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Magnetic fields and electric currents around the dayside magnetopause as inferred from large sets of in situ data

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Based on a new mathematical framework and large multi-year pool of satellite data, we reconstruct the magnetic field and electric currents around the dayside magnetopause, as well as their dependence on the IMF, solar wind pressure, and the Earth's dipole tilt. The model is based on representing the magnetosheath and adjacent outer magnetosphere by two separate blocks with essentially different architectures and responses to external drivers. The magnetosheath magnetic field is modeled by a sum of toroidal and poloidal components, each expanded into spherical harmonic series of angular coordinates and powers of the normal distance from the boundary. The outer magnetosphere is represented by a dipole field of variable magnitude confined within a best-fit magnetopause, whose shape, size, and solar wind/IMF control are concurrently derived from in situ magnetometer data. The spacecraft database covers the period from 1995 through 2022 and is composed of data from Geotail, Cluster, Themis, and MMS, with the total number of 1-minute averages about ~2.5M. The modeling reveals orderly patterns of the magnetopause currents and normal field component, controlled by the IMF orientation, solar wind ram pressure, and the Earth's dipole tilt angle. The obtained results are discussed in terms of the magnetosheath magnetic flux pile-up and the subsolar magnetosphere erosion during periods of northward or southward IMF, respectively.