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Quantitative Evaluation of Solar Wind Prediction Model ”SUSANOO-SW” by Comparison with in-situ Measurements

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The solar wind disturbance is one of the most important elements in the space weather. The space weather forecast is the attempt of predicting the disturbance before arrival at the earth. At present, in the most reliable prediction, we usually use in situ solar wind observations by space probes, locating in front of the earth, like the Advanced Composition Explorer (ACE). However, we can get the leading time about only 1 hour for which the solar wind propagates through the ACE-Earth distance because we cannot know the information of the solar wind before arrival at the ACE position by using only this method. Accordingly, magnetohydrodynamics (MHD) simulation enable to predict the further future solar wind.

In recent years, our group have developed a space weather prediction model: SUSANOO (Space-weather-forecast-Usable System Anchored by Numerical Operations and Observations), which can predict fluctuation of high-energy electrons in the radiation belt based on minimal input, real-time observation of the solar photospheric magnetic field. SUSANOO’s solar wind model (SUSANOO-SW) [Shiota et al. (2014)] is the MHD simulation reproducing three-dimension structure of solar wind in the inner heliosphere with magnetic field model and empirical model for the solar surface magnetic field data. The calculated time profiles of solar wind velocity and interplanetary magnetic field (IMF) at positions of planets agreed with observed ones in solar minimum (2007 - 2009): the correlation coefficients of one-year time profiles of velocity and IMF ranges 0.54 - 0.73 and 0.40 - 0.58, respectively [Shiota et al. (2014)]. It can be interpreted that this model can reproduce well the global structure of the solar wind. However, when we focused on shorter time scale variation (period of one rotation), often see some disagreements. The cause of these disagreements can be included in the setting of the inner condition of SUSANOO-SW. Its improvement is needed for practical forecast.

In this research, we performed the SUSANOO-SW for a period from the solar minimum to the solar maximum (2007 - 2014). We evaluated the capability of the model by their comparison with in situ measurements in the following criteria: (1) the correlation coefficient of the velocity fluctuation for each Carrington Rotation (CR), (2) the percentage of agreement of velocity and magnetic field: (2-a) polarity of magnetic field, (2-b) velocity difference, (2-c) the sign of dv / dt. In the evaluation (2), we judged agreement by the hour and then we calculated the percentage of the agreement. As a result, the correlation coefficients are greater than 0.5 in CRs of 42.5%. The percentage of ’YES’ for each criterion in evaluation (2) is larger than that of ’NO.’ According to the results, we examined how the inner boundary condition on the timing of the disagreements with observation, and discuss possible improvement of the models for the inner boundary conditions.

Keywords: solar wind, space weather, MHD