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Evidence for an orographic forcing of SO_2 observed above the clouds with SPICAV/Venus Express.

J.L. Bertaux (1), E. Marcq (1), A. Hauchecorne (1) and S. Lebonnois (2)
(1) LATMOS - UVSQ/CNRS/IPSL, 11 boulevard d' Alembert, 78280 Guyancourt, France (2) LMD, CNRS/UPMC/IPSL, 4 place Jussieu, 75005 Paris, France

Abstract

SPICAV UV spectrometer on board Venus Express (VEX) has routinely observed the quantity of SO_2 above the clouds. A periodogram analysis of the signal shows a distinct peak at 117 days, the length of the Venus day. The same 117 day peak was found also in the zonal wind from Venus Monitoring Camera (VMC) [1]. It is argued that this is the result of a ground-altitude forcing of both phenomena, most likely with the quantity of SO_2 observable above the clouds responding to increased vertical winds The role of orography interacting with the zonal wind and generating gravity waves propagating upward to above cloud level will be examined, as well as the LMD GCM model (containing orography) output for zonal velocity at a constant Local Time.

1. Introduction

The slow retrograde rotation of Venus, combined with the 223 days period of revolution around the sun, results in a length of the day at ground level of 117 days. This is the time interval separating two instants where a particular ground feature (i.e., Ishtar Terra mountains) experiences the same solar Local Time. Therefore, when a period of 117 days is found in one atmospheric parameter (not fixed in geography), it is an evidence that this parameter is influenced by a particular configuration of the sun w.r.t. the ground (orography or albedo feature).

2. SPICAV-UV SO_2 observations

SPICAV (Spectroscopy for the investigation of the characteristics of the atmosphere of Venus) instrument has been operating on board of the European spacecraft Venus Express since 2006 [2]. In the day side nadir mode, the 110-320 nm spectrum of solar back scattered radiation is analyzed and the SO_2 quantity above the cloud top level is extracted. A secular change of SO_2 above the clouds was revealed [3], with a peak in 2007 and subsequent decrease, a behavior reminiscent of a similar decreasing episode detected from Pioneer Venus observations [4] starting in 1978. More recently, we performed a periodogram analysis of the SO_2 quantity time series (figure 1). The peak at 1 day corresponds to orbit sampling (VEX 24 hr orbit). There is also a strong peak at 223 days, resulting from the fact that the orbit of VEX is fixed in inertial space (therefore sweeping all Local Time in 223 days), and several harmonics. The first harmonic at 112 days is distinct from another genuine peak at 117 days that we interpret as the signature of forcing from the ground.

3. Discussion

The analysis of a time series of zonal winds (derived from cloud feature tracking on UV images of VMC/VEX [1] revealed also a peak at 117 days. As a control process, a periodogram of the sampling windows was performed [1], showing a strong peak at 222 days (expected), and no peak at 117 days. Therefore, their peak at 117 days is also genuine.

On the other hand, some wave activity revealed in the UV images of VMC as long stripes of enhanced and decreased brightness (figure 2) was independently studied [5]. These periodic structures are interpreted as gravity waves at cloud top altitude (≈ 62-70 km). They are observed mainly at high northern altitudes (there is a latitude observing bias), and seem to be concentrated above Ishtar Terra (250-330° East Longitude), one major continent-size highland that includes Maxwell Montes with the highest elevations on Venus. The authors of [5] suggest that Kelvin-Helmholtz instabilities and/or surface topography could play a role in the generation of the observed gravity waves.

What will be important is to determine the phases of the periodic signals detected in both the SO_2 and the zonal wind signals, and to correlate them with the geographic position of the sun w.r.t. Ishtar Terra at maxima of the sine functions describing SO_2 and zonal wind variations.

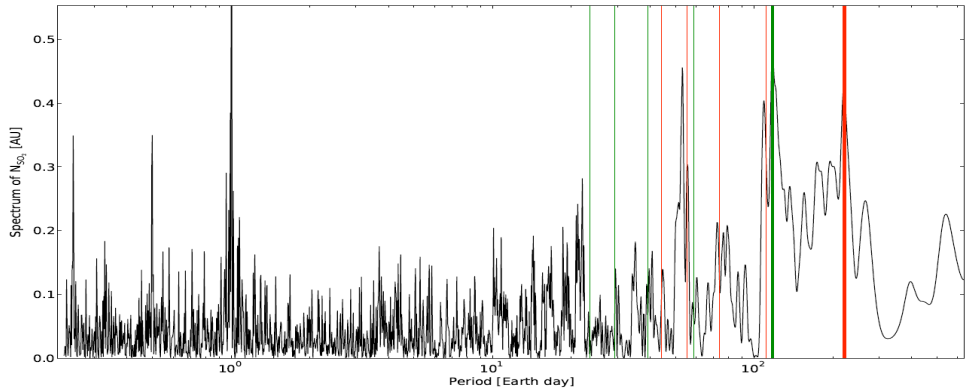

Figure 1. Periodogram of SPICAV UV nadir quantity of SO_2 above the clouds. The peak at 223 days (year of Venus) is indicated by a thick red vertical lines, and the harmonics by thin red lines. The peak at 117 days (day of Venus) is indicated by a thick green vertical lines, and the harmonics by thin green lines.

A possible scenario would be that the zonal wind interaction with Ishtar Terra obstacle generates gravity waves propagating up to cloud tops, bringing more SO_2 above cloud tops in a resulting vertical motion. At this stage, we cannot exclude in addition some feed-back mechanism from SO_2 increasing the solar heating by UV absorption.

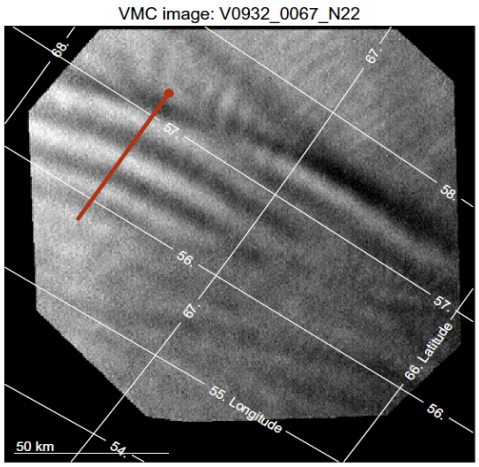

Figure 2. Example of wave packet in VMC image V0932_67 (taken from [5]).

Comparison with GCM models (with topography) will include in priority the detection of any signal taken at a constant local time that would present a 117 days periodic signature. Also, comparisons with VERA/VEX radio-occultation measurements which revealed wave activity [6] should be performed.

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