Variations of the total oxygen ion content of the Venusian ionosphere controlled by the solar wind: Hisaki and VEX observations

Kei Masunaga[1]; Naoki Terada[2]; Kanako Seki[3]; Fuminori Tsuchiya[4]; Tomoki Kimura[5]; Kazuo Yoshioka[6]; Go Murakami[7]; Masato Kagitani[8]; Atsushi Yamazaki[9]; Yoshifumi Futaana[10]; Chihiro Tao[11]; Daikou Shiota[12]; Ichiro Yoshikawa[13]

[1] STEL, Nagoya Univ.; [2] Dept. Geophys., Grad. Sch. Sci., Tohoku Univ.; [3] STEL, Nagoya Univ.; [4] Planet. Plasma Atmos. Res. Cent., Tohoku Univ.; [5] JAXA/ISAS; [6] JAXA/ISAS; [7] ISAS/JAXA; [8] PPARC, Tohoku Univ; [9] ISAS/JAXA; [10] IRF; [11] LPP, Ecole Polytechnique; [12] STEL, Nagoya Univ.; [13] EPS, Univ. of Tokyo

Due to no intrinsic magnetic field on Venus, the solar wind directly interacts with the ionosphere of Venus [e.g., Brace et al., 1980]. The direct interaction efficiently transfers eneregy of the solar wind into the ionosphere, leading a heating and energization of the content of the ionospheric plasma. It can contribute to loss of ions from Venus. Spacecraft observations have shown that solar wind conditions affect the structure of the ionosphere and the ion escape rate at Venus [e.g., Luhmann, 1986; Dubinin et al., 2011]. In-situ data provides us detailed information of local fields and particles, so that we see locally how the fields change, how the particles get energy, and how much fluxes exist. However, we need to collect much data and accumulate them to get a global structure of the ionosphere and total ion escape rate. Since the solar wind condition changes time to time and a spacecraft can fly on limited orbits, the statistical treatment may not show the real ionospheric structure and total ion escape rate. In fact, there is large uncertainty in the total ion escape rates obtained from spacecraft to date [Dubinin et al., 2011].

On Sep 14, 2013, JAXA Hisaki spacecraft was successfully launched and injected into the orbit around the Earth. Hisaki carries the EXtreme ultraviolet spectrosCope for Exsospheric Dynamics (EXCEED) [Yoshioka et al., 2013; Yoshikawa et al., 2014] to observe planets such as Venus, Mars and Jupiter. The observation of Venus was conducted during quasi-continuous 3 periods (Mar 7 to Apr 2, Apr 24 to May 23, and Jun 24 to Jul 17). The EUV spectra obtained from EXCEED has ranges within 52 - 148 nm and slit size of the EXCEED is 60” x 400” which spatially covers Venus disk and tail where the ionospheric and escaping ions exist. Therefore the remote observation of EXCEED may allow us to obtain a global structure of the ionosphere and escaping ions in the Venus tail according to the EUV emissions.

In this study, we investigate the relationship between daily variations of the O^+ emission (83.4 nm) of the Venus disk observed by EXCEED and the solar wind dynamic pressure. We use dataset from the Analyser of the Space Plasma and Energetic Atoms (ASPERA-4) aboard ESA Venus Express to get the solar wind dynamic pressure. We also use dataset of Solar EUV Experiment (SEE) on the NASA Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) mission to remove a periodic EUV variation from the EXCEED dataset shown below. The O^+ emission is mainly dominated by the photoelectron impact on O atoms at 140 km altitude and the resonant scattering also has small contribution to this emission [Gerard et al., 2011]. Because an efficiency of the resonant scattering depends on the solar EUV flux, the O^+ emission is modulated by EUV flux variations caused by the solar rotation which has a periodicity of ˜28 days. Removing the periodic variation from the original emissions by using the solar EUV flux (83.4 nm) of the SEE dataset, we found that the high dynamic pressure triggers a gradual decrease of the O^+ emissions and it lasts for 1-2 days. We suggest that this feature is attributable to changes of the ambient electron and ion populations caused by the compression of the ionosphere depending on the solar wind dynamic pressure. After the compression ceases, the ionosphere starts to recover to be back to the pre-impact level. We find that this recovery also lasts for 1-2 days. From the ion refilling rates into the ionosphere from the recovery period, we can roughly estimate upper limit of the O^+ escape rate, meaning that we can restrict the uncertainties of previously proposed O^+ escape rates for each event.

References

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