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Temperature and Wind in the Venusian Upper Atmosphere Measured by Ground Based Infrared Spectroscopy

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Abstract

During 2010, 2011 and 2012 we accomplished five observing runs with our Tunable Heterodyne Infrared Spectrometer THIS addressing, among other issues, day-side temperatures and winds in the Venusian atmosphere at an altitude of 110 km. The aim was to track the temporal behavior as well as to obtain information about the spatial variation of these physical parameters over the entire planet.

1. Introduction

Dynamics of the Venusian atmospheric transition zone between the sub-solar to anti-solar (SS-AS) flow dominated region above 120km and the superrotation dominated region below 90km is not yet fully understood [1]. Temperatures in the same region are not very well constrained and we lack in a comprehensive understanding of this atmospheric region.

Previous observations and model calculations have shown that waves might have a significant influence at this altitude [2,3]. Therefore long and short term measurements are essential for a global understanding of the atmosphere and the validation of global circulation models.

So far space based observations can only partially provide temperatures and do not offer direct wind measurements at these altitudes e.g.[3]. Ground-based results still lack in time coverage and spatial resolution. Hence measurements on various time scales and on different locations with sufficient spatial resolution on the planet are important. Such observations are carried out with the infrared spectrometer THIS from the University of Cologne.

2. Instrument & Technique

The Tunable Infrared Heterodyne Spectrometer (THIS) was developed at the University of Cologne, I. Physikalisches Institut [5]. The ground-based receiver is transportable and can be used at various telescopes. Beside high spectral resolution ($R>10^7$) this technique also guarantees high spatial resolution on the planet. Temperatures and winds in planetary atmospheres can be retrieved from detection of narrow non-LTE emission lines of CO_2 at 10 µm. These emission lines are induced by solar radiation. Non-LTE emission can only occur within a narrow pressure/altitude region around 110km. Resolving the molecular features allow to retrieve temperatures and wind velocities. Temperatures with a precision of 5K can be calculated from the Doppler-width of emission lines and wind velocities can be determined from Doppler-shifts of emission lines with an precision up to 10 m/s.

3. Observations

Over the course of the last ~2years we accomplished five observing runs targeting Venus. Two runs did provide no or only sparse data due to bad weather. Three observing runs delivered a comprehensive data set to investigate winds and temperatures.

Most of our observation took place at the McMath Pierce Solar Telescope on Kitt Peak. This telescope provides a diffraction limited field-of-view of about 1.6”. During the observing run #2 the apparent diameter of Venus was around 10” so we could easily resolve the planet and observe different latitudinal and longitudinal positions on the planet which was almost fully illuminated. An even better spatial resolution was provided during observing run #4 with an apparent diameter of Venus of ~25”. Illumination

conditions allowed to investigate more than half of the planet.

Table 1: Overview Observations 2011/2012

#	date	telescope	quality of data	remarks
1	2010-08	McMath-Pierce Solar Telescope, Kitt Peak	sparse dataset	due to bad weather
2	2011-06	McMath-Pierce Solar Telescope, Kitt Peak	comprehensive dataset	9 days of obs.
3	2011-11	McMath-Pierce Solar Telescope, Kitt Peak	no data	due to bad weather
4	2012-03	McMath-Pierce Solar Telescope, Kitt Peak	comprehensive dataset	7 days of obs.
5	2012-05	IRTF, Mauna Kea	comprehensive dataset	6 days of obs.

The last observing run so far took place in May this year at the IRTF on Mauna Kea. This telescope provides a better field of view of around 0.7" and with an apparent diameter of Venus of ~50" we had an extraordinary good spatial resolution.

4. Results & Conclusions

Data analysis is still ongoing. From first investigations we conclude to have an indication for a small meridional wind component at the measured altitude.

In addition we took measurements in the northern and southern hemisphere close to the equator. Even though the observed positions are very close to each other there seems to be a systematic difference between the southern and the northern hemisphere.

Detailed analysis of all observations will be done until the autumn and results including conclusions will be presented at the conference.

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