Axisymmetric conductivities of Jupiter's middle- and low-latitude ionosphere

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Ionospheric Hall and Pedersen conductivities are important parameters in determining the electric potential distribution and plasma convection in a magnetosphere-ionosphere system. At Jupiter, meteoric ions deposited by meteoroid ablation are expected to play a major role in the ionospheric conductivities [e.g., Cloutier et al., 1978]. Hall and Pedersen conductivities are expected to be axisymmetric at Jupiter due to the long lifetime of meteoric ions. This study evaluates the modification of the potential distribution and plasma convection in the inner magnetosphere caused by the axisymmetric ionospheric conductivities at Jupiter.

We have developed a photochemical model and an ionospheric potential solver to evaluate the contributions of meteoric ions to the Jovian ionospheric conductivities and dawn-to-dusk electric field in the inner magnetosphere. Our photochemical model includes chemical reactions taken from Kim et al. [1994, 2001], mass deposition of meteoric atoms and ions by meteoroid ablation, ionizations by precipitating electrons, and ambipolar diffusion of ions. The input parameters of field-aligned currents are taken from the Region 2-like current in Khurana [2001] and axisymmetric Hill current. Our ionospheric potential solver has been developed using the methods in Nakamizo et al. [2012]. We calculate the global distribution of ionospheric conductivities using ion and electron density profiles acquired from the photochemical model. The ionospheric potential distribution and the resulting dawn-to-dusk electric field in the inner magnetosphere are obtained by the ionospheric potential solver.

Our simulation results reveal that the largest contributions to the Hall and Pedersen conductivities occur in the meteoric ion layer, and the resulting height-integrated conductivities are axisymmetric in the middle- and low- latitudes. Meteoric ions dominate the ion densities in the altitude region of 350 - 450 km with a peak electron number density of ~10^{11} [m^{-3}]. The obtained electron density profile is almost constant at any local time in the middle- and low-latitudes because the lifetimes of H^+ in the high altitude and meteoric ions in the lower altitude ionosphere are sufficiently longer than the half Jovian day (~ 5h). The ionospheric conductivities reach their maxima at the meteoric ion layer, and the height-integrated Hall and Pedersen conductivities become axisymmetric in the middle- and low- latitudes. At high

latitudes, the conductance are enhanced at dawn side associated with the Region 2-like upward field-aligned current. The dawn-to-dusk electric field generated in the inner magnetosphere is 4 - 27 [mV/m] around Io’s orbit. For comparison, we model another case of ionosphere without H^+ and meteoric ions. In this case, the ionospheric conductance are entirely smaller than the former case, and diminished at night side. The resulting dawn-to-dusk electric field is 45 - 270 [mV/m] around Io’s orbit in this case.

In order to evaluate the validity of our results, we compare our results to observations. Observations by the Hisaki satellite revealed that the variation of dawn-to-dusk brightness intensity ratio of Io plasma torus coincided with a rapid increase in the solar wind dynamic pressure. The correlation between them 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]. Our model results are almost consistent with the Hisaki observations in the case of the existence of meteoric ions in the lower ionosphere. It is concluded that the existence of meteoric ions in the lower ionosphere causes the axisymmetric enhanced ionospheric conductance at Jupiter. The large axisymmetric conductance results in the small dawn-to-dusk electric field in the inner magnetosphere, and our model results can be supported by the Hisaki observations.

キーワード：木星、流星起源のイオン、電離圏磁気圏結合
Keywords: Jupiter, Meteoric ion, M-I coupling