
Swarm DISC Weekly Report 2019/14: 2019/04/01 - 2019/04/07



Abstract : This is the **Swarm Data Innovation and Science Cluster** (Swarm DISC) Weekly report on Swarm products quality, covering the period from 01 April to 07 April 2019.

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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	31 May 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 2.4.

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 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 v3.20p1, L2-Cat2 v01.18p2.
- L0 input products baseline: 02
- L1B baseline: MAGNET and PLASMA 05, ORBATT and ACCELE 04 (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 03
- Input auxiliary files baseline: S/C A - CCDB 0022 (06/03/2019), S/C B – CCDB 0022 (02/01/2019), S/C C – CCDB 0023 (06/03/2019), ADF 0101
- MPPF-CVQ v.03.07 (20/12/2018)

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-SRCP-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

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- [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

Following a high collision warning between Swarm-B and the Cubesat Lemur-2 Lisasaurus (2017-036R), with a collision probability of $4.627e-4$, a collision avoidance manoeuvre was successfully executed on 02/04/2019 to lower the orbit of the satellite and reduce the collision risk. EFI remained on and in ready state during the manoeuvre.

2.2 Plan for operational processor updates

L1BOP: The L1BOP v03.21 has been delivered on 11/03/2019. It contains only the porting of this processor to a more upgraded operational system, i.e., Red Hat Enterprise Linux 7.5. No evolutions of the L1B processor algorithm are included in this delivery. The PDGS Team will generate the test scenarios in order to compare their outputs with the ones from GMV. Also, a comparison with the L1BOP v03.20 will be performed during the cross verification activity. This last, will be performed by the Data Quality Team.

L2 Cat-2: The L2 Cat-2 OP v01.19 has been delivered on 13/03/2019. It contains only the porting of this processor to a more upgraded operational system, i.e., Red Hat Enterprise Linux 7.5. No evolutions of the L2 Cat-2 processor algorithms are included in this delivery. The PDGS Team will generate the test scenarios in order to compare their outputs with the ones from GMV. Also, a comparison with the L1BOP v03.20 will be performed during the cross verification activity. This last, will be performed by the Data Quality Team.

2.3 Quality Working Group and Cal/Val Coordination

The 8th Swarm Data Quality Workshop (DQW#8) held in ESA ESRIN from Monday 08th October (afternoon) to Friday 12th October 2018 (morning).

The main objectives of the workshop were to:

- Provide an overview of Swarm Mission status to the user Community
- Update the data quality status from Magnetic, Electric, GPSR and accelerometer measurements
- Discuss new Swarm-based Scientific results

Besides the usual Cal/Val topics, this Swarm DQW#8 has also allowed to address new technical, scientific and strategic challenges related to:

- Swarm-based Multi-disciplinary applications
- Swarm-based Data processing virtual environments
- Swarm-based Machine Learning methods
- Multi-mission synergies (e.g. with CryoSat, Goce, e-POP, CSES etc.)

The Swarm DQW#8 was an occasion to discuss potential synergetic benefits obtained through collaboration initiatives with ESA's partner agencies and other sensor systems.

A dedicated session on Swarm / Chinese CSES mission synergies were organized for the first time to further discuss and structure future joint Cal-Val activities and scientific cooperation.

A complete summary of the recommendations based on the contributions from Swarm DQW#8 sessions can be found at ([PDF version](#)).

2.4 Summary of observations for 2019, Week 14 (01/04 - 07/04)

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

- On days 01 and 03-05/04/2019, on S/C A B, C, we observe small anomalies on B_NEC – CHAOS5 model plots. It is caused by weak geomagnetic activity, which occurred those days.
- An orbit collision avoidance maneuver was performed on Swarm Bravo on 02/04/2019 at 00:23 UTC for a duration of 64 seconds, equivalent to a Delta V of 0.015 m/s. This maneuver lowered the spacecraft's orbit, and did not contain any slew.

3. Routine Quality control

3.1 Gaps analysis

- Time gaps found in MAGB_CA from 23:53:25 till 23:53:27 on day 01/04/2019, due to suspicious VFM sample.
- Time gaps found in MAGB_CA from 00:03:24 till 00:03:26 on day 02/04/2019, due to suspicious VFM sample.

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 2019, Week 14: 01/04 - 07/04.

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 = +/- 10⁻⁹)
- 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.

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, 01/04 - 07/04, Position difference					
Day	Average difference (m)	Maximum difference (m)		Standard deviation (m)	Notes
01/04	0,12	-7,4 (Y)	9,3	1,12	
02/04	0,07	-7,1	6,9	1,21	
03/04	0,04	-9,2	9,3	1,28	
04/04	0,08	-6,9	9,2	1,45	
05/04	0,07	-6,8 (Y)	6,6 (X)	1,18	
06/04	0,25	-9,2	10,7	1,29	
07/04	0,11	-8,4	8,6	1,19	
Swarm B, 01/04 - 07/04, Position difference					
Day	Average difference (m)	Maximum difference (m)		Standard deviation (m)	Notes
01/04	0,1	-8,7	7,3 (Y)	1,16	
02/04	0,11	-9,4 (Y)	6,3	1,19	
03/04	0,15	-7	6,6	1,25	
04/04	0,09	-8,5	7,1 (Y)	1,17	
05/04	0,11	-6,7	6,1	1,12	
06/04	0,14	-6,1 (X)	6,9	1,12	
07/04	0,16	-6,9 (X)	4,9	1,16	
Swarm C, 01/04 - 07/04, Position difference					
Day	Average difference (m)	Maximum difference (m)		Standard deviation (m)	Notes
01/04	0,08	-7,2	9	1,13	
02/04	0,13	-6,6	7,7	1,29	
03/04	0,09	-8,7	8,9	1,22	
04/04	0,11	-11,8	9,5	1,42	
05/04	0,1	-7,8	7,7	1,23	
06/04	0,25	-9,2 (Y)	7,2	1,29	
07/04	0,06	-6,8	6,1	1,19	

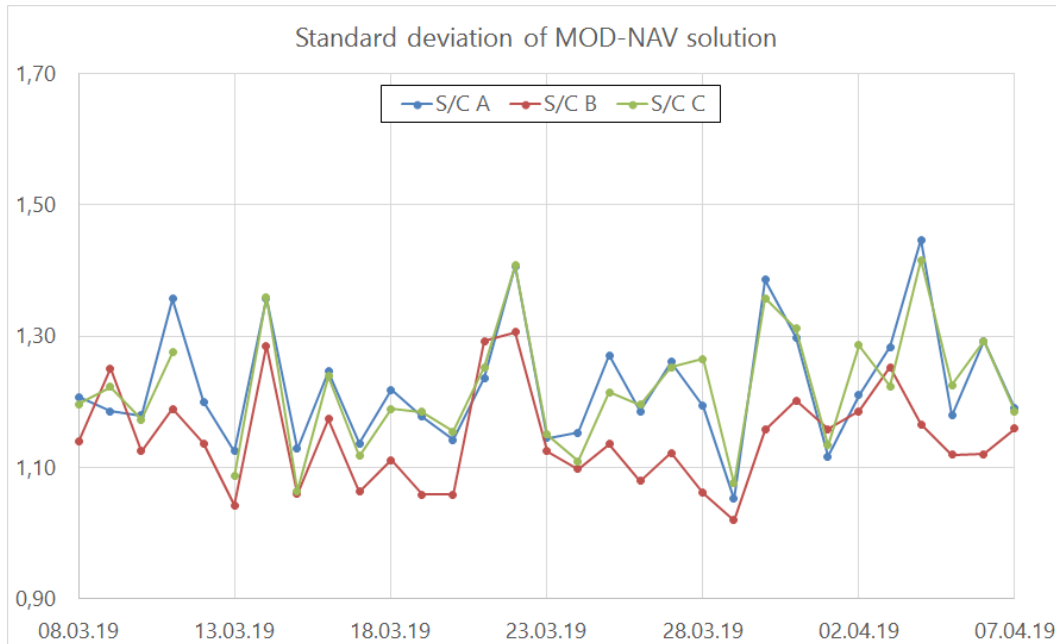


Figure 3-1: Plot of the standard deviation of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

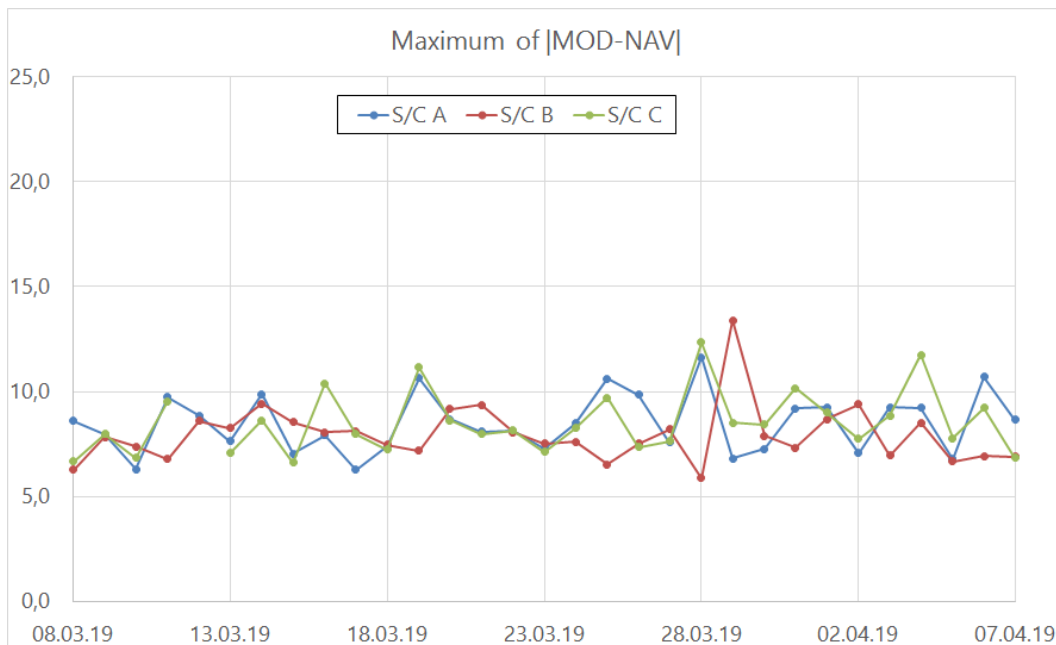


Figure 3-2: Plot of the maximum difference of the absolute value of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

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 (01.04, 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].

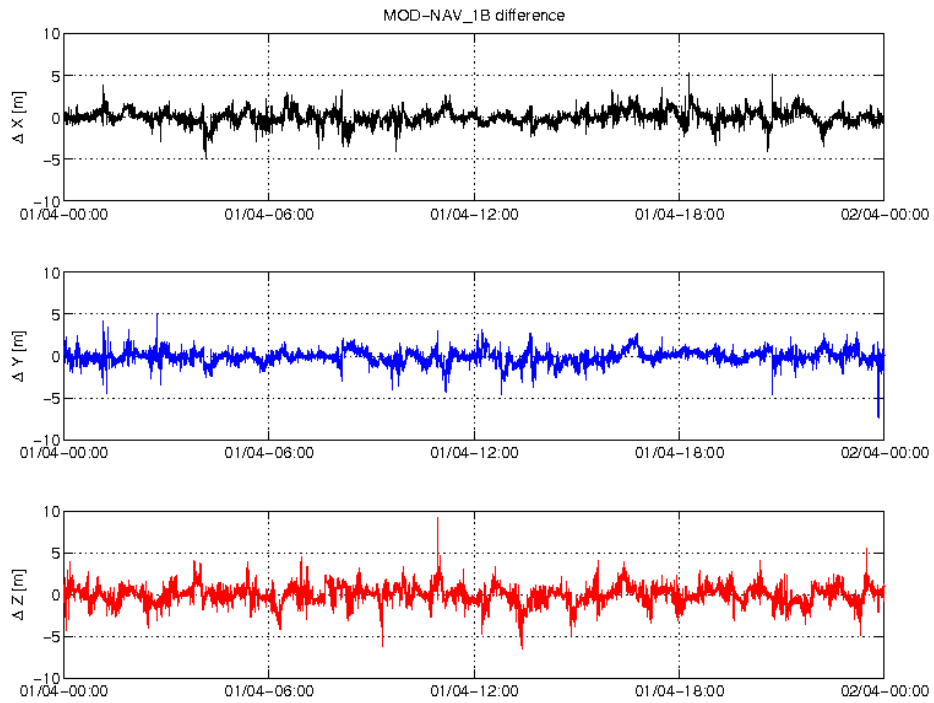


Figure 3-3: Difference MOD-GPSNAV, S/C A, 01.04. From top to bottom: X, Y and Z-axis

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 (01.04, 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].

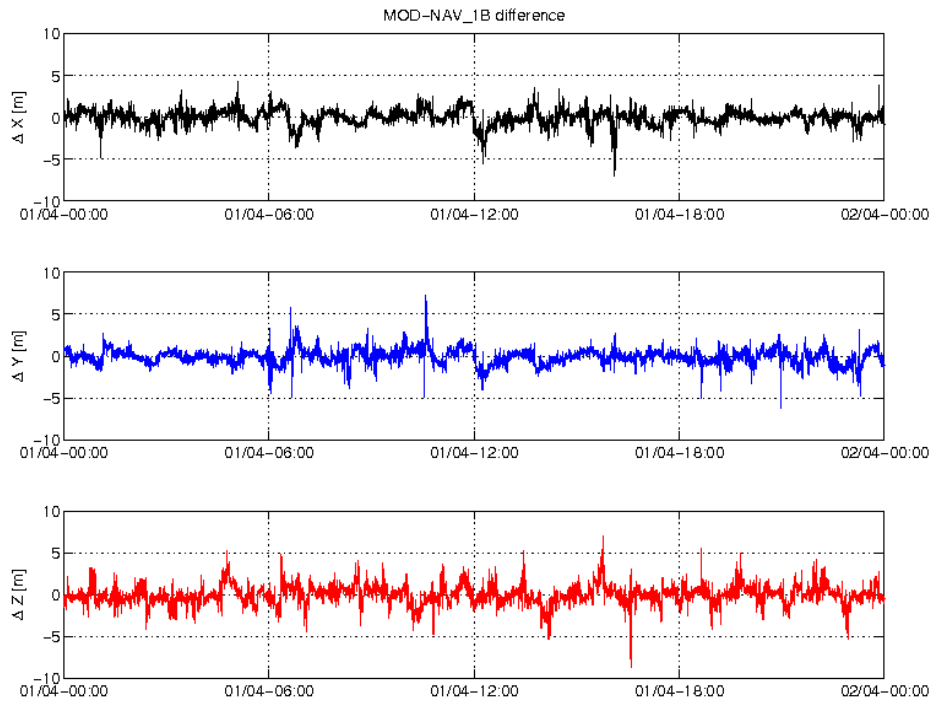


Figure 3-4: Difference MOD-GPSNAV, S/C B, 01.04. From top to bottom: X, Y and Z-axis

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 (01.04, 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].

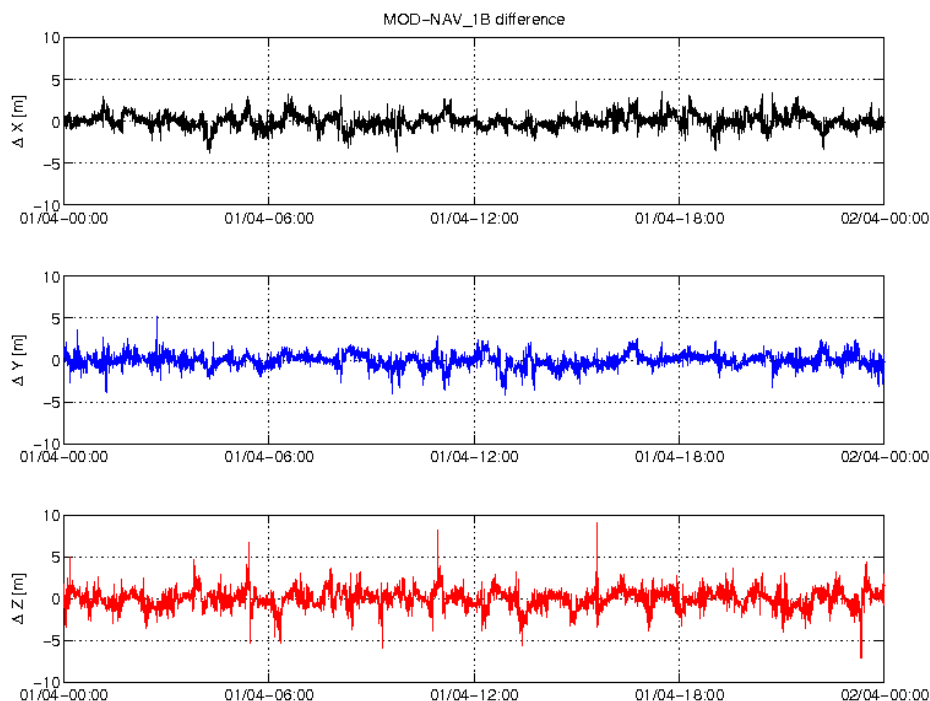


Figure 3-5: Difference MOD-GPSNAV, S/C C, 01.04. From top to bottom: X, Y and Z-axis

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 MAG_{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 MAG_{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/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.

3.3.1 VFM-ASM anomaly

- S/C A – no violations of thresholds.
- S/C B – no violations of thresholds.

3.3.1.1 ASM-VFM difference statistics

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

Swarm A, 01/04 - 07/04, ASM-VFM difference					
Day	Max (nT)	Min (nT)	Standard deviation (nT)	Mean (nT)	Notes
01/04	0,71	-0,75	0,26	0,091	
02/04	0,77	-0,82	0,25	0,083	
03/04	0,64	-0,82	0,22	0,085	
04/04	0,56	-0,7	0,2	0,077	
05/04	0,58	-0,64	0,2	0,067	
06/04	0,62	-0,63	0,22	0,079	
07/04	0,68	-0,68	0,24	0,084	

Swarm B, 01/04 - 07/04, ASM-VFM difference					
Day	Max (nT)	Min (nT)	Standard deviation (nT)	Mean (nT)	Notes
01/04	0,75	-0,55	0,25	0,162	
02/04	0,72	-0,61	0,3	0,162	
03/04	0,75	-0,6	0,29	0,154	
04/04	0,69	-0,5	0,25	0,153	
05/04	0,66	-0,53	0,25	0,151	
06/04	0,52	-0,53	0,21	0,136	
07/04	0,58	-0,54	0,21	0,136	

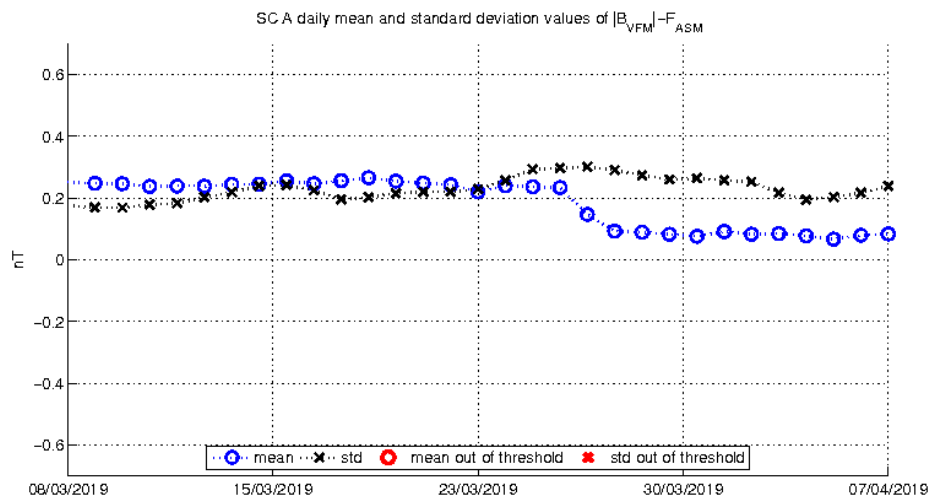


Figure 3-6: Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C A.

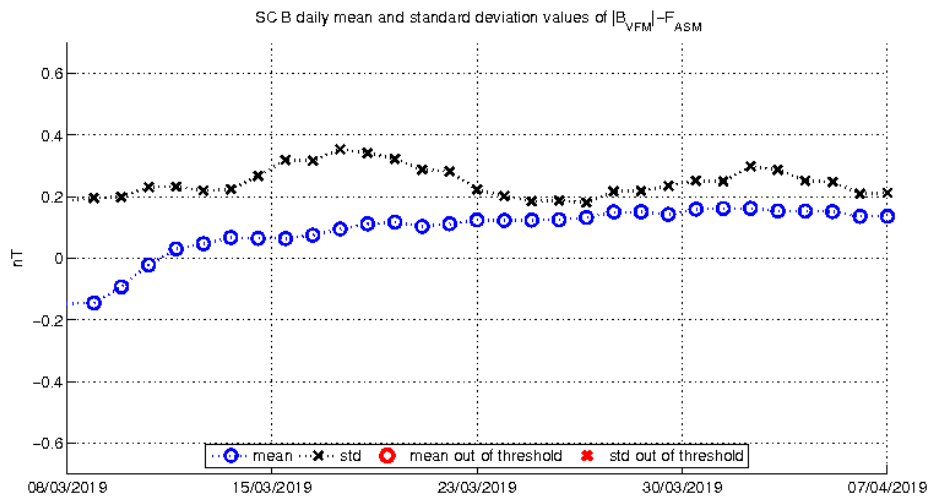


Figure 3-7: Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C B.

3.3.1.2 Swarm A

The daily peak-to-peak difference around the week stays within [-0,82 - 0,77] nT. Below follow two plots of such differences for current week (Figure 3-8).

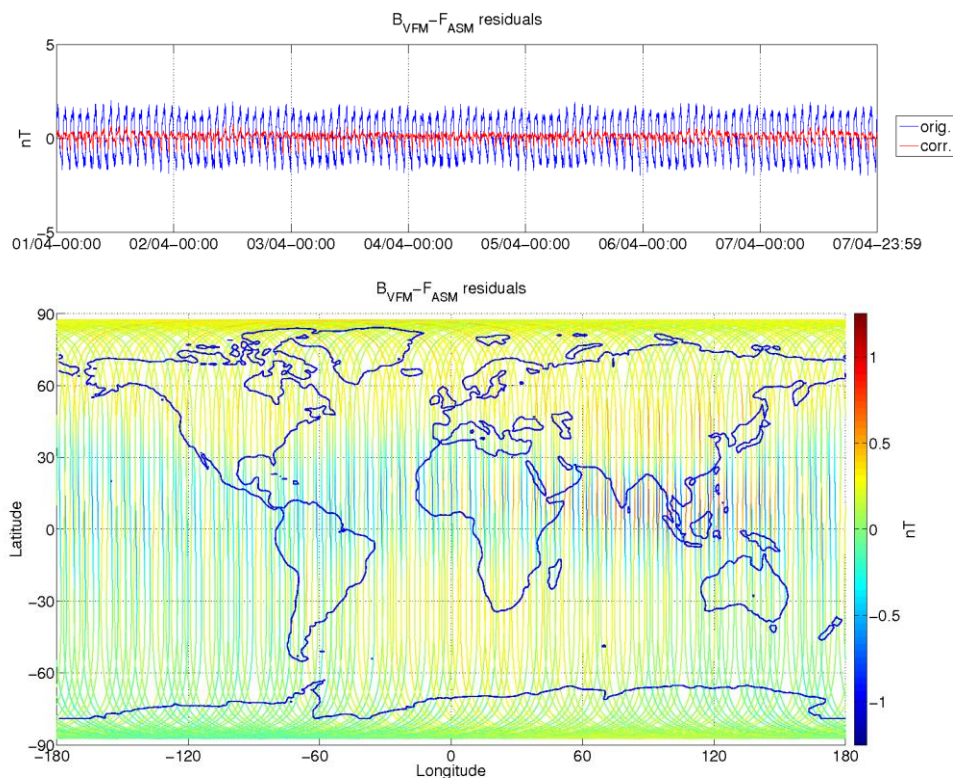


Figure 3-8: ASM-VFM residuals for S/C A, during monitoring period 01/04-07/04. In top figure are plotted: difference between $|B_{VFM}|$ and F_{ASM} (without dB_{Sun} correction) (blue colour), and the residuals with dB_{Sun} corrections (red colour). In bottom figure residuals are presented on the world map.

3.3.1.3 Swarm B

The daily peak-to-peak difference around the week stays within [-0,61 - 0,75] nT. Below follow two plots of such differences for current week (Figure 3-9).

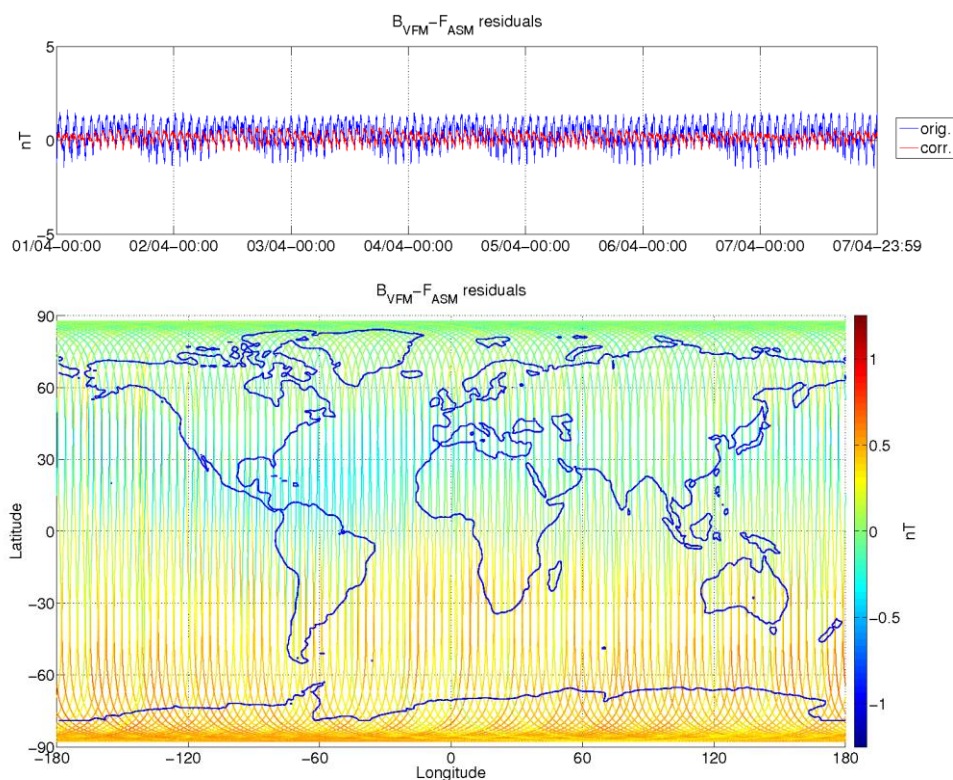


Figure 3-9: ASM-VFM residuals for S/C B, during monitoring period 01/04-07/04. In top figure are plotted: difference between |B_{VFM}| and F_{ASM} (without dB_{Sun} correction) (blue colour), and the residuals with dB_{Sun} corrections (red colour). In bottom figure residuals are presented on the world 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)

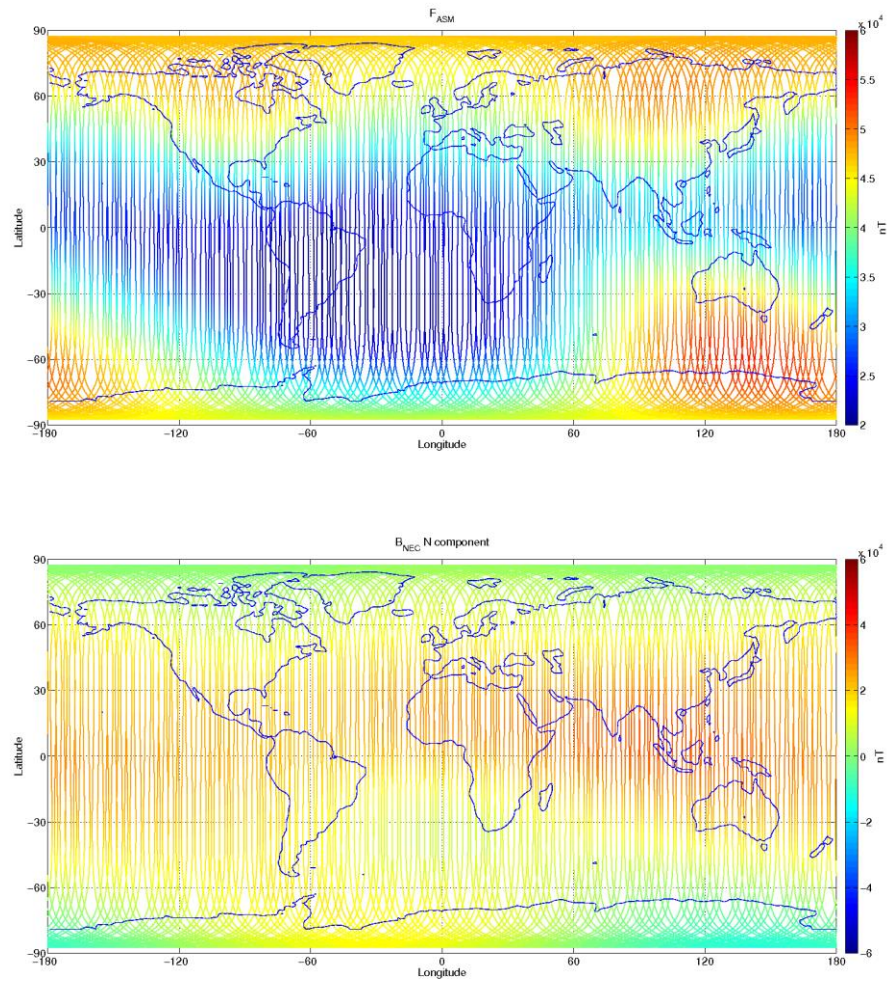
The VFM instrument parameters important for monitoring the instrument health are the VFM sensor temperatures: T_{CDC}, T_{CSC} and T_{EU}.

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



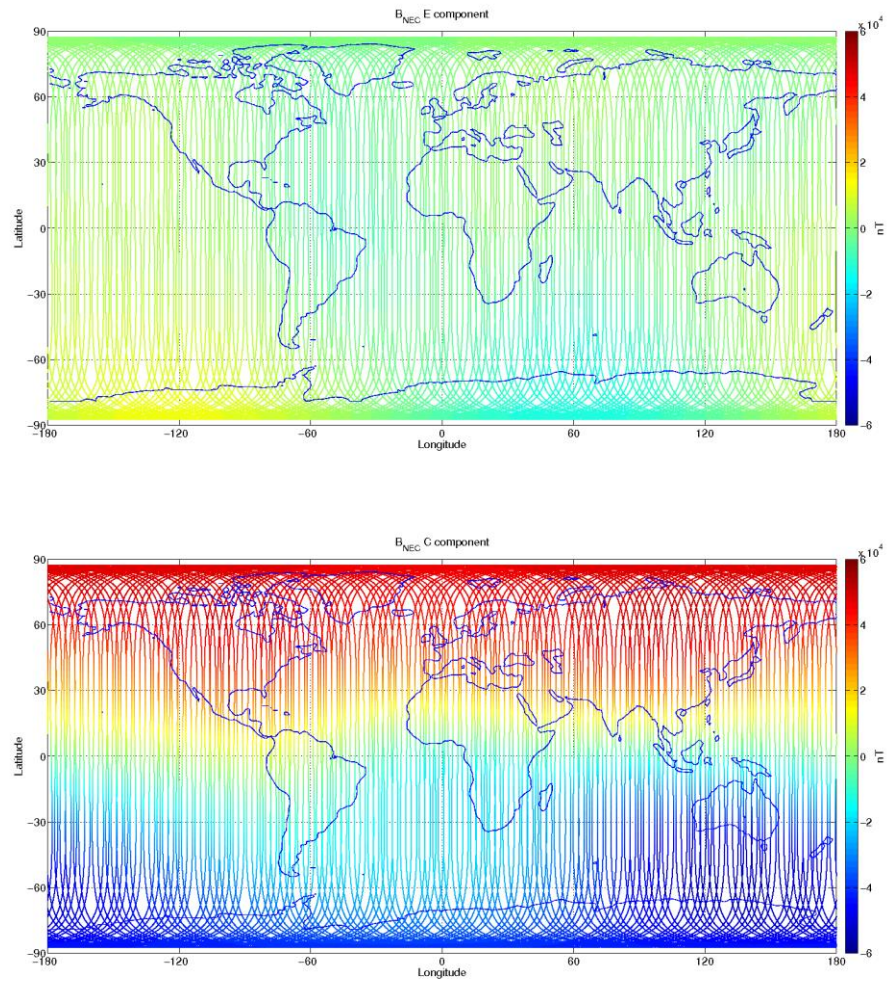
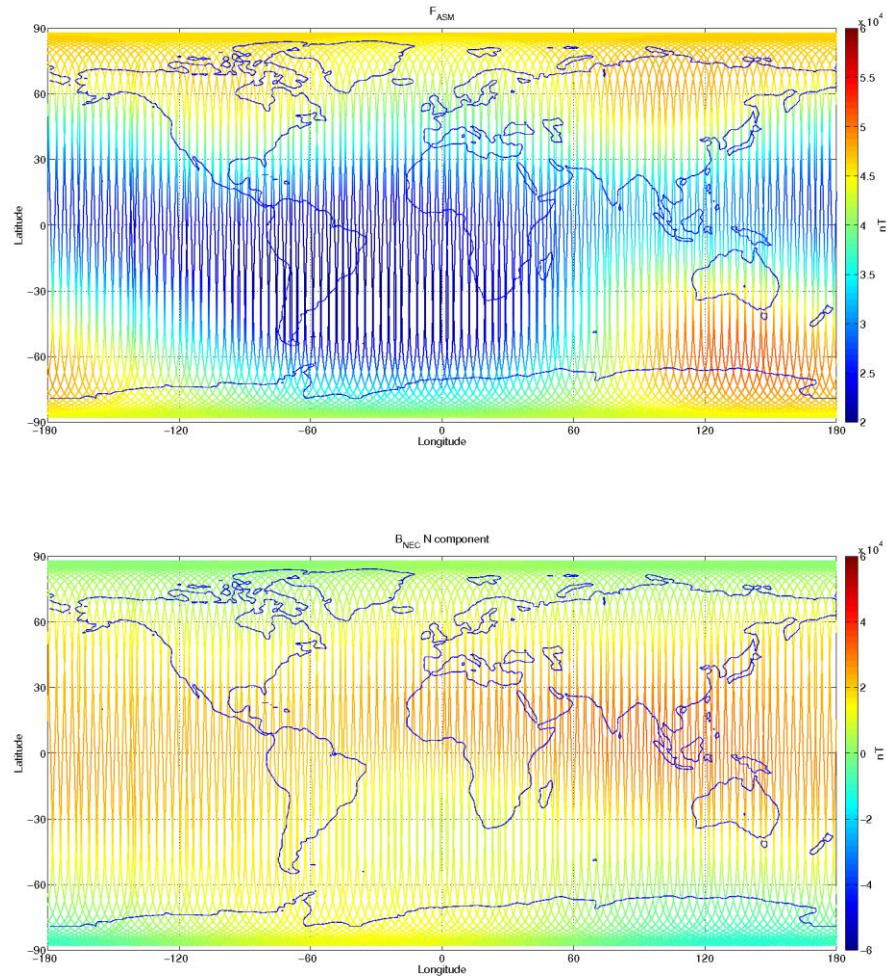


Figure 3-10: S/C A, world map plots of the geomagnetic field and components measured during monitoring period 01/04-07/04. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.2 Swarm B

Map plots of magnetic field measurement for week 14 for S/C B can be seen in Figure 3-11 below.



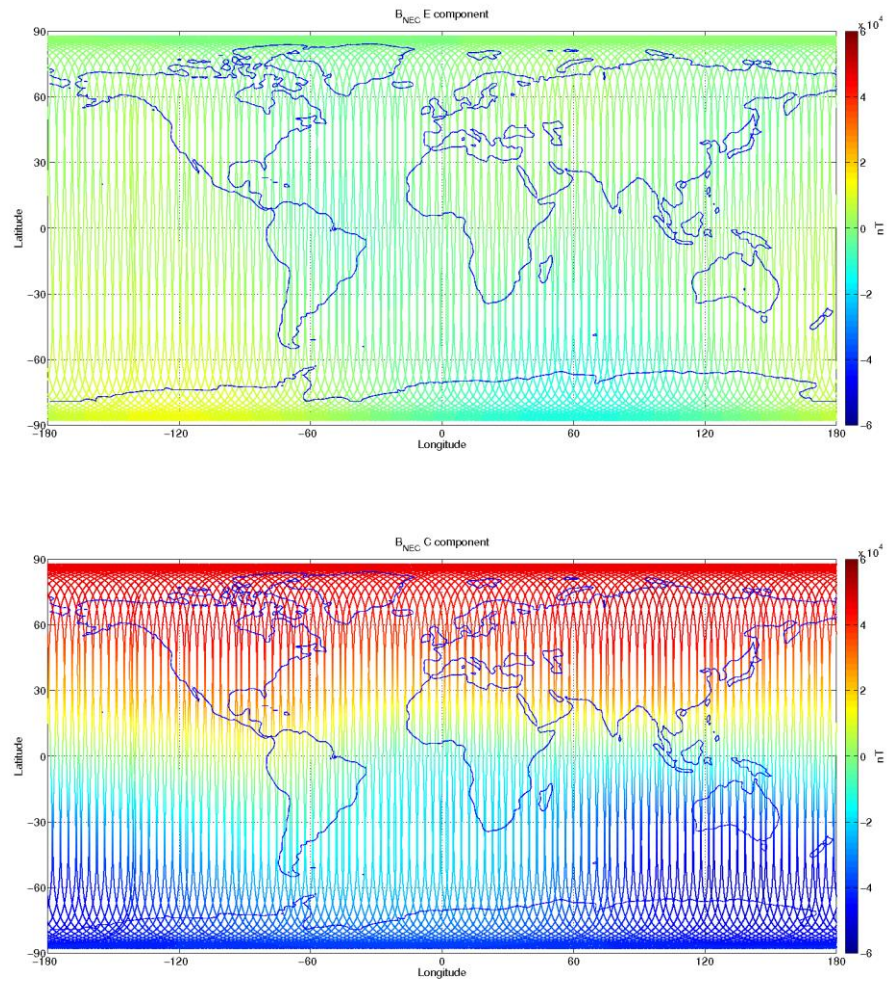


Figure 3-11: S/C B, world map plots of the geomagnetic field and components measured during monitoring period 01/04-07/04. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.3 Swarm C

Map plots of magnetic field measurement for week 14 for S/C C can be seen in Figure 3-12.

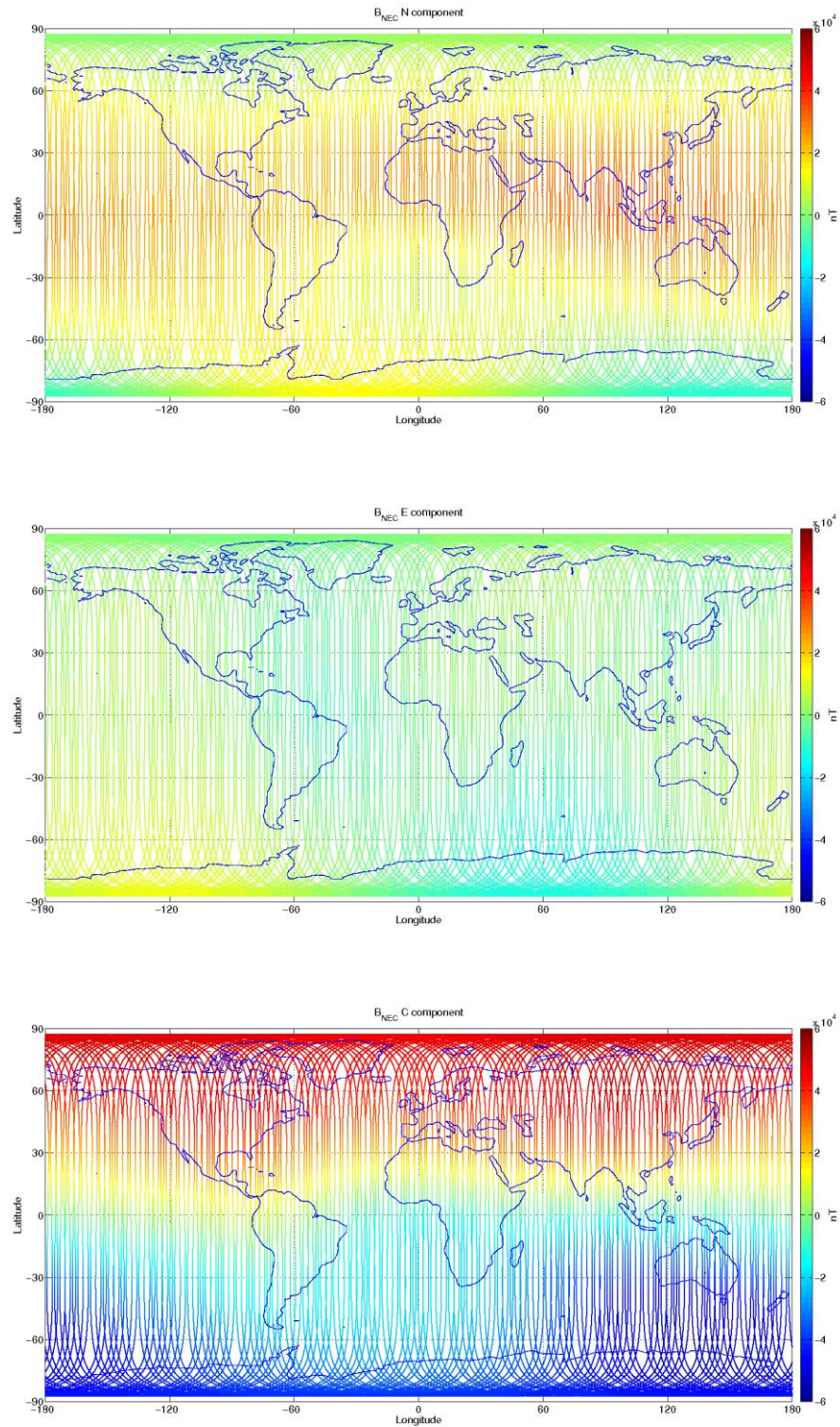


Figure 3-12: S/C C, world map plots of the geomagnetic field and components measured during monitoring period 01/04-07/04. From top to bottom: B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

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.

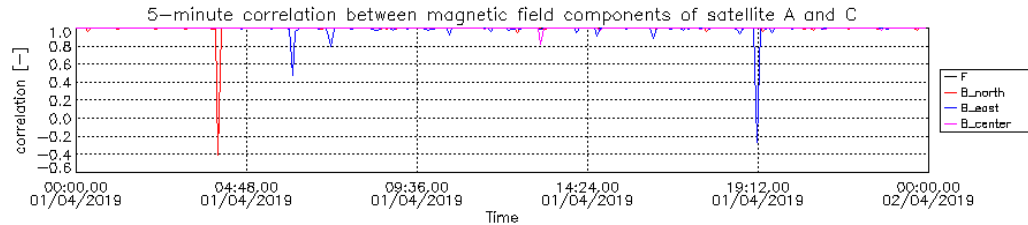


Figure 3-13: Correlation in magnetic data between satellite A and C for B_{north} , B_{east} , and B_{center} components of B_{NEC} are the components of the magnetic field vector in NEC frame

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.

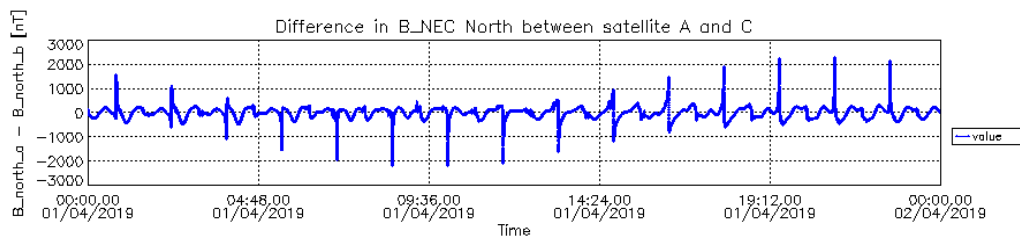


Figure 3-14: Difference in B_{NEC} North component between S/C A and S/C C.

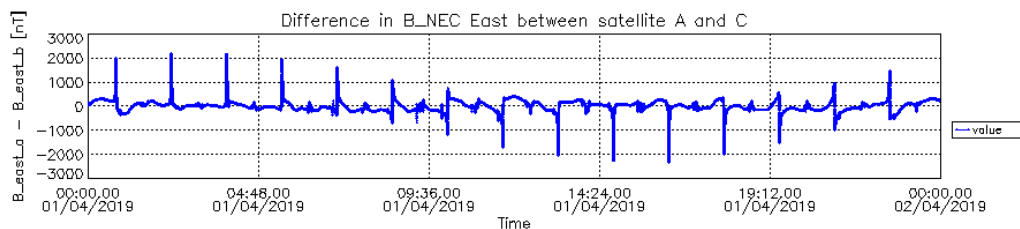


Figure 3-15: Difference in B_{NEC} East component between S/C A and S/C C.

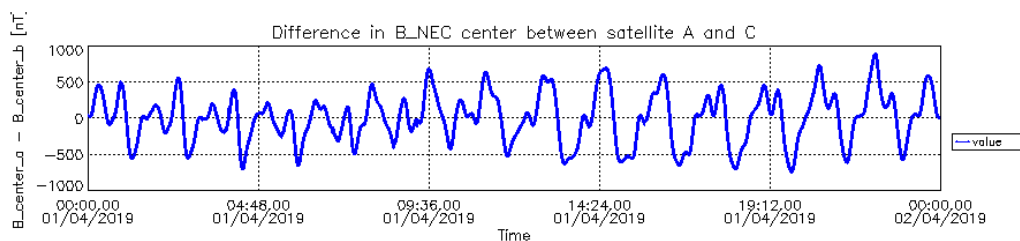


Figure 3-16: Difference in B_{NEC} Center component between S/C A and S/C C.

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 $\Delta B = B_{NEC} - B_{Chaos5}$ (all versus co-latitude in degrees), from top to bottom: 1) B_r , 2) B_θ and 3) B_ϕ .

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 01/04 of: (1-2-3) residuals of $B_{NEC} - B_{Chaos5}$ 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.

On days 01 and 03-05/04/2019, on S/C A B, C, we observe small anomalies on $B_{NEC} - CHAOS5$ model plots. It is caused by weak geomagnetic activity, which occurred those days.

3.3.7.1 Swarm A

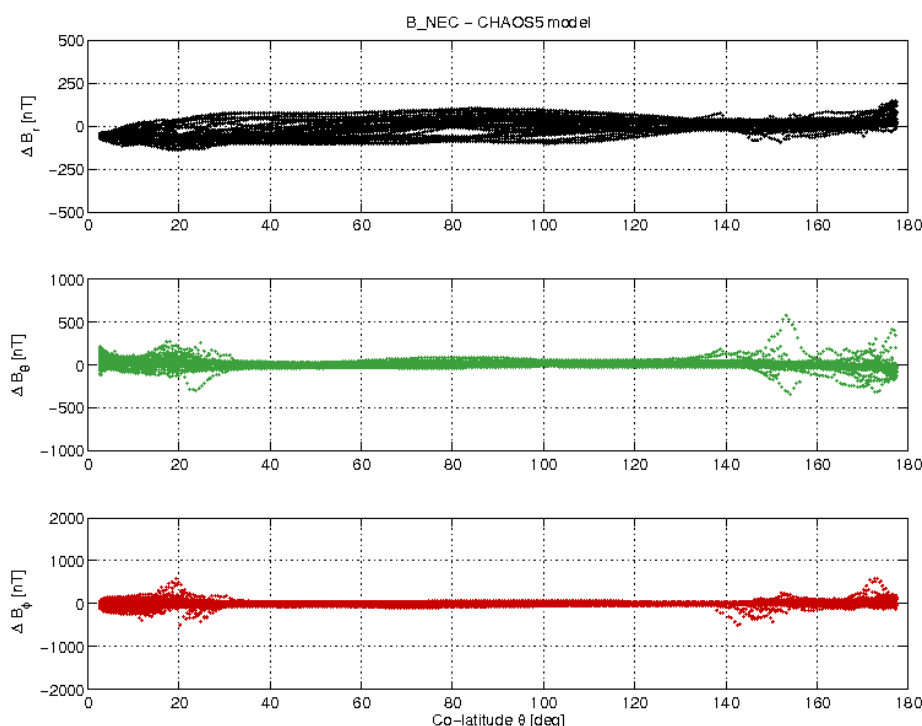


Figure 3-17: S/C A day 01.04 $B_{NEC} - B_{Chaos5}$ vs colatitude.

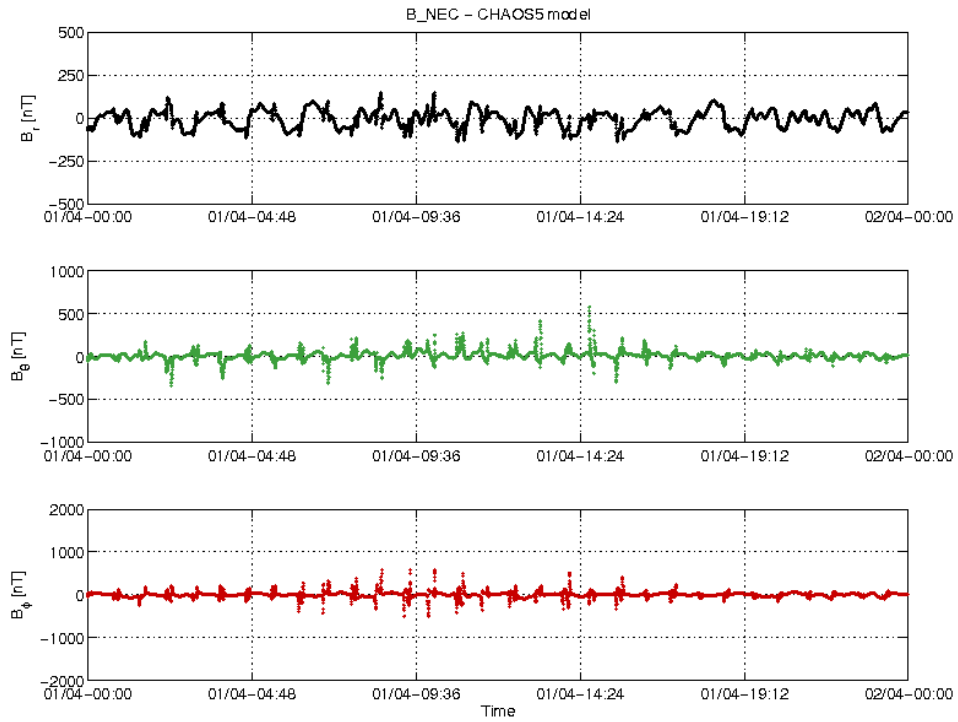


Figure 3-18: S/C A day 01.04: time series of $B_{NEC} - B_{Chaos}$ residuals.

3.3.7.2 Swarm B

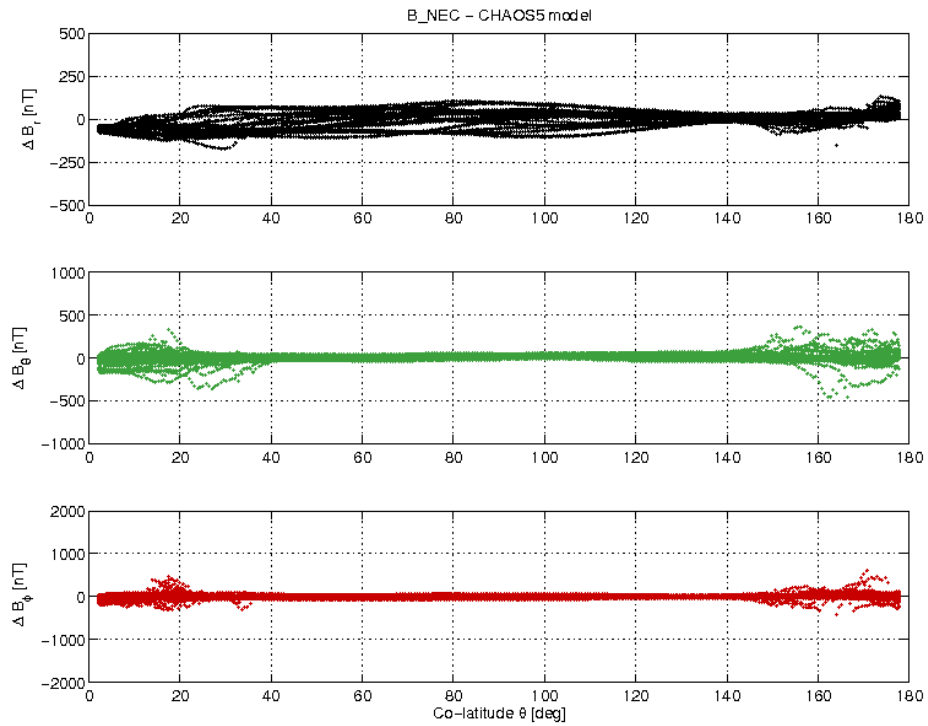


Figure 3-19: S/C B day 01.04 $B_{NEC} - B_{Chaos}$ difference vs colatitude.

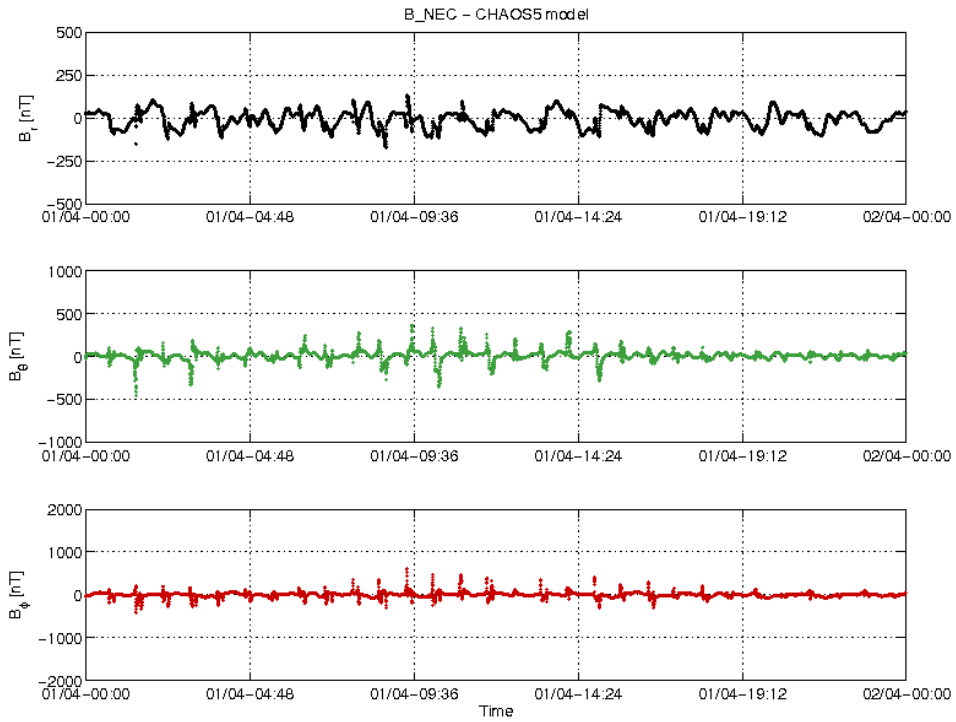


Figure 3-20: S/C B day 01.04 time series of $B_{NEC} - B_{Chaos}$ residuals.

3.3.7.3 Swarm C

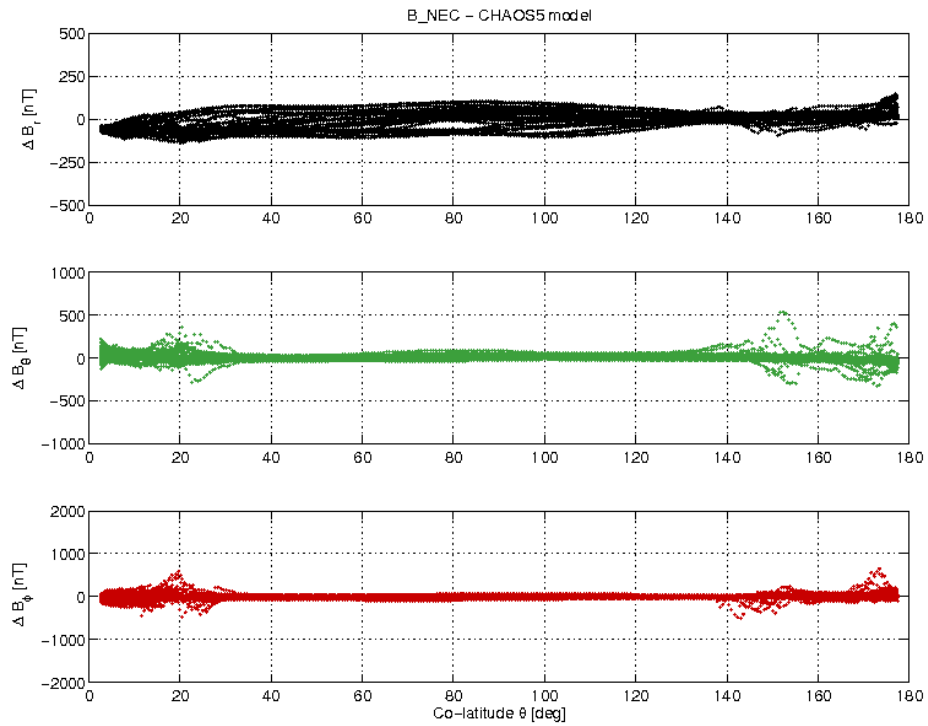


Figure 3-21: S/C C day 01.04 $B_{NEC} - B_{Chaos}$ difference vs colatitude.

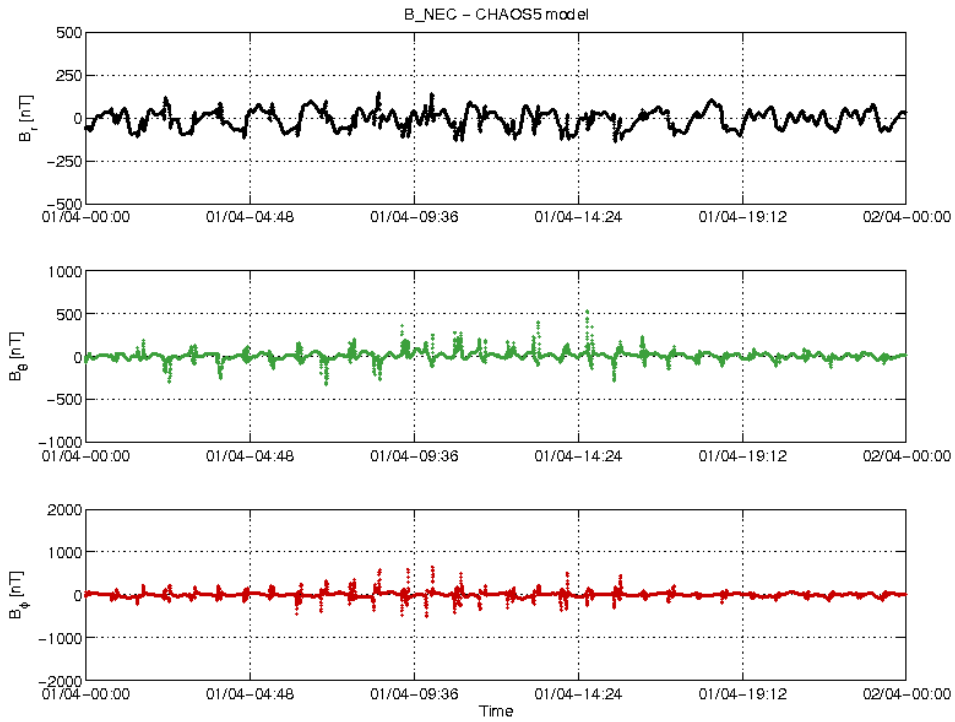


Figure 3-22: S/C C day 01.04 time series of $B_{NEC} - B_{Chaos}$ residuals.

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 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.

3.3.8.1 Swarm A

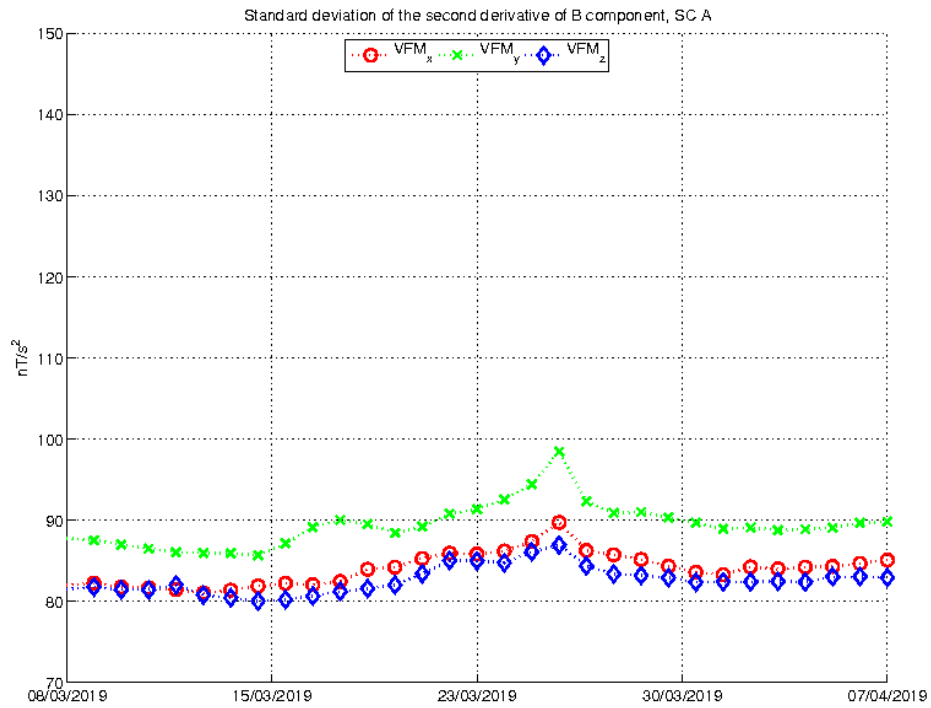


Figure 3-23: Standard deviation of the second derivative of B component

3.3.8.2 Swarm B

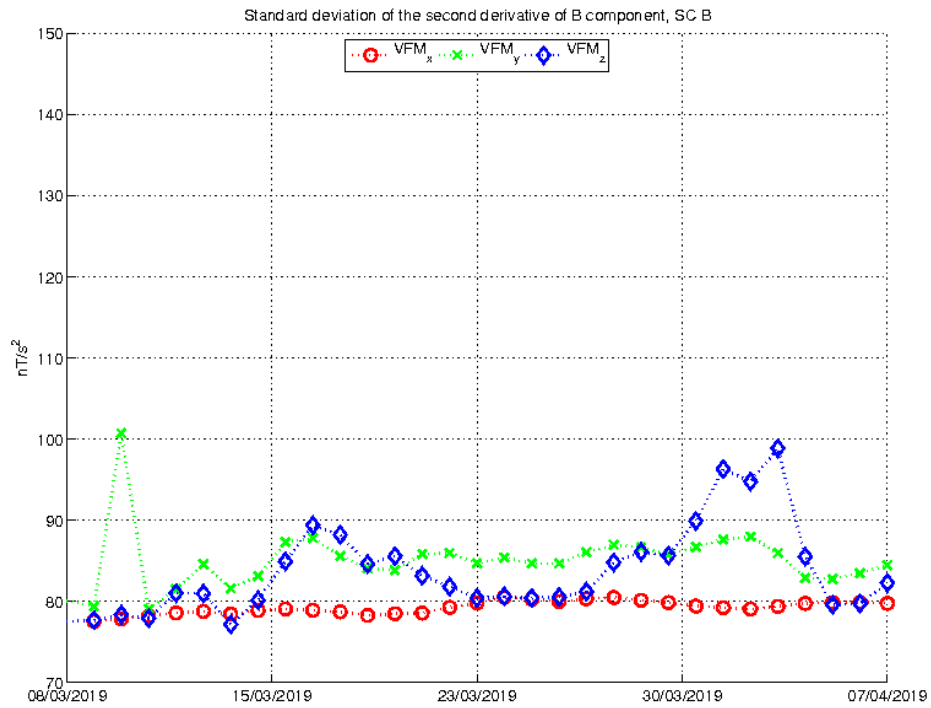


Figure 3-24: Standard deviation of the second derivative of B component

3.3.8.3 Swarm C

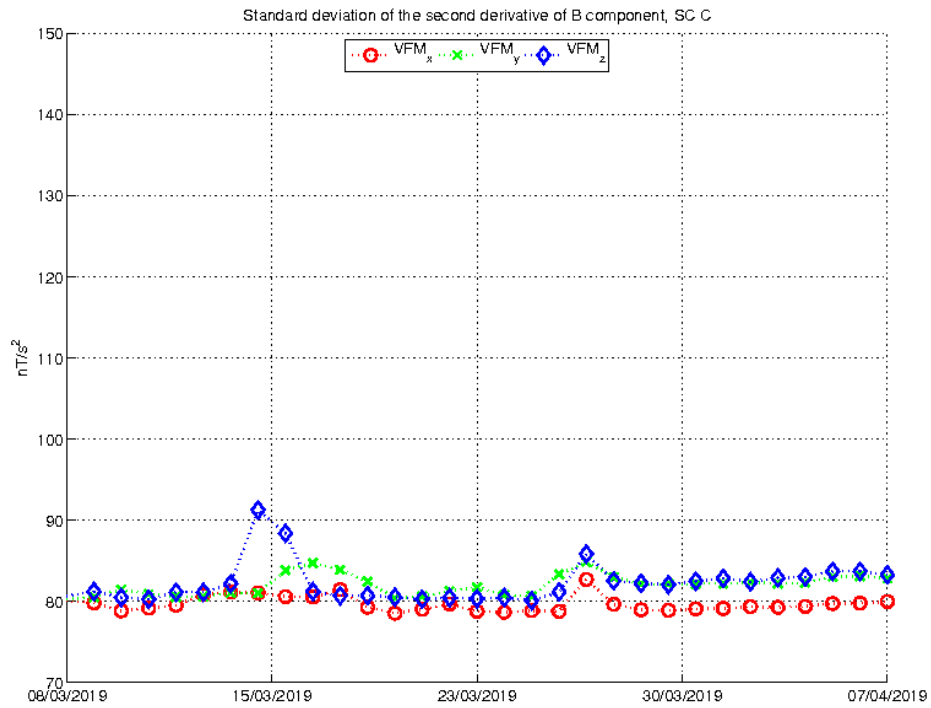


Figure 3-25: Standard deviation of the second derivative of B component

4. ON-DEMAND analysis

Nothing to report.

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