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Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "In-orbit results of the Coupled Dark State Magnetometer aboard the China Seismo-Electromagnetic Satellite" *by* Andreas Pollinger et al.

Anonymous Referee #2

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Contents

1 General

- The paper investigates on the in-flight performance of the Coupled Dark State Magnetometer, a payload on the China Seismo-Electromagnetic Satellite (CSES, launched in 2018) forming together with the FGM magnetometer part the HPM instrument package.
- The paper is a follow-on paper of the pre-flight descriptions in Pollinger et al. 2018. This update with an extended view on the in-flight behaviour of the instrument and it's quirks may well fit into the scope of the journal. It is an thorough analysis of the specific features of the CDSM instrument layout under the flight conditions, even with a limited data subset, and discusses the correctable errors as well as it tries to quantify the unexplained and uncorrectable ones.

  This may be useful to know for the community, in particular for later users of the CSES magnetic field data products – if such products get openly distributed.

2 Comments

- Even an extended part of the paper is presenting detailed analysis of the partly predictable variation of the satellite, i.e. orbit-dependence parameters as the temperature of the various instrument parts on the detuning effects, a conclusion, if the uncertainties and features found are limiting the CDSM's success in the instrument package as an reliable reference for the scalar in-flight calibration required for the HPM fluxgate magnetometer usability is not mentioned.
- Page 3, figure 2 and line 63:

  Is this truncation an idiosyncratic limitation specific to the CDSM, driven by a specific sensitivity, or is this a limitation to the whole HDM instrument package, so

the FGM sensors as well? A hint (or a little figure of an example) describing the type of interferences may be useful. Is it a limitation caused by high gradients or caused by a specific noise from the satellite itself? Mere rotations or attitude jitters itself should not affect the readings of a scalar field experiment.

- On several places in the paper it is mentioned, that the phenomenon `is still under investigation` or similar. Are there some ideas already on the market (for example large local gradients or high frequent satellite signals)? What is already ruled out?

- Page 5, line 106: `These seven samples are averaged and serve as 1 Hz raw data of the CDSM instrument.`:

  And how is the timestamp for this fraction calculated and set? Is it not a kind of challenge to align a patchy, *spotlight*-averaged value like this with other (presumably) *continuously* sampled and presumably averaged or filtered readings?

- Line 164: I assume, all three vector magnetometers are already calibrated beforehand?

- Page 8, line 166, `while the interference of FGM 1 is weak enough to be ignored`:

  What is the threshold or criterion of being irrelevant?

- Page 10, line 186, `where xsat is the flight direction and zsat points to the centre of Earth.`

  Because the *nominal* flight direction and the *true* flight direction may differ (as a function of the attitude control system) and in contrast to the explicit description 'is the flight direction', I assume x_{sat} is still a satellite fix direction. Please clarify.

- Page 11, line 199 `These residuals are dominated by a magnetospheric ring-current distribution, which is not included in the CHAOS model and...`:

  This may be just a misleading wording, as 'distribution' presumably should point here to a second order effect. The tool, freely available to forward calculate `CHAOS` vectors as function of time and position, is very well able to supply estimates of the external field contribution and also describing the ring-current field. There is a dedicated `RC`-time-series-index file, used to parametrise the ring-current part of the external field contribution. But of course, not all possible external field contributions can be covered by such a model, there are asymmetric or imperfectly modelled, also induced constituents, local field aligned currents, ionospheric bubbles or the equatorial electrojet at low latitudes. The recipe itself, to look at 'medium' latitudes and to keep aloof of both, the equatorial and the polar region, around +- 35 degree, is good, nevertheless.

- Page 13, line 227: `For the analysis in this section data from 342 orbit segments between 17-28 November 2018 and 12-18 December 2018 was available.`:

  The idiosyncratic fact, that data over China were not available is already a little bit awkward, but is the covered (not even contiguous) time period limitation driven by technical or quality reasons (for example first successfully processed, lowest activity, most complete time coverage) or caused by *other* constraints? I would naively guess, a hardware supplier would have full access to the raw data frames starting somewhere during the engineering phase of a satellite mission.

- Page 13, ff, all section 3.2: There are a few occasions of the phrase `the entire data set`; and even it is early in the section clearly stated, that the data set in focus is a very limited subset, this should be reminded (i.e. by using `in the entire subset`).

- Page 13, ff, all section 3.2. The section is quite long and partly jumps from the inspection of the in-flight data (sub-)set on one hand to results using flight spare parts on ground calibrations on the other hand and back. I suggest to introduce suitable subsections guiding orientation, for example one for the sensor temperature, one for the PCB temperature, and so on, finally a subsection for the paragraphs which are discussing the final, partly currently uncorrectable, integrated uncertainties.

- Page 21, line 385 ff.:

  The sensor angle dependency, a view from inside the sensor system, is also a dependency driven by the orbit period and position of the satellite, in particular in magnetic dipole coordinates (depending also on the mounted sensor orientation relative to the local S/C system). Please, to illustrate if there is spatial systematic error distribution (which may affect the scientific exploitation or may be the usability for in-flight-calibration purposes), consider to add a map of the accumulated error in magnetic coordinates for some (or all) available orbits. That may give an idea of possible pitfalls for a scientific interpretation.

- All explicit references in the paper to the Swarm satellite are using the all capital word SWARM. But the ESA mission name itself is not an abbreviation, so all occasions should be changed to Swarm.

- I'm also curious indeed to read about the technical strategies to overcome the described inherent error sources, but I well understand that it may be to early to reveal them to the public *here and now*.

3 Minor Remarks

- First I agree with anonymous referee #1 on the need for a consistent use of the word data and the correction of the subsequent typos in his or her comments.

- Page 4, line 75: After the polarizer in the sensor unit...:

  Being not a native english speaker, I found the sentence with After confusing, I would prefer a spatial order (like Behind...). What about something like With the polarizer passed...?

- Page 12, line 225, These deviations from the CHAOS-6 model and the SWARM data...:

  The Reference of These seems a bit unclear to me: only the latter deviations or all the ones mentioned in this paragraph?

- Page 20, figure 18:

  While blue and red give a good contrast (the colors should be a bit brighter and less saturated in combination with black in all affected figures...), the choice of orange and brown results not in an easily readable figure (at least not without the ability to zoom in – so at least not on a paper print...).

- Page 25, line 471, Data availability: The missing availability of the data may limiting the interest in the paper a bit – in particular as it seems not be mentioned in this paper, if the scalar readings were finally useful to inflight-calibrate the FGM vector magnetic field readings. If any further information about the fate of the data is available, please update.

- Page 26, in References, line 507: Private conversation:

  The common phrase seems to be Private communication.

4 Recommendations

- I vote for a minor revision, as some of the suggested modifications are somewhat minor (i.e. figures and colors) or just additions (figure of an example of a geographical/geomagnetic mapping of the errors) – or covered just by adding more verbosity about the data policy and the data used, and about the impact of the findings to the role of the `CDSM` in the `HPM` package.
- If there are news about the situation on the `Data availibilty` meanwhile, this entry should be updated.