EPSC Abstracts
Vol. 11, EPSC2017-525, 2017
European Planetary Science Congress 2017

Akatsuki (space based cloud-tracking) and TNG/HARPS-N (ground based Doppler velocimetry) coordinated wind measurements of cloud top Venus' atmosphere

R. Gonçalves (1), P. Machado (1), J. Peralta (2), Y. J. Lee (2), T. Widemann (3), A. Harutyunyan (4)
(1) Institute of Atrophysics and Space Science IA, Lisbon Portugal, (2) Japanese Aerospace Exploration Agency JAXA, Japan (3) LESIA - Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique and Observatoire de Paris, Université Paris-Diderot, Meudon, France (4) Telescopio Nazionale Galileo, TNG, and Italian Instituto Nazionale di Astrofisica (INAF) (rgoncalves@oal.ul.pt)

Abstract

We present wind velocity results based in the measurements of the horizontal wind field at the cloud top level of the atmosphere of Venus, near 70 km altitude in the visible range on the dayside. The purpose is to characterize the zonal and meridional wind latitudinal behavior and profiles on hour and day timescales, to study wind variability and to constrain the effect of large scale planetary waves, as is the case of the Y shape Venus' wave [2].

The observations (28-29 January 2017) were carried out at the "Telescopio Nazionale Galileo" (TNG) with the spectrograph "High Accuracy Radial velocity Planet Searcher" (HARPS-N). The ground based observations were coordinated with the Japan Aerospace Exploration Agencie's (JAXA) Akatsuki satellite. Venus Climate Orbiter (VCO) "Akatsuki" is currently the only spacecraft operating in Venus' orbit. The ground observations probed the cloud top layer (70km altitude) using the Doppler velocimetry method, enabling a cross-validation with Akatsuki cloud-tracking technique.

HARPS-N is the most stable and precise high resolution spectrograph observing the northern skies in the world, and it was especially made for extrasolar planet searches. However, the stability of the HARPS-N spectrograph provided unprecedented high quality spectra at Venus atmosphere, which allow us to retrieve wind velocities with an unmatched precision and spatial and temporal accuracy. With the data obtained now, we would contribute to better constrain the zonal wind, the meridional wind flow and detect and characterize mesoscale atmospheric waves on Venus' atmosphere. With this project, TNG and HARPS-N opened a new window for Planetary Systems atmospheric characterization. The 3.58-meter Telescopio Nazionale Galileo (TNG) and the Visible Spectrograph HARPS-N provide a highly resolved (115.000) spectrum in the visible range (0.38-6.9 µm). The sequential technique of visible Doppler velocimetry (fine-tuned for CFHT/ESPaDOnS [5], [6] and adapted for the fiber-fed spectroscope HARPS-N) has proven a reference technique to measure instantaneous zonal and meridional winds and is the only technique to retrieve meridional wind profiles for both hemispheres simultaneously, with consistent results [5], [6]. These measurements are necessary to help validating Global Circulation Models (GCMs) [3], and to extend the temporal coverage of available datasets

The TNG observations focused on the zonal wind field near equator (latitudes between 10° S and 10° N) and meridional wind field between latitudes 60° S and 60° N (both hemispheres). The measured meridional wind flow will be compared with a model of a 20 ms-1 meridional wind flow. The zonal wind measures included various points of the dayside hemisphere, between 10° N and 10° S, by steps of 5°, and from sub-Earth longitude [ϕ - ϕE] = -23 to -56. We compared our measurements with simultaneous observations using the instrument from the Akatsuki mission (VCO).

1. Introduction

In the Venus' lower mesosphere (65-85 km), visible observations of Doppler shifts in solar Fraunhofer lines have provided the only Doppler wind measurements near the cloud tops in recent years [4], [5], [6], [7], [8]. The region is important since it constrains the global mesospheric circulation in which zonal winds generally decrease with height while thermospheric SS-AS (Subsolar-Antisolar) winds increase [1]. On Akatsuki, atmospheric circulation at 70 km was measured with cloud tracking techniques. However, winds derived in this manner are mean velocities about time intervals or more than 30 minutes and do not reflect instantaneous wind velocity and its significant variability at shorter time scales.

2. Method and Results

With HARPS-N, the complete optical spectrum, from 383 to 690 nm, is collected over 40 spectral orders in a single exposure at a resolution of about 115,000. In the single scattering approximation, the Doppler shift measured in solar light scattered on Venus dayside is the result of two instantaneous motions: (1) a motion between the Sun and Venus upper clouds particles, which scatter incoming radiation in all directions including the observer's; this Doppler velocity is minimal near Venus sub-solar point; (2) a motion between the observer and Venus clouds, resulting from the topocentric velocity of Venus cloud particles in the observer's frame; this effect is minimal near Venus sub-terrestrial point. The measured Doppler shift is the sum of those two terms. It therefore varies with planetocentric longitude. The Doppler shift vanishes at the half phase angle meridian (see Figure 1), where both terms cancel each other [5], [6] and we use this meridian as "zero-Doppler-reference" to check for instrumental or calibration drifts. The Doppler velocities are modelled using two kinematical templates for the zonal wind: (1) solid rotation with v zonal = v (equator) x cos(latitude), (2) uniform retrograde velocity, v zonal = v (equator). Both models are explored within latitudinal range 60S-60N. Once the best fit is obtained, we define the acceptable domain at 2-sigma.

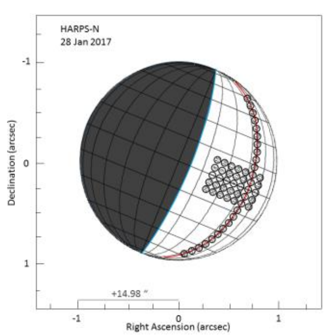

Figure 1: Schematic of Venus observations from TNG/HARPS-N. The black solid circles represent the instrument FOV (1") and each respective pointing along Venus disc. The red solid line is located at the half phase angle, which measures are used to retrieve the meridional wind. Each solid black line in the planetary grid has a step of 15º in both latitude and longitude. The axis units are set to the angular diameter of Venus, which is 14,98".

Acknowledgements

We gratefully acknowledge the collaboration of the TNG staff at La Palma (Canary Islands, Spain). We thank the Akatsuki team for support with coordinated observations. We acknowledge support from Fundação para a Ciência e a Tecnologia, projects FCT (ref. UID/FIS/04434/2013 and ref. PD/BD/128019/2016) through national funds and by FEDER through COMPETE2020 (ref. POCI-01-0145-FEDER-007672).

References

[1] Hueso, R., Peralta, J., Sànchez-Lavega, A., Icarus, Vol. 217, pp. 585-598, 2012.

[2] Imai M. et al., Icarus Vol. 278, pp 204–214, 2016

[3] Lebonnois, S. et al., J. Geophys. Res., Vol. 115, E06006, 2010.

[4] Machado, P., Luz, D. Widemann, T., Lellouch, E., Witasse, O, Icarus, Vol. 221, pp. 248-261, 2012.

[5] Machado, P., Widemann, T., Luz, D., Peralta, J., Icarus, Vol. 243, pp. 249-263, 2014.

[6] Machado, P., Widemann T., Peralta J., Gonçalves R., et al., Icarus, Vol. 258, pp. 8-26, 2017.

[7] Widemann, T. et al., Planetary and Space Science, Vol. 55, pp. 1741-1756, 2007.

[8] Widemann, T. et al., Planetary and Space Science, Vol. 56, pp. 1320-1334, 2008.