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Temperature distributions in the Venus O_2 night airglow layer from spectroscopic observations

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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 2012. Spatially resolved spectra were taken on the Venus nightside disk. The airglow intensity and rotational temperature maps are derived. Monitoring observations detected changes in those distributions. On the other hand, temperatures in the Venus mesosphere and lower thermosphere are also measured from SOIR on board Venus Express. Simultaneous observations from ground and Venus Express spacecraft were conducted in July 2012 and temperatures are compared.

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 expected as a result of adiabatic heating by the 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). In this paper, we show the results of ground-based observations of the Venus 1.27-μm O_2 airglow from 2002 to 2012. Recently, temperatures in the Venus atmosphere are also measured from space. SOIR is a high resolution spectrometer on board the Venus Express (VEX) spacecraft. It performs solar occultation and defines vertical temperature profiles of the Venus high atmosphere at morning and evening terminator. An atmospheric model VAST (Venus Atmosphere from SOIR measurements at the Terminator) has been constructed based on SOIR observations (Mahieux et al., 2012). It includes temperatures at the altitude of O_2 airglow layer.

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, October 2010, and July 2012. Spatially resolved spectra were taken and used to derive maps of the airglow and its rotational temperature. Especially, on 11-14 July 2012, simultaneous observations from ground and from VEX/SOIR were conducted in order to compare the temperatures.

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 the intensity distributions vary drastically day by day. We investigate the changes in the airglow and its rotational temperature distributions to catch physical processes in the Venus upper atmosphere.

4. Comparison with SOIR data

There are 4-days temperature datasets of horizontal distributions and vertical profiles at the altitude of O_2 night airglow layer from simultaneous observations in July 2012. Our horizontal temperature maps are limited on the Venus night side, and the temperature profiles from SOIR are limited on the terminator. Those data doesn't include the exact same location but some data points are very close. We compare the temperatures and its trend.

5.Summary

Ground-based observations of the 1.27-μm O_2 airglow were carried out between 2002 and 2012. The airglow intensity and the rotational temperature show a positive but weak correlation. The adiabatic heating may cause to raise the temperature. These results suggest 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. We investigate trends of the airglow and its temperature distributions, and temperature profiles from VEX/SOIR to obtain information on the dynamics of the upper atmosphere.

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