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Thermal Structure of Venus' Dayside in 110 km Altitude Based on Ground-Based Heterodyne Observations Between 2007 and 2014

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Abstract

We present an extensive comparison of temperature measurements of Venus' upper atmosphere between 2007 and 2014. 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 thermal structure of the Venusian atmosphere in 110 km altitude which can be useful to improve modelling attempts in this altitude region. The measurements provide a large quantity of data points mapping a good part of the dayside of Venus.

1. Introduction

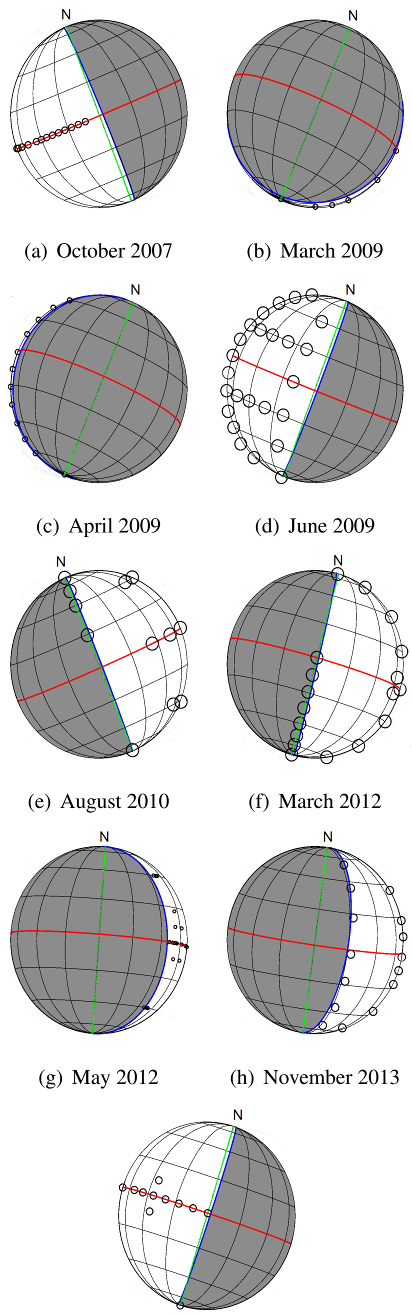
The structure of Venus atmosphere has been the target of intense studies in the past decade. The recent space mission Venus Express (VEX) has shed light on many open questions concerning the thermal and the dynamical behavior of its atmosphere. As to the imminent shut down of the spacecraft and no notion 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. Technique and Instrumentation

Generally heterodyning is the superposition of a local oscillator (LO) with the singal coming from the sky, resulting in one signal in a down converted frequency regime. Since it provides ultra high resolution ($R \propto 10^7$) it is possible to fully resolve the observed CO_2 emission lines. Additionally heterodyning in the infrared regime provides good spatial resolution which enables us to resolve the planet and observe different positions on the apparent disk of Venus.
The data presented here were recorded by the instruments THIS (Tuneable Heterodyne Infrared Spectrometer) built in Cologne, Germany [3] and HIPWAC (Heterodyne Instrument for Planetary Wind and Composition) which is the transportable follower of the first infrared heterodyne spectrometer (IHRS) developed at the NASA Goddard Space Flight Center [4,5].

3. The Campaigns

We present results of temperature measurements from nine observing campaigns between 2007 and 2014. The data were acquired at the McMath-Pierce solar telescope at Kitt Peak National Observatory, Arizona and the NASA Infrared Telescope Facility on Mauna Kea, Hawaii. During the campaigns the apparent diameter and illumination of Venus varied between 22" and 57" and 3% and 55%, respectively. Tab. 1 gives an overview of the important observational parameters for the different campaigns and Fig. 1 shows the corresponding observing geometries.



(a) October 2007 (b) March 2009

(c) April 2009 (d) June 2009

(e) August 2010 (f) March 2012

(g) May 2012 (h) November 2013

(i) March 2014

Figure 1: Observing geometries for the different campaigns indicating the equator (red), the terminator (blue) and the central meridional longitude (green). The black circles indicate the diffraction limited field of view in real scale to the diameter of Venus' apparent disk.

date	illu.[%]	size["]	Fov ["]	Instr.
Oct.2007	47	25	0.9	THIS
Mar.2009	4	57	1.6	THIS
Apr.2009	3	57	1.6	THIS
Jun.2009	50	24	1.6	THIS
Aug.2010	55	22	1.6	THIS
Mar.2012	21	23	1.6	THIS
May.2012	7	51	0.9	HIPWAC
Nov.213	33	35	1.6	THIS
Mar.2014	52	23	0.9	HIPWAC

Table 1: Important observational parameters for the different campaigns.

4. The Results

The observations yield a large quantity of temperature measurements at different positions on the planetary disk which enables us to map a good part of the dayside of Venus. Several plots will give insight into the thermal structure of Venus in 110 km altitude during the different campaigns. In Addition an extensive comparison yields a general impression of the behavior of the temperatures in Venus upper atmosphere which can be useful to improve modelling attempts.
Ongoing analysis of thermal variabilities is in progress and might add to the results which will be presented at the conference.

References

[1] Lopez-Valverde,M.A., Sonnabend, G. , M., Sornig, M., Kroetz, P.: Modelling the atmospheric CO_2 10 μm non-thermal emission in Mars and Venus at high spectral resolution. Planetary and Space Science, Vol. 59, pp. 999-1009, 2011.

[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.

[3] G. Sonnabend. Aufbau und Charakterisierung des Infrarot-Heterodyn-Spektrometers THIS., 2002.

[4] Kostiuk, T. (1994). Physics and Chemistry of Upper Atmospheres of Planets from Infrared Observations. Infrared Physics and Technology 35, 243–266.

[5] Kostiuk, T., and M. J. Mumma (1983). Remote-Sensing by IR-Heterodyne Spectroscopy. Applied Optics 22, 2644–2654.