EPSC Abstracts
Vol. 13, EPSC-DPS2019-1434-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Radar blackouts in Mars' atmosphere produced by space weather events during the life time of Mars Express and Mars Reconnaissance Orbiter

Beatriz Sanchez-Cano (1), Mark Lester (1), Pierre-Louis Blelly (2), Olivier Witasse (3), Marco Cartacci (4), Roberto Orosei (5), Hermann Opgenoorth (6,1), Rob Lillis (7), François Leblanc (8), Stephen E. Milan (1), John M.C. Plane (9)

(1) Department of Physics and Astronomy, University of Leicester, Leicester, UK (bscmdr1@leicester.ac.uk), (2) Institut de Recherche en Astrophysique et Planétologie (IRAP), Toulouse, France, (3) European Space Agency, ESTEC, Noordwijk, The Netherlands, (4) Istituto Nazionale di Astrofisica (INAF), Istituto di Astrofisica e Planetologia Spaziali (IAPS), Rome, Italy, (5) Istituto Nazionale di Astrofisica (INAF), Istituto di Radioastronomia (IRA), Bologna, Italy, (6) Department of Physics, Umeå University, Linnaeus väg 24, 901 87, Umea, Sweden, (7) Space Sciences Laboratory, University of California, Berkeley, California, USA, (8) LATMOS/IPSL, UPMC Univ. Paris 06 Sorbonne Universités, UVSQ, CNRS, Paris, France, (9) School of Chemistry, University of Leeds, Leeds, UK

Abstract

The Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) onboard Mars Express (MEX) and the Shallow Radar (SHARAD) onboard Mars Reconnaissance Orbiter (MRO) suffer from severe degradation in the ground reflection signal almost every time a solar energetic particle (SEP) event strikes Mars. The most notable case occurred in September 2017, when the signals of both radars were completely absent for several days (Figure 1) [1]. The cause was likely the precipitation of SEP electrons of a few tens of keV that are believed to produce a lower ionospheric layer within the collision-dominated atmosphere which can absorb the radar signals. In this study, we go one step further and evaluate when and under which conditions this absorption layer appears and its main properties for the lifetime of both the MEX and MRO missions.

1. 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, 6]. However, no spacecraft has ever directly measured these lower altitude ionospheric layers, and the source of ionization that is able to produce a continuous 10-day radar blackout on the deep nightside of Mars remains unknown.

In this study, we start from the level of attenuation that the MARSIS and SHARAD 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 space weather electron precipitation.

2. Case Study September 2017

The Active Region (AR) 12673 at the western limb of the solar disk emitted a X8.2-class flare on 10 September 2017, and released a powerful Coronal Mass Ejection (CME). SEP electrons (20-200 keV) started to arrive at Mars 3h later, and ions (20 keV-6 MeV) 6h later.

While the radar blackout lasted at least ~10 days for MARSIS, it lasted only ~3 days for SHARAD because radio absorption processes are frequency-dependent. SEP electrons were present during the entire period of the radar blackout and therefore suggests that precipitating energetic electrons, rather than ions, were responsible for the creation of a lower nightside ionospheric layer that absorbed the radar signals [1].

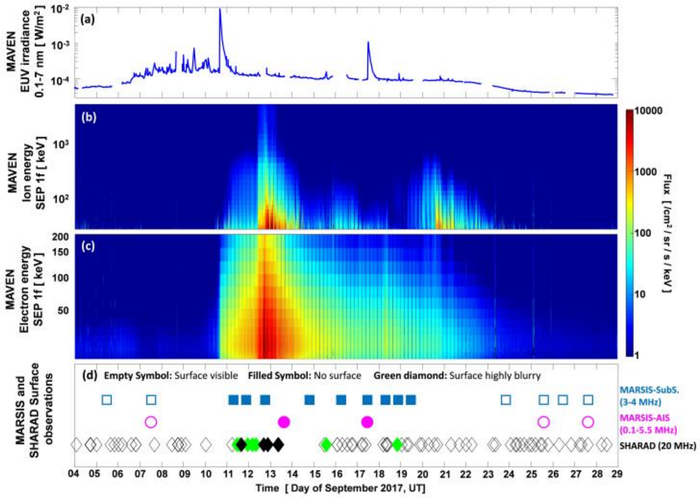

Figure 1: *(a) MAVEN-EUV irradiance observations of wavelength 0.1-7 nm. (b) MAVEN-SEP ion differential flux spectra. (c) MAVEN-SEP electron differential flux spectra. (d) Each symbol denotes when MARSIS and SHARAD were in operation. Empty symbols designate the cases when the surface was observed, and filled symbols when was not observed. The exception are green diamonds that indicate the times when SHARAD observed a highly blurry surface [1].*

3. MARSIS and SHARAD radio blackouts during for the last 15 years

In order to understand whether the characteristics of the September 2017 blackouts are typical, we repeat the same process for the entire life of MEX and MRO missions.

The length of the events seem to be consistent with the length of the SEP electron particles precipitating into Mars' atmosphere (at least for the time that MEX and MAVEN missions coincided). On average, the length of these events is 7 days, which is much larger than the typical duration of a blackout at Earth (~minutes/hours). This indicates a clear different ionization mechanism for both planets, as we will assess.

In addition, these blackouts do not seem to have a preferred location or time of the day to occur, having been observed at both day and night sides, as well as in both the Northern and Southern hemispheres.

4. Conclusions

Taking advantage of a larger dataset during over the lifetime of both the MEX and MRO missions, we evaluate when and under which conditions this absorption layer appears and its main properties. As it is leading to the loss of radar signals at least between 5 and 20 MHz, the outcome of his work will allow better assessment of high frequency radar performance during future space weather events.

Acknowledgements

B.S.-C. and M.L. acknowledge support through STFC grant ST/S000429/1

References

[1] Sanchez-Cano et al, (2019), Origin of the extended Mars radar blackout of September 2017, , J. Geophys. Res., Space Physics, accepted.

[2] 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.

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

[4] 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.

[5] 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.

[6] 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.