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Cloud level winds from the Venus Express Monitoring Camera imaging

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ABSTRACT

Six years of continuous monitoring of Venus by European Space Agency's Venus Express orbiter provides an opportunity to study dynamics of the atmosphere our neighbor planet. Venus Monitoring Camera (VMC) on-board the orbiter has acquired the longest and the most complete so far set of ultra violet images of Venus. These images enable a study the cloud level circulation by tracking motion of the cloud features. The highly elliptical polar orbit of Venus Express provides optimal conditions for observations of the Southern hemisphere at varying spatial resolution. Out of the 2300 orbits of Venus Express over which the images used in the study cover about 10 Venus years. Out of these, we tracked cloud features in images obtained in 127 orbits by a manual cloud tracking technique and by a digital correlation method in 576 orbits. Total number of wind vectors derived in this work is 45,600 for the manual tracking and 391,600 for the digital method. This allowed us to determine the mean circulation, its long-term and diurnal trends, orbit-to-orbit variations and periodicities. We also present the first results of tracking features in the VMC near-IR images. In low latitudes the mean zonal wind at cloud tops (67 ± 2 km following: Rossow, W.B., Del Genio, A.T., Eichler, T. [1990]. J. Atmos. Sci. 47, 2053–2084) is about 90 m/s with a maximum of about 100 m/s at 40–50°S. Poleward of 50°S the average zonal wind speed decreases with latitude. The corresponding atmospheric rotation period at cloud tops has a maximum of about 5 days at equator, decreases to approximately 3 days in middle latitudes and stays almost constant poleward from 50°S. The mean poleward meridional wind slowly increases from zero value at the equator to about 10 m/s at 50°S and then decreases to zero at the pole. The error of an individual measurement is 7.5–30 m/s. Wind speeds of 70–80 m/s were derived from near-IR images at low latitudes. The VMC observations indicate a long term trend for the zonal wind speed at low latitudes to increase from 85 m/s in the beginning of the mission to 110 m/s by the middle of 2012. VMC UV observations also showed significant short term variations of the mean flow. The velocity difference between consecutive orbits in the region of mid-latitude jet could reach 30 m/s that likely indicates vacillation of the mean flow between jet-like regime and quasi-solid body rotation at mid-latitudes. Fourier analysis revealed periodicities in the zonal circulation at low latitudes. Within the equatorial region, up to 35°S, the zonal wind show an oscillation with a period of 4.1–5 days (4.83 days on average) that is close to the super-rotation period at the equator. The wave amplitude is 4–17 m/s and decreases with latitude, a feature of the Kelvin wave. The VMC observations showed a clear diurnal signature. A minimum in the zonal speed was found close to the noon (11–14 h) and maxima in the morning (8–9 h) and in the evening (16–17 h). The meridional component peaks in the early afternoon (13–15 h) at around 50°S latitude. The minimum of the meridional component is located at low latitudes in the morning (8–11 h). The horizontal divergence of the mean cloud motions associated with the diurnal pattern suggests upwelling motions in the morning at low latitudes and downwelling flow in the afternoon in the cold collar region.

1. Introduction

Dynamics of the Venus atmosphere is one of the main puzzles in the planetary physics (Schubert et al., 2007; Limaye, 2007). Near

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