Identifying Terrestrial Magnetospheric Topology using Geodesic Level Set

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The present report introduces a numerical method to identify and visualize the geometrical structure of the earth magnetic field topology with a northward interplanetary magnetic field (IMF) from a 3D global MHD (Magneto-Hydro-Dynamic) simulation. The two-dimensional and one-dimensional stable or unstable manifolds, respectively, are generated from the critical points (CPs) or magnetic nulls obtained in the 3D MHD simulation data using Geodesic Level Set (GLS) method. The Boundary Value Problem (BVP) is solved numerically to forward the next geodesic level set from the current one. These geodesic level sets are placed on the magnetic manifold that determine the magnetic field topology. In the present paper, we introduce: (1) We implement an efficient bisection method applied to BVP to reduce the computation of integrations to avoid computing all subdivided trajectories decided by greater boundaries, which save computation time, significantly; (2) A necessary and reliable method to integrate the shorter trajectory with higher accuracy by a time-reversed 4th order Runge-Kuta method; and (3) a method to prevent the sharp folding angle generated by adjacent mesh that disrupts GLS algorithm. We visualize the separatrices that are the the two magnetic manifolds generated from two CPs or magnetic nulls, and the magnetic topology of the earth magnetosphere in the 3D global MHD simulation.

Keywords: Geodesic Level Set Method, saddle connection topology, Terrestrial Magnetospheric Topology

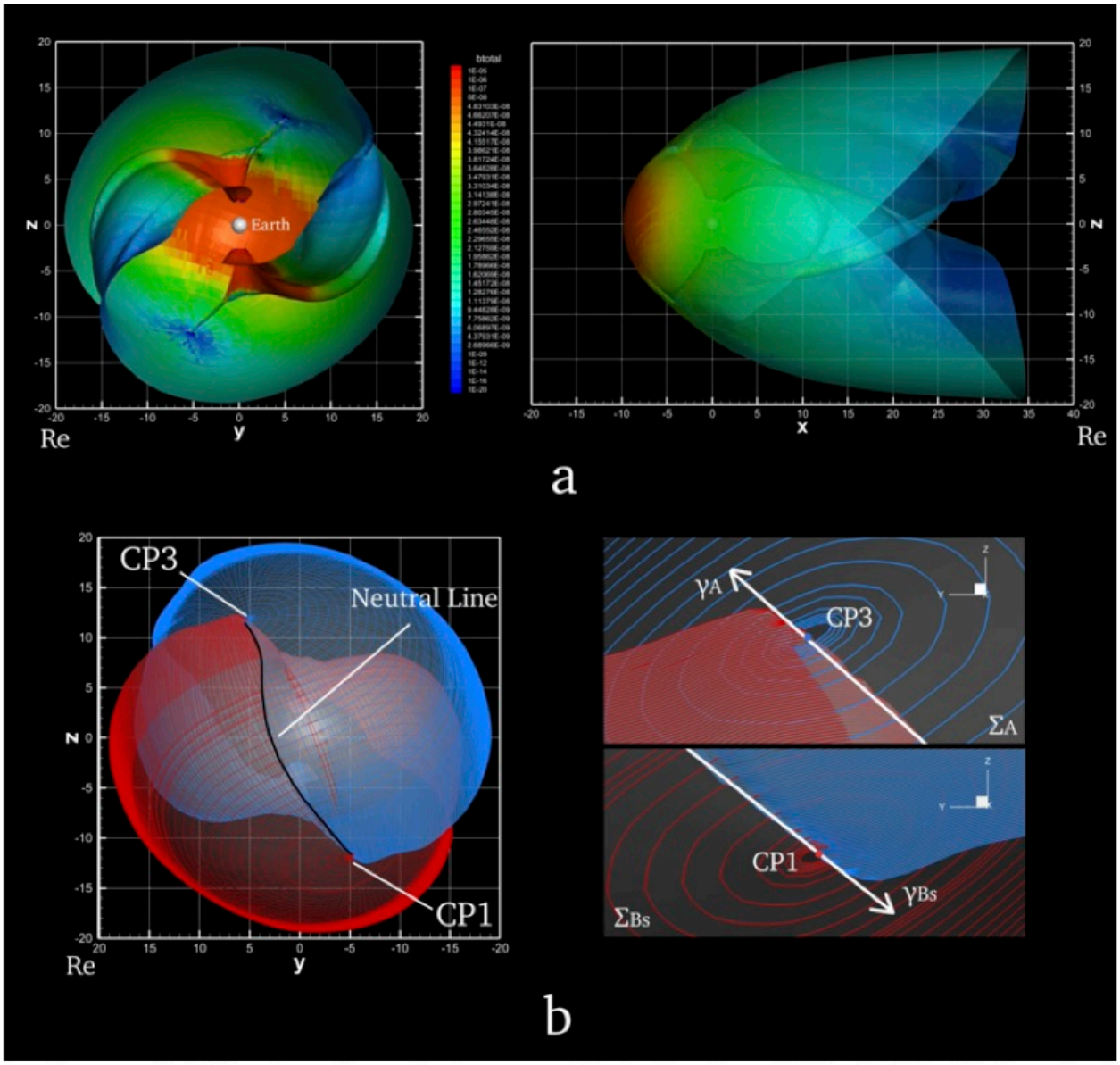

Figure: The magnetic field topology of magnetosphere emerged by the Σ-surfaces of CP1 and CP3 in full data scale. a) the view from the magnetotail that projected into y-z plane on the left, and the view projected into x-z plane on the right, the sun is located in -x. b) the view of the neutral line projected into y-z plane on the left, and the enlarged view in the vicinity of CP1 and CP3 on the right.

