Latitudinal dependence of interplanetary hydrogen atom ionization rate and its solar cycle variations

Hiromu Nakagawa[1]; Hiroshi Fukunishi[1]; Shigeto Watanabe[2]; Yukihiro Takahashi[1]; Makoto Taguchi[3]

[1] Dept. of Geophysics, Tohoku Univ.; [2] Earth and Planetary Sci., Hokkaido Univ.; [3] NIPR

http://pat.geophys.tohoku.ac.jp

Since the solar wind is monitored mostly from space near the Earth, it is difficult to understand the interplanetary structure of solar wind including its latitudinal dependence. Although Ulysses spacecraft takes 10 months to scan near the Sun from the southern pole to the northern pole during its orbital period of 5-6 years, successfully detected a difference in the latitudinal dependence of solar wind velocity and density between solar minimum and maximum. However, it is still an open question how the latitudinal dependence changes from solar minimum to solar maximum.

There is a uniform flow of interplanetary hydrogen (IPH) atoms in the solar system. The distribution of IPH is sensitive to solar wind proton flux, which has a latitudinal distribution in the heliosphere, because the main ionization source of IPH is charge-exchange with solar wind protons (contributing to 80% of the total ionization rate). The most practical technique for determining the latitudinal dependence of IPH is observation of backscattering solar Lyman alpha emission at 121.6 nm.

We observed interplanetary Lyman alpha emission using Nozomi/UVS for 3 years around solar maximum phase in 23RD and SOHO/SWAN instruments for 6 years from solar minimum to solar maximum in 23RD. Using these data, we obtained a trend of the latitudinal dependence of ionization rate for the first time.

From a comparison between model calculations and observed data, higher ionization around the equator is found from 1996 to 1998. Moreover, this type of latitudinal anisotropy is found to be reduced toward solar maximum in 1999. Furthermore, an inverse latitudinal anisotropy higher ionization region at the poles than at the equator is found for the period of 2000-2001. These trends are basically consistent between UVS and SWAN, although the trend of UVS is slightly larger than that of SWAN.

Previous studies suggested that these trends are most strongly influenced by the behavior of the tilt angle of the heliographic current sheet (HCS). In this presentation, we compare the latitudinal dependence of IPH with tilt angle of HCS calculated from measurements by Wilcox Solar Observatory. We also compare our result with coronal hole period observed from interplanetary scintillation (IPS) observations by Solar Terrestrial Environment Laboratory, Nagoya University. It is found that although the tilt angle of HCS begins to decrease in 2000 and the coronal hole appears in the middle of 2001, higher ionization region at the poles continues to exist until the end of 2001.

To explain the higher ionization rate at the poles, it is necessary to investigate whether these discrepancies are due to simply delay time in the response of hydrogen atoms or other possibilities, for example, the effect of frequent coronal mass ejection (CME) occurrences around high latitude at solar maximum. The effect of proton flux from CMEs on interplanetary hydrogen distribution has not been studied yet. One of important unsolved problems is how CMEs change the large scale structure of interplanetary hydrogen distribution.