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Analysis of the radiative budget of Venus atmosphere based on infrared Net Exchange Rate formalism

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Abstract

The thick cloud cover present in the atmosphere of Venus between roughly 47 and 70 km of altitude plays a crucial role in the radiative balance of this system, by reflecting more than 75 % of the incoming solar flux back to space, absorbing half of the remaining flux, and being also optically thick over most of the infrared spectral range. The temperature profile of the atmosphere of Venus is characterized by a very hot troposphere from the surface (∼735 K) to roughly 60 km altitude, in the middle clouds. The strong greenhouse effect is provided by the 92 bars of CO_2 that is the main constituent of the atmosphere and by the thick cloud layer.

Taking advantage of the Net Exchange Rate formalism we use for the infrared radiative transfer in the atmosphere of Venus [1], a detailed analysis of the energy exchanges is proposed here. The extinction coefficients in each layer and wavelength narrow band include (1) the gas absorption opacities that are computed with *kspectrum* (see *http://www.meso-star.com/en_Products.html*); (2) collision-induced absorption (CIA) continuum; (3) cloud opacities based on the cloud model retrieved from VIRTIS/Venus Express and PMV/Venera 15 data by [2].

The computation of the mean vertical temperature profile is done with a 1-dimensional version of the LMD Venus GCM [3], forced with globally-averaged solar flux.

Balance between solar heating and infrared energy exchanges is analysed for each region: upper atmosphere (from cloud top to 100 km), upper cloud, middle cloud, cloud base, and deep atmosphere (cloud base to surface). All solar energy absorbed below the clouds are reaching the cloud base through infrared windows, mostly at 3-4 μm and 5-7 μm. The continuum opacity in these spectral regions is not well known for the hot temperatures and large pressures of Venus deep atmosphere, but strongly affects the temperature profile from cloud base to surface. From cloud base, upward transport of energy goes through convection and short-range exchanges up to the middle cloud where the atmosphere is thin enough in the 20-30 μm window to cool directly to space. Total opacity in this spectral window between the 15 μm CO_2 band and the CO_2 collision induced absorption has a strong impact on the temperature above the cloud convective layer.

We investigate how sensitive the temperature profile is to uncertainties in gas opacity and discuss the chosen cloud model and solar flux deposition profile that we use for our latest GCM simulations.

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References

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