VERTICAL FLOW RATES IN THE MARTIAN IONOSPHERE: CONSTRAINING THE SUPPLY LIMIT IN ATMOSPHERIC ION ESCAPE. Robin Ramstad¹, David A. Brain¹, Yaxue Dong¹, James P. McFadden², David L. Mitchell², Laila Andersson¹, and Bruce Jakosky¹, ¹University of Colorado Boulder, Laboratory for Atmospheric and Space Physics, ²University of California Berkeley, Space Sciences Laboratory

Introduction: Recent studies have reported that the atmospheric heavy ion (O⁺, O₂⁺, CO₂⁺) escape rate from Mars is insensitive to upstream solar wind properties [1,2,3], and rather mainly depends on solar photoionizing radiation (X-rays, extreme ultraviolet). On a fundamental level, we may consider that ion escape from any planetary body can be limited either by the energization of the ionospheric plasma or by the supply (production and transport) of ions. Either factor may act as a bottleneck in the chain of processes that lead to ion escape.

The bulk of escaping atmospheric ions are produced in the lower ionosphere and diffuse upward at sub-escape velocities to be energized and escape in the interaction with the solar wind at higher altitudes. The rate of ion production and diffusion in the atmosphere may thus limit the number of ions that can escape the atmosphere.

Instrumentation: We combine over 4 years of ion flux measurements from the SupraThermal and Thermal Ion Composition (STATIC) instrument on the Mars Atmosphere and Volatile EvolutioN (MAVEN) orbiter [4], corrected for spacecraft potential and velocity (see energy spectra from a single orbit in Figure 1), to reconstruct the average Mars-inertial ion distribution function in the ionosphere from thermal energies (~10² eV) to 30 keV, the upper range of STATIC’s top-hat electrostatic energy analyzer. Here, the spacecraft potential is estimated from combined measurements by the Langmuir Probe and Waves (LPW), Solar Wind Electrons Analyzer (SWEA) and STATIC instruments on MAVEN.

Ionospheric flow rates: The average ion distribution function is subsequently integrated over velocity space and area to find the net vertical flow rate as a function of altitude. Further, we compare the vertical flow rate in the ionosphere to ion escape rates measured in the induced magnetotail and in the pick-up ion plume, and discuss the implications of the supply limit for ion escape drivers and the role of the solar wind in the evolution of the Martian atmosphere.


Figure 1: MAVEN/STATIC time-series energy spectra of omnidirectional H⁺, O⁺ and O₂⁺ ion flux distributions from a single example orbit, corrected for spacecraft potential and spacecraft velocity. The dashed lines indicate local escape energy for each species.