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Sub-Surface Radar for the EJSM mission: discussion on environmental noise limiting performance

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Abstract

The Europa Jupiter System Mission (EJSM) is one of the major European Space Agency (ESA) missions in the Solar System currently under study. It is aimed at exploring Jupiter and its icy moon Ganymede. The Sub-Surface Radar (SSR) instrument is a radar sounder system at low frequency (HF/VHF band) designed to penetrate the surface of Ganymede icy moon of Jupiter for performing a subsurface analysis with a relatively high range resolution. The paper addresses the main sources of environmental noises that can limit the overall performance of the radar: the presence of a relevant Jupiter radio emission and the clutter caused by characteristics of planet's surface.

1. Environmental noise and radar performance limitation

Two main sources of environmental noises have been identified so far as limiting in radar performance: Jupiter's radio emission and Ganymede's surface clutter.

As far as the first noise source, it is well known that Jupiter is a so bright radio object that, as seen from Earth, it is exceeded only by the Sun. The most intense radio emission occurs in the frequency range between few megahertz and about 40 MHz [4], and it is expected to be due to cyclotron radiation originating in and above the ionosphere. These radio emissions dominate the galactic background, which is usually the major source of noise for planetary radar measurements. Decades of ground based and space based observations provided a good knowledge of the characteristics of these emissions. Ground based observations are limited by the terrestrial ionospheric cutoff which reflects out radio waves with frequencies lower than 10 MHz. Space based observations are usually limited at high frequencies because of the limited resources available on a spacecraft. In particular, by using data of the Planetary Radio Astronomy (PRA) experiment on both Voyager spacecrafts and by the Cassini Radio and Plasma Wave Science instrument (RPWS), the expected spectral flux density of Juppiter radiation at Ganymede is shown in figure 1. The effects of such radiation noise on SSR instrument can be evaluated by taking into account either the direct part coming from Jupiter and the portion backscattered by Ganymede's surface [1].

As far as the clutter is concerned, its strength is controlled by statistical parameters of the surface topography. Classical parameters such as root mean square (RMS) height, RMS slope, or correlation length can be used to infer expected backscattering [2]. In this work also a fractal characterization of surface will be taken into account, because it has been shown that classical parameters usually employed to describe natural surfaces change when the scale at which the surface is observed changes. Conversely, fractal parameters of a natural surface are independent of the observation scale. The most useful fractal model for natural surfaces is the fractional Brownian motion (fBm), that has also the advantage of having an analytical evaluation of electromagnetic scattering. In both cases, suitable Digital Elevation Models (DEM) of Ganymede are needed. Some topographic information has been derived for a limited number of areas through stereogrammetry from Galileo and Voyager images. Further information for Ganymede was obtained through a DEM produced from Voyager images shown in figure 2. However, more work is necessary for deriving DEMs of different portions of

Ganymede for a better understanding of the clutter issue.

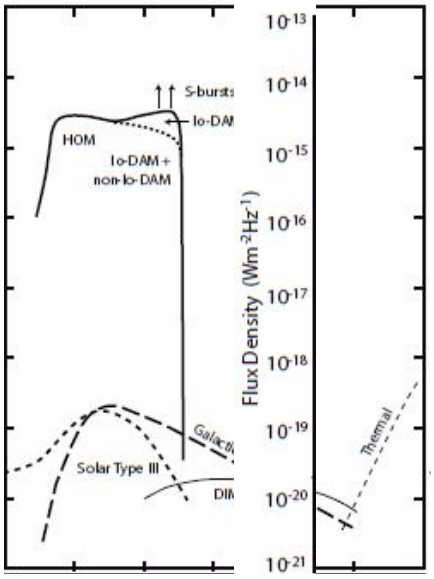

Figure 1: Spectral flux density of Juppiter radiation at Ganymede [1].

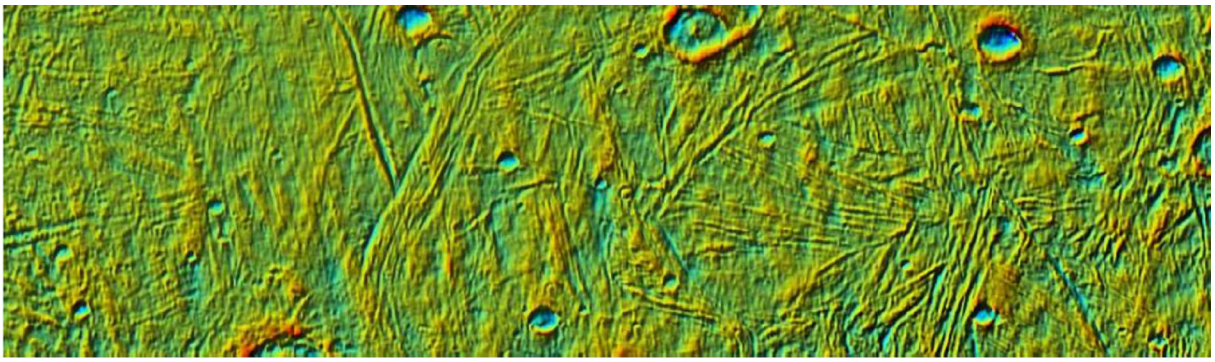

Figure 2: Shaded relief visualization of the digital elevation model produced by [4]

6. Summary and Conclusions

This paper is aimed at studying effects of the main sources of noise on EJSM SSR's performances.

Two main sources of environmental noises have been identified so far as: Jupiter's radio emission and Ganymede's surface clutter. The effects of such radiation noise on SSR instrument can be evaluated by taking into account either the direct part coming from Jupiter and the portion backscattered by Ganymede's surface. As far as the clutter is concerned, its effects on radar performance can be better depicted taking into account a fractal characterization of surface.

References

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