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IDEAS+ Swarm Weekly Report 2015/08 : 16/02/2015 – 22/02/2015

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 16 to 22 February 2015.

Author :
Igino Coco, on behalf of Swarm IDEAS+ Team

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

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

Serco Italia Spa
Via Sciadonna 24/26, 00040, Frascati, Italy
Tel: +39 06 98354400 Fax: +39 06 9419426
www.serco.com

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AMENDMENT POLICY

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

AMENDMENT RECORD SHEET

ISSUE	DATE	REASON
1.0	28 Feb 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

- **TII scrubbing:** all the TIIs are now in active state, after the last scrubbing cycle. The results of the scrubbing are not satisfactory: no further improvements are achieved; even, for S/C B, there is a worsening in the gain depletion in the detector area where ionospheric ions preferably hit. On Swarm C a persistent saturation ring is still observed at the edge of the detectors. The possibility to push the scrubbing procedure further (up to 8000 V on phosphors and -2200 V on MCPs) is under discussion, at least for Swarm C, but a deep review of all the strategy and approach is also needed. The Mission Management and ESA staff is becoming very skeptic about the effectiveness of the scrubbing procedure and they are pushing for having a more complete analysis of the image anomaly phenomenon in order to fully exploit the physical causes underneath.

2.2 Plan for operational processor updates

L1BOP 3.14 p1 has been put in operations the 24th February 2015. Full information of the major changes and implications in data quality are described here: https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/swarm/data-quality.

The most important feature to be noted is the capability to generate magnetic Level 1B products based on Vector Field Magnetometer inputs only, in order to cope with failures of the Absolute Scalar Magnetometer, as occurred on 5 November 2014 on Swarm Charlie.

Therefore, starting from 21 February 2015, the following magnetic product types for Swarm Charlie are again available: MAGC_HR_1B, MAGC_LR_1B, ASMCAUX_1B and VFMCAUX_1B.

Unfortunately, when the operations team tried to recover the past production of Swarm C from 6th November, the processing failed. The processor manufacturer promptly investigated and found the cause of the failure in an error in the function that interpolates the bus currents for calculating the stray fields when there are gaps or overflows. The fix of this is not trivial, as the dependencies and impacts on other systems shall be carefully evaluated and the fix properly tested on many different scenarios. Therefore, a time schedule for a patch release has not been set yet.

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.

According to the last coordination meeting within the MAGNET QWG (22/01/2015) the following decisions have been taken:

- With the data provided by DTU/ESL, further analysis can be performed by industry (ADS, DTU-MI, other scientific groups (e.g. Richard Marchand and Stephan Buchert on plasma induced fields), and of course by ESA. The agreement is - as always - that results will be shared with all others on the Task Force.

- DTU/ESL will further refine the Lesur-Tøffner-Clausen model parametrisation and share a final description of the process (input data, model description, output results and tests) (by mid February).

- In parallel, GFZ will distribute the Lühr-Michaelis results, and a number of people (e.g. Malcolm Dunlop, Yulia Bogdanova, Arnaud Chulliat, Patrick Alken) will further support the analysis of these datasets. (by mid February).

- The PDGS will generate the currently VFM missing data on Charlie due to the ASM failure (by end February).

- DTU/ESL will share the final set of corrected data by early March. These corrected data will also contain the dBsun correction, providing the users the possibility to access to uncorrected data.

- The corrected data will be distributed by ESA to all Swarm users (by early April and no later than 20th April). The correction will also be implemented in the OP. Until this is fully validated, it is agreed that the operational processing will continue as nominal without the correction.

- Next Task Force meeting: **9-10 April**. The meeting will be held in ESTEC.

2.4 Summary of observations for 2015, Week 08 (16/02-22/02)

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

1. **Strange features observed at times 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]), especially on S/C B this week.

2. **90 seconds gap in GPSCOBS_0_ product of day 22/02**. This causes gaps in the GPS Level 1B products and a spike in the MOD-NAV solution difference.

3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

- **Magnetic production lost on S/C C up to 20/02**: starting from 21/02 Swarm C magnetic data are again produced based on VFM data only.

- **90 seconds gap in GPSCOBS_0_ product of day 22/02**: between 01:57:56 and 01:59:26 no data are available for the product mentioned above. As a consequence, a gap exists in the GPSC_RO_1B product of day 22/02, and a huge spike appears in the MOD-NAV solution differences (see Sect. 3.2.3.1)

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)	3.2.2.1	[RD.10]

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for 2015, Week 08: 16/02 - 22/02.

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, 16/02 – 22/02, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard deviation (m)**	**Notes**
16/02	0.19	-11, 10 (Z)	1.7	SW-IDEAS-34 [RD.10]
17/02	0.12	-9 (Y), 7 (Z)	1.1	
18/02	0.17	-7, 10 (Z)	1.6	
19/02	0.14	-10.6 (Z), 6.2 (Y)	1.6	SW-IDEAS-34 [RD.10]
20/02	0.12	-7.3, 8.6 (Z)	1.3	SW-IDEAS-34 [RD.10]
21/02	0.07	-7.4, 9.7 (Z)	1.6	
22/02	0.09	-8.7, 6.3 (Z)	1.3	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 (16/02, Figure 1), in the middle (19/02, Figure 2) and at the end (22/02, 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.

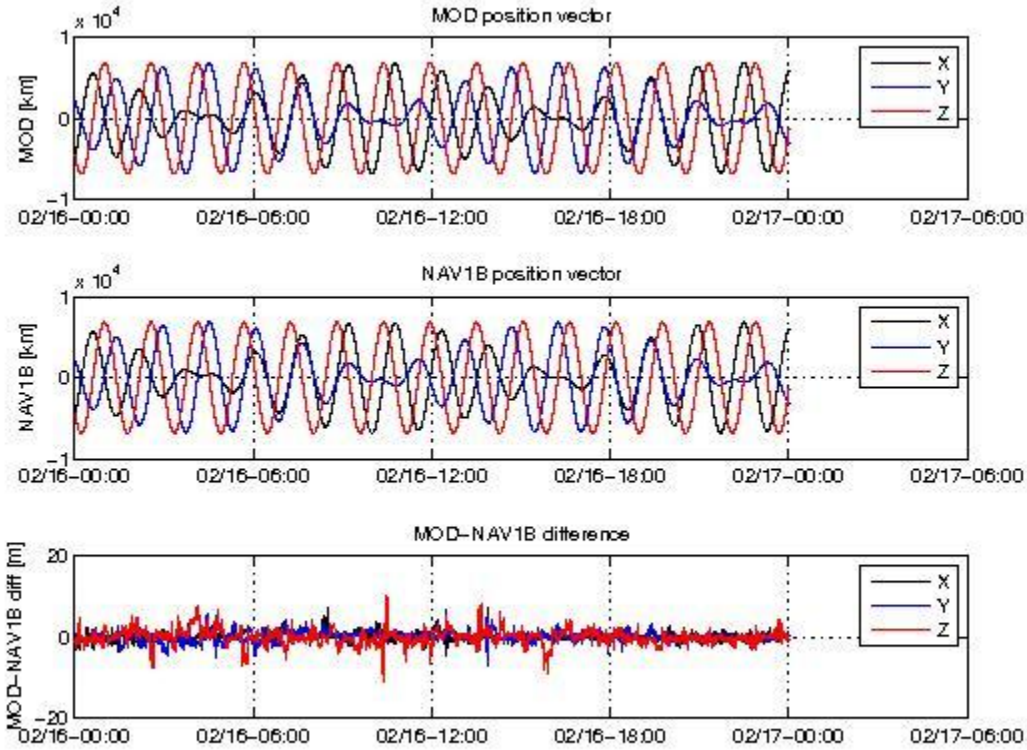

Figure 1: Difference MOD-GPSNAV, sc A, 16/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

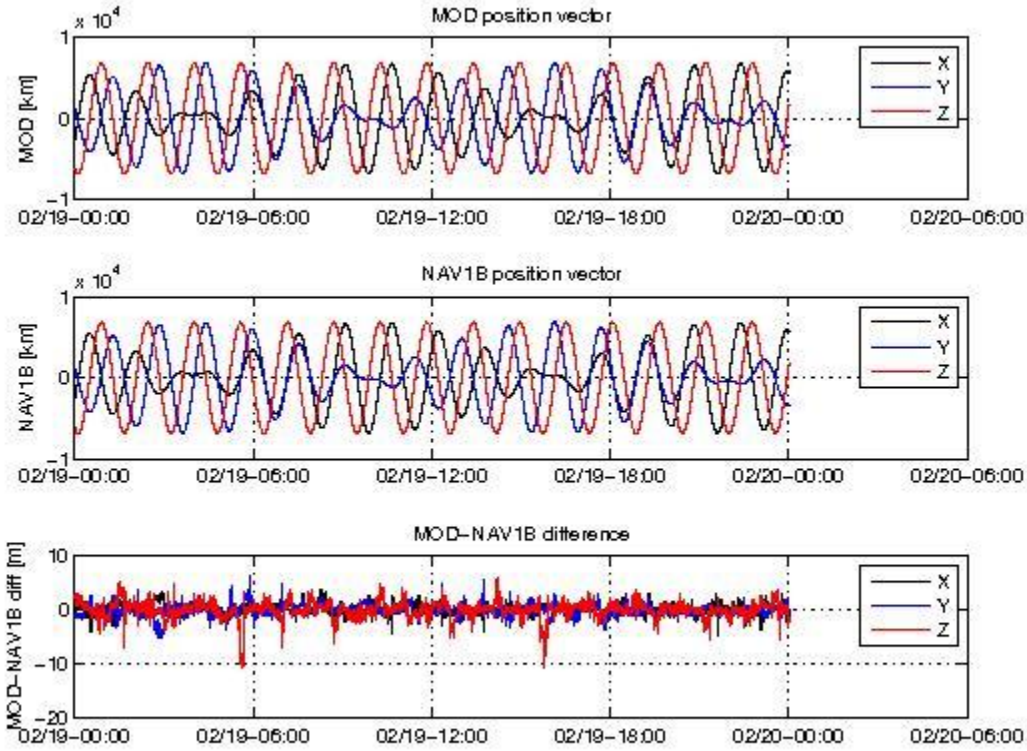

Figure 2: Difference MOD-GPSNAV, sc A, 19/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

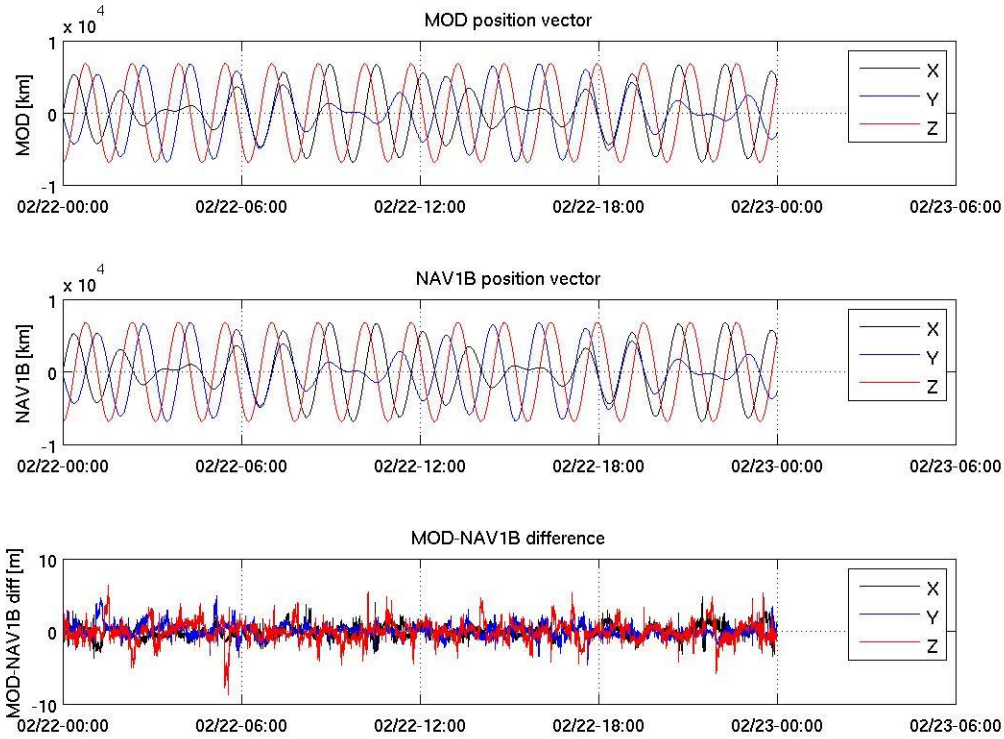

Figure 3: Difference MOD-GPSNAV, sc A, 22/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

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, 16/02 - 22/02, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
16/02	0.17	-11, 7.3 (Z)	1.6	SW-IDEAS-34 [RD.10]
17/02	0.12	-6, 7 (Z)	1.3	SW-IDEAS-34 [RD.10]
18/02	0.14	-6.3, 8.4 (Z)	1.4	
19/02	0.06	-13, 7 (Z)	1.4	
20/02	0.18	-8.2, 7 (Z)	1.3	SW-IDEAS-34 [RD.10]
21/02	0.04	-9.5, 8.1 (Z)	1.6	
22/02	0.09	-6.9(X), 7.3(Z)	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 (16/02, Figure 4), in the middle (19/02, Figure 5), and at end of the week (22/02, 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 examples of SW-IDEAS-34 ([RD.10]) anomaly is shown (red-circled areas): the MOD-NAV solution difference departs from the average value taking higher/lower values for several minutes.

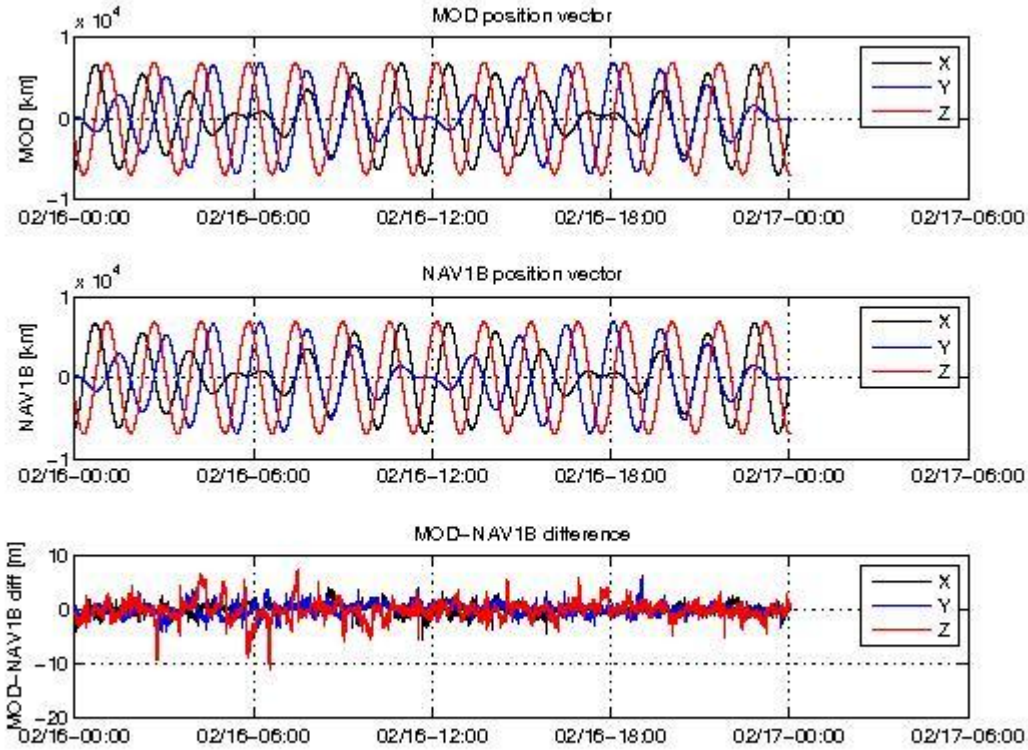

Figure 4: Difference MOD-GPSNAV, sc B, 16/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

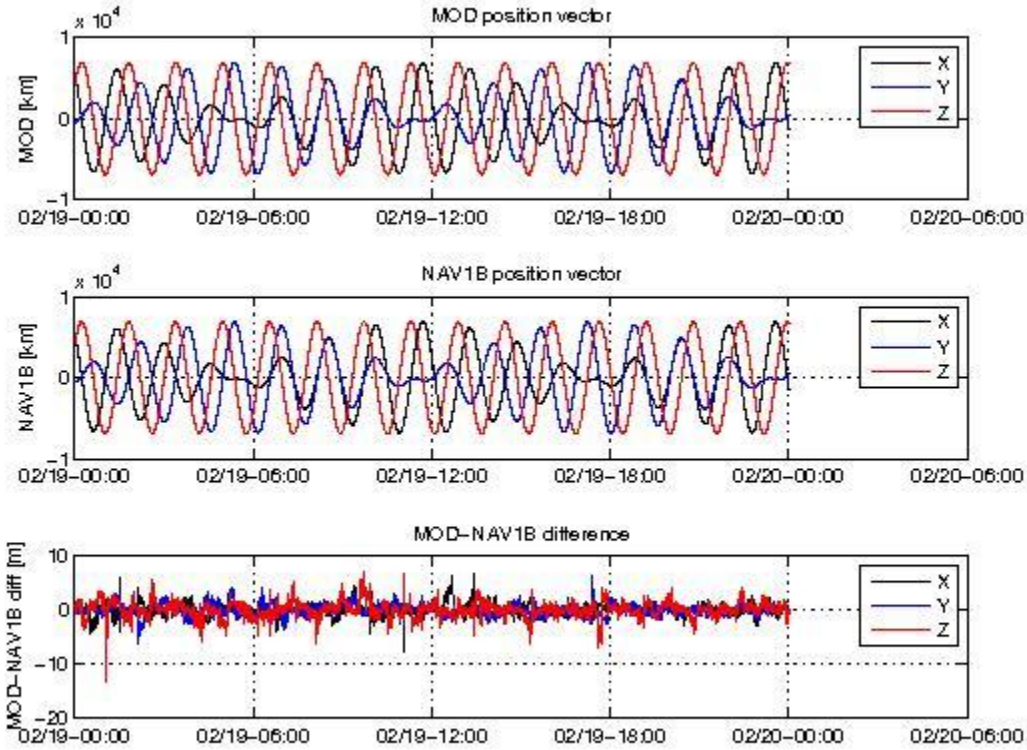

Figure 5: Difference MOD-GPSNAV, sc B, 19/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

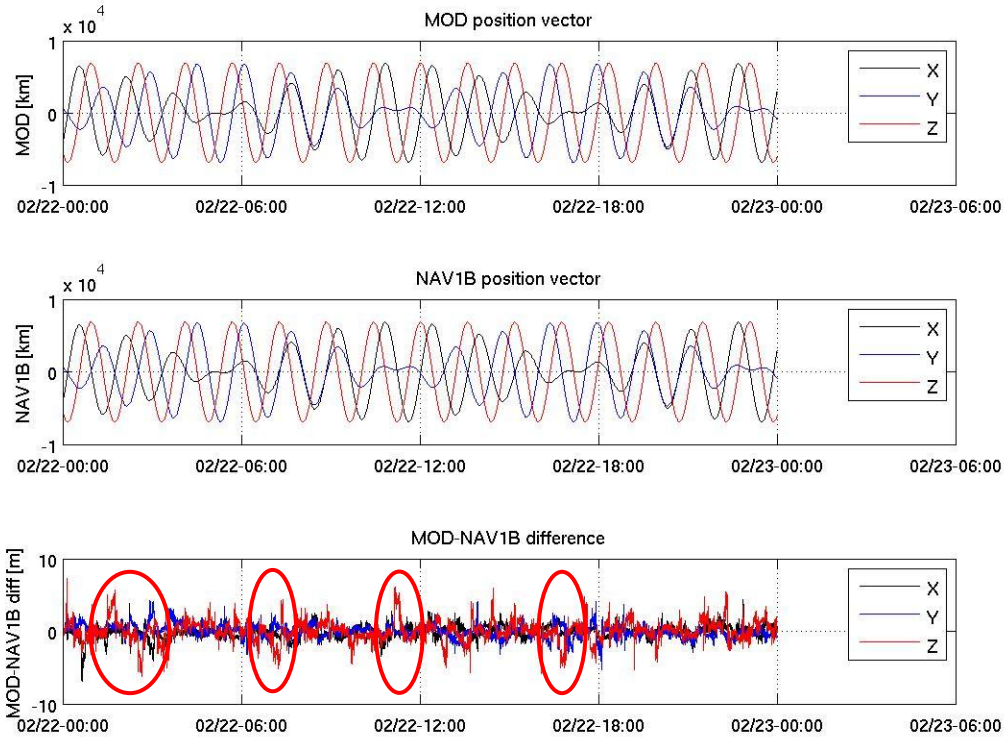

Figure 6: Difference MOD-GPSNAV, sc B, 22/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red-circled areas evidence a time interval characterized by SW-IDEAS-34 ([RD.10]) anomaly occurrence.

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, 16/02 - 22/02, Position difference

Swarm C, 16/02 - 22/02, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
16/02	0.19	-7.4, 10 (Z)	1.6	SW-IDEAS-34 [RD.10]
17/02	0.17	-10.8, 6.7 (Z)	1.2	
18/02	0.13	-7, 9 (Z)	1.5	
19/02	0.16	-10.7, 8 (Z)	1.4	SW-IDEAS-34 [RD.10]
20/02	0.15	-10 (Z), 6.6 (Y)	1.2	
21/02	0.08	-10.6, 10.5 (Z)	1.5	
22/02	0.09	-30.3 (Y), 6.8 (Z)	1.3	Huge spike in Y component due to a gap in GPS data (See Sect. 3.1)

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 (16/02, Figure 7), in the middle (19/02, Figure 8) and at the end (22/02, 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, and the difference between the two. The values are given in Km.

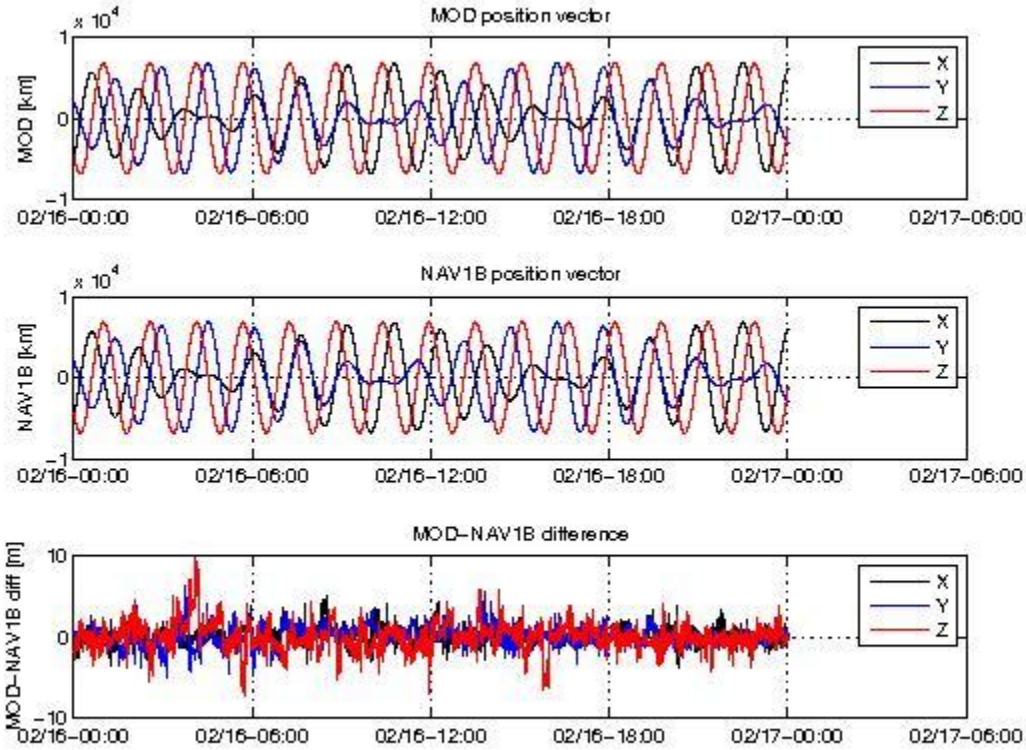

Figure 7: Difference MOD-GPSNAV, sc C, 16/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, and the difference between the two.

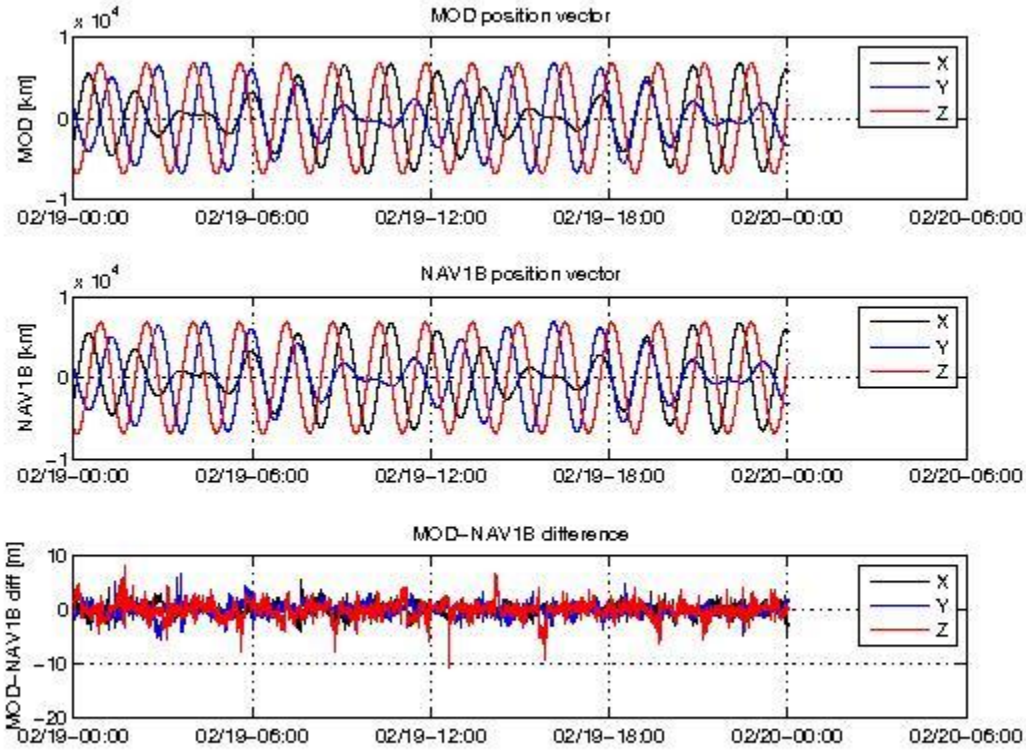

Figure 8: Difference MOD-GPSNAV, sc C, 19/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, and the difference between the two.

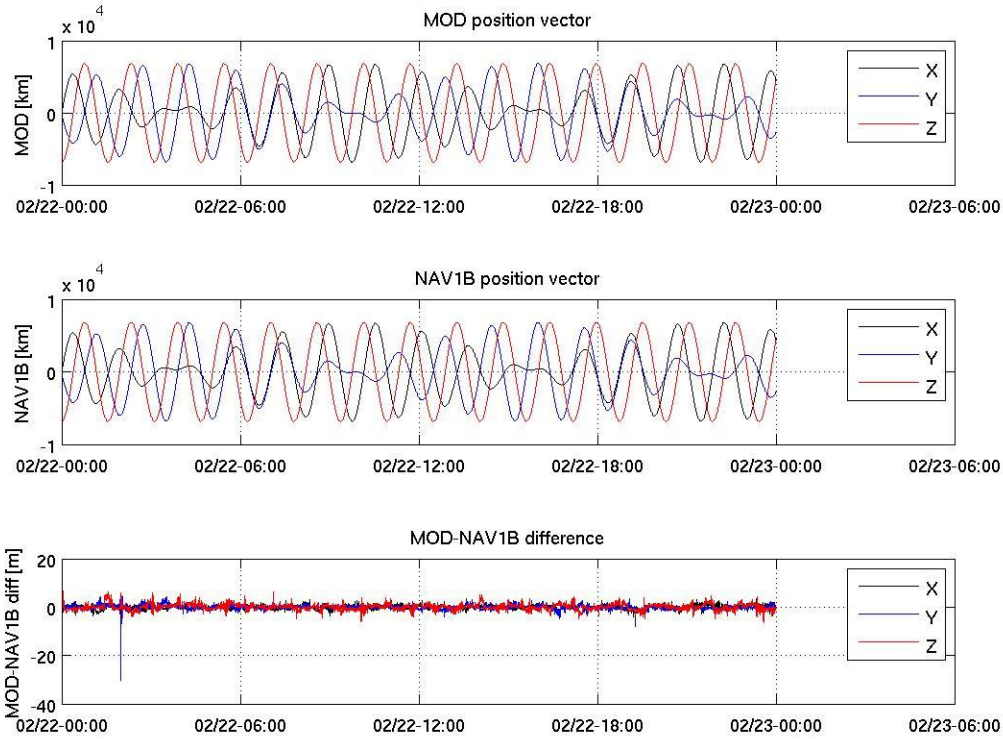

Figure 9: Difference MOD-GPSNAV, sc C, 22/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, and the difference between the two.

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 $|B_{NEC}|$ - 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]: The geomagnetic activity is low throughout the week, so that we do not observe high level of noise in the high frequency region of the spectra.

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 (22/02/2015).

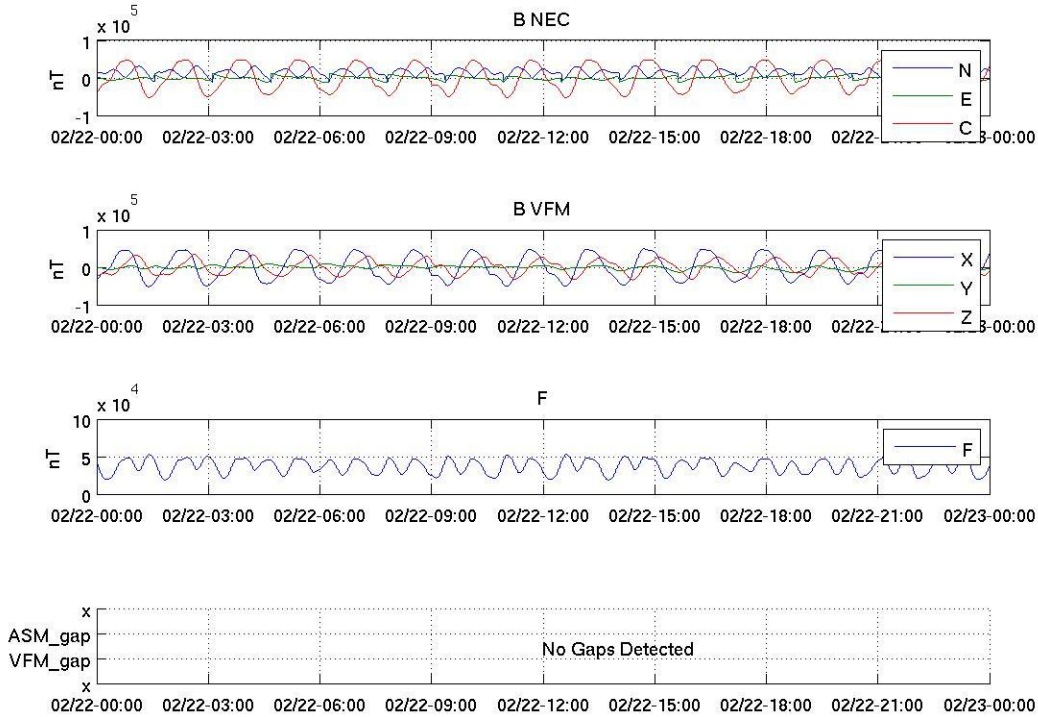

Figure 10: Time series of the geomagnetic field, for 22/02/2015, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.1.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-3.5, 1.5] nT.

Below two example plots of such differences follows: taken at the beginning of the week 16/02 (Figure 11) and at the end of the week 22/02, (Figure 12). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

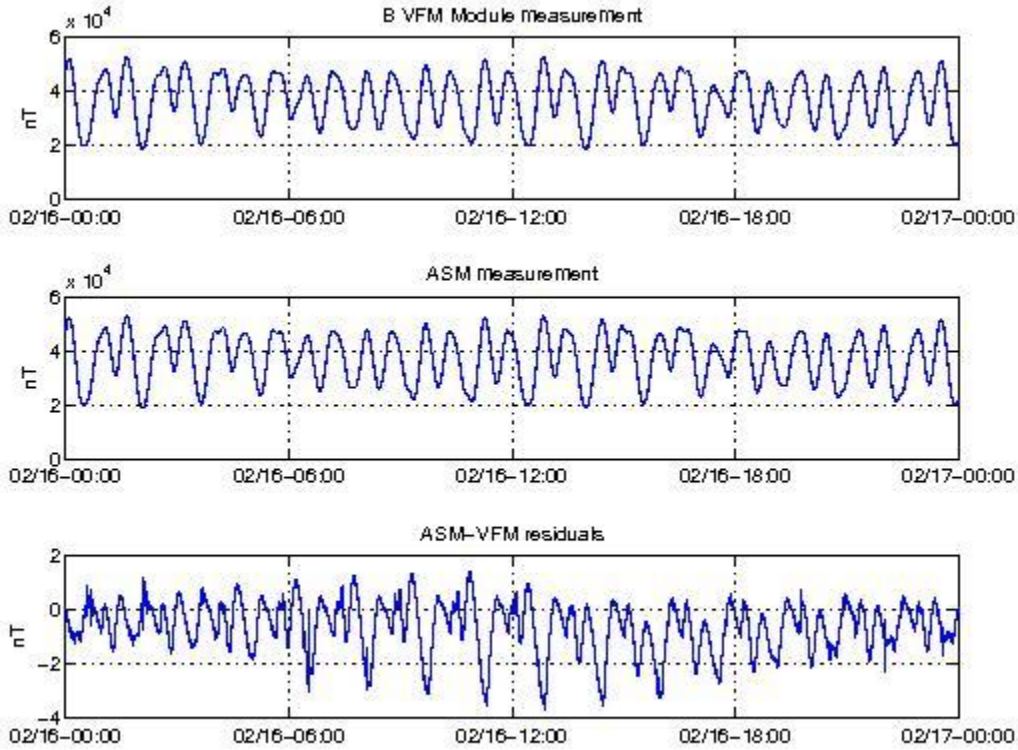

Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 16/02/2015.

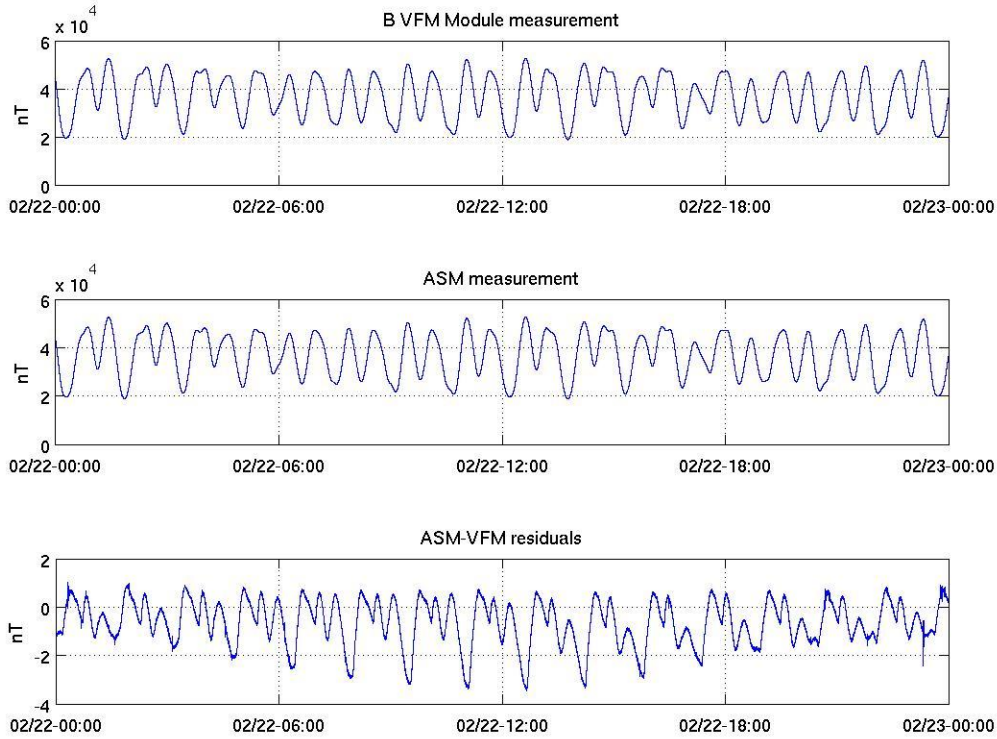

Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 22/02/2015.

3.3.1.3 TCF.VFM monitoring

The TCF.VFM monitoring is a monthly check and will be contained in the first report of March, related to February 2015.

3.3.2 Swarm B

3.3.2.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative magnetic field time series for S/C B (22/02/2015) can be seen in Figure 13 below.

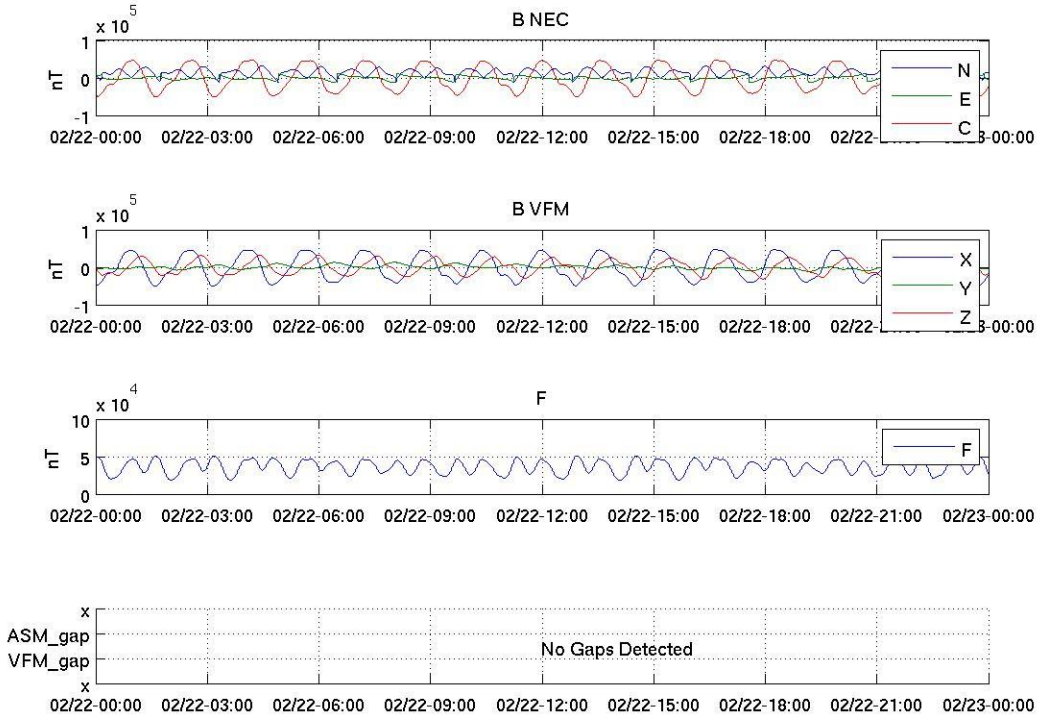

Figure 13: Time series of the geomagnetic field for 22/02/2015, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.2.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-1.5, 2.5] nT, with peaks of about 6 nT.

Below two example plots follows of such differences: 16/02 (Figure 14), and 22/02 (Figure 15). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

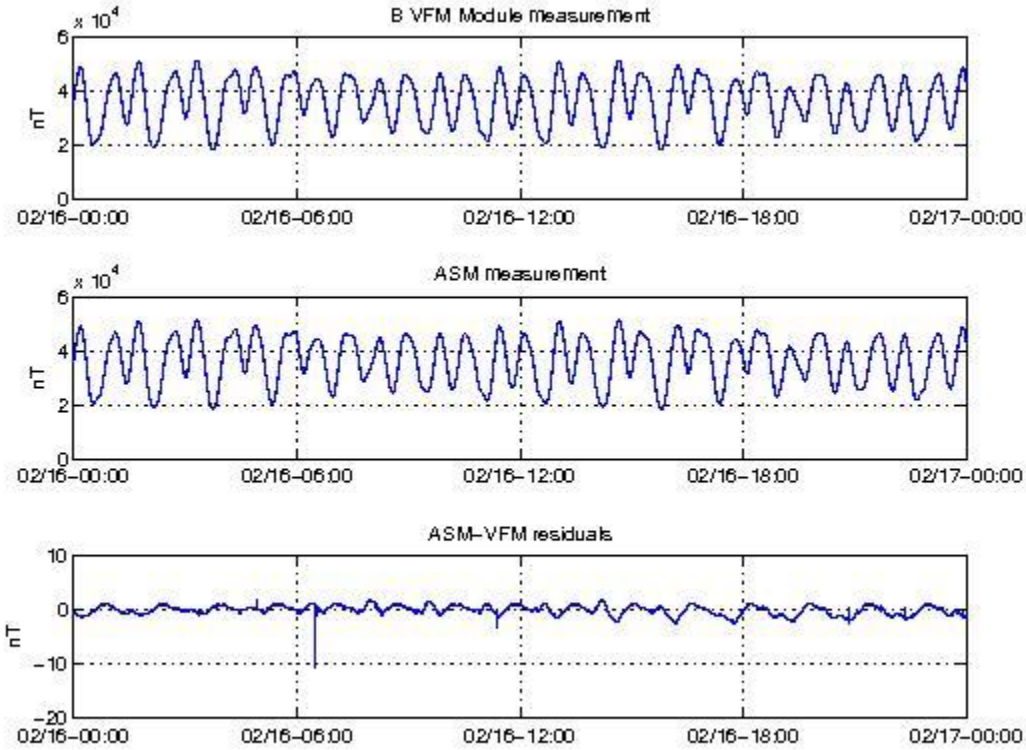

Figure 14: VFM module, ASM module and ASM-VFM residuals for S/C B, 16/02/2015.

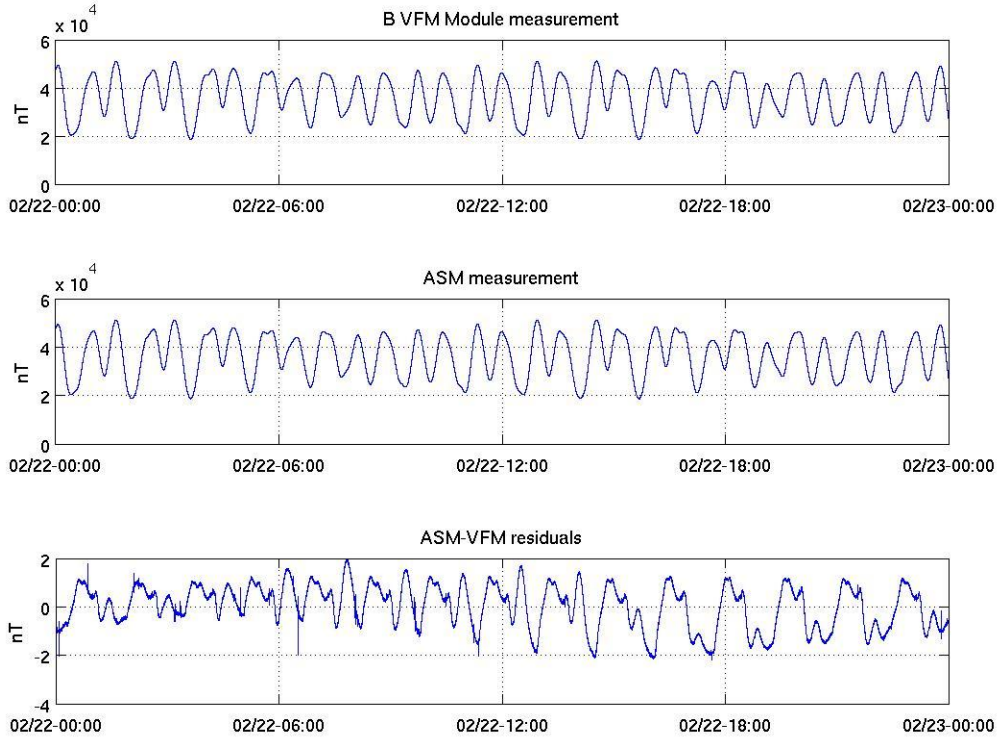

Figure 15: VFM module, ASM module and ASM-VFM residuals for S/C B, 22/02/2015.

3.3.2.3 TCF.VFM monitoring

The TCF.VFM monitoring is a monthly check and will be contained in the first report of March, related to February 2015.

3.3.3 Swarm C

3.3.3.1 Magnetic time series visual inspection

An example of representative magnetic field time series for S/C C (22/02/2015) can be seen in Figure 19.

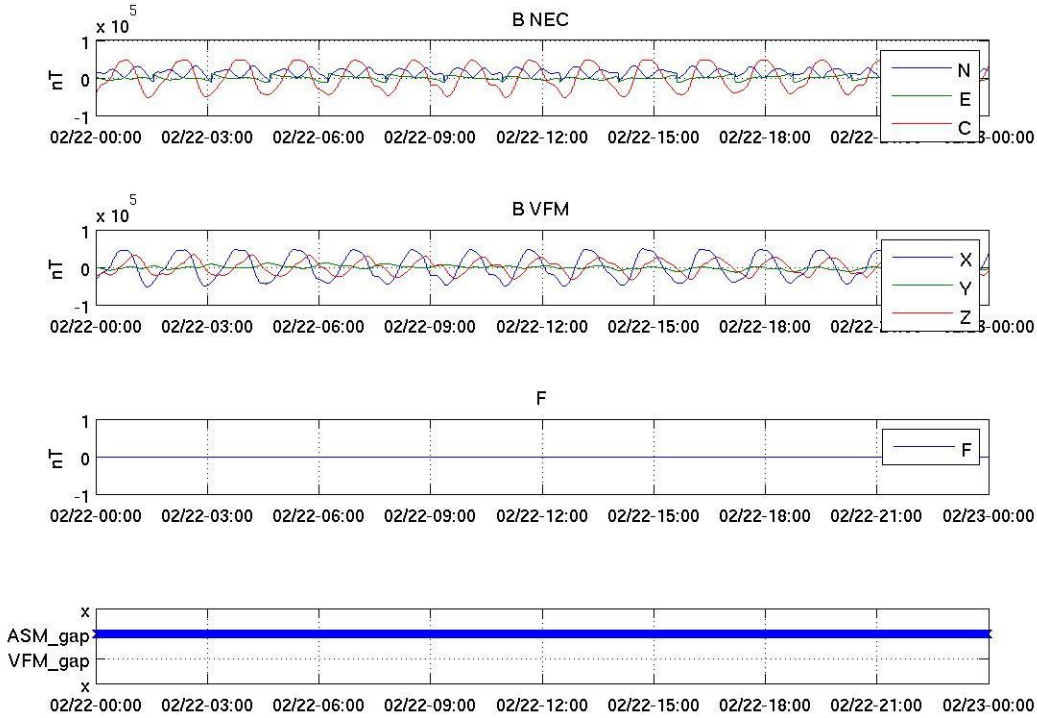

Figure 19: Time series of the geomagnetic field for 22/02/2015, S/C C. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM (no data here because ASM it is still off) and location of gaps.

3.3.3.2 VFM-ASM anomaly

No data because ASM is 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 monitoring is a monthly check and will be contained in the first report of March, related to February 2015.

4. ON-DEMAND ANALYSIS

4.1 MAGNET_C production on again since 6th November 2014: some more detail on the data quality

Since February 21, 2015, magnetic products are again available for Swarm C, based on the VFM data only. In the figures below we give an overview of the quality of such data. In Figure 16 an example of B_{NEC} residuals vs Chaos 4 model is given for day 22/02/2015: from top to bottom one can see the magnetic residuals as a function of geographic co-latitude for the three spacecraft. The values for Swarm C (bottom panel), are fully in line with what is observed for the other two S/C.

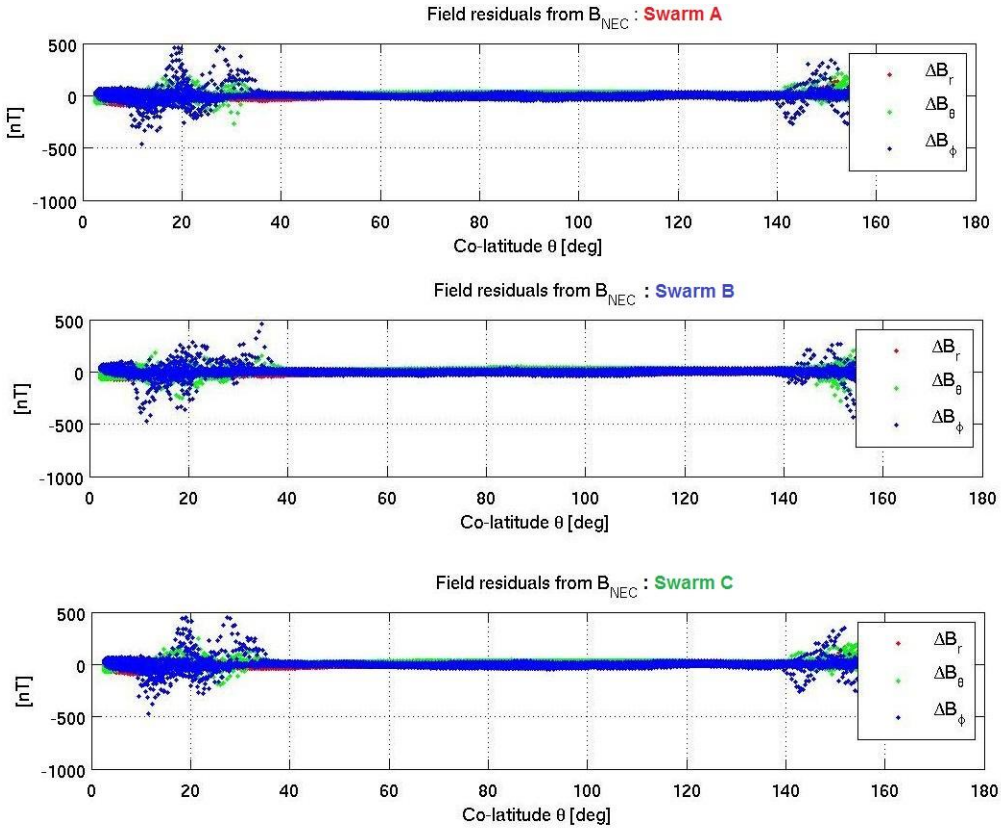

Figure 16: B_{NEC} - B_{Chaos} residuals as a function of Co-Latitude for the three S/C on 22/02/2015.

In Figure 17 the difference between the three B_{NEC} components of S/C A and C is shown for day 22/02/2015. Such differences are always below the thresholds set by the experts (8000 nT on each component), and never exceed +/- 2000 nT in B_{North} and B_{East}: the maxima/minima are located at high latitudes, where, due to the 1 deg. separation between the two S/C, the physical phenomena acting on the magnetic field can be very different.

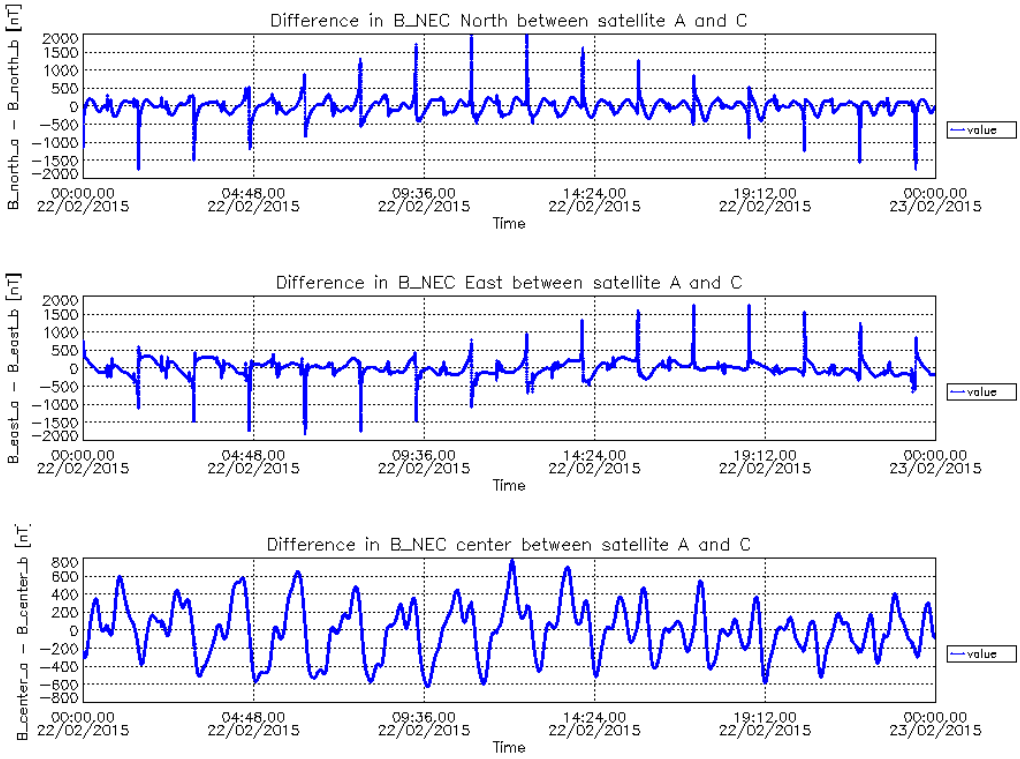

Figure 17: 22/02/2015, B_{NEC} difference between S/C A and C.

Finally, in Figure 18, the correlation between S/C A and C is shown for day 22/02/2015 (over 5 min. intervals). One can see the correlation is close to 1 for most of the time, falling below 0.7 – 05 only for short intervals, mainly corresponding to high latitude passes.

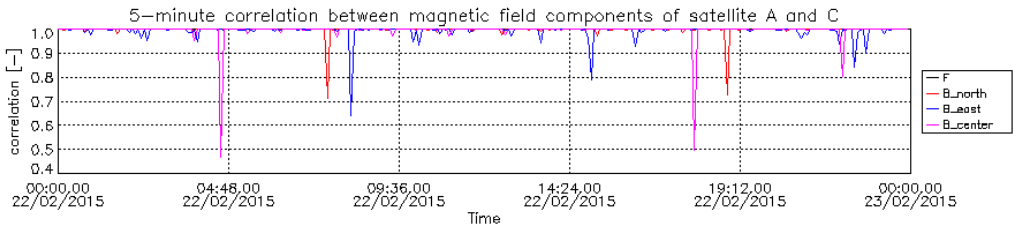

Figure 18: Correlation between S/C A and C, 22/02/2015.

In conclusion, the magnetic data again produced for Swarm C look nominal and fully in line with expectations.

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