EPSC Abstracts
Vol. 7 EPSC2012-529-1 2012
European Planetary Science Congress 2012

Characterization of Atmospheric Waves at the upper clouds in the Polar Region of Venus

J. Peralta (1), D. Luz (1), D.L. Berry (2), C.C.C. Tsang (3), A. Migliorini (4), G. Piccioni (4) and P. Drossart (5)
(1) CAAUL / OAL, Lisbon, Portugal, (peralta@oal.ul.pt / Fax: +351213616752)
(2) Departamento de Física, Universidade de Évora, Évora, Portugal,
(3) Department of Space Studies / Southwest Research Institute, Boulder, CO 80302, USA,
(4) IAPS/INAF, Rome, Italy,
(5) LESIA / Observatoire de Paris, CNRS UPMC, Univ. Paris-Diderot, Meudon, France

Abstract

Non solar-fixed waves at the cloud tops of the southern polar region of Venus are studied in the winds measured with 3.9 and 5.0 μm images taken by the instrument VIRTIS-M onboard Venus Express. Wavenumbers 1, 2 and 3 are detected, with wave amplitudes ranging from 3.6 to 8.0 m/s. The evolution of the phase has been studied in 16 orbits, finding in a subset of orbits wavenumbers 1 and 2 propagating in different directions (zonal wind), and a westward progression with a phase velocity of approximately 5.7 m/s for the wavenumber 1 in the meridional wind. Finally, a new set of analytical solutions to the atmospheric waves is obtained for the planet Venus, and these are used to characterize the found waves in terms of the horizontal wavelength and phase velocity.

1. Introduction

The presence of atmospheric waves at the cloud tops of Venus has been observationally studied for a varied set of atmospheric parameters such as the winds, thermal radiation, cloud brightness distribution or the atmospheric temperature [1]. Despite the important role that waves are expected to have in the region of the polar vortex and its surroundings, the number of studies focusing on the polar region is scarce and Venus GCMs usually restrict the study of the waves propagating in lower latitudes.

2. Dataset and Technique

For the detection and characterization of the waves at the altitude of the cloud tops of Venus, we used a dataset which extends the one used by Luz et al. [2]. Pairs of images taken at 3.9 and 5.0 μm by the VIRTIS-M imaging spectrometer onboard Venus Express were selected for this study as they allow the detection of the waves using cloud top winds from the day and nightside simultaneously. The dataset of VIRTIS-M nadir images included observations from 16 orbits, covering a time span of 289 days in the latitude range 70ºS to 85ºS, and wind velocities have been retrieved using an automated technique of cloud tracking [2].

2.1 Retrieval of wave parameters

For each orbit, zonal and meridional wind deviations from the mean meridional profiles were sorted and averaged into a zonal grid of longitude intervals of ~7º (0.5 hours in local time). A spectral analysis is applied to each set, firstly applying a Lomb-Scargle periodogram to identify the presence of periodic signals, and then using the corresponding sine fits to determine the amplitude, phase and phase velocities.

2.2 Analytical approach to waves in Venus

If we apply a suitable scale analysis to the primitive equations in the Venus case, and assuming an adiabatic and frictionless atmosphere with a background wind $v_0=w_0=0$ and $u_0=u_0(y)$, we arrive at a set of equations for which we can apply the theory of perturbations. As a result, a dispersion relation (1) for sound, gravity and inertia-gravity waves was obtained for the case of Venus. This dispersion relation is quite similar to the one for the terrestrial case (3), but the Coriolis factor, f, is replaced with a parameter proportional to the intrinsic frequency σ and the difference between the meridional shear of the zonal background wind and a centrifugal frequency (2).

$$m^2 = \frac{k^2 \cdot (gB - \sigma^2)}{\sigma^2 - \xi} + \frac{\sigma^2}{c_S{}^2} - \frac{1}{4H_0{}^2} \qquad (1)$$

$$\xi = 2\frac{u_0}{a}\tan\phi\left(\frac{u_0}{a}\tan\phi - \frac{du_0}{dy}\right) \qquad (2)$$

$$m^2 = \frac{k_x{}^2 \cdot (gB - \omega^2)}{\omega^2 - f^2} + \frac{\omega^2}{c_S{}^2} - \frac{1}{4H_0{}^2} \qquad (3)$$

3. Results

A wavenumber 1 dominates the zonal wind disturbances in most of the orbits with similar amplitudes (mean value of ~4.5 m/s, up to 30% the magnitude of the zonal component of the wind in this latitude range). A wavenumber 2 is also apparent in some orbits with amplitudes generally lower than the wavenumber 1 (~3.6 m/s). Concerning the meridional disturbances, the wavenumber 1 is also dominant (see Figure 1) with amplitudes higher than for the zonal component (~8.0 m/s). The wavenumber 2, though also present is not so strong in the meridional direction, and a wavenumber 3 seems apparent in orbit 640. The evolution of the phase in both zonal and meridional disturbances is displayed in Figure 2, showing the sine troughs (retrograde acceleration for zonal winds and poleward acceleration for meridional ones). In orbits 474–479, wavenumbers 1 and 2 in zonal wind propagate in opposite direction. The phase velocity for wavenumber 1 in the meridional wind is westward and about 5.7 m/s.

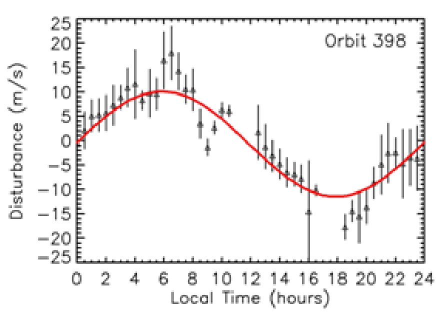

Figure 1: Wavenumber 1 apparent in the meridional wind disturbances during the orbit 398 (3.9 µm).

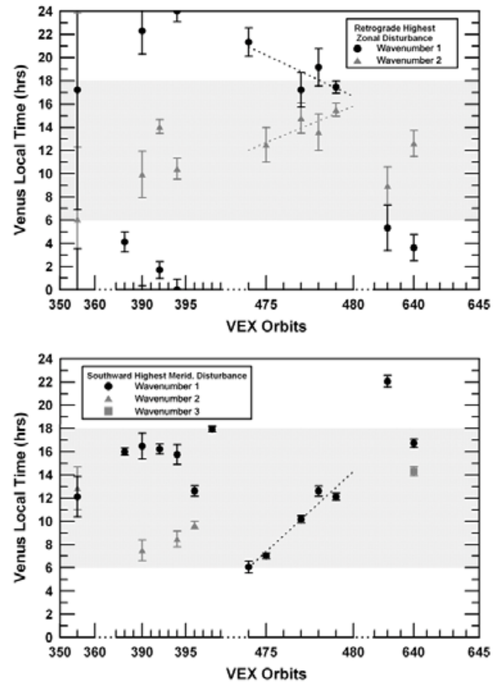

Figure 2: Troughs for the waves apparent in the zonal (up) and meridional (down) wind disturbances.

4. Summary and Conclusions

Global-scale waves with planetary wavenumbers 1 and 2 have been found in the winds at the cloud tops of the southern polar region of Venus. For the zonal disturbances, wave amplitudes are between 3 and 4 m/s with opposite sense in wavenumbers 1 and 2. For the meridional, a westward wavenumber 1 with phase velocity ~5.7 m/s is found.

Acknowledgements

J.Peralta acknowledges support from the Portuguese FCT grants (reference: SFRH/BPD/63036/2009). JP, DL and DB also thank FCT funding through projects POCI/CTE-AST/110702/2009 and PEst-OE/FIS/UI2751/2011. AM and GP acknowledge support from ASI through the contract ASI-INAF I/050/10/0.

References

[1] Forbes, J.M.: Tides in the middle and upper atmospheres of Mars and Venus, Adv.Space Res., 33, 125-131, 2004.

[2] Luz, D., et al.: Venus's Southern Polar Vortex Reveals Precessing Circulation. Science, 332, pp. 577-580, 2011.