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Earth atmospheric loss through the plasma mantle and its dependence on solar wind parameters

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Earth atmospheric loss plays an important phenomenon in the evolution of the terrestrial atmosphere on geological timescales. This phenomenon is driven by atmospheric ions, mainly oxygen ions (O^+) heated through different processes and with sufficient energy to escape the gravity, and becoming ion outflow. The outflowing ions are observed at low and high altitudes in the open magnetic field line regions called the polar cap, cusp and plasma mantle. These regions change configurations under strong solar wind conditions (higher density, velocity or magnetic field), which allows more solar wind flux to enter them. However, it has not been well understood how strong solar wind affects the O^+ escape rate in the plasma mantle. This study aims to answer how the O^+ escape rate depends on the solar wind dynamic pressure, interplanetary magnetic field (IMF) and extreme ultraviolet (EUV).

Using the oxygen data from CODIF instrument onboard Cluster, solar wind data from ACE and EUV data from TIMED, we investigated the O^+ escape rate dependence on solar wind dynamic pressure, IMF and EUV flux (defined as the ratio of the EUV intensity over the photon energy). We found that O^+ escape rate increases with solar wind dynamic pressure and southward IMF. In contrast, the EUV flux does not have a significant influence on the O^+ escape rate. Additionally, we compared the O^+ escape rate with the solar wind transferred power into the magnetosphere (with Akasofu parameter and Vasyliunas et al. formula). The response of the coupling functions is non-linear and starts only after reaching a threshold.

Our results imply that the more solar wind flux penetrate into the magnetosphere, the more O^+ escape through the plasma mantle. However, solar radiations do not have any effect of this rate. Knowing that the Sun had stronger solar wind in the past, we expect that O^+ escape under different solar wind conditions have had a significant influence on the evolution of the Earth's atmosphere. In conclusion, we wonder if the intrinsic magnetic field really protects Earth from atmospheric loss.