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MESSENGER observations and global simulations of highly compressed magnetosphere events at Mercury

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We identify and examine all MESSENGER crossings of Mercury's dayside magnetopause with magnetospheric field intensities $>=$ 300 nT. The 8 such events, which occurred under highly compressed magnetosphere (HCM) conditions, are analyzed in the identical manner utilized by Slavin et al. (2014). The results suggest that the 8 HCM events represent the highest solar wind dynamic pressures for which the MESSENGER's orbit still passed below the magnetopause and provided measurements of the dayside magnetosphere. Using the magnetohydrodynamic model by Jia et al. (2015) that electromagnetically couples Mercury's interior with its magnetosphere, a series of global simulations are conducted to quantitatively characterize the response of Mercury's magnetosphere to solar wind forcing. Combining the MESSENGER observations with the simulations, we have obtained a consistent picture of how Mercury's dayside magnetospheric configuration is controlled, separately and in combination, by induction-driven shielding and reconnection-driven erosion. For solar wind pressures of $\sim$ 40-90 nPa, compared with the average $\sim$ 10-15 nPa at Mercury's orbit, the shielding events of induction in Mercury's core in standing-off the solar wind typically exceeds the erosion of the dayside magnetosphere due to reconnection for these events, most of which occurred under low magnetic shear conditions. For high magnetic shear across the magnetopause our simulation predicts that reconnection would dominate. Mercury's effective magnetic moment as inferred from magnetopause stand-off distance ranges from 170 to 250 nT-R_M^3 for these events. These findings, presented in Jia et al. (2019, JGR), are of crucial importance for understanding the space weathering at Mercury and its contribution to the generation of Mercury's exosphere.