The ionosphere of Mars and its importance for climate evolution

A community white paper for the 2009 Planetary Decadal Survey

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My objectives

• MAVEN is worthwhile
• Extension of MAVEN beyond nominal one Earth year duration will be extremely valuable
• The science of the ionosphere of Mars will not end with MAVEN
• Present some ideas for future ionospheric instruments and missions (with realism)
Structure of white paper

• Introduction
  – Ionospheres in general and the martian ionosphere in particular are great

• What MAVEN will do
  – Excellent neutral/plasma composition
  – First in-depth look at the nightside
  – Effects of magnetic topology
  – Boundary between ionosphere and solar wind

• Important questions that it is clear MAVEN will not answer

• Measurements to answer those questions

• Conclusions
Important questions that MAVEN’s nominal mission will not answer

• Q1 - Solar cycle variations
• Q2 - Below 125 km
• Q3 - Links between solar forcing and ionospheric properties
• Q4 - Temporal variations
• Q5 - Global coverage
• Q6 - Hot atom escape fluxes
• Q7 - Dynamical coupling between neutral atmosphere and ionosphere
Desired measurements and instruments (1)

- **M1** – High cadence magnetic field measurements from surface to study currents induced by plasma motion [surface magnetometer] (Q2, Q4)
- **M2** – High cadence vertical profiles of bottomside electron density [surface ionosonde] (Q2, Q4)
- **M3** – High cadence total electron content measurements [surface riometer] (Q4)
- **M4** – All-sky camera images of airglow [simple surface camera] (Q4)
Desired measurements and instruments (2)

- M5 – Upstream measurements of solar wind and irradiance simultaneous with ionospheric measurements [various small instruments on an orbiter] (Q3)

- M6 – Spacecraft-to-spacecraft radio occultations [minor modification to typical comm system of orbiters] (Q5)

- M7 – Simultaneous neutral winds, ion velocities, plasma density and magnetic field [Fly CINDI payload from C/NOFS on Mars orbiter] (Q7)
Aeronomy Constellation Mission

• This is a PROGRAM - What missions will be inspired by MAVEN's discoveries?
• No chance of near-term flight, but a good place to plant idea of future mission-level concepts
• Upstream monitor of solar conditions, downstream observations of escaping volatiles, plus simultaneous observations of the ionosphere