Local-time Variations In The Jovian System And Possible Connections To Solar Wind/Magnetosphere Interactions

Marie Devinat[1], Zhi-Yang Liu[1], Michel Blanc[1,2], Yuki Nakamura[3], Yuxian Wang[4], Sariah Al-Saati[5], Noé Clément[6], Chongjing Yuan[2], Aneesah Kamran[1], Nicolas André[1,7]

(1) Institut de Recherche en Astrophysique et Planétologie (IRAP), CNRS-University of Toulouse-CNES, Toulouse, France

(2) IGG, CAS, Beijing, China

(3) Graduate School of Science, The University of Tokyo, Tokyo, Japan

(4) State Key Laboratory of Space Weather, NSSC, CAS, Beijing, China

(5) Centre de Physique Theorique, Ecole Polytechnique, Palaiseau, France

(6) IPSL, Paris France

(7) Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-Supaero), Université de Toulouse, Toulouse, France

Many current models of plasma transport in the Jovian equatorial plasma disk (magnetodisk) consider it to be azimuthally symmetric over radial distances extending from the outer edge of the Io torus (6 Jovian radii) to about 50 Jovian radii. But there are also many pieces of evidence pointing to a local time asymmetry in this system at such radial distances, and in the upper atmosphere to which it is coupled. In the magnetosphere, similar local-time asymmetries have been detected in the thickness of the magnetodisk and in high-energy particle fluxes; observations of magnetodisk radial and azimuthal current systems show that they vary with local time, in such a way that their divergence in the disk plane feeds a system of field-aligned currents similar to the so-called Region 2 currents observed at Earth. At ionospheric altitudes, local time asymmetries are systematically observed in the main auroral emissions, and have also been observed in neutral and ion winds detected in the near infrared by Earth-based telescopes. Finally, deep in the magnetosphere, local time asymmetries have been observed during ground-based surveys of the Io torus, as well as by JAXA's Hisaki spacecraft observations which suggested they are modulated by the solar wind pressure. Many of these observed asymmetries have been interpreted as the result of a large-scale dawn-to-dusk electric field generated across the magnetospheric cavity by its interaction with the Solar Wind and which would be superimposed to the dominant corotation electric field.

Despite this many pieces of evidence, no consistent model of this electric field, its generation and its penetration to different magnetospheric radial distances and ionospheric altitudes exists yet. In this study, we attempt to fill this gap by developing a simple semi-analytical model of electric fields, plasma convection and current flows in the Jovian ionosphere and magnetosphere derived from the Earth case. We describe their variations with ionospheric colatitude and magnetospheric radial distance, as well as with longitude and time. We calculate the radial, latitudinal and local time distributions of these quantities for two particular cases, an abrupt onset of an external dawn-dusk electrostatic potential across the polar cap and a steady dawn-dusk potential, as well as various time variable forcings, based on Solar Wind observation at the location of Jupiter. We compare these cases to the observations listed above, and find that the observations fit well with a rapid forcing from the Solar Wind enabling an important penetration of the electric field inside the magnetosphere.