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A modeling approach to infer the solar wind plasma parameters upstream of Mercury based on magnetic field observations

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We use AMITIS, a three-dimensional GPU-based hybrid model of plasma (particle ions and fluid electrons) 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. 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 phenomenon and their correlations with upstream solar wind variations. We select a few orbits of MESSENGER, which have been already analyzed 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. We show that there is a good agreement between our hybrid simulation results and MESSENGER observations for the estimated solar wind plasma parameters upstream of Mercury. 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. We investigate if our model can be used as an upstream solar wind plasma monitor for Mercury to provide estimates for the solar wind variations based on magnetic field observations inside Mercury's magnetosphere. These results have important implications for MESSENGER, and for the future ESA/JAXA mission to Mercury, BepiColombo.