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MARSIS Observations of Phobos: Preliminary Results of the Search for Underground Reflectors

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Abstract

In this paper, we present recent MARSIS observations of the Martian moon Phobos, considering the continued search for underground reflectors.

1. Introduction

The MARSIS radar instrument aboard MARS EXPRESS[1, 2] is a low frequency radar capable of operating at multiple bands with center frequencies of 1.8 MHz to 5 MHz. As described in [3], the instrument was re-programmed to be able to observe the Martian moon Phobos (see also [4] for a summary). Phobos is planned to be the target of several missions, including sample return missions.

In [5], we presented a simulation tool to compute an accurate backscattered radar echo from the surface of a body of arbitrary shape.

Recently, new geo-models of Phobos have been presented[6], derived from HRSC observations, represented as a spherical harmonics coefficient set. Using these new models, we re-computed the surface reflections in order to compare these with MARSIS measurements.

2 Results and discussion

Fig. 1 shows the simulation of the backscattered echo of orbit 4814 at 4 MHz center frequency. When comparing these with the on-board Doppler and SAR processed measurements performed by the MARSIS instrument shown in Fig. 2, it can be seen that echoes in the measurements are also present in the simulated radargram.

Fig. 3 shows echo nº 4 of Figs. 1 and 2 in an overlay. The positions were aligned so that the echo peaks of measurements and simulation match. Signal powers were normalized separately: the simulation is normalized to the strongest echo, while the measured data were normalized to the strongest echo in *all* Doppler filter banks.

3 Conclusions

As of yet, in those MARSIS measurements we analyzed, the radar echoes could be attributed to surface backscattering. There are some hypotheses wich might cause these phenomena. Firstly, with an assumed resolution of ≈60 m when assuming a permittivity of $\varepsilon_\mathrm{r} = 6.25$, surface regolith layers within that range are not separable. Secondly, primary layering might hinder deeper penetration if the material is very lossy. Lastly, multi-path propagation phenomena need to be investigated. Further investigation of the MARSIS data will give a better insight. Mapping the simulated and measured echoes to their respective surface locations will resolve ambiguities in the Doppler and SAR processed echoes.

References

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[2] R. Orosei, R. Jordan, D. Morgan, et al., "Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) after nine years of operation: A summary," *Planetary and Space Science*, vol. 112, pp. 98–114, Jul. 2015.

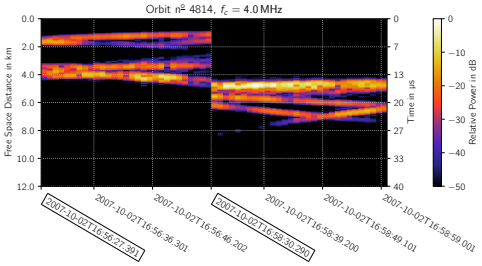
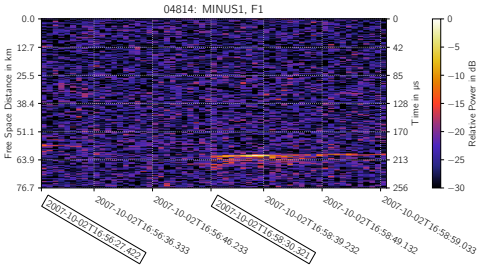
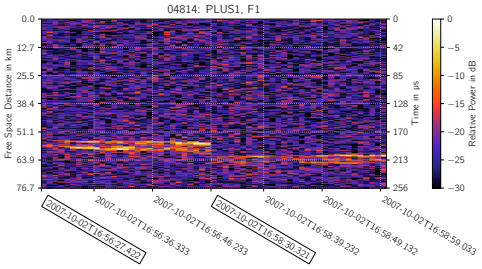


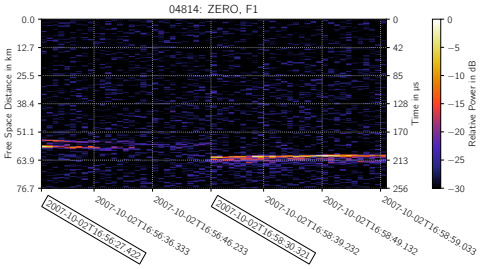
Figure 1: Simulated Radargram at 4 MHz center frequency.



(a) Doppler Filter −1.



(b) Doppler Filter 0.



(c) Doppler Filter +1.

Figure 2: MARSIS Doppler processed measurements of Orbit 04814.

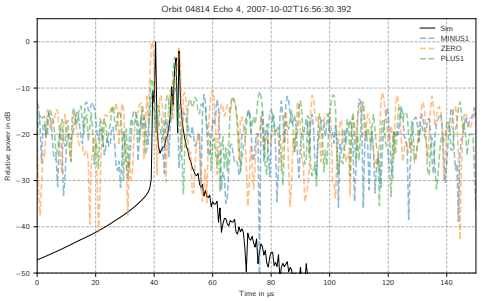


Figure 3: Time-shifted and power-normalized overlay of the measured Doppler filters and the simulation for Echo nº 4 of orbit 04814.

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