EPSC Abstracts
Vol. 5, EPSC2010-613, 2010
European Planetary Science Congress 2010

Solar forcing and plasma escape from magnetized and non-magnetized Terrestrial planets

Rickard Lundin
Swedish Institute of Space Physics, Teknikhuset, 90187, Umea, Sweden

Abstract

The solar wind and the solar XUV/EUV radiation constitute a permanent forcing of the upper atmosphere of the planets in our solar system. The forcing is essentially inversely proportional to the square of the distance to the Sun and, therefore, is most important for the innermost planets in our solar system – the Terrestrial planets. The effect of these two forcing terms is to ionize, heat, chemically modify, and slowly erode the upper atmosphere throughout the lifetime of a planet. The closer to the Sun, the more efficient are these process. Gravity constitutes the major protection mechanism for thermal escape, while the non-thermal escape caused by the ionizing X-rays and EUV radiation and the solar wind require other means of protection. Ionospheric plasma energization and ion pickup represent two categories of non-thermal escape processes that may bring matter up to high velocities, well beyond escape velocity.

Shielding the upper atmosphere of a planet against solar XUV, EUV, and solar wind forcing requires strong gravity and a strong intrinsic dipole magnetic field. For instance, the strong dipole magnetic field of the Earth provides a "magnetic umbrella", fending of the solar wind at a distance of 10 Earth radii. Conversely, the lack of a strong intrinsic magnetic field at Mars and Venus means that the solar wind has more direct access to their topside atmosphere. The induced magnetic field piling up on the frontside of the weakly magnetized planets Mars and Venus provides a feeble protection shield against ionospheric plasma erosion. The induced magnetic field in the pileup region is too weak to prohibit plasma waves, generated in the dayside sheath, from penetrating and affecting the dayside ionosphere. The strong and continuous transport of energized dayside ionospheric plasma towards the nightside from both Mars and Venus bare witness to this. An interesting question is therefore, does the crustal magnetic field "anomalies" at Mars provide a protection or not? Some statistical results on the ion outflow from Mars will be presented in this context (Fig. 1). They give no clear answer to the above question, but are nevertheless quite revealing.

Summary and Conclusions

Planetary plasma escape is a multi-faceted physical process related with e.g. the ultimate source of the atoms/molecules, upward transport, photochemistry, ionization, energization, and circulation or escape. Plasma escape is coupled with solar forcing, the escape strongly connected with solar activity, on short and long terms. Some atoms and molecules escape easier than others. For instance, we have today strong reasons to believe that the main escape products from the Terrestrial planets is hydrogen and oxygen, suggesting water as the ultimate source. On the other hand, the greenhouse gas, carbon dioxide, dominating the atmosphere at Mars and Venus, are more easily preserved on planets because of its low scale-height (rapid cooling). Atmospheric and ionospheric models and measurements are in support of this, i.e. ionized carbon atoms and molecules constitute minor species in the upper ionosphere, and, as a consequence, are less attainable for solar wind forcing.

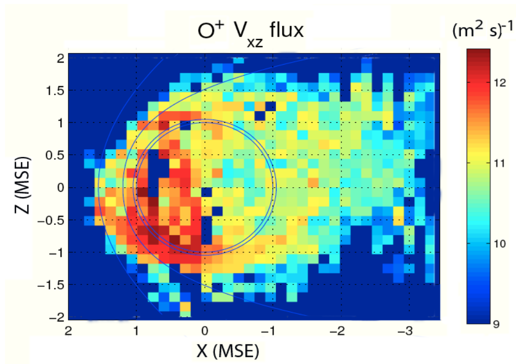

Fig. 1 O+ flow data from the ion mass analyzer on Mars Express. Average ion fluxes are binned in 500x500 km cells, here plotted in Mars solar ecliptic coordinates. X is directed to the Sun and Z directed to ecliptic north. Notice the enhanced dayside fluxes over the magnetic anomalies in the southern hemisphere.