GETTING READY FOR BEPICOLOMBO: A MODELING APPROACH TO INFER THE SOLAR WIND PLASMA PARAMETERS UPSTREAM OF MERCURY FROM MAGNETIC FIELD OBSERVATIONS.
S. Fatemi1, N. Poirier2, M. Holmström1, J. Lindkvist1, M. Wieser1, S. Barabash1, 1Swedish Institute of Space Physics (shahab@irf.se), 2École Nationale Supérieure de Mécanique et d’Aérotechnique, Chasseneuil-du-Poitou, France, 3Department of Physics, Umeå University, Umeå, Sweden.

Introduction: The lack of an upstream solar wind plasma monitor when a spacecraft is inside the highly dynamic magnetosphere of Mercury limits interpretations of observed magnetospheric phenomena and their correlations with upstream solar wind variations. A detailed and accurate knowledge about the solar wind plasma and its variations as it interacts with Mercury is crucial to better understand the morphology of the interaction, structure of the magnetosphere of Mercury, and its associated phenomena and their correlations with solar wind variations.

Model: We use AMITIS, a three-dimensional GPU-based hybrid model of plasma (particle ions and fluid electrons) [1] to infer the solar wind plasma parameters upstream of Mercury by comparing our simulation results with Messenger magnetic field observations inside the magnetosphere of Mercury. We select a few orbits of Messenger, which have been analysed and compared with simulations before. Then, we run nearly 40 simulation runs for each orbit with different solar wind plasma parameters to find the best agreement between our simulations and Messenger magnetic field observations inside Mercury’s magnetosphere.

Results: Figure 1 shows a preliminary magnetic field comparison between our hybrid simulations (red lines), Messenger magnetometer observations (black lines), and the undisturbed intrinsic magnetic dipole of Mercury (blue dashed lines) along the trajectory of Messenger on 23 April 2011 (DOY 113) between 16:00 and 21:00 UTC. Our model estimated solar wind dynamic pressure for this orbit is ~3 nPa, which is lower than the typical solar wind dynamic pressure at the orbit of Mercury (~7 nPa). However, Figure 1 shows that there is a good agreement between our hybrid simulation results and Messenger magnetic field observations for the estimated solar wind plasma parameters upstream of Mercury [2]. We also use our model to determine the location of the magnetospheric boundaries, i.e. bow shock, magnetopause, and magnetotail, and their correlations and variations with the solar wind plasma and compare them with those previously estimated from observations [2].

Conclusion: We show that our model can be used as an upstream solar wind plasma monitor for Mercury to provide estimates of the solar wind variations from magnetic field observations inside Mercury’s magnetosphere. These results have important implications for observations by Messenger, and for the future ESA/JAXA mission to Mercury, BepiColombo [2].

Figure 1. (a,d) Magnetic field comparison between our hybrid model simulations (red lines), Messenger magnetometer observations (black lines), and undisturbed intrinsic magnetic dipole of Mercury (blue dashed lines) along the trajectory of Messenger on 23 April 2011. (e) Magnitude of the electric current density, and (f) solar wind bulk flow speed normalized to the upstream solar wind speed 314 km/s (purple line) and solar wind plasma density normalized to the upstream plasma density 22 cm\(^{-3}\) obtained from our hybrid model simulations along the trajectory of Messenger. The location of the bow shock (BS) and magnetopause (MP) boundaries estimated by Winslow et al., 2013 [3] are shown by the vertical lines.

References