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Correlation of the cloud top wind pattern with cloud morphology at the upper cloud level of Venus at 25°S-75°S from VMC/Venus Express

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Abstract

The Venus Monitoring Camera (VMC) [3] obtained a set of UV images of the upper cloud level during the Venus Express mission. The images were processed by a digital tracking method [1] which analyses correlations between pairs of UV images separated in time. The method allows us to track displacements of cloud features and compute wind velocities.

The comparison of VMC images with plots of wind speed fields shows a relationship between cloud features at the middle latitudes and parameters of the circulation. It can be attributed to the motion of global cloud features, like the Y-feature, due to the super-rotation of the atmosphere.

Introduction

Compact and easily identifiable cloud features are typical for low latitudes. They provide reliable results in the study of zonal and meridional winds at these latitudes. In middle latitudes, cloud details elongated in the zonal direction (streaks) [6] lead to increase of positioning errors causing wider scatter of wind velocities. The mid-latitude jet bulge [1] visible in some zonal velocity profiles can be invisible in other cases [2, 4, 5]. Using the bulk of data processed we tried to clarify the reasons assuming that this phenomenon is not caused only by increasing positioning errors.

The region, where the meridional velocity has a global maximum observed at latitude 50°S between 13:00-15:00 local time [1], was of primary concern also.

Single orbit results

The ramified part of the well-known Y-structure is formed by strong streaks noticeably tilted to latitude circles. Fig. 1 is an example of the image with strong dark streaks crossing latitude circles at high angle in the centre of the image. Such orbits demonstrate the influence of largescale cloud features (probably, the Y-structure) onto the behavior of mesoscale cloud features due to the super-rotation thereby increasing the data spread. The latitudinal profile of the mean zonal velocity for such orbits does not always show the jet bulge because the zonal velocity increases within a short time interval. There are images containing no strong streaks (Fig. 2). Such orbits demonstrate a visible mid-latitude jet bulge.

The set of 257 orbits providing the best spatial coverage has been analyzed. Areas where the wind velocity deflects from the zonal direction were of special interest. We searched for the maximum deflection angle in each orbit using regions 2h×15° in size. Depending on the orbit, the deflection angle changes from -18.5° ± 2.4° to -0.4° ± 2.1°. 30 orbits with the deflection angle below -13° were found. All the analyzed orbits exhibited relations between the angle value and the cloud morphology. The position of the area where the wind velocity has maximum deflection depends on the position of a sharp streak (if present) in the image. The area can lie within the local time interval from 12:00 to 15:00 and the latitudinal range from 40˚S to 55˚S.

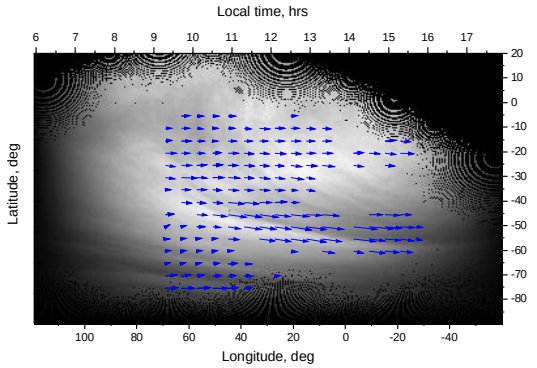

Figure 1: Wind vectors superimposed onto a rectangular projection of UV image 0025 (orbit 0445) containing **a strong streak**. Velocities obtained from all pairs of images were averaged within areas 6°×5°.

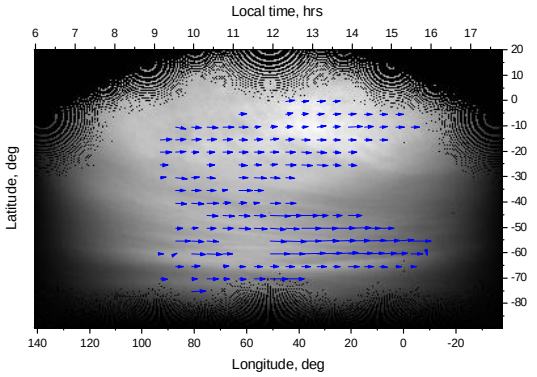

Figure 2: Wind vectors superimposed onto a rectangular projection of UV image 0020 (orbit 0686) containing **no strong streak**.

Averaged deflection angles

Deflection angles obtained by the digital correlation method have been averaged with respect to all 257 orbits for the period from May 2006 to September 2013. The maximum was found at 14:00 local time in 50°S. In the sub-polar region the flow slightly deflects to the equator at morning hours. This deflection we attribute to activity of the polar vortex. The latitude 60°S corresponds to the lower (high-latitude) streak boundary and separates the motion in sub-polar and middle latitudes.

Summary and Conclusions

There is a relationship between the wind pattern at the cloud top and the cloud morphology in the middle latitudes. If the streak at some image intersects latitude circles at a large angle, the flow direction is different on opposite sides of the streak, and there is no jet stream in such orbits.

For the set of 257 orbits the maximum flow deflection angle changes from -18.5º ± 2.4º to -0.4º ± 2.1º. Its position depends on the streak position in the image.

The map of mean deflection angles demonstrates: 1) angle maximum at 14:00 local time in 50°S, 2) in the sub-polar region the flow slightly deflects to the equator at morning hours.

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