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Comment on angeo-2021-59

Anonymous Referee #2

Referee comment on "Reconstruction of Mercury's internal magnetic field beyond the octupole" by Simon Toepfer et al., Ann. Geophys. Discuss.,
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The manuscript "Reconstruction of Mercury's internal magnetic field beyond the octupole" by S. Toepfer and co-authors provides an interesting comparison between different inversion methods to reconstruct the internal magnetic field of Mercury. They used a hybrid plasma code to simulate Mercury's magnetosphere, then they applied different methods to evaluate the "a priori" known coefficients. I think that the manuscript is a valuable contribution, especially for the BepiColombo community but not only. Indeed, these findings could be widely expanded to different environments, as well as, a similar methodological framework is a valuable support to any planetary mission. Furthermore, the manuscript is clear, well written, well organized, and well posed in terms of the existing literature. I would only suggest some improvements for the benefit of the reader as well as to assess their results.

- I would recommend the authors to add errors on their coefficients' estimations as reported in Tables 1 and 2. Since both tables contains the main results of the paper, adding errors could improve the clarity of the results.
- I would suggest the authors to comment on confidence intervals changes in their estimations under different solar wind conditions. Are they related to some specific solar wind parameters, apart the interplanetary magnetic field? I was wondering on plasma parameters like the Mach number(s) or the plasma beta. It would be nice to estimate coefficients under two/three different solar wind conditions or to add a few lines on this aspect.
- Another possible interesting aspect to be mentioned could be the role of considering different harmonics degrees in terms of both l and m . Could the authors comment on the expected changes as a function of m and l ?
- I would suggest to add a few details on some specifics on the inversion models (noise, grid size, resolutions, ...) for clarity.
- In light of the application of inversion methods to BepiColombo data, I would ask the authors to comment on the following aspect. The authors will use the model on magnetic field time series when MPO will explore different regions on the Hermean environment. I was wondering how the fast temporal variability of the Hermean environment as well as that of the different regions could affect the inversion methods

used. Could this be considered as a "noise" for the method? Should be useful to firstly apply some filtering procedures on magnetic field data to remove the short-term variability and then apply the inversion method to the large-scale variability of MAG measurements? Could be some mixing between temporal and spatial scales that could affect the model performances?