Exploring the variability of the venusian atmosphere above the clouds with the IPSL Venus GCM

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To investigate the amount of data recently acquired by the Venus Express (VEx) and Akatsuki missions as well as from ground-based telescopes, Venus Global Climate Models (GCM) are powerful tools. Our understanding of the Venusian climate has increased with recent progresses with these models.

The IPSL Venus GCM has been used recently to investigate all regions of the Venusian atmosphere, as it covers the surface up to the thermosphere (150 km). It involves a photochemical module with a simplified cloud scheme that enables the study of the composition and the coupling with the upper atmosphere, where composition plays a crucial role on the non-LTE and EUV heating processes. Other relevant physical processes in the thermosphere (e.g. molecular diffusion and thermal conduction) are taken into account. Below 100 km, the infrared energy budget is computed based on a Net Exchange Rate formalism. The cold collar structure has been modeled when taking into account the latitudinal distribution of the cloud structure. Globally averaged profiles (e.g spatially and temporally) extracted from the state-of-the-art IPSL Venus GCM provide realistic templates of the atmosphere of Venus.

VEx observations revealed a more variable atmosphere than expected, in particular the “transition” region (~70-120 km) between the retrograde superrotating zonal flow and the day-to-night circulation showed latitude and day-to-day variations of temperature up to 80 K above 100 km at the terminator, and apparent zonal wind velocities measured around 96 km on the Venus nighttime highly changing in space and time. Those variations are not fully explained by current 3D models and specific processes (e.g. gravity wave propagation, thermal tides, large scale planetary waves) responsible for driving them are still under investigation. The role of convectively-generated gravity waves and their impact on zonal wind and temperature in the region of aerobraking can be explored with the IPSL-VGCM, thanks to the inclusion of a stochastic non-orographic gravity waves parameterization, based on the Earth GCM. Data-model comparison of distribution of dynamical tracers above the clouds (e.g O2(1Δ) nightglow, CO and O density) will be crucial to shed a light on a region where no direct wind measurements are available.

Akatsuki’s LIR camera revealed the presence of planetary-scale mountain waves at the cloud top in the afternoon. Simulations of the upper atmosphere suggest that mountain waves can easily
reach the upper atmosphere, to polar latitudes and the nightside, thus affecting atmospheric dynamics as high as 130 km.