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Swarm's Absolute Scalar Magnetometers Burst Mode Results

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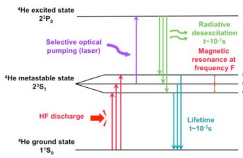
Summary

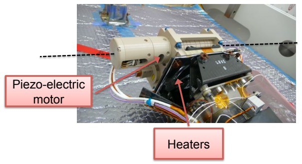
Each of the three Swarm satellites embarks an Absolute Scalar Magnetometer (ASM) to provide absolute scalar measurements of the magnetic field with high accuracy and stability. Nominal data acquisition of these ASMs is 1 Hz. But they can also run in a so-called "burst mode" and provide data at 250 Hz. During the commissioning phase of the mission, seven burst mode acquisition campaigns have been run simultaneously for all satellites, obtaining a total of ten days of burst-mode data. These campaigns allowed the identification of issues related to the operations of the piezo-electric motor and the heaters connected to the ASM, that do not impact the nominal 1 Hz scalar data.

We analyze the burst mode data to identify high frequency geomagnetic signals, focusing the analysis in two regions: the low latitudes, where we seek signatures of ionospheric irregularities, and the high latitudes, to identify high frequency signals related to polar region currents.

Since these campaigns have been conducted during the initial months of the mission, the three satellites where still close to each other, allowing to analyze the spatial coherency of the signals.

1 ASM instrument and setting





- The core of the ASM instrument is a **magnetic field to frequency** converter based on atomic spectroscopy of the ^{4}He in its metastable level 2^3S_1. It exploits the Zeeman effect, with the signal being amplified by optical pumping. The magnetic field modulus B_0 is directly proportional to the magnetometer's resonance frequency F :

$$B_0 = F / \gamma^4He , \quad \text{with } \gamma^4He / 2\pi \approx 28GHz/T$$

- The sensor, including the ^{4}He cell, is based on an isotropic design with a static and a rotating part, optimal resonance conditions are controlled by a piezo-electric motor, which is irregularly activated (but on average 500 times per orbit).
- The instrument has a [0-100 Hz] bandwidth and can be run at a **250 Hz Burst mode**, as during the days analyzed here.
- The instrument is located at the tip of the satellite boom, fixed on a bracket with heaters that maintain it within an appropriate temperature range.

Burst sessions

Burst acquisition	Period	Satellites
1	27/11/2013	A B C
2	11/12/2013	A B
3	7-8/1/2014	A B C
4	19/1/2014	A B C
5	28/1/2014	B C
6	8-9/2/2014	A B C
7	22-23/2/2014	A B C

Results shown here are from sessions #4 #6

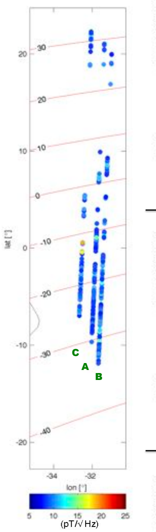
2 Burst data pre-processing

- The analysis of Burst data allowed to find artificial effects that needed to be addressed before analyzing the geophysical signals.
  - Activation of piezo-electric motor could produce outliers.
  - Heaters could interfere with the radiofrequence used to detect the resonance frequency F and produce characteristic oscillations at characteristic values of B affecting few seconds of data.
- Time series of each Swarm satellite have been processed along with the time of activation of the piezo-electric motor, to remove outliers.
- A detection algorithm was used to identify and remove the oscillations caused by the heaters and linear data interpolation has been used to clean the data.
- We analyzed burst data in sliding windows of 3-minutes .
- We removed a 4th order polynomial from the magnetic field data, before computing the PSD.
- Residual magnetic field and PSD are shown for the Swarm satellites while crossing a same region.

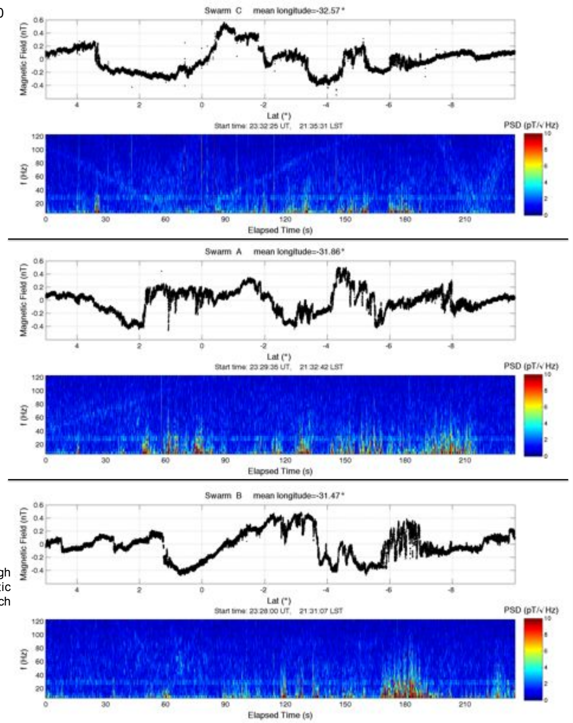
3 Low latitudes geomagnetic signals

19 January 2014

- Quiet day: Ap=0



Map of occurrence of high frequency geomagnetic signals detected by each satellite.

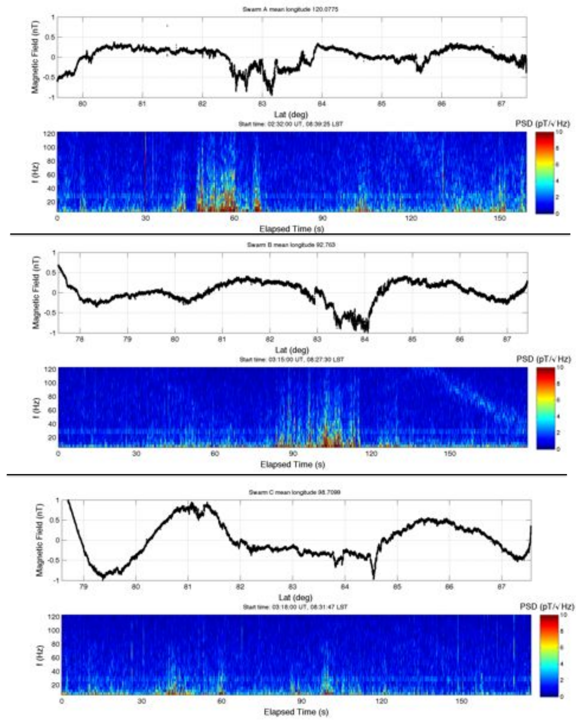


- Satellites descending orbits at 21:30 LT
- This kind of signal is not detected on the day-side ascending orbits
- These signals in the equatorial region are compatible with the occurrence of plasma bubbles
- The satellites were following each other within a distance of 2020 km, 5 minutes to cross the same latitude
- Longitudinal distance between C and B is 130 km in this sector

Satellite order	Name	Distance from previous satellite	Time delay between satellites
1	B	-	-
2	A	726 km	1 min
3	C	1295 km	3 min

4 High latitudes geomagnetic signals

8-9 February 2014



- 8/2/2014 Geomagnetic disturbed period: Ap=23 and 16
- Swarm satellites detected high frequency signals in the auroral regions of both hemispheres.
- Swarm satellite A was separated from B and C.
- Structures crossed by the satellites presents marked spatial differences.

5 Conclusions

- During burst mode acquisition, all three Swarm satellites detected high frequency signals (up to 50 Hz) in the evening in the equatorial region, possibly associated to plasma bubbles.
- During geomagnetic active periods, other signals have been detected in the auroral regions, associated with the ongoing geomagnetic storm.
- These signals are associated with small-scale structures in the ionospheric plasma crossed by the Swarm satellites.
- Further analysis will be done to study other geomagnetic signals (e.g. pulsations).