Customer	**:**	**ESRIN**	**Document Ref**	**:**	**IDEAS+-SER-OQC-REP-2071**
Contract No	**:**	**4000111304/14/I-AM**	**Issue Date**	**:**	**23 June 2015**
WP No	**:**	**6110**	**Issue**	**:**	**1.0**

IDEAS+ Swarm Weekly Report 2015/24: 2015/06/08 - 2015/06/14

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 08 to 14 June 2015.

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TABLE OF CONTENTS

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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	23 Jun 2015	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 life time, 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, user community), anomalies can be triggered and 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 3.15, L2-Cat2 1.12.p1
- L0 input products baseline: 02
- L1B baseline: 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: 01
- Input auxiliary files baseline: CCDB 0009, ADF 0101
- MPPF-CVQ v.2.14.00

1.2 Reference documents

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as RD.n, where 'n' is the number in the list below:

[RD.1] Sensor Performance, Products and Algorithms (SPPA), PGSI-GSOP-EOPG-TN-05-0025. Version 2.3.

[RD.2] Swarm PDGS External DMC Interface Control Document, SW-ID-DS-GS-0001, Issue 3.2.

[RD.3] Swarm MPPF-CVQ Monitoring Baseline Document, ST-ESA-SWARM-MBD-0001, Issue 1.7.

[RD.4] Swarm Level 1B Product Definition, SW-RS-DSC-SY-0007, Issue 5.13.

[RD.5] Swarm IDEAS Configuration Management Plan, IDEAS-SER-MGT-PLN-1081 v0.14.

[RD.6] Swarm Quality Control Project Plan, IDEAS-SER-MGT-PLN-1071

[RD.7] SW_L1BOP_status_20141124_MoM

[RD.8] Planned Updates for Level 1b, SW-PL-DTU-GS-008, Rev: 1dC.

[RD.9] IDEAS+ Swarm Weekly Report: 25/08/2014 – 31/08/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140825_20140831.pdf (ref. for SWL1L2DB-9)

[RD.10] IDEAS+ Swarm Weekly Report: 29/09/2014 – 05/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140929_20141005.pdf (ref. for SW-IDEAS-34)

[RD.11] IDEAS+ Swarm Weekly Report: 06/10/2014 – 12/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20141006_20141012.pdf (ref. for SW-IDEAS-36)

[RD.12] IDEAS+ Swarm Weekly Report: 20/10/2014 – 26/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20141020_20141026.pdf (ref. for SW-IDEAS-40, GPS sync loss)

[RD.13] IDEAS+ Swarm Weekly Report: 15/09/2014 – 21/09/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140915_20140921.pdf (ref. for SW-IDEAS-27)

[RD.14] Swarm L1B 03.15 Validation Report, OSMV-OPMT-SRCO-RP-15-3385, Issue 1.3.

[RD.15] IDEAS+ Swarm Weekly Report: 23/03/2015 – 29/03/2015, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_201513_20150323_20150329.pdf.

[RD.16] SWARM Weekly Operations Report #76, SW-RP-ESC-FS-6172

[RD.17] Olsen, N., H. Luhr, C.C. Finlay, T.J. Sabaka, I. Michaelis, J. Rauberg and L. Tøffner-Clausen, The CHAOS-4 geomagnetic field model, Geophys. J. Int. 197, 815–827, 2014

[RD.18] IDEAS+-SER-IPF-PLN-2272, Swarm Level 1B Operational Processor Verification Plan, IDEAS+-SER-IPF-PLN-2272_L1BOP_316_v1.5_final.pdf

2. SUMMARY OF THE OBSERVATIONS

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

Between 10 and 12 June 2015 the Swarm In-Orbit Performance review n. 2 took place in Friedrichshafen (Airbus premises). Here follows a summary of the discussions.

Mission status overview

The Mission Manager highlights the acknowledged performance of the SWARM magnetic measurements and the ever wider range of applications, a proportion of them venturing into research fields which are new to Earth Observation.

ESA intends to soon initiate a mission extension for several years. Proposal will be function of ESA high level programmatics.

FOS status

It is noted that two Ground station passes per day and per satellite - rather than the originally envisaged single pass - will be continued until further notice.

Mission analysis

Variations in the drag coefficient difference between SWARM-A & -C are reported. These may originate from variations in the satellites attitudes not taken into account in the C_d calculations, rather than from any differing environments, indeed the Flight Dynamics model of each spacecraft is relatively coarse. Estimating the drag coefficients using POD techniques may provide better insight. It is recalled that SWARM-A had been loaded with two more kg of fuel than SWARM-C.

OBC

FOS highlights the limitation in the number of available monitoring IDs: only three out of 100 remain available at this moment.

STR

FOS is able to decode the STR image data, but it cannot understand all the image features, therefore the support from DTU is still needed.
It is regrettable that the STR images are not used for any science: there in fact evidence that auroral light can be caught by the camera units at times.

As in IOP#1 AIRBUS proposes that the priority of the STR sequence be modified periodically along the orbit to avoid the pointing spikes observed in the used attitude TM and often caused by a bright object. Indeed such priority modifications would allow tightening the validity flag of the STR attitude solution. FOS objects that no side effect, e.g. thruster firing, is observed in the current situation.
It shall be noted that the validity flag may have to be maintained as is during slew manoeuvres to remain tolerant to partial moon blinding.
A variation of the inter CHU alignment is observed, this is the target of a seperate investigation

- The variation has been studied by the Inter Boresight Angle between pairs of CHUs
- The Inter Boresight Angles variation correlates with the average temperature of the CHUs
- The variation falls in three categories (~0, ~0.35 and ~0.85 ”/ deg C)

Further investiagtion of the inter CHU alignment is ongoing

GPSR

Interest in having GPSR data packets at a higher rate - 16Hz would match the Langmuir Probe data generation – is raised: RUAG responds that the increase is feasible. ESA shall discuss internally the opportunity of this request.

To assess better the separate performance impact of the widened L2 bandwidth from three other settings modifications included in the last SW patch loaded on-board SWARM- C, the ability to activate only those last three settings modifications may be explored. However ESA would have to first confirm such an interest.

Thermal

The increasing trend of the EFI temperature is noted: only 5K margin is available before hitting the high limit.

Life Limited Items (AIRBUS)

The duration of the thruster pulses could be enlarged to reduce the projected number of pulses by end-of-life if deemed necessary.

ACC

Noting that after each power reset small jumps are observed on polarisation voltages (few millivolts) as well as on proof mass positions, the inaccuracy of the ADC used to produce HK data is spotted. Among the HK parameters used for science data production are the temperatures, but not the polarisation or the proof mass positions.
Additional jumps in the position TM might be caused by cavity distortion.

C. Siemes shows in his presentation that back and forth bigger steps appear in the acceleration signals during October/November 2014, a period harsher in terms of active environment, which also corresponds to the high number of GPS sync loss events. He further indicates that the scale factors and the time constants used to process the raw data are stable, therefore they are not causing the steps. It is unclear to conclude whether the radiation or the environment is causing the bigger steps.
AIRBUS shows in its presentation that the ACC temperatures are very stable in the dawn-dusk orbits. It is expected that the corresponding science data would be of better quality.
From the thermal tests performed last April it appears that the ACC internal temperature TM's cannot be stabilised any better than in the current operational mode. Unexpectedly C. Siemes shows in his subsequent presentation that in some test cases the science data are actually improved, with the best results observed in a test in which both heaters were switched on at the same times. C. Siemes proposes further thermal tests (labelled "2C"), and recommends to have them performed on both SWARM-A and SWARM-C.

ASM

While LETI is not advising any change to the continuous operation of ASM on SWARM-A & -B it is pointed out that the radiation-caused loss of one among nine UCC micro-circuits after one year in orbit is an alarm, the handling of which must be refined before making any conclusion. An improved failure probability is sought, ideally requiring testing of many equivalent flight lot micro-circuits. However due to the scarce availability of such circuits any relevant information must be shared between CNES and ESA to ensure that the interest of any programme may not be forgotten for the sake of any outdated protective measure.

EFI-LP

Discussions on the electron temperatures obtained from the low gain probe will take place among scientists contacted by S. Buchert.

Measurements from both low gain and high gain probes should be distributed at least to a group of expert users.
The electron temperature time series often reveal a mid/high latitude phenomenon: short duration spikes are observed whose origin can rely on instrument processing or on actual physics of the data or a combination of both. Such phenomena might be checked with ground radars, and can also be investigated with UofC.
Combining LP measurements with ground-based measurements into a Level 2 TEC product might be worth investigating.
Consideration should be given to providing expert users with sweep data sets.
Proposed sweep tests would require a procedure similar to the one used for the B2 test executed during Commissioning. Where a TII is required, either the ones on SWARM-A or –B shall be used, preferably shortly after leaving READY state.
A minor SW bug - 16 bit overflow –occurs at a low rate but surprisingly follows a repetitive pattern.

EFI-TII

University of Calgary will identify periods (probably from the Commissioning phase) in which all TII's delivered good quality data. The purpose is to distribute the data to the science community with a reservation note pointing caveats. Focus is on December 2013 – Jan 2014. It is expected that data will be issued by August 2015. Recent data, e.g. from January 2015 on SWARM-A after scrubbing, may be part of it.
Various tests are envisaged to identify possible moisture in the TII's: take advantage of manoeuvres requested for other purposes to expose the TII to either hotter or colder temperatures, reverse the TII grid voltage to try expelling water molecules (dipoles), use lower Phosphor plate voltages, etc.
During the recent yaw tests, the anomalous ring feature in the TII image seemed to follow the movement of the main image spot.

Next IOP meeting

Next IOP meeting will take place from 25 to 27 November 2015.

2.2 Plan for operational processor updates

L1B: On 17 June the new L1B processor (v3.16) has been delivered. Integration tests are on-going by the PDGS team. If no issues are encountered the deployment in operation is foreseen for half July.

L2-Cat2: FAC and IBI have been put into operation the 14/5, basing on uncorrected MAG data whilst TEC have been put in operation the 8/6. The validation of EEF is still on-going.

2.3 Quality Working Group and Cal/Val Coordination

Coordination is in place for organizing the 6^{th} Swarm Data Quality Workshop in Paris (hosted by IPGP) in late September 2015.

Following the QWG recommendations in Potsdam and the scientists need in view of the IUGG conference in June, the preliminary plasma dataset has been released early February 2015.

DTU/ESL shared the final set of corrected data on early April. These corrected data also contain the dB_sun correction, providing the users the possibility to access to uncorrected data.

The Task Force meeting was held on 9-10 April in ESTEC. During this meeting the following decisions have been taken:

- ESA and CNES have to be prepared for potential further ASM failures scenarios.

- The corrected data provided by Lesur-Tøffner-Clausen (DTU) will be distributed by ESA to all Swarm users[1]. Soon, the correction will also be implemented in the OP. Meanwhile, the team agreed that the following investigation should be done:
    i. Clarifications of coordinate systems used (and left out) in models. To confirm overall dynamics and time constants / phase shifts.
    ii. Splinter group with Airbus, DTU-MI, and ESA to further coordinate investigations of "secondary" contributions.
    iii. (v x B) further investigations during: 1) the 4-step-360 rotation data, 2) the Alpha-Charlie rotations.
    iv. Test with same sun attitude conditions (excluding manoeuvres) but different plasma conditions or magnetic longitude.
    v. To better quantify (from models) potential plasma-related effects. Link to MAGx_HR.
    vi. Involvement of EFI-TII team.

The next task force meeting is scheduled for **2-3 July 2015**.

[1] *The corrected Swarm magnetic data have been distributed to all Swarm users on 13/04 (https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/swarm/news/-/article/corrected-swarm-magnetic-data-now-available).*

2.4 Summary of observations for 2015, Week 24 (08/06 - 14/06)

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

- **Some features observed in the MOD-NAV difference:** we observe at times deviations from the average values lasting several minutes (SW-IDEAS-34).
- **Two events of attitude rejection** is observed for S/C A (13/06), and S/C C (14/06), due to simultaneous occurrence of BBOs on all cameras (SW-IDEAS-75).
- **Several few seconds gaps in MAGx_CA_1B products** throughout the week. These seem not to be associated to gaps in telemetry. Monitoring on-going (SW-IDEAS-63).

3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

- Gaps in in MAGA_CA_1B on S/C A and B during whole week 24.

3.2 Orbit and Attitude Products

The following events have to be reported:

Observation ID	Description	Affected parameter	Sect. of Obs. Description	Sect. of Obs. Analysis
SW-IDEAS-34	OBS_ROUTINE: spiky features observed in the NAV-MOD difference	Orbits (position and velocity)	3.2.1.1, 3.2.1.2, 3.2.1.3	[RD.10]
SW-IDEAS-63	OBS_ROUTINE: MAGx_CA_1B gaps	MAGx_CA_1B	3.1	3.1
SW-IDEAS-75	OBS_ROUTINE: 2015, week 24 (08/06 - 14/06), STR S/C A and C out of range.	STRAATT_1B STRASCI_1A	3.2.2	3.2.2

Table 1: List of events related to attitude and orbit products to be reported in the monitoring for 2015, Week 24: 08/06 - 14/06.

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, and reported in tables in the sections below, along with some example 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 which is often the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm A, 08/06 - 14/06, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
08/06	0.1	-7.6	7.3	1.33	
09/06	0.08	-8 (Y)	6.9	1.32	
10/06	0.14	-5	6.2	1.19	
11/06	0.18	-6.8	6.5	1.3	
12/06	0.05	-5.3	6.5	1.18	
13/06	0.13	-8.8	7.9	1.31	SW-IDEAS-34 [RD.10]
14/06	0.03	-8.2	8 (X)	1.5	

Swarm B, 08/06 - 14/06, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
08/06	0.11	-7.3	8.7	1.23	
09/06	0.17	-8.9	7.3 (Y)	1.33	
10/06	0.13	-6.8 (X)	7.1	1.14	
11/06	0.08	-6.1	7.3	1.25	
12/06	0.05	-12.2	7.7	1.22	
13/06	0.11	-6.6	6.5	1.16	
14/06	0.1	-6.5	6.6	1.38	

Swarm C, 08/06 - 14/06, Position difference					
Day	**Average difference (m)**	**Maximum difference (m)**		**Maximum standard deviation (m)**	**Notes**
08/06	0.05	-7	7.1	1.27	
09/06	0.05	-5.9	7.4	1.31	
10/06	0.17	-4.6	5.2 (X)	1.14	
11/06	0.19	-6.6	6.2	1.3	
12/06	0.08	-5.3	5.4	1.1	
13/06	0.13	-8.5	7.3	1.25	SW-IDEAS-34 [RD.10]
14/06	0.05	-7.7	6.2	1.43	

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.

3.2.1.1 Swarm A

Below some plot example follows of MOD-NAV differences, S/C A, taken at the beginning of the week (08/06, Figure 1) in the middle (11/06, Figure 2) and at the end (14/06, 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].

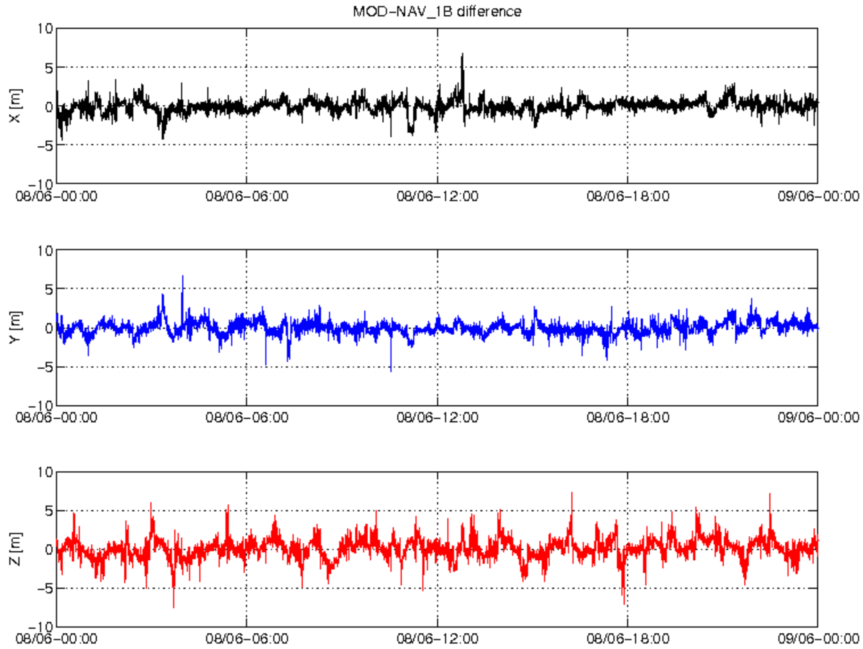

Figure 1: Difference MOD-GPSNAV, S/C A, 08/06. From top to bottom: X, Y and Z axis

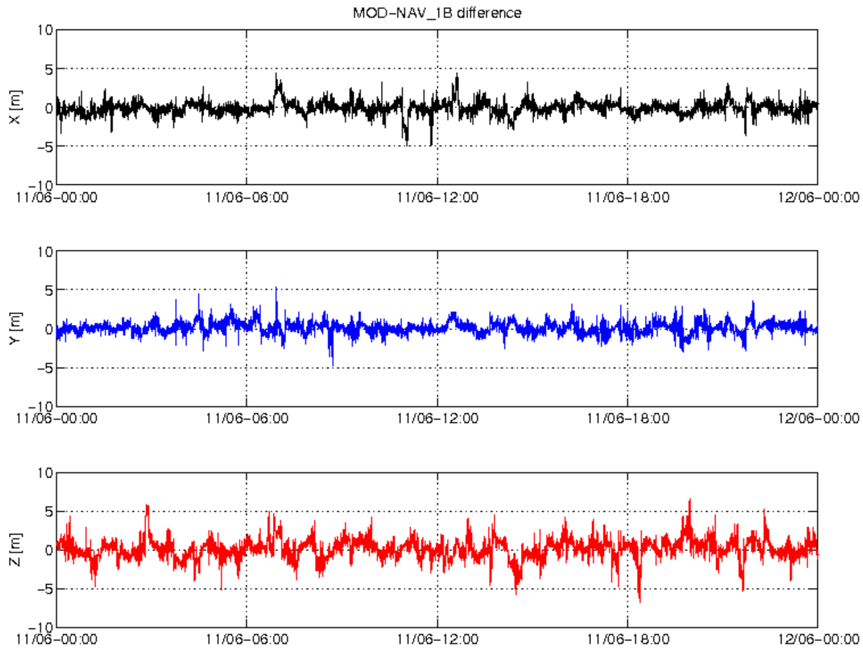

Figure 2: Difference MOD-GPSNAV, S/C A, 11/06. From top to bottom: X, Y and Z axis

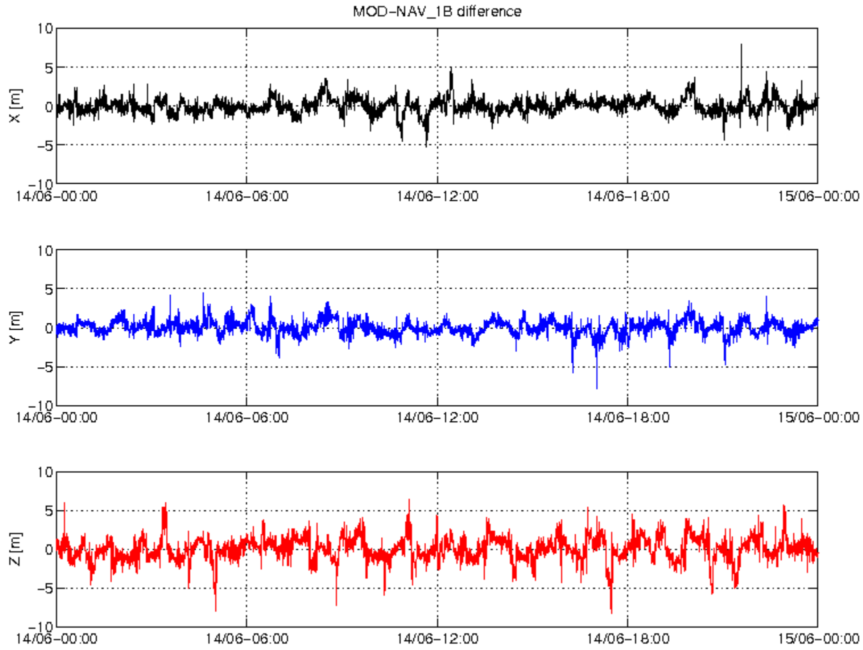

Figure 3: Difference MOD-GPSNAV, S/C A, 14/06. From top to bottom: X, Y and Z axis

3.2.1.2 Swarm B

Below some plot example follows of MOD-NAV differences, S/C B, taken at the beginning of the week (08/06, Figure 4), in the middle (11/06, Figure 5), and at end of the week (14/06, Figure 6). 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].

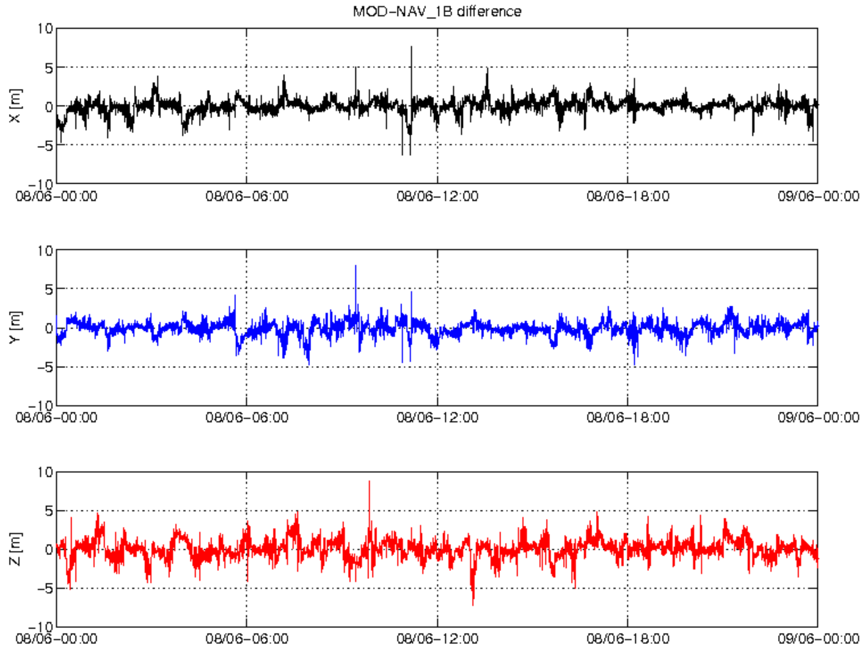

Figure 4: Difference MOD-GPSNAV, S/C B, 08/06. From top to bottom: X, Y and Z axis

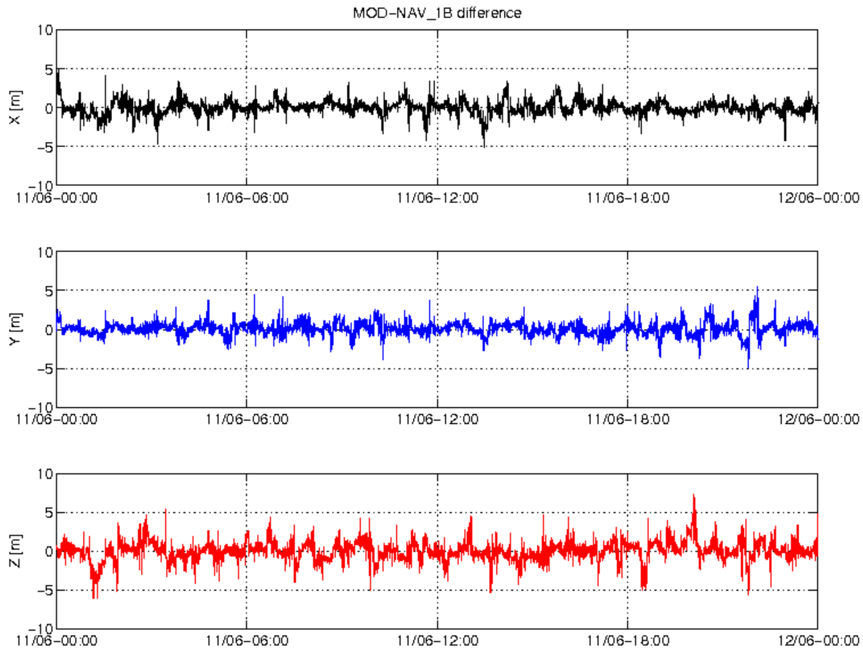

Figure 5: Difference MOD-GPSNAV, S/C B, 11/06. From top to bottom: X, Y and Z axis

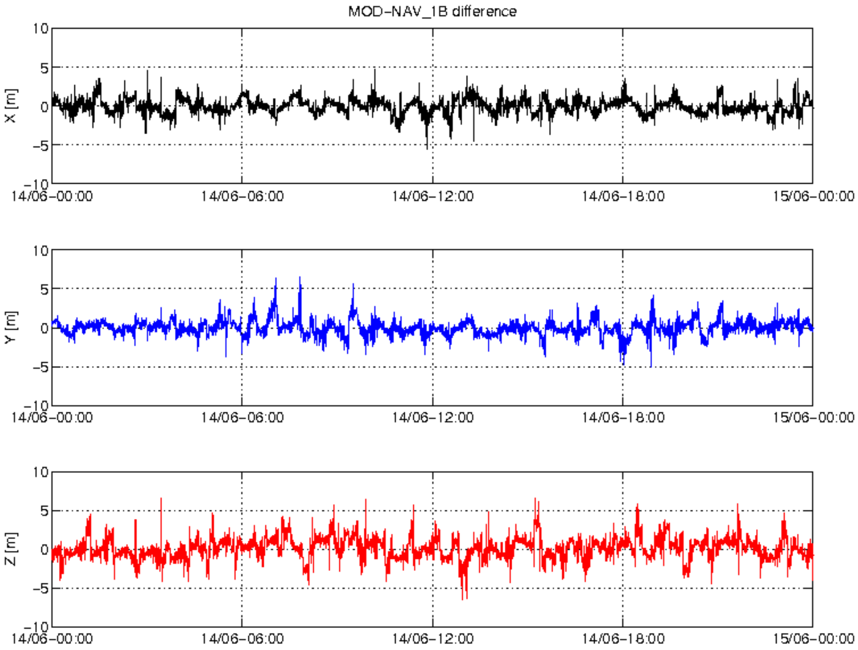

Figure 6: Difference MOD-GPSNAV, S/C B, 14/06. From top to bottom: X, Y and Z axis

3.2.1.3 Swarm C

Below some plot example of MOD-NAV differences, S/C C, follows, taken at the beginning of the week (08/06, Figure 7), in the middle (11/06, Figure 8) and at the end (14/06, Figure 9). 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].

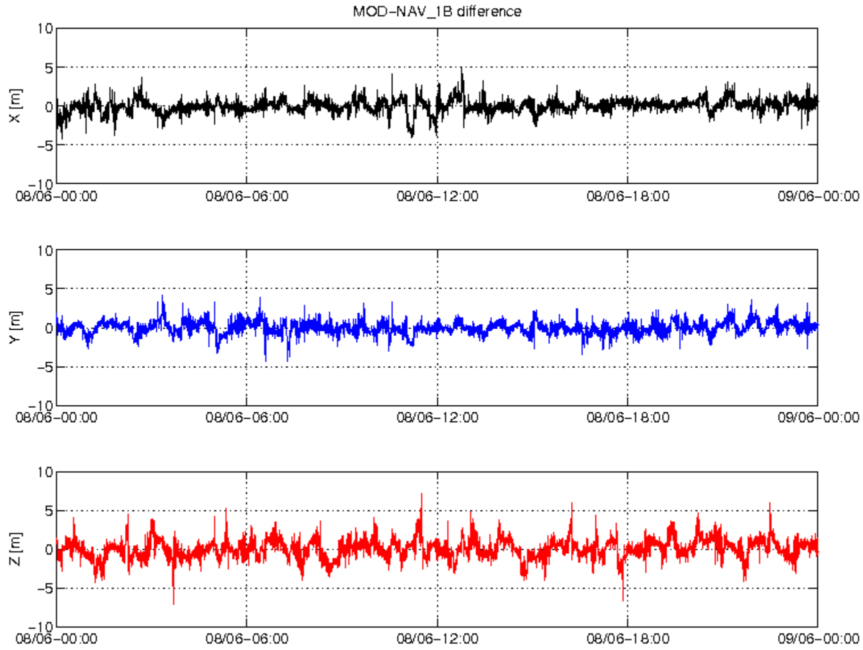

Figure 7: Difference MOD-GPSNAV, S/C C, 08/06. From top to bottom: X, Y and Z axis

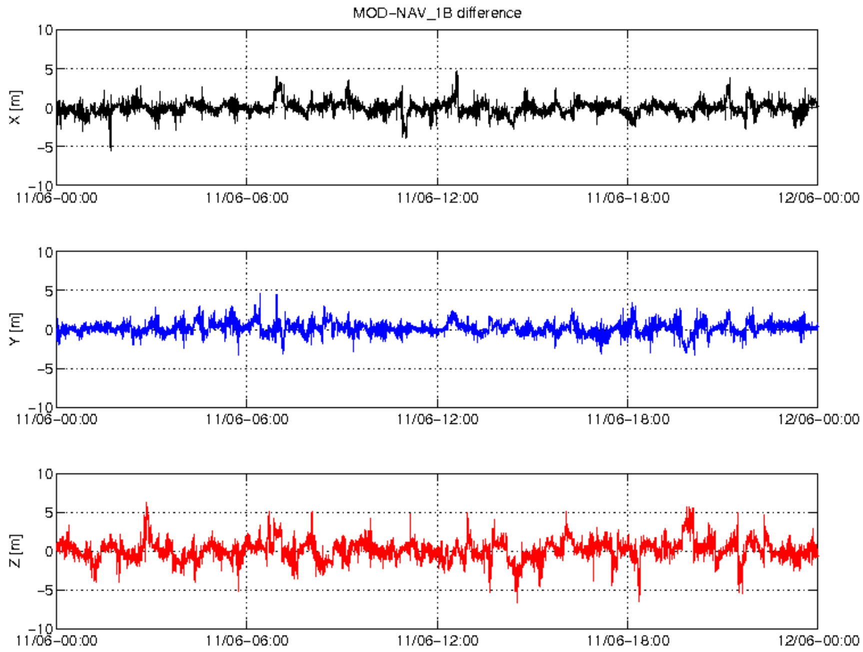

Figure 8: Difference MOD-GPSNAV, S/C C, 11/06. From top to bottom: X, Y and Z axis

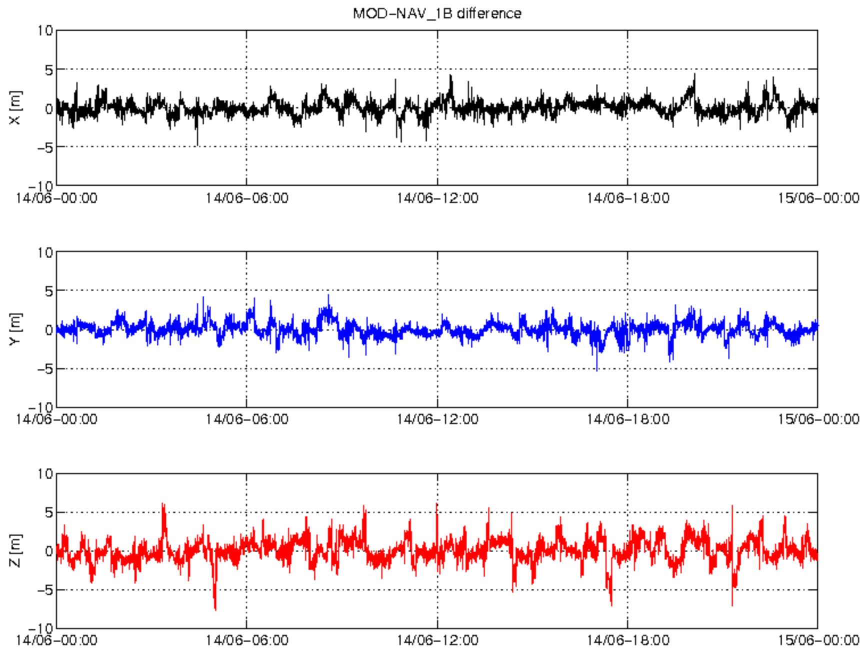

Figure 9: Difference MOD-GPSNAV, S/C C, 14/06. From top to bottom: X, Y and Z axis

3.2.2 Attitude observations

3.2.2.1 Swarm A

- SW-IDEAS-75: We observe an interval of rejected attitudes for S/C A on 10/06 (Flags_q=255). The reason for such rejection is the simultaneous occurrence of BBOs on all CHUs. See below for details.

Table 3 Attitudes out-of-range on S/C A, due to BBOs, week 24.

Start time	Stop time	Value	Length
10/06/2015 02:52:39	10/06/2015 02:52:42	255	4

3.2.2.2 Swarm B

Nothing to report.

3.2.2.3 Swarm C

- SW-IDEAS-75: We observe an interval of rejected attitudes for S/C C on 08/06 (Flags_q=255). The reason for such rejection is the simultaneous occurrence of BBOs on all CHUs. See below for details.

Table 4 Attitudes out-of-range on S/C C, due to BBOs, week 24.

Start time	Stop time	Value	Length
08/06/2015 02:30:18	08/06/2015 02:30:36	255	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
- Monitoring of the **VFM-ASM known anomaly**: visual inspection of $|B_{NEC}|$ - F and recording of daily maximum variations. If +/- 5 nT are exceed on a given day, an alert is raised.
- Visual inspection of daily time series of magnetic field intensity F, $\mathbf{B_{NEC}}$ and $\mathbf{B_{VFM}}$. 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.
- Comparison of magnetic data (BNEC) with a model (Chaos4plus);
- TCF.VFM parameters monitoring (VFM calibration parameters): series of biases, scales, non-orthogonality factors and RMS. **This check is performed on monthly basis.**

3.3.1 ASM Instrument parameters: quartz frequency and ASM temperature (ASMAVEC_0)

For S/C Alpha and Bravo the temperature and quartz frequency behaved as expected.

3.3.2 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 Alpha and Bravo for reported period the temperatures behaved as expected.

3.3.3 ASM-VFM difference statistics

In Table 5, 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.

Swarm A, 08/06 - 14/06, ASM-VFM difference				
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (m)**	**Notes**
08/06	4.5E+00	-5.8E+00	9.5E-01	
09/06	1.2E+00	-3.1E+00	1.0E+00	
10/06	1.0E+00	-3.8E+00	1.1E+00	
11/06	1.2E+00	-3.5E+00	1.1E+00	
12/06	1.1E+00	-3.8E+00	1.2E+00	
13/06	1.2E+00	-3.8E+00	1.2E+00	
14/06	2.2E+00	-4.4E+00	1.3E+00	

Swarm A, 08/06 - 14/06, ASM-VFM difference				
Swarm B, 08/06 - 14/06, ASM-VFM difference				
Day	**Max (nT)**	**Min (nT)**	**Standard deviation (m)**	**Notes**
08/06	7.6E+00	-3.1E+00	4.1E-01	
09/06	2.7E+00	-1.3E+00	4.1E-01	
10/06	2.3E+00	-2.4E+00	4.0E-01	
11/06	1.9E+00	-1.2E+00	3.8E-01	
12/06	1.1E+00	-1.4E+00	4.0E-01	
13/06	1.3E+00	-2.8E+00	3.9E-01	
14/06	3.2E+00	-1.3E+00	4.0E-01	

Table 5: Swarm A and B, difference between magnetic field absolute value measured by ASM and by VFM.

3.3.4 Magnetic time series visual inspection

3.3.4.1 Swarm A

An example of representative magnetic field time series for S/C A (14/06) can be seen in Figure 10 below.

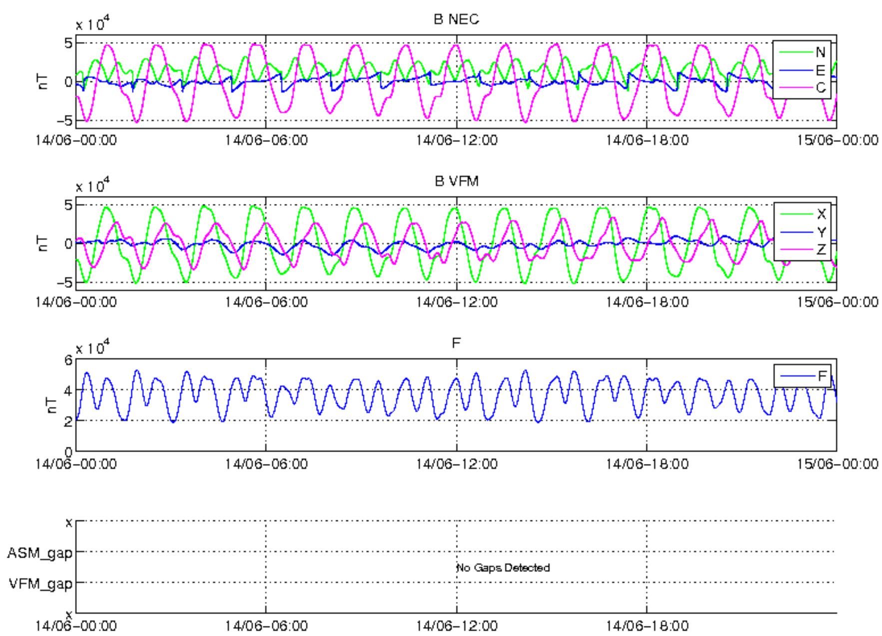

Figure 10: Time series of the geomagnetic field, for 14/06, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.4.2 Swarm B

An example of representative magnetic field time series for S/C B (14/06) can be seen in Figure 11 below.

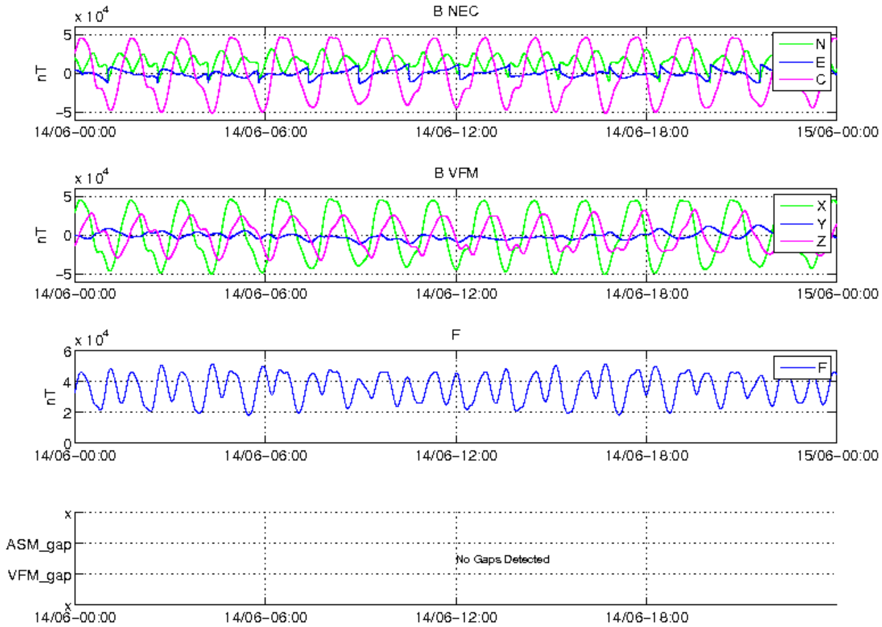

Figure 11: Time series of the geomagnetic field for 14/06, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.4.3 Swarm C

An example of magnetic field time series for S/C C (14/06) can be seen in Figure 12.

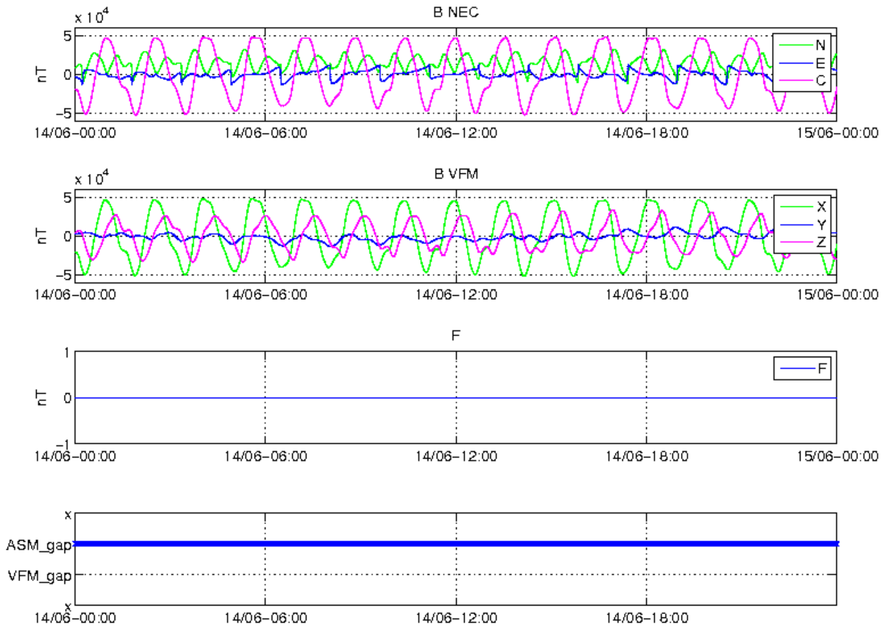

Figure 12: Time series of the geomagnetic field for 14/06, S/C C. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM (no data here because ASM it is off) and location of gaps.

3.3.5 VFM-ASM anomaly

3.3.5.1 Swarm A

The daily peak-to-peak difference for the only available day during current week stays within [-3.8; 1.2] nT with a few spikes not exceeding 1nT. On most spiky day 08/06 two spikes of about 5nT absolute value. Below two example plots follows of such differences: 08/06 (Figure 13), and 14/06 (Figure 14).

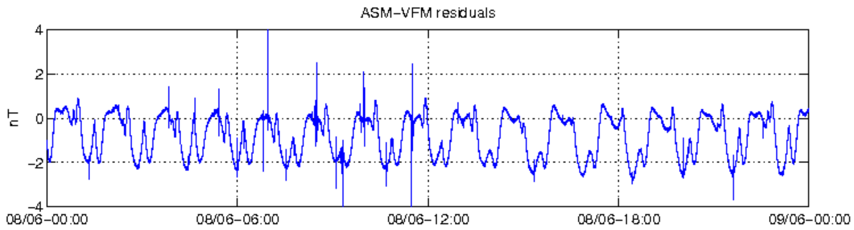

Figure 13: **A**SM-VFM residuals for S/C A, 08/06.

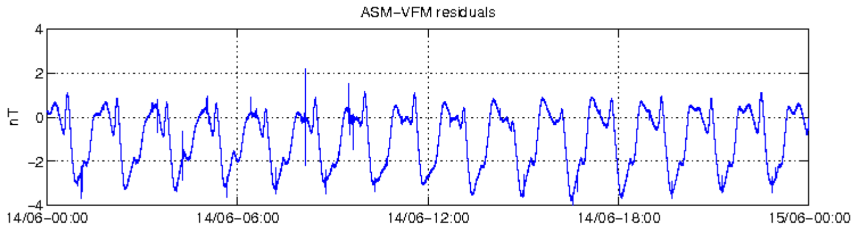

Figure 14: ASM-VFM residuals for S/C A, 14/06.

3.3.5.2 Swarm B

The daily peak-to-peak difference around the week is, on average: [-1.4; 1.4] nT, with a few spikes not exceeding 3 nT. On most spiky day 08/06 two significant spikes of 6 nT and 8 nT absolute value. Below two example plots follows of such differences: 08/06 (Figure 15), and 14/06 (Figure 16).

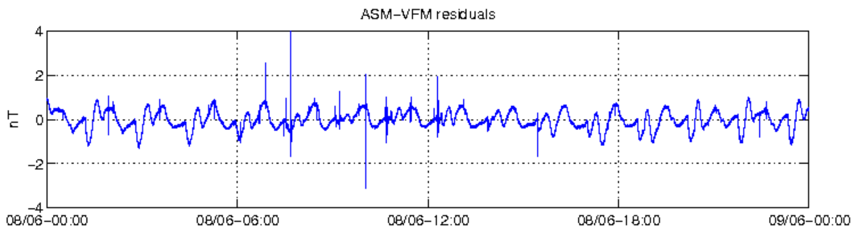

Figure 15: ASM-**VFM** residuals for S/C B, 08/06.

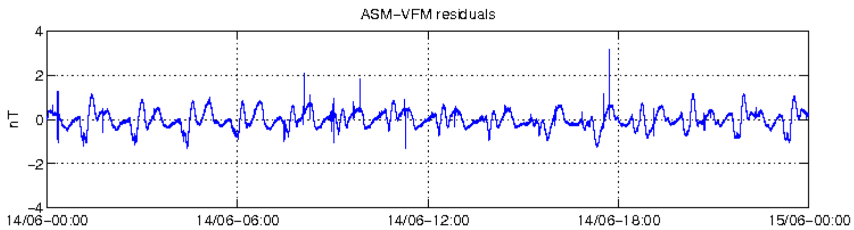

Figure 16: ASM-VFM residuals for S/C B, 14/06.

3.3.5.3 Swarm C

No data because ASM is switched off.

3.3.6 B_{NEC} vs Chaos4plus model residuals

Figure 17, Figure 19 and Figure 21 show field residuals $dB=B_{NEC} - B_{Chaos}$ (all versus co-latitude in degrees), from top to bottom: Br, Bθ and 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 18, Figure 20 and Figure 22 shows, from top to bottom, the time series on 08/06 of: (1-2-3) residuals of B_{NEC}-B_{CHAOS} by components, related to Swarm Alpha, Bravo and Charlie respectively,

The component most affected by residual spikes and variations is B_θ, i.e. the component which shows the variations of the field wrt to co-latitude. At high latitudes, the order of magnitude of the variability is about +/- 200 nT.

3.3.6.1 Swarm A

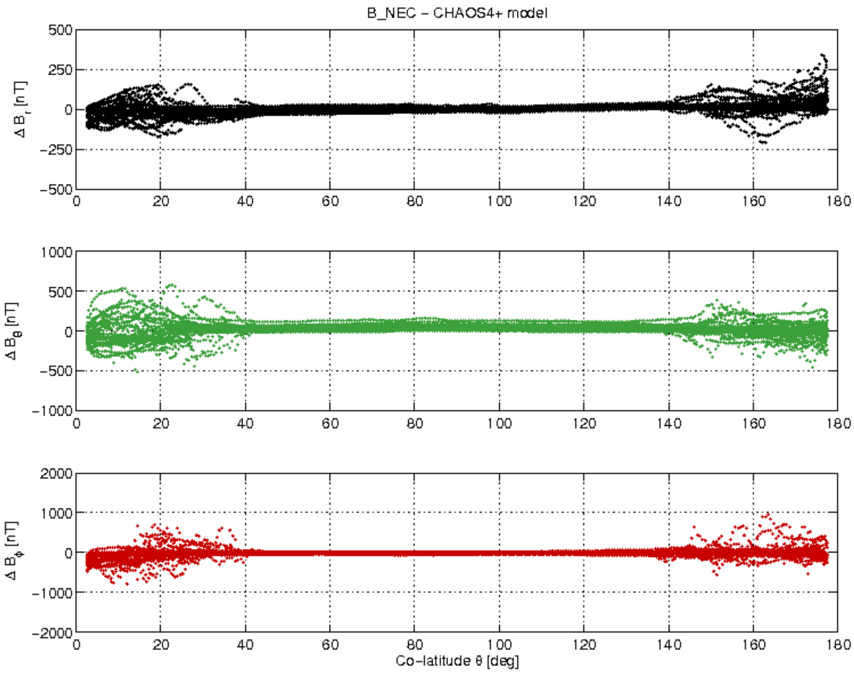

Figure 17: Swarm A day 08/06 B_NEC - B_Chaos vs colatitude.

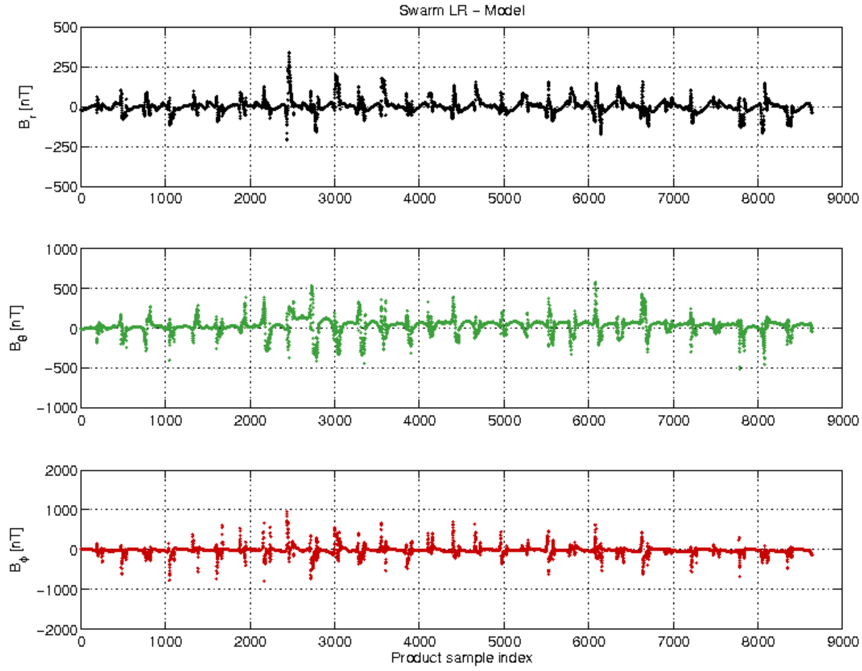

Figure 18: Swarm A day 08/06: time series of B_NEC – B_Chaos residuals.

3.3.6.2 Swarm B

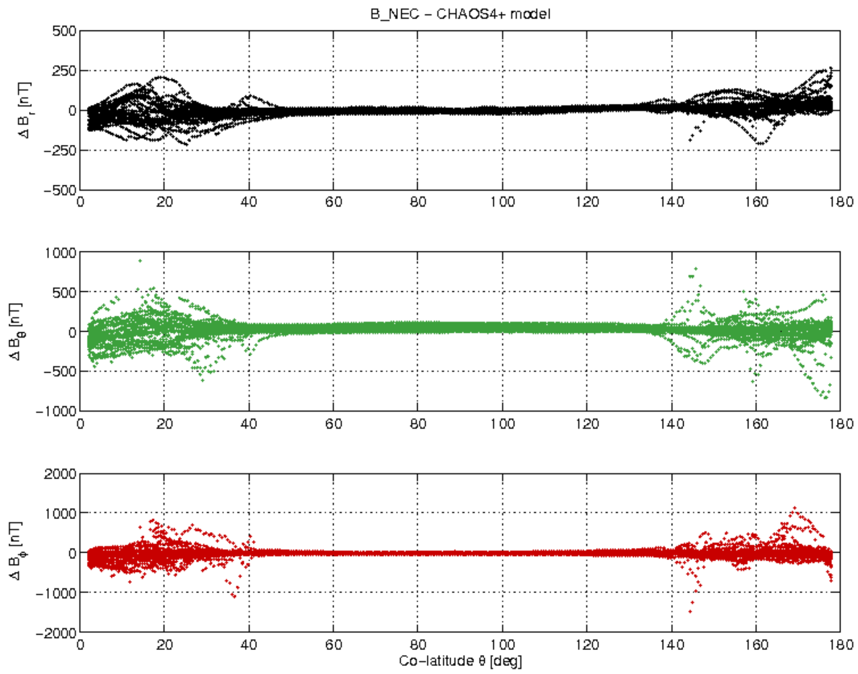

Figure 19 Swarm B day 08/06 B_NEC - B_Chaos difference vs colatitude.

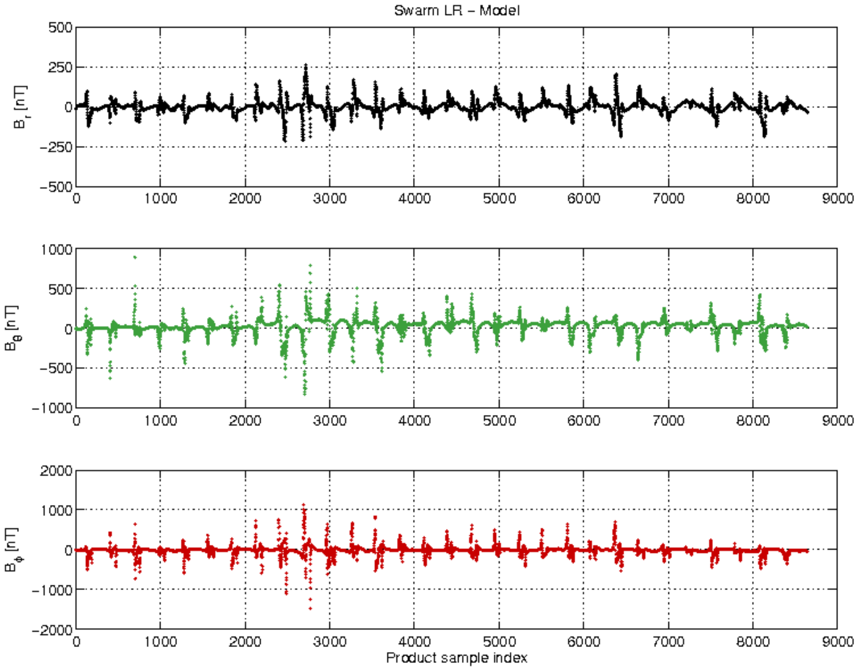

Figure 20 Swarm B day 08/06 time series of B_NEC – B_Chaos residuals.

3.3.6.3 Swarm C

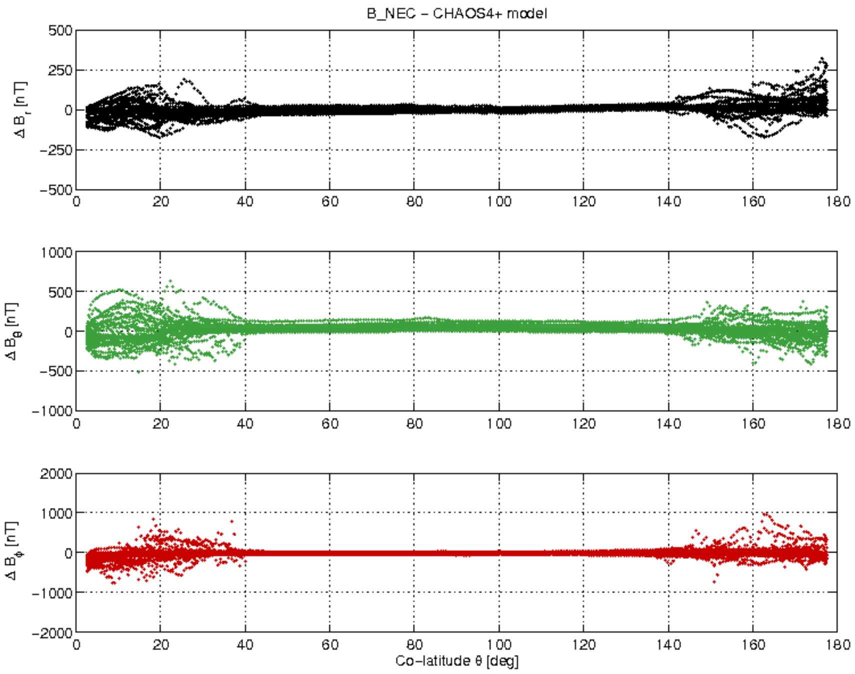

Figure 21 Swarm C day 08/06 B_NEC - B_Chaos difference vs colatitude.

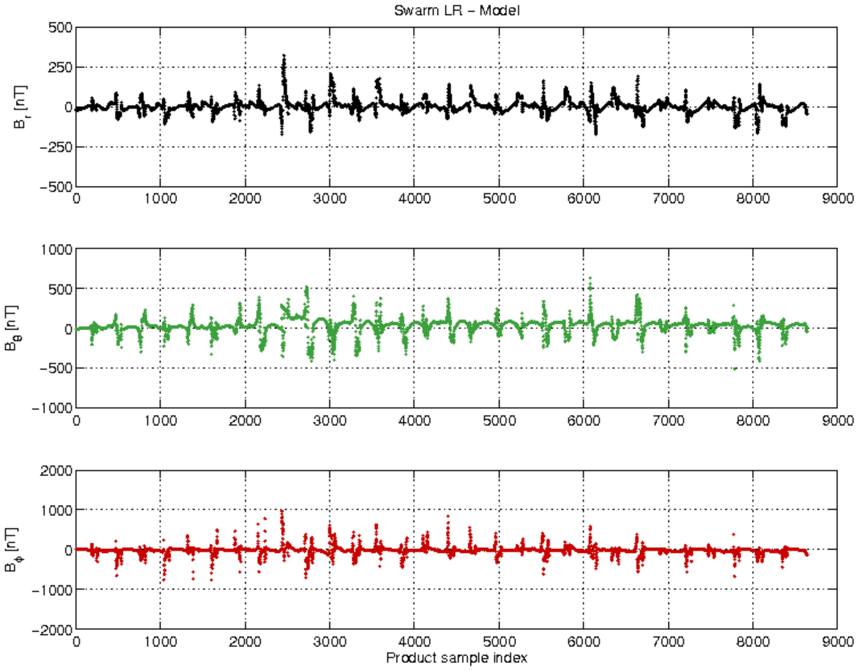

Figure 22 Swarm C day 08/06 time series of B_NEC – B_Chaos residuals.

4. ON-DEMAND ANALYSIS

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