EPSC Abstracts
Vol. 7 EPSC2012-18 2012
European Planetary Science Congress 2012

Temporal variations of zonal wind speed at Venus cloud tops from Venus Monitoring Camera UV images

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Abstract

Venus Monitoring Camera (VMC) [1] on board the Venus Express mission obtained great number of UV images of the upper cloud. The observations cover about 10 Venusian years. 600 orbits or about 25% of all available UV images were processed by the digital wind tracking routine resulting in ~400000 vectors for the whole period of observations. Mean profiles were calculated for individual orbits. Time series of zonal speed for 5 degrees latitude bins centered at 10, 15, 20, 25 and 30 South were created from the individual mean profiles. The time series were investigated for periodicities by using Deeming algorithm [2] for unequally-spaced data. Two groups of the periods were found. The first group is close to the period of superrotation at low latitudes (4.83±0.1 days) with the period 4.1-5.1 days and the amplitude ranging from ±4.26 to ±17.44 m/s. The amplitude and phase of oscillations demonstrates dependence from the latitude and also time variability with preserving stable parameters of oscillation during at least 70 days. The second one is a long term periods caused by orbital motion of Venus (116 days, 224 days) and is related to the periodicity in the VMC observations.

1. Introduction

Mean zonal circulation of the Venusian mesosphere demonstrates significant variability reaching several tens of m/s in low latitudes. We analyzed the time series of the zonal wind speed $u_z(t)$ for periodicities. Time coverage by UV observations is about 10 Venusian years. Measurements of the zonal wind $u_z(t)$ are rather unequally distributed over the mission time. In order to study latitudinal dependencies we applied the analysis separately to 5º latitudinal bands centered at 10, 15, 20, 25, 30 and 35ºS.

2. Long term variations

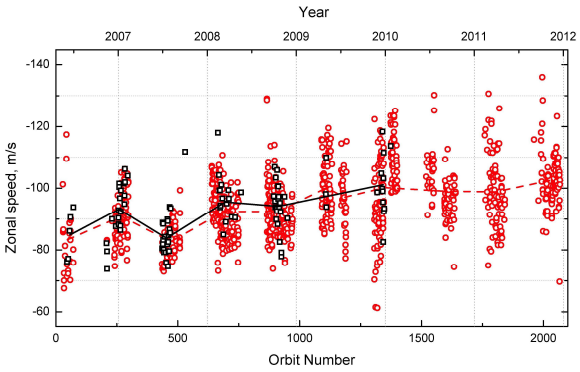

Figure 1: Long term trend of the mean zonal winds at 20º±2.5ºS over the mission time. Black squares orbital averages derived by manual (solid line) and digital (dashed line) methods.

The wind measurements at low latitudes are grouped in “seasons” of about 100 days associated with VMC dayside observations (Figure 1). The analysis of the grouped data usually results in aliasing periods. For this reason for frequency investigations of $u_z(t)$ we applied special technique based on Fourier analysis [2-3].

The time series $u_z(t)$ contains a low frequency trend with a period of ~2850 days which origin is unclear. In this case it may be a manifestation of influence of the solar activity on dynamics of the equatorial region of the Venusian atmosphere.

The trend was subtracted from the time series and analysis of the residual series was continued. We found periodic oscillations of the zonal wind flow with period of 116.92±5.21 days. It is very close to solar day on Venus (116.8 days) suggesting that the long period variations of the mean zonal flow have solar-related behavior. All other long term periods are the aliasing of the found periods.

3. Short term variations

In the equatorial region the time variations of zonal flow have periodic behavior. Deeming algorithm [2] was applied to all "seasons" of observations. The results are presented in Table 1. Analysis of all time series provides a period near the superrotation period of ~4.83±0.1 days with the amplitude ±4.28±0.13 m/s.

Table 1: *Periodicities in the zonal wind speed*

Orbits	Period, days	Mean speed, m/s	Amplitude, m/s
0029-0072	4.18	-84.78	±12.01
0210-0298	5.01	-92.19	±4.35
0436-0510	4.10	-86.63	±8.06
0640-0750	4.83	-94.30	±7.77
0866-0944	4.50	-91.51	±6.00
1090-1193	4.85	-101.39	±11.16
1329-1347	4.50	-102.28	±17.44
1374-1401	4.63	-112.55	±10.29
1595-1636	4.25	-96.61	±4.26
1760-1842	4.15	-101.56	±7.12
2034-2068	4.42	-103.90	±3.75
ALL	4.83	-96.10	±4.28

The maximum amplitude of the oscillations of zonal speed was detected at the level of ±17.44±1.60 m/s in the equatorial region for orbits #1329-1347. The corresponding period is equal to 4.5±0.1 days. The phase diagram for equatorial latitudinal zone representing the mean speed variations converted to one period are shown in Figure 2 together with the original data points. For clearness the phase diagram contains more than 1 cycle (after phase 1.0 the data are repeated). The error of the wind speed measurements is 5-7 m/s. The amplitude and phase of oscillations demonstrates dependence on latitude and time while preserving stable parameters of oscillation for at least 70 days.

4. Summary and Conclusions

Mean zonal wind speed demonstrates the long term variations. Mean zonal speed in the equatorial region changes in the range 85-115 m/s. A slow trend is observed over the time scale of 2850 days that might be a manifestation of the solar activity.

The long-period variations have solar-related behavior with the period of 116.92±5.21 days.

In the equatorial regions short term oscillations of the zonal wind speed were detected. Short term oscillations are characterized by the mean period of ±4.83 days which is close to the superrotation period. It may be caused by wave processes in the mesosphere of Venus at the cloud top level. Wave number of the observed oscillations is 1.

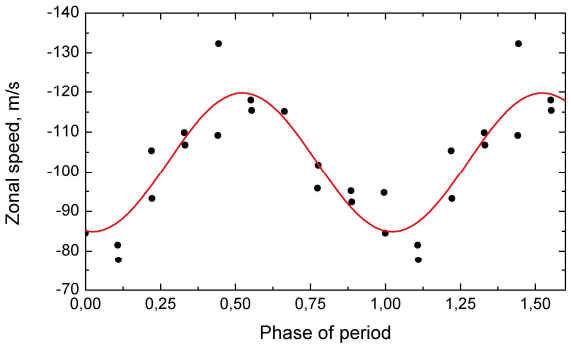

Figure 2: Phase diagram for orbits #1340-1347 (solid lines) together with the measured wind velocities (dots) for equatorial latitude zone.

Acknowledgements

This work has been supported by the Ministry of Education and Science of Russian Federation grant No. 11.G34.31.0074.

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