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Report on Two Campaigns of Wind and Temperature Measurements of Venus' Atmosphere by Ground-Based Heterodyne Observations at 10μm

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Abstract

We report on the two recent campaigns of wind and temperature measurements of Venus' atmosphere during March and November 2013. The data are acquired by analyzing non-LTE CO_2 emission lines which are recorded by ground-based observations at 10 μm. The results show features of the dynamics in Venus' atmosphere which need to be compared to assimilable data to draw a clearer picture of the conditions in the atmosphere of our neighbor planet.

1. Introduction

The structure of Venus atmosphere has been the target of intense studies in the past decade. The recent space mission Venus Express (VEX) has shed light on many open questions concerning the thermal and the dynamical behavior of its atmosphere. As to the imminent shut down of the spacecraft and no notion of near future space missions to Venus, the importance of ground-based observations increases significantly.
We use Doppler shifted non-LTE emission lines of CO_2 at 10 μm to obtain wind velocities and temperatures in Venus' atmosphere at 110 km altitude [1]. These emission lines arise only from insolation hence our measurements are bound to the dayside of Venus. To facilitate observations of these lines from the ground, we use heterodyne spectroscopy which is an eminent technique to provide reasonable high resolution ($R \propto 10^7$) [2].

2. The Campaigns

Results of winds and temperatures from two observing campaigns during March (A) and November (B) 2013 are presented. The data were acquired at the McMath-Pierce solar telescope at Kitt Peak National Observatory in Arizona. During campaign A, Venus was almost fully illuminated (99%) and a large set of measurements along the CML, the equator and the morning and evening terminator was recorded (comp. Fig. 1). Campaign B provides measurements along the terminator and the limb of Venus with an illumination of 30% (comp. Fig. 1).

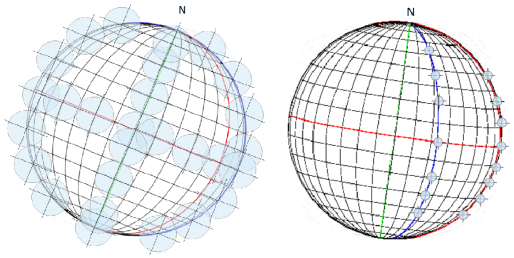

Figure 1: *Observing geometry during March (left) and November (right) 2013. In March the apparent diameter of Venus was 10" and 37" in November. The blue circles indicate the field of view (FoV) in terms of the angular diameter of the target.*

These points of measurement were chosen according to the assumption of the SS-AS flow dominating Venus' atmosphere at this altitude. However a correlation with the superrotation which is assumed to dominate the lower atmosphere cannot be excluded. In addition the measurements facilitate investigations of the short-term variations of the wind as well as they are feasible for long-term studies.

3. The Results

From the recorded CO_2 spectra we obtain the wind and temperature of Venus' atmosphere by fitting a Gaussian function (comp Fig. 2). The peak position gives the wind and the temperature is determined by the width of the line. To compare the data to previous measurements it is reasonable to check the SNR which is 1.9 for campaign A and 1.7 for campaign B.

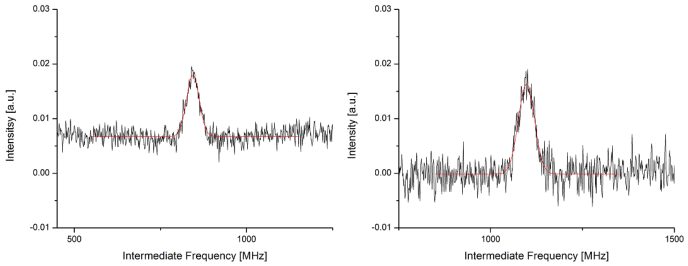

Figure 2: *Typical spectra of the campaigns A (left) and B (right).*

Several plots of the winds according to the observing geometry provide insight into the dynamics of the Venusian atmosphere. An example is a plot with respect to the SZA which shows a linear increase of the wind velocity (comp. Fig. 3). This and other interesting pictures of the wind and the temperature will be presented.

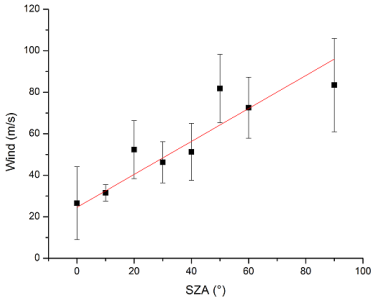

Figure 3: *Averaged wind velocities with respect to the SZA including a linear fit.*

Ongoing analysis of the variability of the wind along the equator and a comparison to previous ground-based measurements is in progress and will be presented at the conference.

References

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[2] Sonnabend, G., Sornig, M., Krötz, P., Stupar, D., Schieder: Ultra high spectral resolution observations of planetary atmospheres using the Cologne tuneable heterodyne infrared spectrometer, JQSRT, Vol.109, Issue 6, 2008.