New ASM 250 Hz burst mode science data

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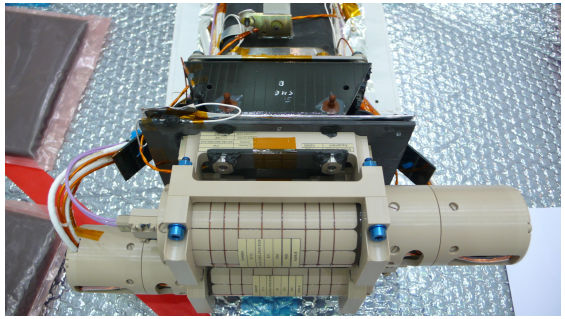
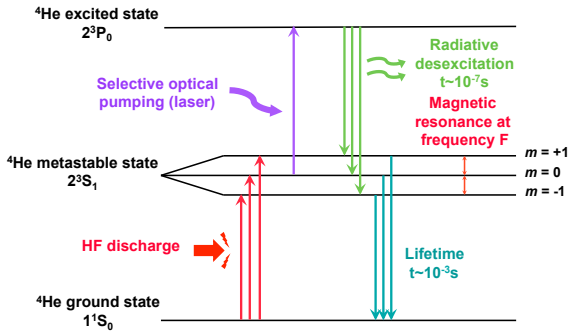
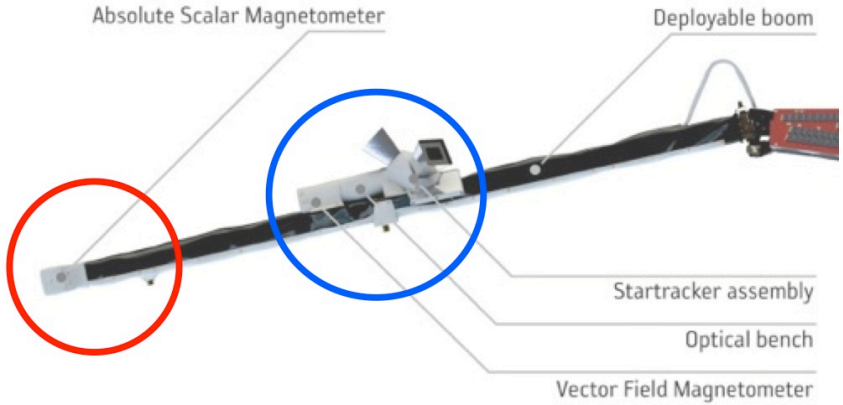
The ASM instrument on Swarm





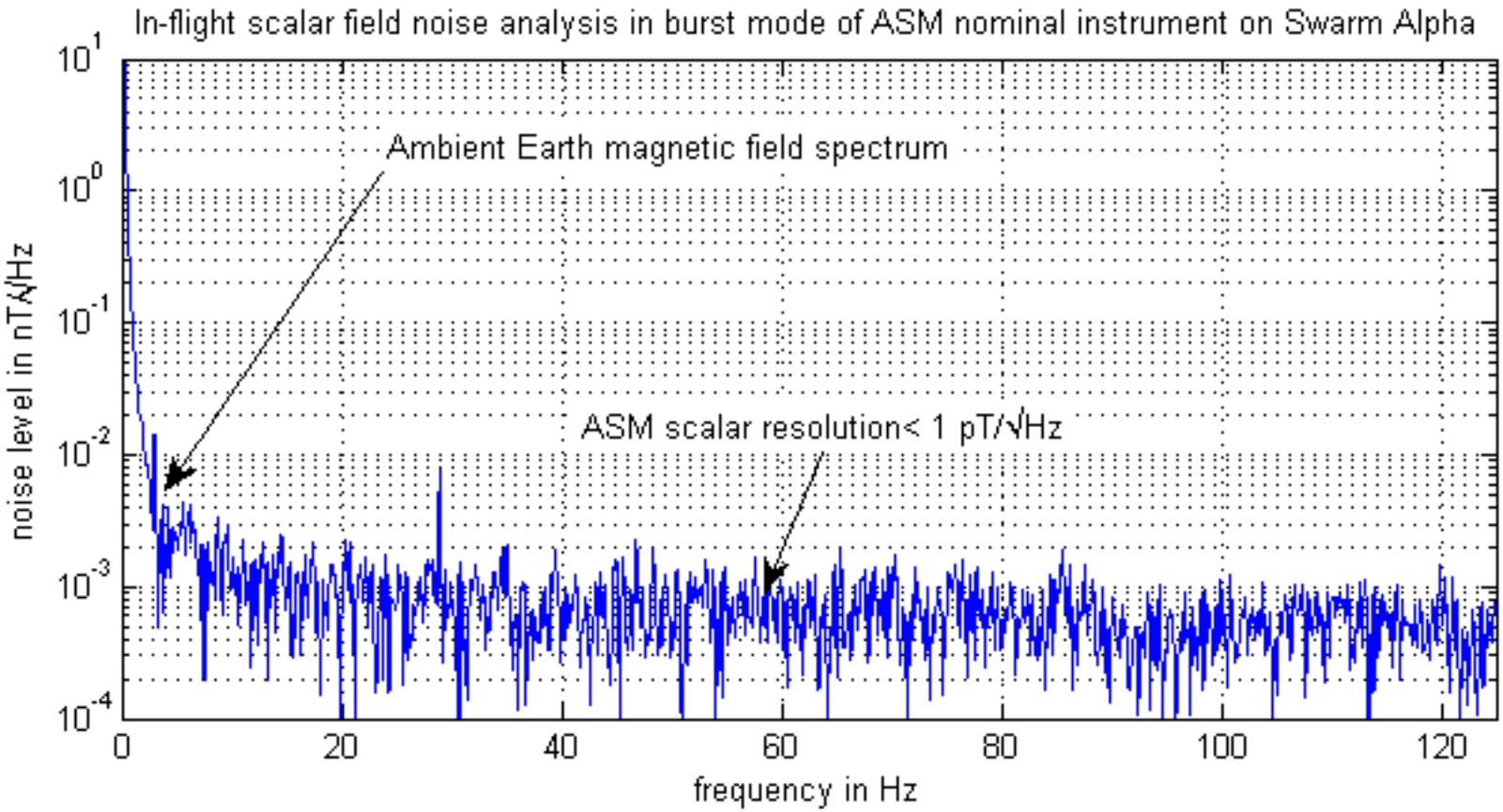


- The **ASM** is **located at the tip of a boom furthest away from the body of the satellite and other instruments.**
- The ASM is an **absolute scalar magnetometer** based on atomic spectroscopy of ^{4}He, and relying on the Zeeman effect measured thanks to magnetic resonance. A **piezo-electric motor is used to rotate the sensor cell and maintain polarization conditions.**
- This concept allows an **internal acquisition rate is of 1 KHz.**
- **So far, its nominal role on Swarm was to produce 1 Hz L1b Scalar for both science purposes and calibration of the (50 Hz and 1 Hz) VFM L1b vector data.**
- **But,** thanks to its high acquisition rate, **it can also be run in a so-called burst mode to provide 250 Hz absolute scalar data.**

Results from early burst mode sessions during commissioning

- **Seven short burst mode sessions** were run during commissioning **early in 2014.**
- This led to the **confirmation of the noise level expected for the ASM.**
- This also **revealed a number of issues important to be aware of**, since they lead to apparent signals NOT to be interpreted as scientific signals.
- But more importantly, this **also led to the identification of scientific signals of interest**, either complementing signals that can also be detected in the 50 Hz VFM data (providing scalar information at a higher frequency and with less noise), or signals that cannot be captured by the VFM.

ASM burst mode noise level



- **Confirmation of the noise level expected for the ASM, with scalar resolution of less than 1 pT/Hz$^{-1/2}$** (see Fratter et al., Acta Astronautica, 2016).

Identification of artefacts produced by the piezoelectric motor

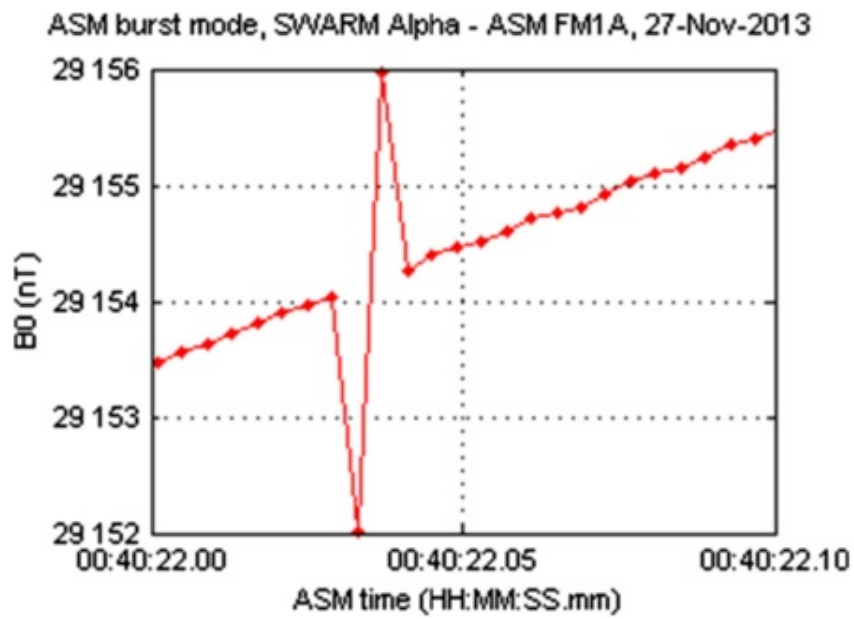
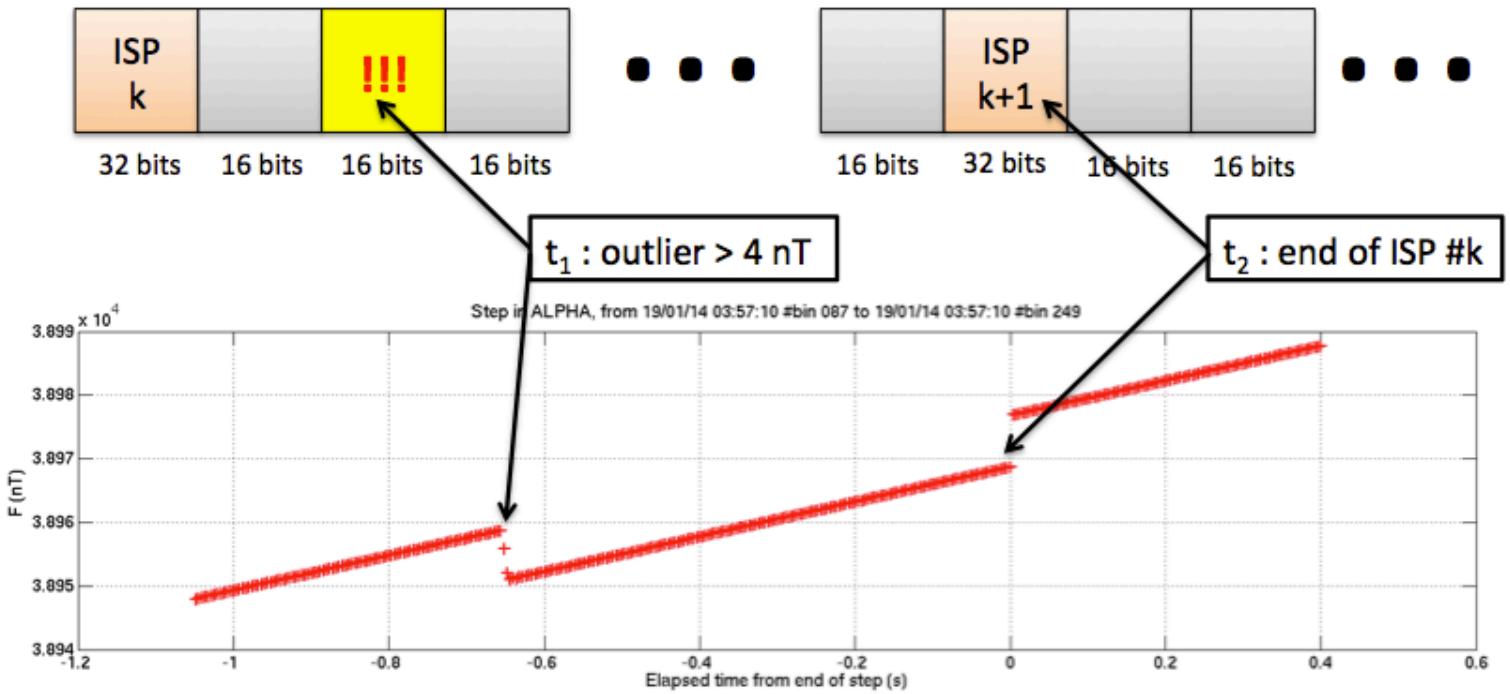


Figure 2 Transient perturbation generated by motor activation in scalar burst mode data. Example of perturbation detected on ASM FM1A (Swarm Alpha) burst mode scalar data, plotted in nT on 27 November 2013 from 00:40:22.00 to 00:40:22.10 (i.e., 25 samples of 250-Hz burst mode data).

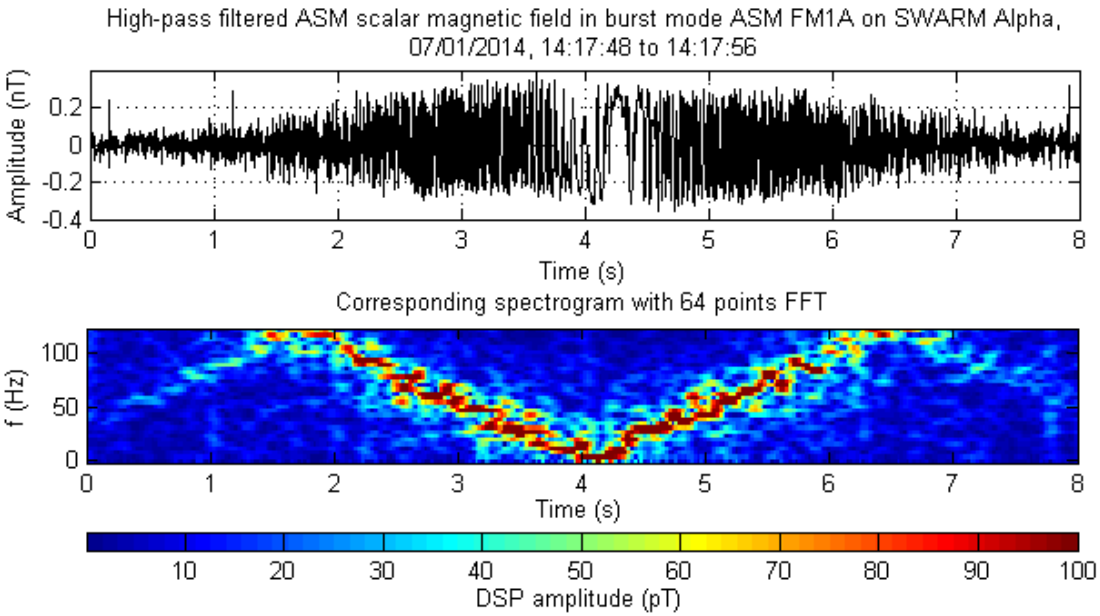
- Such very brief artefacts (a few sample points) arise when the piezoelectric motor is activated (roughly 300 times per orbit).
- **Housekeeping information can be used to flag these artefacts**, and the data can easily be corrected for them (left to the user to do).

Identification of steps produced by digitization overflows



- L0 Burst mode data are coded in Instrument Source Packets (ISP) which contain 250 data (1s), with only the first data coded as unsigned 32 bits integer, the 249 following data being provided via increments coded in signed 16 bits integer. -> **if an increment exceeds 4 nT, an artificial step of (exactly) 8.0289 nT occurs lasting until the next second**.
- **This can be detected and corrected for.**
- **Corrected data are flagged.**

Identification of interferences between heater currents and the RF used by the ASM



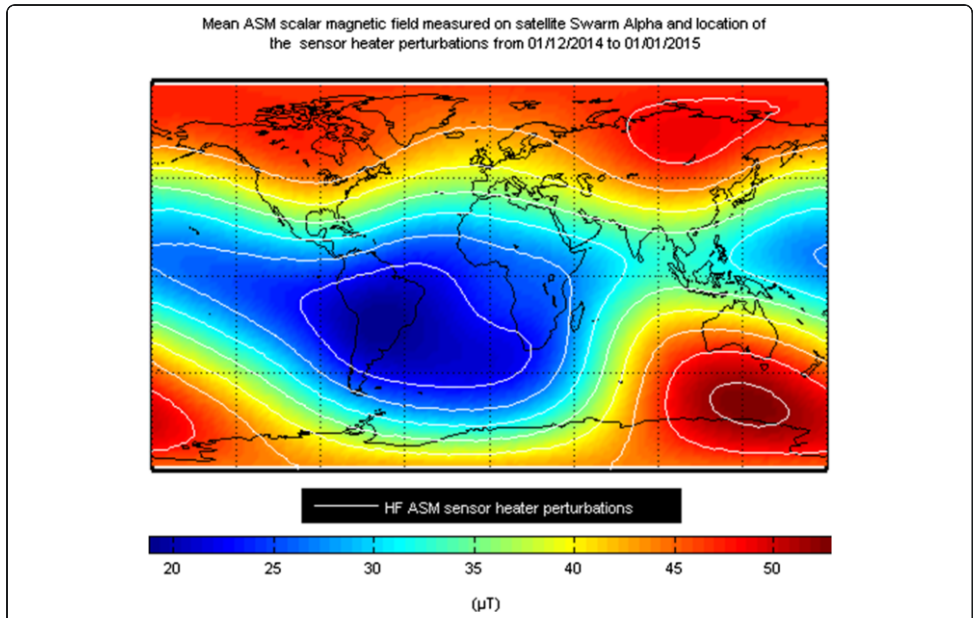
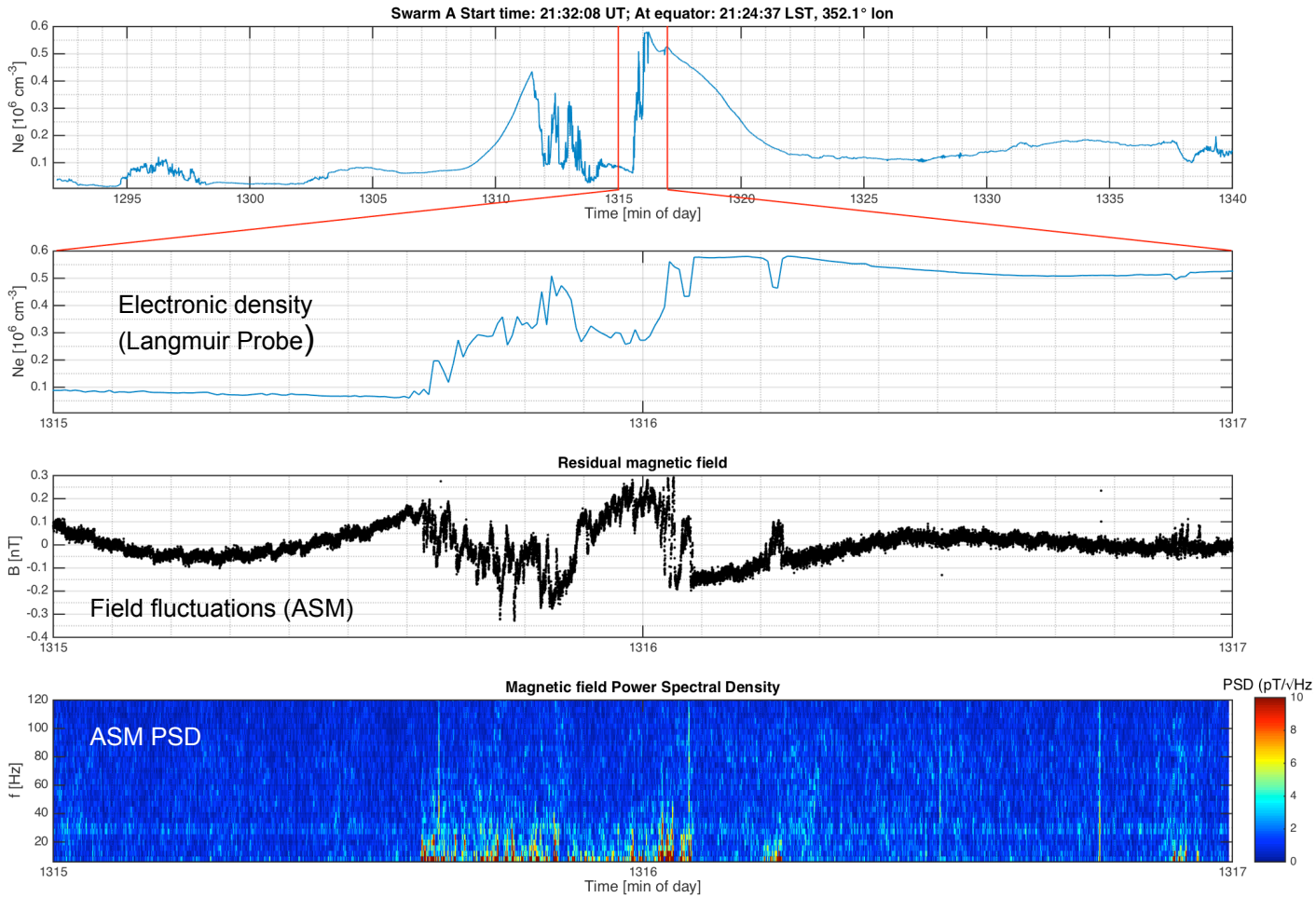


Figure 4 Geographical distribution of locations where a heater's harmonics crosstalk perturbations may occur. This plot is for Swarm Alpha on December 2014. The ASM scalar field measurements are plotted in μT (colorscale); possible perturbation locations are plotted as white lines.

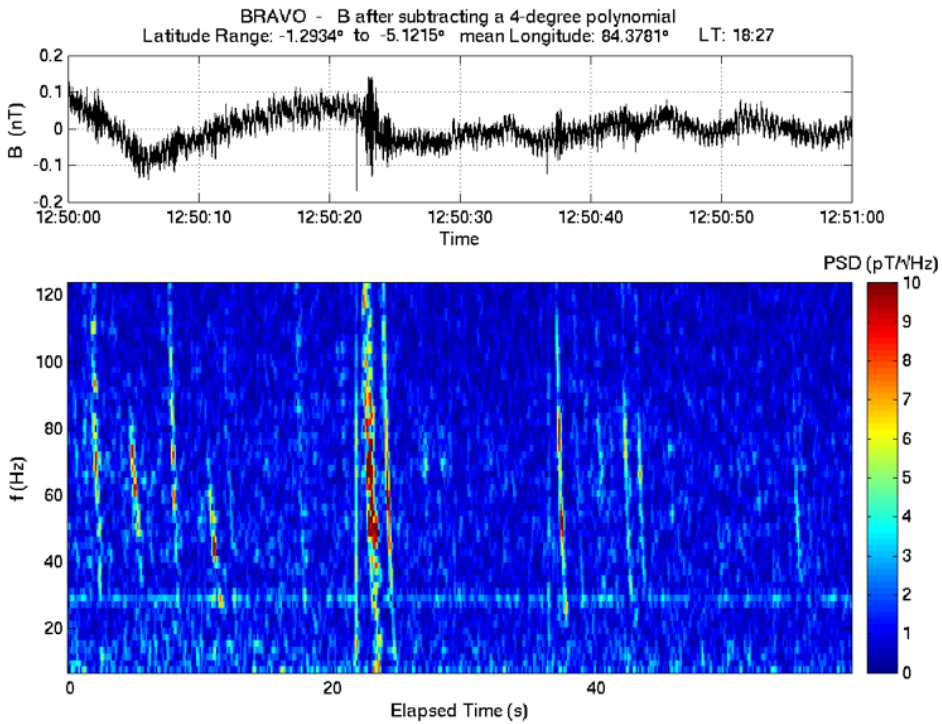
- **L0 Interferences have been identified between the RF used by the ASM for magnetic resonance and the square AC 58 kHz electrical currents feeding the heaters needed to maintain the sensors within operating thermal range** (see Léger et al., EPS, 2015; Fratter et al., Acta Astronautica, 2016).
- This can occur **only when specific conditions are met**, i.e. when the heater is on and the field intensity F satisfies F = (2k+1) x 2.071 μT, to within a margin (currently set to 50 nT)
- **This can be (and is) flagged, but CANNOT be corrected for.**

Identification of plasma bubble signals of interest

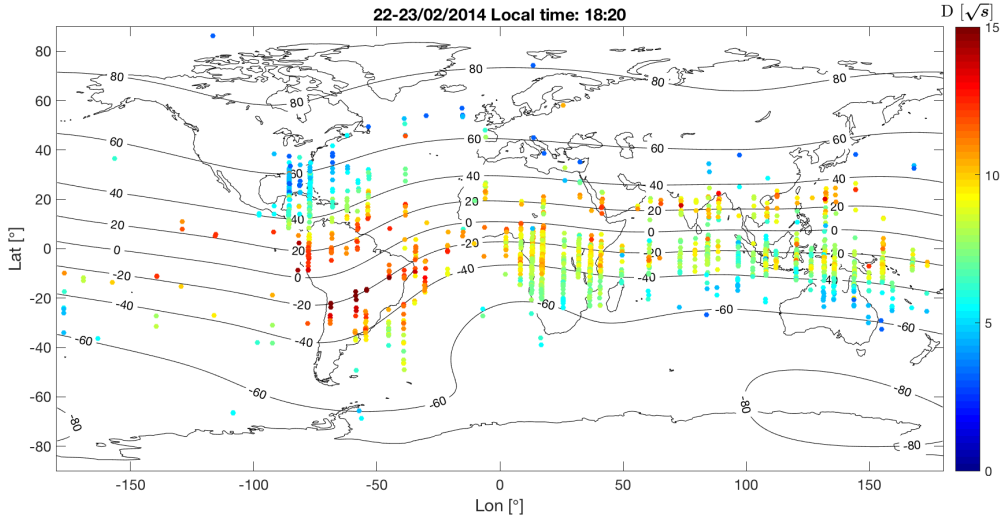


- **Highly detailed signals (with fluctuations on the order of 10 to 200 pT) are captured when crossing the boundaries of the plasma bubbles**

Identification of whistler signals of interest



One minute session on Bravo (LT 18:20)



Two days of whistler events (maps of dispersions), LT 18:20

- **Many such signals have been identified and unambiguously attributed to lightning events in the neutral atmosphere.**
- **Possibility of investigating the state of the ionosphere below the Swarm satellites** (see talk by Coïsson et al., "Swarm ASM burst mode to sound the ionosphere below the satellites", session 6 on Wednesday)

ASM 250 Hz burst mode science data
A new Swarm product

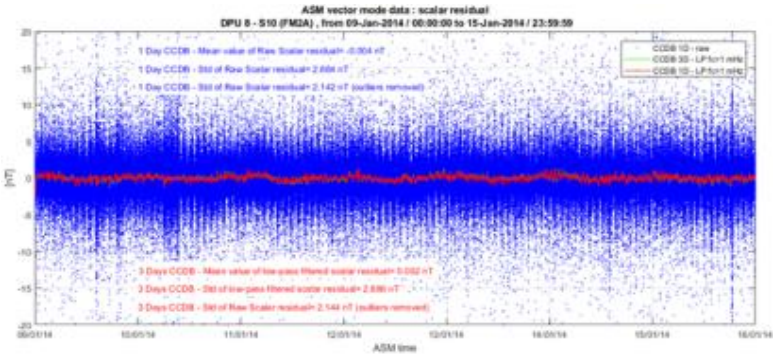
- The science potential of these early ASM Burst mode data has prompted the **decision to now run regular burst mode sessions** (on Alpha and Bravo)
- **A new Swarm product will soon start being produced** under the responsibility of IPGP and CEA-Léti**: ASM 250 Hz burst mode science data**
- Because the ASM burst mode cannot be run simultaneously with the ASM vector mode (more about the ASM vector mode in the next talk)**, such sessions will be run (simultaneously on Alpha and Bravo) for two consecutive weeks in alternation with vector mode sessions of also two weeks.**

ASM 250 Hz burst mode science data Readiness of the production chain

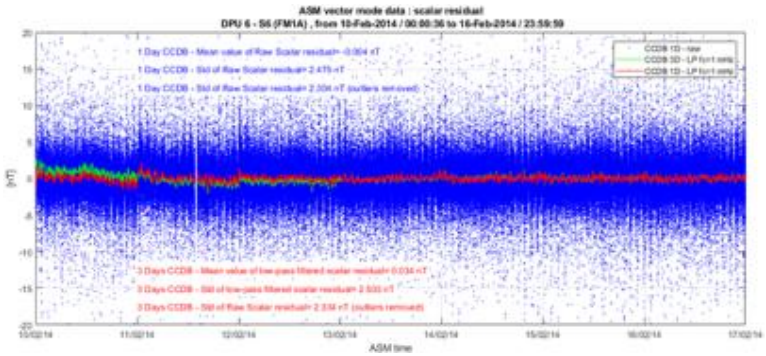
- **The processing chain is nearly ready on IPGP side** (processing of HK data provided by ESA in new file format still to be implemented for flagging of piezoelectric motor and heater perturbations, file format issue to be solved)**.**

- **CEA-Leti checked the ability of the ASM to switch from Burst to vector mode without harming the quality of the data.**

Example of no effect detected after vector mode restart (on the ASM scalar residual)



Example of 'small' effect detected up to 3 days after vector mode restart



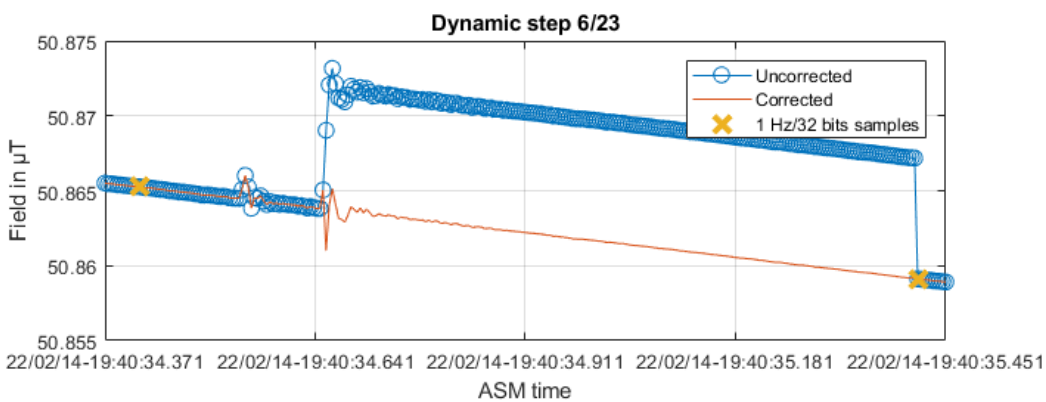
- only 20 to 25 % of the performed on/off transitions have shown significant transient deviations w.r.t nominal calibration behavior.

- performances are back to nominal at the latest 3 days after the restart of vector mode -> **recommendation to stick to two weeks sessions**.

ASM 250 Hz burst mode science data: Readiness of the production chain

- **CEA-Leti provided the algorithm and prototype processor to ensure that 1Hz scalar data could be produced from the burst mode data to feed the production chain of the nominal L1b (VFM) vector data.**

  - Validation of the data timing reconstruction strategy of the “250 Hz” measurements and derived “1Hz” data
  - Filtering compatibility between 1 kHz internal ASM filters and 250 Hz filters to be used on ground in the post-processing
  - Correction for the 16 bits dynamic saturation jumps in the 250 Hz ASM raw data
  - …



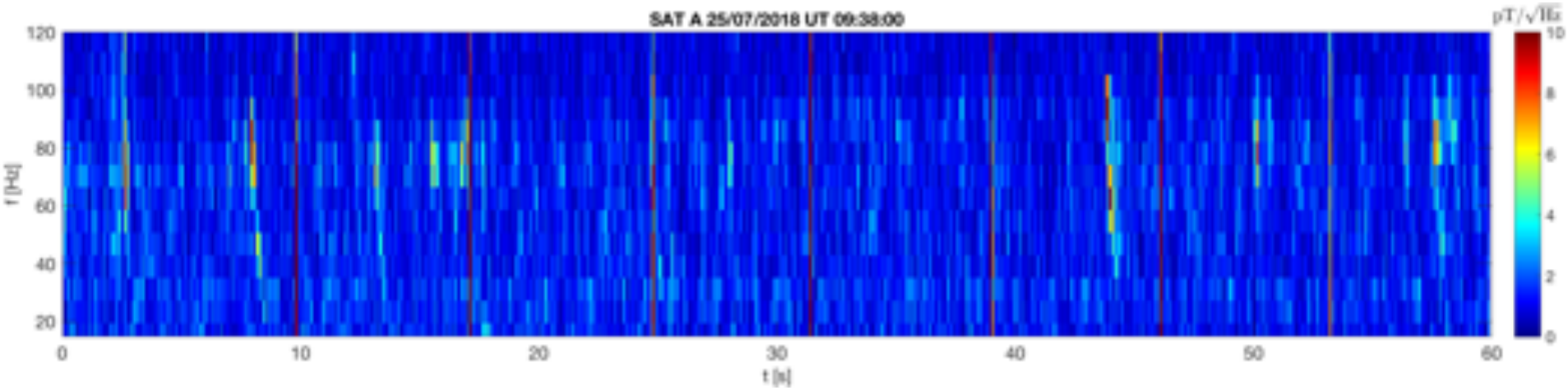
ASM 250 Hz burst mode science data: Data format and content

Data will be made available in the form of **daily files in CDF format with the following information:**

- UTC time of each sample at 250 Hz.
- Location of the satellite (latitude, longitude, radius).
- Value of F (after corrections for 8.0289 nT jumps and stray fields).
- Value of dF stray field corrections that have been implemented.
- Flag_step: Flag for the data that have been corrected for the 8.0289 nT field jumps.
- Flag_outlier: Flag when an outlier has been detected.
- Flag_heater_field_conditions: Flag when field values are such that a heater perturbation is likely to have occurred if the heater was on.
- Time_heater: Times in UTC when the heater was on.
- Time_piezo: Times in UTC when the piezoelectric motor was activated and likely to produce a perturbation.

In addition, for each daily CDF file, a CDF header file will also be produced, containing all relevant information about the input files and parameters used for creating the CDF file.

A new test session was already run on Alpha on 25/07/18



- **More whistlers could be detected** (here an example of 1 mn of data)
- More on this in the talk by Coïsson et al., **"**Swarm ASM burst mode to sound the ionosphere below the satellites", session 6 on Wednesday.
- **STAY TUNED !**