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IDEAS+ Swarm Weekly Report 2015/02 : 05/01/2015 – 11/01/2015

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 05 to 11 January 2015.

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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	16 Jan 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 2.4.

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 (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)

2. SUMMARY OF THE OBSERVATIONS

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

- **The latest EFI** MCP & Phosphor scrubbing procedure was completed on Monday, 5 Jan, for all satellites. EFI was left in Ready State until reception of new Gain Maps and restart in Active State the following week.

- **A VFM power cycle** on SC B was necessary on 10/01, because of corrupted science telemetry sent to ground. More details in Sect. 3.1.

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 weeks, before the final deployment of the processors in operation in January.

An error in Napeos configuration has been found by the manufacturer (**SWL1L2DB-38**), that causes the output MODs to be 10 minutes shorter than expected. A patch to L1BOP3.12 has been already released to fix the issue.

2.3 Quality Working Group and Cal/Val Coordination

Coordination is in place for organizing the 6th 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 will be released end of January 2015 and the MAGNET QWG will prepare a dataset of vector magnetic data, corrected from the Sun disturbances.

2.4 Summary of observations for 2015, Week 02 (05/01-11/01)

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]). Moreover, an occurrence of **SWL1L2DB-9** ([RD.9]) anomaly has been observed: the MOD-NAV solution difference explodes towards the end of the day, due to a too restrictive Napeos configuration.

2. **A couple of attitude rejection events** have to be reported for SC C, due to simultaneous BBOs and/or invalid measurements on the three cameras.

3. Noise superimposed on magnetic data (**SW-IDEAS-27** [RD.13]), observed throughout all the week, due to high geomagnetic activity, mainly at high latitudes.

4. **Anomalous increase** of the residual difference between B_{NEC} and B_{models}, starting at 00 UT of 02/01/2014, particularly marked in the East component. This is related to a bad treatment of the leap seconds by the L1B processor, and the

manufacturer has already found the bug and is testing impacts on the system (**SWL1L2DB-40**).

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.

- **VFM off on SC B** from January 10, 18:17:39 up to January 12**,** 12:33:20. This causes VFMBAUX_1B, ASMBAUX_1B, MAGB_HR_1B, MAGB_CA_1B of day 10/01/2015 to be shorter, while MAGB_LR_1B covers all the day length but from 18:17:39 on, all the parameters that involve a use of the VFM magnetic field are filled with zeros. On day 11/01/2014 all the L1B magnetic production for SC B fails. Due to partial magnetic coverage, also the L1B plasma production for SC B fails for day 10,11 and 12/01/2015. The event is caused by corrupted Science telemetry sent by VFM-B starting from 10/01 on. The instrument provider suggested to power cycle the VFM and, after having done that, the problem disappeared. The causes of the anomaly are still under investigation, but it is likely that radiation hit the software board when passing over the South Atlantic Anomaly.

- **Telemetry gap on day 11/01/2015**, between 14:21:07 UT and 14:54:09 UT on SC B, because of a persistent SEFI on the MMU, which led to a Soft reset as from procedures.

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)	3.2.3.1	[RD.10]
SWL1L2DB-9	L1B: MOD - NAV1B discrepancies...	Orbits (position and velocity)	3.2.2.1	[RD.9]
SW-IDEAS-48	OBS_ROUTINE: 06/01/2015 and 11/01/2015, STR S/C C out of range.	STRCSCI_1A STRCATT_1B	3.2.3.2	3.2.3.2
SWL1L2DB-40	L1BOP: anomalous increase of the magnetic field residuals starting from 02/01/2015	STRxATT_1B STRxSCI_1A (quaternions) MAGx_LR_1B ($B_{NEC,}$ lat, lon, radius)	4.1	4.1

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for 2015, Week 02: 05/01 - 11/01.

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 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, 05/01 – 11/01, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard deviation (m)**	**Notes**
05/01	0.09	-6.6, 5.7 (Z)	1.3	SW-IDEAS-34 [RD.10]
06/01	0.1	-13, 7.4 (Z)	1.5	SW-IDEAS-34 [RD.10]
07/01	0.11	-12.2, 7.6 (Z)	1.6	SW-IDEAS-34 [RD.10]
08/01	0.04	-13.7, 8.5 (Z)	1.5	
09/01	0.14	-11 (Y), 8.5 (Z)	1.4	
10/01	0.11	-13, 8.3 (Z)	1.5	

Swarm A, 05/01 – 11/01, Position difference				
11/01	0.08	15.2, 7 (Z)	1.6	

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 (05/01, Figure 1), in the middle (08/01, Figure 2) and at the end (11/01, 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.

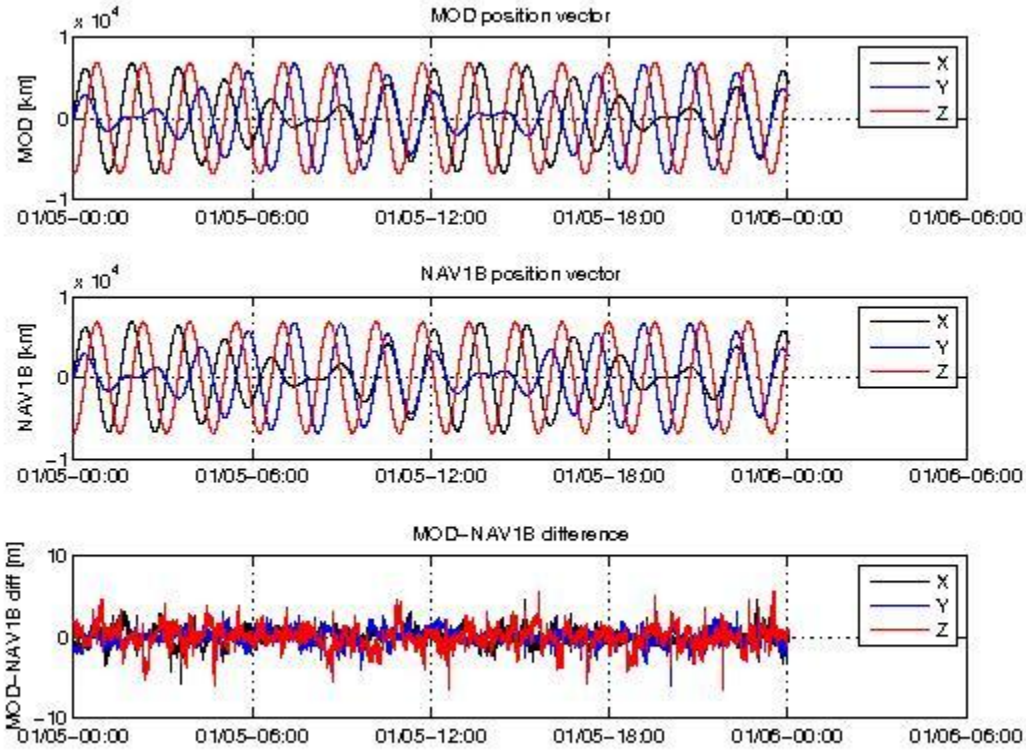

Figure 1: Difference MOD-GPSNAV, sc A, 05/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

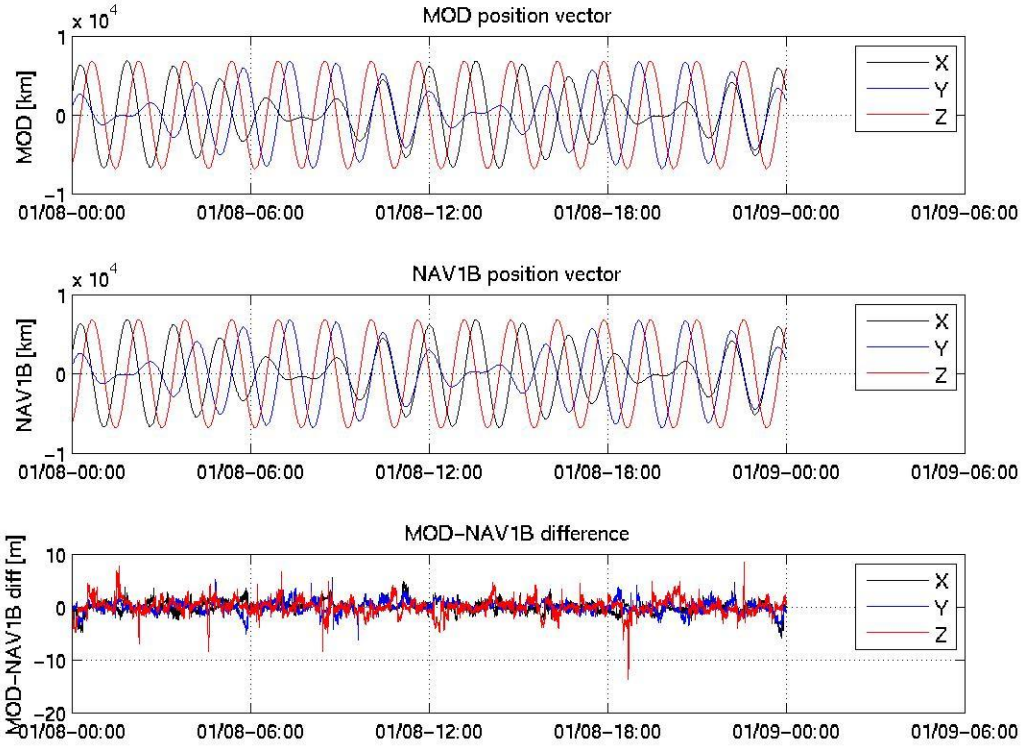

Figure 2: Difference MOD-GPSNAV, sc A, 08/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

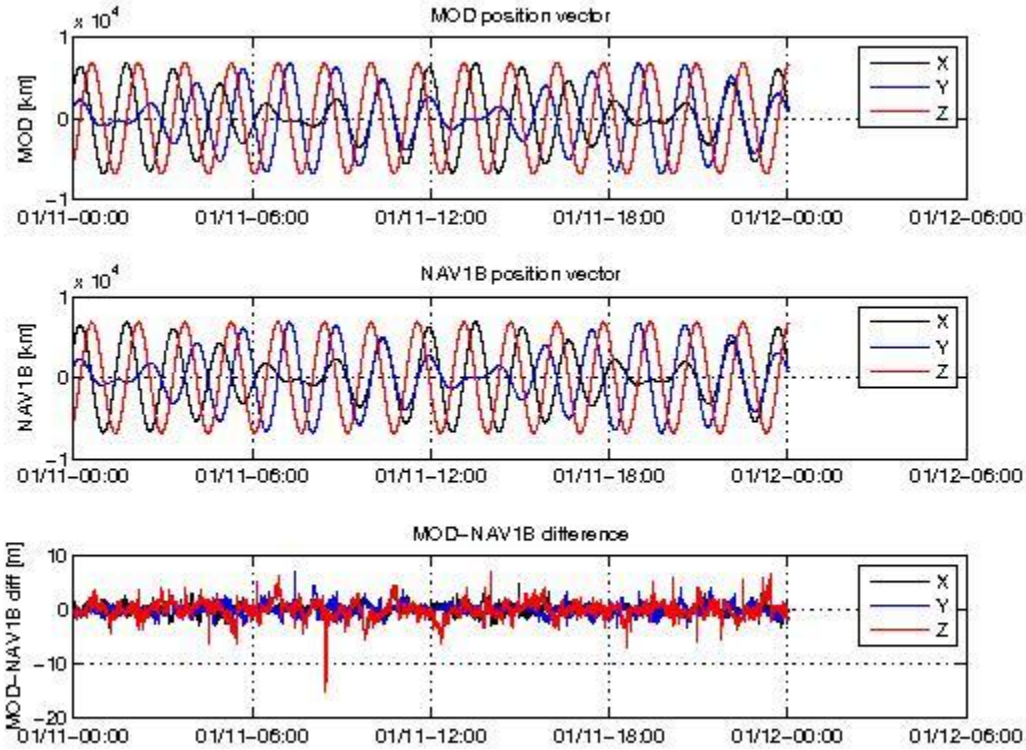

Figure 3: Difference MOD-GPSNAV, sc A, 11/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

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, 05/01 - 11/01, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
05/01	0.07	-12, 6.7 (Z)	1.3	
06/01	0.12	-13.5, 7.6 (Z)	1.5	SW-IDEAS-34 [RD.10]
07/01	0.12	-8 (Z), 7.5 (Y)	1.5	SW-IDEAS-34 [RD.10]
08/01	0.17	-6 (Y), 6 (Z)	1.3	
09/01	0.05	-6.5, 5.5 (Y)	1.2	
10/01	0.05	-14.4, 10.2 (Z)	1.7	SW-IDEAS-34 [RD.10]
11/01	0.25	-10.3, 11 (Z)	2.1	SWL1L2DB-9 [RD.9]

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 (05/01, Figure 4), in the middle (08/01, Figure 5), and at end of the week (11/01, 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 6 (red-circled area), an example of **SWL1L2DB-9** anomaly occurrence ([RD.9]) is shown: all the components of the MOD-NAV solutions difference start to depart from the average from about 21 UT until the end of the day. This is due to a problem with too restrictive rejection criteria in Napeos, which at times causes the calculated solution to be not very reliable. The issue has been resolved in the new version of the processor recently delivered (but not yet deployed in operations)

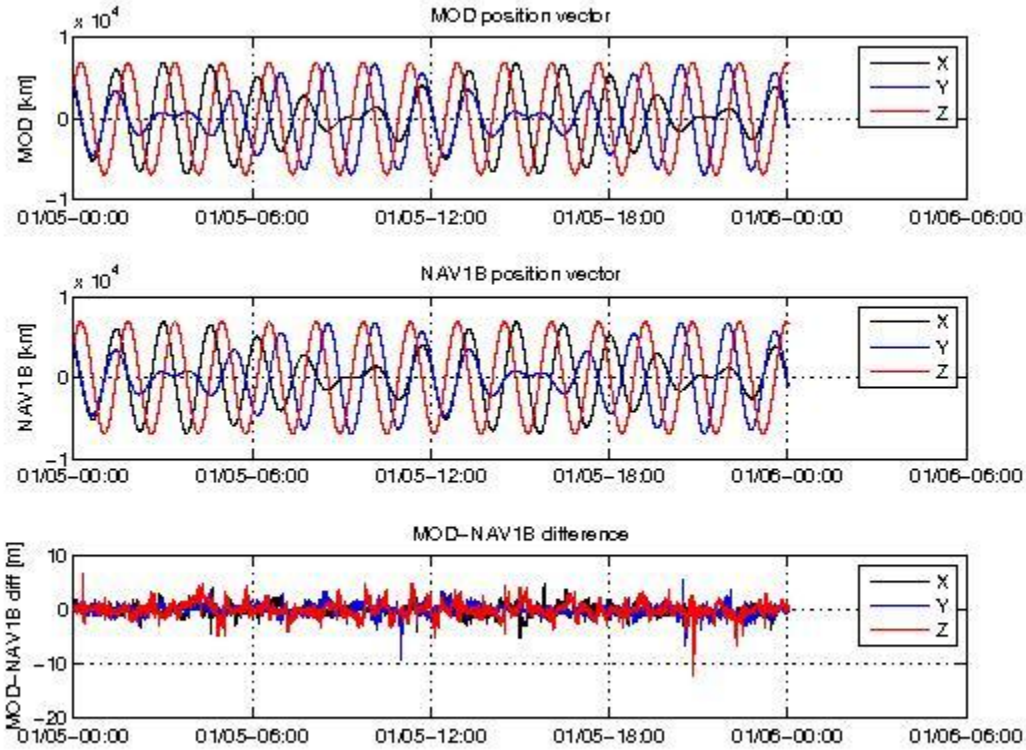

Figure 4: Difference MOD-GPSNAV, sc B, 05/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

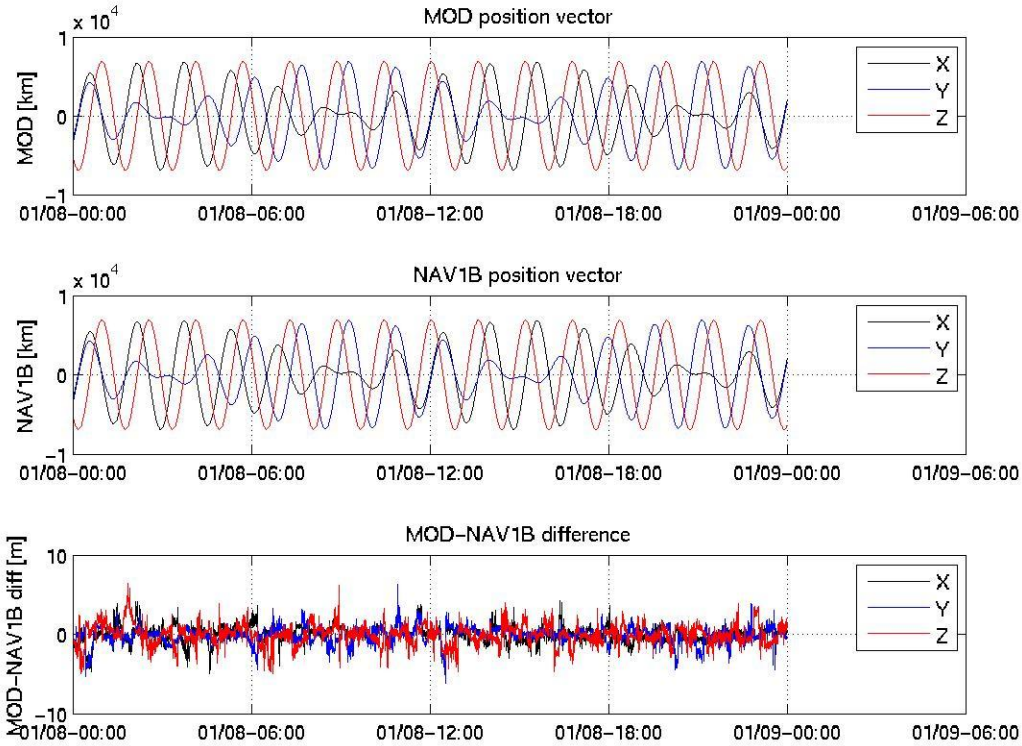

Figure 5: Difference MOD-GPSNAV, sc B, 08/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

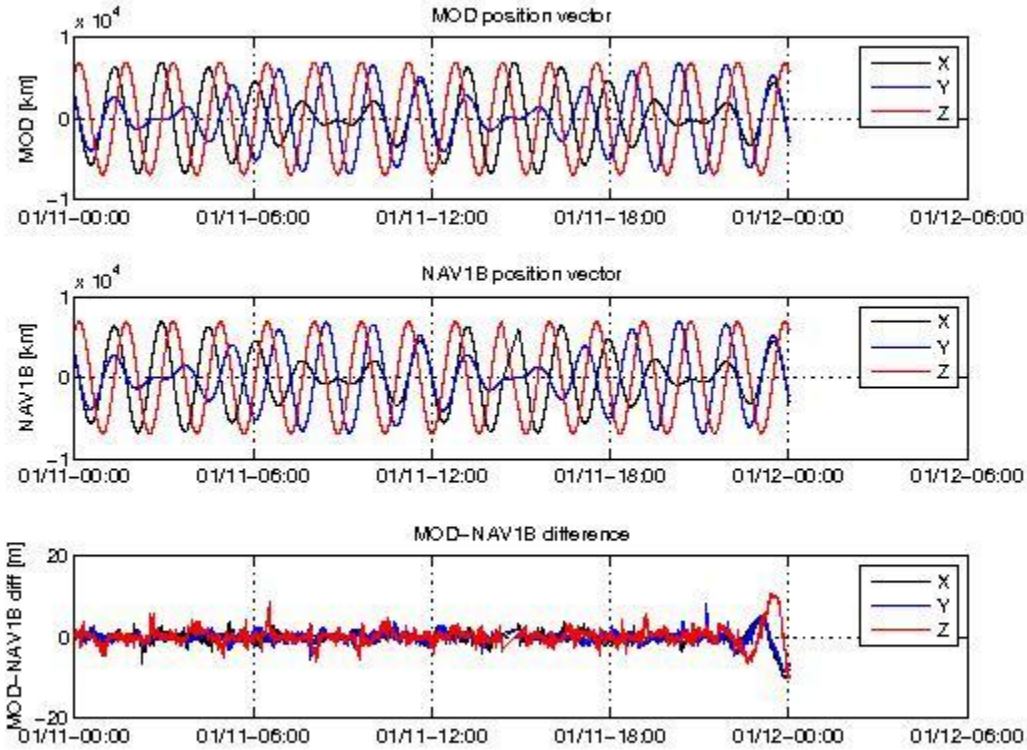

Figure 6: Difference MOD-GPSNAV, sc B, 11/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

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, 05/01 - 11/01, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
05/01	0.17	-5.5, 7 (Z)	1.3	
06/01	0.07	-11, 8.5 (Z)	1.4	SW-IDEAS-34 [RD.10]
07/01	0.13	-8.5, 7.4 (Z)	1.5	SW-IDEAS-34 [RD.10]
08/01	0.14	-9.7, 7.7 (Z)	1.4	SW-IDEAS-34 [RD.10]
09/01	0.15	+/- 6 (Z)	1.2	
10/01	0.14	-9, 8 (Z)	1.4	
11/01	0.04	-18, 8 (Z)	1.5	

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 (05/01, Figure 7), in the middle (08/01, Figure 8) and at the end (11/01, 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 an example (red-circled areas) of **SW-IDEAS-34** ([RD.10]) anomaly occurrence: several spikes depart from the average value of the MOD-NAV solutions difference, keeping higher/lower values for several minutes.

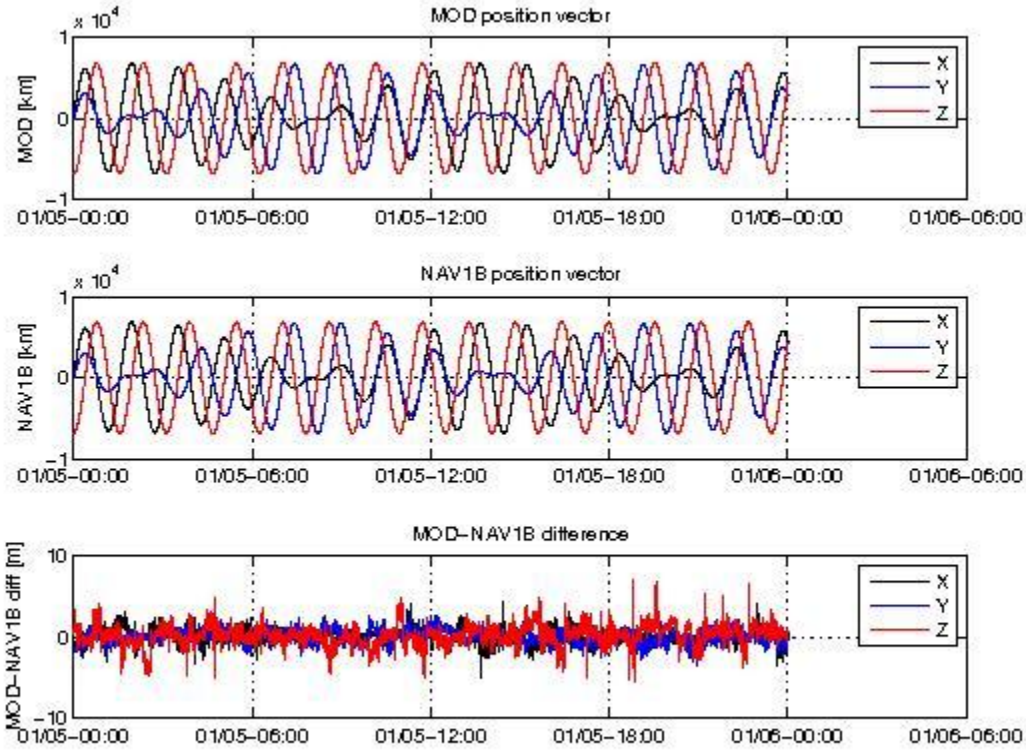

Figure 7: Difference MOD-GPSNAV, sc C, 05/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

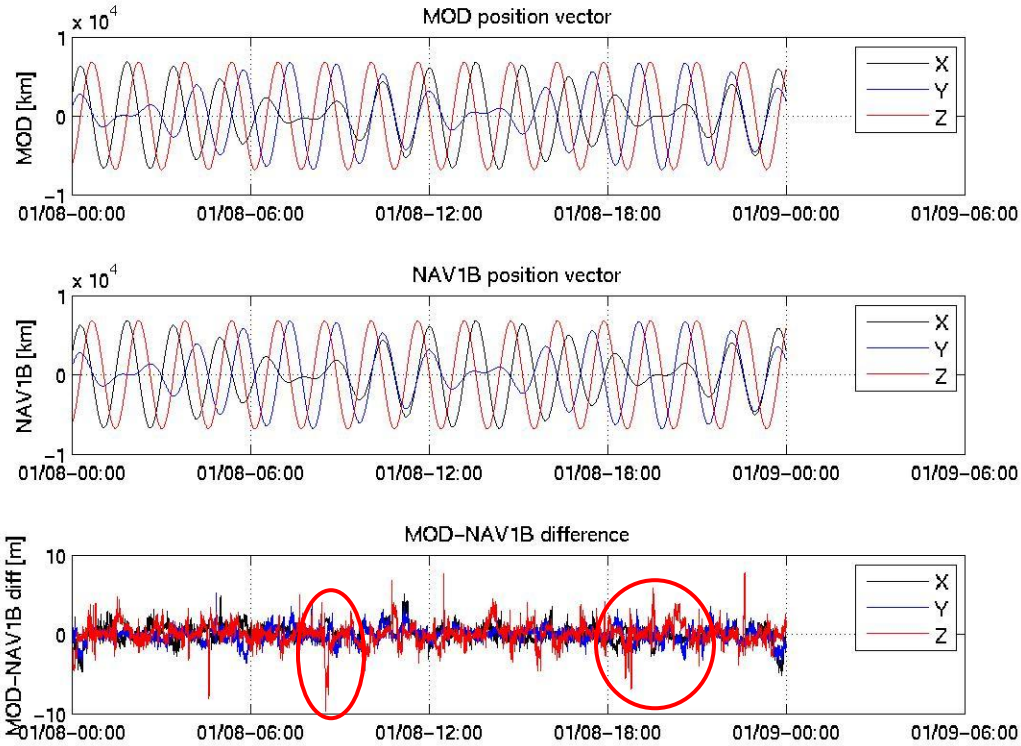

Figure 8: Difference MOD-GPSNAV, sc C, 08/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The two red circled areas identify time intervals when **SW-IDEAS-34** ([RD.10]) anomaly occurs.

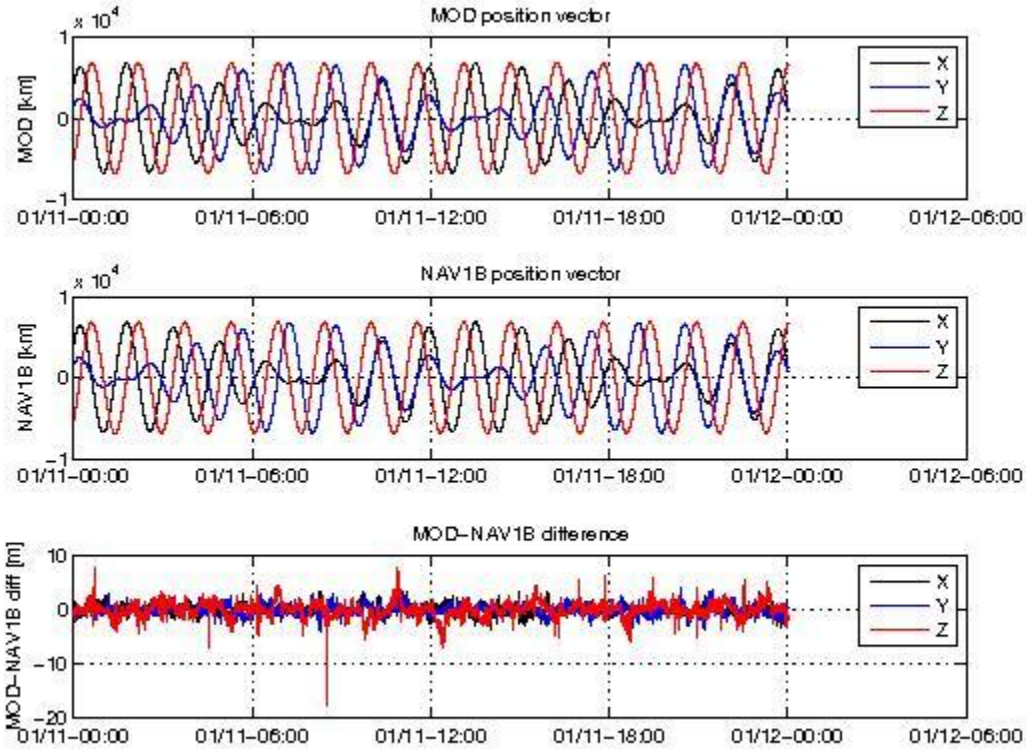

Figure 9: Difference MOD-GPSNAV, sc C, 11/01/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.3.2 Attitude observations

- **SW-IDEAS-48**

  Affected products:

  SW_OPER_STRCATT_1B_20150106T000000_20150106T235959_0302

  SW_OPER_STRCATT_1B_20150111T000000_20150111T235959_0302

  8 seconds out of range (Flags_q=255, no attitude available). See details in Table 5 below.

Start Out-of-range	Stop Out-of-range	Duration (s)
06JAN2015 10:01:48	06JAN2015 10:01:51	4
11JAN2015 10:25:34	11JAN2015 10:25:37	4

Table 5: Attitudes out-of-range, S/C C, 2015, week 02.

The cause of such rejected attitudes is the simultaneous occurrence of BBOs and invalid measurements on all cameras for the specified interval.

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 $|B_{NEC}|$ - F and recording of daily maximum variations. If +/- 5 nT are exceed 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]: A moderate geomagnetic activity as from previous week is still observed during the first days of CW02: a substorm is evidenced on day 07/01 starting at about 9 UT and reaching peaks of 2000 nT in the AE index, and a moderate storm is observed the same day, with Dst going at about -100 nT. Some noise in the magnetic residuals spectra is therefore present. The noise is evidenced as an increase in the power spectral density in the frequency band 0.04 – 0.1 Hz.

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 (10/01/2015).

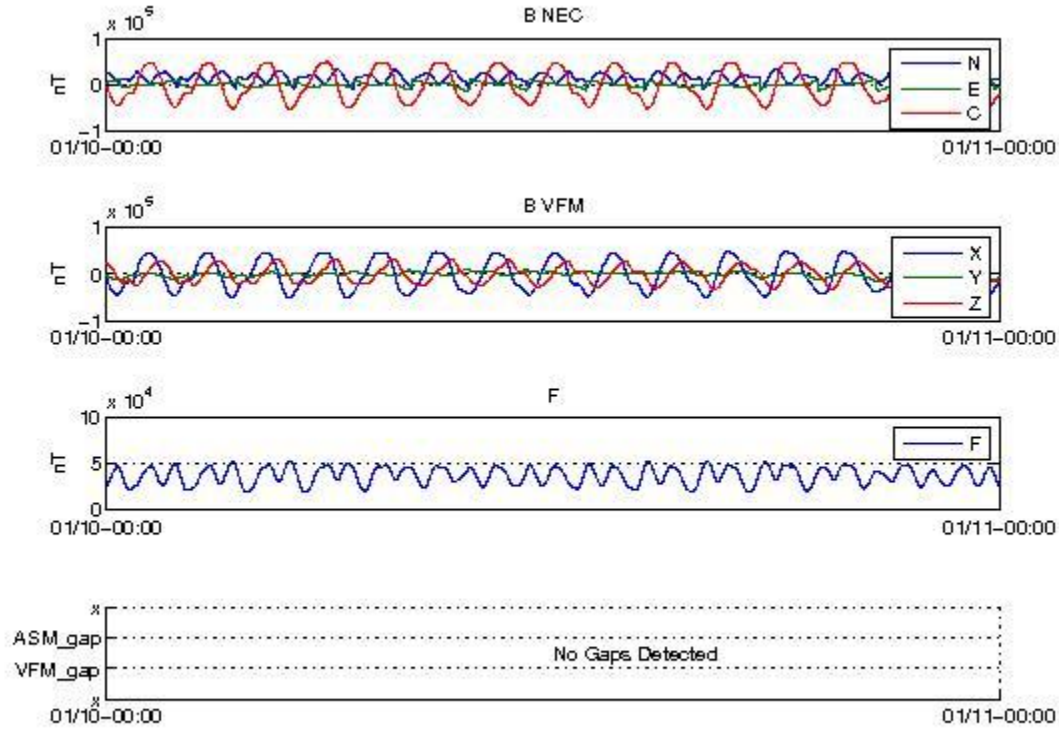

Figure 10: Time series of the geomagnetic field, for 10/01/2015, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.1.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-3, 2] nT, with occasional spikes up to about 7 nT.

Below two example plots of such differences follows: taken at the beginning of the week 06/01 (Figure 11) and 10/01, (Figure 12). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

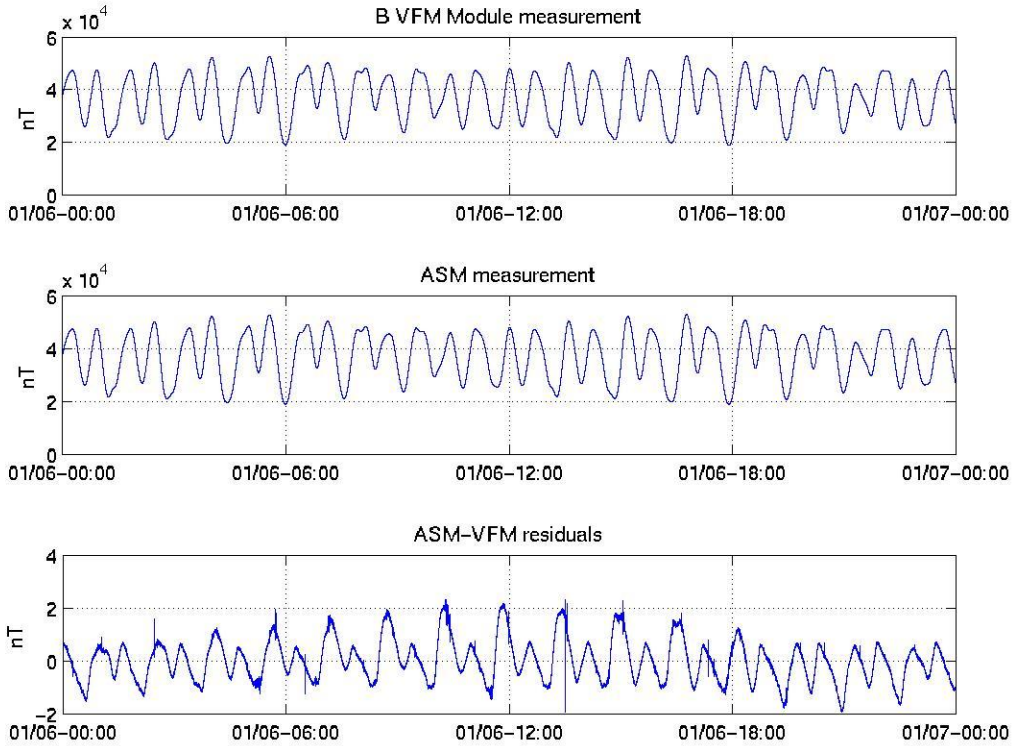

Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 06/01/2015.

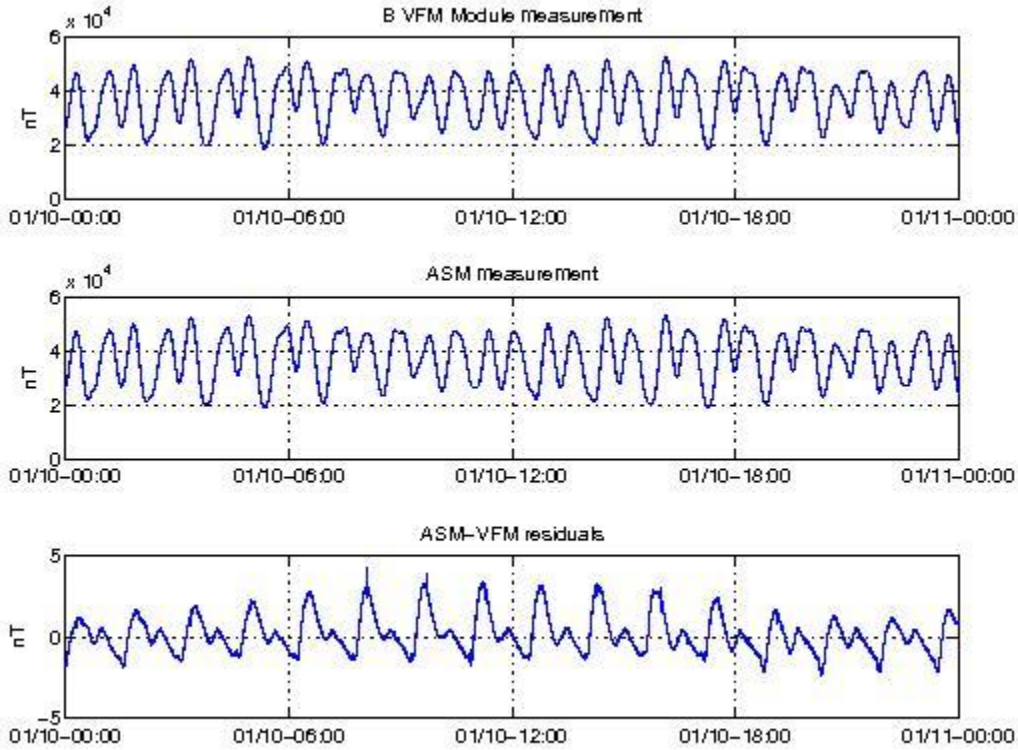

Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 10/01/2015.

3.3.1.3 TCF.VFM monitoring

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

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 (10/01/2015) can be seen in Figure 13 below. From 18:17:39 UT, the VFM started to send corrupted telemetry and therefore no science data were produced.

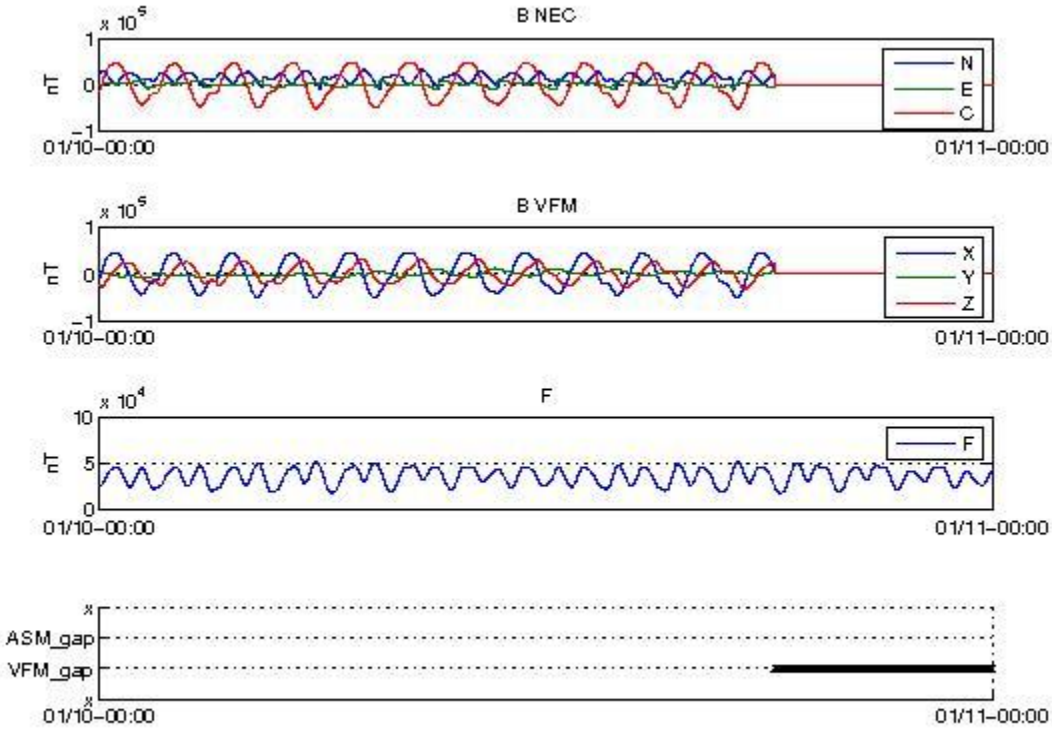

Figure 13: Time series of the geomagnetic field for 10/01/2015, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps.

3.3.2.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-2, 1.5] nT, with peaks of about 10 nT.

Below two example plots follows of such differences: 09/01 (Figure 14), and 10/01 (Figure 15). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

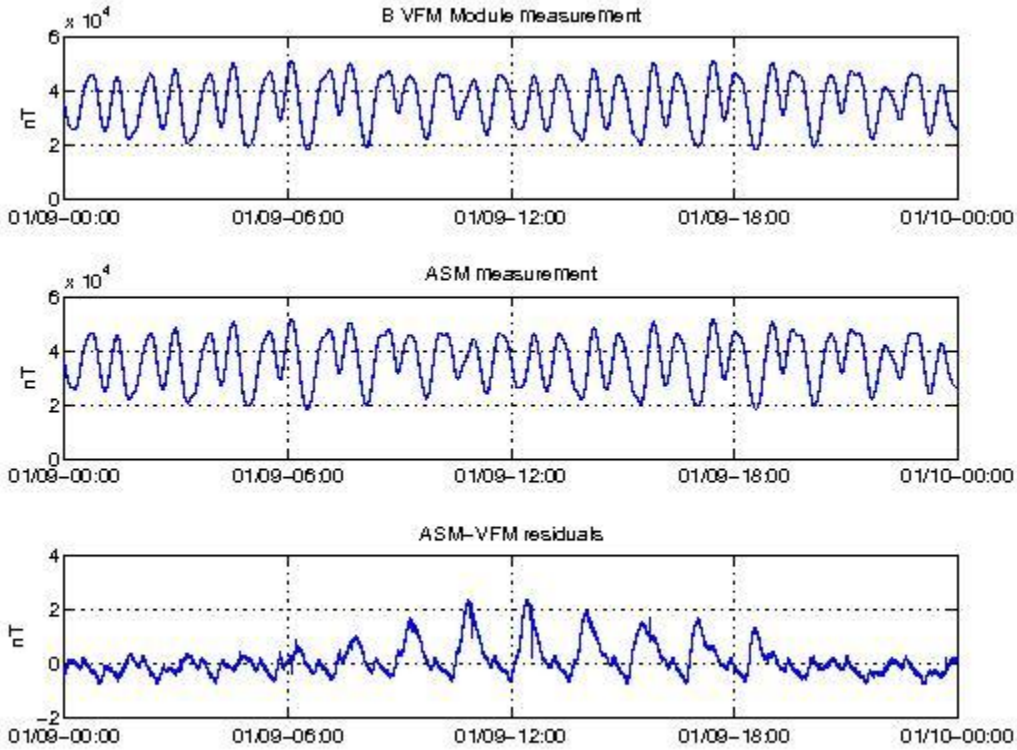

Figure 14: VFM module, ASM module and ASM-VFM residuals for S/C B, 09/01/2015

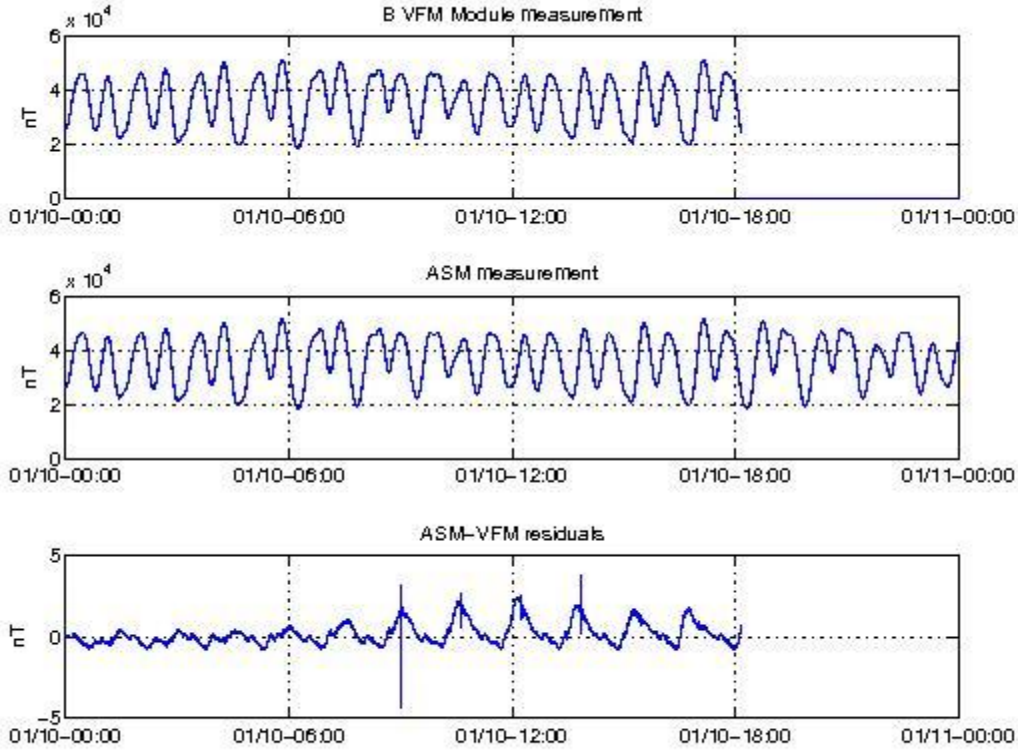

Figure 15: VFM module, ASM module and ASM-VFM residuals for S/C B, 10/01/2015.

3.3.2.3 TCF.VFM monitoring

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

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 January.

4. ON-DEMAND ANALYSIS

4.1 SWL1L2DB-40: B_{NEC}_east(data) – B_{NEC}_east(model) anomalous increase from 02/01/2015

On January 9, BGS reported us about the following issue (email from Brian Hamilton to Lars Tøffner-Clausen):

"When checking the MMA and QL outputs we think we've noticed a change in the behaviour of the Swarm A and B phi-component data. The attached plot shows B_R, B_Theta, and B_Phi magnetic components for 1st and 2nd January 2015 with the predicted field from the AUX_COR model (SW_OPER_AUX_COR_2__20130101T000000_20160101T000000_0001.DBL) subtracted.

On midnight of the morning of 02 Jan 2015 the residuals appear pretty much as before for the R- and Theta-components but are an order of magnitude larger for the Phi-component. Although the plot only shows the 1st and 2nd of January, this behaviour persists through to the most recent files we have (4th Jan)."

In Figure 16 one can see the plot described above, pointing out the reference system is B_{NEC}, where B_{North} = B_Th, B_{East} = B_Ph, B_{Center} = B_R.

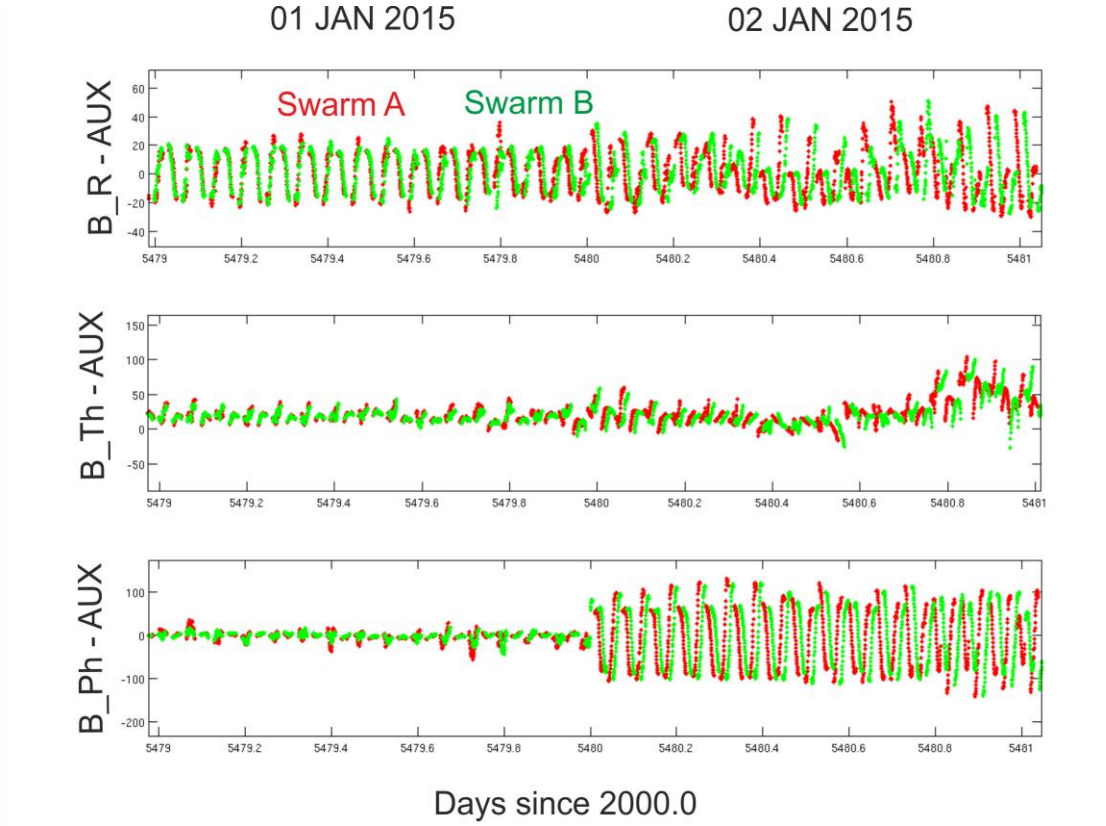

Figure 16: B_{NEC} residuals of Swarm A (red) and Swarm B (green) between 1 and 2 January 2015.

Our independent monitoring based on both IGRF and CHAOS-4 comparisons confirmed the above picture. In Figure 17 below, one can see the B_{NEC} – B_{IGRF}, east component, for SC A, 01/01 (upper panel) and 02/01 (lower panel): looking at the y-axis scale one can see the residual is roughly doubled in January 2nd with respect to January 1st .

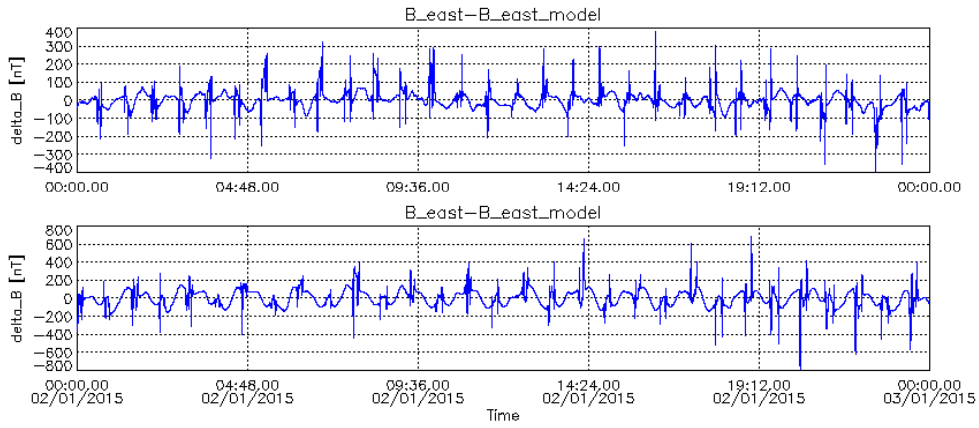

Figure 17: B_{NEC} - B_{IGRF} for SC A, B_{east} component, for day 01/01 (upper panel) and 02/01 (lower panel).

Check #1: ASM-VFM residuals.

We first verified the behavior of the ASM-VFM residuals: as described in the weekly report for past week

(IDEAS+-SER-OQC-REP-
2071_SPPA_SwarmWeeklyReport_201501_20141229_20150104),

except for a general increase of the high frequency noise due to the high geomagnetic activity, there are no indications of an increase of the absolute value residuals.

It is to be noted, however, that such test can only give a partial view of the story, because the intensity of the radial component vastly dominates above the other two and gives the most important contribution to the module of B_{VFM}. Unfortunately we cannot compare ASM and VFM by single components, as the treatment of the ASM vector measurements is not trivial and is not part of the official processing chain.

Check #2: ASM and VFM instrument temperatures

We verified the trend of the instrument temperatures time series: t_crc, t_csc, t_eu (for VFM) and ASM_SensorTemp_MST10706 (for ASM). As an example, in Figure 18 below one can see the t_crc and t_csc behavior for SC A between 20/12/2014 and 08/01/2015: the trend follows the expected daily and seasonal variations and nothing peculiar seems to happen between 01 and 02 January.

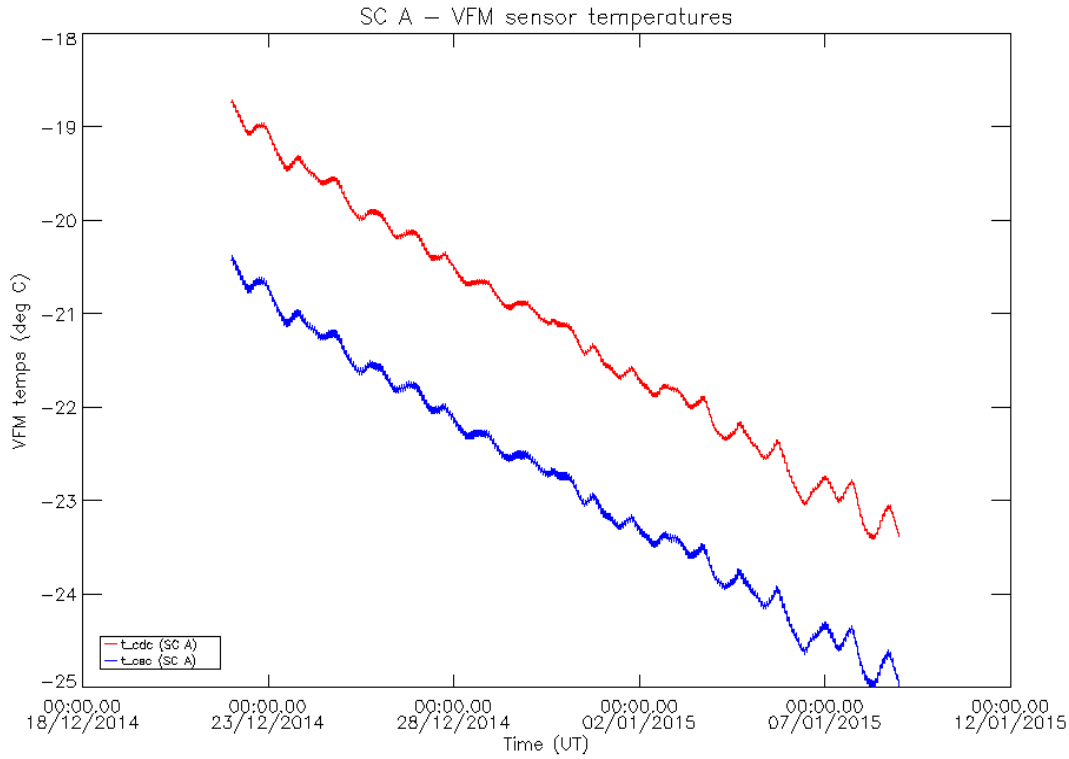

Figure 18: VFM t_cdc and t_csc for SC A between December 2014 and January 2015.

Check #3: Orbit and Attitude verification.

The strange thing about this anomaly is that it seems to start exactly at midnight of day 2/1, and seems therefore related to something happening in the processing. Again, both position and attitude seem not to show jumps or discontinuities between 01 and 02 January.

Check #4: Processing flow analysis.

We had a look at the processing working directories. Except, of course, for the Level 0s, which are different for day 01 and 02 January, the only other difference observed is an update of the auxiliary file AUX_USLEAP, which now has been upgraded in the processing with file counter "0002" and contains an additional row at the end:

2015 JUL 1 =JD 2457204.5 TAI-UTC= 36.0 S + (MJD - 41317.) X 0.0 S

I.e. the number of leap seconds will be increased of one unity starting from July, 1st, 2015. The leap seconds are needed by all the processing steps, because a common class which encapsulates the leap second treatment is used for all the time conversions. We ran manually the MAGNET processor for day 02/01 using the old leap second file and the output was identical to the operational one (which uses AUX_USLEAP 0002), as expected.

But for ORBATT the story is different. We also ran ORBATT manually for day 02/01 using the old leap second file and while the MOD output is identical to the operational one, the STRxATT outputs differ one each other: the difference on the quaternions can amount up to 0.002 arcseconds (excluding a spike at about 11 UT). The example for SC A can be seen in Figure 19.

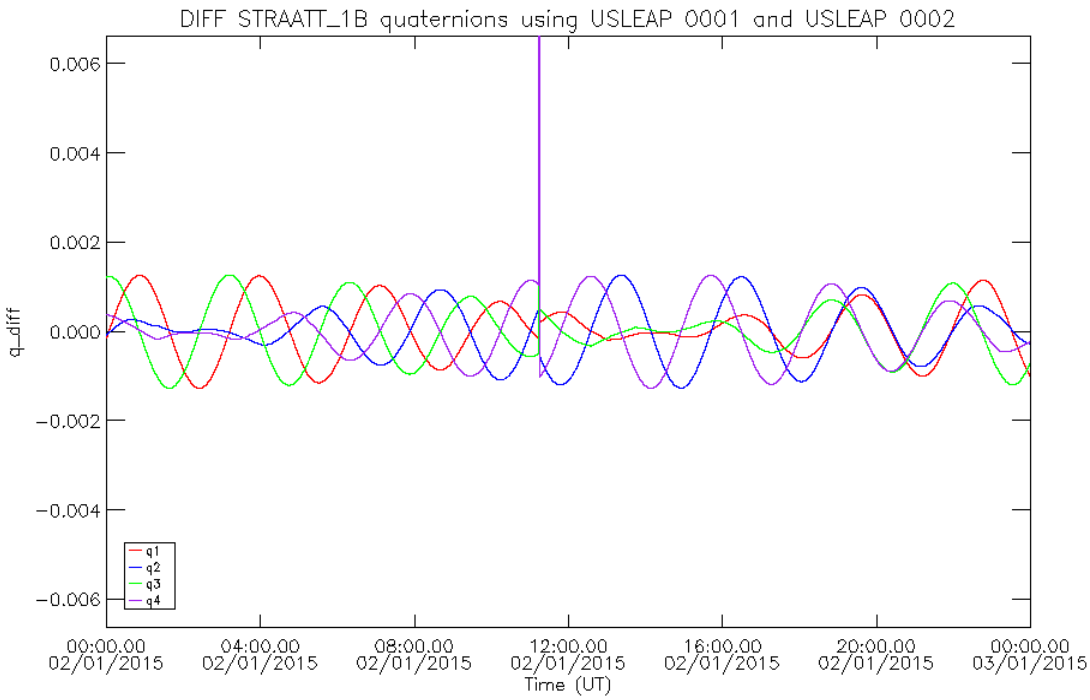

Figure 19: quaternion difference for SC A, 02/01/2015, using different USLEAP files as inputs.

Transferring the STRxSCI_1A input into MAGNET, the two slightly different attitudes produce as outputs remarkably different B_{NEC}, as can be seen in Figure 20: on the East component, especially, the difference between the two runs reaches up to 100 nT. The B_{VFM} field, on the other hand, is not affected.

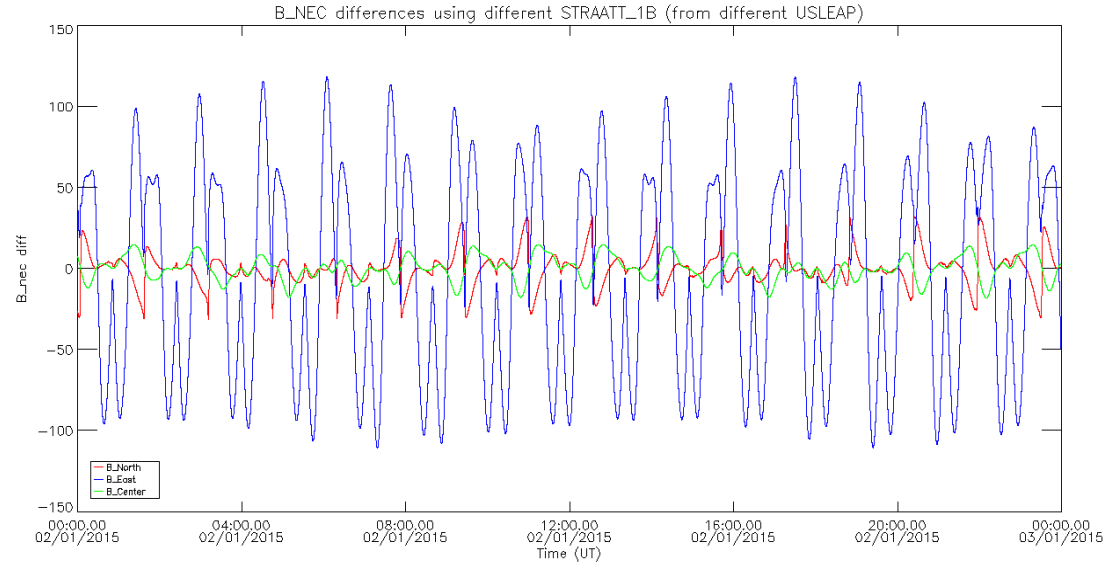

Figure 20: B_NEC differences for SC A, on 02/01/2015, using different STRxSCI_1A as input, from different USLEAP.

It is clear that such difference can emerge when performing a comparison with the most common geomagnetic models. In Figure 21 one can see difference between B_{NEC} and CHAOS-4 as a function of the co-latitude for day 02/01/2015, SC A. In the upper panel plot, USLEAP 0002 has been used for generating the attitudes; in the lower panel plot,

USLEAP 0001 has been used. With the new USLEAP applied, B_{east} has oscillations around the equator of about 100 nT.

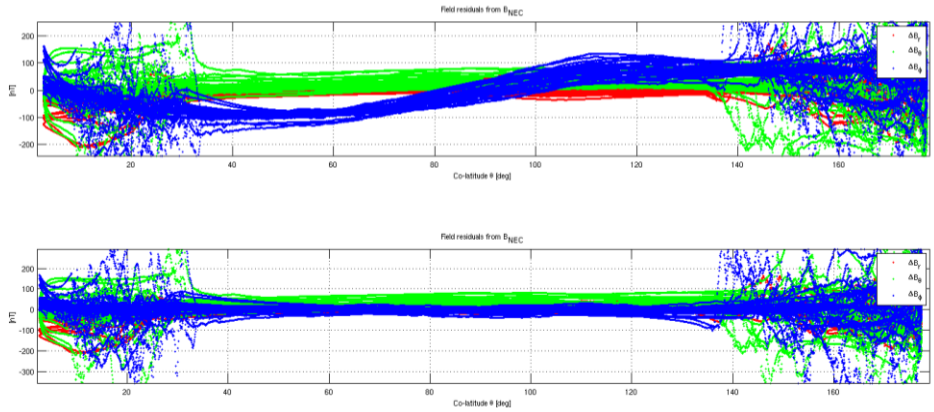

Figure 21: difference between B_{NEC} and CHAOS-4 as a function of the co-latitude for day 02/01/2015, SC A. Upper panel: USLEAP 0002 has been used for generating the attitudes; lower panel: USLEAP 0001 has been used.

We have reported the issue to the processor manufacturer, which has performed some investigations and found the origin of the discrepancy in the quaternions by using the two different USLEAP files, is due to the initialization of EOP class. EOP EarthOrientation, class is a generic function of the L1BOP used to compute the rotation matrix to convert ICRF to ITRF. Right now, the manufacturer is checking the impacts of a possible correction to the problem to other parts of the ORBATT processor.

5. YEAR 2014, WEEK 51 (15/12 – 21/12): SUMMARY OF THE OBSERVATIONS

Week 51 production was smooth and without relevant issues. We report here a quick summary of the main observations.

5.1 Swarm A

- **46 seconds telemetry gap** to be reported on day **21/12/2014**, 10:35:30 – 10:36:16 UT. This seems to cause an anomaly in the treatment of gaps for MAGA_LR_1B: the F field is set to zero from the beginning of the day up to the end of the gap; in the other products the gap appears as expected. Issue reported to L1BOP manufacturer through SPR **SWL1L2DB-41**.

5.1.1 Orbit and Attitude Products

- **MOD-NAV difference:** no major issues. Usual occurrence of several SW-IDEAS-34 ([RD.10]) events throughout all the week. The average difference is around 0.14 m, with a standard deviation on the Z component of about 1.3 m on average. An example for day 18/12/2014 is shown in Figure 22 below.

- **Attitudes:** nothing to report.

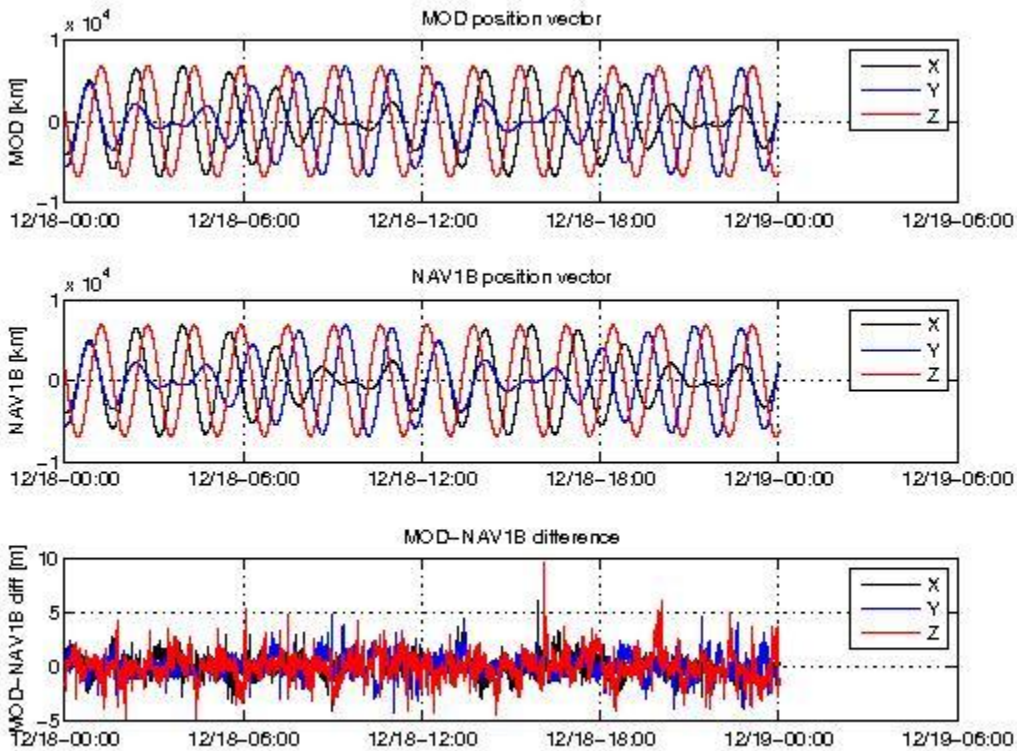

Figure 22: MOD-NAV solution difference for SC A, 18/12/2014.

5.1.2 Magnetic Products

Nothing special to report. In Figure 23 below, an example of ASM-VFM residual for day 16/12/2014 is shown. On average the residual is in the range [-2, 1.8] nT, with occasional spikes that reach up to 6 nT. The high-frequency noise during the week is moderate to low (**SW-IDEAS-27**, [RD.13]).

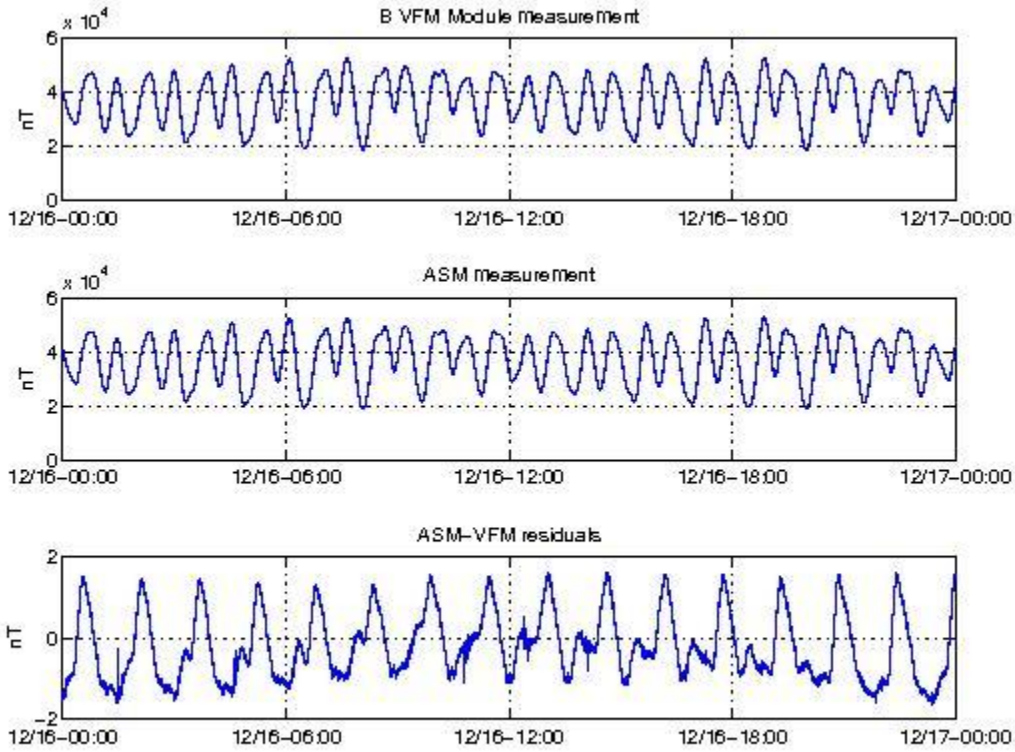

Figure 23: VFM module, ASM module and ASM-VFM residuals for S/C A, 16/12/2014.

5.2 Swarm B

5.2.1 Orbit and Attitude Products

- **MOD-NAV difference:** no major issues. Usual occurrence of several SW-IDEAS-34 ([RD.10]) events throughout all the week. The average difference is around 0.13 m, with a standard deviation on the Z component of about 1.4 m on average. An example for day 18/12/2014 is shown in Figure 24 below.

- **Attitudes:** nothing to report.

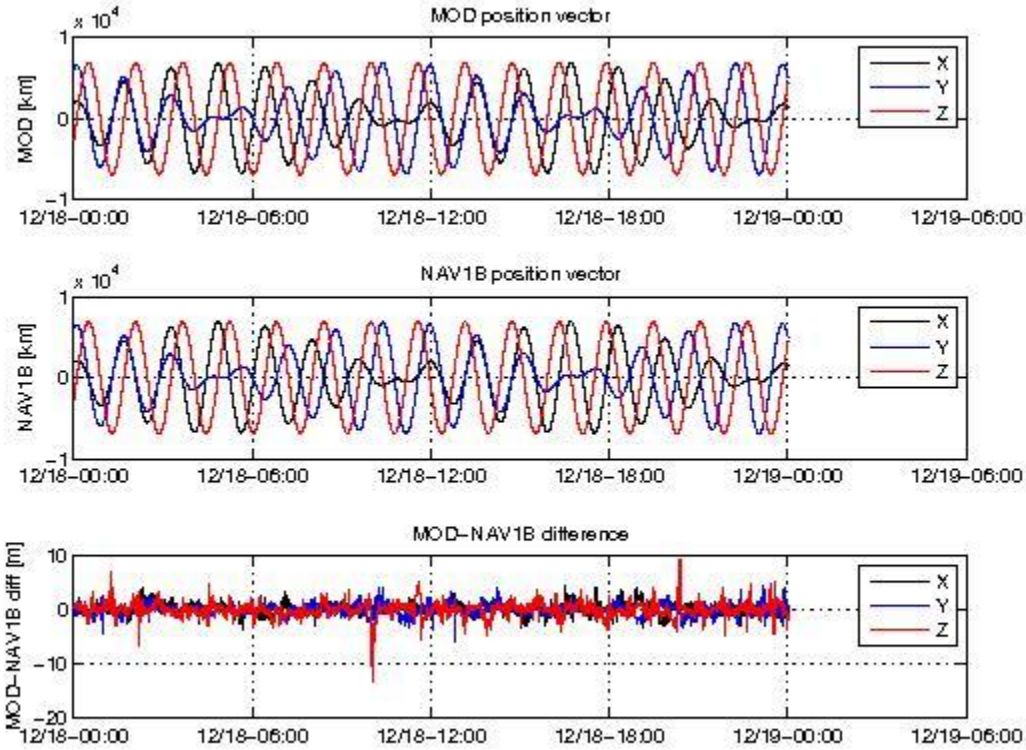

Figure 24: MOD-NAV solution difference for SC B, 18/12/2014.

5.2.2 Magnetic Products

Nothing special to report. In Figure 25 below, an example of ASM-VFM residual for day 16/12/2014 is shown. On average the residual is in the range [-1.7, 2] nT, with occasional spikes that reach up to 8 nT. The high-frequency noise during the week is moderate to low (**SW-IDEAS-27**, [RD.13]).

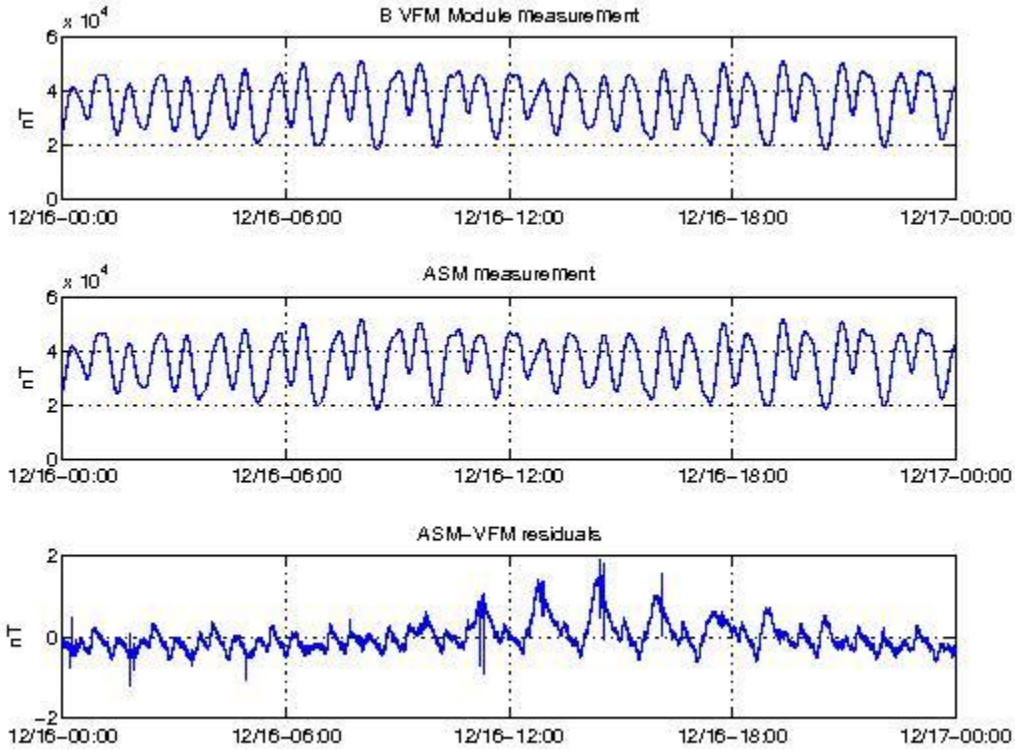

Figure 25: VFM module, ASM module and ASM-VFM residuals for S/C B, 16/12/2014.

5.3 Swarm C

5.3.1 Orbit and Attitude

- **MOD-NAV difference:** no major issues. Usual occurrence of several SW-IDEAS-34 ([RD.10]) events throughout all the week. The average difference is around 0.13 m, with a standard deviation on the Z component of about 1.4 m on average. An example for day 18/12/2014 is shown in Figure 26 below.

- **Attitudes:** nothing to report.

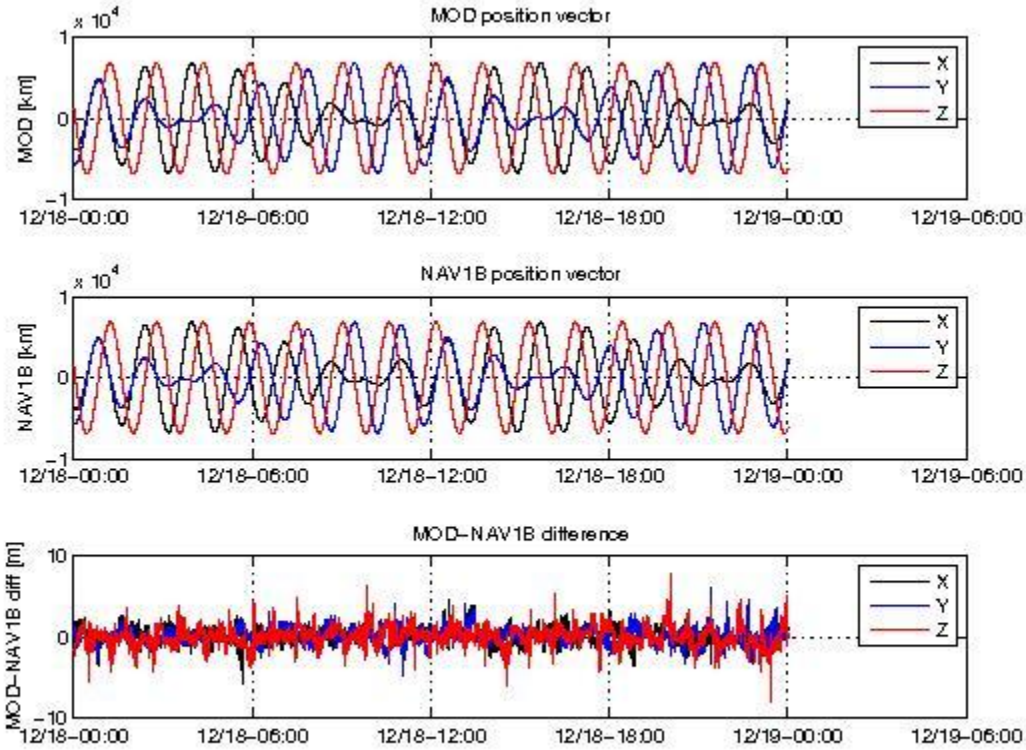

Figure 26: MOD-NAV solution difference for SC C, 18/12/2014.

End of Document