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Juno and Juno-Supporting Observations of Jupiter's 2018-2019 Equatorial Zone Disturbance

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Abstract

A predicted quasi-periodic disturbance in Jupiter's Equatorial Zone began in 2018 with a significant darkening of its typical white appearance. Observations of this disturbance were made over a broad range of wavelengths using Earth-based and Juno instruments. The disturbance may be associated with a slowly descending wave of dry air that reduces the opacity of visible clouds that are near the ammonia condensation level around 700 mbar of pressure. We predict that this phenomenon will continue to descend to deeper levels in the coming months.

1. Introduction

Jupiter's Equatorial Zone (EZ) is typically bright and white-colored, but it is subject to 3-5 year episodes of distinct darkening [1]. These changes take place quasi-periodically in intervals of 6-7 years, although in some years, the coloration fails to appear or is very short lived [1]. Antuñano et al. [2] have shown that during these episodes of EZ coloration, the normally cold thermal emission from the EZ at 5 µm can become unusually bright, an appearance that lasts 1-1.5 years. Jupiter's 5-µm radiance is dominated by thermal emission that is sensitive to the opacity of clouds in the 1-4 bar region of the atmosphere. The brightest regions detected at 5 µm therefore indicate a dearth of cloud opacity, and are known as 5-µm "hot spots", located primarily at the southern edge of Jupiter's visibly dark North Equatorial Belt (NEB). These regions are often associated with areas that appear to have a dark bluish-gray visible appearance. The appearance of the EZ is consistent with its characterization as a region of upwelling, in which saturated gases, dominated by NH_3, create a ubiquitous layer of clouds at and below the 700-mbar condensation level of NH_3. This, in turn, is consistent with results from Juno's Microwave Radiometer (MWR) instrument, that this upwelling column is extremely deep, rising from hundreds of bars of pressure [3,4]. Thus, a drop in the opacity of deep clouds in the EZ has direct consequences for the interpretation of MWR results for the EZ, particularly with respect to adiabaticity, consistent with this vigorous upwelling.

2. The current EZ disturbance

Antuñano et al. [2] predicted the appearance of an EZ disturbance in 2019-2020. The first indications of such an event was a marked decline in the brightness of the EZ around mid 2018, starting with a light- orange-brown color, as documented by the amateur-astronomy community (see the Orton et al. abstract in session ODA2), a change also evident in JunoCam images and HST (OPAL and WFCJ) images of the EZ (see the Wong et al abstract in this session).

Further evidence for the progression of the disturbance came in the appearance of strips of bright 5-µm emission appearing in 2018 August in the mid-southern part of the EZ (Figure 1). In 2019 January, increased 5-µm brightening was detected in longitudinal strips. Some oblique bright 5-µm streaks that crossed the EZ completely also appeared, but these were not seen again in February through late April (this writing). Narrow isolated strips of 5-µm-bright regions persisted through late April.

Measurements were also made during this period in the mid-infrared, including the detection of increased radiance at 8.7 µm, consistent with the reduction of the opacity of an ammonia cloud (Figure 2).

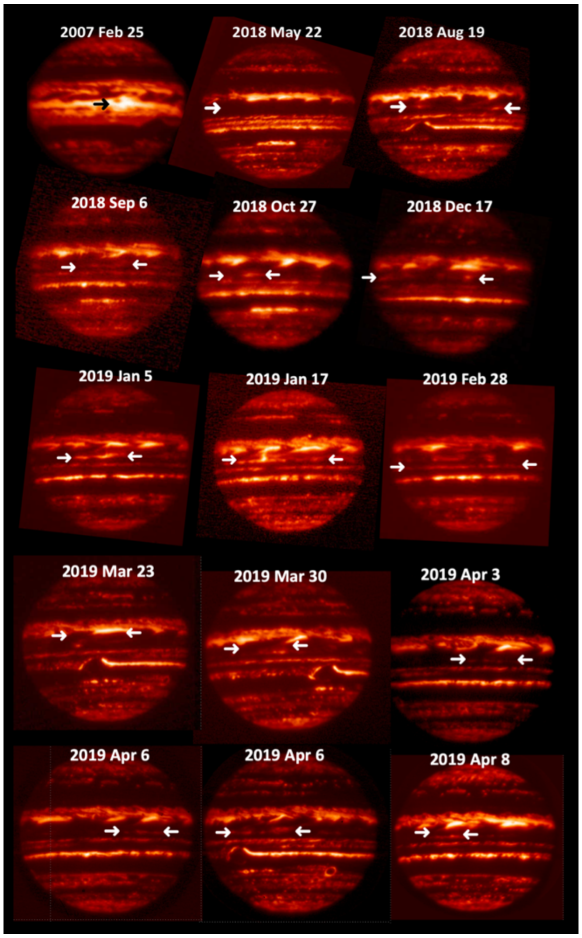

Figure 1: NASA Infrared Telescope Facility (IRTF) images of Jupiter at 5 µm. A sequence of 5.1-µm images is shown from before the onset of the disturbance (2018 May 22). These are compared with a 4.78-µm image taken at the peak of a major EZ disturbance in 2007 [2]. Arrows indicate bright regions in the otherwise dark/cold EZ.

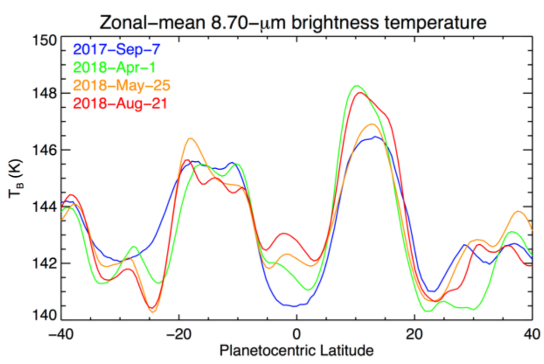

Figure 2: Zonal-mean 8.7-µm brightness temperatures for the dates shown. Substantial brightening is evident at the equator that is coincident with the onset of coloration in the EZ. This wavelength is sensitive to the cloud opacity near 0.7 bars, the NH_3 condensation level.

2). This was well before any brightening was detected in the EZ at 5 µm, sensitive to the opacity of a deeper clouds at pressures of 1-4 bars. This suggests that the disturbance is propagated from above, rather than from below.

3. Conclusions

The beginning of a predicted disturbance in Jupiter's EZ has been confirmed at visible wavelengths, with general corroboration at 8.7 µm that shows a reduction in the opacity of an ammonia cloud. Up to this writing, no significant changes in the ammonia gas condensation in the EZ have been measured. Changes of cloud opacity at 1-4 bars in the EZ have been sporadic, consistent with a wave propagating downward that has not consistently reached depths of several bars of pressure. Further observations will continue over a broad spectral range and results through September will be reported.

Acknowledgements

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