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IDEAS+ Swarm Weekly Report : 01/12/2014 – 07/12/2014

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 01 to 07 December, 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	12 Dec 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.2.12p1

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: 06/10/2014 – 12/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20141006_20141012.pdf
- [RD.12] IDEAS+ Swarm Weekly Report: 20/10/2014 – 26/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20141020_20141026.pdf
- [RD.13] IDEAS+ Swarm Weekly Report: 15/09/2014 – 21/09/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140915_20140921.pdf



2. SUMMARY OF THE OBSERVATIONS

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

The reports of the following weeks will contain a summary of the most important discussions, after the Data Quality Workshop held in Potsdam.

Only observation to be quickly reported for this week:

- **ACC in SWARM-B switch-off by L2 FDIR:** As was reported by FOS on the early morning on 03/12/2014, the ACC in SWARM-B was switched off by Platform L2 FDIR on 02/12/2014. The unit stopped generating Science packets at 09:06:09z (last HK packet received at 09:06:02z) and the platform FDIR therefore switched it off at 09:07:25z. The satellite was flying over the South Atlantic Anomaly. The unit has been successfully switched on again few hours later. VZLU consider that a Latch-up (LU) in the UART circuit as the most probable cause of the missing telemetry. The UART is equipped with the LU protection circuit. Latch-Up circuit limits the current and switches off the UART in case of passing a certain threshold. In this way it is guaranteed that UART current is limited to acceptable values.

2.2 Plan for operational processor updates

L1BOP 3.12 and L2-Cat2OP 1.13 have been delivered to PDGS the 28th of November. Verification and integration tests will take place in the next two weeks, before the final deployment of the processors in operation in January.

2.3 Quality Working Group and Cal/Val Coordination

The fourth QWG – Cal/Val meeting has been held the 2-5 December 2014 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 49 (01-07/12/2014)

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]). Some evidence also reported about quasi-sinusoidal behaviour of the MOD-NAV difference associated with failures in the MOD clock calculation (**SW-IDEAS-36**, [RD.11]). Finally, one further occurrence of **SWL1L2DB-9** ([RD.9]) anomaly is observed: close to the end of the day, the MOD and NAV solutions diverge one each other, due to incorrect Napeos configurations.
2. **Telemetry gap on S/C B:** 4 minutes gap in all science products the 03/12.
3. **Failure of ORBATT C, 07/12:** known anomaly to be fixed with the new version of the processor.



4. Noise superimposed on magnetic data (**SW-IDEAS-27** [RD.13]), observed the 07/12.



3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

- **Magnetic production lost on S/C C for the whole week**, because of the ASM switched off.
- **ORBATT failed on S/C C the 07/12/2014**, because of a known anomaly of the processor. Therefore no Orbit and Attitude products are available. This production will be recovered once the new L1BOP v3.12 will be deployed in operations.
- **Telemetry gap on S/C B the 03/12/2014**: from 08:03:27 to 08:07:21 no science telemetry was transmitted (all instruments and product types).

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-36	OBS_ROUTINE: deviations of MOD-NAV solution apparently correlated with GPS clock deterioration	Orbits (position and velocity)	3.2.2.1	[RD.11]
SWL1L2DB-9	L1B: MOD - NAV1B discrepancies on day ...	Orbits (position and velocity)	3.2.3.1	[RD.9]

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for Week 49: 01 - 07/12/2014

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),



- 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 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, 01-07/12/2014, Position difference				
Day	Average Difference (m)	Maximum difference (m)	Standard deviation (m)	Notes
01/12	0.13	-11, 12 (Z)	1.9	SW-IDEAS-34 [RD.10]
02/12	0.09	-8, 10 (Z)	1.6	SW-IDEAS-34 [RD.10]
03/12	0.09	-12 (Y), 12 (Z)	1.7	SW-IDEAS-34 [RD.10]
04/12	0.05	-15, 9 (Z)	1.6	SW-IDEAS-34 [RD.10]
05/12	0.19	-6, 10 (Z)	1.4	SW-IDEAS-34 [RD.10]
06/12	0.1	+/- 10 (Z)	1.4	
07/12	0.05	-9.4 (X), 12 (Z)	1.4	SW-IDEAS-34 [RD.10]

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 (01/12, Figure 1), in the middle (04/12, Figure 2) and at the end (07/12, 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 one can see few examples of time intervals affected by SW-IDEAS-34 anomaly ([RD.10], red-circled areas in the figure): the difference between MOD and NAV solutions departs from the average and keeps higher/lower values for several minutes.

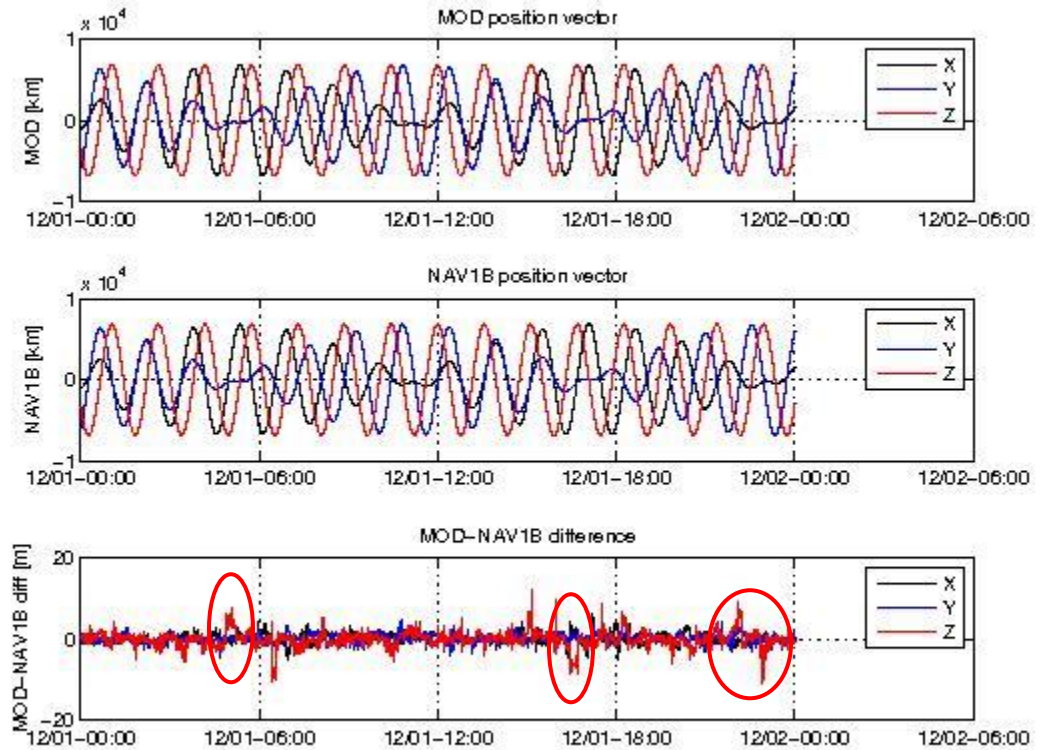


Figure 1: Difference MOD-GPSNAV, sc A, 01/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red circled area highlights intervals affected by SW-IDEAS-34 anomaly ([RD.10]).

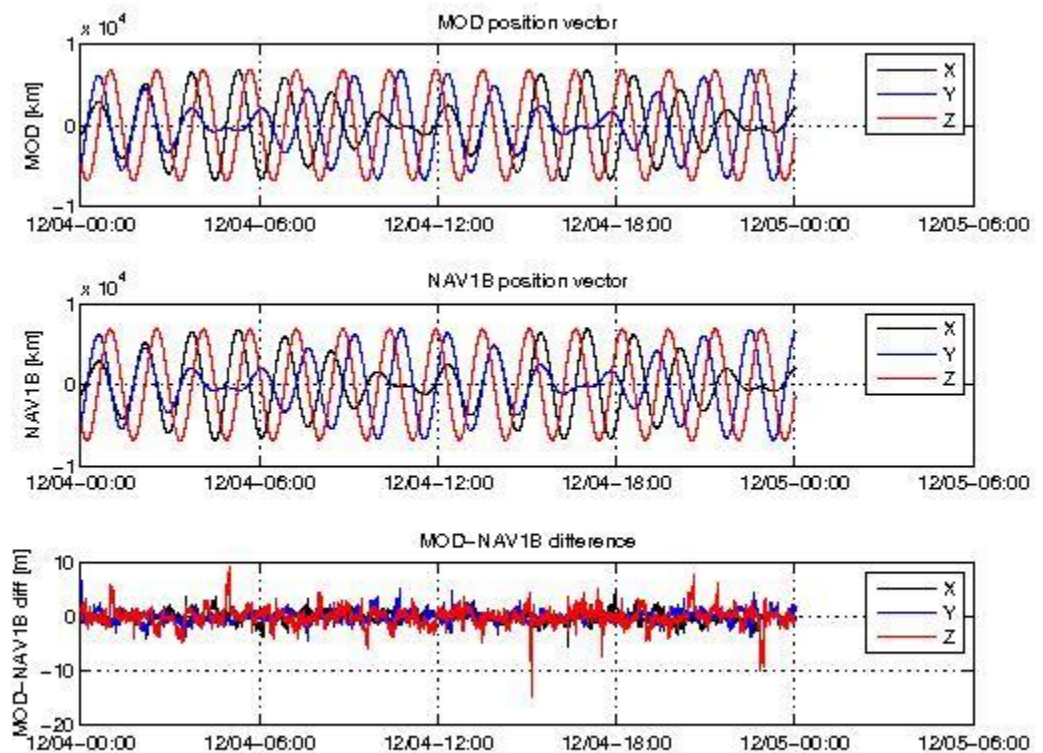


Figure 2: Difference MOD-GPSNAV, sc A, 04/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

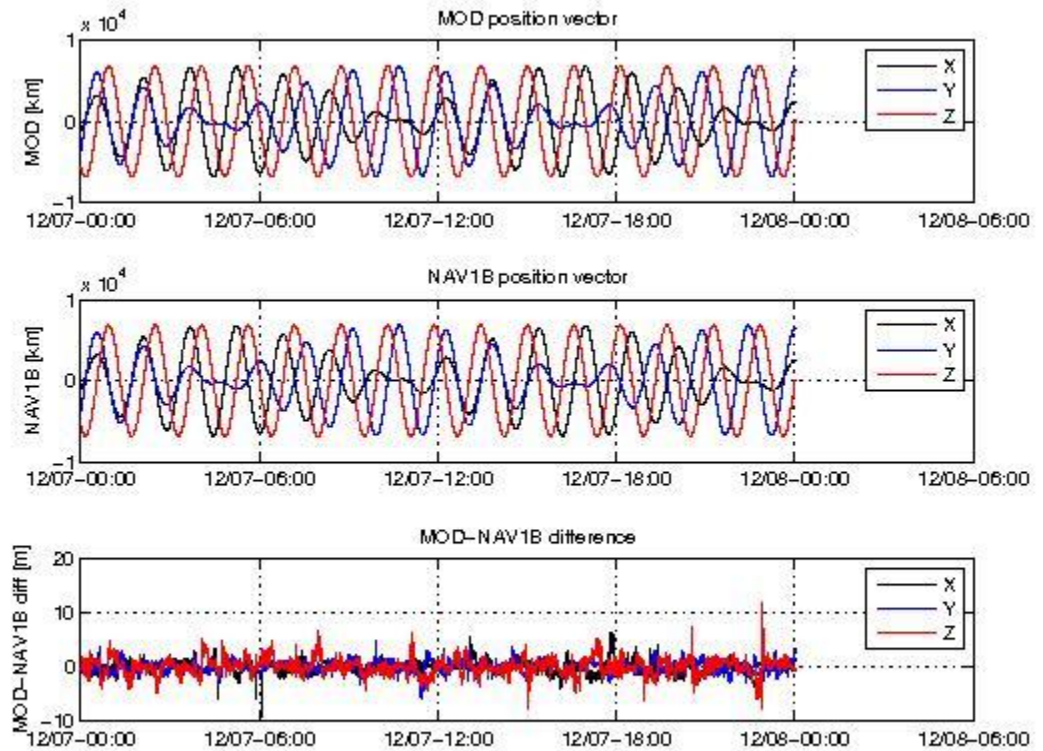


Figure 3: Difference MOD-GPSNAV, sc A, 07/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

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, 01-07/12/2014, Position difference				
Day	Average Difference (m)	Maximum difference (m)	Standard Deviation (m)	Notes
01/12	0.14	+/- 11 (Z)	1.8	SW-IDEAS-34 [RD.10]
02/12	0.04	-9.4, 6.6 (Z)	1.4	
03/12	0.13	-14, 9.3 (Z)	1.7	SW-IDEAS-36 [RD.11]
04/12	0.04	-9.5, 12 (Z)	1.5	SW-IDEAS-34 [RD.10]
05/12	0.12	+/- 9 (Z)	1.5	SW-IDEAS-34 [RD.10]
06/12	0.19	-12, 8 (Z)	1.5	SW-IDEAS-36 [RD.11]
07/12	0.07	-9, 7 (X)	1.5	SW-IDEAS-34 [RD.10]

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 (01/12, Figure 4), in the middle (03/12, Figure 5), and at end of the week (07/12, 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.

In Figure 5 one can see an example of SW-IDEAS-36 anomaly occurrence ([RD.11]): the red-circled area evidences a time series when the X component of the MOD-NAV difference has an oscillatory behaviour around the average; during the same interval (not shown), several failures of the GPS clock calculation in the MOD product are observed.

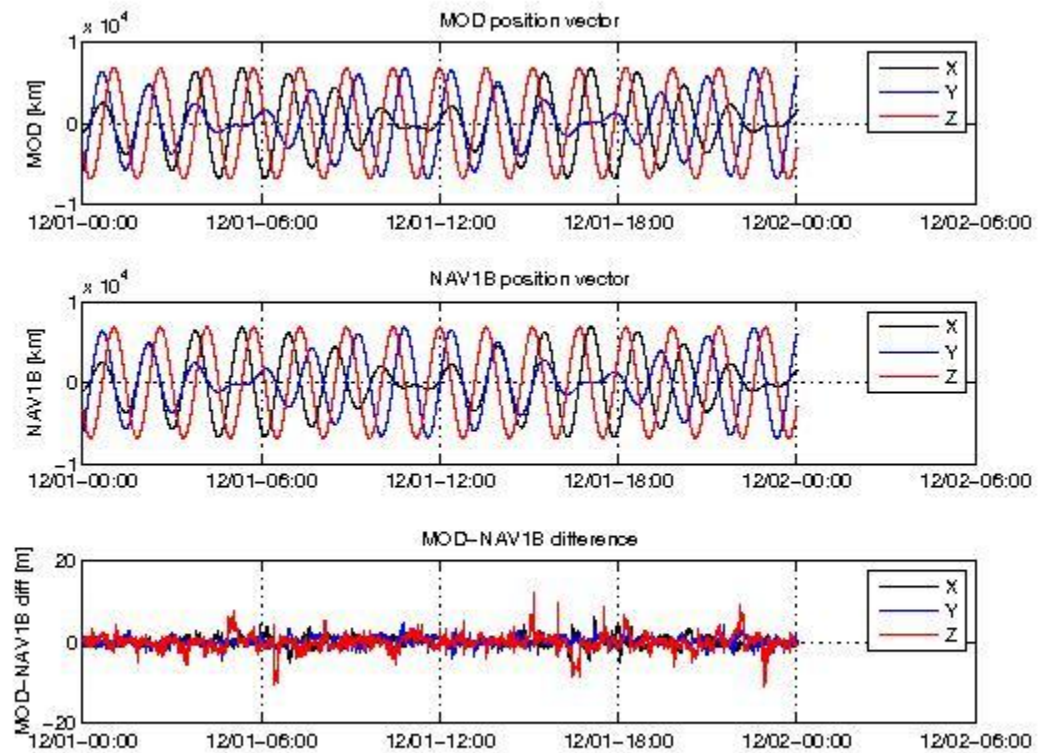


Figure 4: Difference MOD-GPSNAV, sc B, 01/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

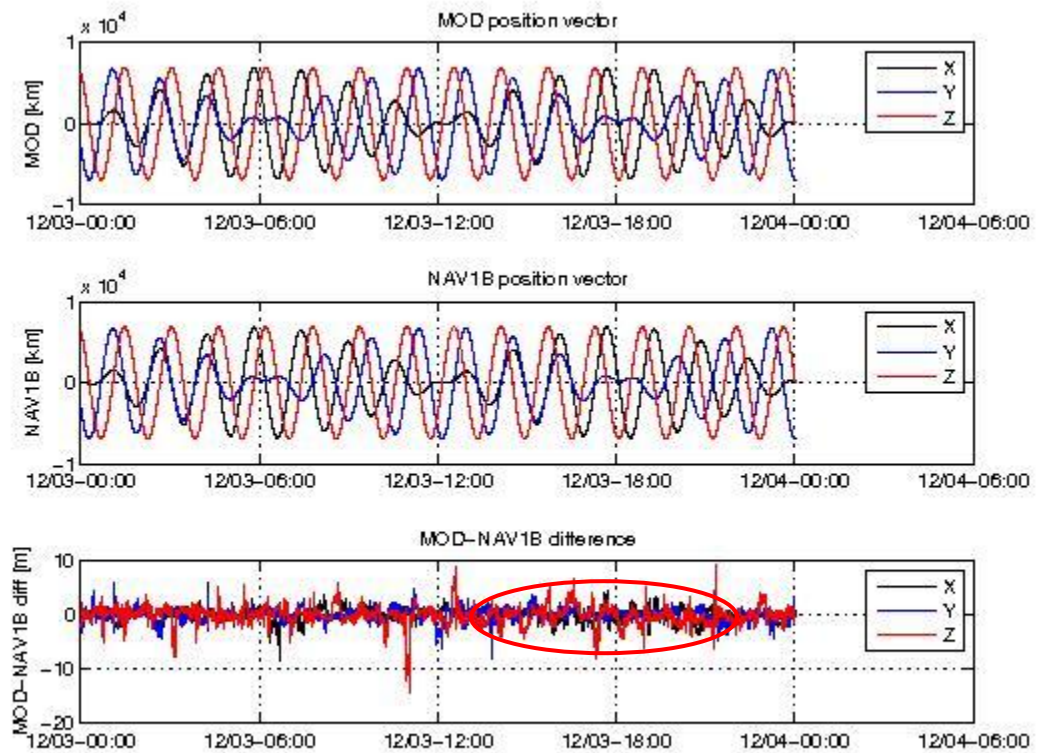


Figure 5: Difference MOD-GPSNAV, sc B, 03/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red-circled area evidences a time interval affected by SW-IDEAS-36 anomaly ([RD.11]).

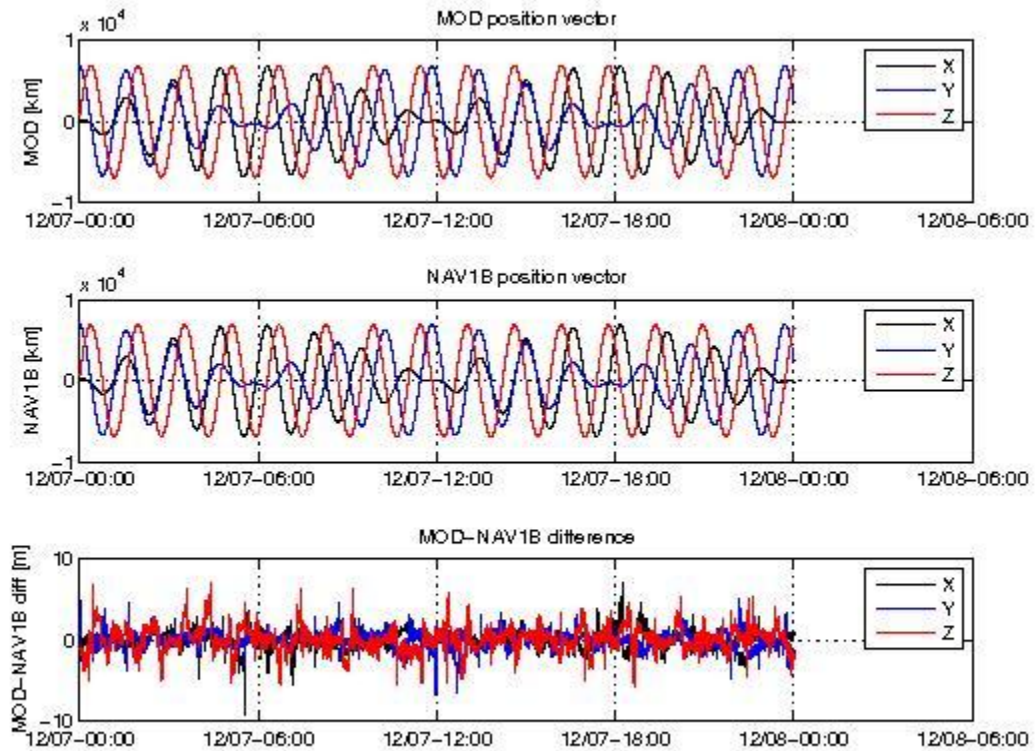


Figure 6: Difference MOD-GPSNAV, sc B, 07/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.2.2 Attitude observations

Nothing to report.

3.2.3 Swarm C

3.2.3.1 Position Statistics

In Table 4 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, 01-07/12/2014, Position difference				
Day	Average Difference (m)	Maximum difference (m)	Standard Deviation (m)	Notes
01/12	0.15	-10, 11.5 (Z)	1.8	SW-IDEAS-34 [RD.10]
02/12	0.1	-12.6, 9.3 (Z)	1.4	
03/12	0.1	-10, 14.7 (Z)	1.5	
04/12	0.19	+/- 9 (Z)	1.5	SWL1L2DB-9 [RD.9]
05/12	0.24	-7, 5.8 (Z)	1.3	SW-IDEAS-36 [RD.11]
06/12	0.05	+/- 8 (Z)	1.3	
07/12	NN	NN	NN	Missing Data because of ORBATT_C failure

Table 4: 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 (01/12, Figure 7), in the middle (04/12, Figure 8) and at the end (06/12, 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.

In Figure 8 one can see a case of **SWL1L2DB-9** anomaly occurrence: the red circled area at the end of the day evidences a time interval when the MOD and NAV solutions start diverging one each other, due to configuration issues in the Napeos software.

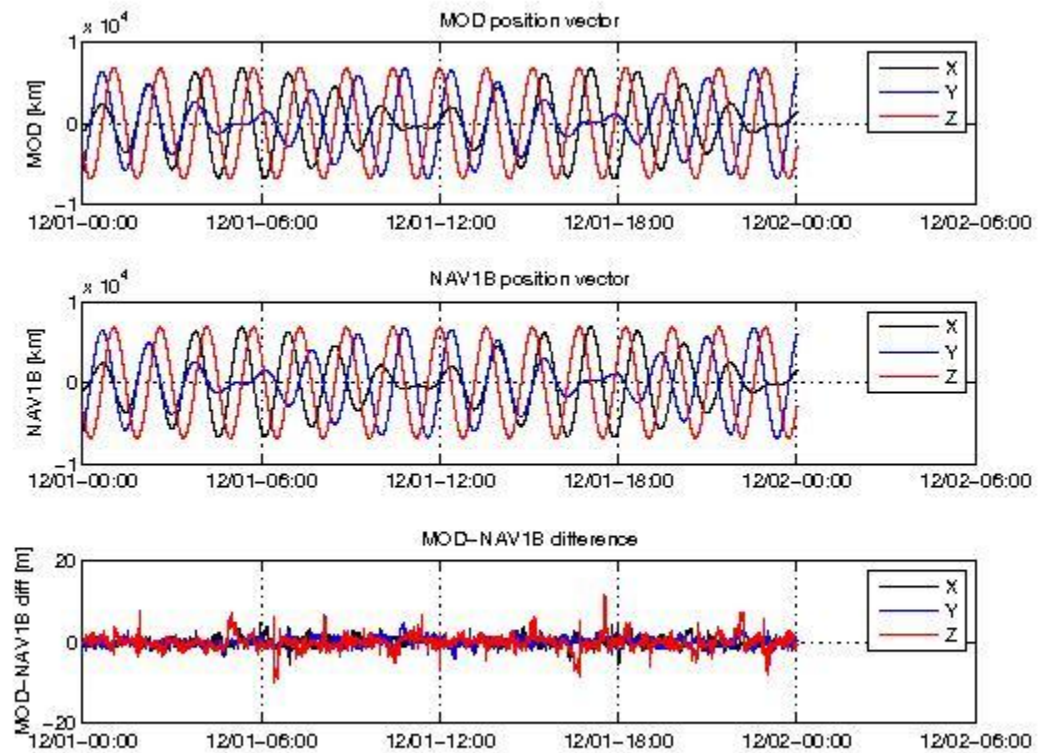


Figure 7: Difference MOD-GPSNAV, sc C, 01/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

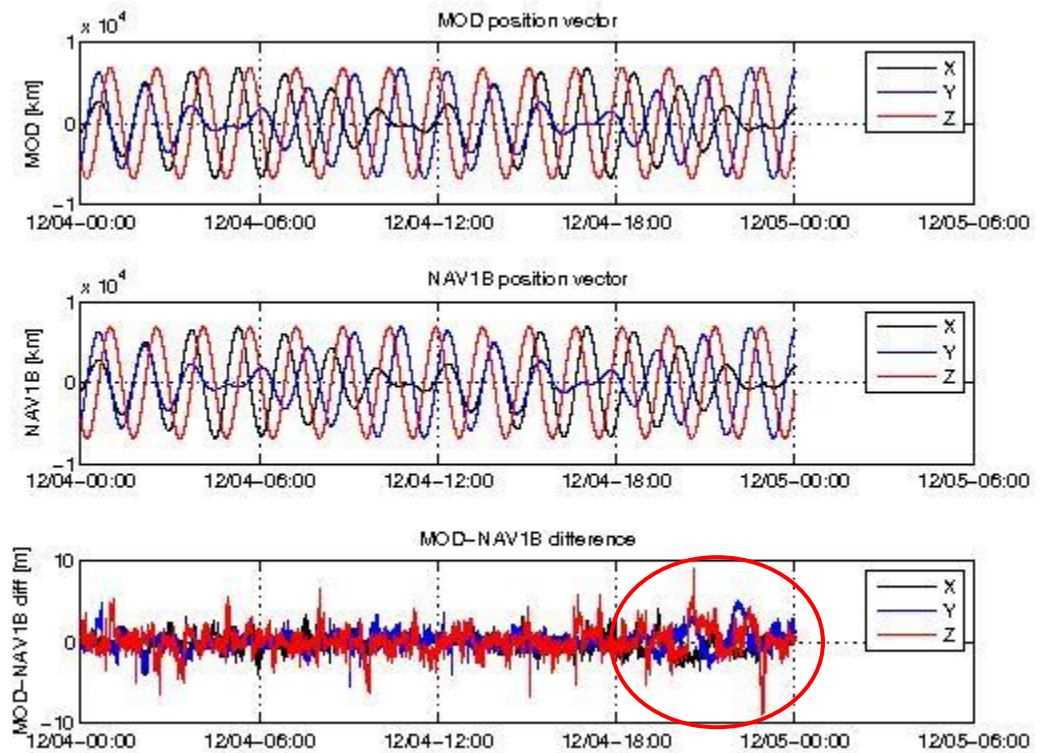


Figure 8: Difference MOD-GPSNAV, sc C, 04/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red-circled area highlights an interval when SWL1L2DB-9 anomaly occurs ([RD.9]).

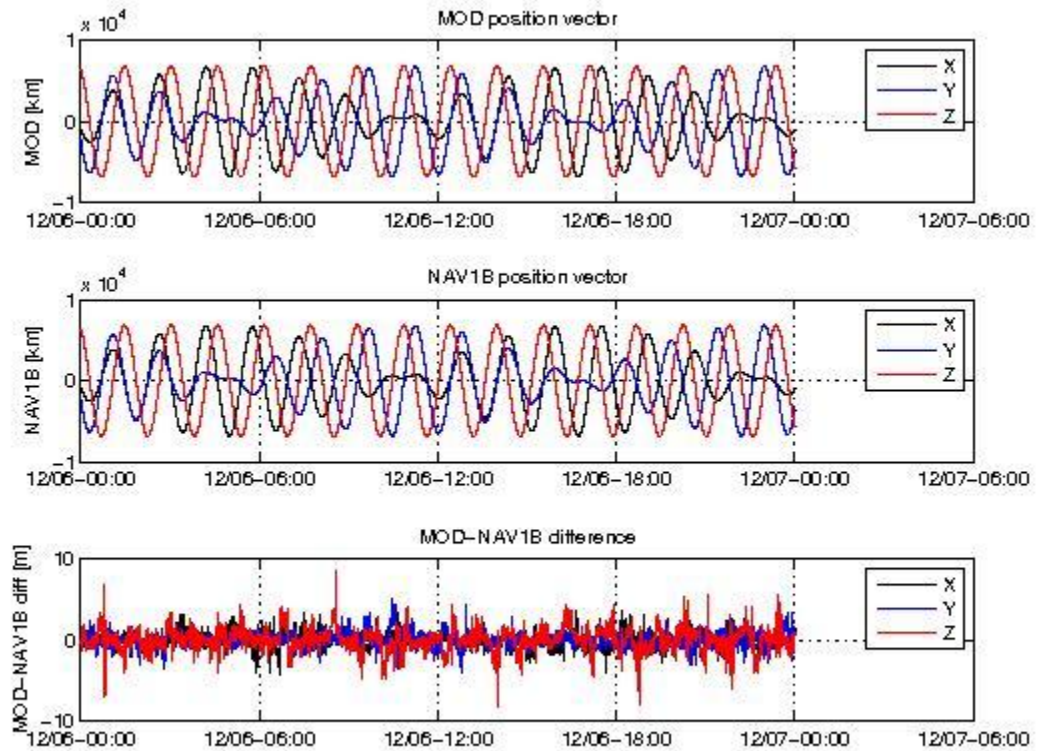


Figure 9: Difference MOD-GPSNAV, sc C, 06/12/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.3.2 Attitude observations

Nothing to report.

3.3 Magnetic Products

For the magnetic products the weekly monitoring consists in:

- 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.
- Monitoring of the **VFM-ASM known anomaly**: visual inspection of $|\mathbf{B}_{\text{NEC}}| - F$ 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.**

SW-IDEAS-27 [RD.13]: Noise superimposed on the magnetic time series is observed in both SC A and B, the 07/12/2014. The noise is evidenced as an increase in the power

spectral density in the frequency band 0.04 – 0.1 Hz. This phenomenon is usually related to periods of high geomagnetic activity, as it is the case for this event too: the Kp index during 07/12 reaches 5 a couple of times, mainly due to substorm activity in the auroral regions (AE index often above 1500 nT).

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 (07/12/2014).

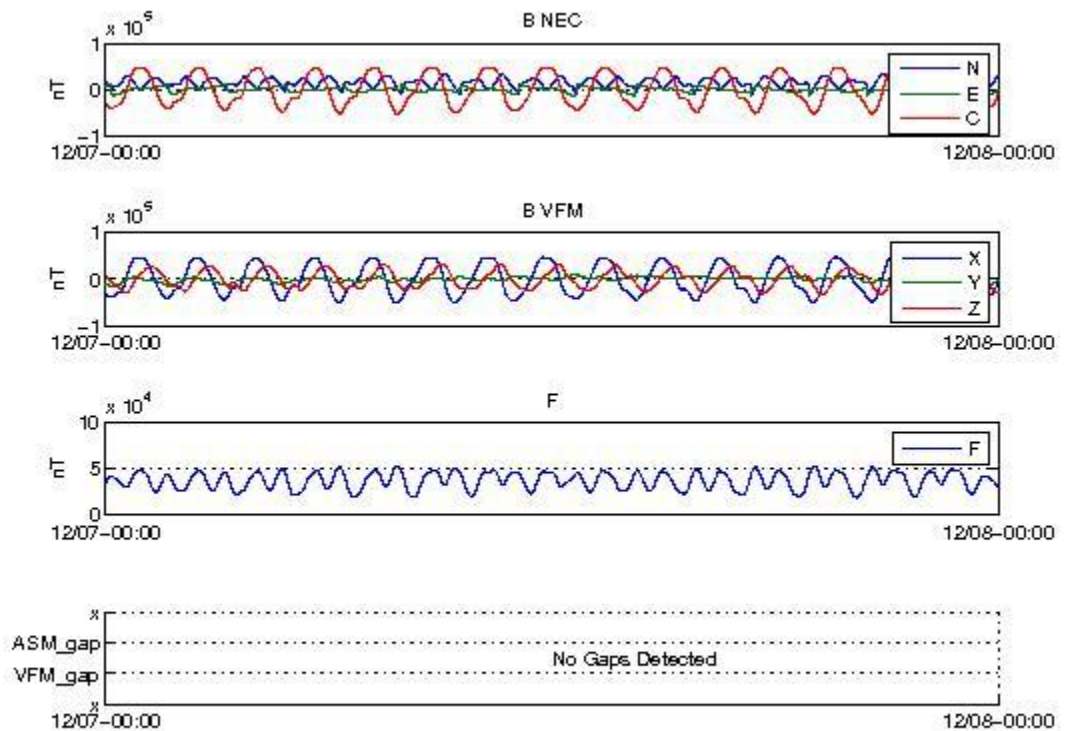


Figure 10: Time series of the geomagnetic field, for 07/12/2014, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.1.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-2.5, 2] nT, with occasional spikes of about 5 nT.

Below some plot example of such differences follows, taken at the beginning of the week (01/12, Figure 11) and at the end (07/12, Figure 12). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

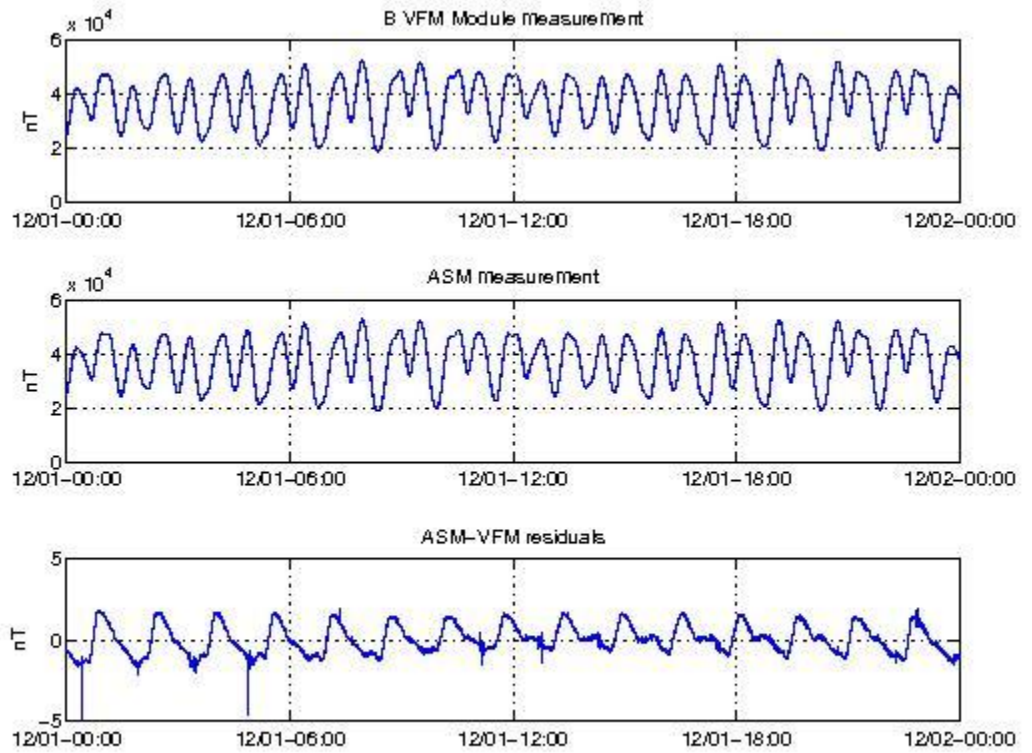


Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 01/12/2014.

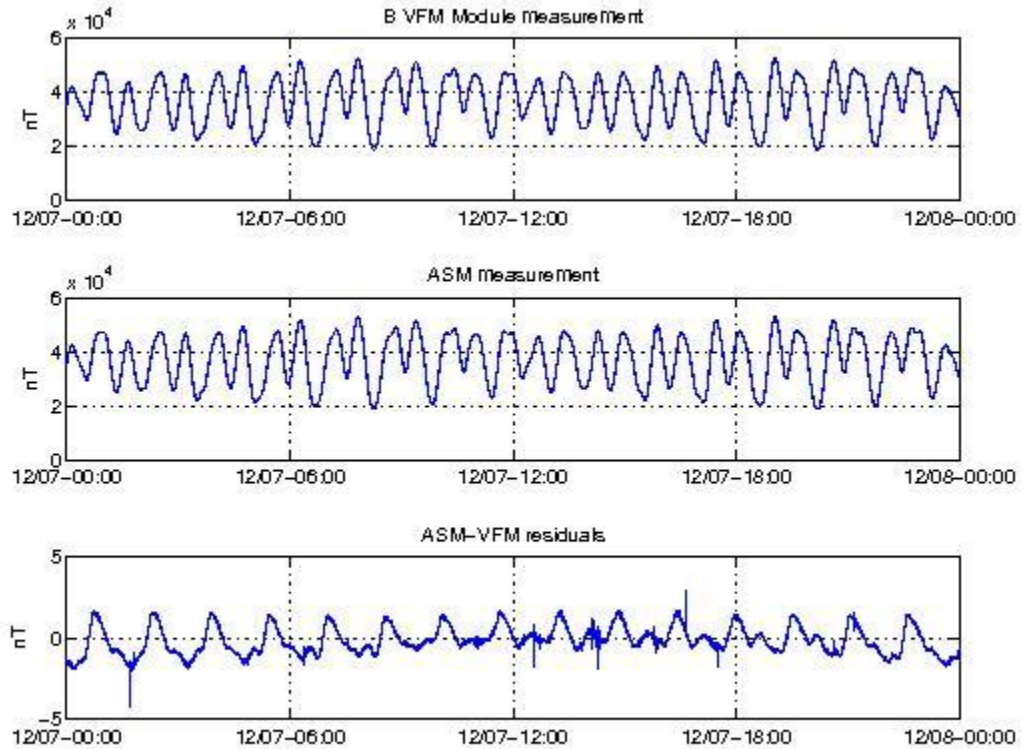


Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 07/12/2014.

3.3.1.3 TCF.VFM monitoring

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

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 (07/12/2014) can be seen in Figure 13 below.

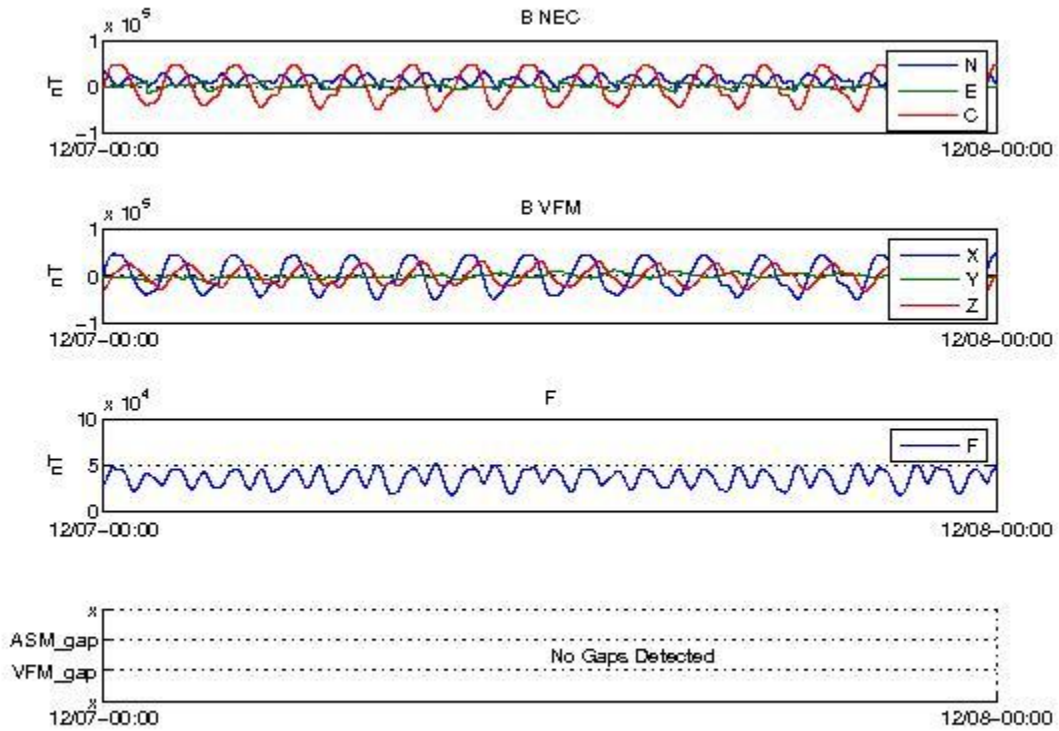


Figure 13: Time series of the geomagnetic field for 07/12/2014, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.2.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-2.3, 1.5] nT, with isolated spikes (gradients) that reaches up to 5 nT.

Below some plot example follows of such differences taken at the beginning of the week (02/12, Figure 14), and at the end of the week (07/12, Figure 15). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

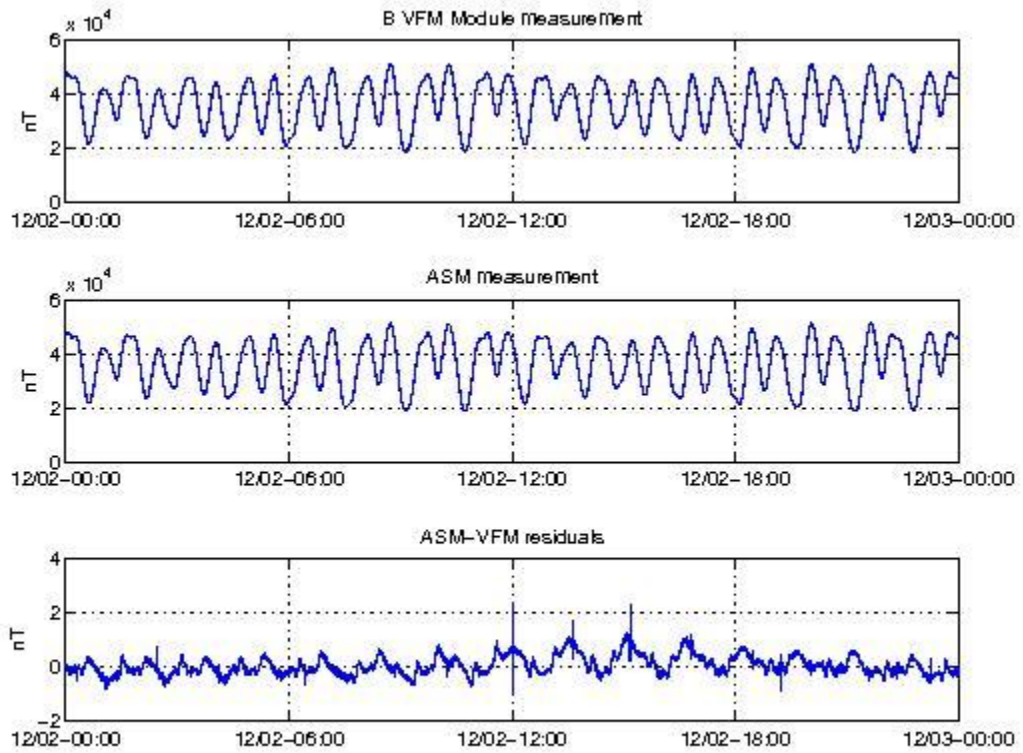


Figure 14: VFM module, ASM module and ASM-VFM residuals for S/C B, 02/12/2014

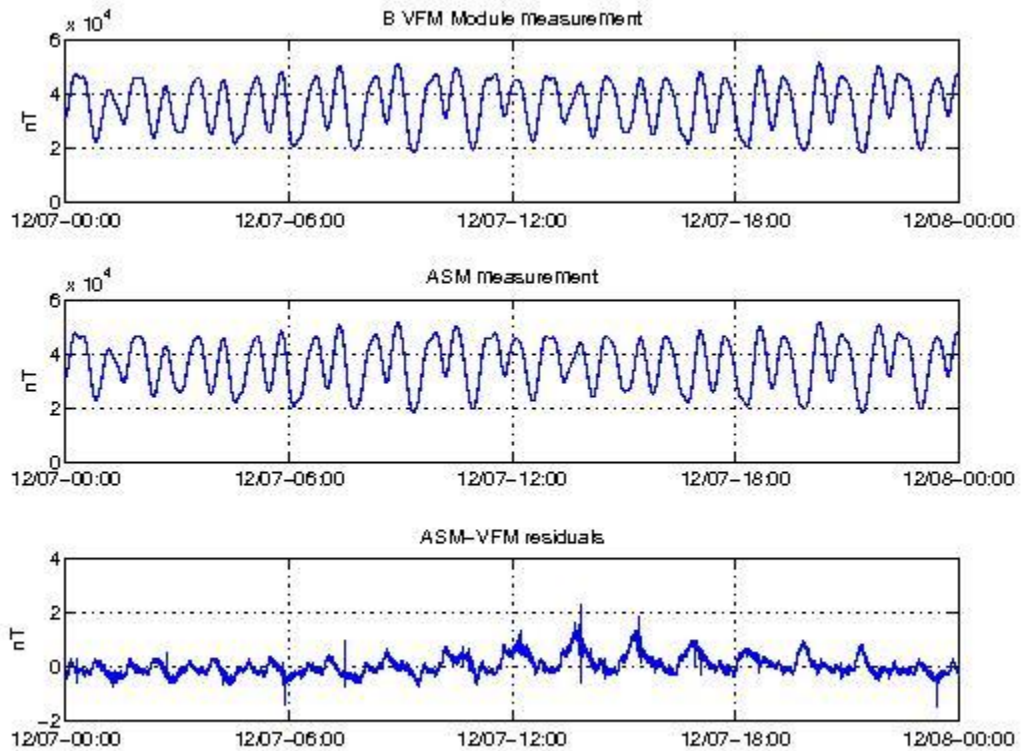


Figure 15: VFM module, ASM module and ASM-VFM residuals for S/C B, 07/12/2014.

3.3.2.3 TCF.VFM monitoring

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

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

No data because ASM is still switched off



3.3.4 Summary of TCF behaviour for the three S/C

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



4. ON-DEMAND ANALYSIS

Nothing to report.



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