Comparison of scalar magnetic field data of CSES, MSS and Swarm satellites

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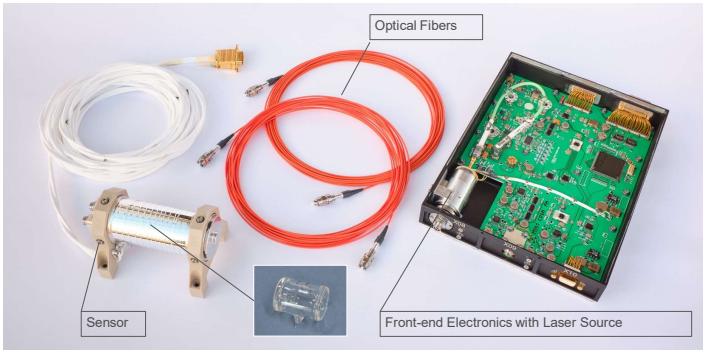
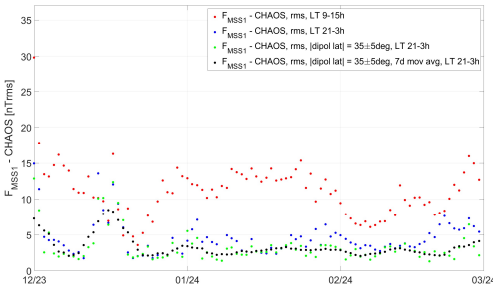
ABSTRACT

The Coupled Dart States Magnetometer (CDSM) is a quantum-optical, scalar magnetometer, whose sensor and near sensor electronics have been developed by the Austrian Space Research Institute in close cooperation with the University of Technology Graz. It has been successfully launched on the China Seismo-Electromagnetic Satellite 1 (CSES 1) in February 2018 and Macao Science Satellite 1 (MSS 1) in May 2023. The former is on a polar, sun-synchronous, low Earth orbit with an altitude of about 500 km while the latter has a nearly circular orbit with an inclination of 41 degree and an altitude of about 450 km. We compare the scalar magnetic field data of both CDSMs to the scalar data on the Swarm satellites. A special emphasis is placed on the times the satellites are close to each other with a distance of less than 250 km, as it allows us to correlate the measurements in a straightforward manner. [1][2][3]



Flight model of the Coupled Dark State Magnetometer aboard Macau Science Satellite 1

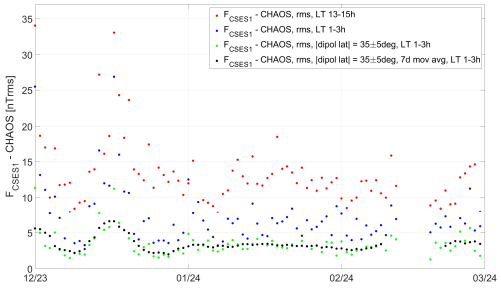
MSS 1 AND CSES 1 COMPARED TO THE CHAOS MODEL



The data of both missions (MSS 1 left and CSES 1 right) show a good agreement with the CHAOS model.

In both plots you can see the increased solar activity during the middle of December because the data is not reduced to low kp index.

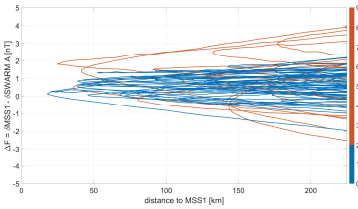
The averaged difference is about 3 nT for dipolar latitudes around 35 deg.



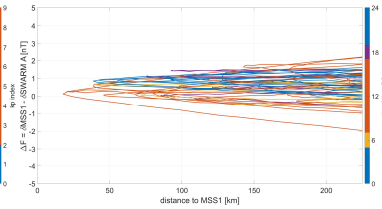
MSS 1 CLOSE APPROACHES TO CSES 1 AND SWARM

Due to its orbit, MSS 1 has several close approaches (CA) to the other satellites per month. Data (CDSM; MAGx_LR_1B) between 1.12.2023 and 29.2.2024 was analysed. Below, the Swarm A comparison is shown in full as well selected plots for Swarm B and CSES 1. More plots, especially for all Swarm satellites using the VFM data, can be found by scanning the QR-code.

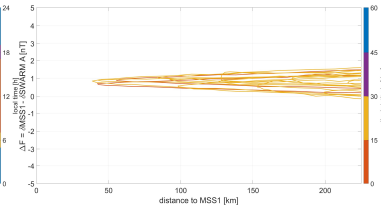
In the following plots, ΔF was calculated by subtracting $\delta SAT = F_{SAT} - CHAOS$ from $\delta MSS1 = F_{MSS1} - CHAOS$.



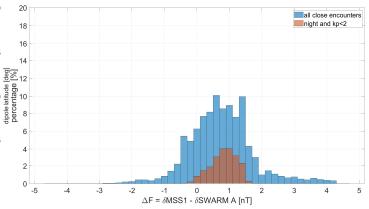
All Swarm A CA including data with high kp index



Swarm A CA with kp<2 and coloured local time

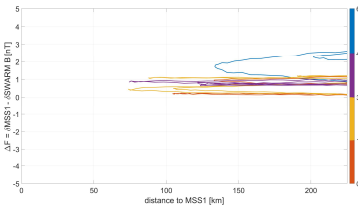


Swarm A CA with kp<2 & night side & coloured dipolar latitude

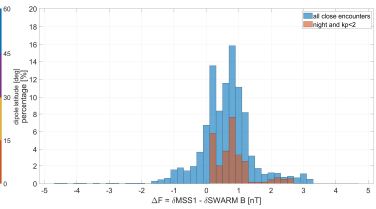


Histogram of all Swarm A CA as well as of a reduced data set with kp<2 & night side

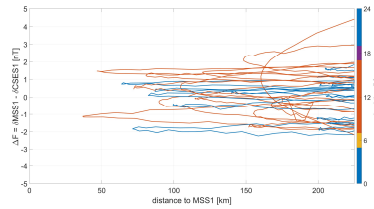
For Swarm A there were 60 evaluable approaches during the 3 month period. As expected, solar activity clearly leads to a bigger spread in the distribution. For nightside and kp index < 2 there is one consistent "cone", which is offset from zero by about 1 nT. A very similar offset is seen if the MSS 1 data is compared to Swarm B and Swarm C. Therefore, the reason is either MSS 1 or methodical.



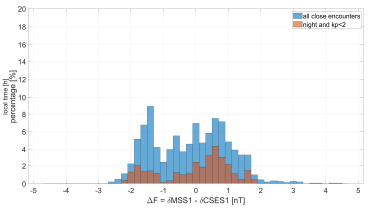
Swarm B CA with kp<2 & night side & coloured dipolar latitude



Histogram of all Swarm B CA as well as of a reduced data set with kp<2 & night side



CSES 1 CA kp<2 with kp<2 and coloured local time



Histogram of all CSES 1 CA as well as of a reduced data set with kp<2 & night side

For Swarm B there were 45 evaluable approaches during the 3 month period. In contrast to Swarm A the lines are mostly flat, but the offset is very similar. For higher dipolar latitudes the ΔF becomes larger. The comparison doesn't look as consistent as for Swarm A.

For CSES 1 there were 47 evaluable approaches during the 3 month period. As can be seen in the histogram there are two distinct distributions in the data, while there is only one for all other satellites. Thus, the feature has to be caused by CSES 1.

ACKNOWLEDGEMENT

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SUMMARY

- The CDSM on CSES 1 and MSS 1 are in good agreement with the CHAOS model.
- At closest approach, the ΔF between MSS 1 and Swarm is usually below 2nT, but it has a positive offset. The comparison with Swarm A shows the best result.
- The CSES 1 comparison shows two distinct distributions and in general the results are further apart.

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