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IDEAS+ Swarm Weekly Report : 24/11/2014 – 30/11/2014

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 24 to 30 November, 2014.

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TABLE OF CONTENTS

Contents

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	05 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.2.11p2

1.2 Reference documents

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

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

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

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

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

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

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

[RD.7] SW_L1BOP_status_20141124_MoM

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

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

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

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

2. SUMMARY OF THE OBSERVATIONS

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

Data Quality workshop on-going on Potsdam. The report of next week will contain a summary of the most important discussions.

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

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

2.4 Summary of observations for Week 48 (24-30/11/2014)

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

1. **Strange features observed again in the MOD-GPSNAV solution difference:** again we often notice a marked “spiky” behaviour, with deviations from the average which are not normal spikes but lasts for several seconds if not minutes (**SW-IDEAS-34**, [RD.10]). 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]).

2. **Magnetic production lost on S/C C for the whole week**, because of the ASM switched off.

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.

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]

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for Week 48: 24 - 30/11/2014

The relevant parameters that have been monitored are:

- Position difference between calculated Medium Accuracy orbits (**MODx_SC_1B**) and on-board solution (**GPSxNAV_0**). Threshold values for such differences have not been assessed yet: we have just monitored the average values and maximum variations around the week, and reported in tables in the sections below, along with some example from the HTML daily reports. For the time being we evaluated an anomaly should be raised if one (or more) of the following conditions occurs:
    - 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, 24-30/11/2014, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard deviation (m)**	**Notes**
24/11	0.1	-10, 12 (Z)	1.7	SW-IDEAS-34 [RD.10]
25/11	0.2	+/- 9 (Z)	1.5	SW-IDEAS-34 [RD.10]
26/11	0.02	-10, 9 (Z)	1.5	
27/11	0.11	-7.3, 9 (Z)	1.4	
28/11	0.12	-8 (Z), 9.6 (Y)	1.5	SW-IDEAS-34 [RD.10]
29/11	0.12	-7.2 (X), 14 (Z)	1.4	
30/11	0.18	-13.2, 12.2 (Z)	1.9	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 (24/11, Figure 1), in the middle (27/11, Figure 2) and at the end (30/11, Figure 3). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

In Figure 1 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.

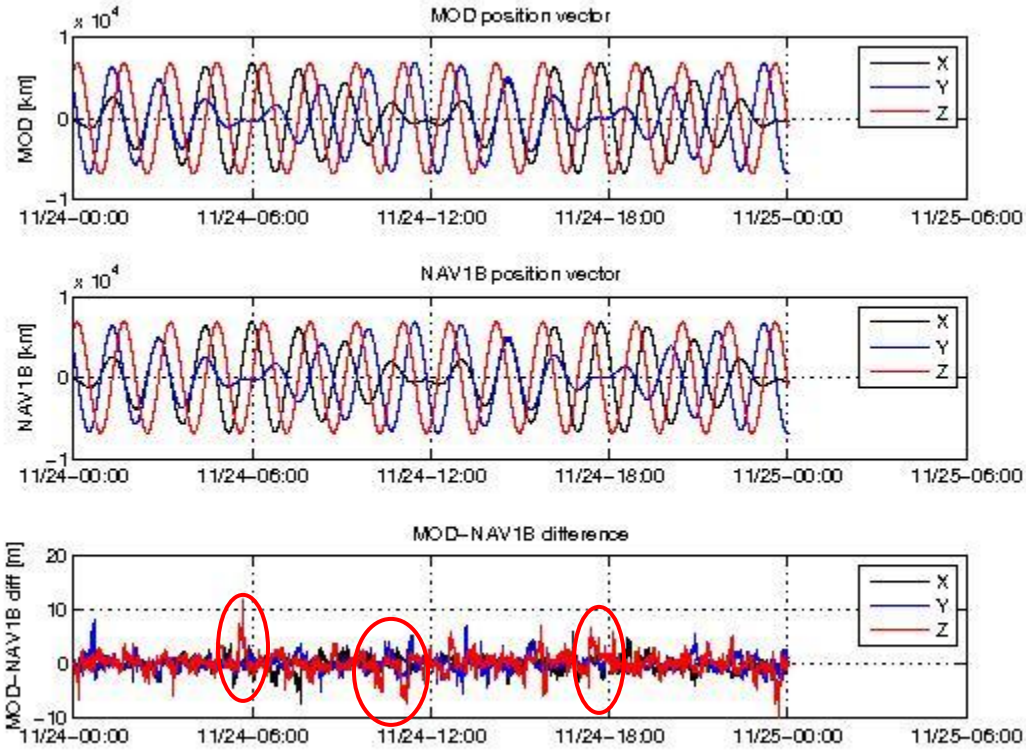

Figure 1: Difference MOD-GPSNAV, sc A, 24/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red circled area highlight intervals affected by SW-IDEAS-34 anomaly ([RD.10]).

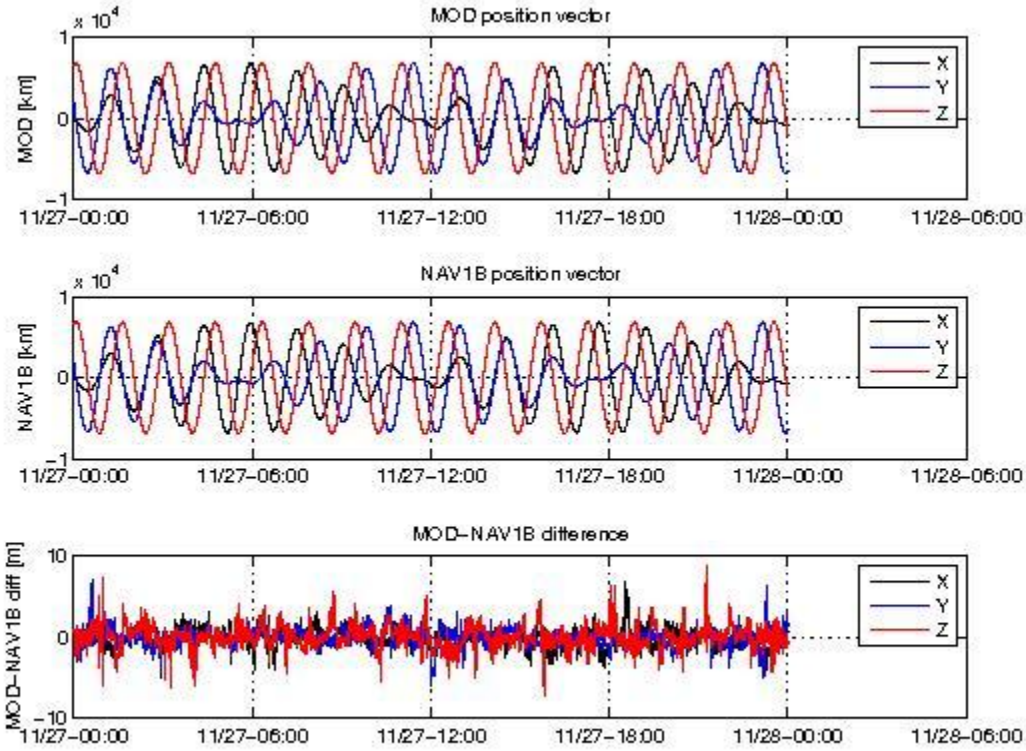

Figure 2: Difference MOD-GPSNAV, sc A, 27/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

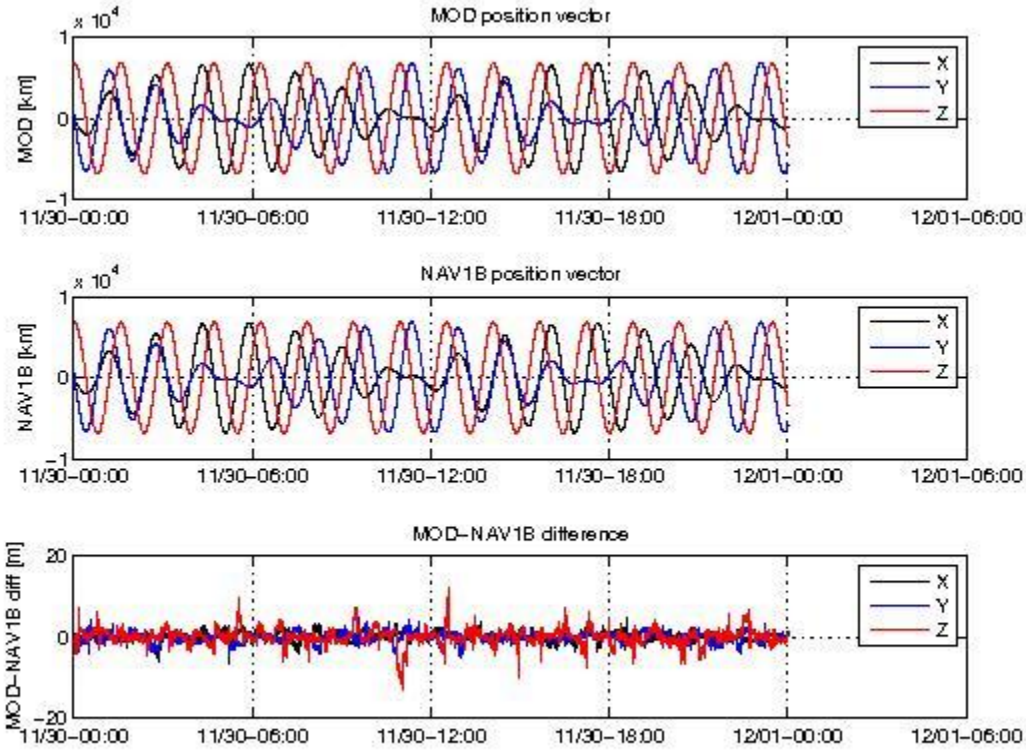

Figure 3: Difference MOD-GPSNAV, sc A, 30/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.1.2 Attitude observations

Nothing to report.

3.2.2 Swarm B

3.2.2.1 Position Statistics

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

Swarm B, 24-30/11/2014, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
24/11	0.08	-14.4, 10.2 (Z)	1.7	SW-IDEAS-34 [RD.10]
25/11	0.16	+/- 9 (Z)	1.5	SW-IDEAS-34 [RD.10]
26/11	0.11	-13, 12 (Z)	1.7	SW-IDEAS-34 [RD.10]
27/11	0.16	-6.6 (Z), 11 (Y)	1.5	SW-IDEAS-36 [RD.11]
28/11	0.11	-9.2 (Z), 8.3 (Y)	1.4	SW-IDEAS-34 [RD.10]
29/11	0.1	-9.8 (Z), 11.6 (X)	1.4	SW-IDEAS-34 [RD.10]
30/11	0.07	-7.7, 11 (Z)	1.6	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 (24/11, Figure 4), in the middle (27/11, Figure 5), and at end of the week (30/11, Figure 6). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

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.

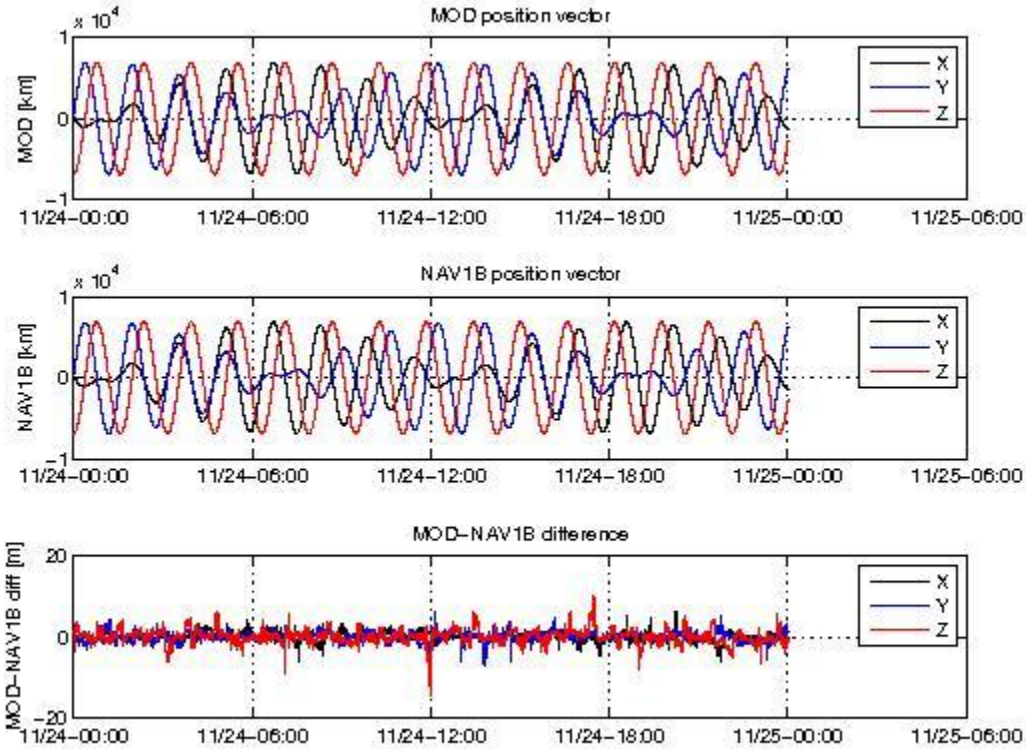

Figure 4: Difference MOD-GPSNAV, sc B, 24/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

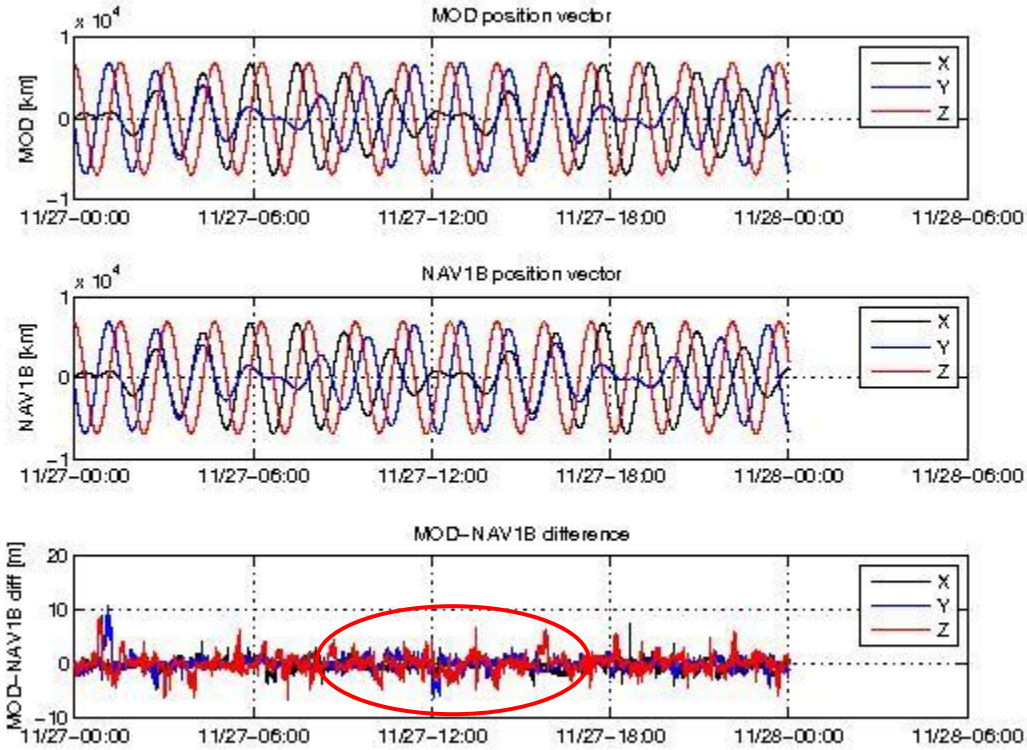

Figure 5: Difference MOD-GPSNAV, sc B, 27/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red-circled area evidences a time interval affected by SW-IDEAS-36 anomaly ([RD.11]).

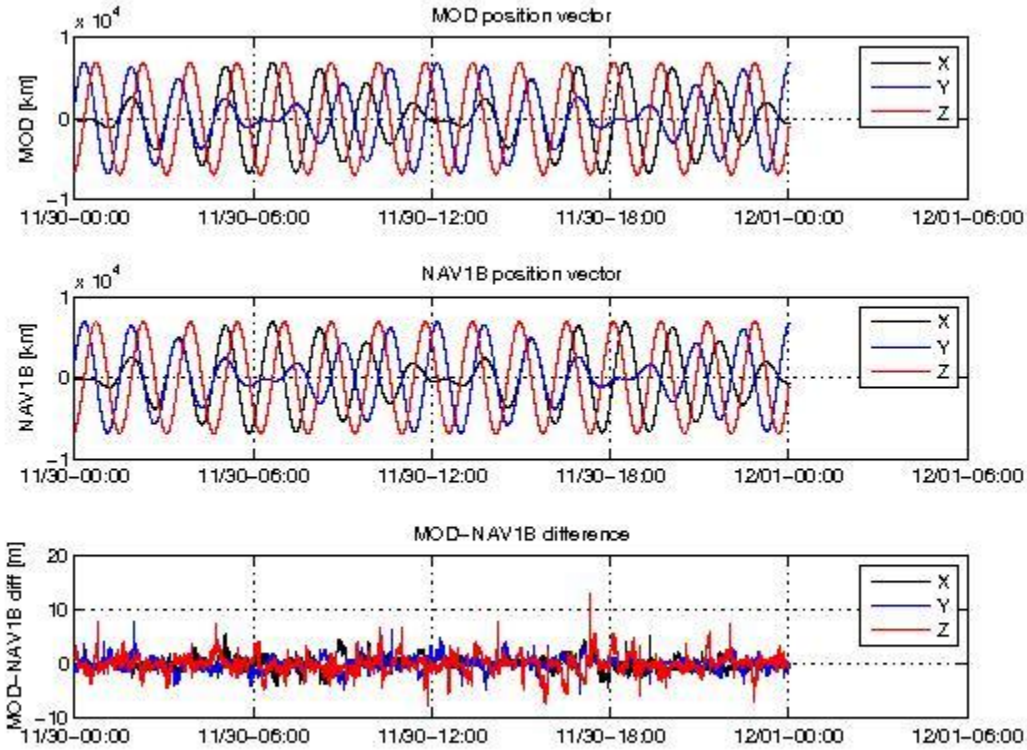

Figure 6: Difference MOD-GPSNAV, sc B, 30/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.2.2 Attitude observations

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, 24-30/11/2014, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
24/11	0.12	-12.3, 11.7 (Z)	1.7	SW-IDEAS-34 [RD.10]
25/11	0.2	-6.7 (Y), 8.6 (Z)	1.5	SW-IDEAS-34 [RD.10]
26/11	0.01	-8.6, 10 (Z)	1.6	
27/11	0.12	-6.6, 8.6 (Z)	1.4	
28/11	0.12	-11.3, 8.7 (Z)	1.5	
29/11	0.15	-8 (Y), 13 (Z)	1.4	SW-IDEAS-36 [RD.11]
30/11	0.15	-12.4, 10.5 (Z)	1.9	SW-IDEAS-36 [RD.11]

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 (24/11, Figure 7), in the middle (27/11, Figure 8) and at the end (30/11, Figure 9). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

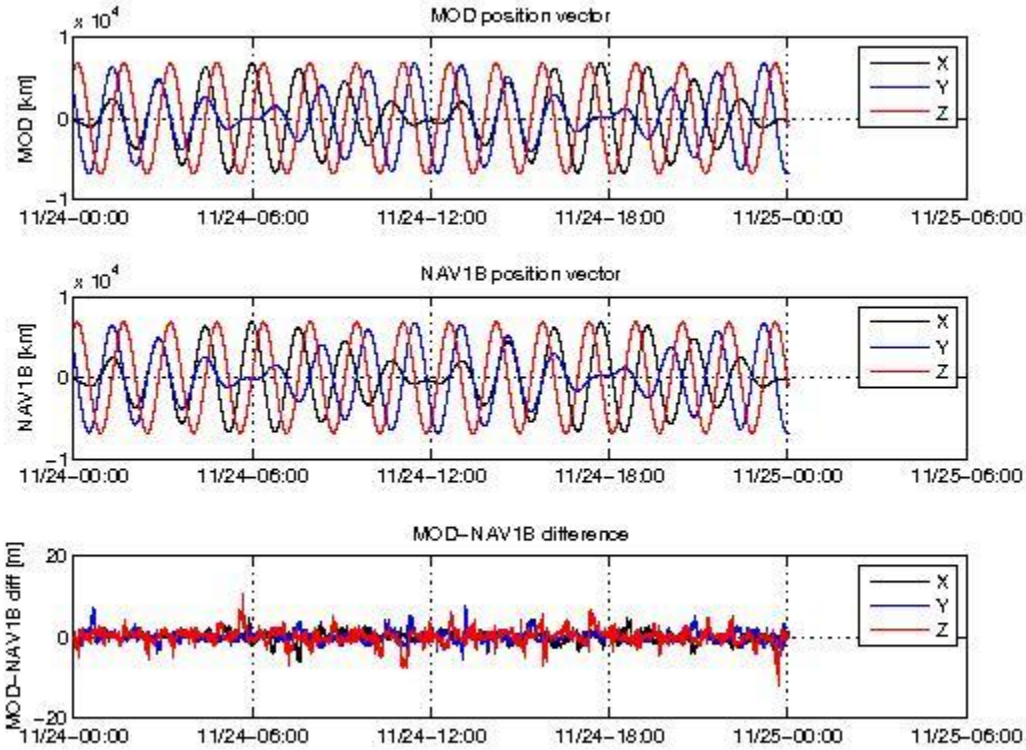

Figure 7: Difference MOD-GPSNAV, sc C, 24/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

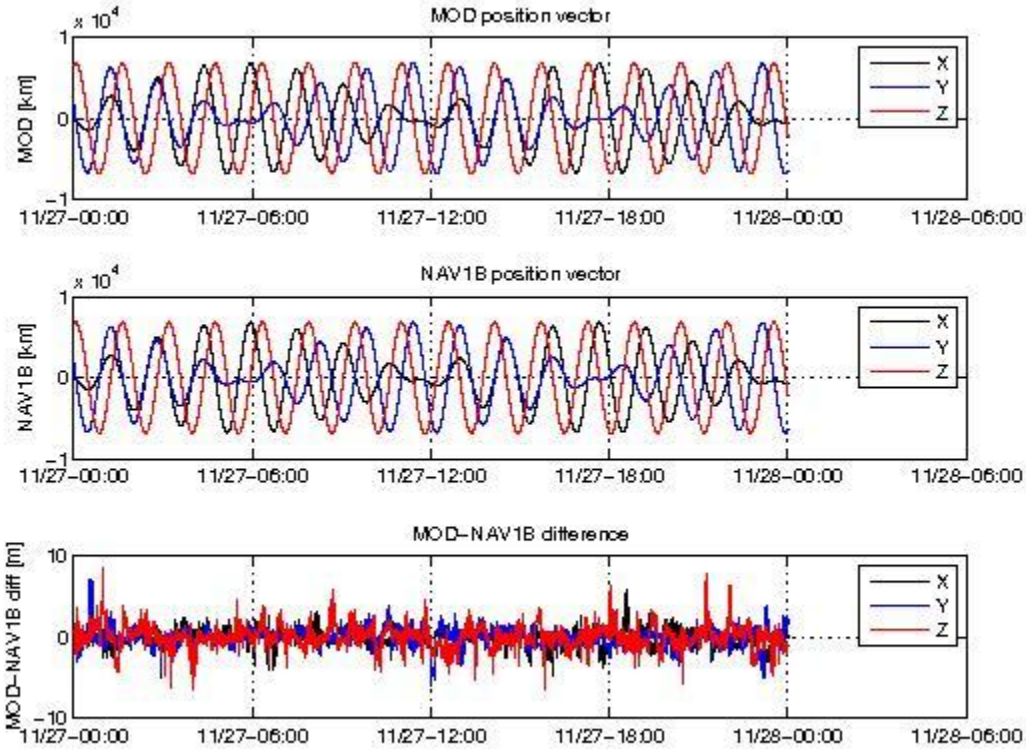

Figure 8: Difference MOD-GPSNAV, sc C, 27/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

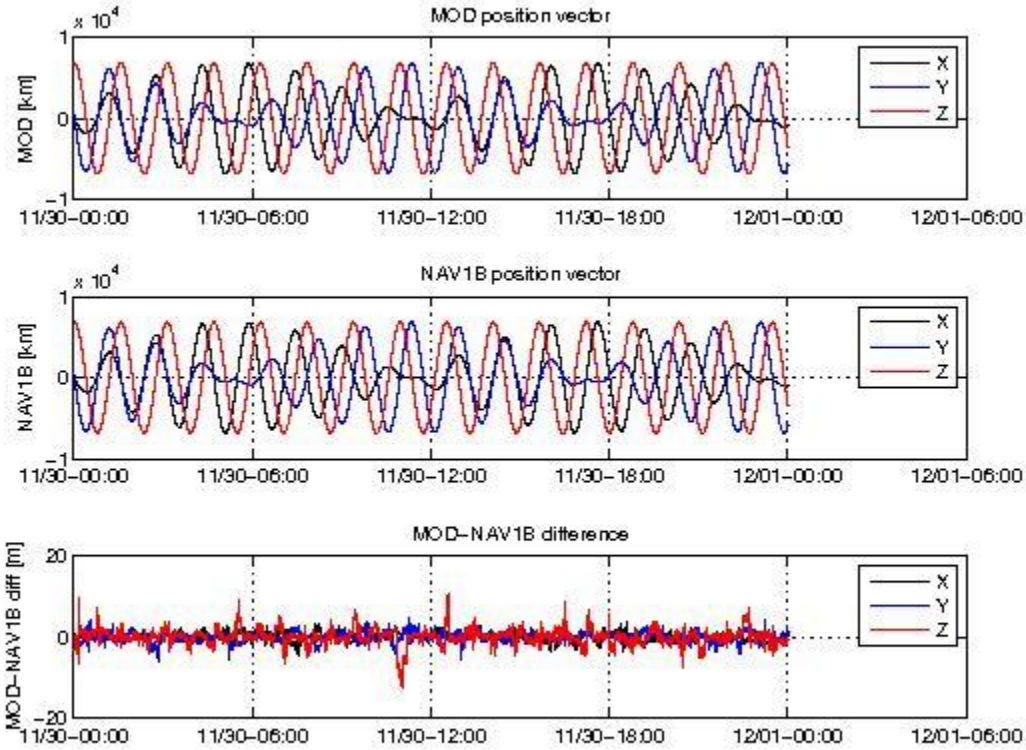

Figure 9: Difference MOD-GPSNAV, sc C, 30/11/2014. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.3.2 Attitude observations

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.**

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 (30/11/2014).

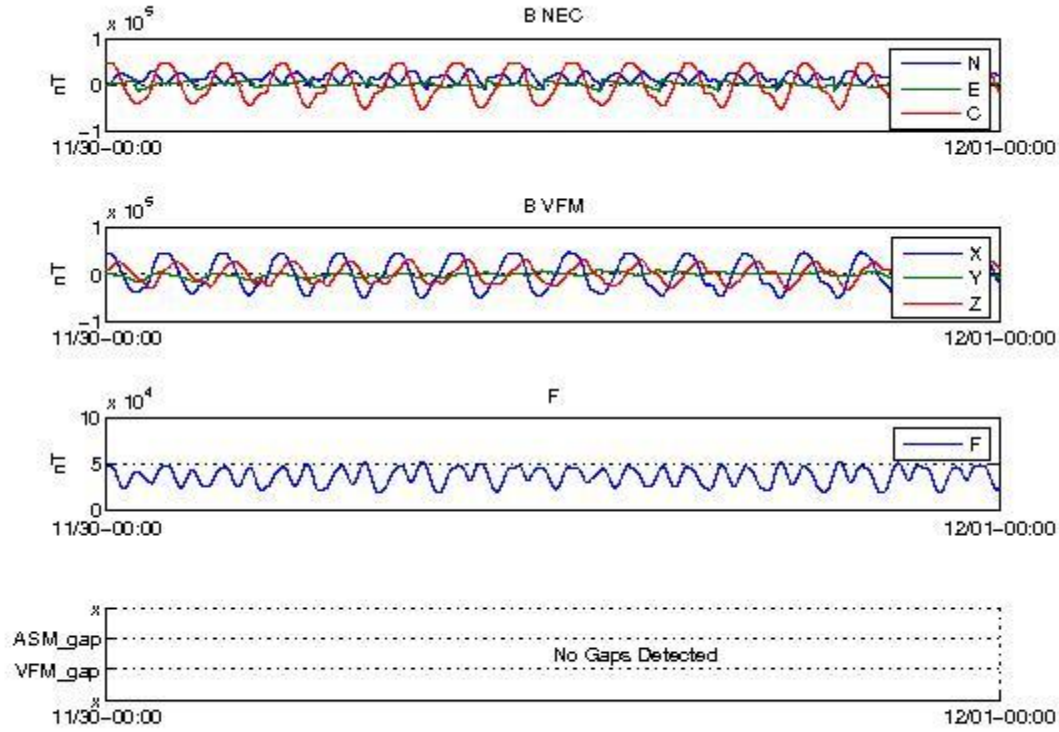

Figure 10: Time series of the geomagnetic field, for 30/11/2014, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.1.2 VFM-ASM anomaly

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

Below some plot example of such differences follows, taken at the beginning of the week (24/11, Figure 11) and at the end (30/11, Figure 12). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

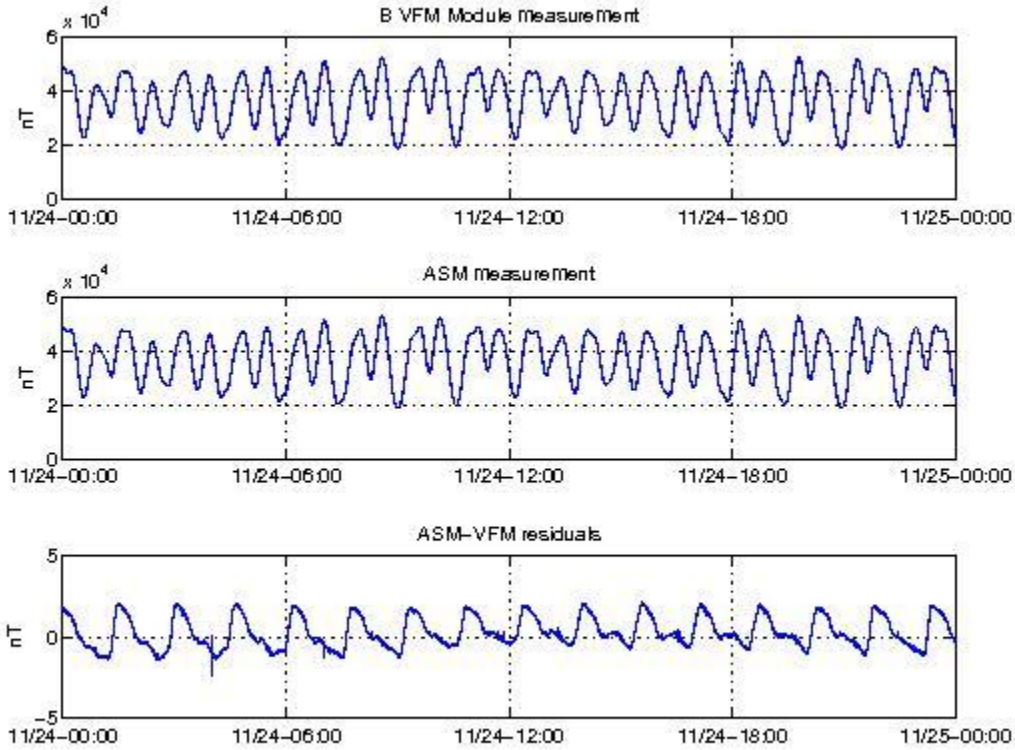

Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 24/11/2014.

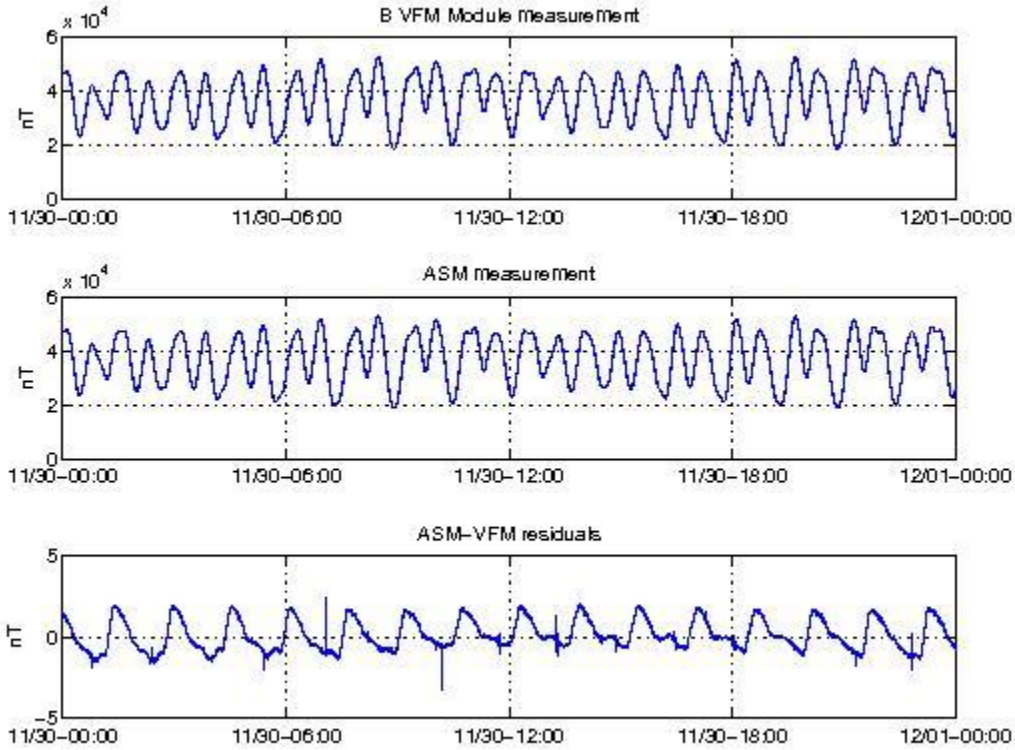

Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 30/11/2014.

3.3.1.3 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm A, for the month of November[1]: Biases (**Error! Reference source not found.**), Scales (**Error! Reference source not found.**) and Non-orthogonalities (**Error! Reference source not found.**). Each group is actually a three-component vector in the compact detector coil frame. All the parameters are rather constant and steady throughout the month, with the only exception of the Scale X component (Figure 14), which is recovering a higher average value, after the decrease experienced in the past two months.

[1] *Data covers up to 22/11, because of the unavailability of the quality operators during week 49 (DQW meeting in Potsdam) and the consequent impossibility to gather data from remote. The complete TCF coverage for the last part of November and December will be contained in the last report of December 2014 or the first report of January 2015.*

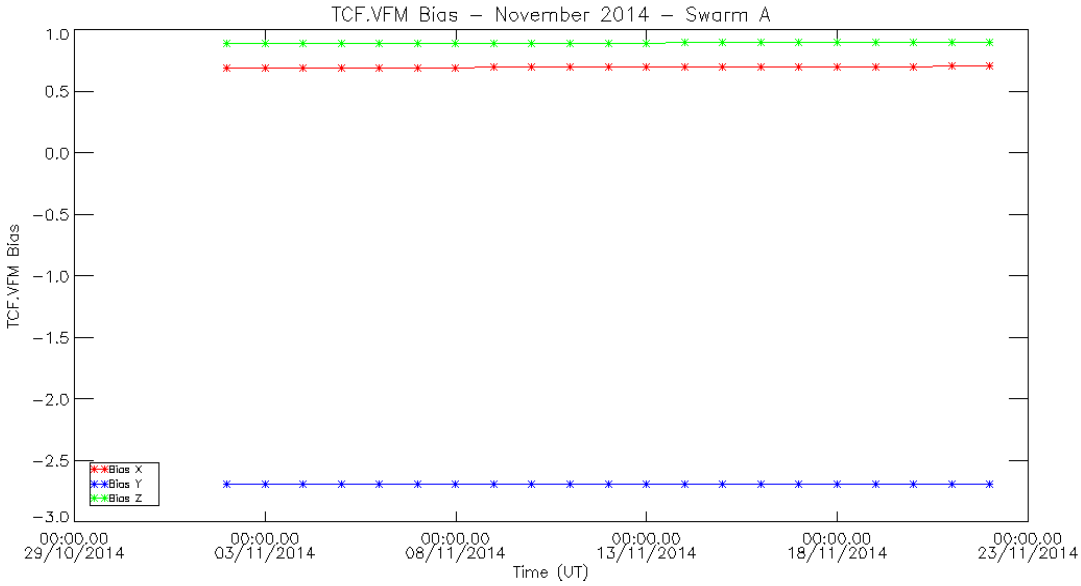

Figure 13: TCF.VFM Biases for S/C A, November 2014.

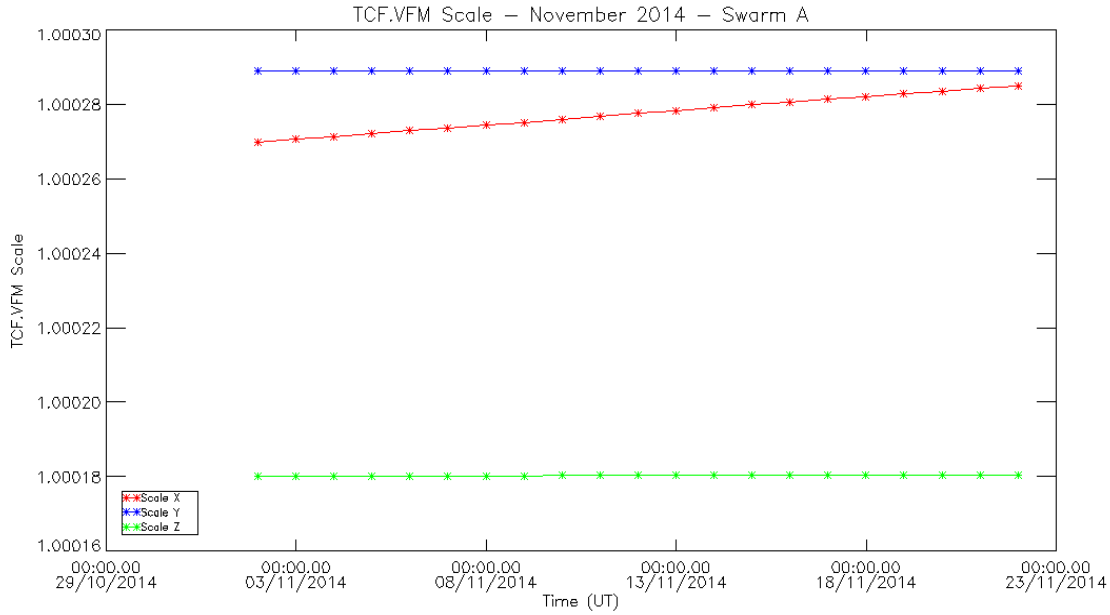

Figure 14: TCF.VFM Scales for S/C A, November 2014.

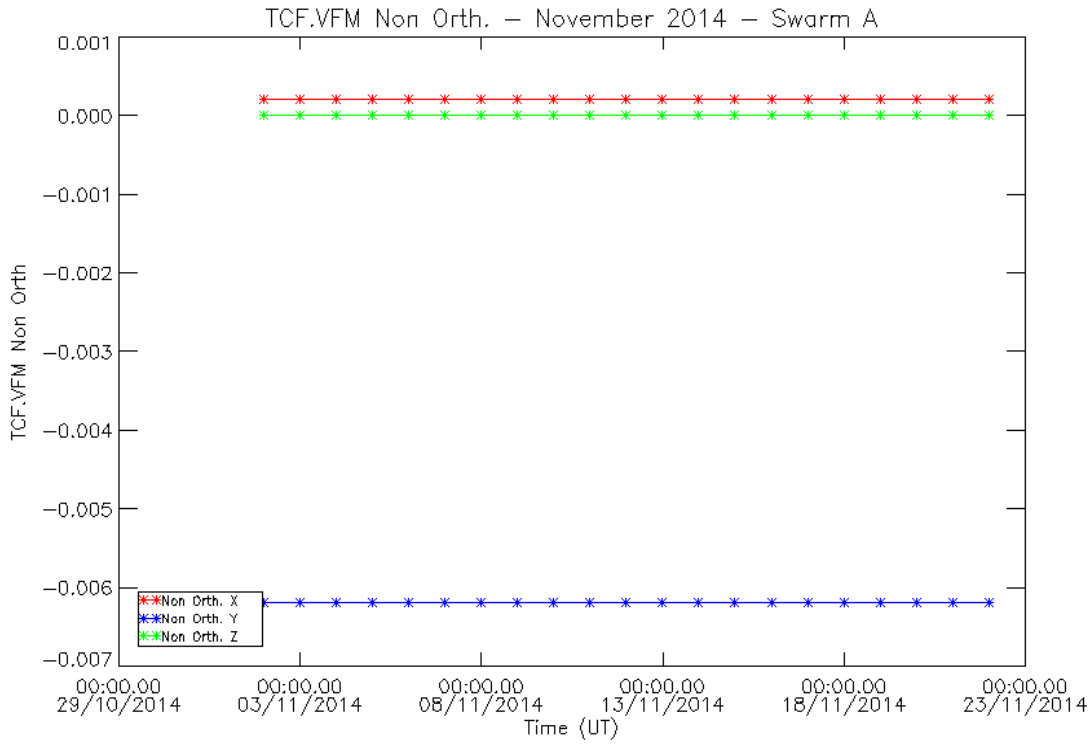

Figure 15: TCF.VFM Non Orthogonalities for S/C A, November 2014.

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 (30/11/2014) can be seen in Figure 16 below.

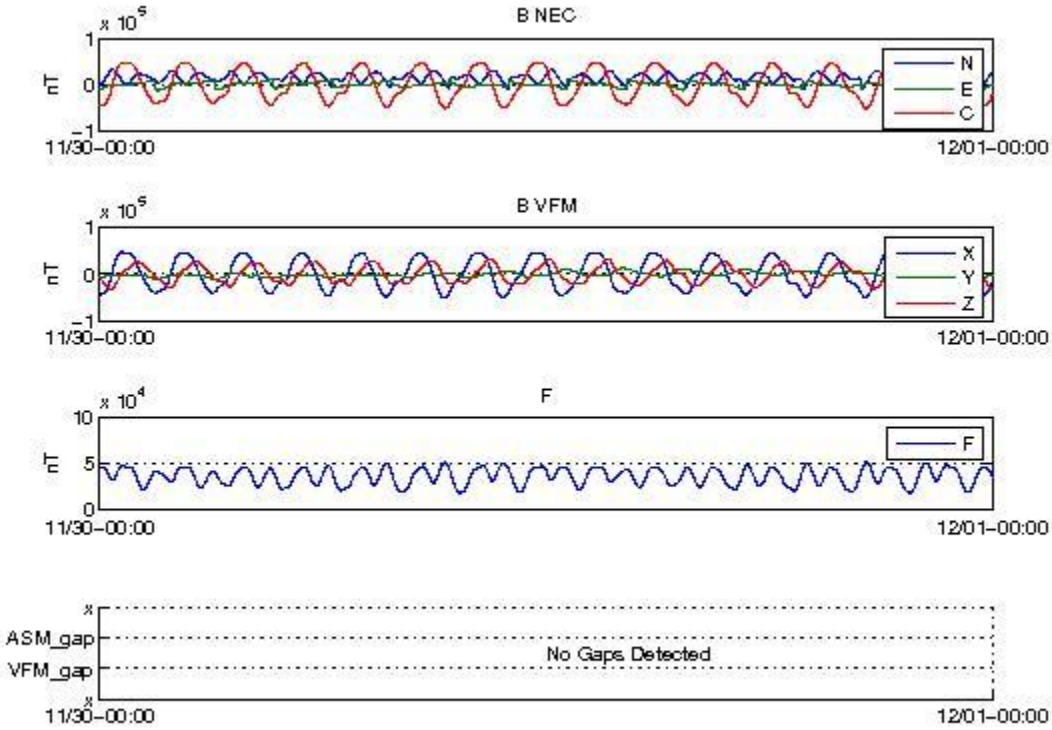

Figure 16: Time series of the geomagnetic field for 30/11/2014, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.2.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-3, 3] nT, with isolated spikes (gradients) that reaches up to 10 nT.

Below some plot example follows of such differences taken at the beginning of the week (25/11, Figure 17), and at the end of the week (30/11, Figure 18). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

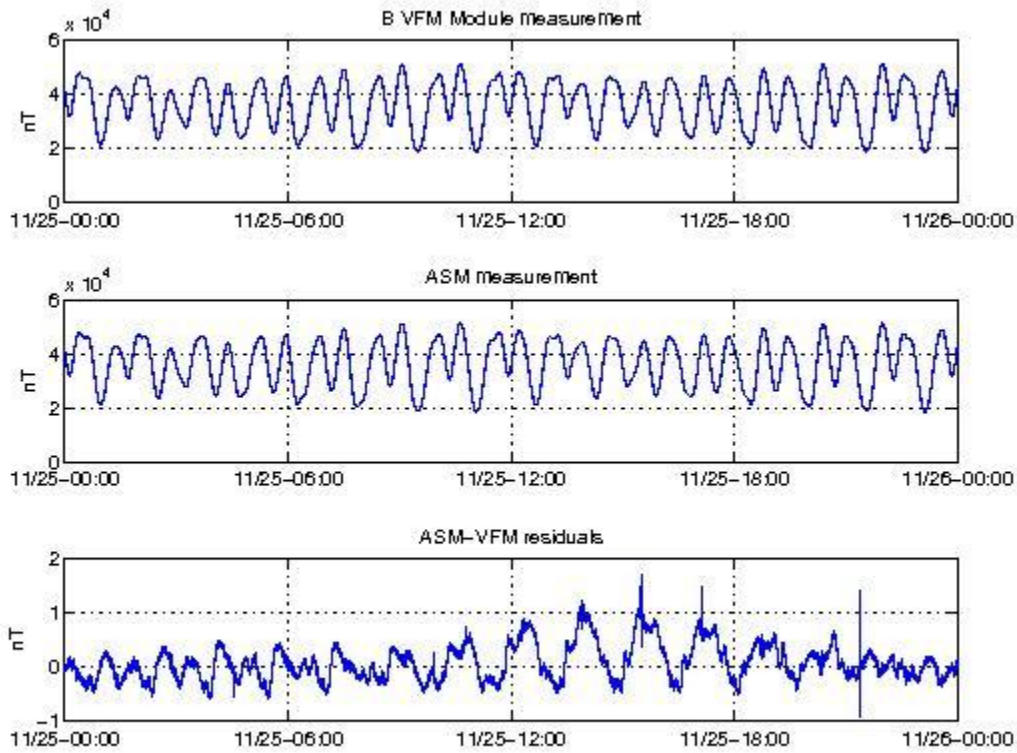

Figure 17: VFM module, ASM module and ASM-VFM residuals for S/C B, 25/11/2014

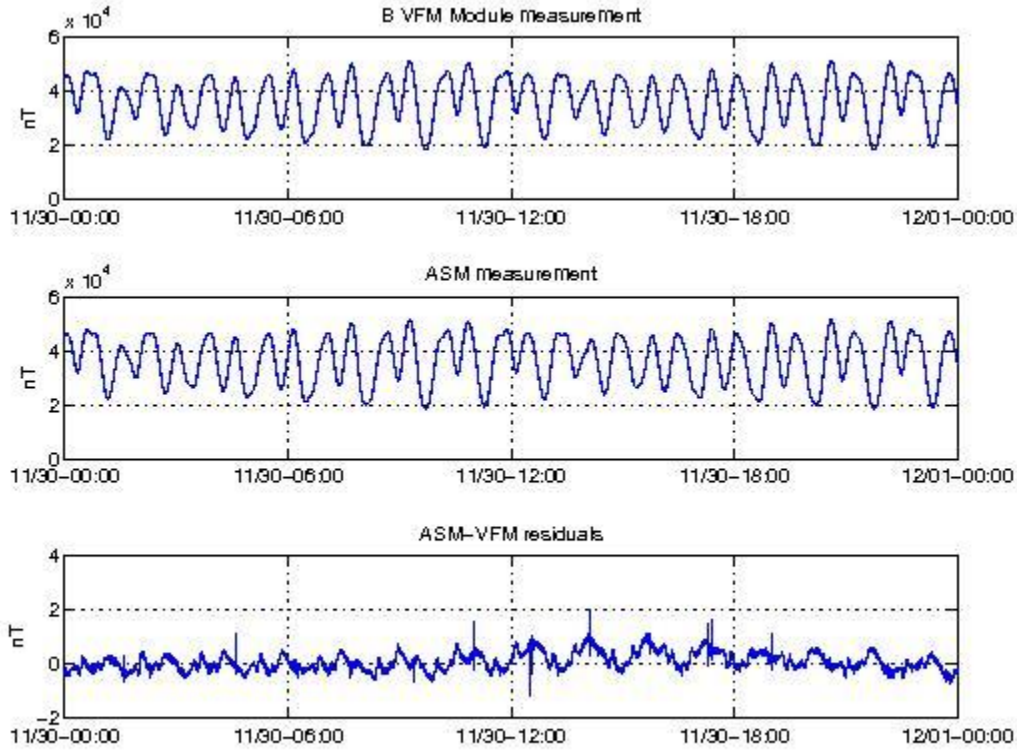

Figure 18: VFM module, ASM module and ASM-VFM residuals for S/C B, 30/11/2014.

3.3.2.3 TCF.VFM monitoring

In the following plots one can see the three groups of TCF VFM calibration parameters for Swarm B, for the month of November[2]: Biases (**Error! Reference source not found.**), Scales (**Error! Reference source not found.**) and Non-orthogonalities (**Error! Reference source not found.**). Each group is actually a three-component vector in the compact detector coil frame. All the parameters are rather constant and steady throughout the month, except for the Scale X and Z components (see Figure 20), which shows a slow rise of about 0.002%: it seems actually the trend is recovering the pre-September level.

[2] *Data covers up to 22/11, because of the unavailability of the quality operators during week 49 (DQW meeting in Potsdam) and the consequent impossibility to gather data from remote. The complete TCF coverage for the last part of November and December will be contained in the last report of December 2014 or the first report of January 2015.*

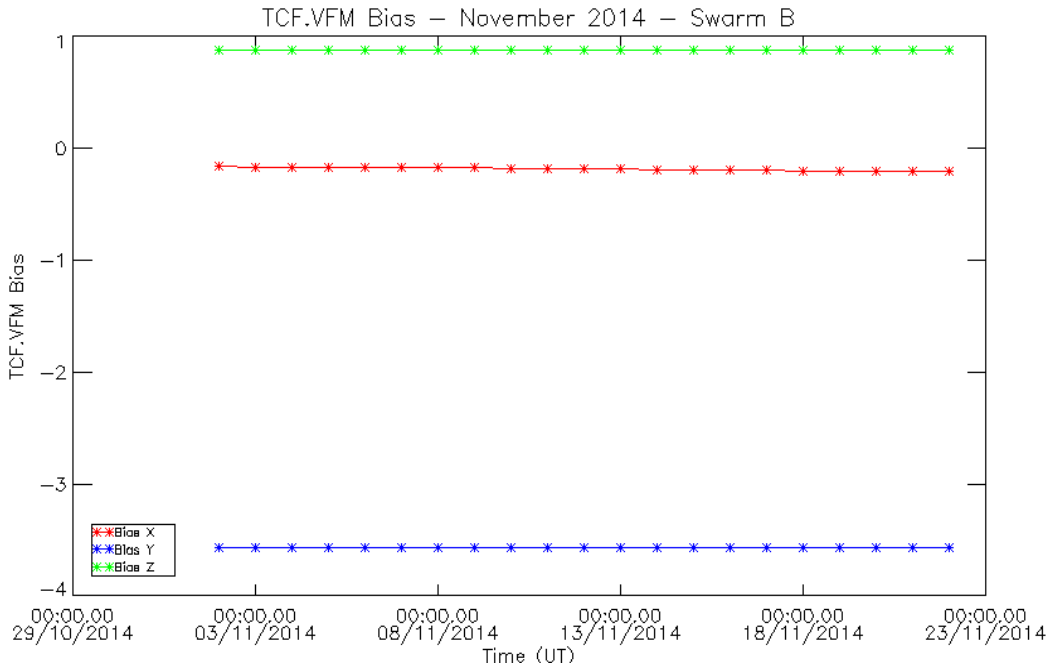

Figure 19: TCF.VFM Biases for S/C B, November 2014.

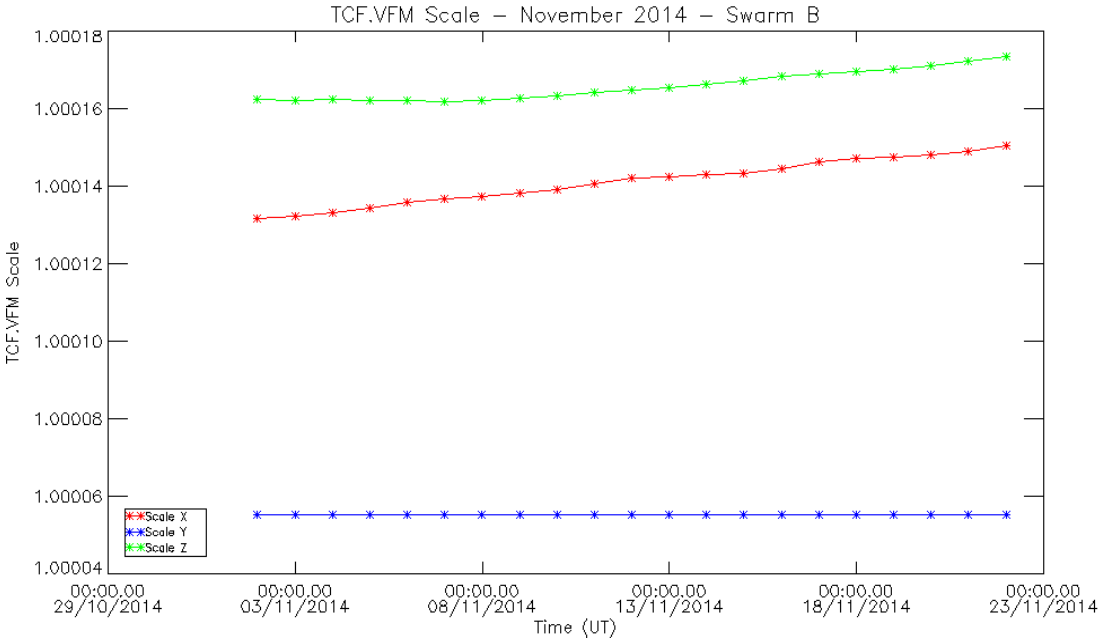

Figure 20: TCF.VFM Scales for S/C B, November 2014.

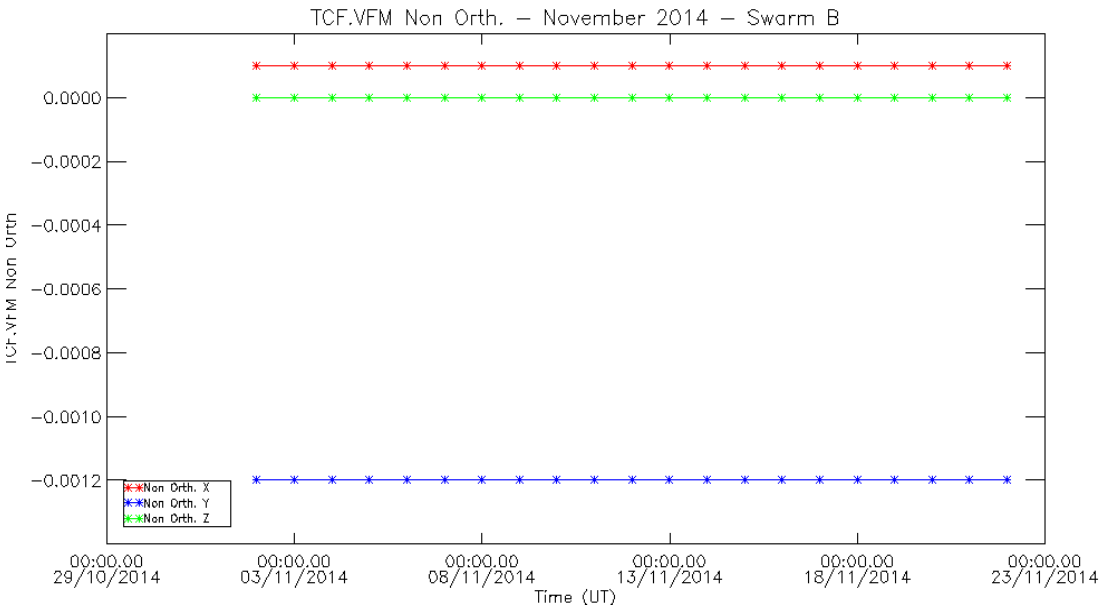

Figure 21: TCF.VFM Non Orthogonalities for S/C B, November 2014.

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

Due to the ASM failure and consequent switch-off occurred on 05/11, only few days in November are available. When we will be able to process magnetic data again, after the deployment in operation of L1BOP 3.12, all the same the Swarm C TCF will not be reliable anymore, as the last available (from 05/11) will always be used.

3.3.4 Summary of TCF behaviour for the three S/C

An important parameter which characterizes the quality of the TCF calculation is the weighted Root Mean Square (RMS) value of the residuals after the estimation. Figure 22 summarizes the RMS behavior for all S/C during November 2014 (Red curve = S/C A, blue curve = S/C B). RMS variations are rather small during the month.

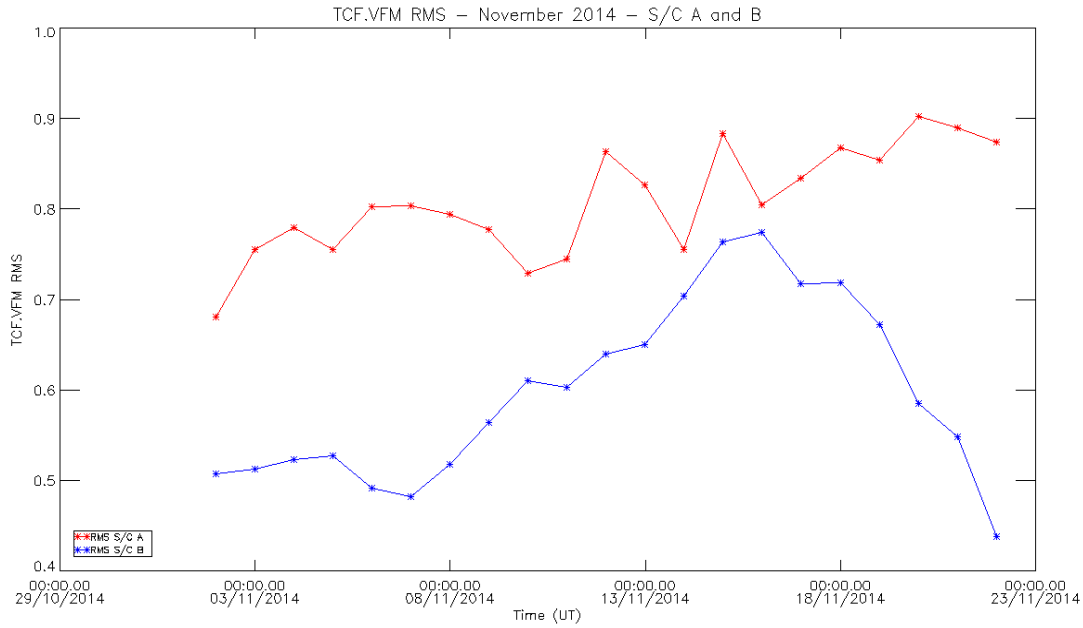

Figure 22: weighted RMS of the residuals after the TCF estimation, all S/C, November 2014.

4. ON-DEMAND ANALYSIS

Nothing to report.

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