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Physics-based validation of global MHD models

Therese Moretto Jorgensen (1), Michael Hesse (1), Masha Kuznetsova (2), Lutz Rastaetter (2), Susanne Vennerstrøm (3), and Paul Tenfjord (1)

(1) Birkeland Center for Space Science, University of Bergen, Bergen, Norway (therese.jorgensen@uib.no), (2) NASA GSFC, Greenbelt, MD, USA (maria.m.kuznetsova@nasa.gov), (3) Danish Technical University, Lyngby, Denmark (sv@space.dtu.dk)

Global MHD models constitute a unique tool for developing a forecast capability for space weather effects in the near-Earth space environment. In combination with modules for the ionosphere, inner magnetosphere, and radiation belts they offer a comprehensive, physical description of the morphology and dynamics of the coupled solar wind-magnetosphere-ionosphere system. Several such solutions have been developed over the last decades. Their further advancement is key to improving space weather forecasting accuracy and lead times. It is unlikely that skill score comparisons alone will provide sufficient guidance for this development. Scientific evaluations and comparisons are needed in addition.

Here we present the results of carrying out a physics-based evaluation and comparison of four different global MHD models available for runs-on-request at the Community Coordinated Modeling Center (CCMC). One condition that model simulations should meet, in the absence of parallel electric fields, is that ionospheric footprints of closed field-lines are at the same potential in the two hemispheres. How well this condition is met by global MHD models relates to understanding how well models represent the ionospheric potential and symmetries or asymmetries thereof. Dipole tilt and a significant east-west component in the interplanetary magnetic field are both examples of effects that create complex potential patterns in the ionosphere with large differences and asymmetries between the northern and southern hemispheres. The degree to which these are reproduced correctly in the models is an important open question. We report here on an investigation of the extent and comparison of the equal potential-condition between the four global MHD models and discuss its possible implication for answering this larger question.