Influence of the Solar Wind on the Polar Upper Atmosphere of Mars. L. Andersson[1] and M. Pillinski[1], [1]LASP at University of Colorado, USA (laila.andersson@lasp.colorado.edu).

Introduction: Even though Mars does not have an intrinsic magnetic field directing solar wind energy into the thermosphere, there are key differences between the equator and the polar upper atmosphere. For instance, the seasonal variability in the polar region ionosphere and thermosphere is different from that at the equator due to the way that the tilt-axis alignment conspires with the ellipticity of the Martian orbit.

The solar wind interacts with the atmosphere mainly as a draped magnetic field with the clock angle of that magnetic field varying over time. On average however, the interplanetary magnetic field lies dominantly in the ecliptic resulting the draped magnetic field 'sliding' over the planet from lower latitudes towards the poles. This results in a magnetospheric 'sling-shot' effect wherein the ionosphere can be effectively eroded.

The polar regions are located at 'high' solar zenith angles leading to smaller atmospheric scale heights and moving many of the transition regions down in altitude. As a result, the electron temperature profiles at high latitudes are different from those at the equator. This affects the chemical reaction speeds when comparing polar and equatorial regions.

Using the observations by the NASA MAVEN missions made over 5 Earth-years (2.5 Mars-years) we investigate the importance of energy input from the solar wind into the lower atmosphere, how the polar regions participate in this energy input, and what this means for ion escape. The result is compared to Earth, where the energy from above the polar region drives the global thermosphere.

Ionospheric Shielding: At Earth the main magnetospheric energy input to the thermosphere is through the polar regions. Due to the lack of an intrinsic dipole magnetic field at Mars this is not the case, and the upper ionosphere can shield the lower ionosphere from external forces. Consequently, the Martian polar region does not contribute as much in channeling energy into the thermosphere.

The polar regions tend to be close to the terminator where day-to-night transport and ionospheric currents are developed. The upper ionosphere will shield the lower atmosphere from most increases in solar wind pressure buffering the lower ionosphere from instantaneous changes. Given a large enough solar pressure that is sustained over time however, ionospheric erosion will couple into the lower ionosphere and to the enhanced thermospheric winds which are expected to behave similarly to the 'fly-wheel' currents at Earth [1]. The effect of this is a nonlinear response of the polar atmosphere/ionosphere to solar wind forcing that might lead to the more quiet times being more effective in driving changes in the atmosphere.

Diurnal Variation: At Earth, the day-night thermospheric difference is relatively small and the EUV illumination at dawn mainly affects the ionosphere which takes 1-2 hours of local time to reach a 'semi-equilibrium' state. On Mars, where both the thermosphere and ionosphere change significantly from day to night, it takes up to 6 hours local time (closer to noon) to reach this state [2].

The diurnal variations at the polar regions are not as strong when compared to the equator due to the smaller variation in solar zenith angles at higher latitudes. As a result, the ionospheric relative abundance is different at the poles and the equator.

Atmospheric Loss: The properties of the Martian polar atmosphere/ionosphere described above lead to more heavy ion escape than at Earth.

With the lower exobase and a changing magnetic field direction, magnetic flux tubes can be mass loaded and heavy particles can be transported to higher altitudes where their lifetimes can be long. Examples of these erosion processes will be presented.

References:

[1] Deng W., Killeen T. L., Burns A. G., (1991), GRL, Vol. 18, No. 10, 1845~1848, "The flywheel effect: Ionospheric currents after a geomagnetic storm"

[2] Pilinski M. D., Andersson L., Fowler C., Peterson W.K., Thiemann E., Elrod M. K., (2019), JGR accepted, "Electron Temperature Response to Solar Forcing in the Low-Latitude Martian Ionosphere"

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