MARTIAN IONOSPHERIC VARIABILITY AS OBSERVED BY MARSIS: THE EFFECTS OF SOLAR ENERGETIC PARTICLES, IONIZING RADITION, METEORS, AND DUST ACTIVITY.

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Summary: We present observations from the subsurface sounding mode of the MARSIS instrument onboard Mars Express that imply radar wave absorption because of increased amounts of ionization in the upper Martian atmosphere during the fall of 2005. On at least two occasions these radar disruptions lasted for several days and we find that these periods are correlated with periods when other instruments indicate elevated levels of solar energetic particles. Another disruption lasted for over a month and we find that it was likely caused by a combination of solar activity and observing through the daytime ionosphere. There is no evidence in the present results for the constant ionospheric layer predicted to be created by the normal infall of cosmic dust, although the effects of enhanced infall during meteor showers remains uncertain. The effects of dust activity also remain uncertain but will be tested in during the 2007 dust season.

Data: Figure 1 shows MARSIS subsurface sounder radar returns from three different orbits displayed as delay vs. time echograms: (a) A typical return. (b) A marginal return. (c) A poor return.

Figure 1

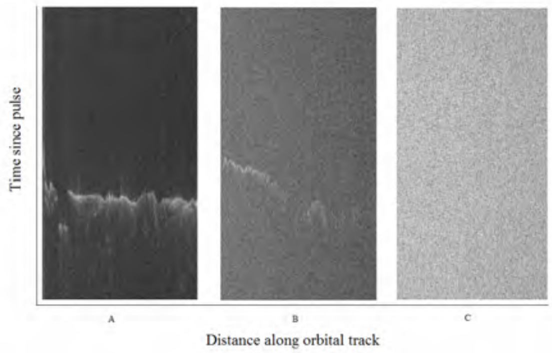

Figure 2 shows time series data from the period of radar disruption. (a) A qualitative assessment of whether the Subsurface Sounder showed a clear ground signal (1 for very clear, 0.5 for faint or strongly distorted, and 0 for a complete "blackout" like figure 1c.) (b) A similar dataset from the Active Ionospheric Sounder experiment [1]. (c) The total countrate in the 10-21 keV energy channels from the MGS Electron Reflectometer. These electrons mainly represent high energy (> 20 MeV) particles. The asterisks show when Mars crossed the path of a comet. (d) The average subsolar magnetic field magnitude as measured by the MGS magnetometer. (e) The total number of dust storms observed in MOC images from across the planet. The black bar represents a period when several large regional dust storms developed.

Figure 3 gives a time series comparing the MARSIS blackouts with the MEX periapses. (a) The time between the MEX periapsis and MEX's passage through either the dawn or dusk terminator. Positive values represent times when periapsis happened in the daylight and negative values represent periapsis happened in the night. The dots at the top show when a periapsis occured over the region of most prominent crustal magnetic fields. (b) Shows the subsurface data quality index like in fig. 2a.

In both figures 2 and 3 we denote three different blackout periods by the letters A, B, and C.

Interpretation: Our central assumption is that the blackouts were caused by either an increase in number density in the current layers or by new temporary layers of increased ionization that absorbed or scattered the radar signal. But what caused the additional ionization?

Possible Causes	Event A (9 days)	Event B (4 days)	Event C (~ 2 months)	Generally
Solar energetic particles[1]	Y	Y	Y	Y
Dust activity[2]	N	N	?	?
Diurnal cycle[3]	N	N	Y	Y?
Constant meteoric infall[4]	N	N	N	N?
Meteor showers/storms[5]	N	N?	N	?
Crustal fields[6]	N	N	N	?

[1] First proposed by [1] for AIS results

[2] To be tested in the 2007 Mars dust season

[3] Predicted to have an effect [2] but not entirely black out all frequencies (also see "non"-event in Aug. 2006)

[4] Predicted by several models [3] to exist

[5] To be tested in 2007 during Martian meteor shower

[6] Some effects possible directly over crustal fields

References: [1] Morgan, D. D. et al. (2006), *GRL, 33*, L13202. [2] Safaeilini, A., et al. (2001), *P&SS., 51*, 505-515. [3] Molina-Cuberos, G. J., et al. (2003), , *P&SS., 51*, 239-249.

Figure 2

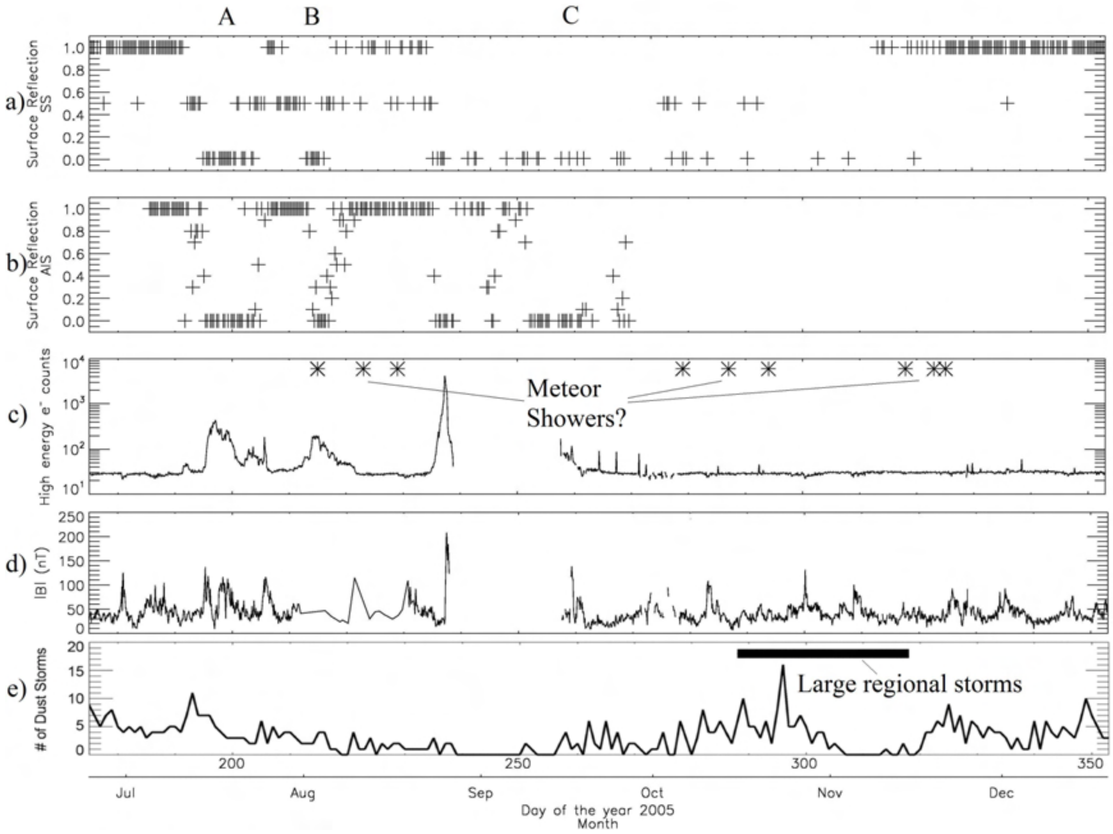

Figure 3