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IDEAS+ Swarm Weekly Report 2016/06: 2016/02/08 - 2016/02/14

Abstract : This is the **Instrument Data Quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 02 to 14 February 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	24 Feb 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 ADF handling (both for the operational processors and for the prototypes).

This weekly report constitutes a work in progress throughout the mission lifetime, and new parts and complements will be added while the consolidation of knowledge on Swarm data and instruments will progress.

Section 2.1 always gives an overview of the general quality status of the mission instruments and products, while the main observations of the week are summarized in Section 2.1.

The document also includes information on data quality for the three Swarm spacecraft, inferred from automated HTML quality reports, which are produced on daily basis for each product. Please contact the IDEAS+ Swarm team if interested in accessing the reports via web or FTP (all details about interfaces and folder structure available on [RD.2]). Such quality reports represent the core of the Routine Quality Control (Chapter 3). A description of the implemented quality checks is given in [RD.3], and references therein.

Basing on specific findings of the routine quality control, or on-demand from other entities (i.e. Swarm PDGS, FOS, Mission Management, Post-Launch Support Office, Expert Support Laboratories, Quality Working Groups, and user community), anomalies can be triggered. Preliminary characterisations and investigations of such anomalies are given in Chapter 4.The anomalies documented in the Weekly Reports are tracked in the following way:

1. If triggered by ESA Eohelp or within the Service: IDEAS+ action and ticketing system (http://requests-sppa.serco.it/RT3/index.html).

2. If triggered by IDEAS+ Swarm team or other entities:

   2a. If the observation/analysis leads to an anomaly to be addressed to the processor provider (GMV): SPR on EO ARTS (https://arts.eo.esa.int), **SWL1L2DB** project;

   2.b. If the observation/analysis does not lead to an anomaly or the investigation shall be escalated to other entities (PLSO/industry, ESL, PDGS): Action tracked on EO ARTS, **SW-IDEAS** project, then addressed to the proper tracking system if needed (e.g. JIRA for ESLs, SW-CP-AR project on EO ARTS for PDGS).

Information on Level 1B Swarm products can be found in [RD.4].

1.1 Current Operational configuration of monitored data:

- Processors Version: L1BOP 3.16.p2, L2-Cat2 1.15.p4.
- 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: CCDB 0010 (04/02/2016), 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

[RD.19] SW-RP-ESC-FS-6212_Swarm_Weekly_Operations_Report#116_08-02-2016_14-02-2016

2. SUMMARY OF THE OBSERVATIONS

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

TII Image anomaly update: Investigations are progressing and several new tests have being conceived. In particular, for Swarm Charlie, a procedure called “Inner Dome Scrubbing” (AGC=OFF, VMCP = -2000 V; VPHOS ~ +100 V, VG at different values) has been carried on, with, for now, unclear results: the aim is to try to scrub the inner dome of the sensors from deposited contaminants and let them flow out of the instruments aperture. Another test under study concerns the possibility to perform a yaw manoeuver exposing the face plate to the Sun as long as possible, in order to try to heat up the phosphor screens and let the contaminants to evaporate out of the sensors.

2.2 Plan for operational processor updates

The L1BOP 3.17 has been released by GMV the 15th of February. The PDGS team has put the validation activity in pipeline after the APDF patch needed for handling new Level 2 Cat1 accelerometer products. The activity will start in the coming days.

Contrarily to what previously agreed, the correct exponential dependency of the VFM calibration scale factor from time will be not taken into account since the deployment of the processor, and the new CCDB parameters s_exp and s_beta will be temporarily set to zero. This is because DTU realized that a clear dependency of the beta angle (azimuth with respect to the VFM) is observed on the temperature of the VFM electronics, and a better modelling is required for inferring the correct parameters of the exponential function.

In the meantime, other two changes to be implemented into the ORBATT processor are under discussion.

- A STR Inter-Boresight Angles correction model
- An increase of the frequency of the STR L0 product from 1 Hz to 2 Hz

Any delivery of the Level 2 – Cat 2 OP is postponed after the PDGS evolution activity (April – July 2016).

2.3 Quality Working Group and Cal/Val Coordination

Following the decisions of the 5th QWG in Paris, these activities will be carried on in order to better understand the origin of the ASM-VFM residuals:

- Investigation on boom alignment error budget (from industry) that could help in developing a thermos-elastic correction approach.
- Investigation on plasma-induced stray field in order to focus on any possible current flow near the VFM (and not the ASM), because the intensity of such a current may be stronger near the VFM due to the accumulation of charged plasma particles near the STR baffles.
- Investigation of ASM-V magnetic data especially during the 4x90° yaw slew (13-14 May 2015) and 180° yaw bias (23 January 2014) manoeuvres.

The former "Task Force" deputed to study the ASM-VFM residuals, has been reshaped in a Magnetic Measurements Expert Group (MMEG), that will convene for the first time in Warsaw (GMV premises) the **10-11/03/2016** for discussing the open issues in magnetic data:

- Report on the Euler angle update and Level 1b data regeneration
- Update on the Level1b Operational Processor status
- STR IBA correction update (algorithm & implementation)
- Ideas to improve the STR measurement noise
- Further results from the investigation of ASM-V data
- ASM-VFM alignment results
- New findings from inter-satellite comparison analysis
- Further disturbance field model enhancements: temperature gradient correlations, introduction of a thermal filter
- Update from plasma-induced stray field analysis
- Summary of pre-flight tests on time synchronisation and non-orthogonality estimation

The "16 Hz Faceplate currents and derived electron density" dataset, delivered by IRF, has been published in the ESA ftp server (/Advanced folder). Considering the great interest expressed by the users community, this dataset will be accessible to all users since the beginning, and not to expert users only as it was originally decided.

IRF is about to deliver other two new datasets, for the benefit of expert users (/Advanced folder):

- Single-probe derived electron temperatures and S/C potential (by end of February)
- Sweep mode derived electron density and temperature and S/C potential (by end of March).

Moreover, investigations are on-going with the help of GFZ, on the spike occurrences on the electron temperature: we have provided GFZ with HK_BUS_1A products in CDF, containing the solar panel currents, in order to investigate possible correlation of the spikes with solar illumination and/or currents activations.

2.4 Summary of observations for 2016, Week 6 (02/08 – 02/14)

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

- MAGNET processor failure for SC C on 10/02. The reason was a VFM soft out of limits (more details in [RD.19] in Section 6.3), which occurred around 02:27 (10/02/2016), over the South Pole. As a result also PLASMA processor was not executed. For the reported day no magnetic and plasma products of level 1A and 1B have been generated.
- **Several few seconds gaps in MAGx_CA_1B products** throughout the week. Some of them seem not to be associated to gaps in telemetry. Monitoring on-going.

3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

- **Magnetic and plasma Level 1B data unavailable for S/C C on 10/02/2016.** The unavailability is due to a Single Event Upset on the VFM occurred at about 2:27 UT, and, for the following 8 hours, several soft out of limits were reported in the VFM monitoring voltage levels. At 13:53 UT the instrument has been power cycled and after 14 UT the behavior came back to nominal. The telemetry coverage for that day is therefore almost complete (except for the few minutes around the power cycle), but the Science data are seriously affected and the Level 1B processor was not able to process it. More details can be found in Sect. 4.1.
- **Several few seconds gaps in MAGx_CA_1B products** throughout the week. Some of them seem not to be associated to gaps in telemetry. Monitoring on-going.

3.2 Orbit and Attitude Products

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

Table 1: List of events related to attitude and orbit products to be reported in the monitoring for 2016, Week 6: 02/08 - 14/02.

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 2, one can see the statistics of the differences between MOD and on-board solution positions for S/C A, B and C respectively. In the third column the maximum

differences (maximum negative and maximum positive) are reported. The maximum standard deviation is in the fourth column. Maxima, minima and standard deviations usually refer to the Z component that is often the most disturbed; in case another component is most affected, it will be specified in parentheses. Figure 1 shows a cumulative trend of the maximum daily standard deviation for the past 30 days of operations of the MOD-NAV difference, while Figure 2 shows the daily maximum difference, in absolute value, of the MOD-NAV difference, always for the past 30 days of operations.

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

Swarm A, 02/08 - 14/02, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
02/08	0.01	-8.6	6.1	1.29	
02/09	0.09	-8.6	7	1.29	
02/10	0.06	-9	10.5	1.08	
02/11	0.18	-6.4	7.1	1.18	
02/12	0.1	-7.5	8.9	1.15	
13/02	0.08	-8.9	10.5 (X)	1.34	
14/02	0.06	-7.6	8.4	1.31	
Swarm B, 02/08 - 14/02, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
02/08	0.12	-5.6	7.2	1.21	
02/09	0.11	-7.2	5.9	1.27	
02/10	0.09	-5.9 (Y)	5	1	
02/11	0.07	-7.3	9.3 (X)	1.19	
02/12	0.04	-8.8	7.6	1.19	
13/02	0.04	-11.4 (X)	10.2 (Y)	1.3	
14/02	0.11	-7.2 (X)	6.7	1.18	
Swarm C, 02/08 - 14/02, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
02/08	0.03	-7.4	7.6	1.27	
02/09	0.1	-9.9	6.7	1.29	
02/10	0.09	-5.8	6.9	0.98	
02/11	0.17	-5.8	7.8	1.15	
02/12	0.08	-7.4	6.4	1.14	
13/02	0.07	-8.1	7	1.31	
14/02	0.13	-7.7	8.2	1.29	

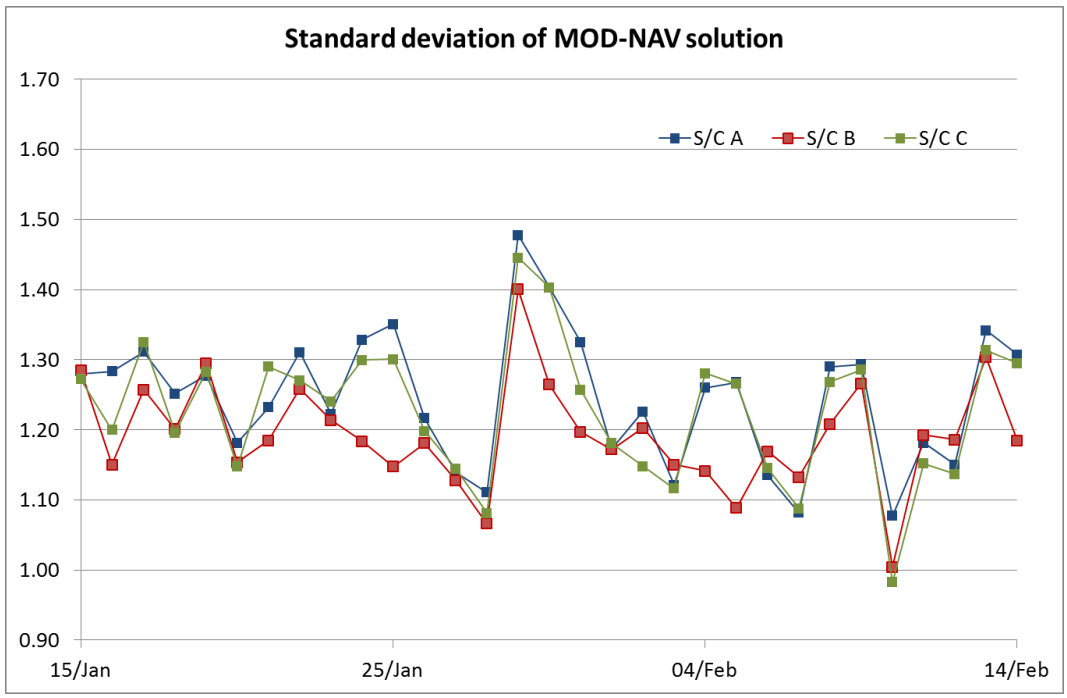


Figure 1 Plot of the standard deviation of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

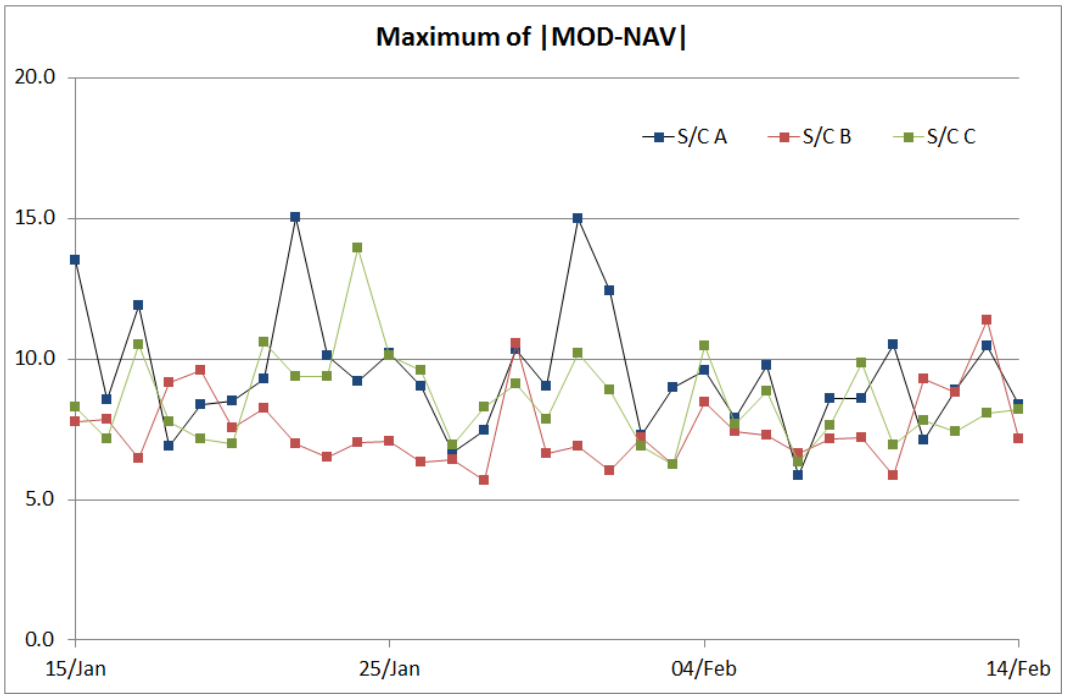


Figure 2 Plot of the maximum difference of the absolute value of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

3.2.1.1 Swarm A

Below is presented plot of MOD-NAV differences for S/C A, taken at the beginning of the week (08/02, Figure 3). From top to bottom, the plots show of MOD-NAV differences in ITFR reference frame: on X, Y and Z-axis respectively. The difference between both solutions is given in [m].

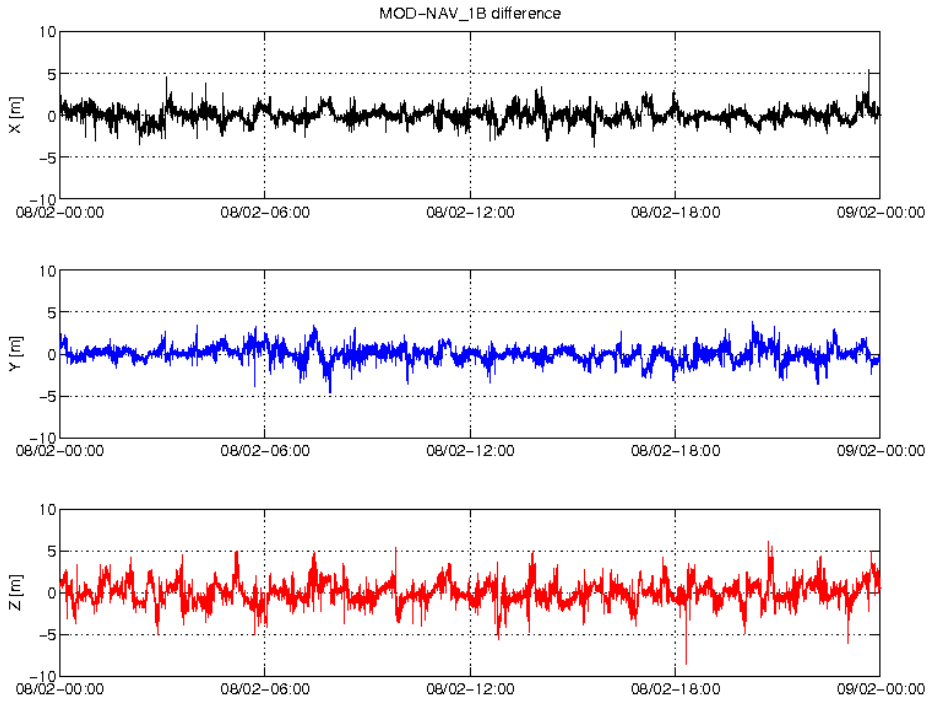


Figure 3: Difference MOD-GPSNAV, S/C A, 08/02. From top to bottom: X, Y and Z-axis

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 (08/02, Figure 4). From top to bottom, the plots show of MOD-NAV differences in ITFR reference frame: on X, Y and Z-axis respectively. The difference between both solutions is given in [m].

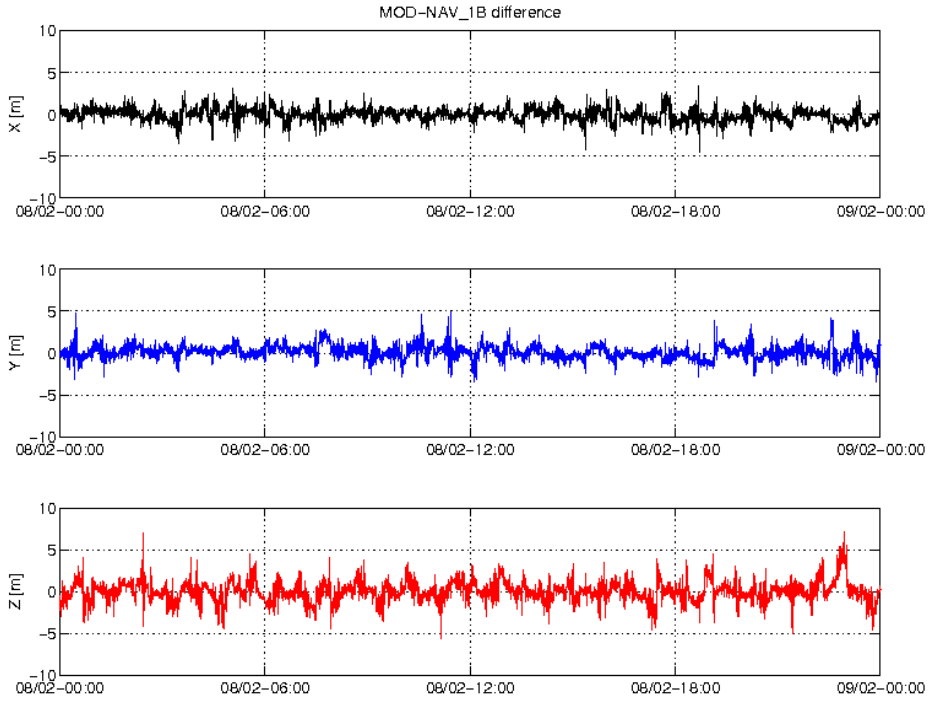


Figure 4: Difference MOD-GPSNAV, S/C B, 08/02. From top to bottom: X, Y and Z-axis

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 (08/02, Figure 5). From top to bottom, the plots show of MOD-NAV differences in ITFR reference frame: on X, Y and Z-axis respectively. The difference between both solutions is given in [m].

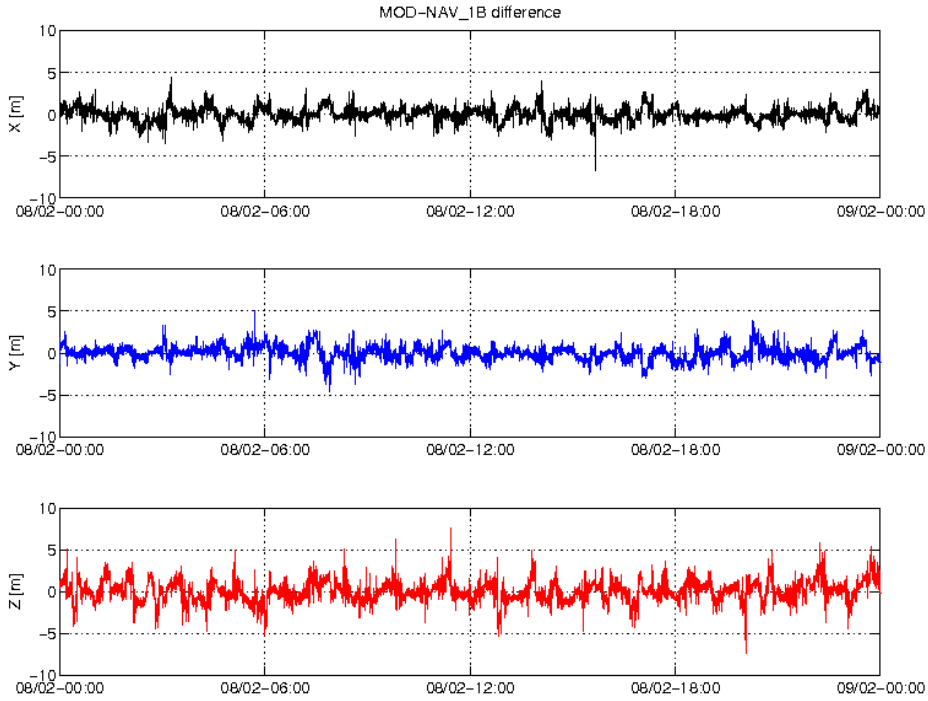


Figure 5: Difference MOD-GPSNAV, S/C C, 08/02. From top to bottom: X, Y and Z-axis

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 and ASM temperature.
- VFM instrument monitoring: temperatures.
- 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. Moreover, alerts are also raised if the average value of $|B_{VFM}|$ - F exceeds 0.3 nT and the standard deviation exceeds 0.4 nT. 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).

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

Table 3 List of events related to magnetic products to be reported in the monitoring for 2016, Week 6: 02/08 - 14/02.

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:

- SC A – violation of:
  - VFM-ASM residuals threshold on 02/08, 02/09, 02/10, 02/11, 13/02, 14/02;
  - Standard deviation of residuals threshold 02/09, 02/10, 02/11.

3.3.1.1 ASM-VFM difference statistics

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

The ASM-VFM difference is defined as follow:

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

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

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

Swarm A, 02/08 - 14/02, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
02/08	**1.06**	-0.79	0.35	0.249	
02/09	**1.1**	**-1.05**	**0.42**	0.214	
02/10	**1.2**	**-1.11**	**0.44**	0.204	
02/11	**1.03**	-0.98	**0.41**	0.189	
02/12	0.97	-0.71	0.37	0.183	
13/02	**1.01**	-0.69	0.35	0.172	
14/02	**1.11**	-0.57	0.33	0.17	
Swarm B, 02/08 - 14/02, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
02/08	0.81	-0.42	0.19	0.29	
02/09	0.76	-0.35	0.18	0.284	
02/10	0.67	-0.34	0.18	0.252	
02/11	0.74	-0.24	0.19	0.24	
02/12	0.9	-0.41	0.27	0.223	
13/02	0.83	-0.46	0.27	0.219	
14/02	0.85	-0.65	0.28	0.197	

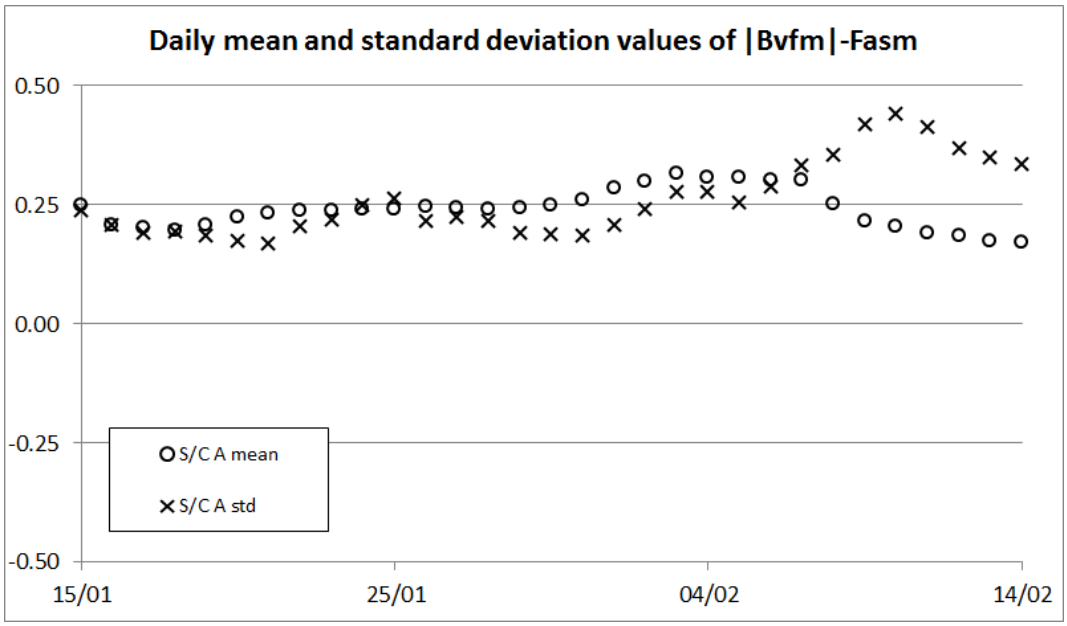


Figure 6 Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C A.

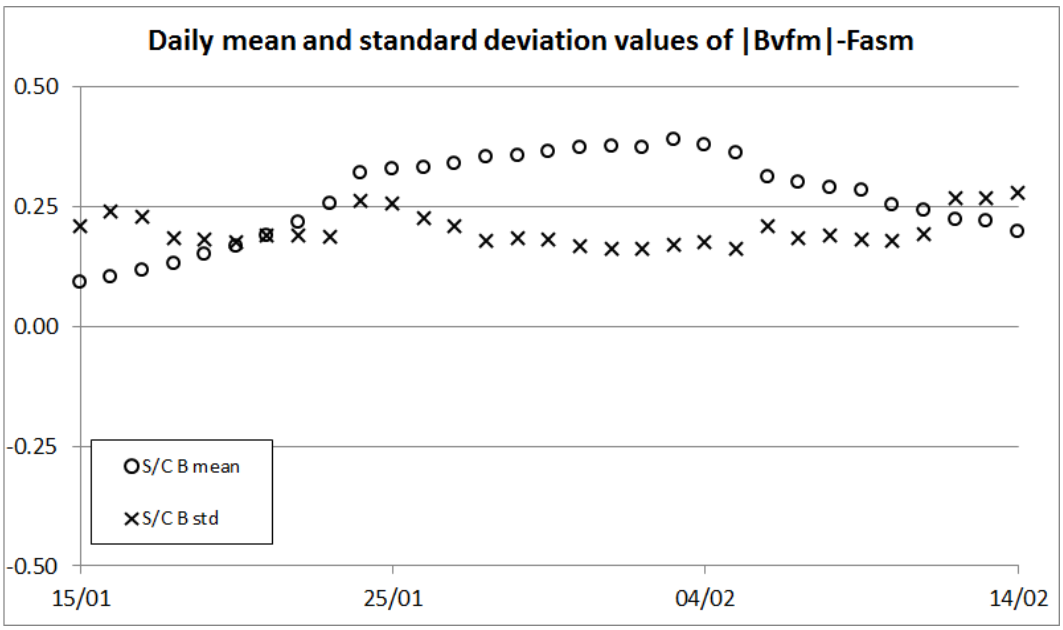


Figure 7 Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C B.

3.3.1.2 Swarm A

The daily peak-to-peak difference around the week stays within [-1.11, 1.2] nT. Below follow two plots of such differences for current week (Figure 8).

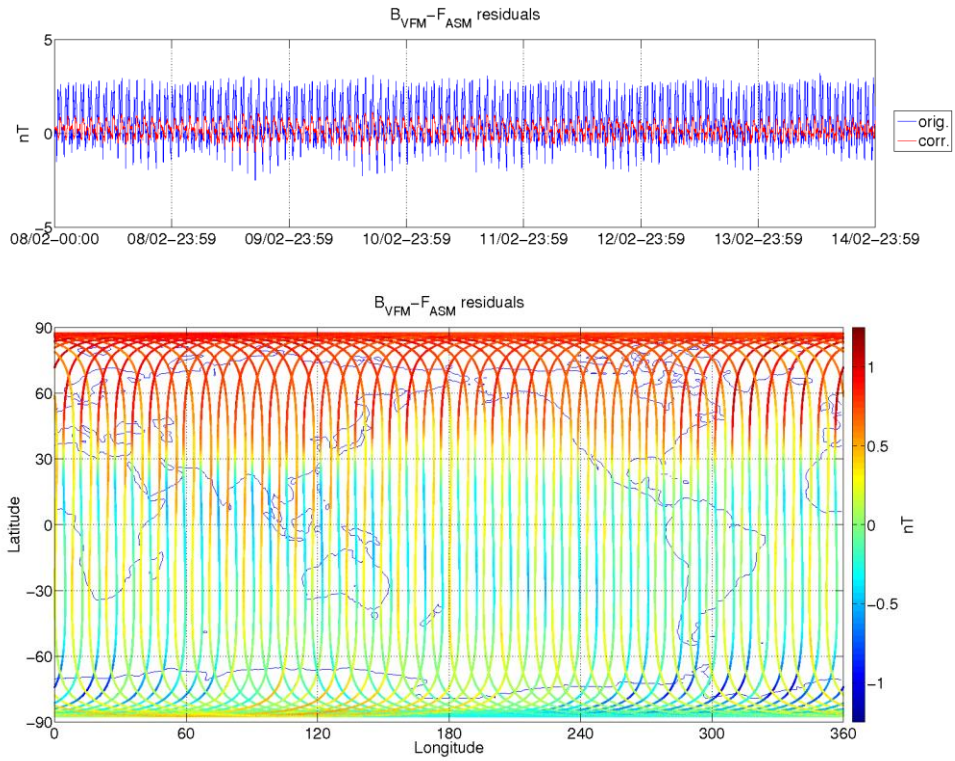


Figure 8: ASM-VFM residuals for S/C A, during monitoring period 02/08-14/02. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map.

3.3.1.3 Swarm B

The daily peak-to-peak difference around the week stays within [-0.65, 0.9] nT. Below follow two plots of such differences for current week (Figure 9).

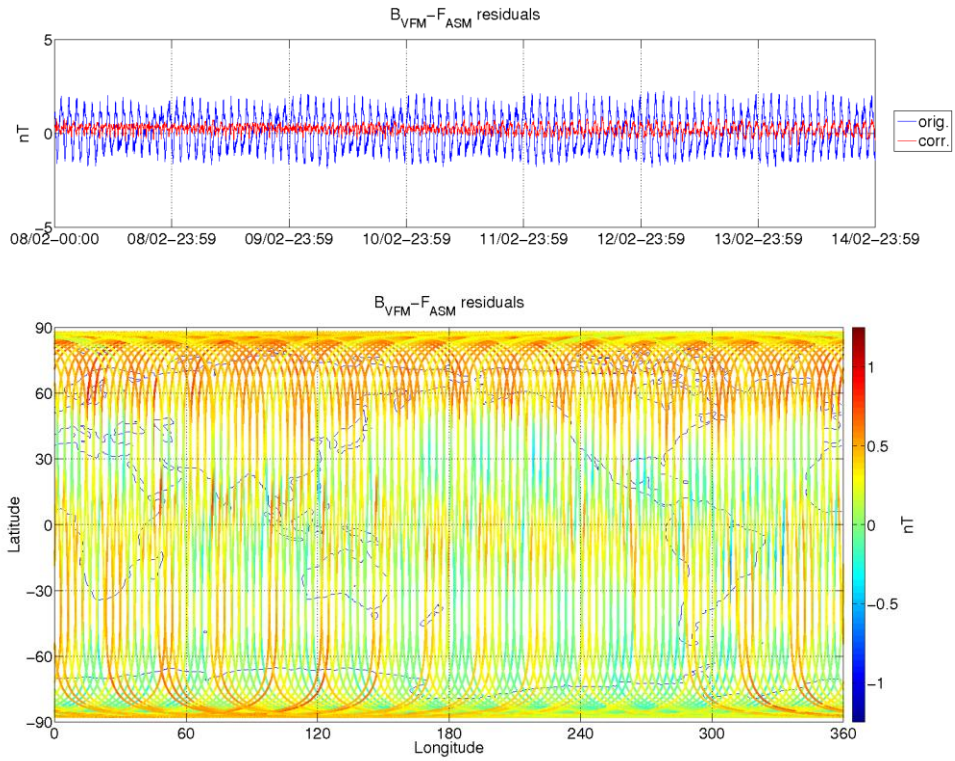


Figure 9: ASM-VFM residuals for S/C B, during monitoring period 02/08-14/02. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map.

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)

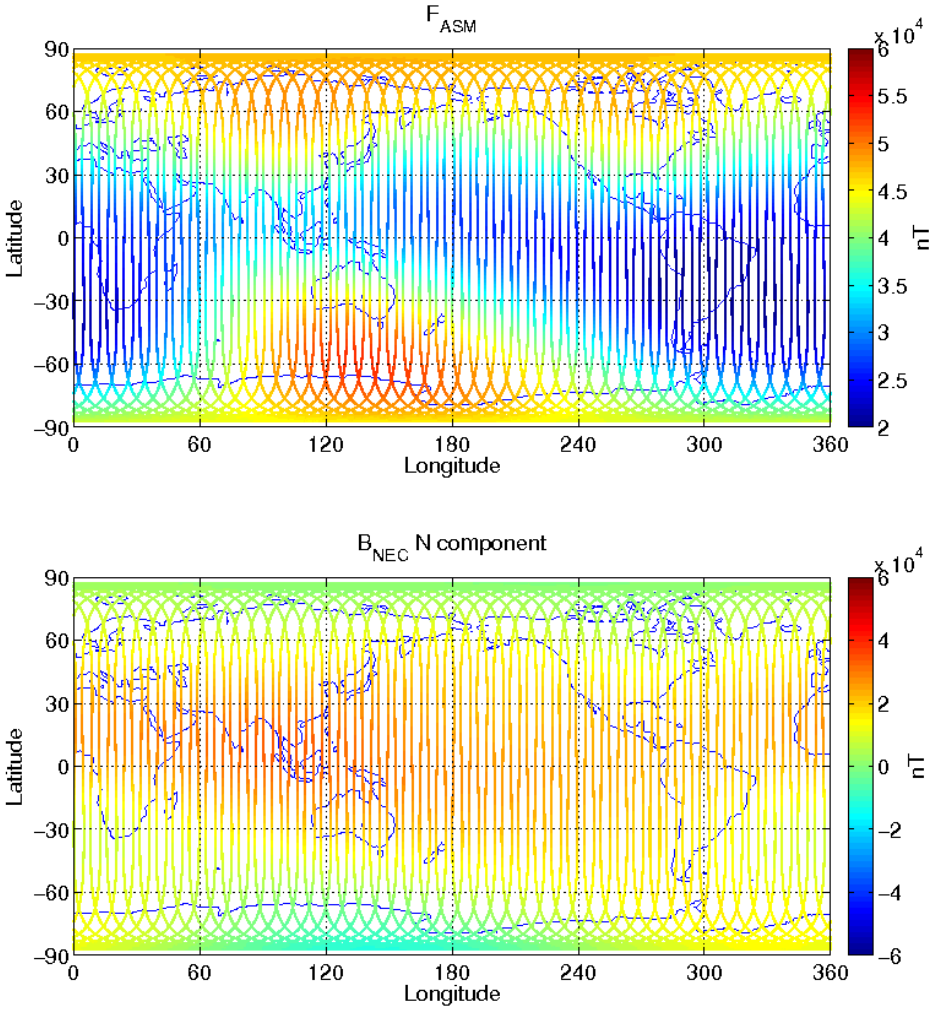
The VFM instrument parameters important for monitoring the instrument health are the VFM sensor temperatures: T_CDC, T_CSC and T_EU.

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 6 for S/C A can be seen in Figure 10 below.



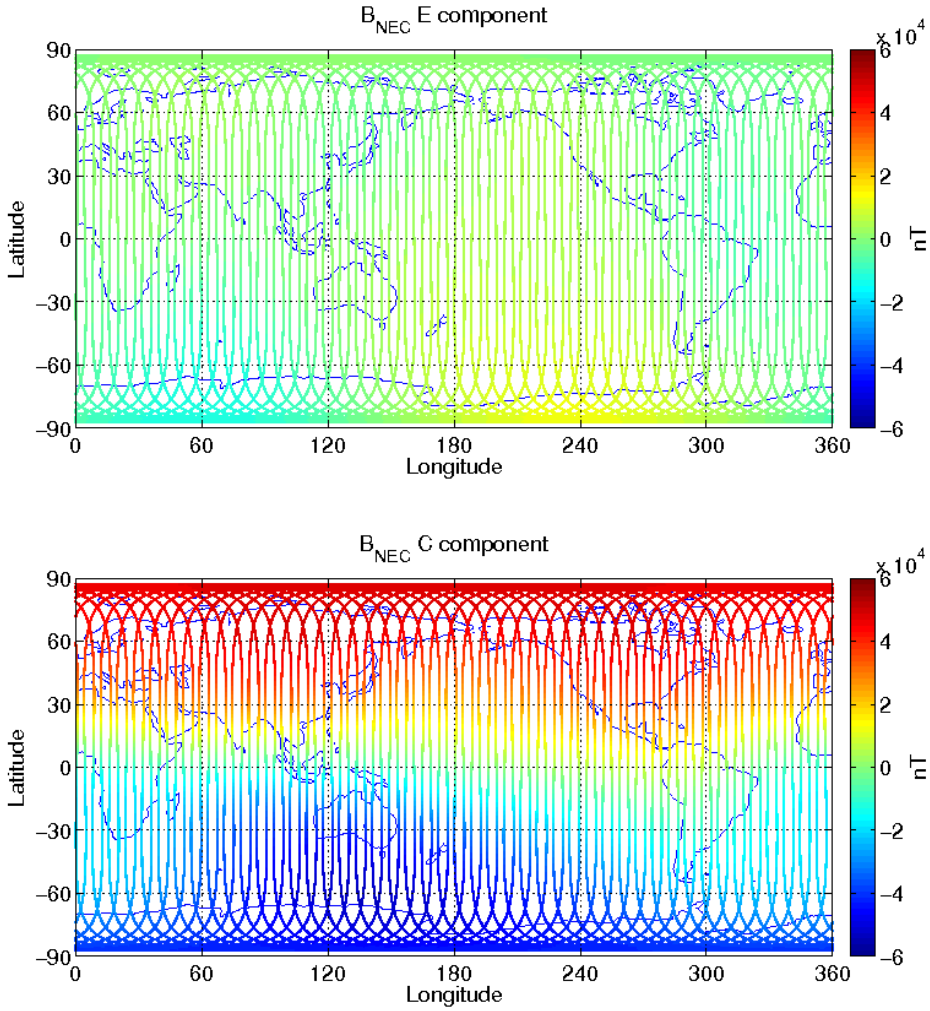
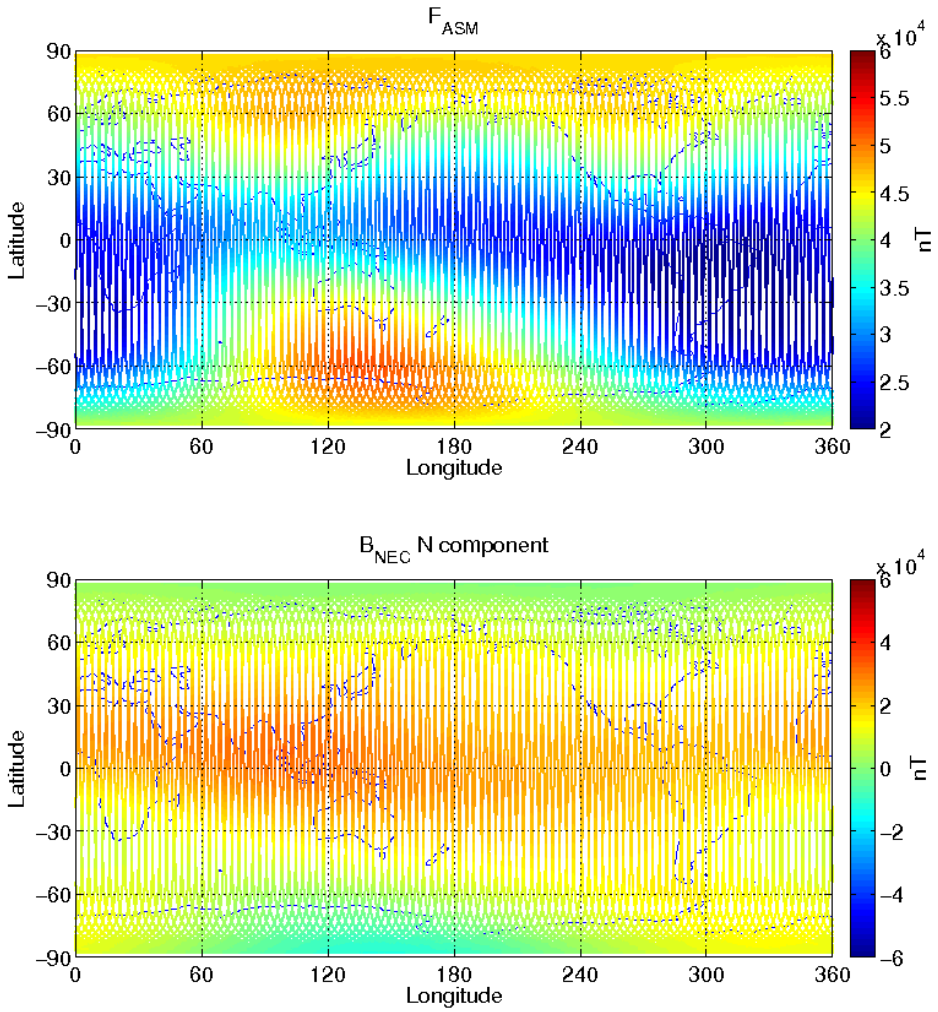


Figure 10: SC A, world map plots of the geomagnetic field and components measured during monitoring period 02/08-14/02. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.2 Swarm B

Map plots of magnetic field measurement for week 6 for S/C B can be seen in Figure 11 below.



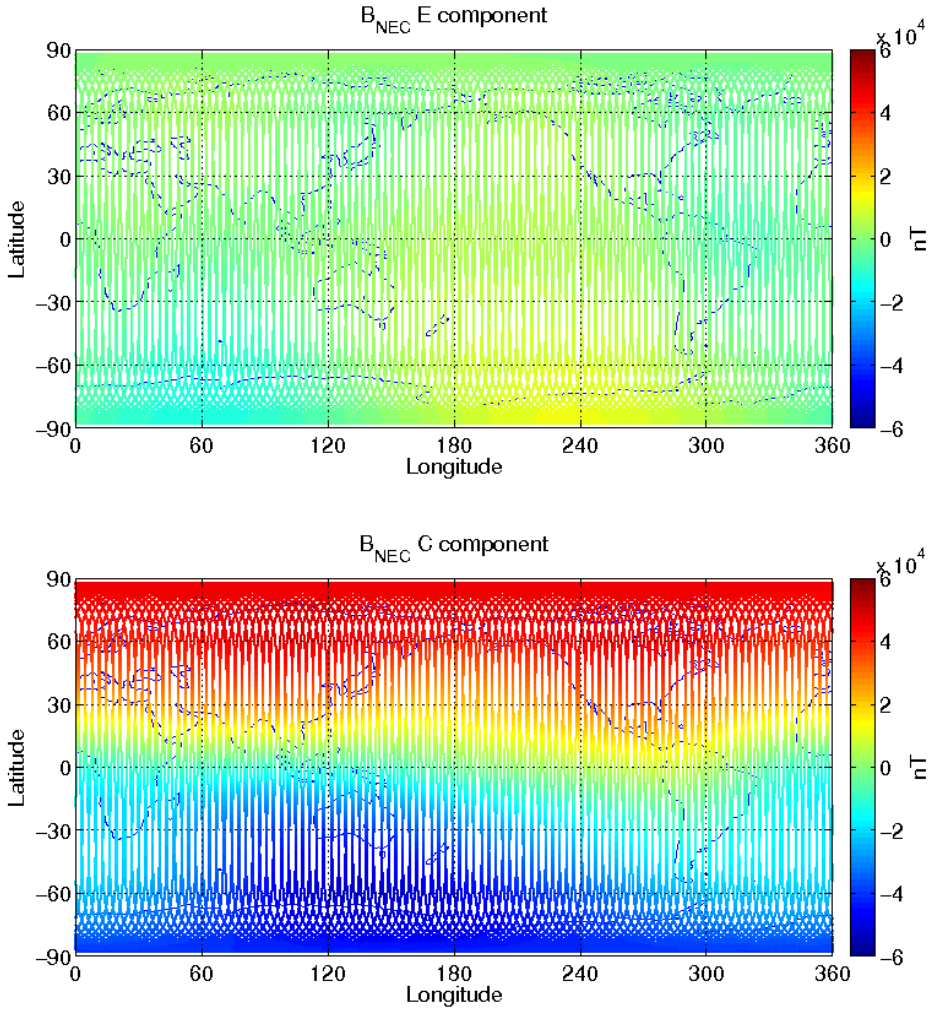


Figure 11: S/C B, world map plots of the geomagnetic field and components measured during monitoring period 02/08-14/02. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.4.3 Swarm C

Map plots of magnetic field measurement for week 6 for S/C C can be seen in Figure 12.

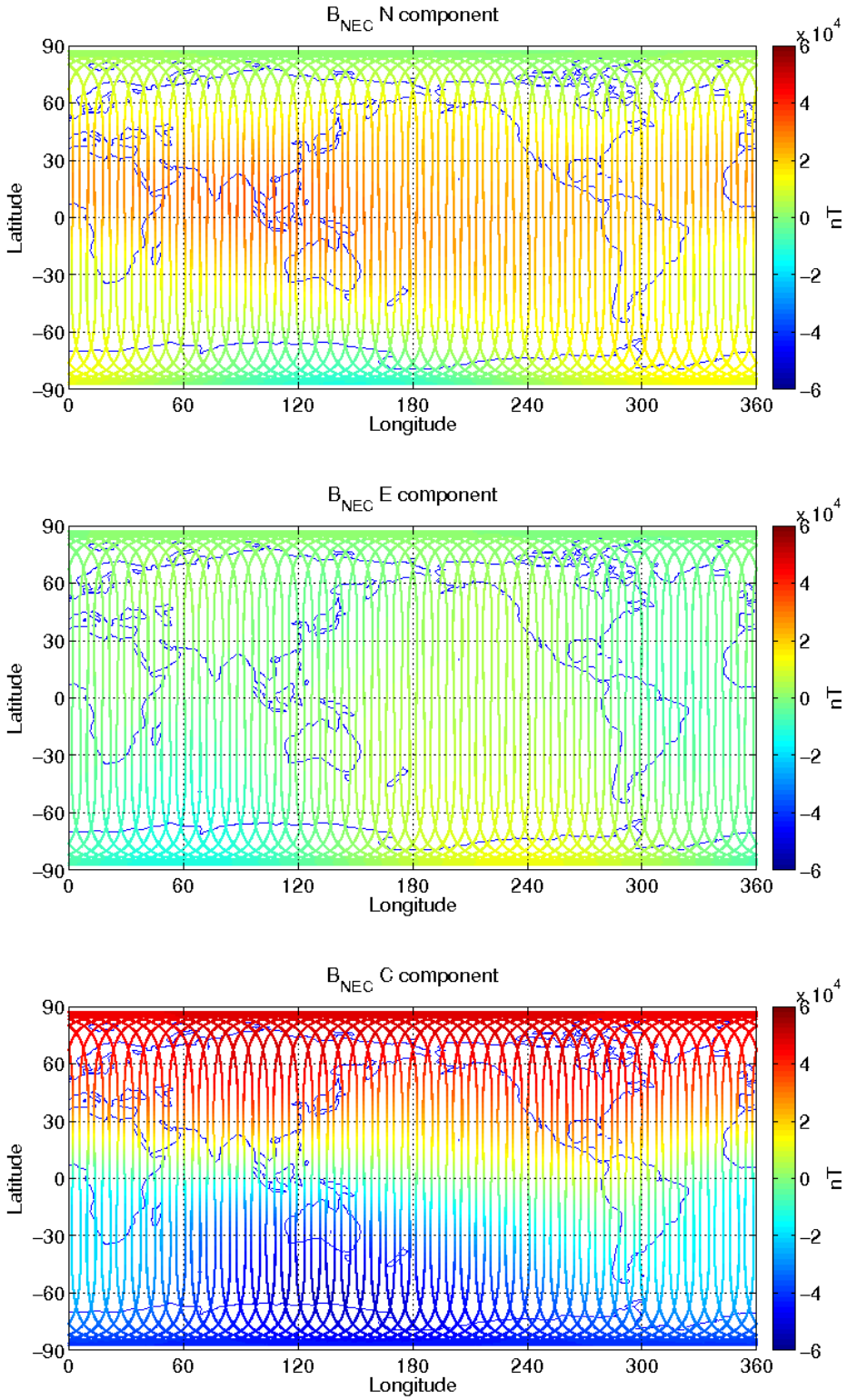


Figure 12: SC C, world map plots of the geomagnetic field and components measured during monitoring period 02/08-14/02. From top to bottom: B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement.

3.3.5 B_{NEC} vs Chaos5 model residuals

The magnetic field measurement is compared to magnetic field estimation calculate from Crustal and Core contributions of model Chaos5. Currently in the monitoring rotines the external contribution based on Dst index is not taken into account.

Figure 13, Figure 15 and Figure 17 show field residuals $dB=B_{NEC} - B_{Chaos}$ (all versus co-latitude in degrees), from top to bottom: 1) Br, 2) $B\theta$ and 3) $B\varphi$.

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 14, Figure 16 and Figure 18 show, from top to bottom, the time series on 02/08 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.

3.3.5.1 Swarm A

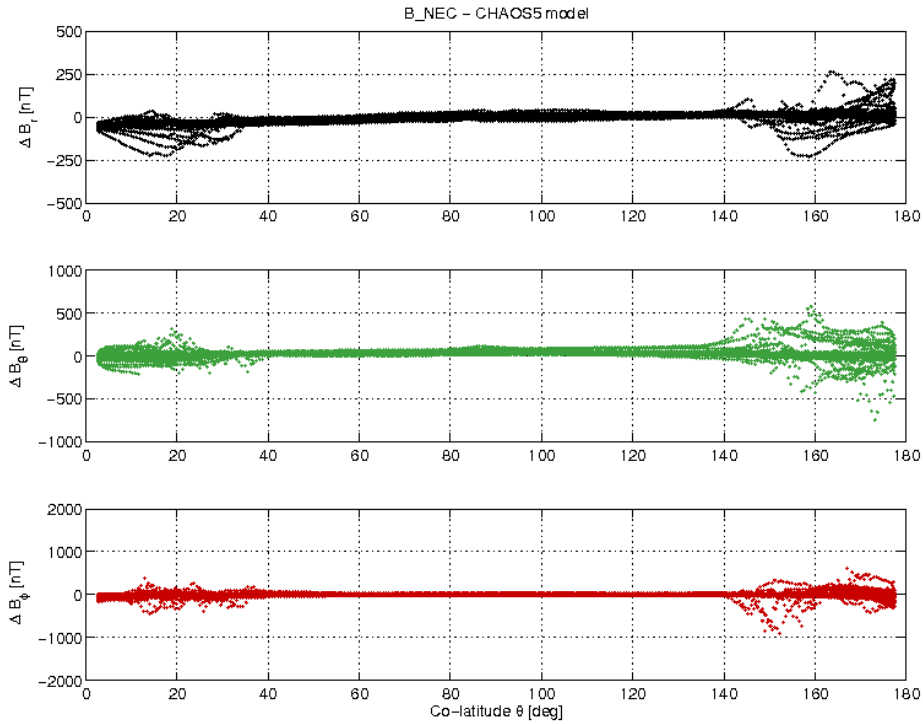


Figure 13: Swarm A day 08/02 B_{NEC} - B_{Chaos} vs colatitude.

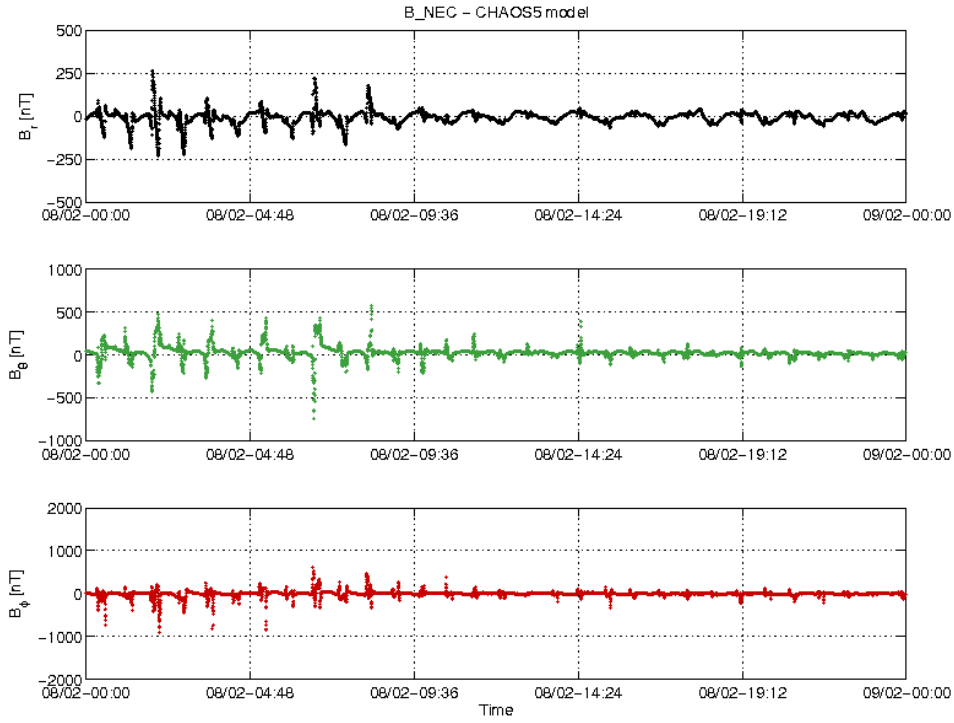


Figure 14: Swarm A day 08/02: time series of B_{NEC} – B_{Chaos} residuals.

3.3.5.2 Swarm B

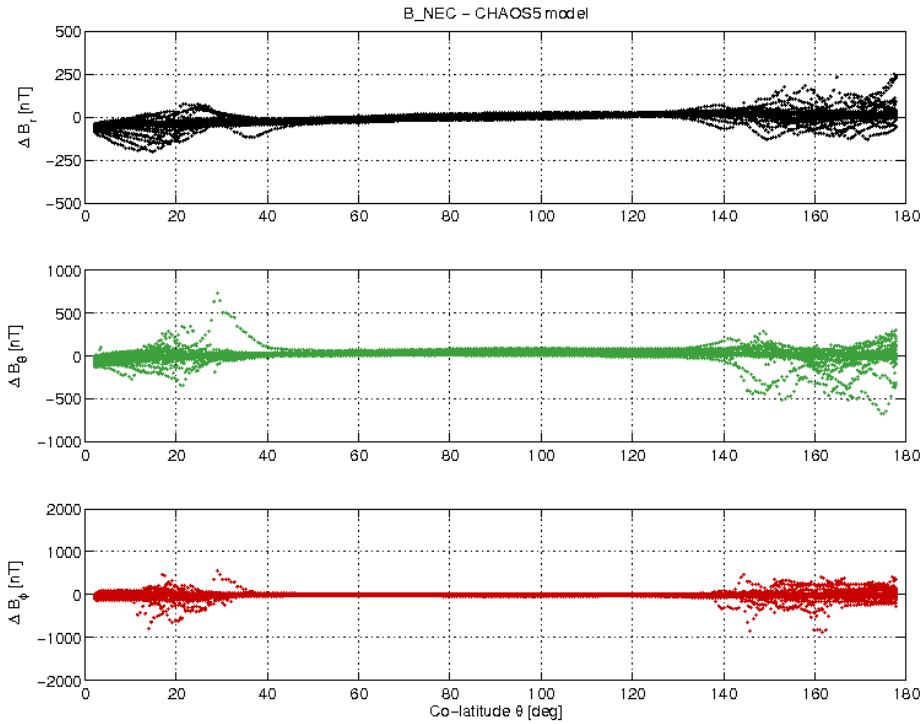


Figure 15 Swarm B day 08/02 B_{NEC} - B_{Chaos} difference vs colatitude.

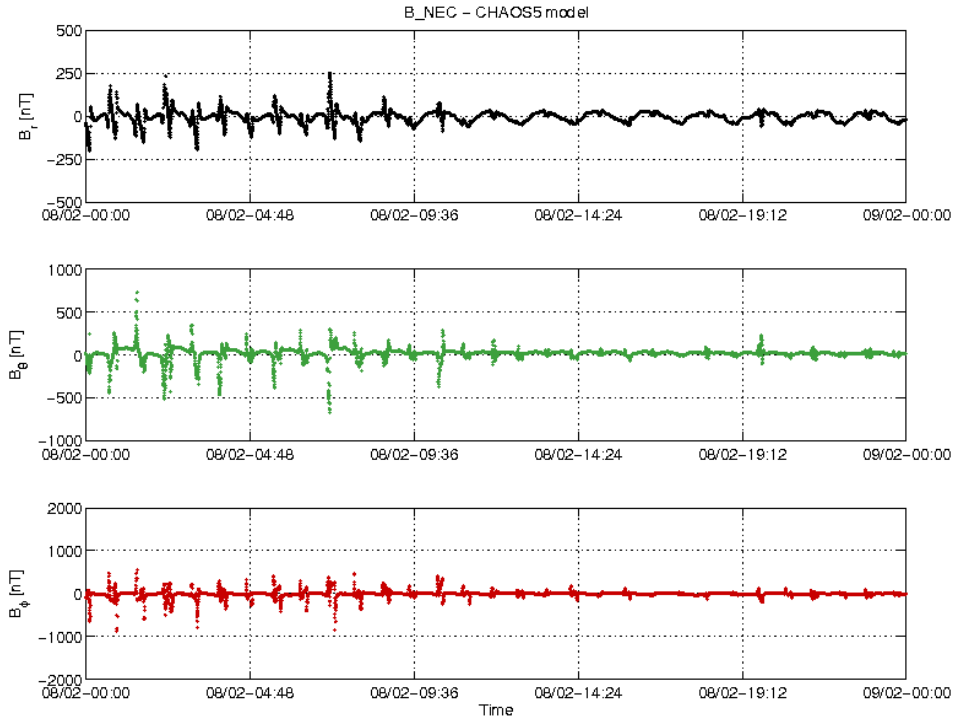


Figure 16 Swarm B day 08/02 time series of B_{NEC} – B_{Chaos} residuals.

3.3.5.3 Swarm C

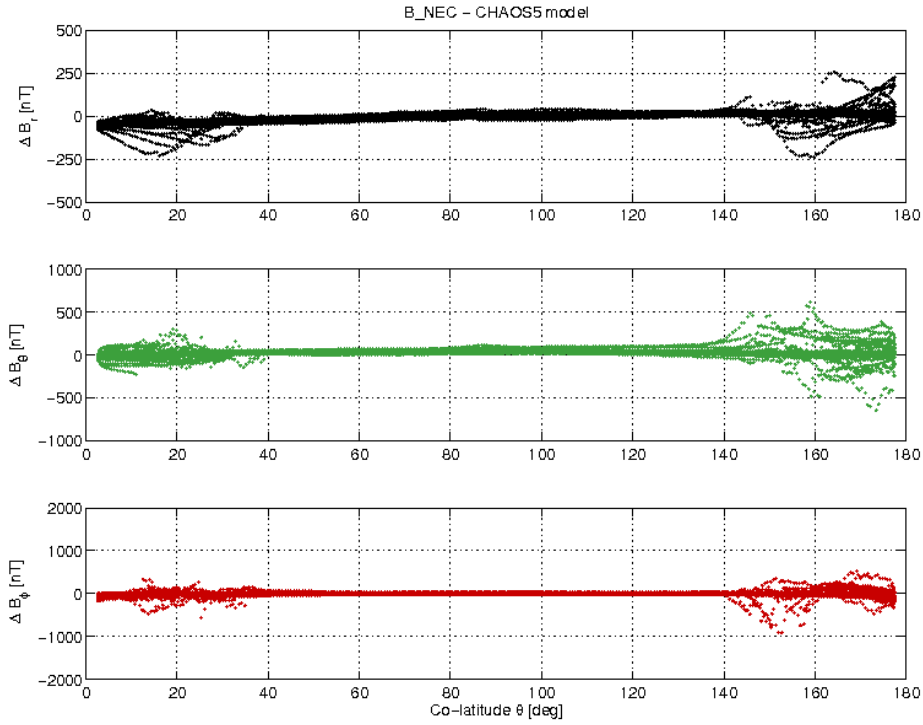


Figure 17 Swarm C day 08/02 B_{NEC} - B_{Chaos} difference vs colatitude.

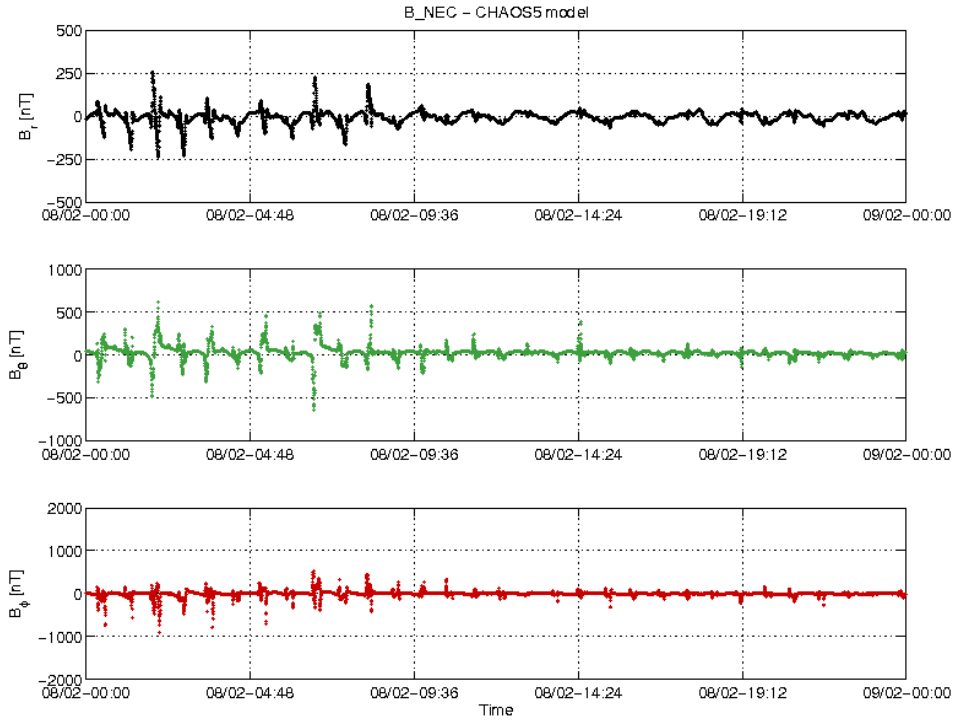


Figure 18 Swarm C day 08/02 time series of $B_{NEC} – B_{Chaos}$ residuals.

4. ON-DEMAND ANALYSIS

4.1 VFM-C power cycle on 10/02/2016 and Level 1B processor failure

From the FOS Weekly Operations report n. 116 [RD.19]:

"On the 10th of February, during the pass at 10.48z there were several VFM *[onboard Swarm C]* soft out of limits:
VST00184 VFM_Vref2p5Volt = 3.2188
VST00183 VFM_VExcVol = 3.2188
The above parameters were also flagged out of limit during last Swarm-B anomaly in Nov 2015.
VST00182 VFM_VDIG2VOLT = 3.2188
VST00186 VFM_VA2VOLT = 3.2188
VST00178 VFM_VA1VOLT = 3.2188
The anomaly occurred around 02:27z (10/02/2016), over the South Pole.
The signature was not exactly the same as in November 2015 (see AR SWARM_SC-41): this time the voltages jumped to 3.2188V and the Science VFM data was affected. The VFM ScienceData50Tm packets (APID 688) generated during the anomaly were all uncompressed packets and several packets were generated within one second (packet generation rate is 1Hz), the packet SSC was not consecutive and, for some cases, duplicated.
During the pass at 13.53z on the 10/02/2016, the VFM was power cycled and at 14.00z the unit was back to nominal operations."

In order to understand what does it mean: "the Science VFM data was affected", please refer to Figure 19, which shows the VFM C raw data, X component (in the VFM reference frame) during 10/02/2016, sampled at 1 Hz. The red data corresponds to compressed packets, which is the nominal telemetry packaging for the VFM; blue data corresponds to uncompressed packets: a packet is NOT compressed in the telemetry and it is therefore transmitted with the 50 Hz full values if one of the differences B[i+1] – B[i] > 8bit, where *i+1* and *i* are consecutive measurements. The plot below clearly shows that, during the onboard anomaly, the raw data showed high variability, with frequent duplicated 50 Hz packets in the same timestamp sequence.

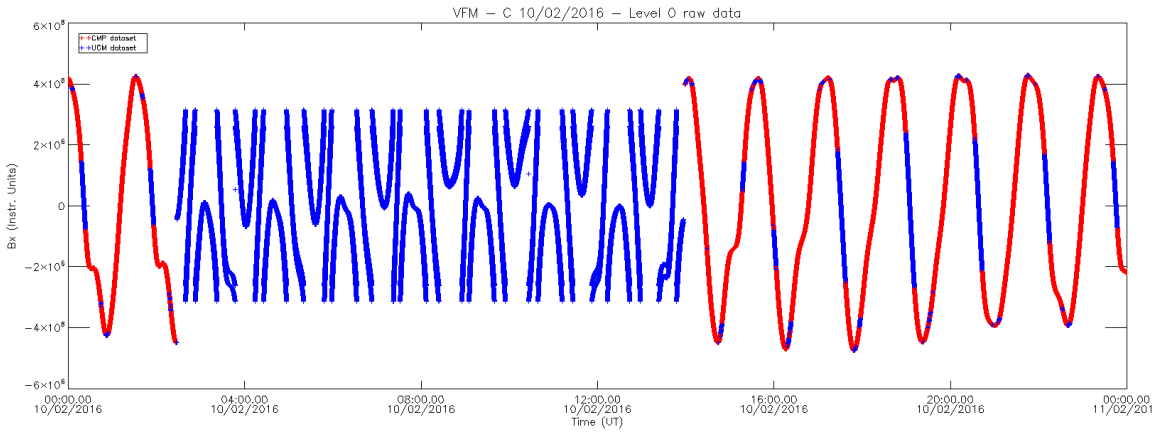


Figure 19: VFM C raw data, X component, on 10/02/2016. In red data from the compressed packets are represented, in blue one can see the uncompressed packets

See listed below, as an example, the first packet's timestamps after the anomaly start:

2016/02/10-02:27:40.919262
2016/02/10-02:27:41.919195
2016/02/10-02:27:42.919128
2016/02/10-02:27:43.919062
2016/02/10-02:27:44.918995
2016/02/10-02:27:45.918928
2016/02/10-02:27:**47**.809705
2016/02/10-02:27:**47**.954105
2016/02/10-02:27:**48**.098438
2016/02/10-02:27:**48**.242838
2016/02/10-02:27:**48**.820438
2016/02/10-02:27:**48**.964838
etc…

In a nominal situation, the telemetry generates one packet per second, each containing 50 measurements. Within this anomaly, the VFM DPU started generating multiple packets for each seconds, often containing the same measurements. Therefore, the Level 1B processor was not able to correctly sort the time stamps and failed in the linear interpolation of time.

This behavior, however, is not satisfactory, because, as one can see from Figure 19, an extended interval with good data exists for 10/2, so that the processor should be able to handle such kind of exceptions and produce data at least for the intervals unaffected by the onboard anomaly. The issue is under investigation within the processor manufacturer.

End of Document