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IDEAS+ Swarm Weekly Report 2016/04: 2016/01/25 - 2016/01/31

Abstract : This is the **Instrument Data Quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 25 January to 31 January 2016.

Author :
Igino Coco, Jan Miedzik and Enkelejda Qamili on behalf of Swarm IDEAS+ Team

Approval :
Lidia Saavedra de Miguel
IDEAS+ Science and Ops. Coordinator

Distribution : ESA/ESRIN EOP-GMQ
ESA/ESRIN EOP-GM Swarm MM
IDEAS+ Leadership Team
IDEAS+ subcontractors
ESA/ESTEC Swarm PLSO
ESA/ESOC Swarm FOS

Telespazio VEGA UK Ltd
350 Capability Green, Luton, Bedfordshire, LU1 3LU, United Kingdom
Tel: +44 (0) 1582 399 000 Fax: +44 (0) 1582 728 686
www.telespazio-vega.com

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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	10 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-6210_Swarm_Weekly_Operations_Report#114_25-01-2016_31-01-2016.pdf

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 new delivery of the L1BOP will be delivered in the coming days. This new delivery will cope with the following issues:

1. RINEX correction due to a better alignment of the Instrument Measurement Time,
2. Fixing ORBATT bugs (related to Leap second handling and handling of minor SPRs)
3. Separating the time dependent calibration corrections and the external disturbance effects in the VFM data: introduction of “s_beta” (scale factor depending on elevation angle Beta) and “s_exp” (“aging” scale factor modelled as an exponential function) in the scale calibration.
4. Possibly, a correction in the conversion from Level 0s into Level 1B of the Langmuir Probe offset parameters.

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

A new delivery of the Level 2 – Cat 2 EEF processor that will allow us to produce EEF data also for Swarm C after the ASM stop will be delivered.

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

IRF has just delivered the “16 Hz Faceplate currents and derived electron density” dataset that will be published in the ESA ftp server (/Advanced folder) in the coming days. 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 4 (25/01 - 31/01)

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

- Multiple gaps in magnetic and attitude products on all SC on 26/01. The reason was GPS synchronization status issue, more details in section 4.
- **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

- **Multiple gaps in magnetic and attitude products**, for all SC on 26/01 due to GPS synchronization status issue, more details in section 4 and section 3.2.2.
- **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 4: 25/01 - 31/01.

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, 25/01 - 31/01, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
25/01	0.16	-7.6	10.2 (Y)	1.35	
26/01	0.1	-7.9	9	1.22	
27/01	0.06	-6.7	5.5	1.14	
28/01	0.07	-7.5	6.6	1.11	
29/01	0.14	-10.3	8	1.48	
30/01	0.15	-7	9	1.4	
31/01	0.09	-15	6.6	1.33	
Swarm B, 25/01 - 31/01, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
25/01	0.07	-7.1	5.7	1.15	
26/01	0.09	-6.3	5.9 (X)	1.18	
27/01	0.02	-6.4	6.4	1.13	
28/01	0.1	-5.5	5.7	1.07	
29/01	0.12	-6.3	10.5	1.4	
30/01	0.04	-6	6.6	1.26	
31/01	0.1	-6.9 (Y)	6.5	1.2	
Swarm C, 25/01 - 31/01, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
25/01	0.18	-7.9	10.1	1.3	
26/01	0.09	-9.6	6.6	1.2	
27/01	0.03	-6.9	6.1	1.14	
28/01	0.08	-7.5 (X)	8.3	1.08	
29/01	0.13	-9.1	8.3	1.45	
30/01	0.14	-7.5	7.9	1.4	
31/01	0.08	-10.2	6.9	1.26	

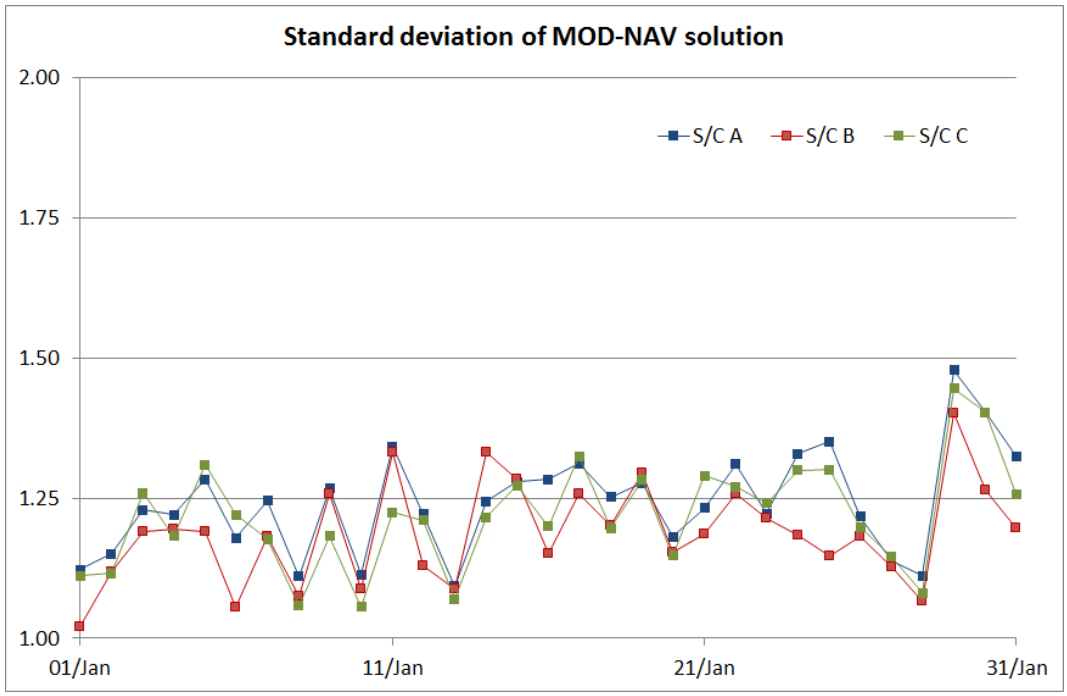


Figure 1: Plot of the standard deviation of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

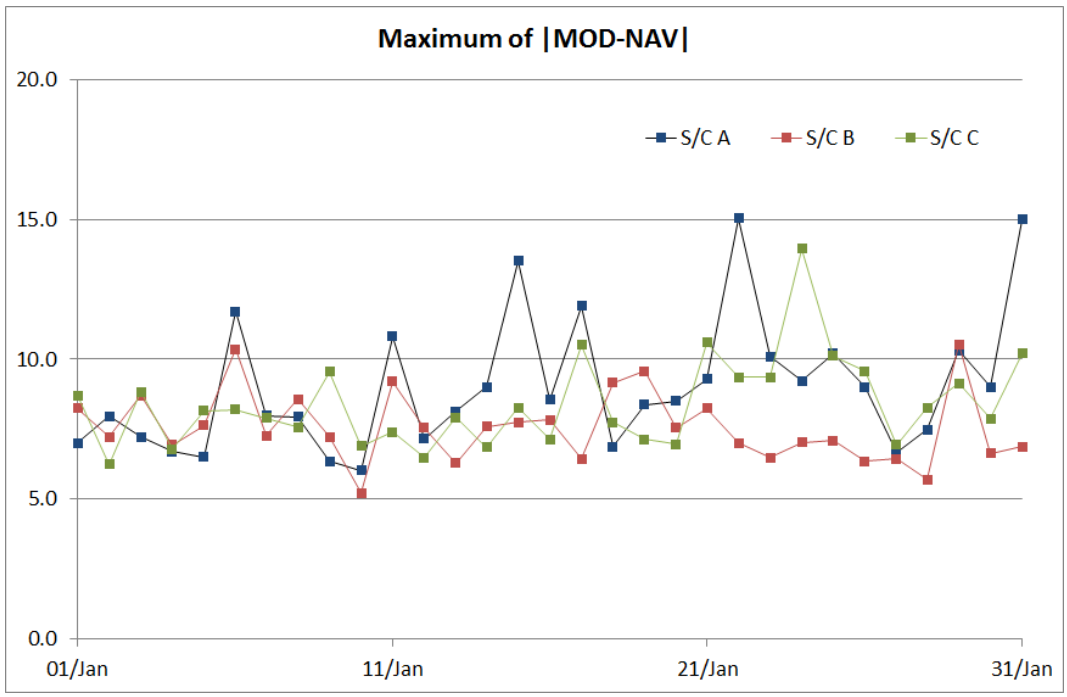


Figure 2: Plot of the maximum difference of the absolute value of the difference between MOD and NAV solutions for all satellites. Plot covers last month of operation.

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 (25/01, 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].

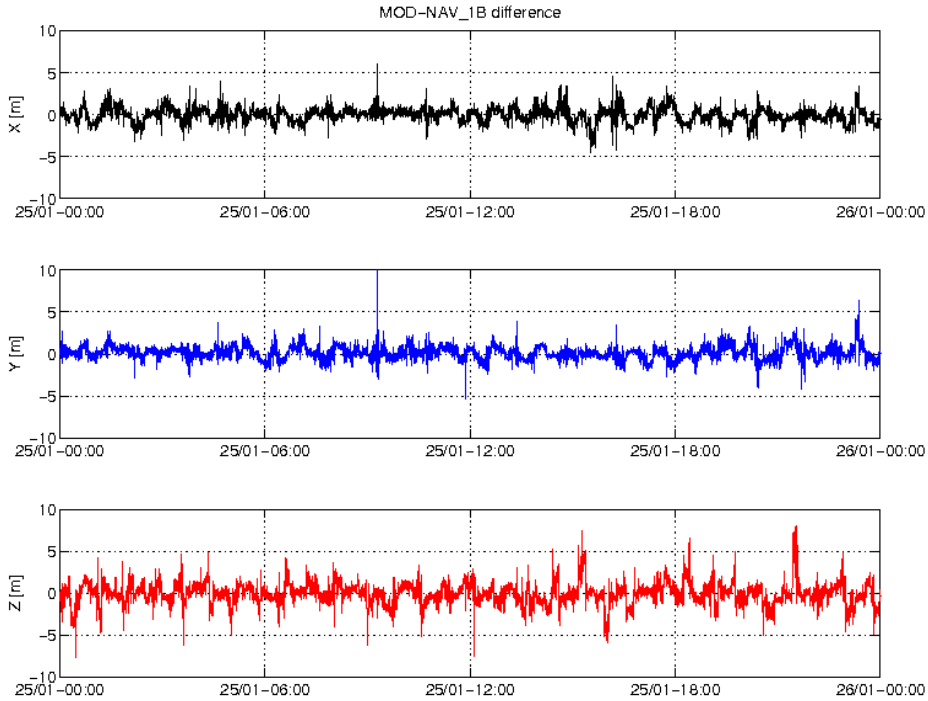


Figure 3: Difference MOD-GPSNAV, S/C A, 25/01. From top to bottom: X, Y and Z-axis

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 (25/01, 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].

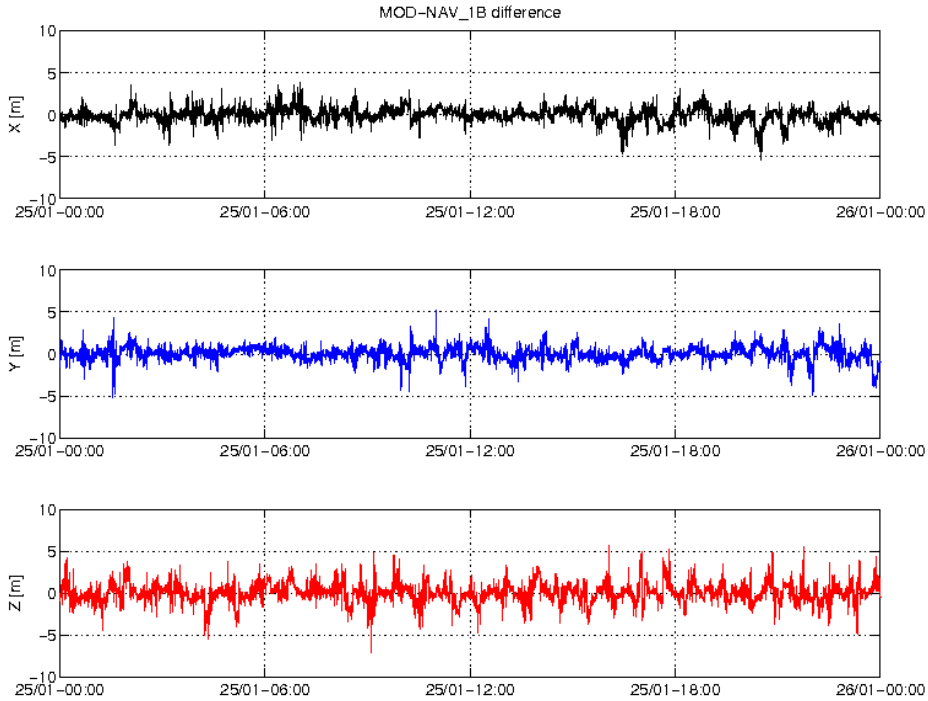


Figure 4: Difference MOD-GPSNAV, S/C B, 25/01. From top to bottom: X, Y and Z-axis

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 (25/01, 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].

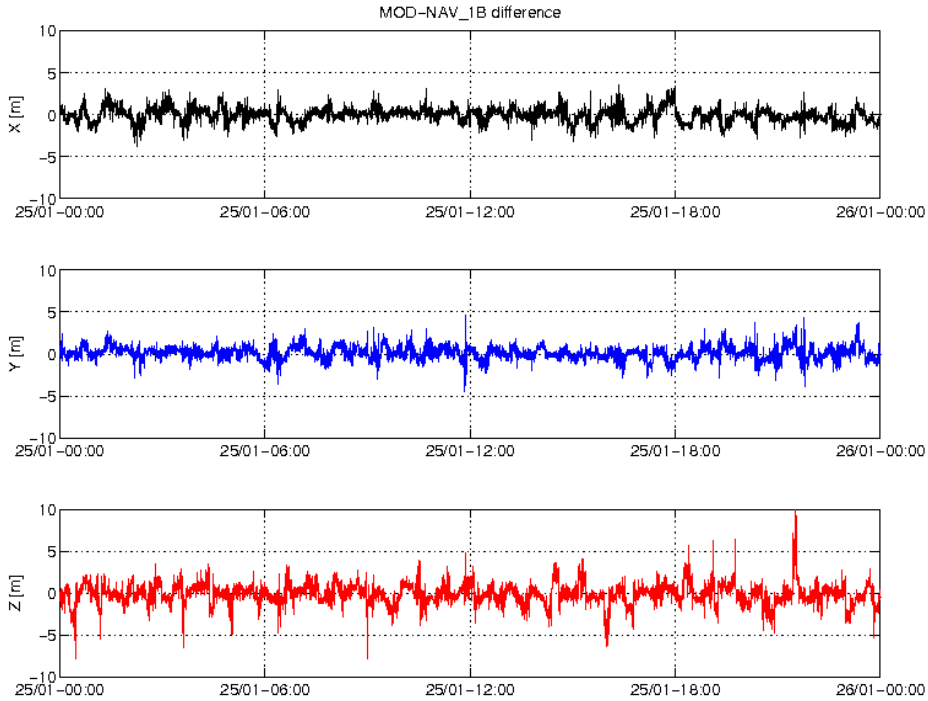


Figure 5: Difference MOD-GPSNAV, S/C C, 25/01. From top to bottom: X, Y and Z-axis

3.2.2 Attitude observations

3.2.2.1 Swarm A

Multiple gaps on 26/01 caused by GPS synchronization issue. More details in [RD.19].

3.2.2.2 Swarm B

Multiple gaps on 26/01 caused by GPS synchronization issue. More details in [RD.19].

3.2.2.3 Swarm C

Multiple gaps on 26/01 caused by GPS synchronization issue. More details in [RD.19].

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. 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 4: 25/01 - 31/01.

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: on day 26/01, on all SC, we observe gaps in magnetic products. This is caused by GPS synchronization status issue.

- SC A – violation of:
  - VFM-ASM residuals threshold on 25/01, 27/01;
- SC B – violation of:
  - VFM-ASM residuals threshold on 25/01, 26/01;
  - mean value of residuals threshold on 25/01 - 31/01;

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, 25/01 - 31/01, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
25/01	**1.03**	-0.36	0.26	0.24	
26/01	0.99	-0.26	0.21	0.246	
27/01	**1**	-0.3	0.22	0.243	
28/01	0.93	-0.3	0.21	0.239	
29/01	0.84	-0.27	0.19	0.242	
30/01	0.84	-0.25	0.19	0.247	
31/01	0.82	-0.28	0.18	0.26	
Swarm B, 25/01 - 31/01, ASM-VFM difference					
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (nT)**	**Mean (nT)**	**Notes**
25/01	**1.16**	-0.31	0.26	**0.329**	
26/01	**1**	-0.43	0.22	**0.329**	
27/01	0.91	-0.28	0.21	**0.34**	
28/01	0.88	-0.19	0.18	**0.352**	
29/01	0.86	-0.29	0.18	**0.356**	
30/01	0.92	-0.28	0.18	**0.364**	
31/01	0.85	-0.24	0.17	**0.373**	

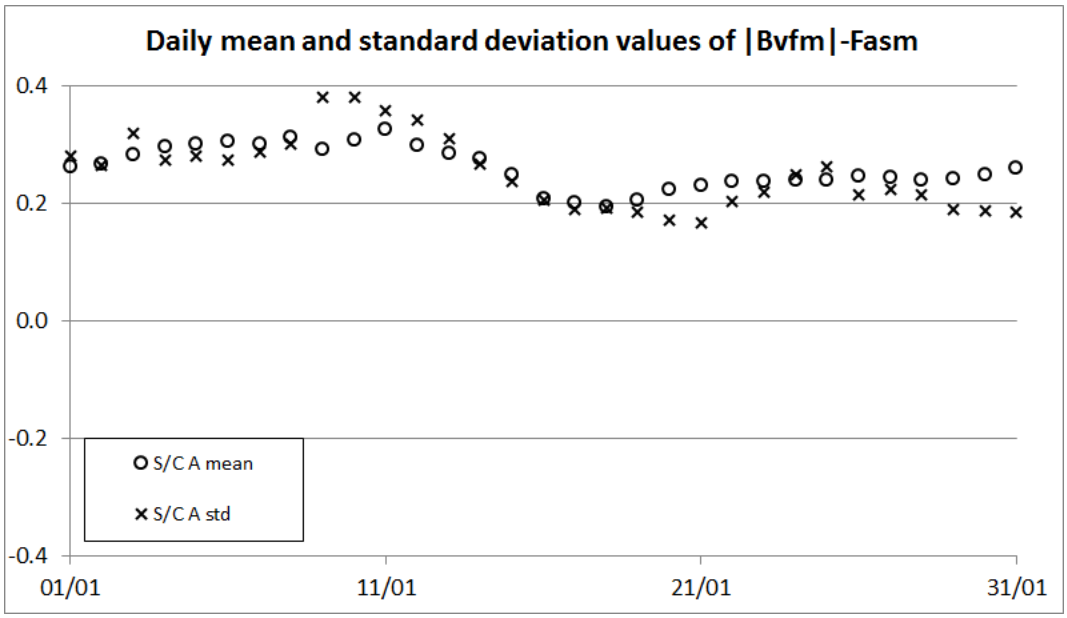


Figure 6: Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C A.

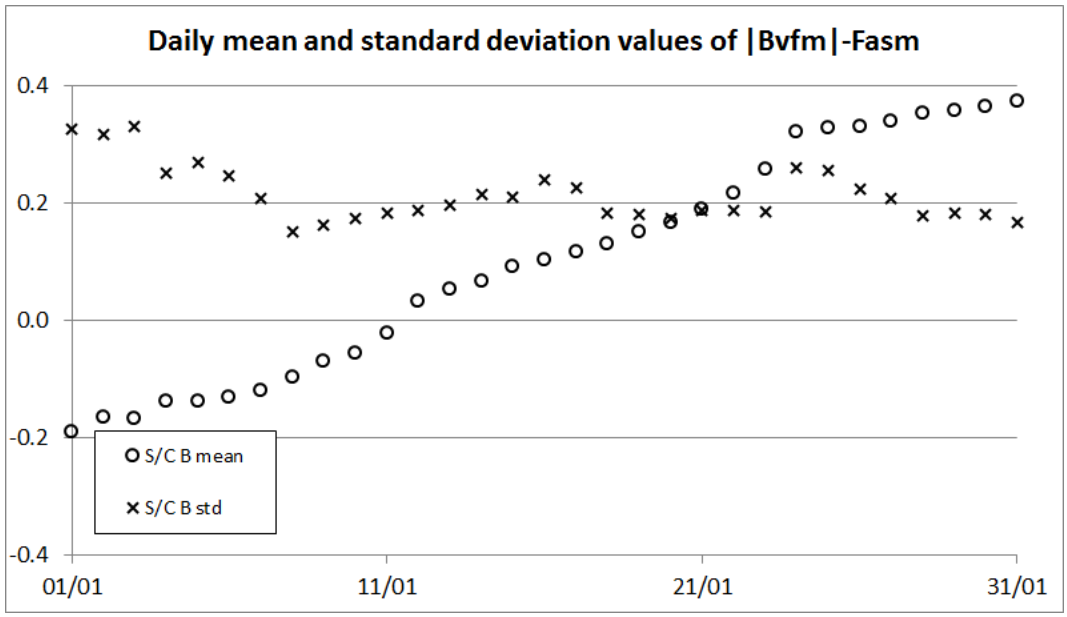


Figure 7: Daily mean and standard deviation values of ASM-VFM residuals (defined as $dF=|B_{VFM}|-F_{ASM}$) for S/C B.

3.3.1.2 Swarm A

The daily peak-to-peak difference around the week stays within [-0.36, 1.03] nT. Below follow two plots of such differences for current week (Figure 8).

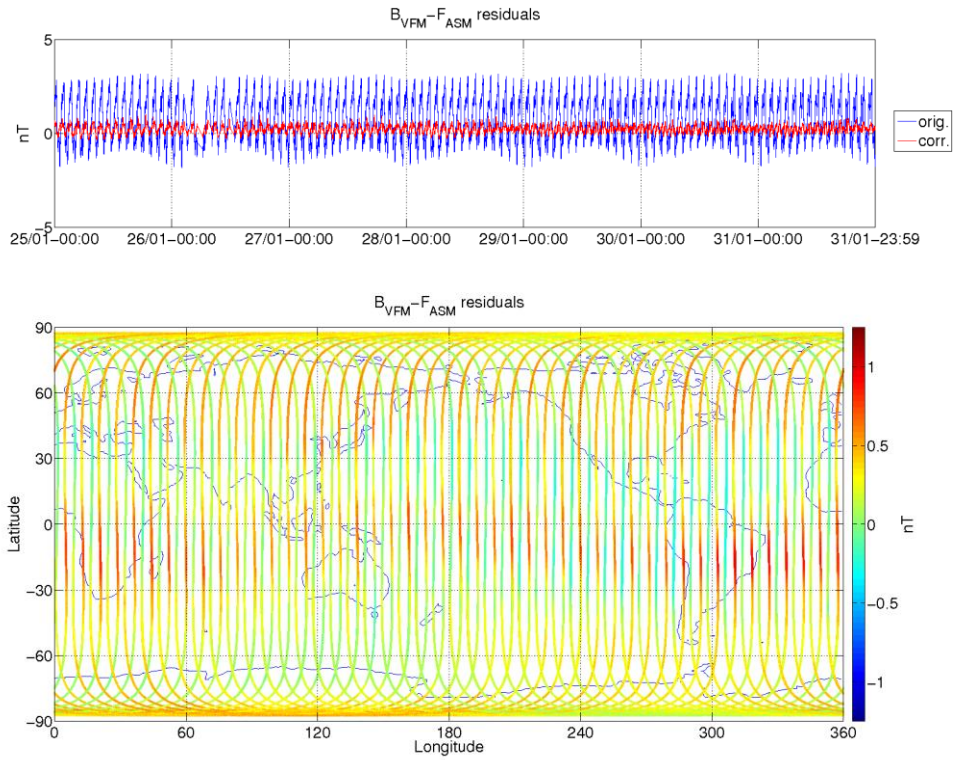


Figure 8: ASM-VFM residuals for S/C A, during monitoring period 25/01-31/01. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map. On the top plot it is clearly seen the influence of GPS synchronization loss on 26/01.

3.3.1.3 Swarm B

The daily peak-to-peak difference around the week stays within [-0.43, 1.16] nT. Below follow two plots of such differences for current week (Figure 9).

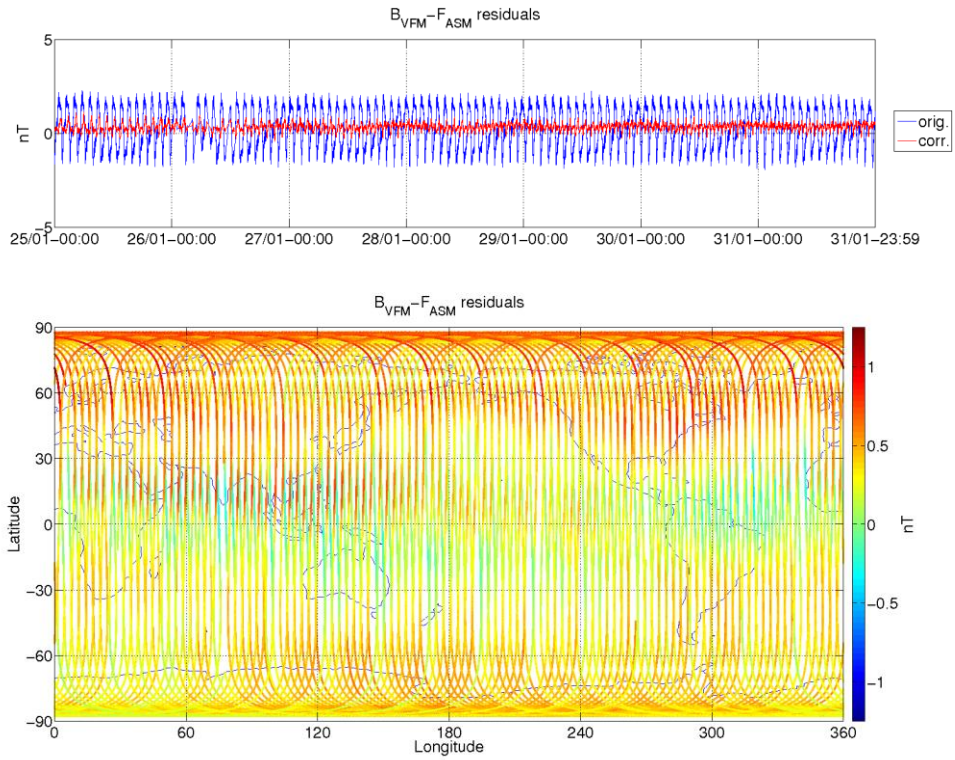


Figure 9: ASM-VFM residuals for S/C B, during monitoring period 25/01-31/01. In top figure are plotted: difference between |B_VFM| and F_ASM (without dB_Sun correction) (blue colour), and the residuals with dB_Sun corrections (red colour). In bottom figure residuals are presented on the world map. On the top plot it is clearly seen the influence of GPS synchronization loss on 26/01.

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)

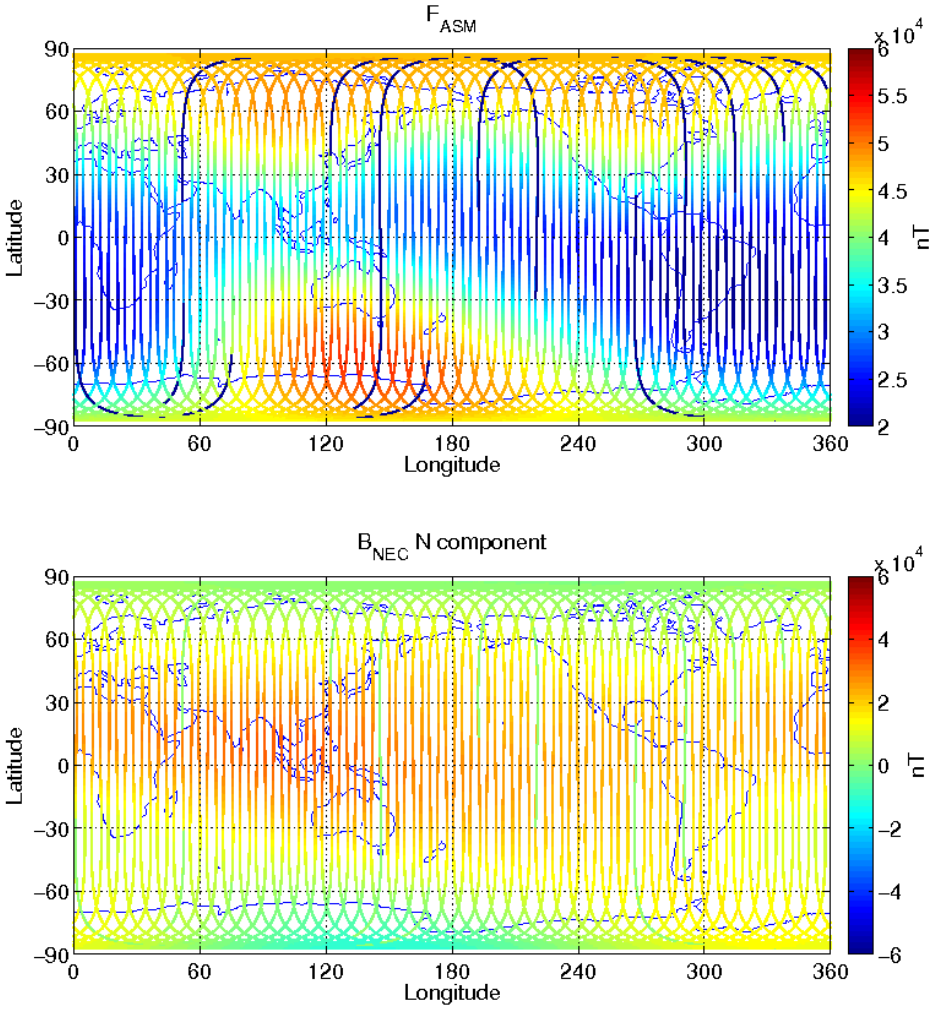
The VFM instrument parameters important for monitoring the instrument health are the VFM sensor temperatures: T_CDC, T_CSC and T_EU.

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



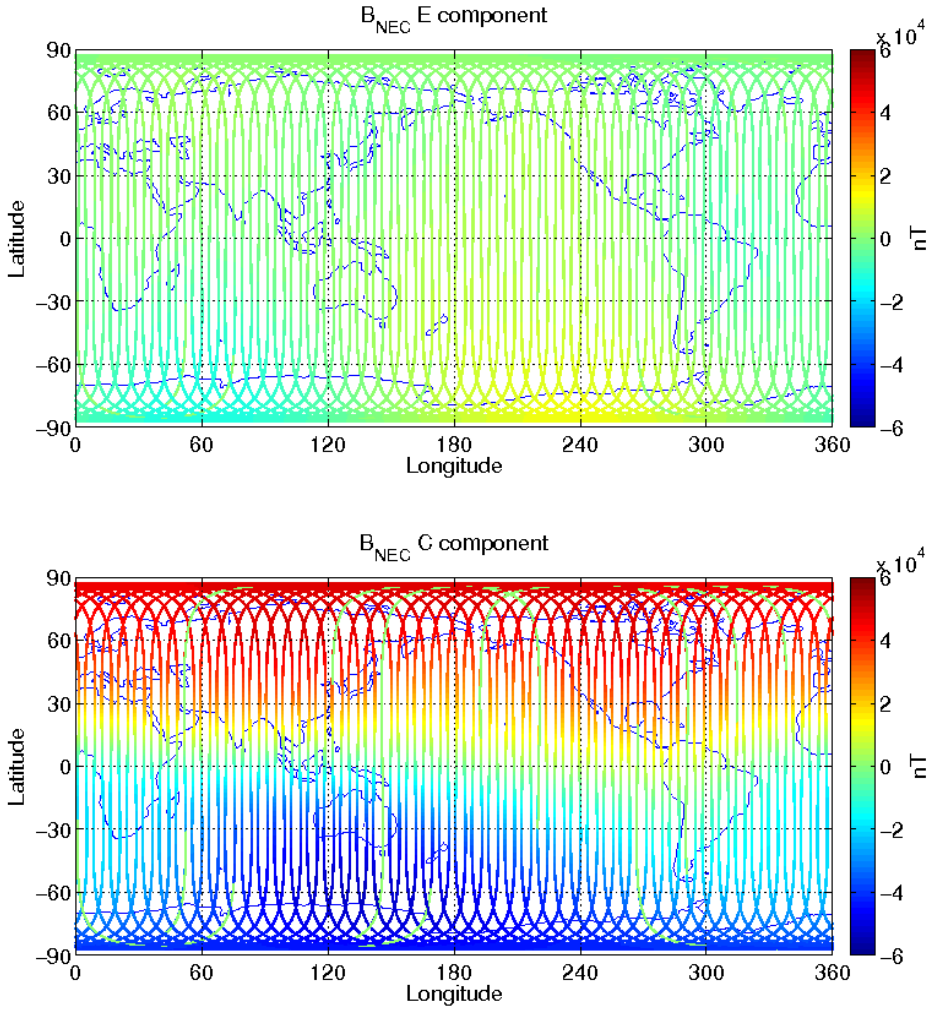
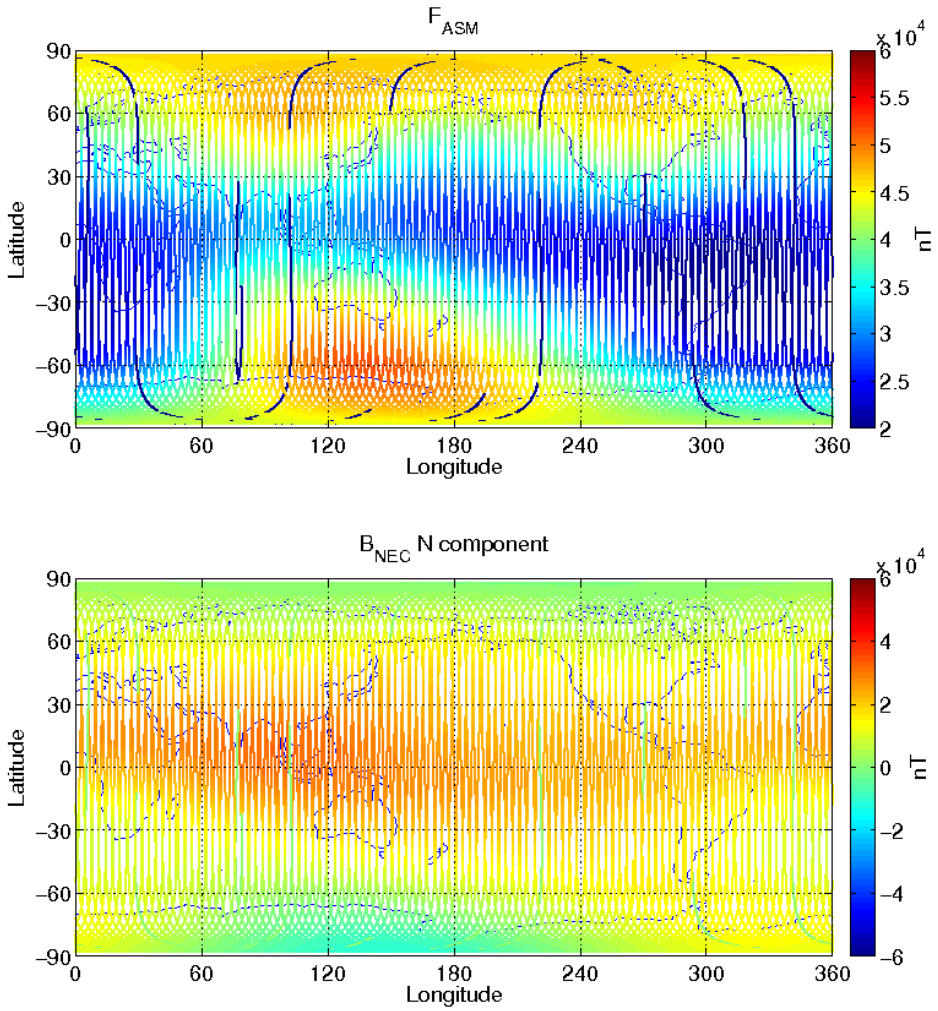


Figure 10: SC A, world map plots of the geomagnetic field and components measured during monitoring period 25/01-31/01. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement. On the plots it is clearly seen the influence of GPS synchronization loss. On the F plot 0 value plotted with blue colour covering up to half of the orbit. On B_{NEC} components plots this is less visible. The zero value here is plotted with green colour.

3.3.4.2 Swarm B

Map plots of magnetic field measurement for week 4 for S/C B can be seen in Figure 11 below.



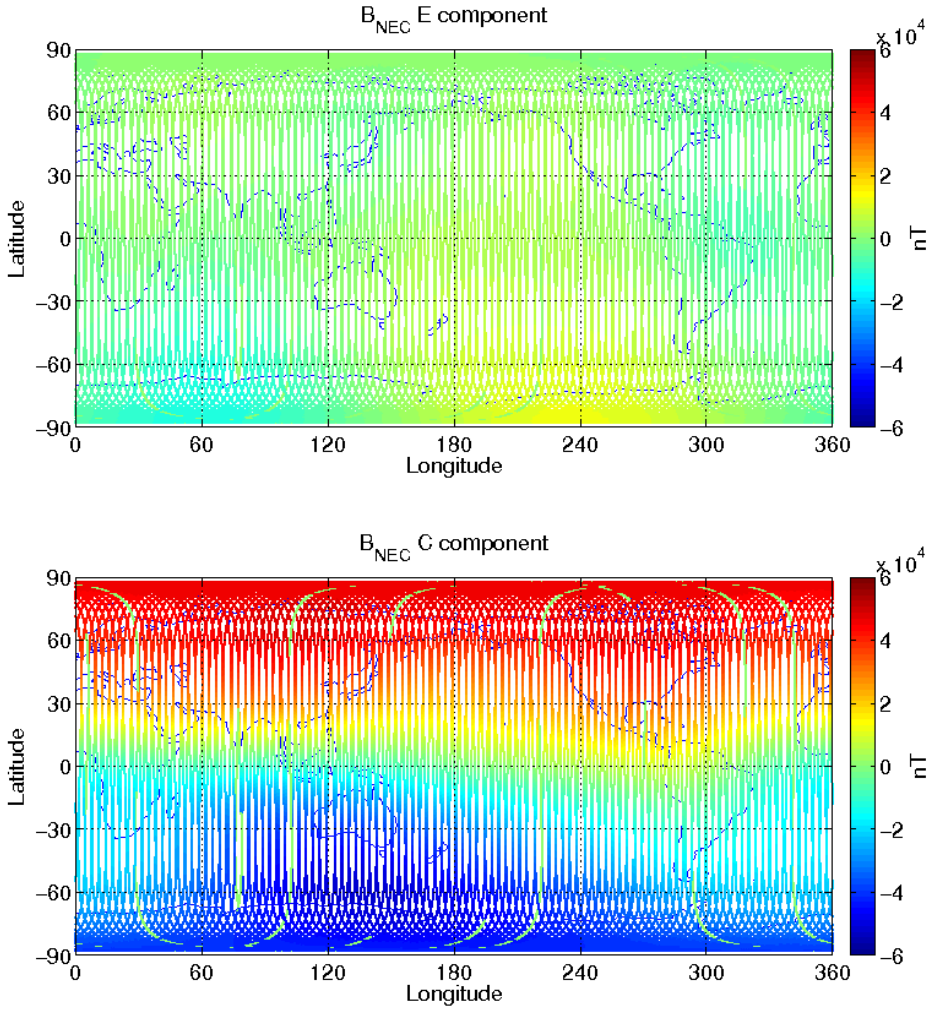


Figure 11: S/C B, world map plots of the geomagnetic field and components measured during monitoring period 25/01-31/01. From top to bottom: F-magnetic field from ASM measurement, B_{NEC} components (North, East, and Centre) of magnetic field from VFM measurement. On the plots it is clearly seen the influence of GPS synchronization loss. On the F plot 0 value plotted with blue colour covering up to half of the orbit. On B_{NEC} components plots this is less visible. The zero value here is plotted with green colour.

3.3.4.3 Swarm C

Map plots of magnetic field measurement for week 4 for S/C C can be seen in Figure 12.

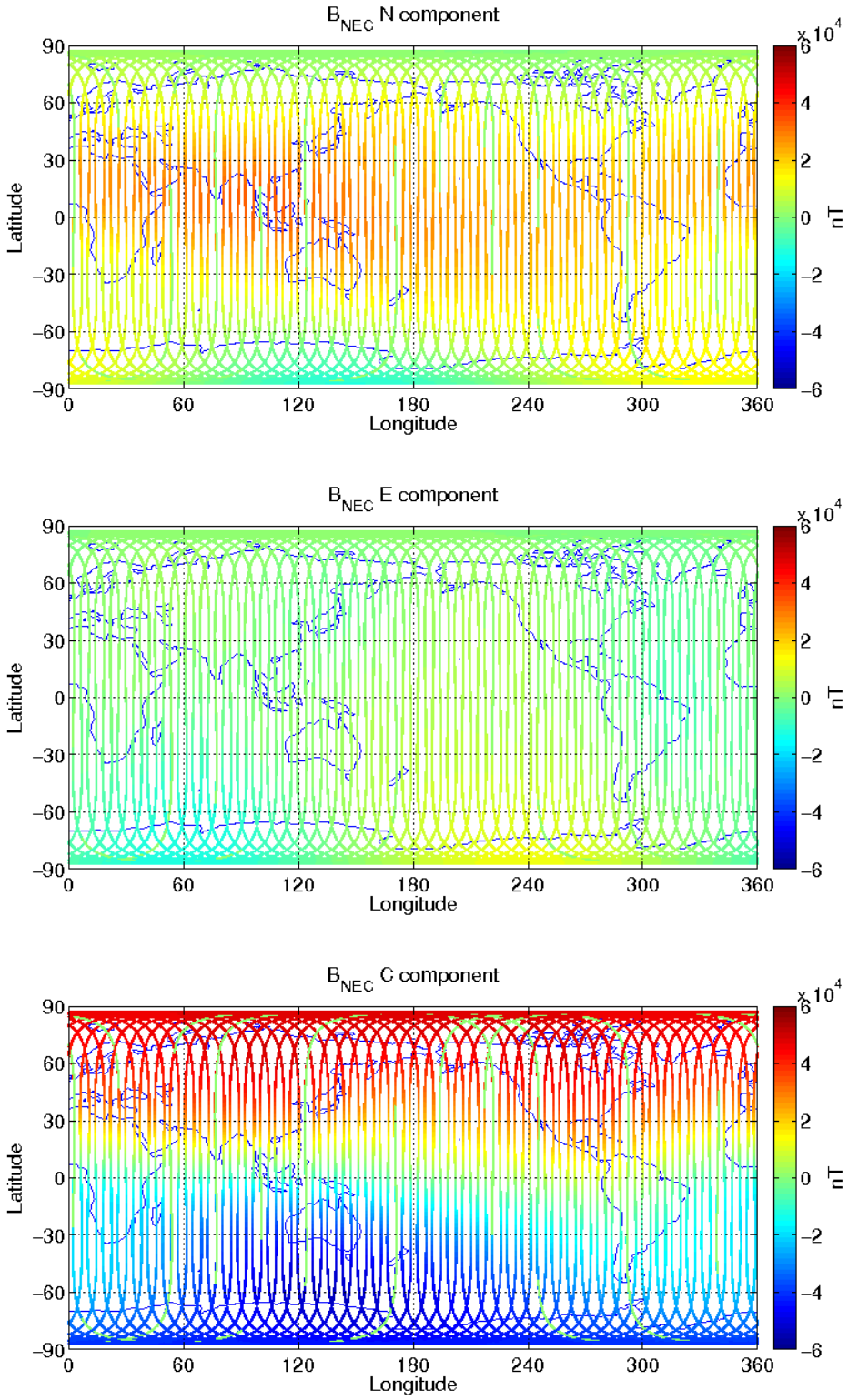


Figure 12: SC C, world map plots of the geomagnetic field and components measured during monitoring period 25/01-31/01. From top to bottom: B_{NEC} components (North,

East, and Centre) of magnetic field from VFM measurement. On the plots, it is slightly visible the GPS synchronization issue. The zero value here is plotted with green colour.

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 routines 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) 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 14, Figure 16 and Figure 18 show, from top to bottom, the time series on 25/01 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

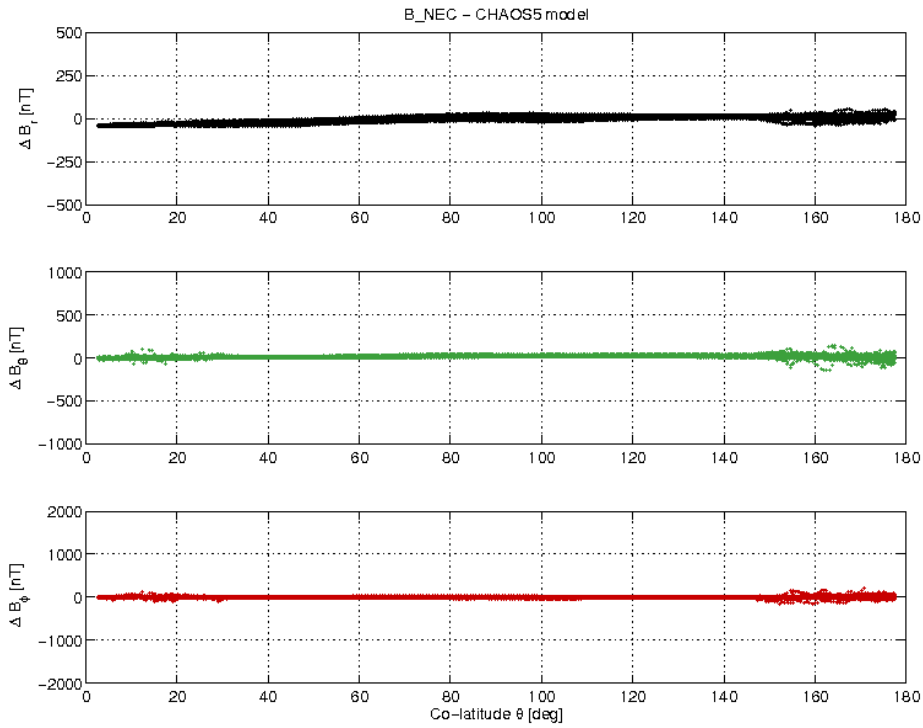


Figure 13: Swarm A day 25/01 B_{NEC} - B_{Chaos} vs colatitude.

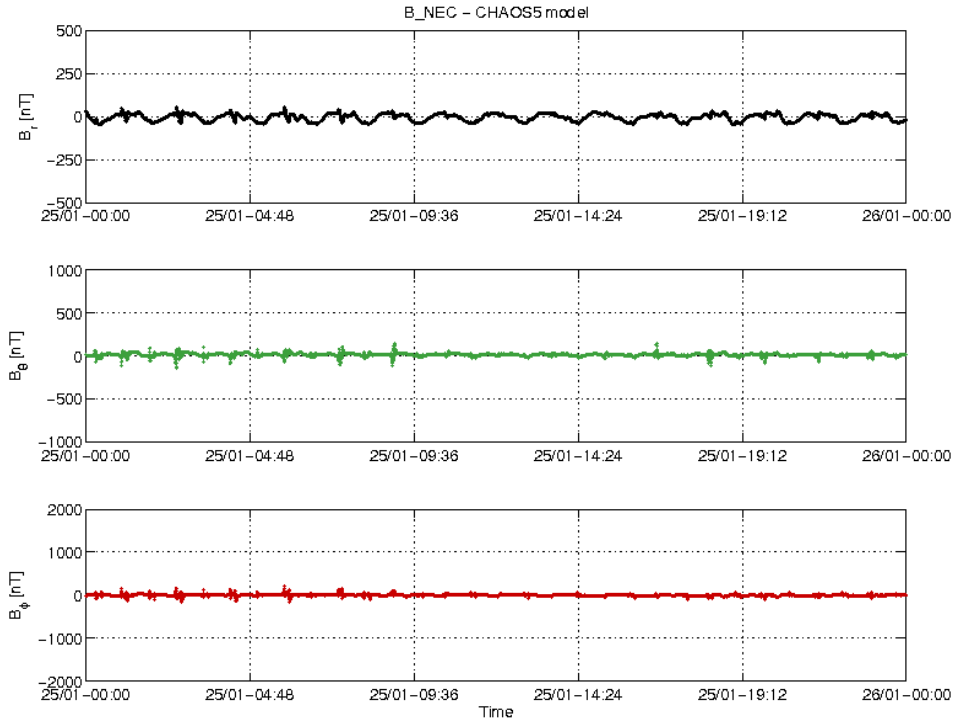


Figure 14: Swarm A day 25/01: time series of B_{NEC} – B_{Chaos} residuals.

3.3.5.2 Swarm B

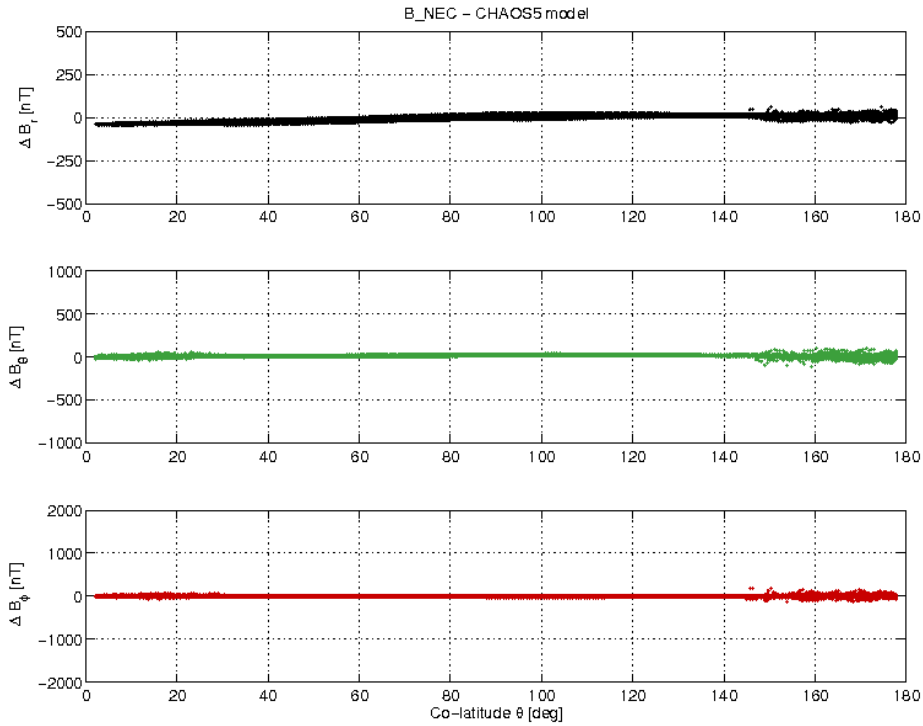


Figure 15: Swarm B day 25/01 B_{NEC} - B_{Chaos} difference vs colatitude.

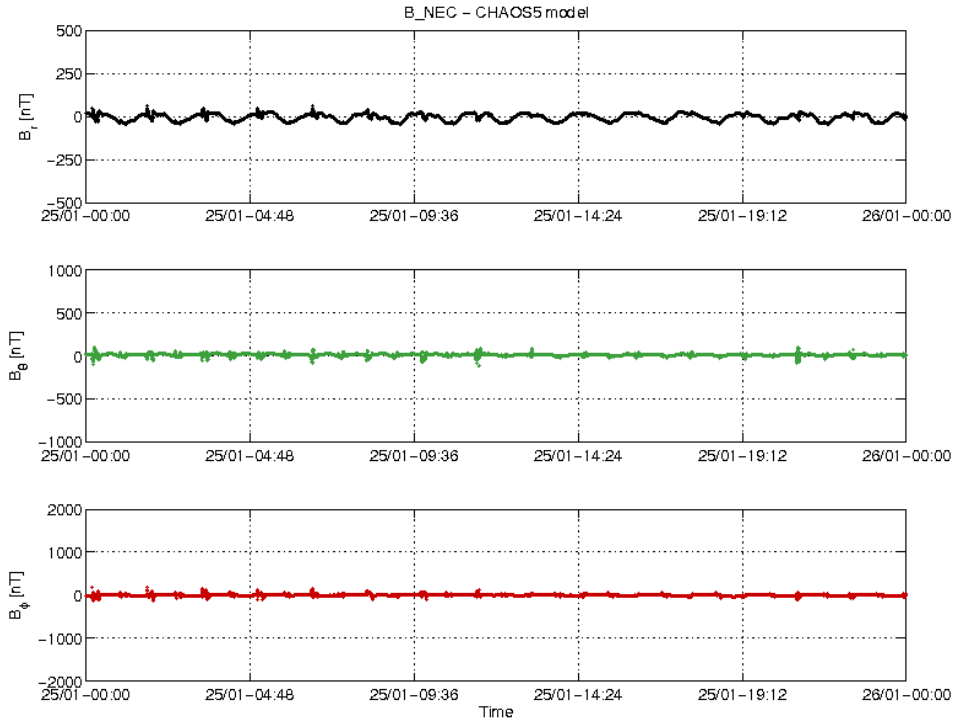


Figure 16: Swarm B day 25/01 time series of B_{NEC} – B_{Chaos} residuals.

3.3.5.3 Swarm C

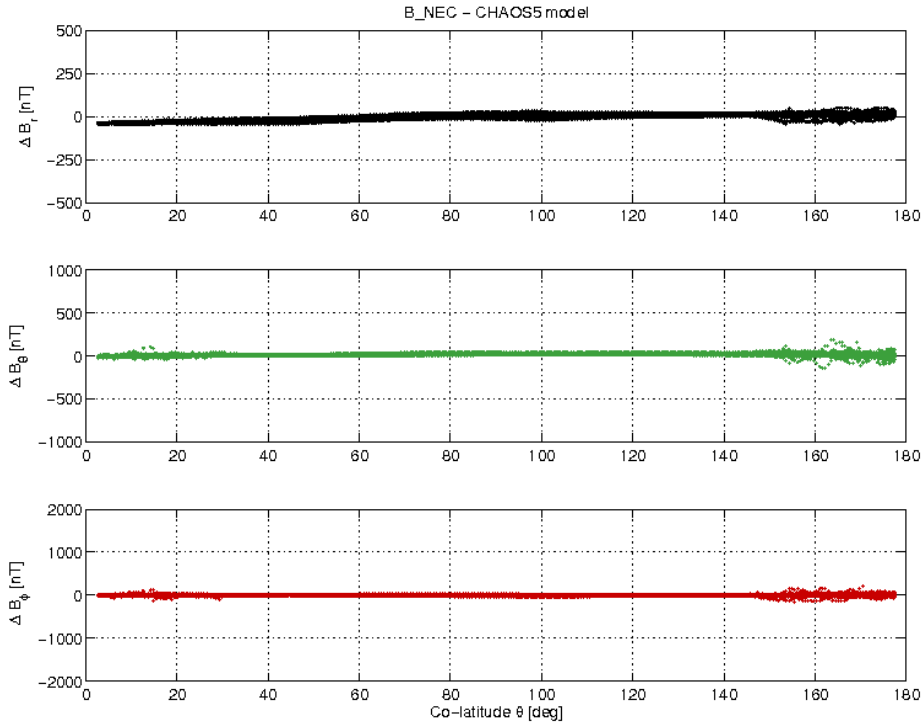


Figure 17: Swarm C day 25/01 B_{NEC} - B_{Chaos} difference vs colatitude.

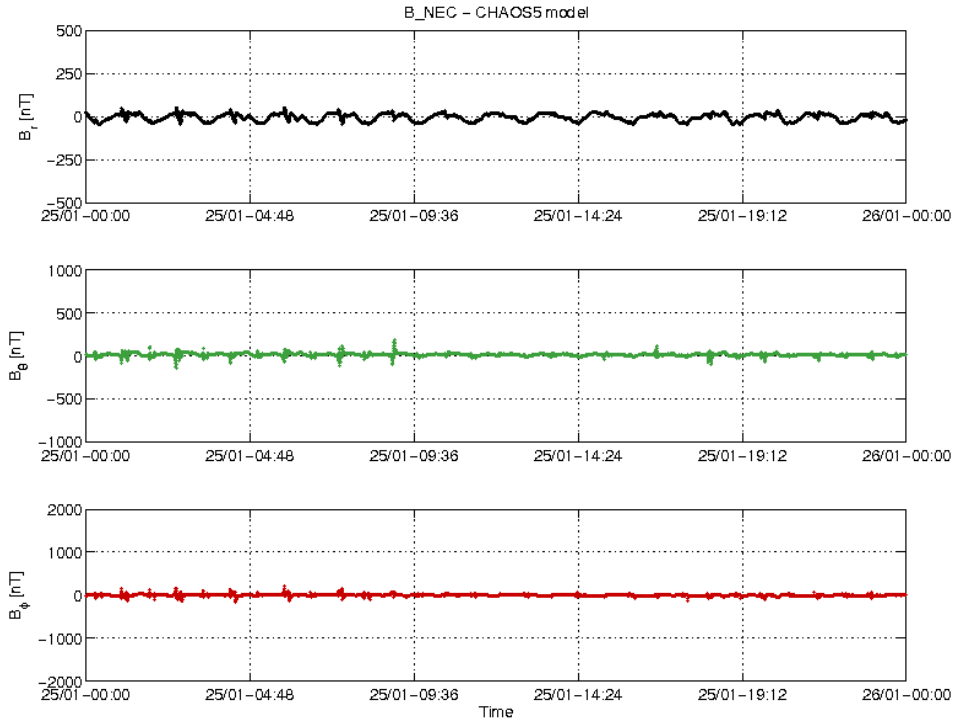


Figure 18: Swarm C day 25/01 time series of $B_{NEC} – B_{Chaos}$ residuals.

4. ON-DEMAND ANALYSIS

4.1 GPS sync loss on 26/01/2016

First observations come from FOS on 26/01/2016:

"*[From Laurent Maleville, two separate messages]*

[26/01 – 10:56]

For your information we are experiencing occurrences of GPS Synchronisation Loss on Swarm B since 1:06z today (DoY 26) of duration between 25 minutes and 1 hour. We have seen 5 occurrences so far. They don't seem to be caused by the GPS which appears to be valid and may the due to the anomaly of the time synchronisation on board (OBC). We will continue to monitor the situation and keep you informed. […]

[26/01 – 15:36]

I would like to report that we have seen on the two other Swarm A and C a repetition of the GPS time synchronisation lost where the GPS data stay valid. It can be noted that the first event on Swarm B and C are occurring at the same time and the first of Swarm A is at the same time then the second one of Swarm C.
The synchronisation between satellites appears then to show that the problem is different from the known issue on the OBC synchronisation error".

An Anomaly Review Board was called by PLSO for the day after, the main conclusions of which were *[From Pierre Vogel, 27/01/2016]*:

"FOS recalls briefly the observations made yesterday (see Laurent's messages further below) pointing out a different signature with respect to the past sync loss anomalies. FOS also mentions that the anomaly has now disappeared on all satellites. Responding to a query from AIRBUS, FOS indicates that such an anomaly was not observed on other satellites yesterday, in particular on Sentinel-2.

AIRBUS has identified that, whenever the anomaly is present, the time provided by GPSR includes 13 micro-seconds instead of zero micro-second. Therefore AIRBUS suspects a problem in GPSR.
AIRBUS also mentions that, despite the anomaly, the On-Board Computer continues to synchronise the On-Board Reference Time with the GPS UTC, therefore no impact of the anomaly is anticipated on the Payload data.
AIRBUS notes that, while the anomaly was present, the GPSR Quality Index remained well below 1000 (around 75), a sign of correct GPSR functioning in principle.
PLSO points out that the anomaly event on any satellite occurs at a time including as seconds either 08 or 38:.such a systematic time might originate in the GPS constellation.

In summary, with FOS indicating that EDDS includes now all the anomaly relevant data dumps, AIRBUS will contact RUAG asking that the 13 micro-second offset be investigated and that further support be provided to find the cause of the anomaly. "

After the ARB a notice was sent by US Air Force that they faced an issue when updating the software of a new GNSS satellite that recently replaced an old one and such offset were introduced, but the issue is now fixed and no further problems have been encountered since then.

We had a look at the Level 1B production of 26/01/2016 and an example is herein described.

In Figure 19 the time series of the magnetic field magnitude (blue) from the MAGA_LR_1B product on 26/01/2016, S/C A is shown. Gaps are clearly seen. In red the "Sync Status" parameter is plotted, read from the data field header of the VFMANOM_0_ products. Rejected data (zero value of magnetic field magnitude) correspond exactly to the sync loss intervals. Please note that the sync status shown in figure is not in scale, and it has been shifted only to show it together with the magnetic data. The sync loss intervals when the Level 1B data are rejected corresponds to a SyncStatus=32.

From the Level 0 data products document (SW.IF.EAD.GS.00017, Issue 13), pages 19-20, and considering the IMDD convention for the endianness (little endian fields, starting from the most significant digit) we infer that:

- PPS Source = 2 → Synch in Progress – inaccurate PPS and OBRT used.
- Sync quality index = 0 → PPS received, Spacecraft O/B Time packet received

Actually there are other shorter intervals where SyncStatus=48 and Level 1B data are not rejected. This would correspond to:

- PPS Source = 3 → Synch in Progress – accurate PPS and OBRT used.
- Sync quality index = 0 → PPS received, Spacecraft O/B Time packet received

Level 1B processor correctly rejects the packets, because it first looks at the PPS source and discards data flagged as PPS_source = 2. This has been finally confirmed by AIRBUS, and the investigation is therefore completed.

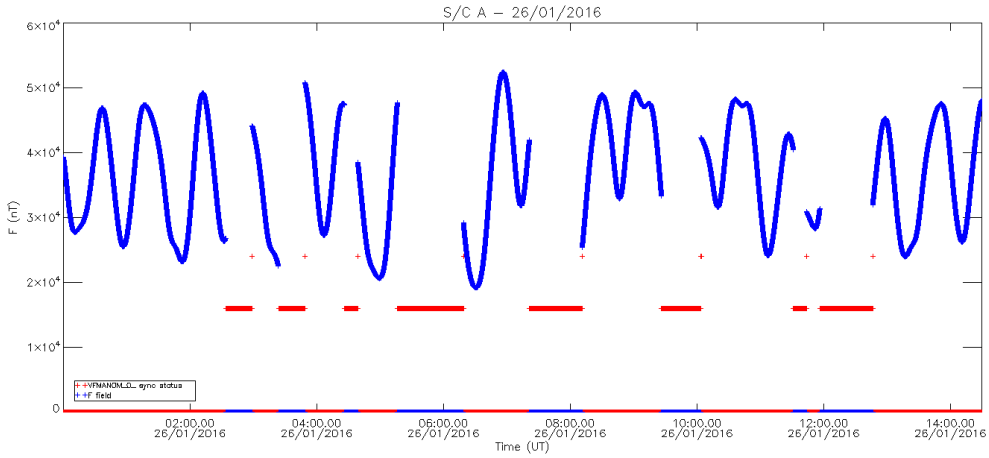


Figure 19: Time series of magnetic field magnitude from MAG_LR product for SC A (blue) and of GPS Sync Status from VFM NOM L0 (red) for the day 26/01.

End of Document