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Three-Dimensional Venusian Ionosphere with the Venus PCM

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▪ Introduction

For twenty years, a Planetary Climate Model (PCM) has been developed for the Venus atmosphere, from the surface up to 250 km altitude ([2], [3], [4] and [5]), at “Institut Pierre-Simon Laplace” (IPSL), in collaboration with LMD (Paris), IAA (Granada) and LATMOS (Paris). With the recent implementation of the ion chemistry and ambipolar diffusion, Venus PCM (VPCM) is currently able to model the Venusian ionosphere and is validated with observations from Venus Express and Pioneer Venus.

▪ Recent implementations

Based on the works of [6,7], the VPCM was implemented with an ionospheric model including photoionization (13 for CO₂, CO, O, NO, N₂, N, H and O₂) and ion chemistry (64 reactions for CO₂⁺, CO⁺, O⁺, O₂⁺, N₂⁺, N⁺, H₂O⁺, H₃O⁺, HCO⁺, NO⁺, H⁺, C⁺, OH⁺, HCO₂⁺ and e⁻), and a vertical ambipolar diffusion model. The electron temperature used in VPCM is based on the model of [8]. There is no electron impact or horizontal electromagnetic transport in this current version. These improvements are presented and discussed in more detail in [1].

The validation was performed using ion and electron number densities data from the Pioneer Venus (PV) and Venus Express (VEX) missions. These simulations provided the fields included in the Venus Climate Database 2.3 (VCD, see <http://www-venus.lmd.jussieu.fr>).

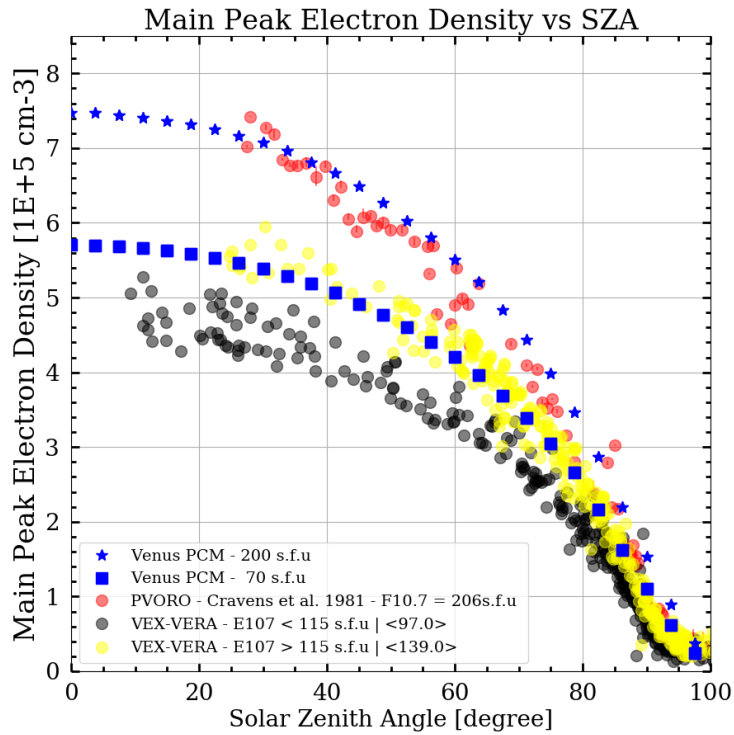


Figure 1: Electron number densities at the ionospheric peak versus solar zenith angle. Red circles correspond to PV data from [9] at high solar activity. Black and yellow circles correspond to the VEX observations for low solar activity and intermediate solar activity conditions, respectively. The number in brackets corresponds to the average E10.7 value for each selection of VEX-VERA data. This figure is taken from [1].

▪ Results and Discussions

The electron number density of the main Chapman electron peak simulated by the VPCM is consistent with the PV data of [9] from PV-ORO (Radio Occultation) observations (for high solar activity, see Figure 1). The VPCM well reproduces the evolution of the electron number density and its altitude with the solar zenith angle on the dayside. However, the VPCM overestimates by 15% the electron density peak at 140 km on the dayside at low solar activity

The ambipolar diffusion for ions is necessary above 180 km altitude. With the addition of this process, the electron number density predicted by the VPCM is in good agreement with PV observations. Below 180 km, the photochemistry processes dominate over the ambipolar diffusion and its effects are negligible as expected. Yet, the VPCM fails to reproduce the electron variation on the nightside, probably due to an underestimation of ion transport from day to night, linked to the absence of electromagnetic horizontal transport process. Day-to-night ion transport and ion chemistry will be explored in future work in order to improve the Venus PCM.

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