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Indirect identification of a low-altitude layer in the Martian nightside ionosphere during a space weather event with Mars Express-MARSIS radar data

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Abstract

The Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) on board the Mars Express (MEX) mission suffered from a complete blackout for 10 days in September 2017 when it was sampling the subsurface of the planet during the nightside. We propose that this blackout of MARSIS data was caused by the solar energetic particles (SEP) of few tens of keV associated with a space weather event that hit Mars between the ~11th and the 21st of that month. Electron precipitation are believed to produce a low ionospheric layer on the nightside, which absorbed the radar signals. In this study, we assess the properties of this low ionospheric layer based on the radar attenuation observations.

1. Introduction

September 2017 was a very active month in terms of space weather. The Sun emitted the two largest solar flares of the current solar cycle, a X9.3 flare on the 6th and a X8.2 flare on the 10th. This second flare was accompanied by a large coronal mass ejection (CME) that arrives at Mars on the 13th, and by a solar energetic particle (SEP) event that hit Mars during 10 days starting few minutes after the flare was emitted on the 10th of September.

All spacecraft at Mars detected this space weather event. At that time, the MARSIS radar aboard Mars Express was sampling the southern hemisphere subsurface on the nightside and suffered from a complete blackout for 10 days (Figure 1).

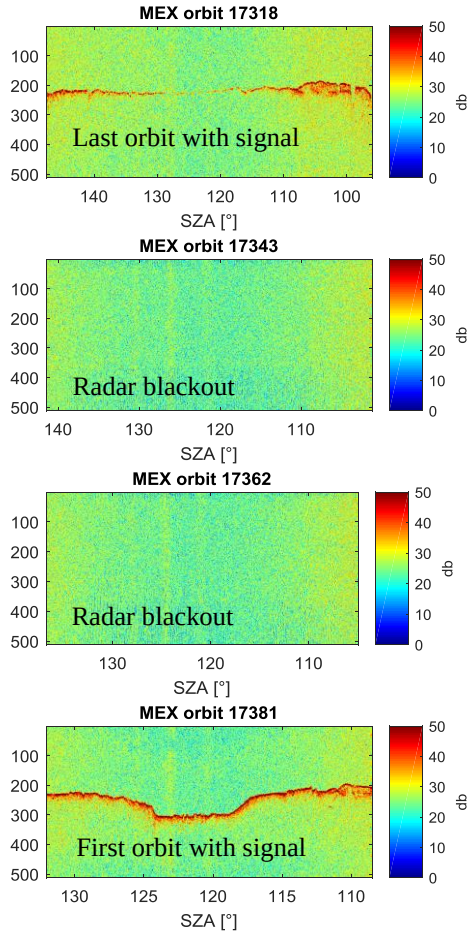

Figure 1: Example of MARSIS data with and without radar blackout during this space weather event

The timing of this blackout coincides well with the observations of the electrons from the SEP event duration measured by the MAVEN spacecraft.

In this study, we interpret the radar blackout as the effect caused by the absorption of a low ionospheric layer formed from precipitation of SEP electrons.

2. Radar signal attenuation

It is well established at Earth that energetic electron and proton precipitation can produce enhancements of the lower ionospheric layers, the D and E layers, which then absorb radio signals. At Mars, previous studies have shown that different phenomena, such as meteoritic showers, CMEs, corotating interaction regions (CIRs) or SEPs, can result in radar absorption both on the nightside and dayside due to a rise in the electron density of the low ionosphere [1, 2, 3, 4, 5]. However, no spacecraft has ever directly measured this low ionospheric layers, and it is not clear which is the source of ionization that is able to produce a continue 10-day radar blackout on the deep nightside of Mars.

In this study, we start from the level of attenuation that the MARSIS radar signal suffered, and after considering the radar frequencies, the appropriate electron-neutral collision frequency of the nightside atmosphere, and the altitude deposition of the SEP particles, we indirectly estimate the properties and possible shape of the ionospheric absorption layer created by this space weather event.

3. Summary and Conclusions

In this work, we assess the shape and main properties of the ionospheric layer formed at low altitude on the nightside ionosphere after the impact of a powerful space weather event at Mars. We also discuss the most probably source of continuous ionization that led to this low ionospheric layer to survive for 10 days. This work will lead to an improved assessment of radar performances during space weather events.

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References

[1] Witasse, O., J. F. Nouvel, J. P. Lebreton, and W. Kofman (2001), HF radio wave attenuation due to a meteoric layer in the atmosphere of Mars, Geophys. Res. Lett., 28(15), 3039–3042.

[2] Morgan, D. D., et al. (2010), Radar absorption due to a corotating interaction region encounter, Icarus, 206, 95–103.

[3] Espley, J. R., W. H. Farrell, D. A. Brain, D. D. Morgan, B. Cantor, J. J. Plaut, M. H. Acuña, and G. Picardi (2007), Absorption of MARSIS radar signals: Solar energetic particles and the daytime ionosphere, J. Geophys. Res., 34, L09101, doi:10.1029/2006GL028829.

[4] Nemec, F., D. D. Morgan, C. Diéval, and D. A. Gurnett (2015), Intensity of nightside MARSIS AIS surface reflections and implications for low-altitude ionospheric densities, J. Geophys. Res. Space Physics, 120, doi:10.1002/2014JA020888.

[5] Withers, P. (2011), Attenuation of radio signals by the ionosphere of Mars: Theoretical development and application to MARSIS observations, Radio Sci., 46, RS2004, doi:10.1029/2010RS004450.