ATMOSPHERIC EFFECTS OF ENERGETIC PARTICLE EVENTS MEASURED BY MAVEN. R. D. Jolitz[1], R. J. Lillis[1], S. Curry[1], D. A. Brain[2], D. L. Larson[1] and B. M. Jakosky[2], [1]Space Sciences Laboratory, University of California Berkeley (rjolitz@berkeley.edu), [2]Laboratory for Atmospheric and Space Physics, University of Colorado.

Introduction: Solar energetic particle (SEP) precipitation contributes to energy and ion flow in the upper atmosphere. SEPs consist of energetic charged (protons, electrons and heavy ions) and neutral particles usually produced during intense solar activity. SEP precipitation causes effects such as ionization, excitation, dissociation, neutral heating and altered neutral and photochemistry [1].

While energy deposition from SEPs in polar regions at Earth have been observed to alter atmospheric chemistry and increase electron and ion plasma density [2], quantitative observations and models of SEP effects at Mars are scarce. There is evidence of SEP-produced ionization from radar wave absorption in the dayside ionosphere as seen by MARSIS [3, 4] and derived total electron content increases [5]. During a 2006 SEP event, MEX observed heavy ion outflow flux was enhanced by one-order of magnitude [6]. This enhancement could have been due to increased ion population, allowing subsequent CME shocks to induce wave-heating and plasma instabilities, leading to increased atmospheric escape [7, 8].

Modeling. Existing models of particle precipitation in the Martian atmosphere are written for energetic neutral atoms (ENAs) [9] and electrons [10].

We use a model to determine rates of secondary electron production, atmospheric heating and total energy loss. We wrote a Monte Carlo code to track a population of SEPs (energetic protons, electrons and ENAs) in an atmosphere. Magnetic and electric displacement of energetic protons and heavy ions are determined by a Lorentz tracing algorithm to account for longer gyroradii in Martian crustal fields. Major atmospheric constituents cause energy loss and scattering. An adaptive optical depth algorithm is used to accurately model collision locations in dense and sparse atmospheric regions. Collision type and neutral species impacted is calculated using an approach from [10].

The model framework is parallelized, open to multiple planetary-specific inputs (three-dimensional atmosphere neutral densities, electric and magnetic fields) and collision databases (cross-sections, energy losses, and deflection angles of ion-neutral collisions). The collisional code was validated by comparison with results from the Michigan Precipitation Algorithm [11].

Results. Using the predicted 3-D models of electric and magnetic fields from the Michigan Mars MHD code, 3-D neutral densities from the MTGCM, and a cross-section database from the Michigan Precipitation Algorithm [12], we simulated proton and ENA precipitation in the Martian upper atmosphere. Secondary electrons were simulated using MarMCET [10]. We see strong deflection by crustal fields in southern polar regions (Figure 1). We will present three-dimensional ionization rates and energy deposition using the October 2014 MAVEN spectra. Ultimately this will form part of a comprehensive model of solar wind interactions with Mars and long-term Martian atmospheric erosion for comparison to results from the Mars Atmosphere Volatile EvolutioN (MAVEN) mission.

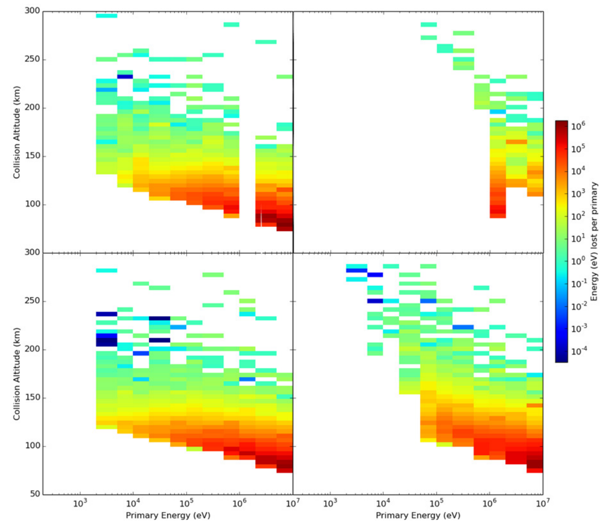

Figure 1: Energy deposited (eV) per primary proton. Left: Incident angle is 0°. Right: Incident angle is 60°. Top: (50° S, 180° E) (290 nT). Bottom: (20° N, 260° E) (21 nT).

References:

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