EPSC Abstracts
Vol. 6, EPSC-DPS2011-968-1, 2011
EPSC-DPS Joint Meeting 2011
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Temporal and spatial variations of the Venus 1.27-μm O_2 airglow observed from ground

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Abstract

Imaging spectroscopic observations of the Venus 1.27-μm O_2 airglow were carried out with ground-based telescopes from 2002 to 2010. Spatially resolved spectra were taken on the Venus nightside disk. The airglow intensity and rotational temperature maps are derived. The temperature shows weak positive correlation with the airglow intensity. However, there are some regions that have almost same intensities but different temperatures. The intensities tend to decrease from the anti-solar point to the terminator besides local features. These results indicate that there are local strong downward flows superimposed on the subsolar-to-antisolar circulation. Monitoring observations detected changes in these airglow distributions.

1. Introduction

The Venus 1.27-μm O_2 airglow was discovered by Connes et al. (1979) and since then the behavior of the night airglow has been investigated by ground-based observations. Allen et al. (1992) observed airglow enhancements on the morning side of the anti-solar point. Crisp et al. (1996) found that the airglow shows complicated distributions and variations of more than 20% on time-scales as short as 1 h. Since the spatial variations of O_2 night airglow resemble those of NO night airglow, the standard scenario for O_2 airglow based on the case of the NO airglow (Bougher et al., 1990) was proposed; the oxygen atoms generated by the UV photolysis of CO_2 in the dayside upper atmosphere are transported to the night hemisphere, and recombine to form excited oxygen molecules at around 95–100km in downward flow (Allen et al., 1992; Zhang et al., 1996). A positive correlation between the O_2 brightness and the rotational temperature has been downward flow. The rotational temperature maps in the airglow layer were derived from observed spectra. There were some warm regions overlapping bright regions (Ohtsuki et al., 2005, 2008a, 2008b; Bailey et al., 2008). The shift of the bright region toward the dawn suggests a drag effect by the super-rotation in the thermosphere. The rapid change may be due to modulation by atmospheric waves coming from the lower atmosphere. In this paper, we show the results of ground-based observations of the Venus 1.27-μm O_2 airglow from 2002 to 2010.

2. Observations

Imaging spectroscopic observations of the Venus nightside were conducted in Japan and Hawaii before or after the Venus inferior conjunctions in October 2002, June 2004, January 2006, August 2007 and October 2010. Spatially resolved spectra were taken and used to derive maps of the airglow and its rotational temperature. Table 1 lists our observations.

Table 1: Summary of the observations

Date	Observatory /Instrument	Venus diameter
Dec.11, 2002	OAO,NAOJ/ SuperOASIS	38”
May11, 2004	GAO/GIRCS	42”
Dec.14, 2005	IRTF,NASA/ CSHELL	45”
Feb.16-17, 2006	IRTF,NASA/ CSHELL	41”
Jul.13-15, 2007	IRTF,NASA/ CSHELL	39”
Sep.22-24, 2007	IRTF,NASA / CSHELL	38”
Sep.16-21, 2010	IRTF,NASA / CSHELL	37”

3. Brightness and temperature

O_2 rotational temperature has been derived from each observed spectrum by using the HITRAN2000 molecular spectroscopic database, its high-temperature analog HITEMP and an empirical model of the Venus atmosphere VIRA1985. The airglow brightness and rotational temperature maps are shown in Ohtsuki et al. (2005, 2008a, 2008b). In most cases, the intensity distributions have the brightest patch at around the anti-solar point and some warmer regions overlapping bright regions. A correlation between the airglow intensities and temperatures is positive but very weak. Moreover there were some regions, which have almost the same intensities but have different rotational temperatures. That means that the intensity and the temperature are not in the simple proportional relation and that there are more complicated physical and chemical processes in the Venus thermosphere. For example, the difference between the time scale of emission and cooling can cause a warm but dark region. The long-time monitoring of the intensity and the temperature is required to observe this effect.

4. Temporal variations

The distributions of the airglow vary considerably from day to day. The temporal variations are thought to be caused by the upward momentum transport and fluctuations by atmospheric waves. Recently, GCM simulations considering the planetary-scale waves which are prominent at the cloud top is performing in order to understand effects of the waves on the airglow. We conducted monitoring observations in 2007 and 2010 to catch the change and to detect the atmospheric waves in the nightside upper atmosphere of Venus. The spatial resolution achieves down to about 500km at the center of the Venus disk and it is comparable with the planetary-scale waves. From those data, we investigate the process of changes in the airglow and its rotational temperature distributions.

5.Summary

Ground-based observations of the 1.27-μm O_2 airglow were conducted between 2002 and 2010. The airglow intensity and the rotational temperature show a positive but weak correlation. There are some regions that have almost same intensities but different temperatures. The adiabatic heating may that warmer region is caused by local strong downward flow and bright region is caused both by the number of O atoms and by downward flow. Our monitoring observations have detected the changes in the airglow distribution and will provide us new information on the dynamics of the upper atmosphere.

Acknowledgements

The authors acknowledge generous support from Dr. S.B. Bus, the IRTF Support Scientist, Dr. E. Volquardsen, the telescope operator, and all staffs of IRTF and GAO. We also wish to thank Prof. M. Nakamura for many helpful discussions. This research was supported in part by a Grant-in- Aid for JSPS Research Fellows (for O.S., H.S., T.K., and N.H.) and by KAKENHI 17349147 and 22244060.

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