3-D MHD Model of the Sun-Solar Wind System

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We have developed a 3-D MHD simulation model of the solar surface–solar wind system. We report the construction method of the model and its results.

By implementing a grid system with angularly unstructured and increasing radial spacing, we realized a spherical grid that have no pole singularity and realized a fine grid size around the inner boundary and a wide-range grid up to a size of 1 AU simultaneously. The magnetic field at the inner boundary is specified by the observational data. In order to obtain the supersonic solar wind speed, parameterized source functions are introduced into the momentum and energy equations. These source functions decay exponentially in altitude as widely used in previous studies. The absolute values of the source functions are increased inside the magnetic flux tube with sub-radial expansion and reduced inside the magnetic flux tube with over-radial expansion. This adjustment aims to reproduce the variation of the solar wind speed according to the coronal magnetic structure.

The simulation simultaneously reproduces the plasma-exit structure, the high- and low-temperature regions, the open and closed magnetic field regions in the corona, the fast and slow solar wind, and the sector structure in interplanetary space. It is confirmed from the comparison with observations that the MHD model successfully reproduces many features of both the fine solar coronal structure and the global solar wind structure.

With the further improvement and refinement, the model will be applied to the integrated space weather simulation system being developed at NiCT (National Institute of Information and Communication Technology), Japan.

Keywords: solar wind; MHD simulation; expansion factor; space weather.