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Temporal evolution of the planetary-scale UV feature at the Venusian cloud top observed by Akatsuki/UVI

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Abstract

Akatsuki/UVI observed prominent 3.5–4-day Kelvin and 5-day Rossby waves in 2017 and 2018. Time evolutions of these waves at the Venusian cloud top were captured for the first time, and we could find corresponding temporal changes in planetary-scale UV features. Connections between the periodic wind variations caused by waves and UV brightness patterns were investigated.

1. Introduction

Planetary-scale waves at the Venusian cloud-top cause periodic variations in both winds and ultraviolet (UV) brightness. The prominent planetary-scale UV features (sometimes called "Y-features" or "ψ-features") might be related to the prominence of these waves, and they hold an important clue to understand the atmospheric dynamics of Venus. Our ground-based observation (Imai et al., 2016) implemented long-term monitoring of the rotation period of planetary-scale UV features. Two significant periodicities, at 5.1- and 3.5-day, should be manifestations of these planetary-scale waves, which were subjected to temporal variations within several months. However, the temporal evolution of these variations still remains largely unknown. To date, more than five Venusian years of observations have been conducted by Japanese Venus orbiter Akatsuki and the onboard UV Imager (UVI), and we could analyze the continuous periodicities changes in both UV brightness and wind variations over the half of Venusian years.

2. Periodical analysis and Results

We analyzed the periodicities in the 365-nm brightness and cloud-tracking wind variations (Horinouchi et al., 2017), obtained from June to October 2017 and September to November 2018. We used the successive time blocks having time range of ±14 days extracted from the original time series and conducted time-shifting Lomb-Scargle analysis (Figure 1).

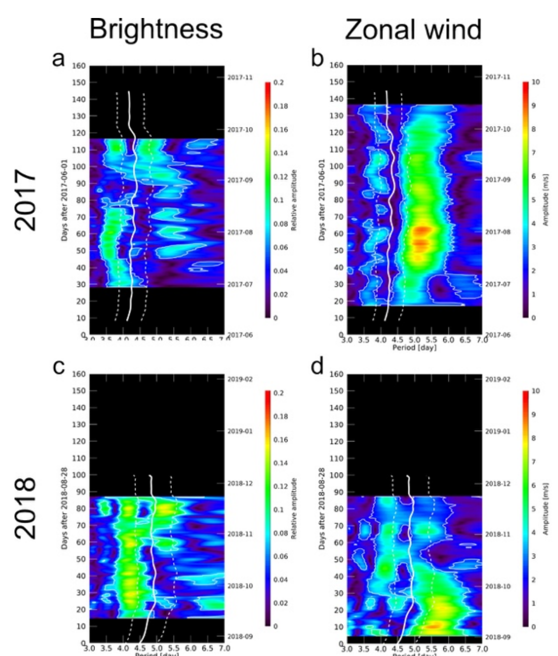

Figure 1: Results of time-shifting Lomb-Scargle analysis of the UV brightness (a, c) and zonal wind (b, d) as a function of observation time for S10°–N10° latitudinal region. The colored regions enclosed with thin white lines denote the regions with >99% significance. The thick solid white line and dashed white lines indicate the corresponding period of the background dayside mean zonal wind and ±10 m s^{-1} uncertainty.

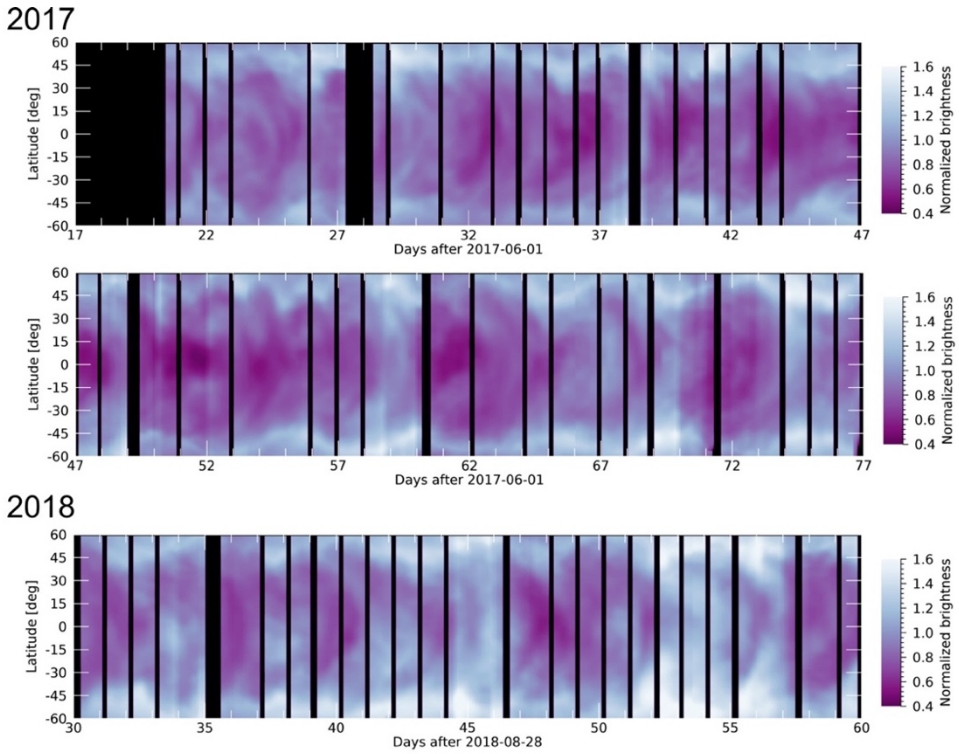

Figure 2: UV brightness patterns as functions of observation time and latitude. The time series of the brightness data was partitioned into 1-hour intervals, with 8-hour smoothing applied.

3. Evolution of UV features

Figure 1 clearly shows the temporal changes of the periodical signals. In 2017, the 3.8-day signal was prominent in both brightness and zonal wind, and about 1 month later, ~5-day signal became relatively dominant. Both signals were confirmed having the characteristics of Kelvin wave and Rossby wave respectively.

The temporal evolutions of wave packets of Kelvin and Rossby waves were captured for the first time, and the dramatic evolution of planetary-scale waves and corresponding changes in planetary-scale UV features were captured (Figure 2). ~5-day wave was accompanied by the planetary-scale vortices were nearly equatorially symmetric and centered at ~35° latitude in both hemispheres. The amplitude of winds variation associated with the observed Rossby wave packet was amplified gradually, and the brightness variation emerges to form rippling white cloud belts in the 45–60° latitudes of both hemispheres.

In 2018, on the other hand, only ~4-day periodic signals were observed in winds and brightness variations especially latter half of the observation season. This characteristic might be due to a Kelvin wave packet, which may be the cause of the dark clusters in the equatorial region as observed early 2017 observation season. The averaged super-rotation speed was ~105 m s^{-1} in 2017, however, it was decreased to ~95 m s^{-1}. This might be one reason for the Kelvin wave signal became more prominent in 2018.

Acknowledgements

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