The Effects of Precipitating Solar Energetic Protons in the Martian Atmosphere

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What is Particle Precipitation?

The Basics

- highly energetic electrons, protons, neutrons, and ions
- Accelerated into atmosphere
- Cause chemical changes in the atmosphere
- geomagnetic polar regions

Image Credit: NASA
Where do these highly energetic particles come from?

Image credit: T. Benesch and J. Carns for the NASA Science Mission Directorate
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Image credit: NASA/ESA

Sinnhuber et al., 2012
Auroral electrons: 1–10 keV, penetrate to ~80–130 km
Solar Proton Events: 10’s - 100’s MeV, penetrate to mesosphere & upper stratosphere
Galactic Cosmic Rays: several 100 MeV far into the EeV range, penetrate to lower stratosphere and sometimes reach the surface.
How is the Atmosphere Affected?

Sinnhuber et al., 2012

Seppälä et al., 2014

Sinnhuber et al., 2012
How Mars is Different?

- Weak, scattered crustal magnetic field
- Smaller in size
- More distant from the sun
Effects on the Martian Atmosphere

- Atmospheric heating
- Localized effects by crustal magnetic field
- Atmospheric Sputtering (animation)

Credit: ESO/Wikimedia Commons

Credit: Kallio, Janhunen 2001

Jolitz et al., [2017]
How the Code Works

- Uses NIST stopping power data
- Uses density of atmospheric elements to calculate column mass
- Inputs pre-determined energy of incident protons (in MeV)
- Calculates the incident energy flux, total energy dependent on mass & volume
- Outputs the total ionization result
References


Questions?