EPSC Abstracts
Vol. 6, EPSC-DPS2011-1269, 2011
EPSC-DPS Joint Meeting 2011

Solar Tides in the winds of the southern polar region of Venus using VIRTIS-M/Venus Express images

J. Peralta (1), D. Luz(1), D.L. Berry (2), G. Piccioni (3), P. Drossart (4), R. Hueso (5) and A. Sánchez-Lavega (5)

(1) I CAAUL / Observatório Astronómico de Lisboa, Lisboa, Portugal (peralta@oal.ul.pt / Fax: +351-213-616-752), (2) Departamento de Física, Universidade de Évora, Évora, Portugal, (3) IASF / INAF, Rome, Italy, (4) LESIA / Observatoire de Paris, CNRS UPMC, Univ. Paris-Diderot, Meudon, France, (5) Dep. Física Aplicada I / Escuela Superior de Ingeniería, Universidad del País Vasco, Bilbao, Spain.

Abstract

The effect of the solar tides on the winds at the top of the clouds in Venus has been studied using cloud tracking technique applied to the Venus Express/VIRTIS-M images taken at wavelengths of 3.8 and 5.0 µm. Both these wavelengths probe about the same altitude on the clouds top, allowing for the first time to retrieve winds in the dayside and nightside simultaneously. The dataset included observations from 17 orbits, covering a time span of 290 days and a latitude range between 70ºS and 85ºS, a region where resides the so called cold collar. Both the diurnal (wavenumber 1) and the semidiurnal (wavenumber 2) tides are present, with the diurnal tide being the dominant harmonic for both the zonal and meridional components of the wind. The diurnal tide induces wind oscillations with amplitudes of about 4.5 m/s and 8.0 m/s for the zonal and meridional winds respectively. These amplitudes are in good accordance with the Rayleigh friction expected for this level of the Venus atmosphere, and support the important role of the diurnal tide in the maintenance of the mean zonal flow and in determining the sense of the meridional flow. While the tidal amplitude seems not to undergo important changes, the phase displays a temporal variability of about 1.4 hours in the local time coordinate. The rate of change of the phase seems different for the diurnal and semidiurnal component, indicative of a dispersive character of the solar tides, and is consistent with the expected change due to the tidal vertical propagation. Finally, a persistent lag is apparent in most cases between the tidal phases of zonal and meridional disturbances, implying that the diurnal tides tend to force equatorward winds when in the sense of the mean flow, and poleward winds when in the opposite sense.

1. Introduction

The superrotation of the Venus atmosphere is one of the most intriguing phenomena in the planetary atmospheric dynamics, and after several decades its mechanism still remains unclear, regardless of the more than 25 spatial missions that have explored the planet up to date. The solar tides are a plausible candidate for maintaining this superrotation, carrying momentum away from the excitation region at the subsolar point and, consequently, accelerating the excitation region in the opposite direction of the transmitted wave [3]. This special case of global-scale gravity waves are present in all types of atmospheric variables and have been observed in Venus from infrared remote sensing temperatures [6], aerosol concentrations [8], cloud brightness distribution [1] and wind measurements [4]. In the present work we characterized the solar tides in the wind field at the top of the clouds in Venus' southern polar region, which has been poorly covered by previous studies in terms of winds. To this purpose, we analyze the wind field obtained with automated cloud tracking in pairs of images taken by the instrument VIRTIS-M [2] onboard Venus Express.

2. Procedure

The winds for the detection and characterization of solar tides at the cloud tops of Venus were inferred using an improved version of the automated cloud-tracking technique by [5]. Wavelengths of 3.8 and

5.0 µm were selected for this study as they allow sensing the cloud tops both in the day and nightside [7]. The dataset of VIRTIS-M nadir images included observations from 17 orbits, covering a time span of 290 days in the latitude range from 70ºS to 85ºS. Zonal and meridional velocity disturbances relative to the zonally averaged mean flow were obtained and sorted in solar-fixed coordinates. These samples were studied with Lomb-Scargle periodograms and sinus fits in order to detect the expected solar tide oscillations. An example of solar-fixed meridional disturbances and its corresponding periodogram is displayed in Figures 1 and 2 respectively.

3. Figures

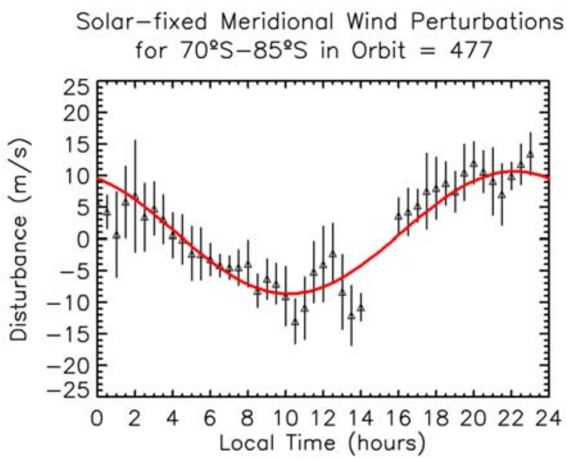

Figure 1: Solar-fixed meridional velocity disturbances and corresponding sinus fit. K=1 is apparent in this case with a wave amplitude of 9.65 m/s and highest poleward acceleration occurring close to 10pm.

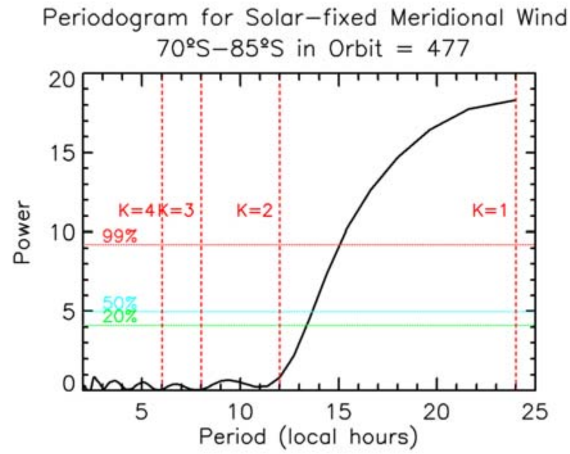

Figure 2: Lomb-Scargle Periodogram for the solar-fixed meridional velocity disturbances shown before. K=1 is apparent with power above 99% of confidence.

4. Summary and Conclusions

For the first time, the solar tides have studied in the windfield of Venus at the day and nightside simultaneously, using wavelengths sensing the cloud tops. Both the diurnal (wavenumber 1) and the semidiurnal (wavenumber 2) solar tides are apparent in a set of zonal and meridional velocities covering 17 Venus Express orbits, a time span of 290 days and a latitude range between 70ºS and 85ºS. This region is of great interest as it has been poorly covered in previous works and is related with the interesting feature called "cold-collar". The diurnal tide seems to be the dominant solar tide harmonic for both components of the wind, with the semidiurnal only present in some orbits. The diurnal tide induces wind oscillations with amplitudes of about 4.5 m/s and 8.0 m/s for the zonal and meridional winds respectively, amplitudes are in good accordance with the Rayleigh friction expected for this level of the Venus atmosphere. These zonal amplitudes implies modifications up to 20% of the zonal flow, supporting the important role of the diurnal tide in the maintenance of the mean zonal flow. On the other hand, the tidal amplitudes also seem to drastically determine the sense of the meridional flow. While the amplitude seems not to undergo important changes, the tidal phase displays a temporal variability of about 1.4 hours in the local time coordinate, rate consistent with the expected change due to the tidal vertical propagation. Finally, a persistent lag is apparent in most cases between the tidal phases of zonal and meridional disturbances, implying that the diurnal tides tend to force equatorward winds when in the sense of the mean flow, and poleward winds when in the opposite sense.

This work is expected to provide new insights on the solar tides and constrictions for the development of Venus atmospheric numerical models. Moreover, we expect that wind measurements from the VMC camera onboard Venus Express will help extending the spatial coverage of the solar tides, in addition to infer their horizontal structure. And the higher accuracy of Doppler-shift winds from ground-based observations will allow the detection of secondary harmonics and confirm the validity of our results.

Acknowledgements

J. Peralta acknowledges a Postdoctoral Fellowship by the Portuguese "Fundação para a Ciência e a Tecnologia".

References

[1] Del Genio, A.D. and Rossow, W.B.: Planetary-scale waves and the cyclic nature of cloud top dynamics on Venus, Journal of the Atmospheric Sciences, 47, 293-318, 1990.

[2] Drossart, P. and 43 colleagues: Scientific goals for the observation of Venus by VIRTIS on ESA/Venus express mission, *Planetary and Space Science*, 55, 1653-1672, 2007.

[3] Gierasch, P.J., Goody, R.M., Young, R.E., Crisp, D., Edwards, C., Kahn, R., Rider, D., del Genio, A., Greeley, R., Hou, A., Leovy, C.B., McCleese, D. and Newman, M.: The General Circulation of the Venus Atmosphere: an Assessment, in Venus II: Geology, Geophysics, Atmosphere, and Solar Wind Environment, University of Arizona Press, p. 459, 1997.

[4] Limaye, S.S.: Venus atmospheric circulation - Known and unknown, Journal of Geophysical Research, 112, E04S09, 2007.

[5] Luz, D., Berry, D.L. and Roos-Serote, M.: An automated method for tracking clouds in planetary atmospheres, *New Astronomy*, 13, 224-232, 2008.

[6] Taylor, F.W., Beer, R., Chahine, M.T., Diner, D.J., Elson, L.S., Haskins, R.D., McCleese, D.J., Martonchik, J.V., Reichley, P.E., Bradley, S.P., Delderfield, J., Schofield, J.T., Farmer, C.B., Froidevaux, L., Leung, J., Coffey, M.T. and Gille, J.C.: Structure and meteorology of the middle atmosphere of Venus Infrared remote sensing from the Pioneer orbiter, *Journal of Geophysical Research*, 85, 7963-8006, 1980.

[7] Tsang, C.C.C., Irwin, P.G.J., Taylor, F.W. and Wilson, C.F.: A correlated-k model of radiative transfer in the near-infrared windows of Venus, *Journal of Quantitative Spectroscopy & Radiative Transfer*, 109, 1118-1135, 2008.

[8] Zasova, L., Khatountsev, I.V., Ignatiev, N.I. and Moroz, V.I.: Local Time Variations of the middle atmosphere of Venus: Solar Related Structures, Advances in Space Research, 29, 243-248, 2002.