Monitoring of Short Term Wind and Temperature Variations in Venus Upper Atmosphere Derived from Ground-based Infrared Spectroscopy

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Motivation:

Ground-based Investigations on short term changes in the Venusian wind system with focus on the equatorial region in an altitude of ~110km

Theory & Modeling:

- stable wind system from subsolar to antisolar point and retrograde flow found
- variations from planetary scale waves predicted in the atmosphere of Venus
- strong wave activities of Kelvin waves predicted along the equator
- variation up to 12 m/s in wind velocity modeled [2]

Investigations:

- measurement north and south of equator (see Fig. 1)
- limb due to highest line-of-sight wind velocity
- resolution down to a few meters per second
- 30 measurements covering nine Earth days

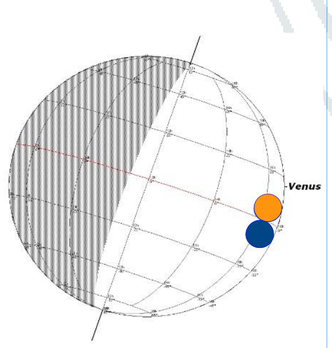


Fig. 1: measurement points; size to scale field of view; Venus' diameter was 23"

Observations:

- dates: 19th-30th March 2012
- telescope: McMath-Pierce Solar telescope on Kitt Peak with a field of view of 1.7"
- instrument: THIS (tuneable heterodyne infrared spectrometer), Cologne, high spectral resolution
- method:
  - spectra of CO_2 emission lines @ 10µm taking place in an altitude of ~110km [1]
  - Doppler shift of line center correlates with the wind velocity, line width with temperature
  - repeating measurements of the same positions which cover the time span of several Earth days

Fig. 2: McMath-Pierce Solar Telescope

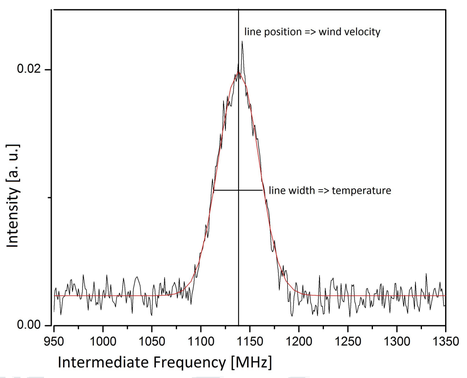


Fig. 3: Example of a measured line and needed values

Observed Winds & Temperatures:

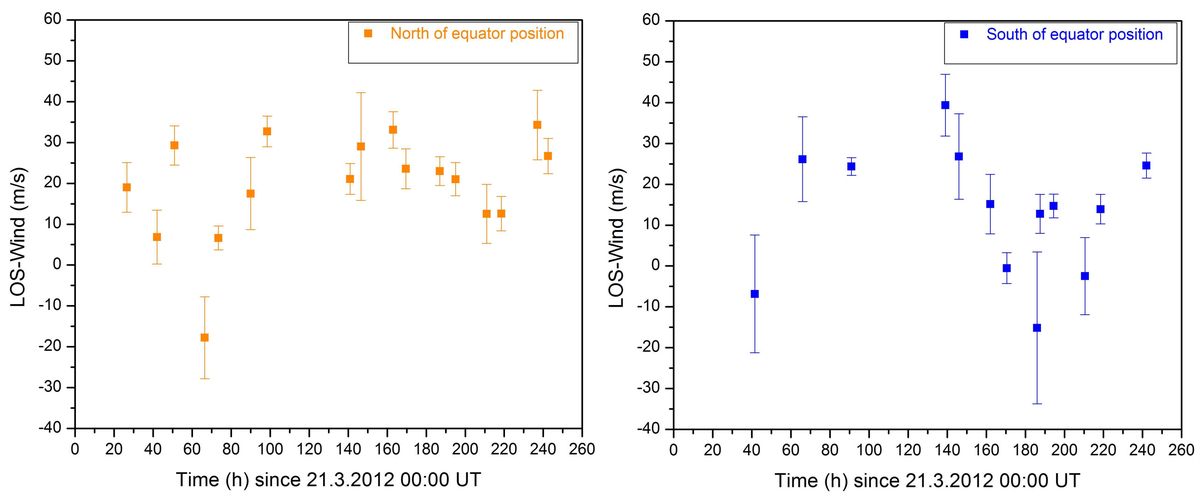


Fig.4: Measured wind velocity for the points north and south of the equator, time in hours from begin of the March 2012 measurements

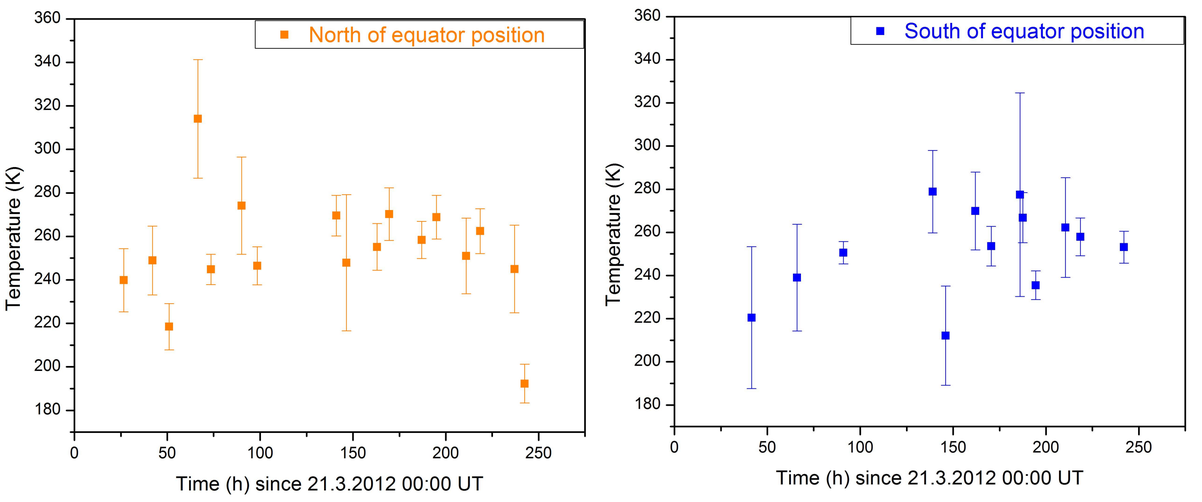


Fig. 5: Measured temperature for the points north and south of the equator, time in hours from begin of the March 2012 measurements

Interpretation & Conclusion:

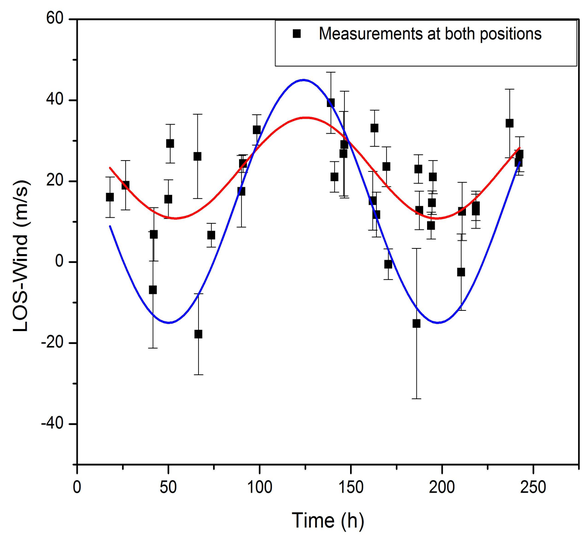


Fig.6: data points show all measured wind velocity data, the sine curves are for interpretation, red is the best sine fit blue is a fit with an exaggerated amplitude

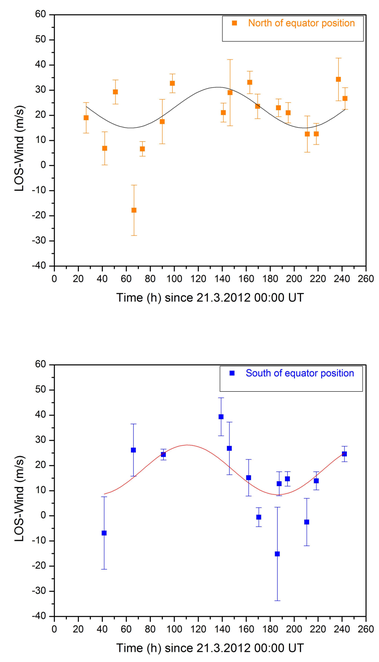
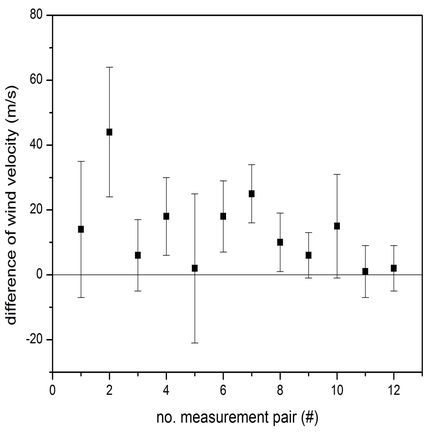


Fig.7: North (up) and south (bottom) data with best sine fit

- best fit with simple sine delivers a period of 144 h and an amplitude of 12.5 m/s for all data; reduced χ^2 is 5.4
- fits for both position deliver similar periods (north: 144 h; south 150 h)
- differences between northern and southern measurements (likewise in time) => variations over small areas



Right: Fig. 8: Plot shows the differences in the wind velocity between two measurements (positions north and south of the equator) which took place directly after each other

References:

[1] "Modelling the atmospheric CO_2 10-µm non-thermal emission in Mars and Venus at high spectral resolution" M.A.Lopez-Valverde et al 2011, Planetary and Space Science

[2] "Characteristics of planetary-scale waves simulated by a new venusian mesosphere and thermosphere general circulation model" N.Hoshino et al 2011, Icarus

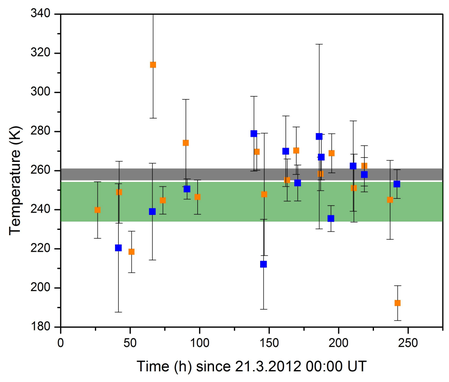
[3] "Direct observations of Venus upper mesospheric temperatures from ground based spectroscopy of CO_2" G.Sonnabend et al 2010, Geophysical Research Letters

[4] "Temperatures in Venus upper atmosphere from mid-infrared heterodyne spectroscopy of CO_2 around 10 µm wavelength" G.Sonnabend et al 2008, Planetary and Space Science

Outlook:

- long-term investigation with one instrument could show whether there are really periodic structures
- data of earlier campaign should be reanalysed to search for periodic structures
- need of a better analysis of periodic structures in the data

=> the work goes on



Left: Fig. 9: Temperature data in comparison to earlier observations in 2009 [3] (green) and 2007 [4] (grey) at the Subsolar point

- mean of this measurement is 253 ± 25 K for North and 252 ± 21 K for South point
- correspond to values from earlier observations
- temporal and spatial variations detected