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## **A Statistical Analysis of Radar Blackouts at Mars: MARSIS, SHARAD and MAVEN Observations**

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## A Statistical Analysis of Radar Blackouts at Mars: MARSIS, SHARAD and MAVEN Observations

Mark Lester et al.

We present an analysis of radar blackouts observed by MARSIS on Mars Express and SHARAD on Mars Reconnaissance Orbiter for the interval 2006 – 2017. The period of interest encompasses the extended solar minimum between solar cycles 23 and 24 as well as the solar maximum of cycle 24. Blackouts have been identified by eye through scanning daily plots of the surface reflection for both radars. A blackout occurs when, for no apparent instrumental reason, the surface reflection normally expected is either not observed (total) or when the surface reflection is seen for only part of the orbit or the surface reflection is both weaker and spread over a significant time delay (partial). Such blackouts are caused by enhanced ionisation at altitudes below the main ionospheric electron density peak resulting in increased absorption of the radar signal. There are more occurrences observed by MARSIS than SHARAD, which is expected due to the lower absorption at the higher operating frequency of SHARAD. We also observe more blackouts during solar maximum than solar minimum. Indeed, there are no total blackouts during the extended solar minimum, although both radars do have partial blackouts. There is no apparent relationship between blackout occurrence and crustal magnetic fields. Following previous work, which has indicated that solar energetic particles, specifically electrons are responsible for the enhanced ionisation in the atmosphere, we also present the analysis of the MAVEN SEP electrons between 20 keV and 2 MeV during events when all three spacecraft were operational. We find that the SEP electron flux-energy relationship is much enhanced during the total blackouts, in particular where both radars are impacted, while for partial blackouts the flux-energy spectrum is closer to those from orbits where no blackout occurs. We also find that for certain events, the average spectrum which result in a blackout is particularly enhanced at the higher energy end of the spectrum, above 50 keV. The average spectra from each condition is presented. We conclude that there is a higher probability of a radar blackout during solar maximum, that crustal magnetic fields play no apparent role in their observational occurrence, that the higher energy (< 50 keV) electrons are responsible, and that for events where both radars observe a radar blackout the SEP electron fluxes are at their highest.

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