MARS' MAGNETIC ATMOSPHERE: IONOSPHERIC CURRENTS, LIGHTNING (OR NOT), E&M SUBSURFACE SOUNDING, AND FUTURE MISSIONS.

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Summary: Mars' ionosphere has no obvious magnetic signs of large-scale, dust-produced lightning. However, there are numerous interesting ionospheric currents (some associated with crustal magnetic fields) which would allow for E&M subsurface sounding.

pected to produce magnetic signals in its ionosphere. These include solar wind induced currents, interactions with the localized crustal magnetic fields, and perhaps electromagnetic activity associated with atmospheric dust (e.g. lightning). Furthermore, these time varying signals may be detectable on the martian surface and thus afford the possibility of probing the martian subsurface with electromagnetic sounding. We present observations from the magnetometer onboard Mars Global Surveyor (MGS) and discuss the implications for possible sources of the observations. We also comment on the opportunities presented by upcoming missions such as MAVEN, InSIGHT, and future geophysical sounders.

Observations: MGS magnetometer data is available from both the ~400 km altitude circular mapping orbit and the elliptical aerobraking orbits which had periapses as close as ~80 km. We use both types of data (so altitudes from 80km to 400+ km) but preferentially use the lowest altitude aerobraking data in order to focus on the main part of the ionosphere.

We look primarily at time varying signals and so use a variety of frequency analysis techniques (e.g. FFTs, wavelets, etc.). This is especially important given the relatively small amplitudes of the signals seen to date (< 0.1 to 1 nT). The magnetometers were mounted on MGS' solar arrays, which despite careful back wiring, can create magnetic signals so care must be taken

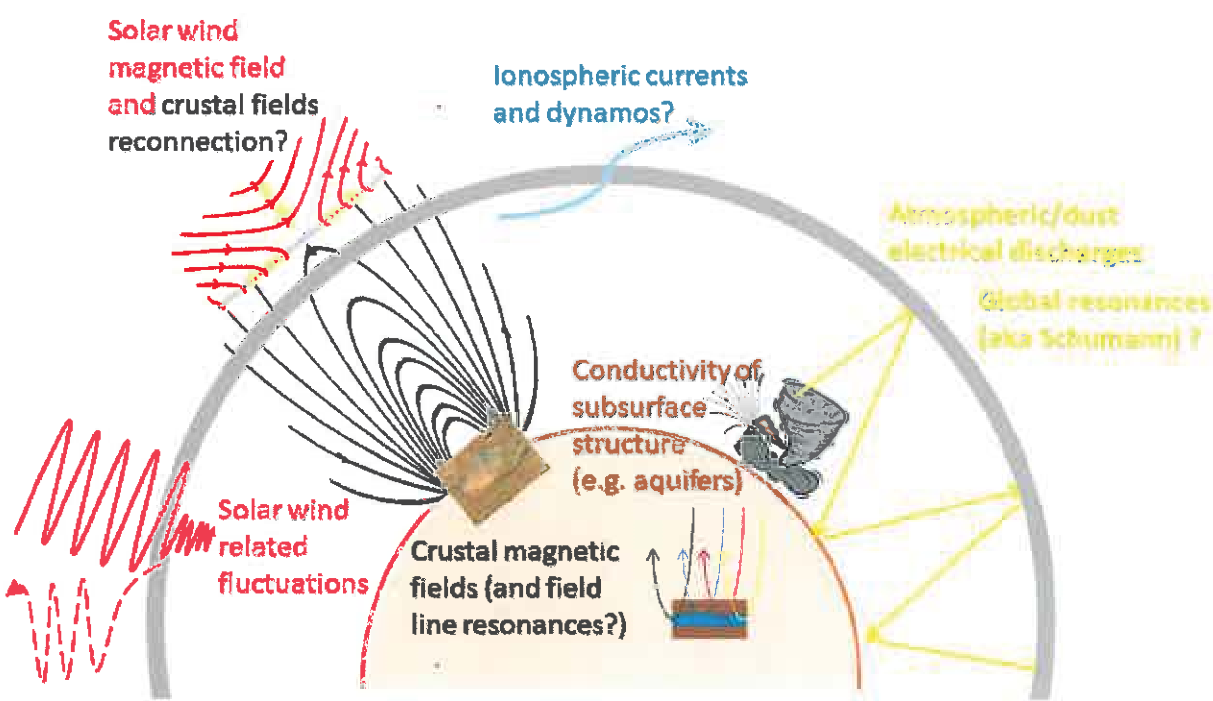
about 0.1 Hz to 16 Hz, depending on telemetry allocations throughout the MGS mission.

Results and implications: We will present our preliminary results and discuss their implications.

Non-detection of lightning: Dust activity at Mars has long been predicted to create atmospheric electricity. Some authors have predicted lightning in the form that we see in terrestrial thunderstorms while others are supportive of glow plasma discharges. Radar observations by MARSIS, Galileo, and Cassini have not seen evidence of large-scale, earth-like lightning. Conversely, observations with the Deep Space Network have been interpreted as consistent with lightning from dust storms.

We have looked for low frequency (~11 Hz) magnetic signals that ought to arise from a global resonance of trapped broadband electromagnetic radiation from any putative lightning strikes (aka Schumann resonances). We see no obvious signs of the resonant low-frequency signals that ought to be associated with earth-like lightning occurring at Mars.

Ionospheric currents and crustal fields: In contrast to the non-detection of Schumann resonances we find



multiple signals presumably related to ionospheric currents and their connections to the crustal magnetic fields. Some of these have amplitudes of order 1 nT around 1 Hz and are often seen adjacent to strong crustal fields. However, there are also time-varying signals far from any crustal fields. Further examination is ongoing.

Future missions: The upcoming MAVEN mission will add immensely to our dataset. MAVEN's periapsis is about 150 km and it will also occasionally do deep-dip orbits with periapses as low as about 125 km. Furthermore, since MAVEN carries a full plasma science package, not only we will we get a significant amount of new magnetometer data at ionospheric altitudes, we will get full particles and fields information about what is occurring in the ionosphere. This wealth of detail will be tremendously helpful in deciphering the signals seen to date.

The InSIGHT mission, which will land on Mars in Elysium Planitia in 2018, carries an engineering magnetometer onboard. While this instrument is not designed to do science it may nonetheless be possible to do comparisons between observations seen at ionospheric alitudes and on the surface. This will also be tremendously helpful in understanding how the signals propagate through the atmosphere.

Electromagnetic Subsurface Sounding: Given all these observations of ionospheric signals, regardless of uncertainty of how they propagate to the surface and what their sources are, it is reasonable to expect that signals useful for electromagnetically probing the conductivity of the martian subsurface are available. We are optimistic about this possibility for future missions.