EPSC Abstracts
Vol. 7 EPSC2012-690 2012
European Planetary Science Congress 2012

Maps of the O_2 nightglow on Venus and circulation at mesopause level

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Abstract

This work is devoted to revisit the VIRTIS-M VEX nadir data on the O_2 1.27μm nightglow. To avoid the noisy data only those, obtained with exposure > 3s were used. For absolute intensity of the airglow calculation (by comparison 1.27 and 1.18 μm windows) the thermal emission of the surface and lower atmosphere was excluded more accurately: it was considered effects of the H_2O absorption at 1.18 μm, cloud opacity and surface altitude [1]. Maps of airglow were obtained in coordinates local time - latitude for individual cubes of measurements as well as global map averaged over 718 orbits. Individual maps of airglow show highly variable character of the O_2 nightglow distribution. Maximum emission in equatorial region are observed in the interval LT = 20h ÷ 4 h. Wind speed map were calculated for practically the same set of orbits as the global map of airglow intensity. Horizontal divergence map shows the areas with divergence and convergence of the flow: high positive values of divergence correspond to the areas with minimum intensity of the airglow, and vice versa, negative values (mean convergence) coincide with the maxima intensity of airglow.

1. Introduction

Horizontal distribution of the $O_2(a^1\Delta_g)$ 1.27 μm nightglow is test of circulation at 95 – 100 km. It may be defined by SS-AS mode of circulation, typical for thermosphere (maximum emission at AS – point), superposed by retrograde zonal superrotation typical for mesosphere – maximum is shifted to the morning, and wave activity. The maps of airglow intensity were obtained from nadir measurements with the mapping VEX VIRTIS–M spectrometer, with its IR–channel, with spectral range 1 - 5.1 μm and spectral sampling of 10 nm. [2]. In VIRTIS spectra at 1.27 μm the nightglow is recovered by thermal emission of the lower atmosphere. It may be taken into account by comparison with thermal emission in 1.18 μm [3]. However, in 1.18 μm window there are the H_2O absorption and surface emission which should be taken into account. The VIRTIS-M nadir measurements cover Southern hemisphere and only low latitudes of Northern one.

2. Correction for surface altimetry

Using the 1.18 μm window for correction of the 1.27 μm emission one should have in mind that at 1.18 μm an input of the surface radiation may reach up to 30%. Surface temperature on Venus is defined by altitude (at least there is no strong indication to another), thus input of the surface emission will depend on surface altitude. In Fig.1 it is shown an example of retrieved map of the airglow with consideration of surface altitude and without it. One may see artefact in (b) corresponding to altimetry feature in (a).

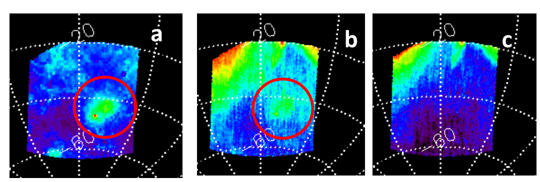

Figure.1: (a) Magellan altimetry, (b) and (c) – intensities of airglow without taking into account altimetry and with it respectively.

3. Results

Examples of maps, retrieved for single orbits and the global one are shown below. In Figure 2 a map obtained for two cubes: orbit 793 -02 (LT= -4÷ -0.5h) and 793-03 (LT= -0.5÷2h) is given. Maximum intensity is observed in equatorial region, but shifted to the evening terminator. This example shows pretty good quality of data correction (no boundary between cubes is seen)

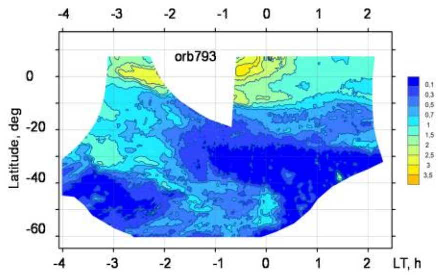

Figure 2: Map of the O_2 emission (MR) 793-02-03.

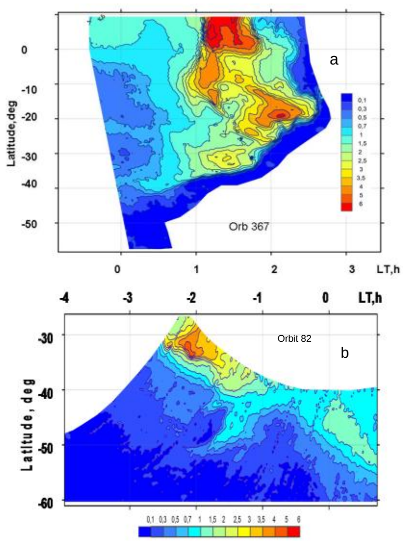

Figure 3: Intensity of the airglow (MR), orbit 367 (a), 82(b).

In Figure 3 (a) one may see maximum emission of 6 MR at 1.5h in equatorial region and at 2h at 20°S, it may indicate to superposition of SS-AS and zonal superrotation. But in many other cases like in (b) maximum intensity of 6 MR may be found before midnight. The global averaged map of the O2 nightglow is given in Figure 4. In the map (averaged over 718 orbits) emission maximum is observed at low latitudes, around midnight (20N - 20S, LT=22h-3h, without absolute maximum in antisolar point). At middle southern latitudes asymmetry in local time distribution of the airglow is observed with higher intensity before midnight at all latitudes [4]. Low intensity near terminators as well as wide spot of higher intensity around midnight indicate on wind flows through terminators from the day side, with higher speed in the morning.

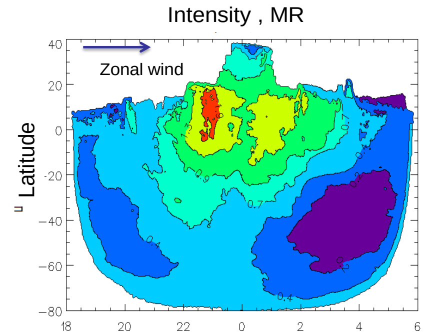

Figure 4: Global map of the $O_2(a^1\Delta_g)$ airglow based on 718 orbits in coordinates local time (x-axis)–latitude.

4. Conclusion

From chosen set of 718 nadir orbits it was found averaged value of intensity 0.35±0.3 MR with highest intensity exceeded 6 MR. It was found correlation with horizontal wind speed: higher intensity of the emission corresponds to lower horizontal wind speed, as well at high airglow intensity areas the negative horizontal divergence (convergence) was observed and vice versa. Circulation at mesopause level should be combination of SS-AS, zonal superrotation and waves activity; relative importance of these components is time variable

Acknowledgements

Authors thank ASI, CNES, Roscosmos, and Russian co-authors acknowledge also the Program 22 of Presidium RAS for financial support of this work.

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