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Improved Knowledge of Venus Atmospheric Structure

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Abstract

Experiments onboard the European Space Agency's Venus Express orbiter has extended our knowledge about the vertical temperature and density structure above the clouds. The observations have been obtained by different techniques at different local times and latitudes and with different vertical and horizontal resolutions and coverage.

1. Introduction

Atmospheric structure of Venus has been measured from Venera and Pioneer Venus entry probes, inferred from radio occultation method from Mariner 5 and 10 fly-by spacecraft, Venera 9-16 missions as well as Pioneer Venus, Magellan and Venus Express orbiters and retrieved from infrared, solar and ultra-violet stellar occultations from Venus Express orbiter, derived from infrared observations from Pioneer Venus and Venus Express orbiters and sampled from atmospheric drag on Pioneer Venus, Magellan and Venus Express orbiters. The numerous new results from ground-based and spacecraft observations refine our knowledge of the Venus atmospheric structure from the different experiments using different techniques.

2. Experiments Considered

In this study we considered ground-based measurements obtained recently from infrared and sub-mm experiments as well as the results of five experiments on Venus Express orbiter (**Table 1**).

Table 1. Venus Express Experiments

Experiment	Remarks
SOIR	Vertical profiles of CO_2 abundance and atmospheric temperature derived from solar occultation from CO_2 number density as well as molecular rotational temperatures from CO_2 spectral structure [1]
SPICAV	Stellar occultations allow determination of CO_2 density and temperature vertical profiles[2]
VeRa	Vertical profiles of temperature, pressure and neutral number density [3]
VIRTIS-M VIRTIS-H	Medium spectral resolution maps and High spectral resolution nadir observations [4, 5]
VIRTIS-H	Limb observations of airglow [6]
VEXADE	Atmospheric Drag Experiment using spacecraft solar panels near periapsis

Ground-based results include:

- Thermospheric temperature structure profiles [7, 8, 9]
- Transit of Venus [10]

Since the different experiments use different techniques and have different horizontal and vertical resolutions and starting assumptions, we examined the inherent measurement errors and the variability of the respective data.

Some experiments on Venus Express have multiple modes which need different methods to infer temperature or density information as a function of altitude. Further, in some case different groups have used different approaches or assumptions to analyse the same observations. Thus, it was natural to compare the results from different experiments and compare them. However, in most cases the altitude and horizontal coverage from the different experiments is different and often obtained at different times. Hence results from each experiment were binned in latitude and altitude or pressure levels and averaged to enable a comparison of the averaged results. This inter comparison is the first step in updating the Venus International Reference Atmosphere (VIRA) model adopted through COSPAR [11].

3. Main Results

The atmospheric structure knowledge has been improved from recent ground-based and spacecraft observations from cloud tops to about 200 km. Below the cloud tops no new measurements have been obtained since the VeGa balloons and the VeGa 2 lander. All experiments present a consistent picture of the thermal structure which agrees with the warming of the atmosphere by the absorption of incident solar energy in the cloud-haze layer, however, inversion layers are found in the 90-140 km region which are local time dependent. The presence of these warmer and cooler layers may be due to large scale dynamics as well as due to presence of ozone discovered by Venus Express in the thermosphere.

A greater variability in atmospheric density is observed in the 90-130km region from SOIR and SPICAV results, but the validity of such variability is as yet uncertain as it is not seen in the VeRa results or in the atmospheric drag results.

4. Summary and Conclusions

An international team formed under the auspices of International Space Science Institute (ISSI) has considered the post VIRA observations and compared the results from different experiments on Venus Express orbiter. News aspects of thermal structure have been discovered – presence of a very cold region from SOIR and SPICAV observations, presence of inversion layers – alternating warm and cooler layers above 95 km, substantial local time variations above 90 km among the significant findings. VeRa profiles show presence of small scale gravity waves. Thermal tide signatures are also present in most data but the team did not have adequate resources to look into details of the large and small scale waves.

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References

[1] Mahieux et al. (2015) PSS, Accepted.

[2] Piccialli et al. (2015) PSS, Accepted.

[3] Tellmann . et al. (2009) JGR 114.

[4] Grassi et al. (2008) JGR., 113, 2, E00B09.

[5] Migliorini et al. (2012) Icarus, 217 640–647.

[6] Gilli . et al. (2015) Icarus, 248(0):478 – 498.

[7] Clancy et al. (2012) Icarus, 217, 779-793.

[8] Sonnabend et al.(2010) G. Res. Let., 37,11.

[9] Rengel et al. (2008) PSS 56, 1688–1695.

[10] Widemann et al. (2014) American Astronomical Society, DPS meeting #46, #302.06.

[11] Kliore et al. (1985) Adv. Space Res., vol. 5, no. 11, 1985, pages 1—305.