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Jupiter's 2018 South Temperate Belt Disturbance: Observations and numerical modelling

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Abstract

Jupiter's atmosphere exhibits a wide variety of atmospheric phenomena that are investigated by ground-based and spacecraft observations. The Juno mission around the planet observes the planet from close-in in perijoves separated by 53 days. The mission has attracted a strong observational support from amateur astronomers through an organized collaboration with the JunoCam instrument and also from large telescopes including observations by the Hubble Space Telescope scheduled close to many of the Juno perijoves. Convective storms in Jupiter develop frequently at different latitudes, with different intensities and trigger important changes in the planet. In February 2018 a series of convective storms erupted in the South Temperate Belt (STB), inside an elongated cyclonic region of low contrast known as the STB "Ghost", close to oval BA. The interaction between the storms and the cyclone resulted in the development of intense turbulence initially confined to the cyclonic region. Here we report an analysis of observations of this activity from amateur, JunoCam and public HST observations combined with detailed numerical simulations of the event. The event resulted in a complex evolution of the pre-existing ghost and altered oval BA. Our modelling constrains the vertical characteristics of the cyclone and the amount of energy released in the storms.

1. Dynamical context

After being in an overall calm state throughout most of 2016 [1], Jupiter's atmosphere started to display convective activity at different latitudes. In October 2016 four convective storms in Jupiter's North Temperate Belt (NTB) ended up developing a planetary scale disturbance that lasted months [2]. In December 2016 a convective storm in the South Equatorial Belt (SEB) developed also a large-scale disturbance in this region with large-scale turbulence extending over several months. In October 2017 a disturbance in the South Tropical Zone observed by several telescopes and the JunoCam instrument on Juno developed a South Tropical Zone Disturbance with a recirculation of the zonal winds followed by its interaction with the Great Red Spot over 2018. In February 2018 a series of convective storms erupted in a matter of 3 days in the South Temperate Belt (STB) inside a low-contrast elongated cyclonic region (the so-called STB Ghost) developing strong turbulence initially confined to the cyclonic Ghost developing a South Temperate Belt Disturbance (STBD).

2. Amateur observations

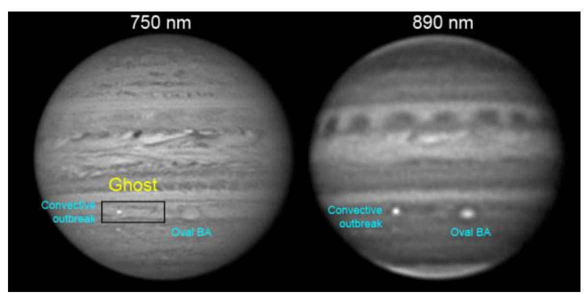

Figure 1: Convective outbreak in the STB Ghost. Observations by A. Wesley on 4 February 2018.

The onset of convection was discovered on observations obtained by different amateur astronomers on February 4, 2018 including observations in the strong methane absorption band demonstrating the convective nature of the bright spot (figure 1). We have followed the later evolution of this event from amateur observations available on the databases: PVOL (http://pvol2.ehu.eus/pvol2/) and ALPO-Japan (http://alpo-j.asahikawa-med.ac.jp/indexE.htm). The convection left the whole region perturbed with bright and dark filaments. Before the convective eruption the ghost was drifting in longitude in Jupiter's STB with a drift rate of 0.26 deg/day. By the date of the convective eruption the ghost was at a distance of 17 deg from the large anticyclone BA. The interaction of the East side of the ghost with BA modified their longitudinal drift. The perturbed ghost evolved to break-up on April 1 and produced several anticyclones that were expelled from the cyclonic system through its southwest side. Both ground-based observations and HST show that the close interaction between the STB Ghost and oval BA resulted in a diminishing size of oval BA at an average rate of 0.02 deg/day between February and April 2018.

3. JunoCam and HST observations

We used JunoCam and HST [3] observations of the Ghost feature obtained over 2017 to investigate its nature before the onset of the perturbation. The JunoCam images showed the structure of the ghost but the small time separation between the images resulted in a ghost circulation of 80±20 m/s. Wind measurements over 2017 HST images showed that the cyclone is an elongated feature with a size of 28,000x4,500 km with an external cyclonic circulation (clockwise) of 60±10 m/s. HST observations on April 17, 2018 showed the broken perturbed system and its interaction with oval BA (Figure 2).

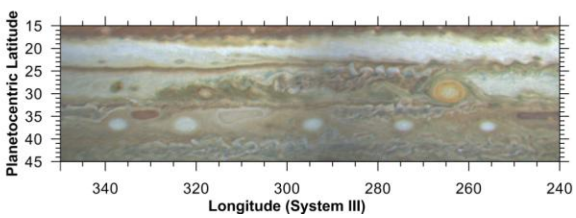

Figure 2: Map of the STB Disturbance and oval BA based on HST observation on April 17, 2018.

4. Simulations

We used the Explicit Planetary Isentropic-Coordinate Atmospheric Model (EPIC) model [4] to investigate the complex interaction between the ghost, the convective outbreaks and the anticyclone BA. We created a numerical "ghost" with the same size, circulation and drift rate as the observations and introduced oval BA. We later perturbed the "ghost" with discrete heat impulses at the location of the convective events following the methodology on [5], and simulate the interaction of the systems. Figure 3 shows an example of one of these simulations.

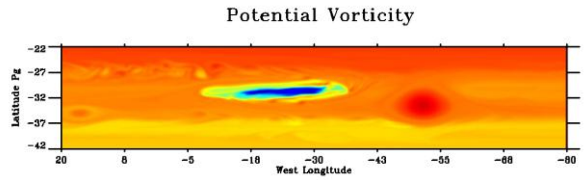

Figure 3: EPIC Simulation of the elongated cyclonic ghost (blue) and the anticyclone BA (red).

5. Summary and Conclusions

Time-resolved observations obtained by amateur astronomers allowed to characterize the evolution of this complex system observing the formation of new ovals expelled from the system. We explored the space of parameters of the modelled atmosphere, STB Ghost vertical structure and intensity of the convective eruptions strongly constraining the dynamics of this complex system.

Acknowledgements

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