

## Wave signature found at 60 km in the Venus atmosphere

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### Abstract

We performed infrared spectroscopic measurements of the Venus' dayside to find out atmospheric wave structures at 58-64 km in the cloud layer by quantifying carbon dioxide absorption. This is the first investigation of atmospheric waves at this altitude region. This effective absorption altitude lies in between that of 70 km by the ultraviolet measurements and of 50 km by the infrared thermal emission measurements. The apparent rotation periods of wave-like signature found are 3.5, 4.9 and 8.4 days, respectively, in May 2007, November 2007 and August 2010 assuming dominance of wavenumber one structure. Those apparent periods may be interpreted as superposition of the mean zonal flow and waves such as the Kelvin and the Rossby.

## Outline

- CO<sub>2</sub> equivalent width
- cloud height deviation
- apparent rot period
- wave phase speed

## Final goal: Super Rotation

- wave info at 70 km by dayside UV and
- wave info at 50 km by nightside IR available
- wave Info at 60 km is important

Table 1: Instrumental parameters

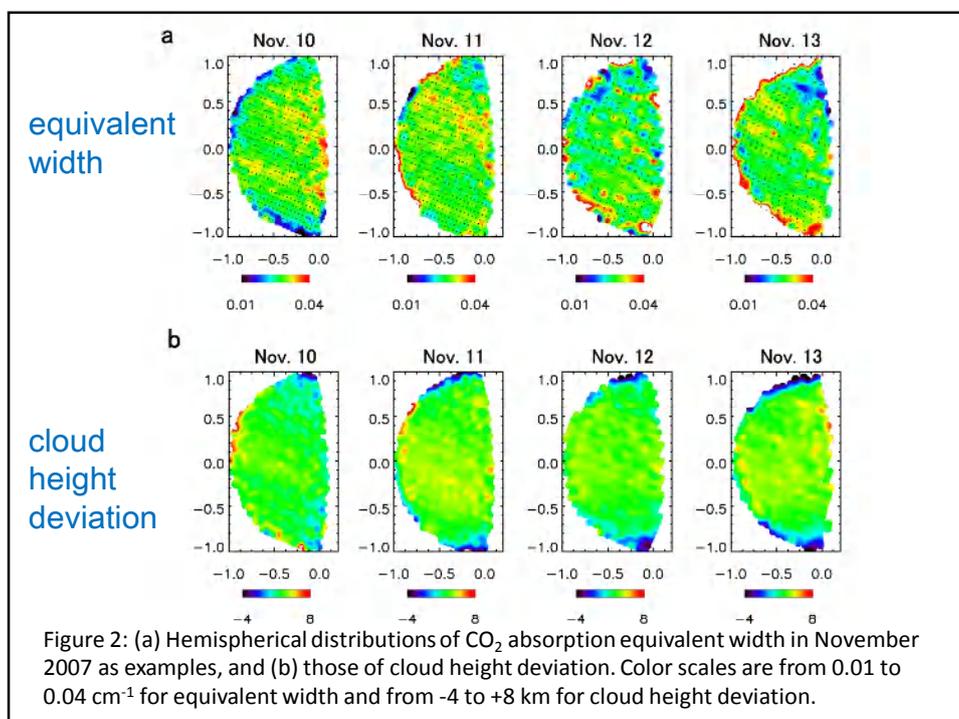
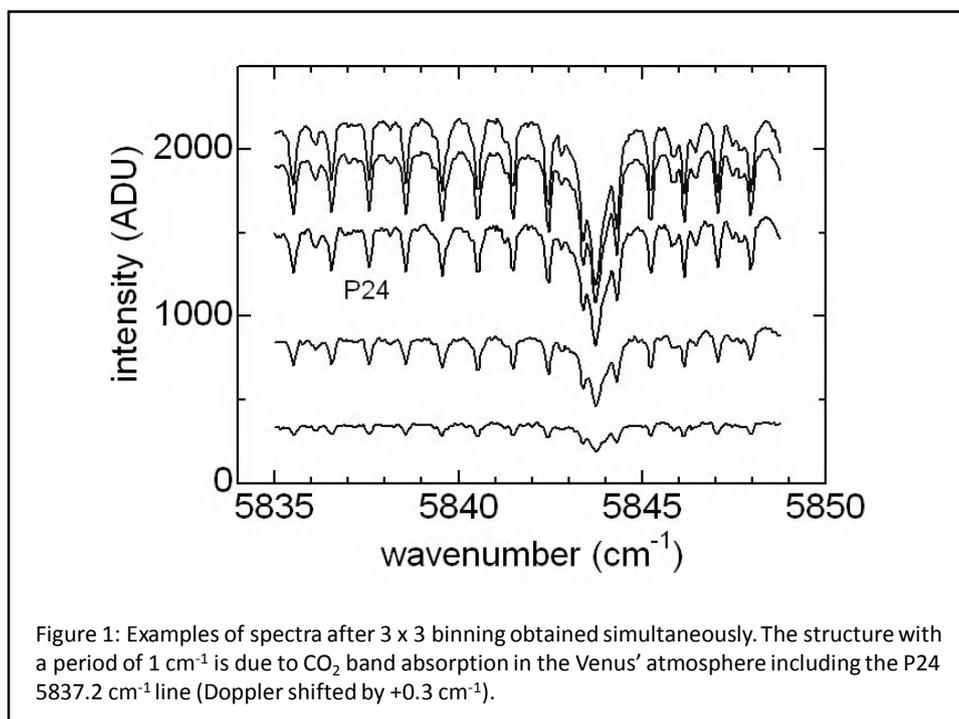
Object :	Dayside reflected sunlight
Site height:	4,200 m
Telescope diameter:	3.0 m
Spectral resolution:	36,500 (measured)
Slit width:	0.5"
Slit length:	30"
Pixel pitch:	0.2"

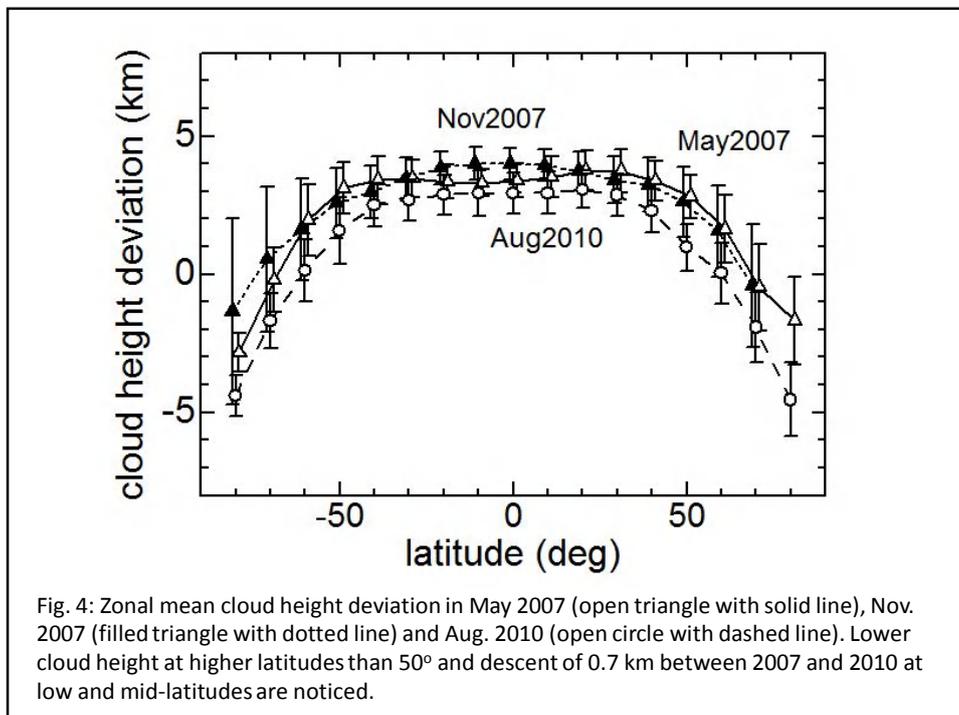
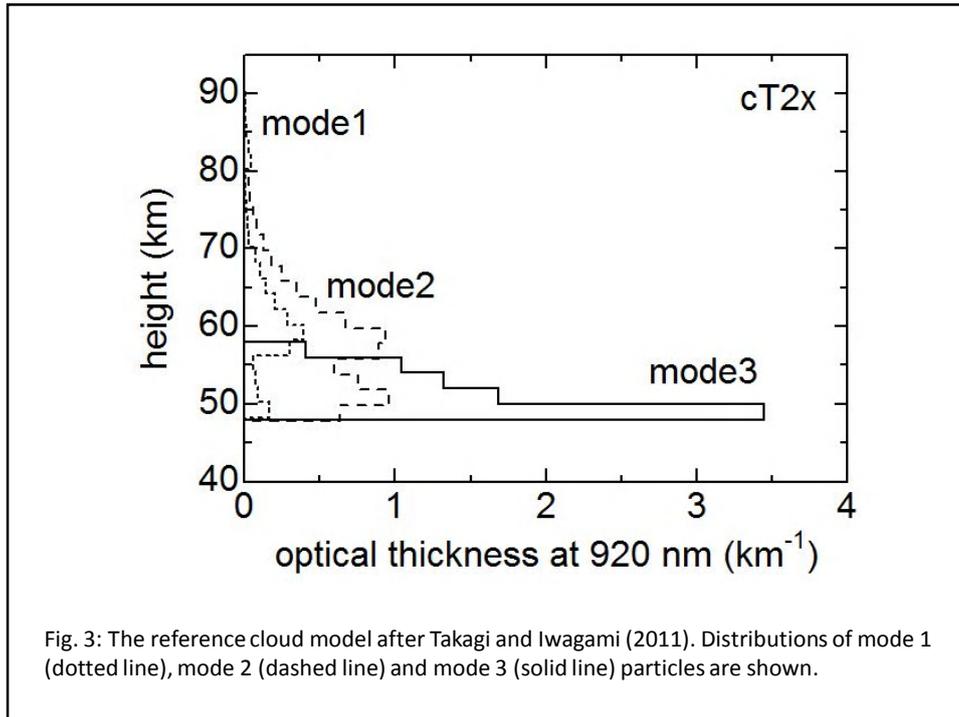
Table 2: Observation parameters

	May 2007	Nov 2007	Aug 2010
Date (HST*)	25–31**	10–13	2–9
Time (HST, hours)	18–21	05–10	15–18
Venus diameter (")	20.5	20.9	21.1
Obliquity (CCW, deg)	7.9	22.8	22.8
Phase angle (deg)	83	81	83
Doppler speed (km s <sup>-1</sup> )	-13.6	+12.7	-14.0
Typical Seeing (")	1.0	1.0	1.8
Venus' zenith angle (deg)	46–61	45–56	20–35

\*HST (Hawaiian Standard Time) = UT – 10 hours

\*\*No observation on 27 May





global map examples

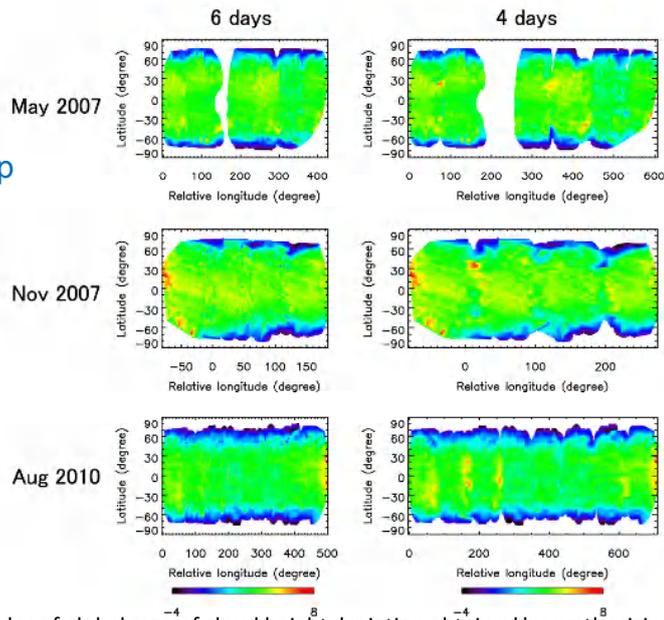


Fig. 5: Examples of global map of cloud height deviation obtained by synthesizing the hemispherical distributions such as shown in Fig. 2b. The color code is from -4 to +8 km. They are produced by assuming different rotation periods of 6 days (left) and 4 days (right).

looking for unity wavenumber structure

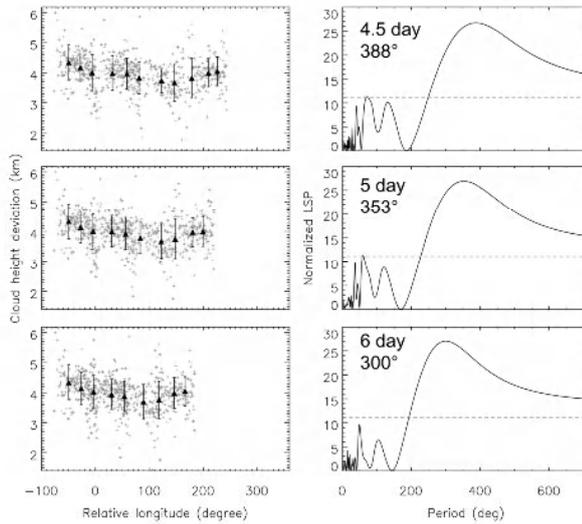
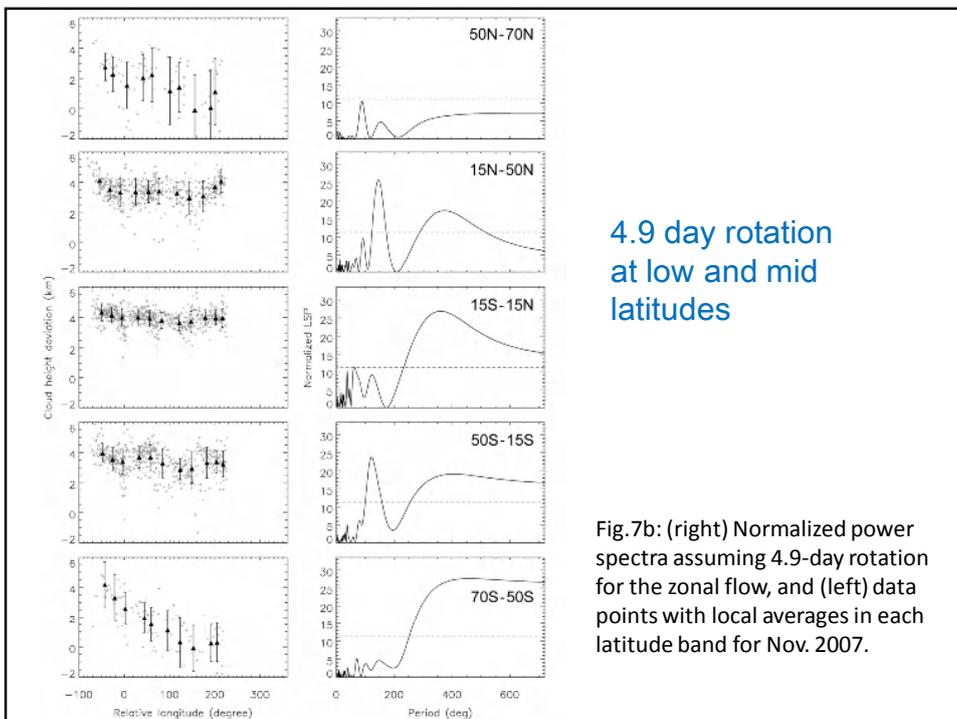
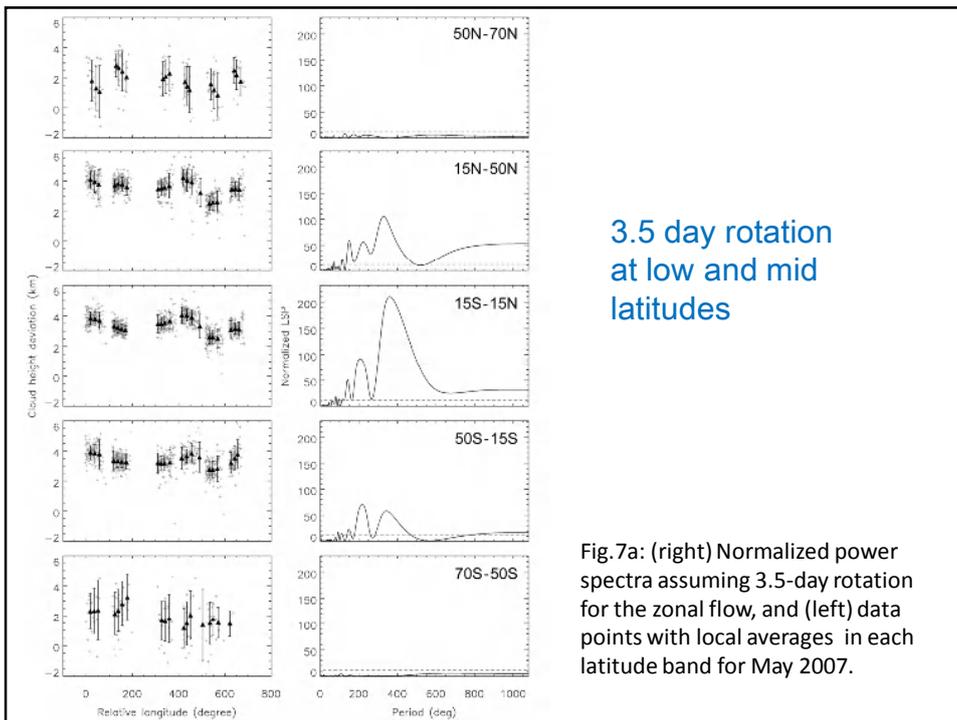


Figure 6: An example of the procedure to search for the most probable rotation period of the zonal flow for 15°S - 15°N in Nov. 2007; (right) Normalized spectral densities obtained by the LSP procedure assuming three different rotation periods (4.5, 5 and 6 days) as functions of period in unite of degree. Also the 95% significance level (horizontal dashed line) and the period of the peak position found are shown; (left) the raw data points and their local averages as functions of relative longitude.



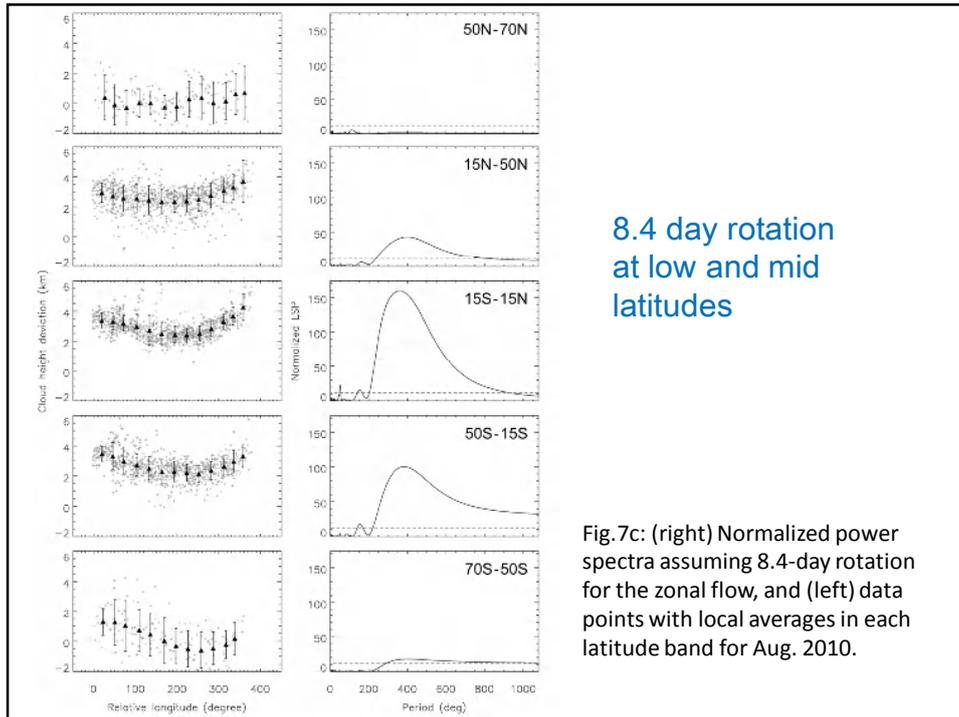
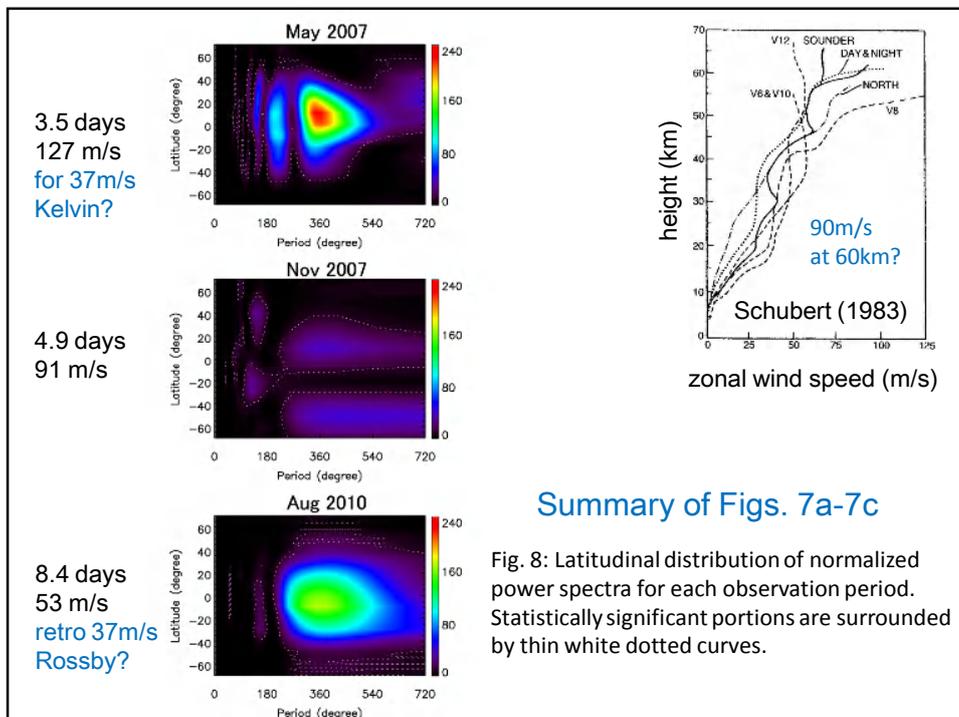


Fig. 7c: (right) Normalized power spectra assuming 8.4-day rotation for the zonal flow, and (left) data points with local averages in each latitude band for Aug. 2010.



### Summary

1. Atmospheric wave structures at 58-64 km in the cloud layer are found by using the CO<sub>2</sub> absorption equivalent width. This is a new height region for investigating atmospheric waves located between 70 km by dayside UV and 50 km by nightside IR measurements.
2. The rotation periods of the apparent structure found are 3.5, 4.9 and 8.4 days, respectively, in May 2007, Nov 2007 and Aug 2010 based on an assumption that it should show a wavenumber one structure.
3. Latitudinal distribution of the wave-like structures found in the present work are similar to those of the Kelvin wave detected near the cloud top by the UV observations; however, such wave with a period of 4 days is not found in the present height region 58-64 km.
4. The cloud altitude in 2010 is found to be 0.7 km lower than in 2007.