Global field modelling using experimental ASM vector mode data

- Kaibara core field model component 3 at core surface on 28/08/16, only using Swarm experimental ASM vector mode data (n = 1-3).
- Atlantic core field model component 3 at core surface on 28/08/16, only using Swarm experimental ASM vector mode data (n = 1-3).

Isonospheric studies using burst mode ASM data

- Burst mode sessions run during commissioning of Swarm revealed the ability of the ASM Burst mode to detect isonospheric signals related to plasma bubbles and whistlers within the 20-120 Hz frequency bandwidth. Burst mode measurements are now regularly acquired and have become a normal part of the Swarm operating product. A study has been funded by ESA to take advantage of these data to produce detailed products about the state of the isonosphere below the satellites. The MAM instrument could provide even better data (up to 1 kHz) for such studies, which could also benefit from the high-frequency even more sensitive magnetic field HMF instrument, as well as the high-frequency m-NLP Langmuir probe, also planned on the NanosatMag payload (Box 5).

Example of high frequency signals detected when crossing plasma bubbles (19/01/2014, 13.30 local time).

ELF frequency whirls produced by lightning in the neutral atmosphere below the satellite, the dispersive character of which can be used to investigate the state of the isonosphere along the satellite path between their entry points in the isonosphere and the satellites (here on 22-23/02/2014, LT 18:20).

More details can be found in section A10 on Sunday 14/07/19 at 17:30.

References

- Léger et al., In-flight performance of the Absolute Scalar Magnetometer vector mode on board the Swarm Earth satellites, Earth Planet. Space, 67,57.

Conclusion and Perspectives

Swarm has not only proven to be a scientific success, it also allowed in-flight scientific validation of the CEA-LETI ASM magnetometer dual mode concept.

A miniaturized version of this ASM will shortly be available.

A Phase 0 study with CNES, followed by very active ongoing studies, points at the possibility of relying on a dual platform (such as proposed by Open Cosmos) to build a nanosatellite concept with a high TRL, payload and SRL readiness.

Several such NanoMagSats could quickly be developed for a multiple launch in 2024, to complement, enhance and go over the Swarm constellation magnetometry and ionospheric scientific goals.

Such a NanoMagSat concept could pave the way to permanent low-cost multi-satellite collaborative observation of the geomagnetic field and ionospheric environment, complementing the International Magnetic Reference System (IMRS) and providing a basis for global geodynamic and geomagnetic models.

Box 5

To enhance Swarm’s scientific capabilities and potentially enable the development of a full-fledged nanosatellite mission, an ASM payload based on an isonospheric scalar measurement has been proposed (Fig. 5). The ASM dual mode nano-satellite concept presented here could serve as a proof-of-concept platform to demonstrate key elements of an isonospheric mission.

The proposed satellite configuration is shown in Table 5.

For this project to join/support, the please let us know (cn@isp.fr).

In the case of an ASM for Swarm and the MAM for the CEA-LETI project, the team has proposed to use the same miniaturized technology as the one developed for the MAGSAT I-2 nanosatellite mission. This technology is based on a miniaturized version of the same magnetometer that has been developed by CEA-LETI in the frame of the interagency MagnetoEncephaloGraphy (MEG) project. The MEG project is a European Space Agency (ESA) program aimed at developing the MEG technology for medical applications.

The MiniMagSat 12U concept

A joint CNES/HEC/CEA-LETI Phase I study was carried out to define the concept of a nanosatellite (20 cm x 20 cm x 30 cm, when folded) that could accommodate the following payload:

- MAM magnetometer simultaneously providing 1 Vector and up to 12 scalar data, located on an altitude of several hundreds of km.
- A set of two stars (ST) located on the same optical bench for absolute attitude restitution (5 Hz).
- A miniature high frequency magnetometer (HFM) providing relative vector magnetic values in the 0.01 kHz-10 kHz range with very low noise level (see Box 6). Further down the boom (or on the body of the satellite) to complement the MAM high frequency scalar values.
- A cubestat multi-needle Langmuir probe m-NLP, providing 1 kHz at 1 Hz, the localization of which remains to be finalized (see Box 7).
- Available cubestat dual frequency GPS.

Need for ACOS:

- Gravity gradient stabilization solution could be used, with a 2 m long deployable boom (see Box 6).
- Propulsion only for initial phase and basic orbit maintenance (low risk for orbit control), aiming at 3 years lifetime.
- Minimum attitude control for initial detumbling and rough attitude requirements (avoiding significant spinning).

High frequency HMF and m-NLP

A miniature high frequency vector Magnetometer (HFM) developed by CEA-LETI for MagnetoEncephaloGraphy (MEG) medical applications, can be adapted to provide complementary very low noise 1 kHz (relative) vector field measurements.

A needle Langmuir Probe (m-NLP) concept by University of Oslo, already flown on the NORSAT-1 cubestat (Hsang et al., 2018) could be used to provide 1 kHz electron density data.

Local time provided by orbits on days 1, 9, 18 and 27. Imaging the full LT coverage a ±125 km orbit module orbit would provide in 3 days:

- Such a constellation launched before decommissioning of Swarm would help improve:
- Temporal resolution of isonospheric Sq field models (monthly).
- Temporal resolution of core field secular variation and acceleration (sub-annual).
- Isonospheric field models (removing North-South biases), investigations of currents induced in the solid Earth, and currents produced by oceanic circulation, investigations of instabilities, current paths in the ionosphere at equatorial and non-equatorial latitudes, investigations of ELF lightning induced whislers.

The Full IUGG 2019 conference programme can be found at the IUGG2019 website http://iugg2019montreal.com/