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Temperatures and CO_2 Densities in Venus' Lower Thermosphere: Comparison of VTGCM and SOIR Profiles at the Terminator

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Abstract

The thermospheric general circulation model for Venus (VTGCM) produces results that are comparable to Venus Express (VEx) observations. This study will examine the simulated temperatures and the CO_2 density distributions near the terminators in comparison with observations from the Solar Occultation in the InfraRed (SOIR) instrument. Sensitivity tests with the VTGCM will be conducted to show possible sources of variability. The study will help characterize Venus' upper atmosphere near the terminators and give insight into the physical mechanisms responsible for the observed behaviour.

1. Introduction

Venus Express (VEx) has been observing atmospheric properties to glean information regarding the dynamics in the middle to upper atmosphere of Venus; specifically the wind system and the variability seen in the observations. The SOIR instrument, which is mounted on top of SPICAV (Spectroscopy for Investigation of Characteristics of the Atmosphere of Venus), is making measurements of CO_2, CO, and other minor species near the terminators. From CO_2 and CO measurements, temperatures can be derived [5]. Currently, terminator profiles of CO_2 densities and temperatures have been compiled for 79-selected orbits obtained between 2006-2011 (e.g. [4]). These profiles represent a global view of the atmospheric characteristics at the Venusian terminator over an altitude range from ~70 km to 170 km. These profiles show a general trend of having a strong temperature minimum around 125 km and the weaker of the two maximum temperatures near 100-115 km. The temperature structure is reflected in the corresponding CO_2 density profiles. These profiles provide detailed constraints for global circulation models of the upper atmosphere of Venus, therefore continuing the development of our understanding of Venus' upper atmosphere.

2. Data-Model Comparisons

The VTGCM is a three dimensional model that can calculate temperatures, zonal winds, meridional winds, vertical winds, and concentration of specific species. The VTGCM also computes the O_2 IR and NO UV nightglow intensity distributions. The VTGCM produces results that are comparable to recently obtained VEx data (e.g. [1], [2], [3]). Recent simulations have been conducted for conditions appropriate to the SOIR observations. In particular, solar minimum fluxes are specified and mean values of eddy diffusion and wave drag parameters are utilized.

For comparisons, VTGCM temperature profiles are extracted from the terminator that corresponds to five latitude bins (0-30N, 30-60N, 60-70N, 70-80N, and 80-90N) presently used in the SOIR data analysis. Averaging of VTGCM temperature profiles in each of these bins (at each side of the terminator) is conducted to match SOIR sampling. Initial comparisons has resulted in the VTGCM reproducing the observed temperature minimum near 125 km and the weaker temperature maximum over 100-115 km at the correct pressure level (Figure 1). However, magnitudes of simulated and measured temperatures are somewhat different. In addition, the underlying thermal balance processes are identified that give rise to the VTGCM simulated temperatures (Figure 2). Data-model comparisons will also be considered for variable VTGCM parameters, including solar minimum and moderate fluxes as well as extremes of the wave drag parameter yielding minimum and maximum terminator winds.

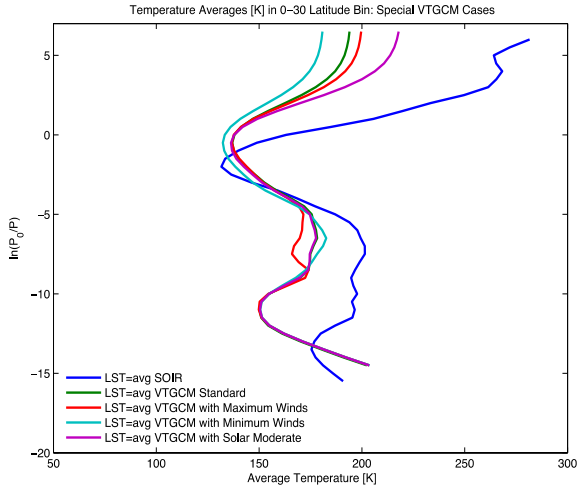

Figure 1: Averaged temperature profiles from the VTGCM and SOIR for latitudes between 0-30 north (Po = 5E-3 µbar).

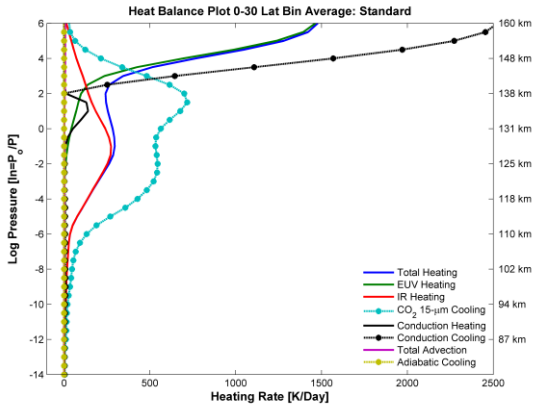

Figure 2: Averaged heat balance profiles from the VTGCM for latitudes between 0-30 north corresponding to Figure 1.

6. Summary and Conclusions

The VTGCM displays temperature and CO_2 density results which have similar trends as the SOIR observations near the terminator. Sensitivity tests have been conducted and show variability within the VTGCM simulations but the magnitude is still smaller than the SOIR observations. With direct comparison with observations and sensitivity tests, our goal is to provide an interpretation of the varying dynamics in Venus' upper atmosphere.

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