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Martian water ice clouds affected by gravity waves as seen by the OMEGA/MEX imaging spectrometer

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Abstract

The OMEGA imaging spectrometer on board Mars Express reveals the presence in the Martian atmosphere of water ice clouds showing the characteristic features of the presence of gravity waves. In this work, we use the water ice band at 1.5 µm to map the activity of the waves.

1. Introduction

Gravity waves (GWs hereafter) are widely studied on Earth and it is well established that they play an important role in the circulation and structure of the middle and upper atmosphere, transferring momentum and energy from the troposphere to the stratosphere. GWs observed on Mars show amplitudes larger than on Earth, implying their importance for the dynamic of the atmosphere ([1]; [2]; [3]; [4]). There are many mechanisms, which can explain the formation of GWs, such as wind shear instability, terrain irregularities, and convection of volatiles. [5] found that even if GWs well correlate with topography in some regions such as Tharsis, not always the activity is strong enough, as the models predict, on regions with important orography. Also, over the tropics the wave activity cannot be explained with the effect of surface topography. In our work we want to analyze the spectral features of the region where the GWs are detected and the properties of the water ice clouds in order to infer the excitation mechanism and the effect of the GWs we are observing.

2. Data set

OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) is an imaging spectrometer on board Mars Express (MEX). OMEGA covers a spectral range from 0.35 µm to 5.1 µm with a mean spectral resolution of 0.15 µm ([6]).

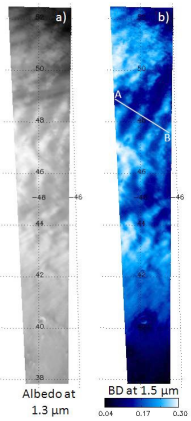

Figure 1: a) albedo map at 1.3 µm for orbit 2189_7; b) map of band depth at 1.5 µm.

We analyze a region in the northern hemisphere, which shows a strong wave activity revealed by the presence of oscillation in water ice clouds. Figure 1a shows the map at 1.3 µm for OMEGA orbit 2189_7. The solar longitude of the observation is 296.07° and latitudes range from 38° to 52° in the northern hemisphere for longitudes between -50° and -46°E. The waves are well defined thorough the clouds between 46° and 50°N. We evaluate the water ice absorption feature (Figure 1b) considering the band depth at 1.5 µm and using the method of [7].

The wave-like trend of the band depth in Figure 2 clearly shows the effect of the waves on the cloud. The profile is obtained along the track shown in Figure 1b, parallel to the waves' propagation direction and shown as a white line (starting from point A up to point B).

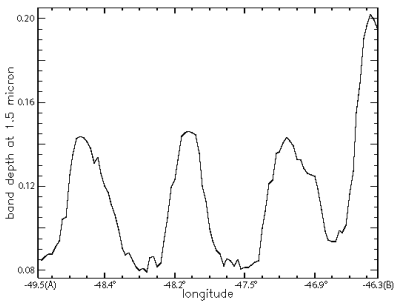

Figure 2: band depth at 1.5 µm versus longitude.

Water ice has its spectral signature at 1.5 µm and at 2.0 µm in the reflectance spectrum as shown in Figure 3. The figure shows 2 spectra taken respectively from a maximum and a minimum of the wave front. Gaseous CO_2 is removed according to [8].

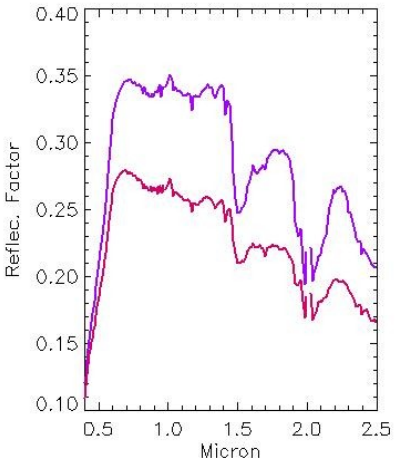

Figure 3: reflectance of a region of minimum water ice band depth (red spectrum) and a region of maximum water ice band depth (violet spectrum).

3. Summary and future work

We identify gravity waves in the Martian atmosphere using the OMEGA/MEX data. The NIR spectra show the water ice bands and we can infer the presence of waves by means of their band depth. Also the maps at 1.3 µm clearly point out the effect of GWs on the clouds. We will present the results of the GWs effect on the water ice grains by means of the radiative transfer algorithm [9] and the procedure to minimize the cost function based on Gauss-Newton procedure.

Acknowledgements

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