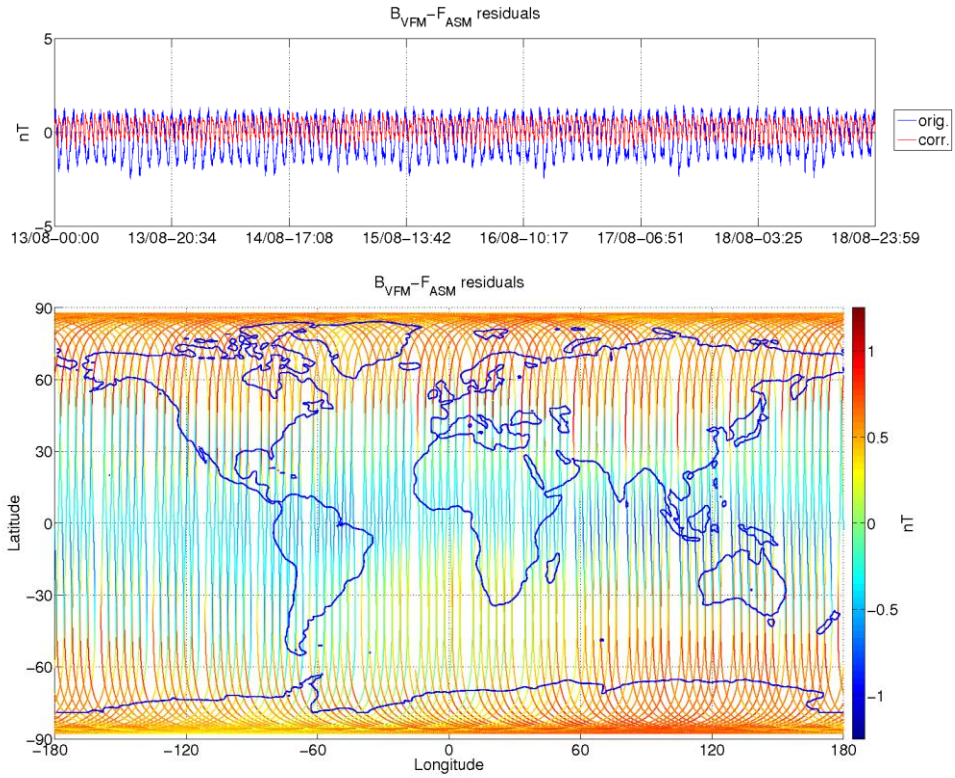


Figure 3-9: ASM-VFM residuals for S/C B, during monitoring period 13/08-19/08. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map.

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.

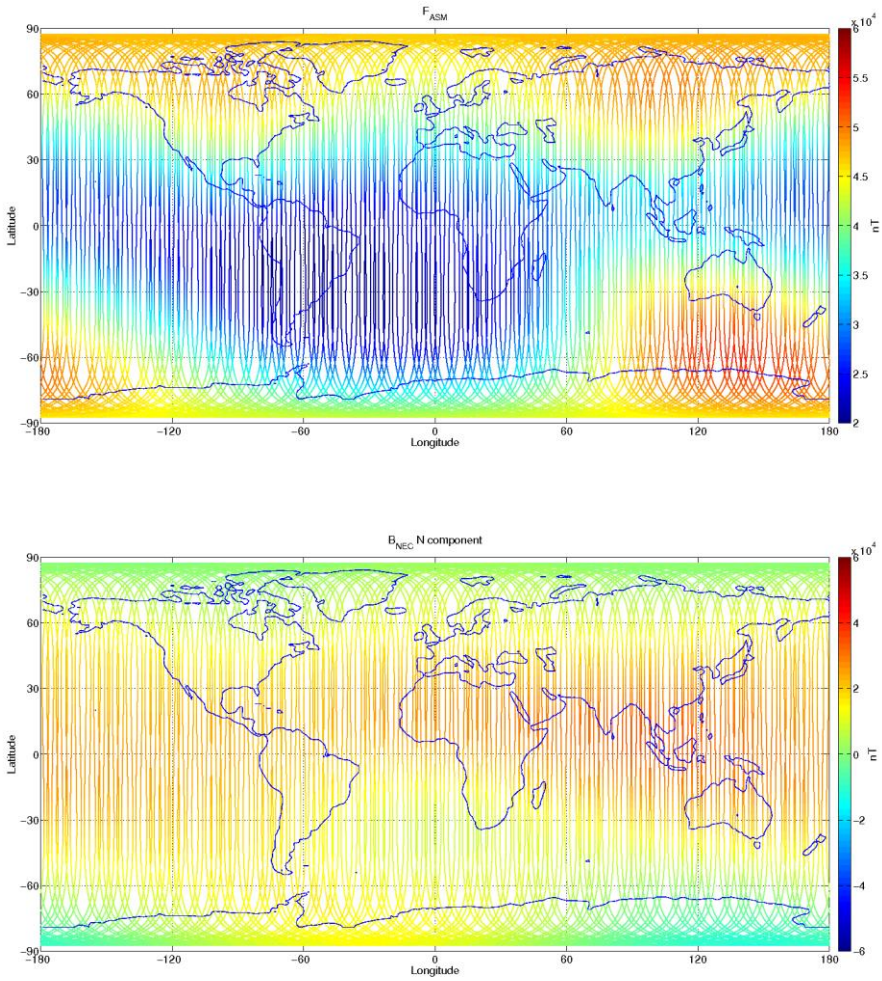
For S/C A, B and C, for reported period, the temperatures behaved as expected.

For SC B day 19.08.2018 no data available.

3.3.4 Magnetic time series visual inspection

3.3.4.1 Swarm A

Map plots of magnetic field measurement for week 33 for S/C A can be seen in Figure 3-10 below.



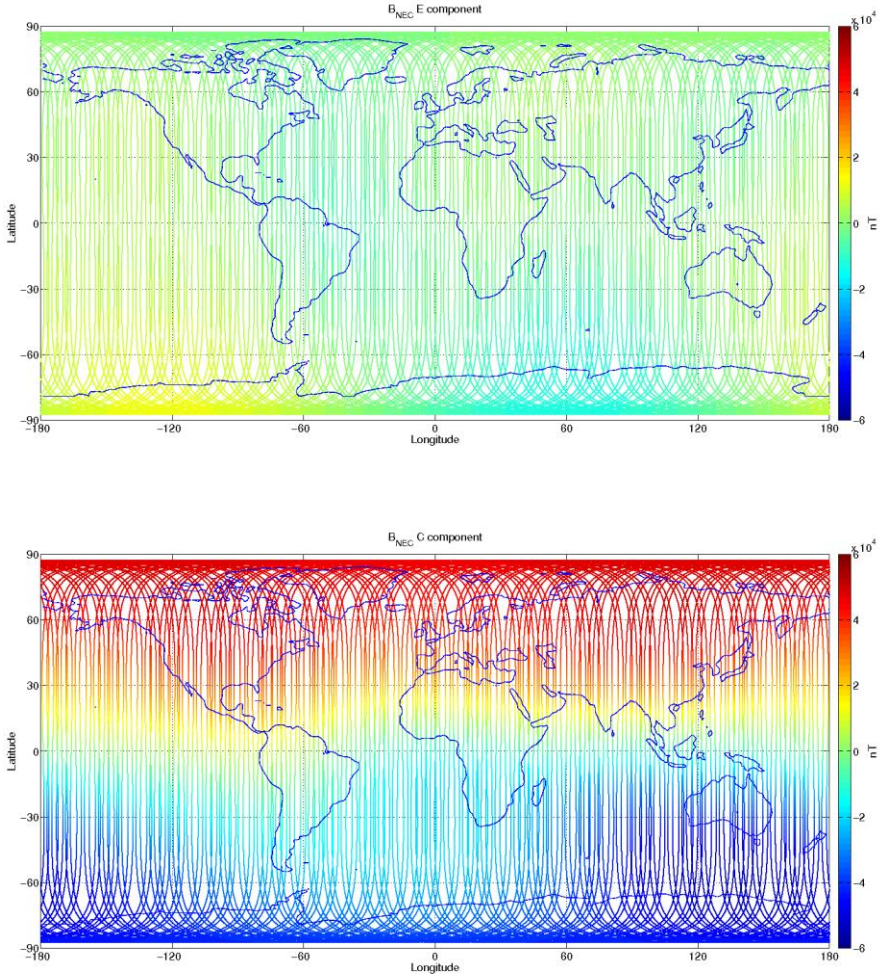
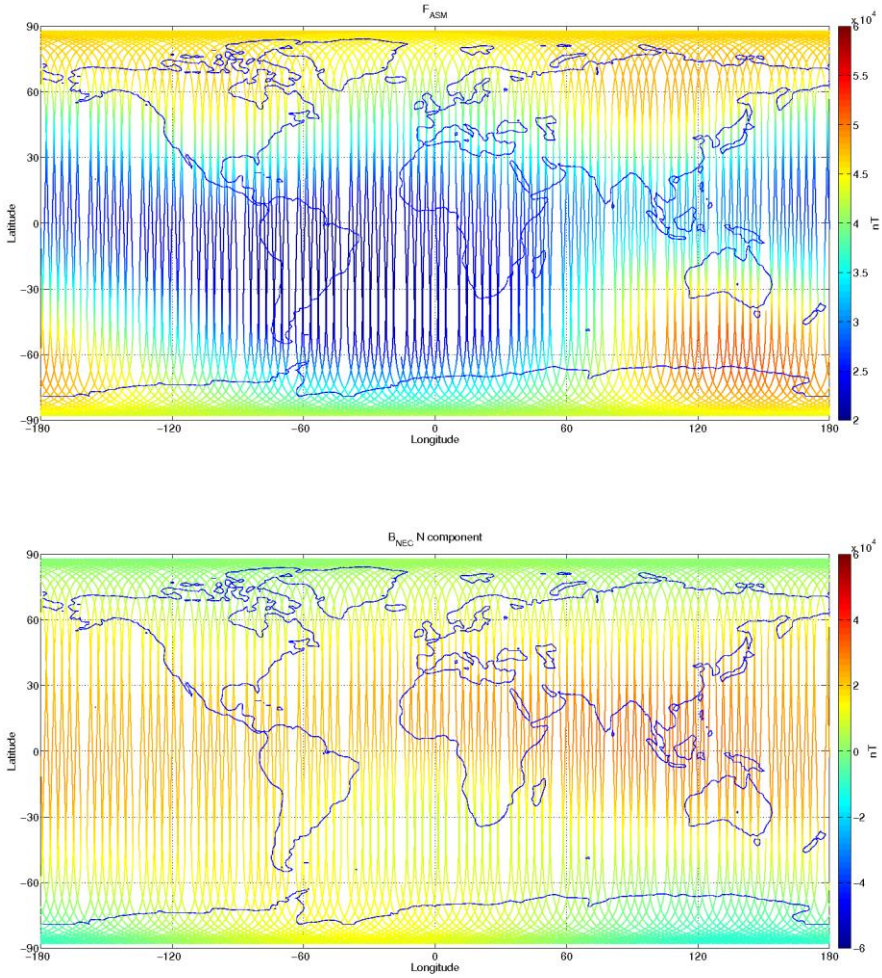


Figure 3-10: S/C A, world map plots of the geomagnetic field and components measured during monitoring period 13/08-19/08. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.2 Swarm B

Map plots of magnetic field measurement for week 33 for S/C B can be seen in Figure 3-11 below.



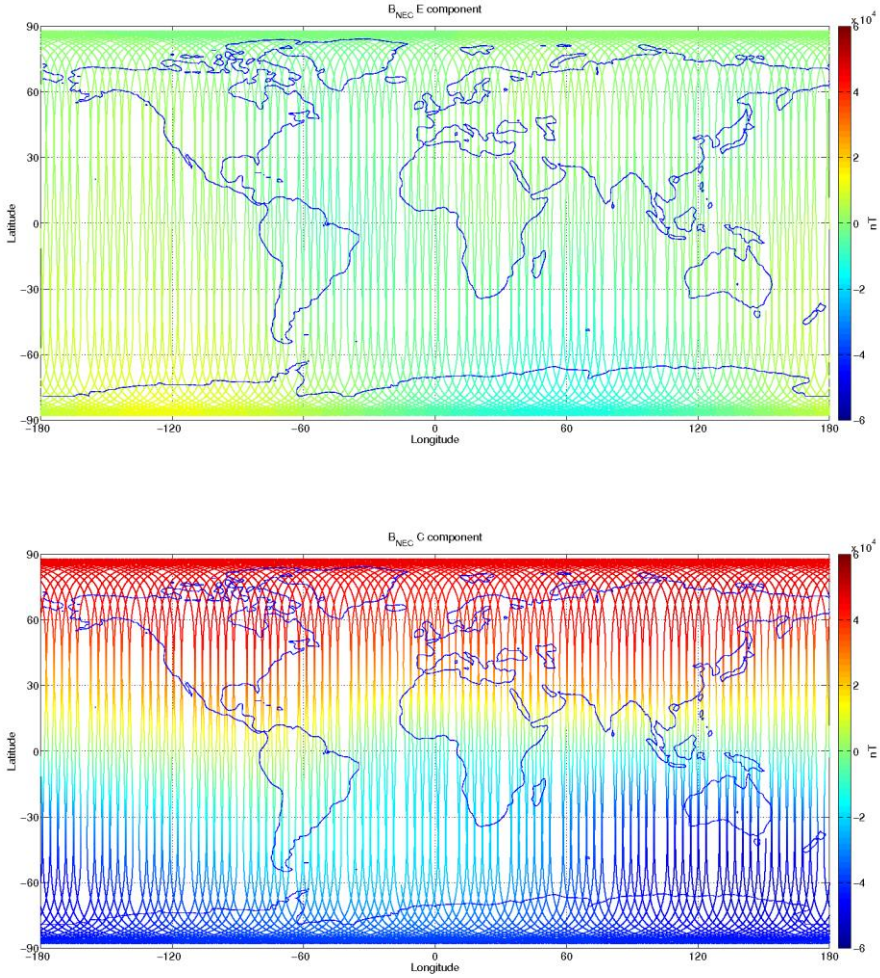
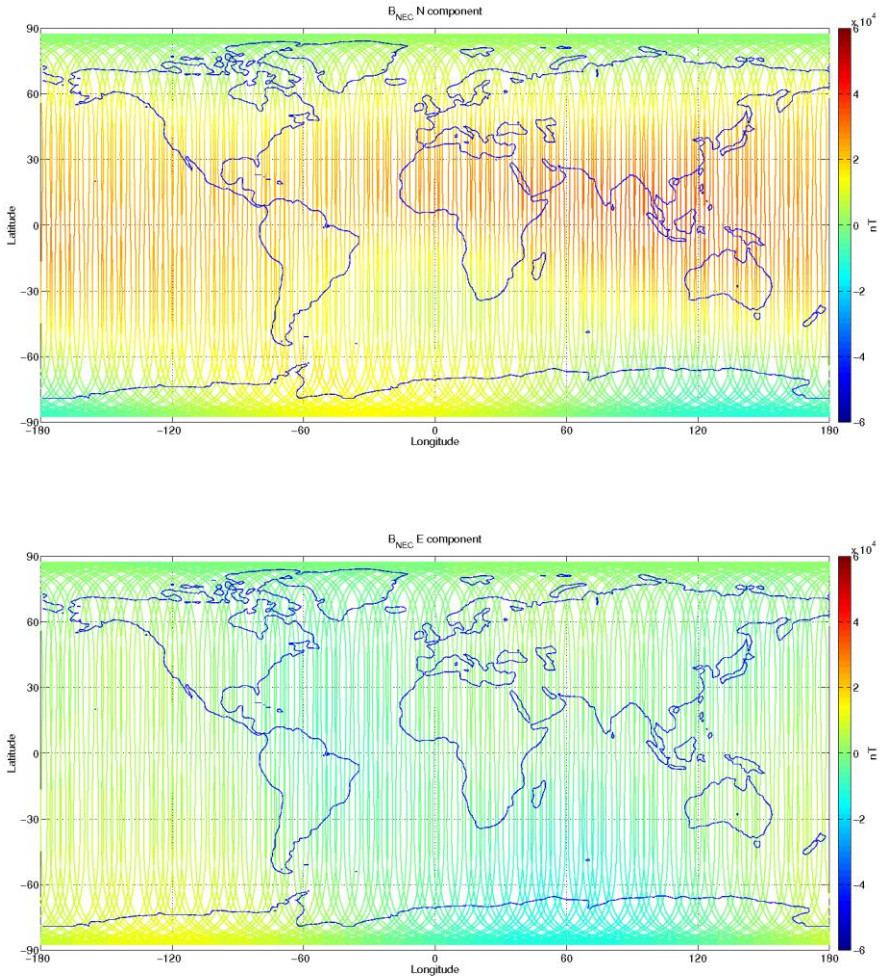


Figure 3-11: S/C B, world map plots of the geomagnetic field and components measured during monitoring period 13/08-19/08. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.3 Swarm C

Map plots of magnetic field measurement for week 33 for S/C C can be seen in Figure 3-12.



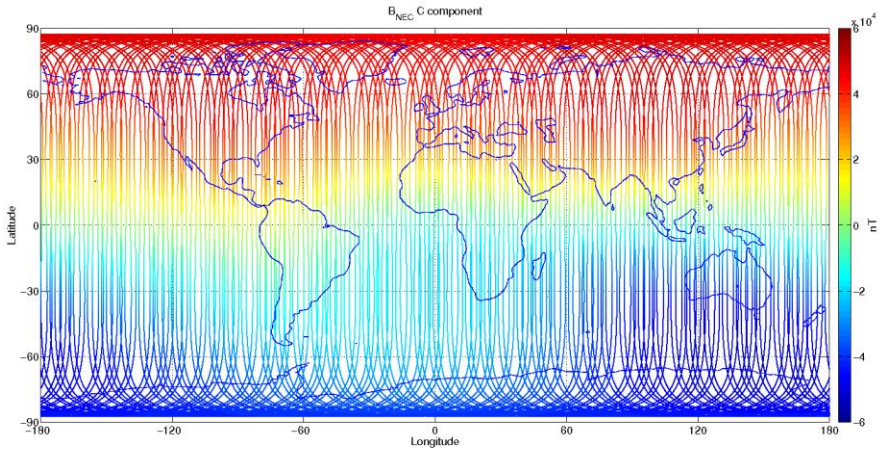


Figure 3-12: S/C C, world map plots of the geomagnetic field and components measured during monitoring period 13/08-19/08. From top to bottom: B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

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.

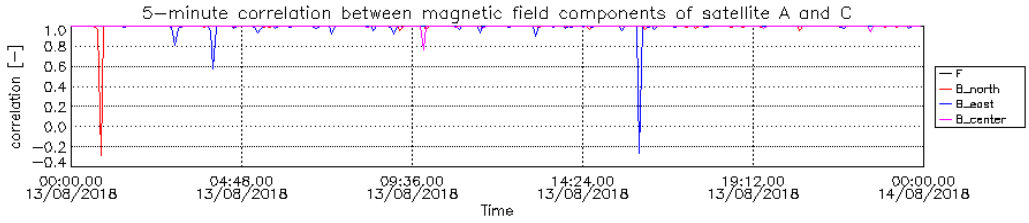


Figure 3-13: Correlation in magnetic data between satellite A and C for B_north, B_east, and B_center components of B_{NEC} are the components of the magnetic field vector in NEC frame

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.

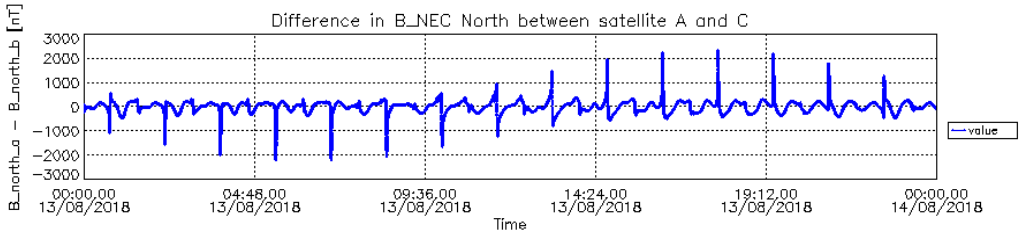


Figure 3-14: Difference in B_{NEC} North component between S/C A and S/C C.

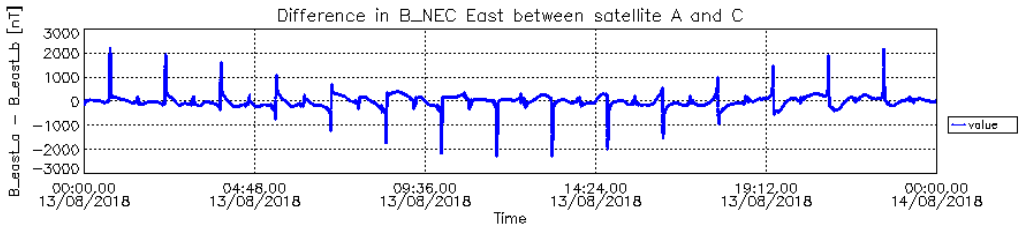


Figure 3-15: Difference in B_{NEC} East component between S/C A and S/C C.

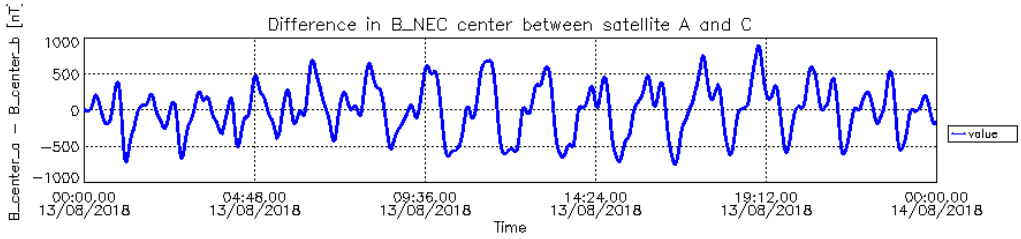


Figure 3-16: Difference in B_{NEC} Center component between S/C A and S/C C.

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 13/08 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

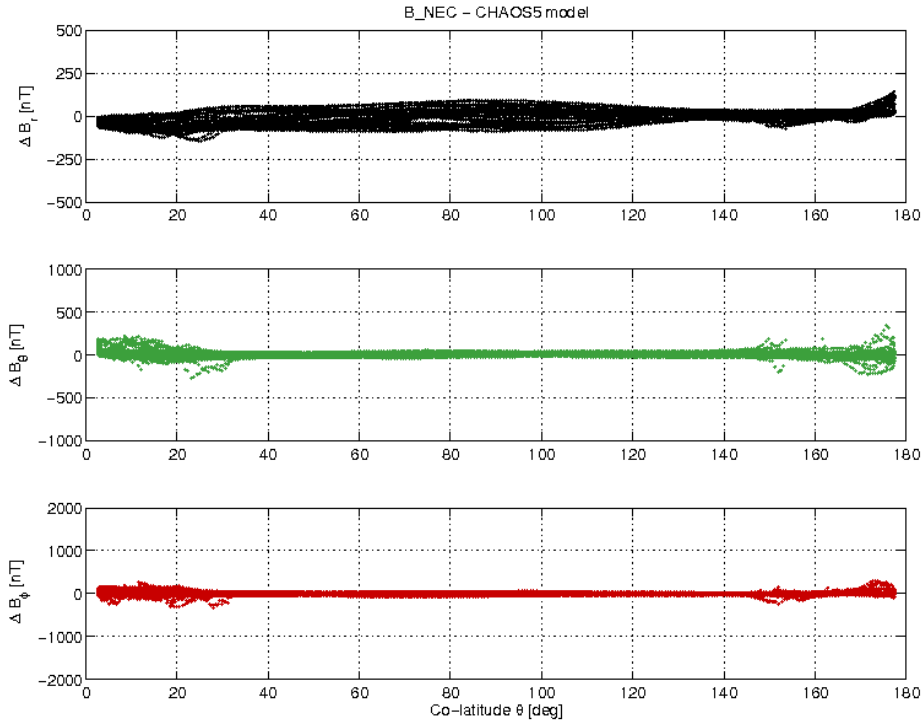


Figure 3-17: S/C A day 13.08 B_{NEC} - B_{Chaos} vs colatitude.

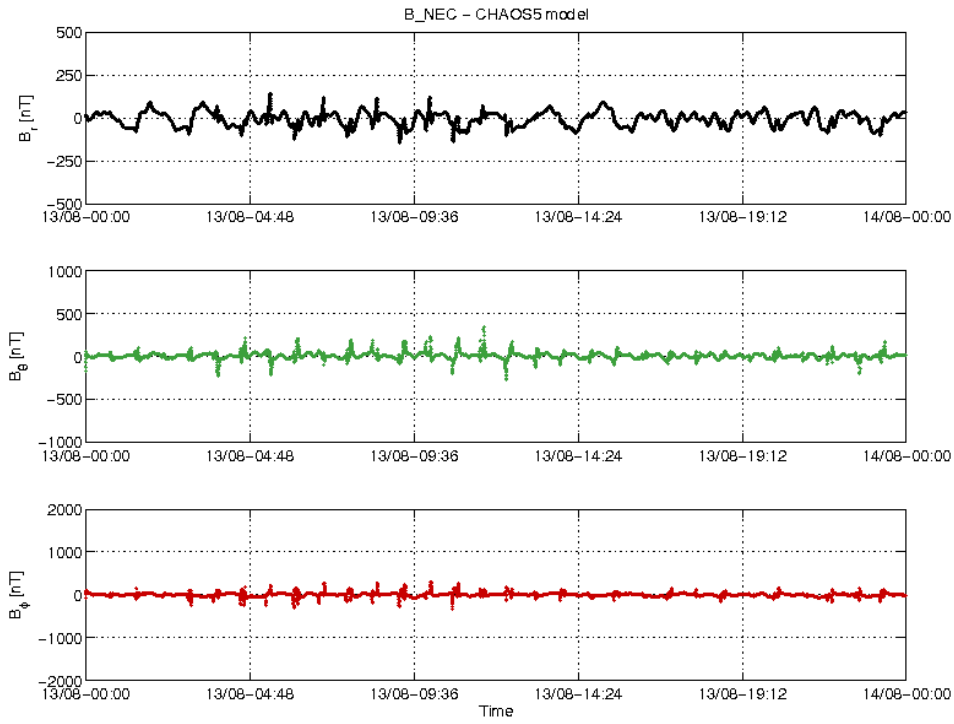


Figure 3-18: S/C A day 13.08: time series of $B_{NEC} - B_{Chaos}$ residuals.

3.3.7.2 Swarm B

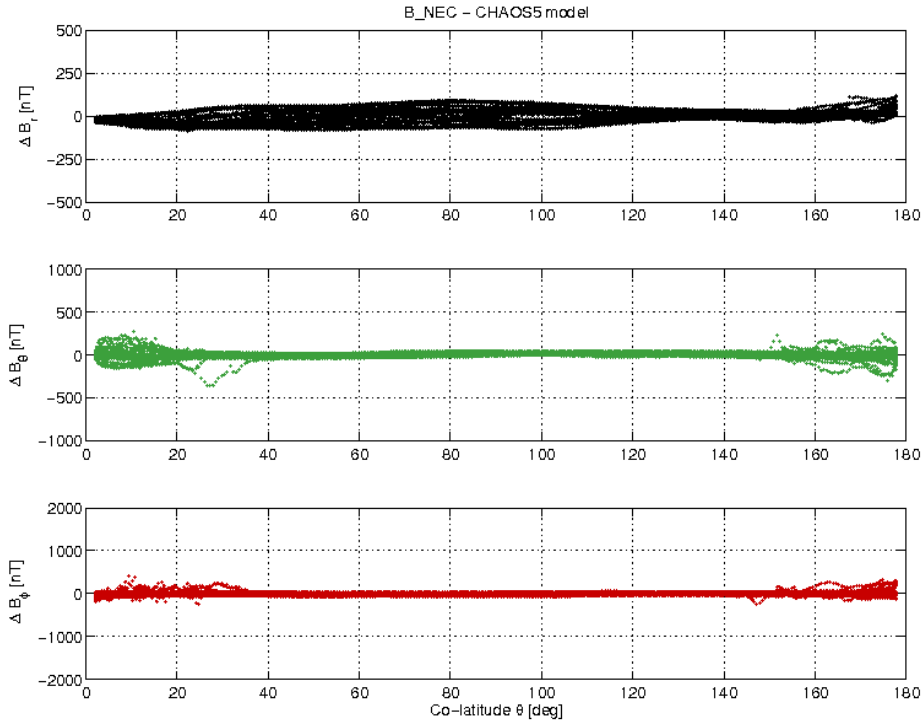


Figure 3-19: S/C B day 13.08 B_{NEC} - B_{Chaos} difference vs colatitude.

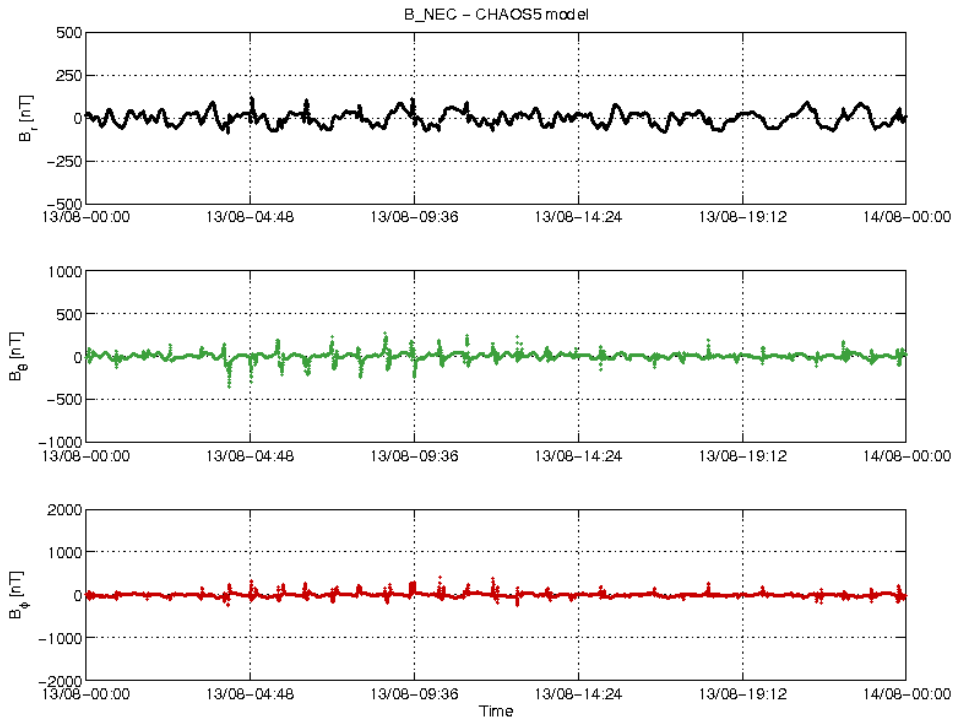


Figure 3-20: S/C B day 13.08 time series of $B_{NEC} - B_{Chaos}$ residuals.

3.3.7.3 Swarm C

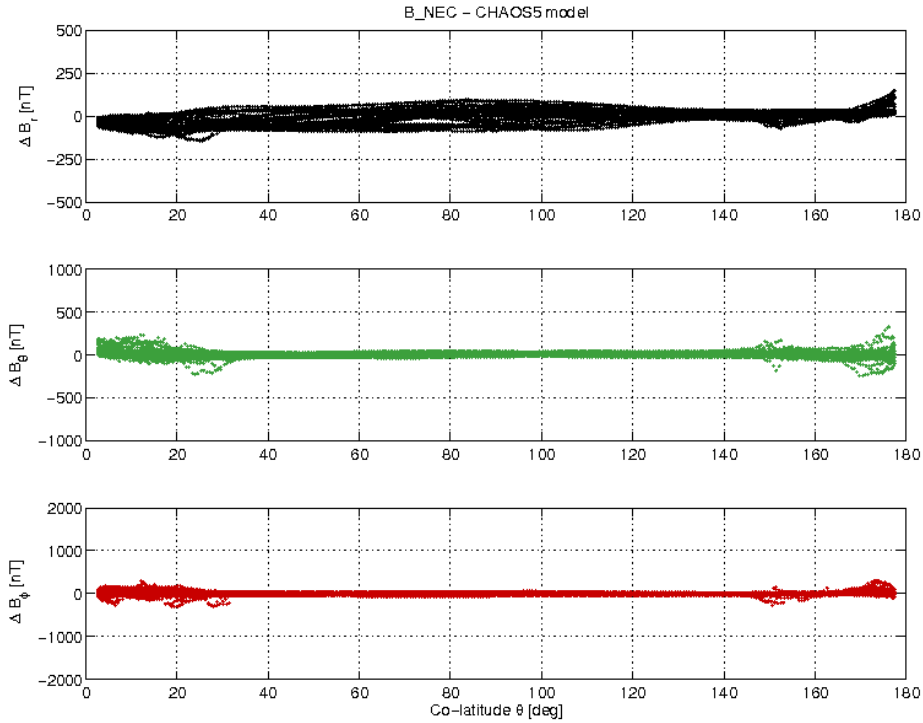


Figure 3-21: S/C C day 13.08 B_{NEC} - B_{Chaos} difference vs colatitude.

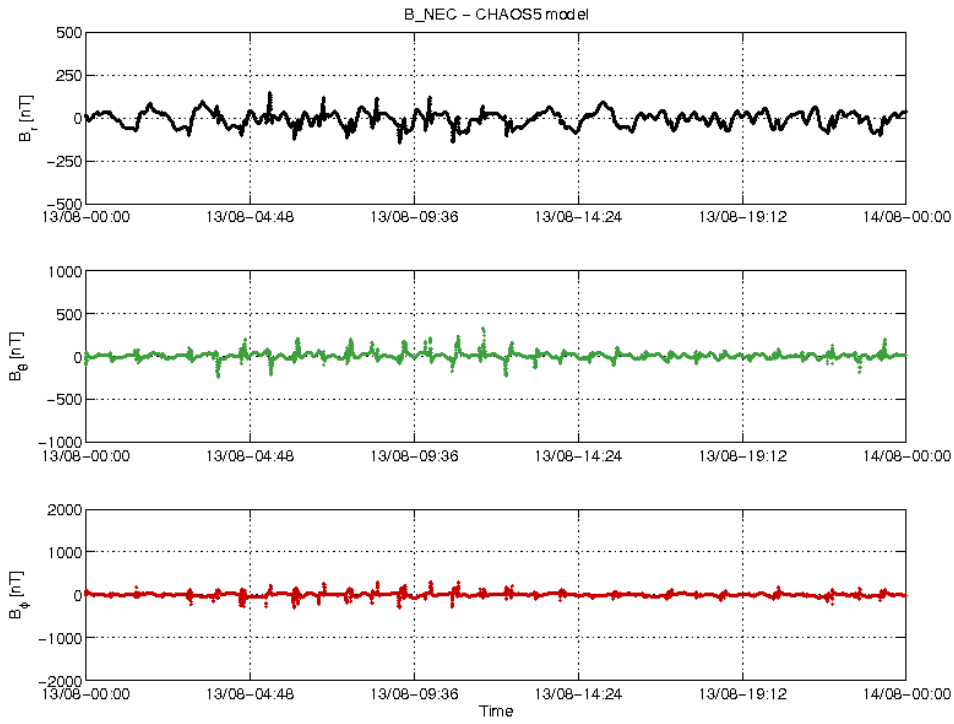


Figure 3-22: S/C C day 13.08 time series of $B_{NEC} - B_{Chaos}$ residuals.

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.

Spike observed for S/C A on 26/07/2018 is possibly due to a test performed on the ASM (Absolute Scalar Magnetometer). The magnetic field intensity derived from the ASM in the MAGA_LR_1B and MAGA_CA_1B products is set to zero from 24 July 2018 at 14:44 UTC to 26 July 2018 at 07:00 UTC.

Two time gaps observed for S/C A on 12/08/2018 for MAGA_CA_1B, with a duration of 105s starting from 01:44:19 and of 9s starting from 14:36:20. These could generate the spike observed in Figure 3-23 on the 12/08/2018.

3.3.8.1 Swarm A

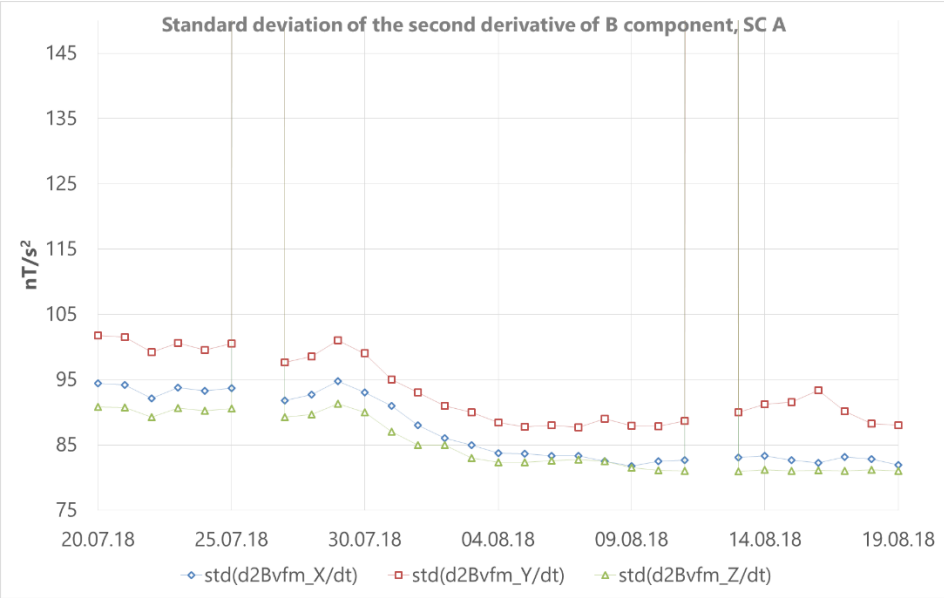


Figure 3-23: Standard deviation of the second derivative of B component

3.3.8.2 Swarm B

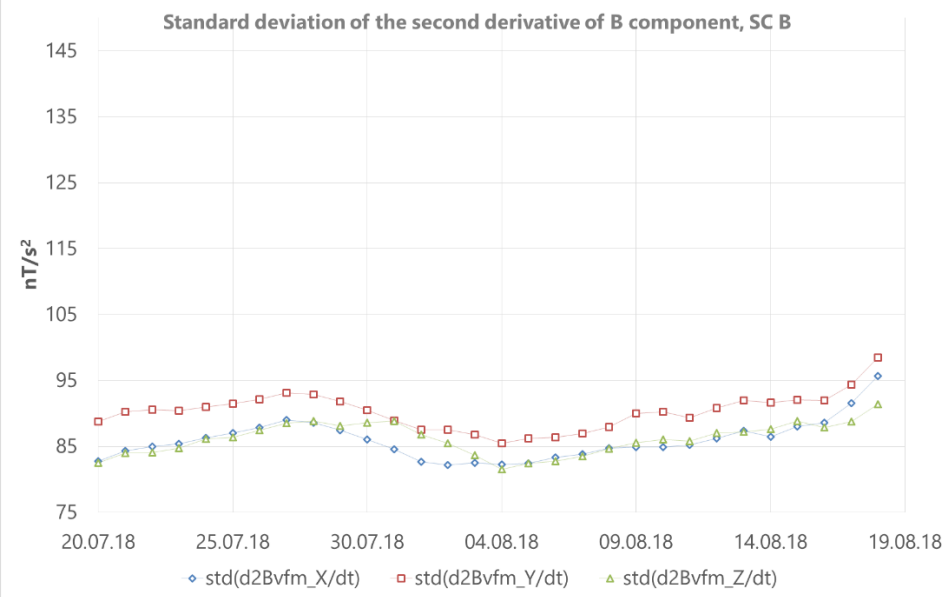


Figure 3-24: Standard deviation of the second derivative of B component

3.3.8.3 Swarm C

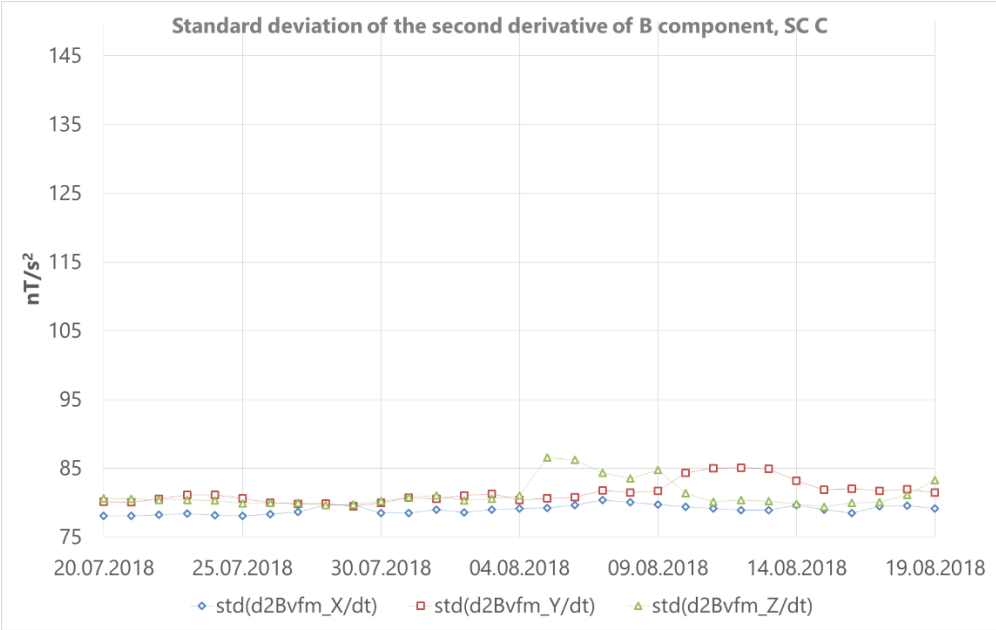


Figure 3-25: Standard deviation of the second derivative of B component

4. ON-DEMAND analysis

Nothing to report.

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