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Cloud tracked winds at the lower cloud level using Venus' night side observations at 2.28 μm with TNG/NICS

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Abstract

We present results based on observations carried out with the Near Infrared Camera and Spectrograph (NICS) of the *Telescopio Nazionale Galileo* (TNG), in La Palma, on July 2012. We observed for periods of 2.5 hours starting just before dawn, for three consecutive nights. We acquired a set of images of the night side of Venus with the continuum K filter at 2.28 microns, which allows to monitor motions at the lower cloud level of the atmosphere of Venus, close to 48 km altitude. Our objective has been to measure the horizontal wind field in order to characterize the latitudinal zonal wind profile, to study variability, to help constrain the effect of large scale planetary waves in the maintenance of superrotation, and to map the cloud distribution. These observations were part of the network of ground-based observations of Venus coordinated with ESA's Venus Express orbiter for the 2012 Venus transit campaign. Ground-based observations are complementary to orbiter measurements, allowing simultaneous determination of the winds. We will present first results of cloud tracked winds from ground-based TNG observations and winds retrieved from coordinated space-based VEx/VIRTIS observations.

1. Introduction

The atmosphere of Venus is in superrotation, a state in which its averaged angular momentum is much greater than that corresponding to co-rotation with the surface. The circulation up to the cloud tops is characterized by an increasing zonal retrograde wind (in the East-West direction). The wind starts to build up at 10 km and amplifies with altitude, reaching a maximum at cloud tops ($\sim$ 70 km), where the atmosphere rotates about 60 times faster than the surface. Although the clouds are almost featureless in visible light, there are prominent features in UV and infra-red wavelengths. Dominant length scales are larger than 1000 km and few features are smaller than 20-30 km [6]. The cloud deck extends in altitude from 45 to 70 km, and can be divided into three main regions, centered at 48, 54 and 60 km [1]. The lowest of these is the lower cloud, where fundamental dynamical exchanges that help maintain superrotation are thought to occur [2]. The lower venusian atmosphere is a strong source of thermal radiation, with the gaseaous CO_2 component allowing radiation to escape in windows at 1.74 and 2.28 μm. At these wavelengths radiation originates below 35 km, and unit opacity is reached at the lower cloud level, close to 48 km. Therefore, in these windows it is possible to observe the horizontal cloud structure, with thicker clouds seen silhouetted against the bright thermal background from the low atmosphere.

2. Method and results

Our objective is to provide direct absolute wind measurements and a map of cloud distribution at the lower cloud level in the Venus troposphere, in order to complement Venus Express (VEX) and other ground-based observations of the cloud layer wind regime. By continuous monitoring of the horizontal cloud structure at 2.28 μm (NICS Kcont filter), it is possible to determine wind fields using the technique of cloud tracking. We acquired a series of short exposures of the Venus disk. The best 10% of images have been selected, registered to a common coordinate system and co-added to form image A. A subsequent series were taken at a later time, forming image B. Cloud displacements in the night side of Venus, between images A and B, can be computed using both an automated technique [3] and a visual one [5]. This observing strategy was similar to the one used previously by Young et al. [9] and Tavenner et al. [8] at IRTF (Fig. 1). The Venus apparent diameter at observational dates was greater than 32" allowing a high spatial precision. The 0.13" pixel scale of the the NICS narrow field camara allowed to resolve $\sim$ 3-pixel displacements. The absolute spatial resolution on the disk was $\sim$ 100 km/px at disk center, and the (0.8–1") seeing-limited resolution was $\sim$ 400 km/px. By co-adding the best images and cross-correlating regions of clouds the effective resolution was significantly better than the seeing-limited resolution. In order to correct for scattered light from the (saturated) day side crescent into the night side, a set of observations with the Br_γ filter were performed. Cloud features are invisible at this wavelength due to the high optical depth of the gaseous CO_2 component, and this technique allows for a good correction of scattered light [8].

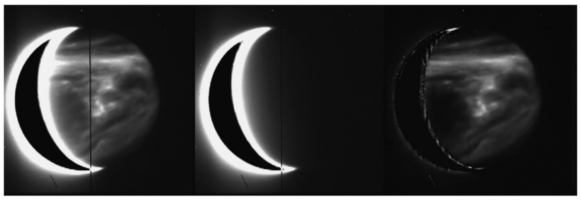

Figure 1: (From Tavenner et al., 2008 [8]): From left to right, a Continuum-K image, a Bracket-gamma, and the result of subtracting a scaled Bracket-gamma image from the one taken in Continuum-K. The black line seen in the first two images is from the IRTF SpeX slit. On these images the dark regions are clouds, the bright regions are optically thinner areas between the clouds that allow thermal emission from the lower atmosphere to escape, and the outlined crescent is the saturated day side of the planet. Images from September 14, 2007.

The data analysis is ongoing. In this poster we will present the progress made and first results of cloud tracked winds for the Venus lower cloud in the night side. With a 3 hr baseline we expect to obtain about 5 m/s resolution on cloud feature velocities [9], which provides a basis for comparison with VEX-VIRTIS measurements [7].

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