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IDEAS+ Swarm Weekly Report : 17/11/2014 – 23/11/2014

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 17 to 23 November, 2014.

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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	27 Nov 2014	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 2.4.

The document also includes information on data quality for the three Swarm spacecraft, inferred from automated HTML quality reports which are produced on daily basis for each product. Please contact the 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 3.11p3, L2-Cat2 1.12
- 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.2.11p2

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
- [RD.10] IDEAS+ Swarm Weekly Report: 29/09/2014 – 05/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140929_20141005.pdf
- [RD.11] IDEAS+ Swarm Weekly Report: 20/10/2014 – 26/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20141020_20141026.pdf
- [RD.12] IDEAS+ Swarm Weekly Report: 22/09/2014 – 28/09/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140922_20140928.pdf



2. SUMMARY OF THE OBSERVATIONS

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

Nothing new to report.

2.2 Plan for operational processor updates

On the last L1B teleconference (24/11/2014, [RD.7]) we have finalized the details for the 28th of November delivery:

- The remaining scenarios that delayed the closure of SPRs 277, 279 and 282 have been handled, so no other blocking points remain.
- The corrections introduced for fixing the issues above caused a regression and a failure of some scenarios with the new Napeos version. This also will be solved in due time for the delivery.
- The PLASMA is cross-verified for what concerns the LP part, while for the TII part some off-procedure tests have been done comparing the OP results with the Calgary “sandbox” outputs. A detailed analysis will be included in the cross-verification report.

The delivery is confirmed for the 28th and, by the way, also a new L2-Cat2 release will be issued.

2.3 Quality Working Group and Cal/Val Coordination

The third QWG – Cal/Val meeting is being planned for the 2-5 December 2014 at GFZ premises in Potsdam, Germany.

A number of Task forces, each dedicated to an instrument group, continuously coordinates the investigation of the various anomalies.

2.4 Summary of observations for Week 47 (17-23/11/2014)

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

1. **Strange features observed again in the MOD-GPSNAV solution difference:** again we often notice a marked “spiky” behaviour, with deviations from the average which are not normal spikes but lasts for several seconds if not minutes (**SW-IDEAS-34**, [RD.10]).
2. **Few cases of GPS loss of sync occurred during the week.** The phenomenon involves S/C B and C. This causes rejection of the corresponding Level 0 packets in the Level 1B processing and consequent data gaps in STR and magnetic products (**SW-IDEAS-40**, [RD.11]).
3. **Telemetry gap on STR C.** 69 seconds gap observed the 19/11.
4. **Magnetic production lost on S/C C for the whole week**, because of the ASM switch off mentioned above.





3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

- **Magnetic production lost on S/C C for the whole week**, because of the ASM switch off mentioned above.
- **SW-IDEAS-40:**

The GPS sync losses already mentioned in Sect. 2.4 affect all the Level 0 products. The Sync Status is = 32 for all the intervals specified in Sect. 3.2.1.2, 3.2.2.2 and 3.2.3.2, also for the ASMxVEC_0_ and VFMxNOM_0_ product types of Swarm A, B and C affected by such sync loss, and this causes the corresponding records to be rejected and not processed further.

In the MAGx_HR_1B product types a gap is left corresponding to the a GPS sync loss interval, while in the MAGx_LR_1B product types, in the same intervals, all the magnetic values are set to exactly zero (but properly flagged as not good).

- **STR C telemetry gap:**

This occurred between 05:51:46 and 05:52:55 UT of 19/11/2014 on STR S/C C. The gap lasts for 69 seconds, between the following two Level 0 products:

SW_OPER_STRCNOM_0__20141118T154907_20141119T055146_0201

SW_OPER_STRCNOM_0__20141119T055255_20141119T085706_0201

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: large number of spiky features observed in the NAV-MOD difference	Orbits (position and velocity)	3.2.1.1	[RD.10]
SW-IDEAS-40	OBS_ROUTINE: STR out of range - ANOMALOUS CASES	STRBATT_1B STRBSCI_1A, STRCATT_1B, STRCSCI_1A	3.2.1.2, 3.2.3.2	[RD.11]

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for Week 47: 17 - 23/11/2014



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:
 - o The **average difference** on a given day exceeds the position accuracy requirement for the mission (1.5 m),
 - o The variability around the average is quite high: **standard deviation** threshold has been arbitrarily chosen to be twice the position accuracy requirement for the mission (2-sigma = 3 m).
 - o At least 4-5 spikes are observed on a given day, exceeding +/- 50 m.
- Visual inspection of Star Tracker characterisation flags (**STRxATT_1B**)
- Deviation of the quaternion norm from unity (deviation threshold = +/- 10⁻⁹)
- Visual inspection of Euler Angles derived from quaternions.

3.2.1 Swarm A

3.2.1.1 Position statistics

In Table 2 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm A, 17-23/11/2014, Position difference				
Day	Average Difference (m)	Maximum difference (m)	Standard deviation (m)	Notes
17/11	0.05	-9.6, 6.7 (Z)	1.4	SW-IDEAS-34 [RD.10]
18/11	0.15	-7.6 (Y), 5.3 (Z)	1.4	SW-IDEAS-34 [RD.10]
19/11	0.08	-11.4, 7.8 (Z)	1.4	
20/11	0.04	+/- 10 (Z)	1.5	SW-IDEAS-34 [RD.10]
21/11	0.12	-9, 10 (Z)	1.8	SW-IDEAS-34 [RD.10]
22/11	0.08	-10, 7 (Z)	1.4	
23/11	0.08	-13, 9 (Z)	1.4	

Table 2: Swarm A, difference between MOD and on-board solution positions.

Below some plot example follows of such differences taken at the beginning of the week (17/11, Figure 1), in the middle (20/11, Figure 2) and at the end (23/11, Figure 3). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

In Figure 1 and Figure 2 some examples of occurrences of **SW-IDEAS-34** anomaly ([RD.10]) are shown (red circled areas): spiky behaviours are evidenced, where the MOD-NAV solution difference takes levels higher/lower than the average and keeps such values for several minutes.

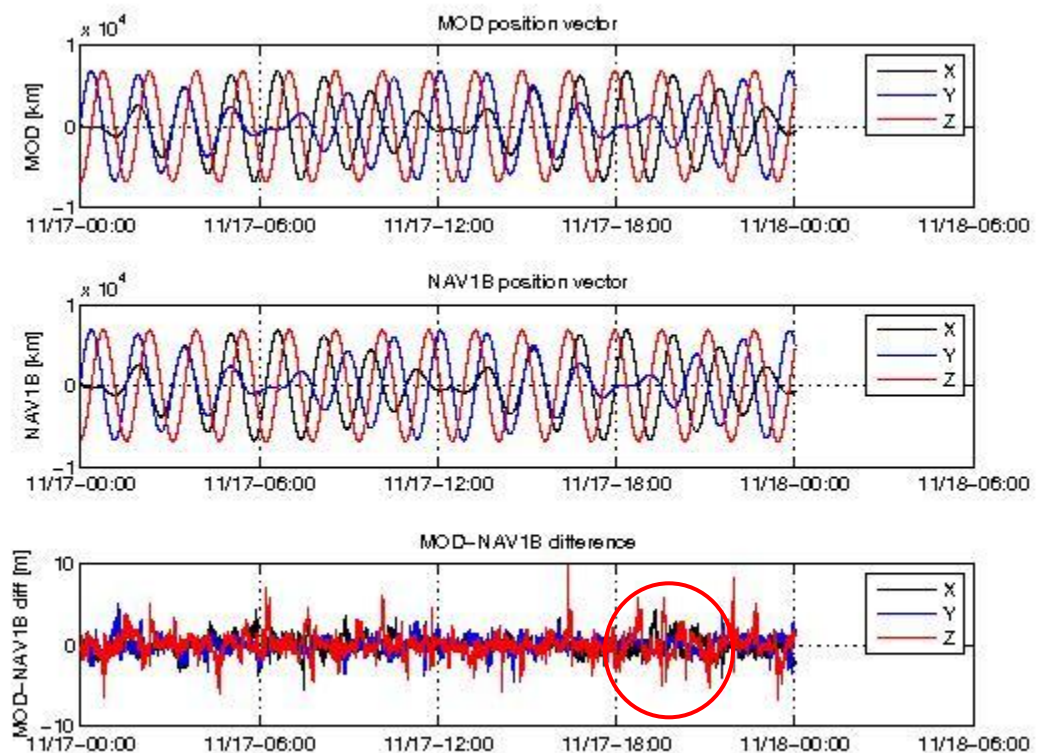


Figure 1: Difference MOD-GPSNAV, sc A, 17/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red-circled area evidences some occurrence of SW-IDEAS-34 anomaly ([RD.10]).

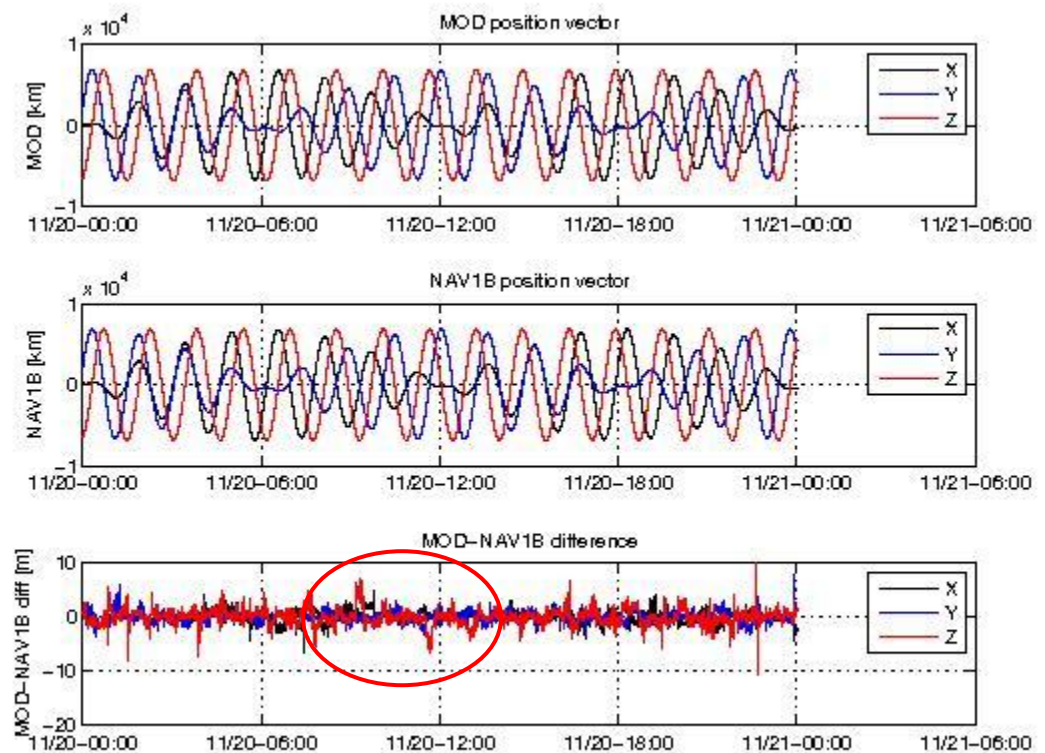


Figure 2: Difference MOD-GPSNAV, sc A, 20/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red-circled area evidences some occurrence of SW-IDEAS-34 anomaly ([RD.10]).

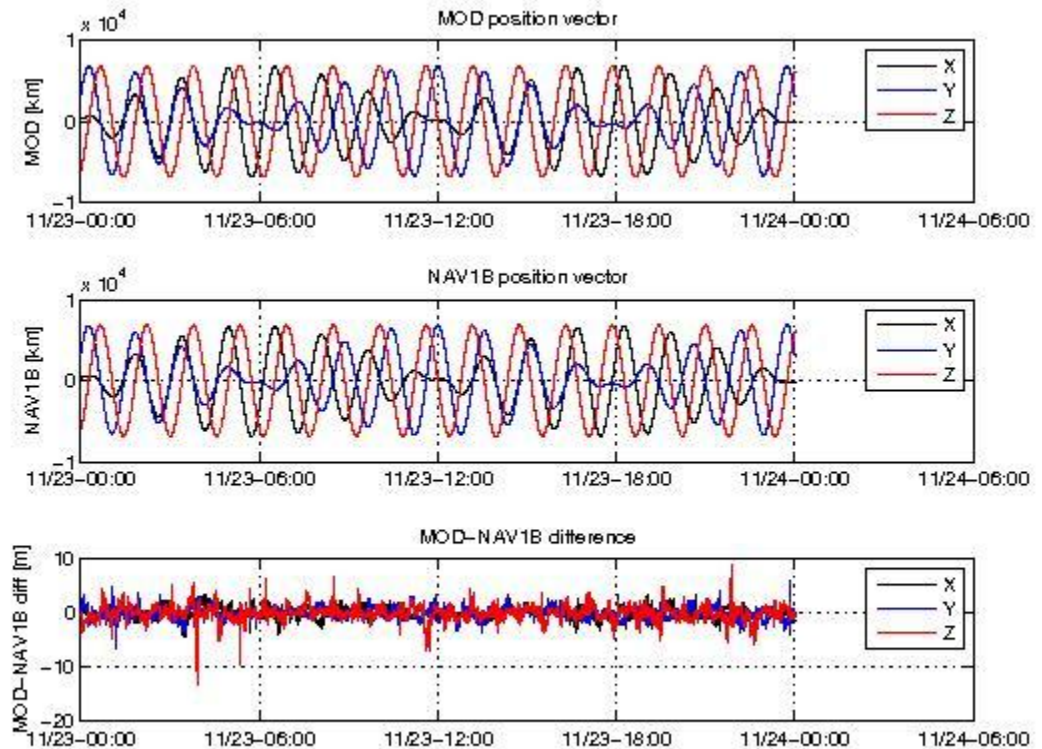


Figure 3: Difference MOD-GPSNAV, sc A, 23/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.1.2 Attitude observations

Nothing to report.

3.2.2 Swarm B

3.2.2.1 Position Statistics

In Table 3 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.



Swarm B, 17-23/11/2014, Position difference				
Day	Average Difference (m)	Maximum difference (m)	Standard Deviation (m)	Notes
17/11	0.05	-12 (Y), 9.3 (Z)	1.3	SW-IDEAS-34 [RD.10]
18/11	0.11	-13, 16 (X)	1.3	Isolated spike in the X component around 22 UT
19/11	0.05	-15 (X), 29 (Y)	1.3	Isolated spikes in the X and Y components around 21 UT (GPS loss of sync)
20/11	0.06	-10, 8 (Z)	1.4	SW-IDEAS-34 [RD.10]
21/11	0.05	-9.6 (Z), 13 (X)	1.7	SW-IDEAS-34 [RD.10]
22/11	0.13	-9.6, 8.7 (Z)	1.4	
23/11	0.1	-9 (Z), 7 (Y)	1.3	

Table 3: Swarm B, difference between MOD and on-board solution positions.

Below some plot example follows of such differences taken at the beginning of the week (17/11, Figure 4), in the middle (20/11, Figure 5), and at end of the week (23/11, Figure 6). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

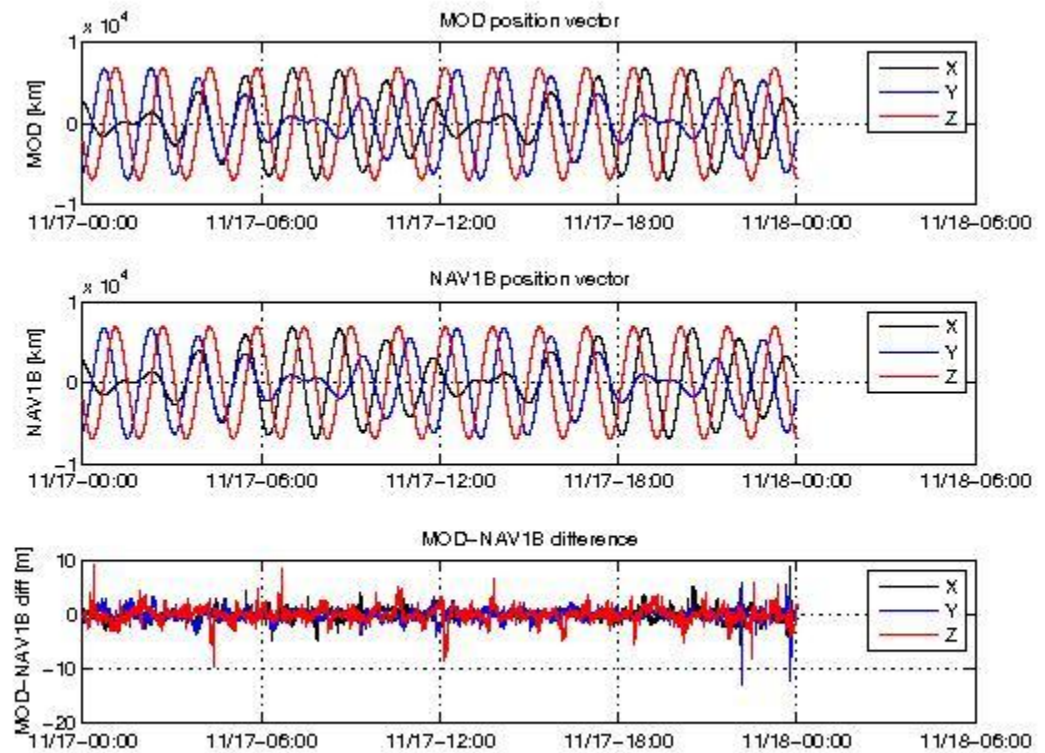


Figure 4: Difference MOD-GPSNAV, sc B, 17/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

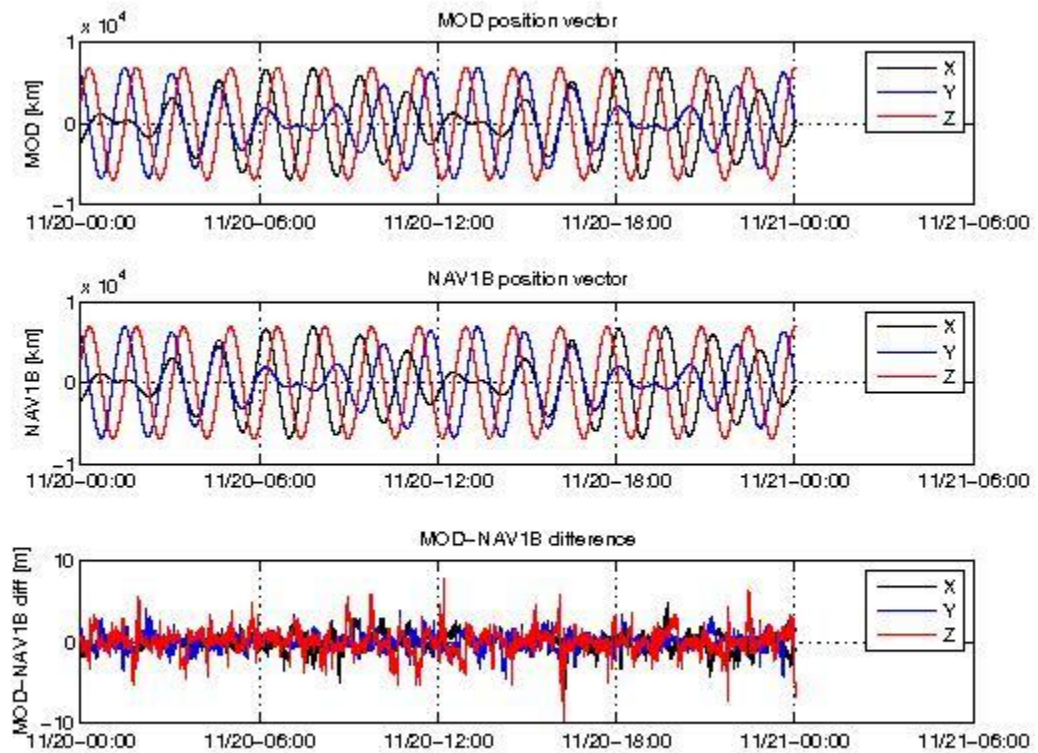


Figure 5: Difference MOD-GPSNAV, sc B, 20/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

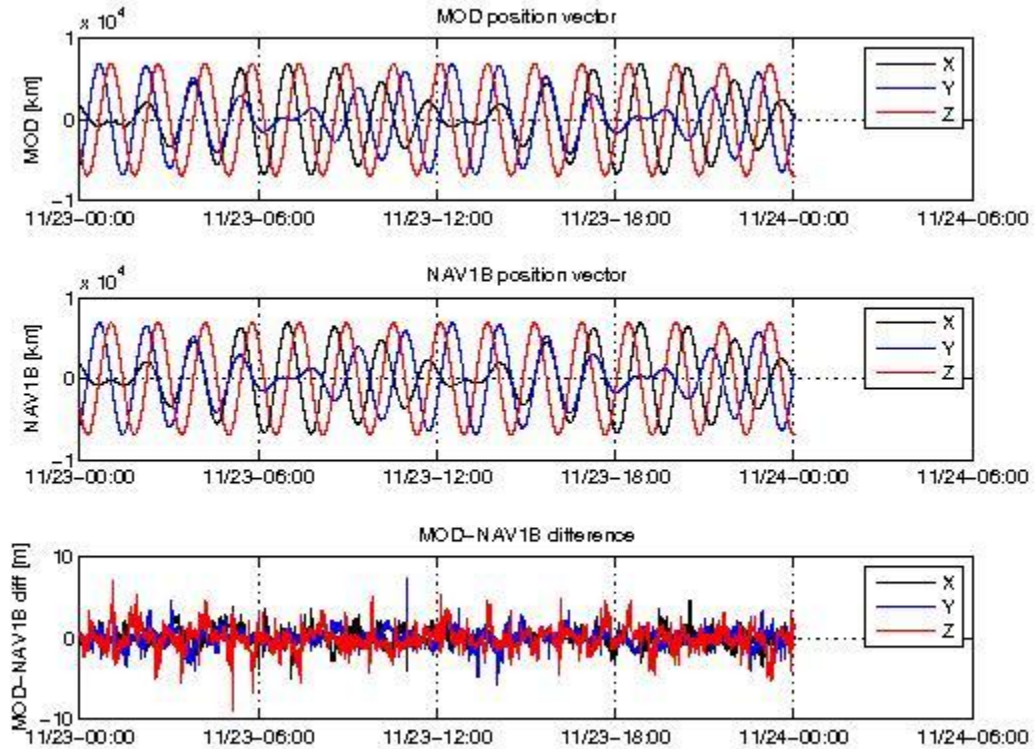


Figure 6: Difference MOD-GPSNAV, sc B, 23/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.2.2 Attitude observations

- **SW-IDEAS-40**

During week 47 several GPS out-of-Sync were detected. As explained in [RD.11], this affects the STR data, causing rejection of packets in the Level 1A products and filling gaps with zero quaternions and Flags_q = 255 in the Level 1B products. In Table 4 below, the list of such events for S/C B is given.

Start Out-of-range	Stop Out-of-range	Duration (s)
17NOV2014 23:38:35	17NOV2014 23:39:08	33
17NOV2014 23:46:31	17NOV2014 23:47:08	30
19NOV2014 21:28:16	19NOV2014 21:28:38	22
22NOV2014 22:14:33	22NOV2014 22:15:38	65

Table 4: Attitudes out-of-range due to GPS out-of-sync, S/C B, 17 – 23/11/2014.



3.2.3 Swarm C

3.2.3.1 Position Statistics

In Table 5 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm C, 17-23/11/2014, Position difference				
Day	Average Difference (m)	Maximum difference (m)	Standard Deviation (m)	Notes
17/11	0.02	-11 (X), 9 (Z)	1.4	SW-IDEAS-34 [RD.10]
18/11	0.17	-8.4, 6.8 (Z)	1.3	SW-IDEAS-34 [RD.10]
19/11	0.08	-9.3, 8 (Z)	1.4	SW-IDEAS-34 [RD.10]
20/11	0.02	-10.8, 9.6 (Z)	1.4	
21/11	0.1	+/- 11 (Z)	1.8	
22/11	0.1	-10, 7 (Z)	1.4	
23/11	0.1	-14.4, 11.4 (Z)	1.4	

Table 5: Swarm C, difference between MOD and on-board solution positions.

Below some plot example of such differences follows, taken at the beginning of the week (17/11, Figure 7), in the middle (20/11, Figure 8) and at the end (23/11, Figure 9). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

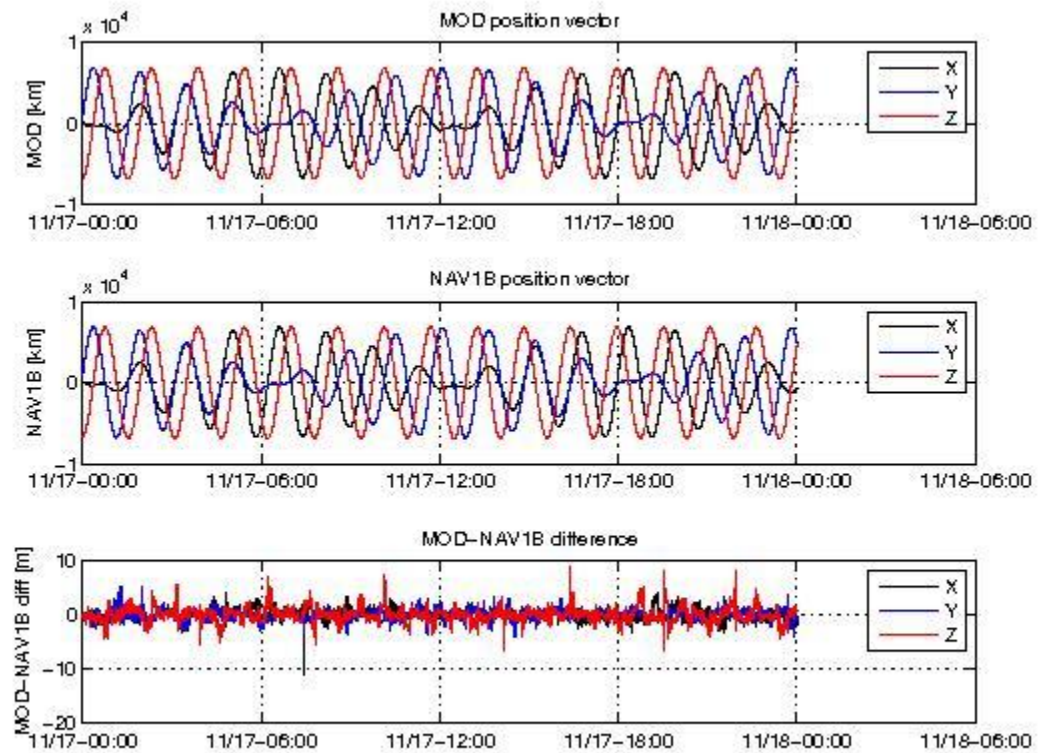


Figure 7: Difference MOD-GPSNAV, sc C, 17/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

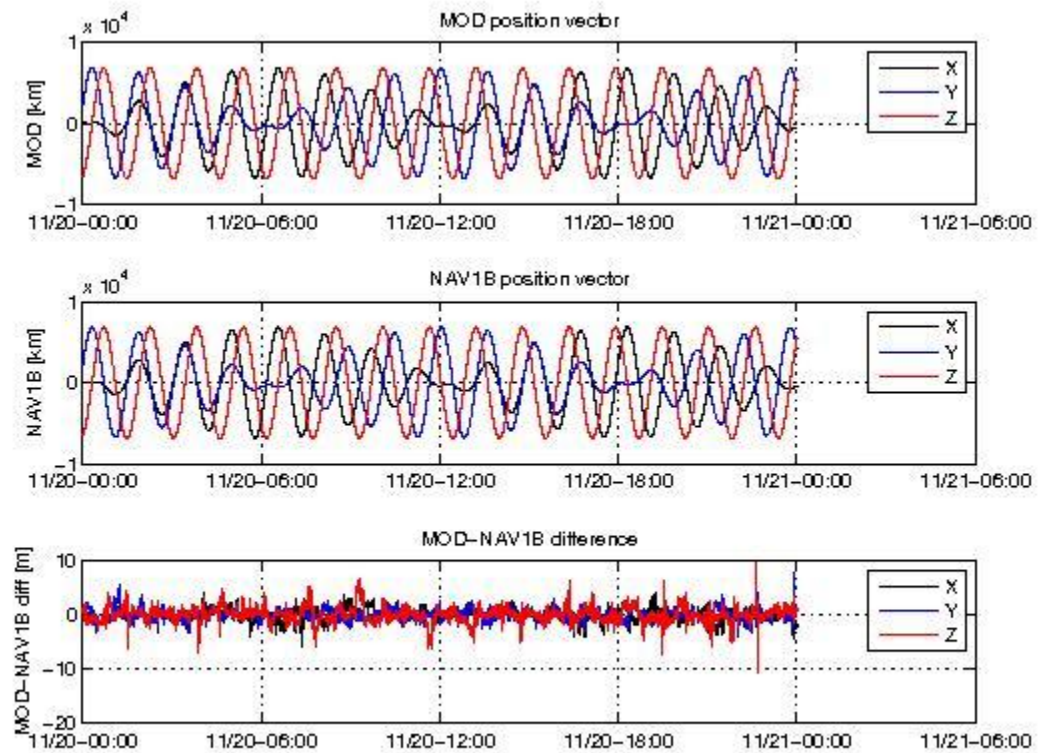


Figure 8: Difference MOD-GPSNAV, sc C, 20/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

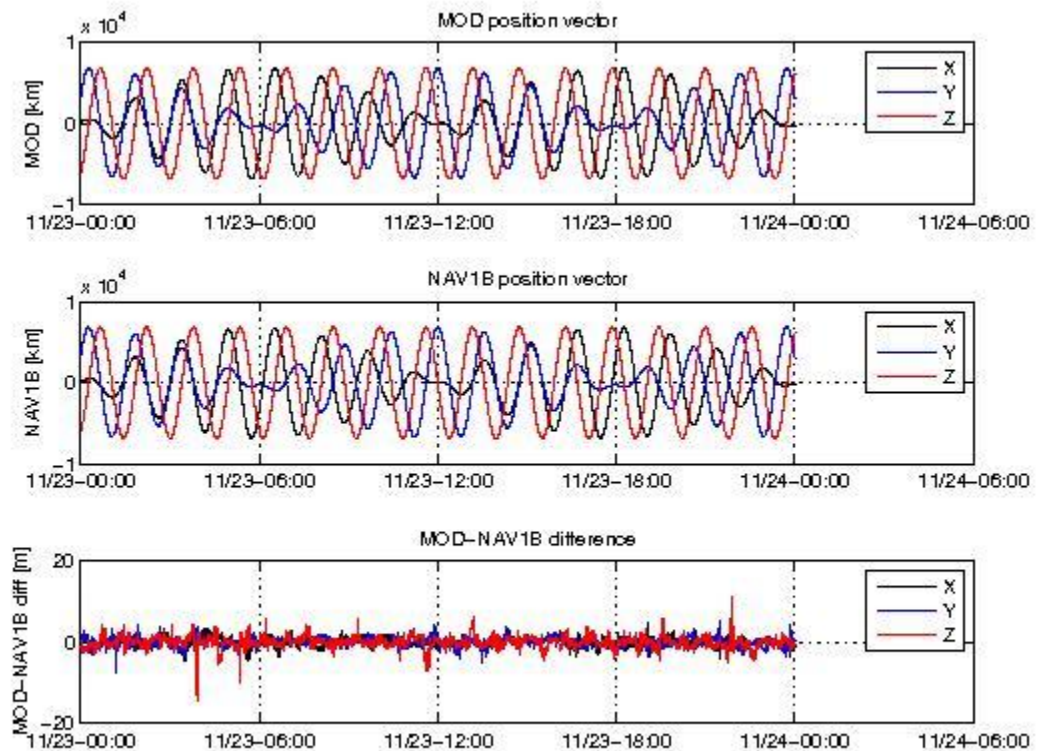


Figure 9: Difference MOD-GPSNAV, sc C, 23/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.3.2 Attitude observations

- SW-IDEAS-40

During week 47 a GPS out-of-Sync was detected. As explained in [RD.11], this affects the STR data, causing rejection of packets in the Level 1A products and filling gaps with zero quaternions and Flags_q = 255 in the Level 1B products. In Table 6 below, the list of such events for S/C C is given.

Start Out-of-range	Stop Out-of-range	Duration (s)
23NOV2014 07:23:05	23NOV2014 07:23:47	42

Table 6: Attitudes out-of-range due to GPS out-of-sync, S/C C, 17 – 23/11/2014.

- 69 seconds gap in telemetry in day 19/11 (see Sect. 3.1).

3.3 Magnetic Products

For the magnetic products the weekly monitoring consists in:



- 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.
- Monitoring of the **VFM-ASM known anomaly**: visual inspection of $|B_{NEC}| - F$ and recording of daily maximum variations. If +/- 5 nT are exceeded on a given day, an alert is raised.
- 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 Swarm A

3.3.1.1 Magnetic time series visual inspection

An example of representative magnetic field time series for S/C A can be seen in Figure 10 (23/11/2014).

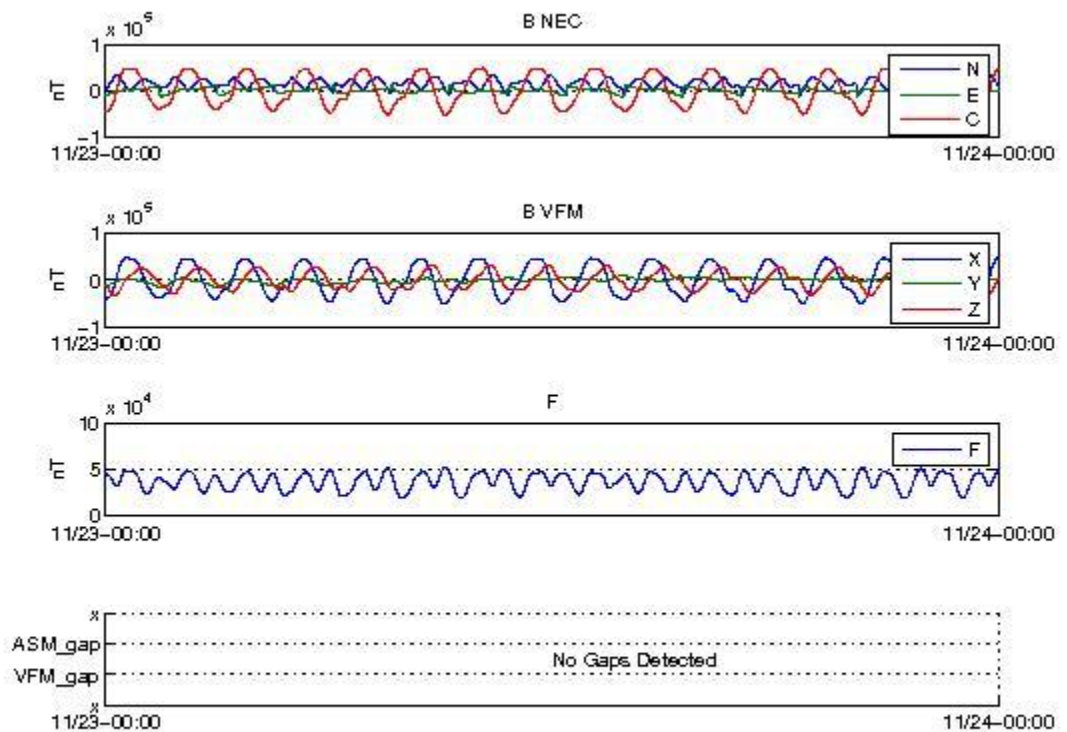


Figure 10: Time series of the geomagnetic field, for 23/11/2014, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.1.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-2.5, 2] nT.

Below some plot example of such differences follows, taken at the beginning of the week (17/11, Figure 11) and at the end (23/11, Figure 12). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

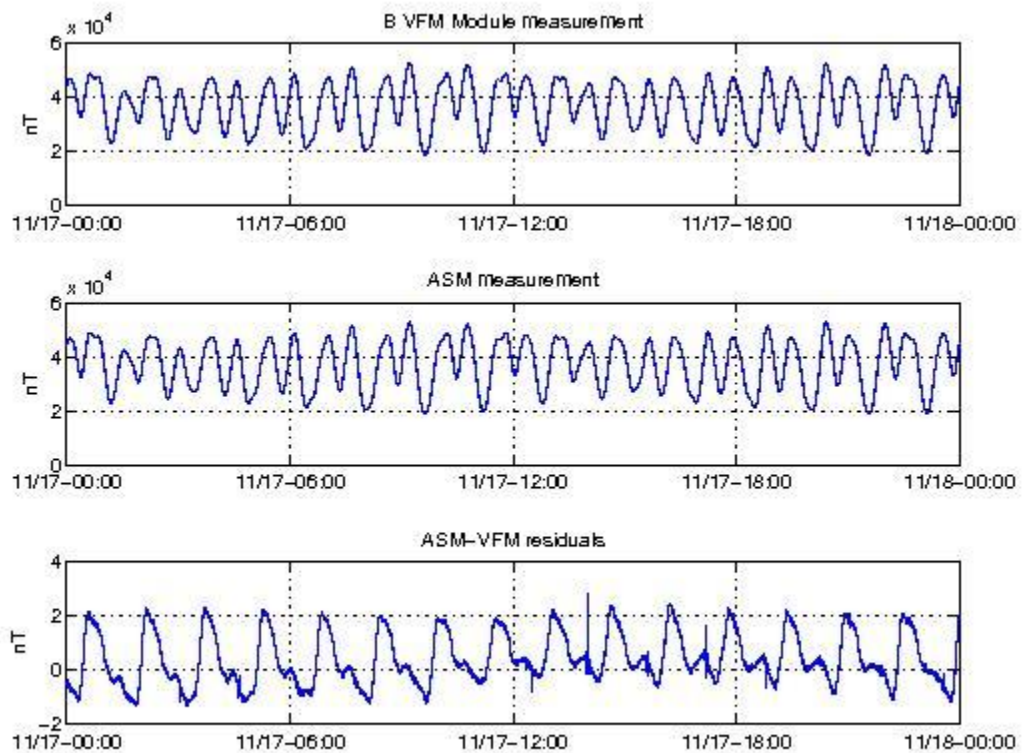


Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 17/11/2014.

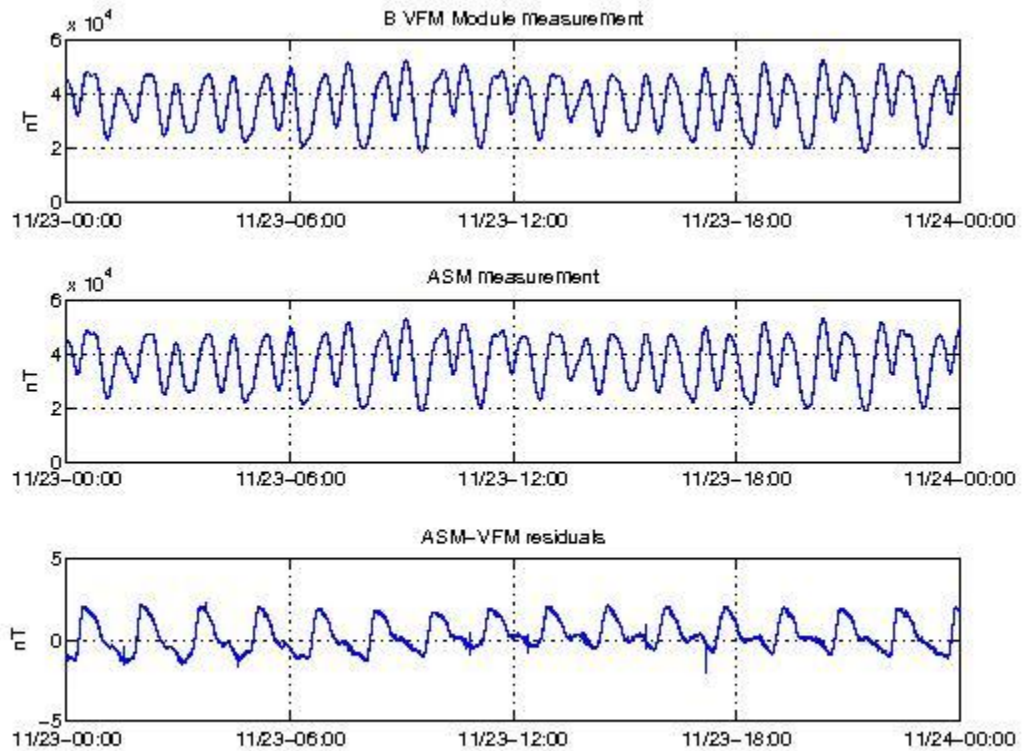


Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 23/11/2014.

3.3.1.3 TCF.VFM monitoring

The TCF.VFM analysis will be included in the last report of the month.

3.3.2 Swarm B

3.3.2.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative F time series for S/C B (23/11/2014) can be seen in Figure 13 below.

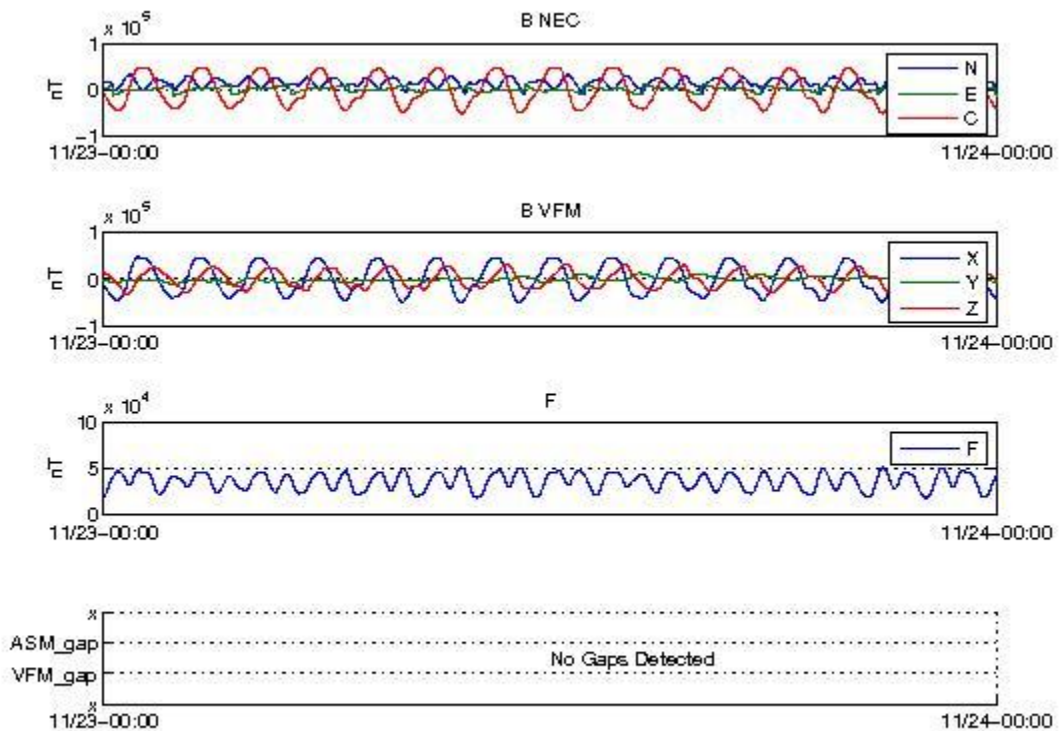


Figure 13: Time series of the geomagnetic field for 23/11/2014, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.2.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-1.8, 2] nT, with isolated spikes (gradients) that reaches up to 8 nT.

Below some plot example follows of such differences taken at the beginning of the week (19/11, Figure 14), and at the end of the week (23/11, Figure 15). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

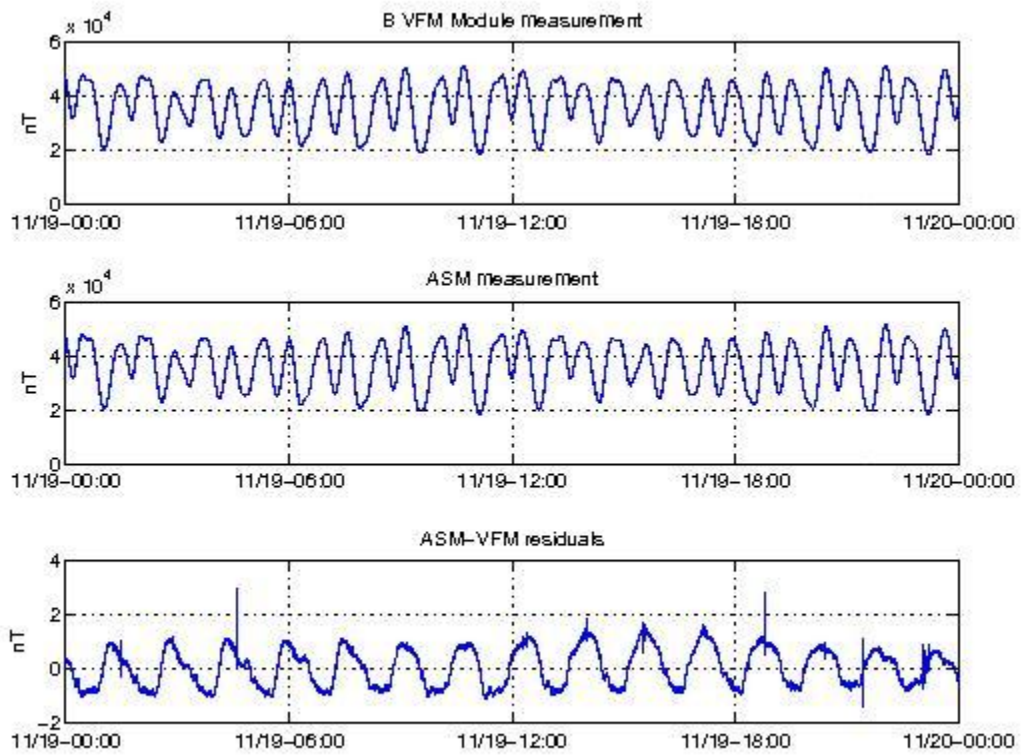


Figure 14: VFM module, ASM module and ASM-VFM residuals for S/C B, 19/11/2014

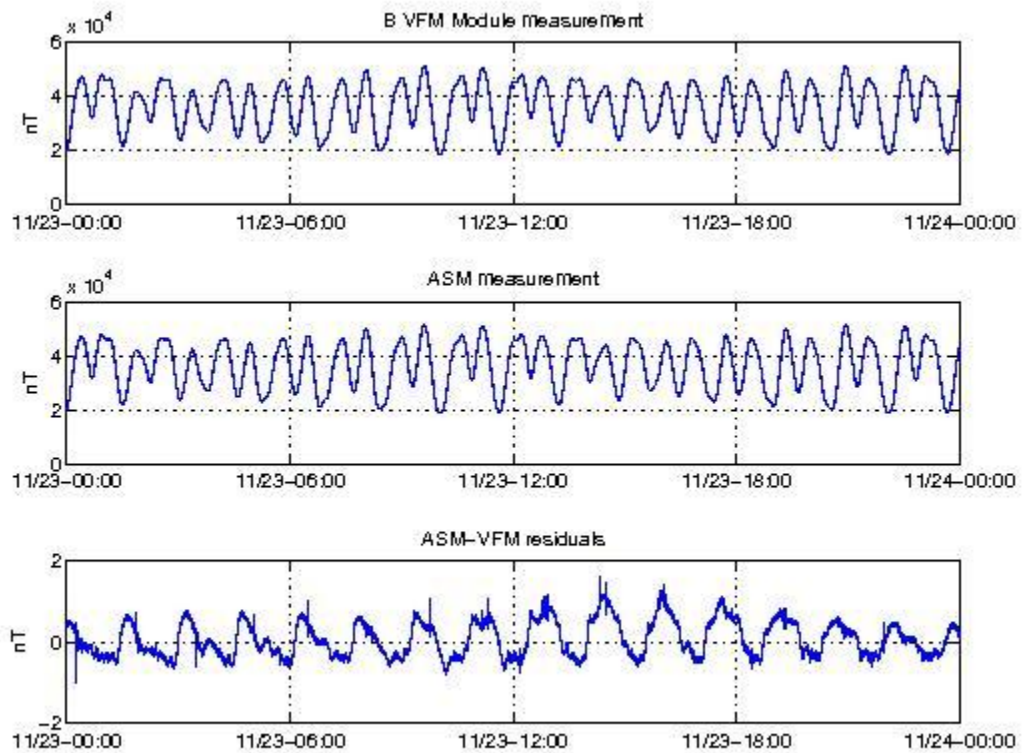


Figure 15: VFM module, ASM module and ASM-VFM residuals for S/C B, 23/11/2014.

3.3.2.3 TCF.VFM monitoring

The TCF.VFM analysis will be included in the last report of the month.

3.3.3 Swarm C

3.3.3.1 Magnetic time series visual inspection

No data because ASM is still switched off

3.3.3.2 VFM-ASM anomaly

No data because ASM is still switched off

3.3.3.3 TCF.VFM monitoring



The TCF.VFM analysis will be included in the last report of the month.

3.3.4 Summary of TCF behaviour for the three S/C

The TCF.VFM analysis will be included in the last report of the month.



4. ON-DEMAND ANALYSIS

Nothing to report.



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