Study of the solar wind influence on the Jovian inner magnetosphere using an ionospheric potential solver

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The solar wind hardly influences the plasma convection in the Jovian inner magnetosphere, because the corotation of magnetospheric plasma dominates the convection there. However, the extreme ultraviolet spectroscope (EXCEED) onboard the Hisaki satellite observed that the brightness distribution of the Io plasma torus (IPT) changed asymmetrically between the dawn and the dusk sides. Furthermore, it was confirmed that this asymmetric change coincided with a rapid increase in the solar wind dynamic pressure. This asymmetric change can be explained by the existence of a dawn-to-dusk electric field of ~4-9 [mV/m] around Io's orbit [Murakami et al., 2016]. The dawn-to-dusk electric field shifts the position of IPT toward dawn side. The plasma in the torus is heated adiabatically at dusk and cooled at dawn. The following processes generated by the solar wind interaction have been suggested as a possible cause of the electric field. First, the solar wind compresses the Jovian magnetosphere. Then, the magnetosphere-ionosphere coupling current system is modified, and the field-aligned current (FAC) at the high-latitude ionosphere increases. As a result, the ionospheric electric field increases and penetrates to low-latitude regions. It is mapped to the equatorial plane of the magnetosphere along the magnetic field line, and the dawn-to-dusk electric field is created in the vicinity of Io's orbit (~6 R_J) in the inner magnetosphere. Here the distribution and density of the FAC was observationally estimated from the divergence of the ring current on the equatorial plane using the Galileo spacecraft data [Khurana, 2001].

We have constructed a 2-D ionospheric potential solver in order to demonstrate this scenario quantitatively. We investigate how the global distribution of the ionospheric potential changes responding to the input of the FAC using the potential solver. We use the intensity of the total FAC obtained from the Galileo observation [Khurana, 2001] and adopt a Gaussian function for its horizontal distribution in a similar way to the Earth's modeling. Also, we model the ionospheric conductivities from the collision frequencies, the cyclotron frequencies of charged particles and the density distribution in the Jovian upper atmosphere. We deduce the collision frequencies from ion-H_2 and electron-H_2 collisions [Tao, 2009]. We need to use more accurate global distributions of the conductivities because the dawn-to-dusk electric field of at Io's orbit strongly depends on the spatial distributions of the ionospheric conductivities. The limited area of the ionosphere was observed by Galileo and Voyager, therefore we use a Jovian thermosphere-ionosphere-magnetoshere coupling model [Tao et al., 2014] to obtain the global thermospheric and ionospheric distributions of the density and the temperature in this study. The model considers heating caused by the precipitation of aurora electrons and provides the distributions of the conductivities around the footprint of FACs.

We calculate the Jovian electric potential distribution and the magnetospheric dawn-to-dusk electric field for the aforementioned FAC and conductivity distributions. We assume that the plasma of the IPT flow along the equipotential lines. Under this assumption, we estimate the dawnward shift of the equipotential lines which results from the dawn-to-dusk electric field and the corotation field, and the dawn-to-dusk ratio of plasma brightness. The estimated values are compared with the Hisaki observations in order to evaluate the validity of the above scenario. We will present these results.

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