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Spatial distribution of the infrared O₂ ($\alpha^1\Delta_g$) airglow in the night Venus hemisphere based on the SPICAV IR/VEX nadir observations in 2006-2014.

Daria Evdokimova et al.

Introduction

Infrared O₂ ($\alpha^1\Delta_g$) airglow at 1.27 μm on the night side of Venus was for the first time identified during ground-based observations in 1975 (Connes et al., 1979). The airglow reaches its maximal intensity at ~ 96 km. These altitudes correspond to the transitional region between two regimes of global atmospheric circulation on Venus. Below 70 km, the cloud layer is involved in the zonal super-rotation. At altitudes higher than 110 km, the subsolar to anti-solar (SSAS) circulation transfers atoms and ions produced by photolysis in the sunlit hemisphere to the night side. Here, downwelling oxygen atoms recombine to the excited O₂ ($\alpha^1\Delta_g$) molecules which radiative relaxation to the ground state results in the IR emission formation. Thus, the O₂ ($\alpha^1\Delta_g$) airglow is a tracer of the dynamical processes occurring in the 90-100 km range on the night side.

The maximal emission brightness was observed around the anti-solar point by ground-based and orbital measurements; this result demonstrated a domination of the SSAS circulation in the 90-100 km range. The VIRTIS-M infrared spectrometer on board the Venus Express spacecraft studied in detail the morphological features of the emission in 2006-2009 (Gérard et al., 2008; Piccioni et al., 2009; Shakun et al., 2010; Soret et al., 2012). Gérard et al. (2008) and Piccioni et al. (2009) concluded that intensity of the anti-solar emission maximum is equal to 3 MR and 1.2 MR respectively. The work of Shakun et al. (2010) revealed a slight shift of the nightglow's statistical maximum towards the evening terminator and a latitude of $\sim 10^\circ$ N. However, a simultaneous independent analysis of VIRTIS-M limb and nadir observations (Soret et al., 2012) confirmed the previous conclusions.

Analysis of the SPICAV IR observations contributes to the O₂ ($\alpha^1\Delta_g$) airglow study. The instrument dataset extends the long-term and latitudinal coverage of the VIRTIS-M experiment, which poorly observed the Northern Hemisphere of Venus at night.

Data analysis

The SPICAV IR instrument (0.65-1.7 μm) accumulated a dataset encompassing almost the entire Venus globe by nadir night observations in 2006-2014. The spatial resolution changes in range of 50-1000 km depending on the spacecraft distance to the planet due to the orbit elongation (Korablev et al., 2012). The SPICAV IR spectral range also covers several transparency windows where the thermal emission originating from the Venus deep atmosphere and surface escapes to space. The transparency window at 1.28 μm overlaps the O₂ ($\alpha^1\Delta_g$) emission band at 1.27 μm . However, the high resolving power of the spectrometer (~ 1400) allows a robust algorithm to extract the oxygen emission spectrum. For each measurement Venus thermal emission is optimized by a 1-D radiative transfer model with multiple scattering. The direct model is computed by the SHDOMPP program solving the radiative transfer equation by the method of discrete ordinates and spherical harmonics in a plane-parallel atmosphere. This routine developed by Bézard et al. (2011) and Fedorova et al. (2015) is used in this study with a cloud layer model of Haus et al. (2016). The thermal emission model is computed for three atmospheric windows at 1.1, 1.18 and 1.28 μm to increase the accuracy, and it is set by 3 free parameters: a scaling factor applied to mode 2 and 3 particle distributions of the cloud layer model, the H₂O mixing ratio in the lower atmosphere of Venus and the surface emissivity.

Result

In total, 605 sessions of nadir observations (~ 6000 spectra) with chosen emission angle $\leq 2^\circ$ were analysed. Based on these observations, the local time and latitude distribution of the O₂ ($\alpha^1\Delta_g$) airglow in the night hemisphere was obtained. It has the maximum at the anti-solar point with the intensity value of ~ 2 MR. An emission tendency to be slightly shifted towards the morning terminator can be suggested. In general, the pattern is fairly symmetrical about the equator. The result is in correspondence with the analysis of VIRTIS data (Shakun et al., 2010; Soret et al., 2012).

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