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Jupiter cloud morphology and zonal winds from ground-based observations during Juno's first year around Jupiter

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Abstract

Jupiter's upper atmosphere displays a variety of meteorological phenomena at a wide range of spatial scales. Changes, local and global, occur at several time-scales and affect differently the cloud and hazes observable at different vertical altitudes sampled in the visible and in weak and strong methane absorption bands. Ground-based observations are required to understand the meteorological activity in the long time spans between high-resolution observations attained by Juno and other powerful observational means like the Hubble Space Telescope (HST). We here report the evolution of meteorological systems in the planet over 2017. We base our analysis on the following sources: (i) Observations obtained by our PlanetCam UPV/EHU instrument on the 2.2-m telescope at Calar Alto Observatory in Spain and covering the spectral range from 0.38 to 1.7 μm; (ii) Observations attained with small telescopes by amateur astronomers including images acquired with 1-m size telescopes and covering the 0.4 to 1.0 μm range. We focus our analysis on the following topics: (a) Dynamics of the South Equatorial Belt outbreak since December 2016; (b) Changed colors of the North Temperate Belt following a planetary-scale disturbance that largely finished by November 2016; (c) Global winds and their evolution from December 2015 to April 2017; (d) Short-scale waves at the North Equatorial Belt; (e) Dynamics of the polar regions above 60 deg latitudes.

1. Introduction

Prior to and during Juno's first perijove ground-based and HST/OPAL observations show that Jupiter was in a quiescent normal state [1]. The only exception was a longitudinally limited small northwards latitudinal expansion of the North Equatorial Belt (NEB) that has been linked to thermal waves in the upper atmosphere [2]. This situation broke in October 2016 with the nearly simultaneous outburst of four moist convective plumes in the North Temperate Belt (NTB) that grew to a planetary scale disturbance that evolved until November 2016 [3] changing the colors and morphology of the NTB. Instead of resuming to a quiescent state a large outburst of activity in the South Equatorial Belt started at the end of December 2016 and progressed at least until late April 2017. Short-scale wave features, similar to gravity waves previously found in HST observations in 2015 [4], were observed by several amateur astronomers since February 2017 and at least up to April 2017 in the North Equatorial Belt (NEB).

2. Planetcam images

PlanetCam UPV/EHU is a dual camera that uses the lucky imaging technique at the 2.2-m telescope in Calar Alto observatory in Southern Spain. The light from the telescope is separated by a dichroic mirror and is sent into two detectors in the wavelength ranges 0.38-1.0 μm (visible) and 1.0-1.7 μm (Short wave infrared, SWIR) [5-6]. Fast images (10-50 images per second) improve the spatial resolution over the seeing by a factor of 4 and long exposures are used in narrow band filters sampling several weak intermediate and strong methane absorption bands. We ran one Jupiter observing campaign in 26-31 March 2016 and a similar campaign is scheduled for June 2016; another one has being requested in July 2016. Images were calibrated with observations

of spectrophotometric standard stars and enable the study of the vertical distribution of clouds and hazes and the spatial distribution of colors.

3. Amateur observations

Amateur observers constitute a major source of high-quality observations of Jupiter. High-quality amateur images were downloaded from the PVOL2 database (http://www.pvol2.ehu.es) [7] and ALPO Japan (http://alpo-j.asahikawa-med.ac.jp/indexE.htm).
These images were used to measure zonal winds in different moments in time over 2016-2017 exploring small-scale changes in the winds associated to the activity at the SEB outbreak and the aftermath of the NTB planetary-scale disturbance.

5. Results

We present zonal winds from -75 to +74 degrees planetographic latitudes from ground-based Planetcam and amateur images obtained over several months in 2017. We compare these zonal winds with previous wind retrievals over similar data from December 2015 to May 2016 [1]. We explore changes in the zonal winds associated to the past activity in the NTB [3] and to the current disturbance in the SEB.

We present color indices from PlanetCam photometrically calibrated images as a tool to quantify the different colors in the NTB to the rest of the planet and its usual state [8].

We discuss the NEB waves observed from February to April 2017. Amateur observations showed several systems of wavy features with typical wavelengths of 1-2º in the North Equatorial Belt close to the location of convective outbreaks. This was the first time such waves were observed by amateurs, but similar systems have been observed in the past in HST images [3] and in data from several spacecrafts. We present the visual characteristics of these features and their characterization as gravity waves from a comparison with theoretical expectations for gravity waves in Jupiter.

We also present polar maps of the planet in a variety of filters. In particular, PlanetCam observations in the SWIR channel are very effective to show structures at high latitudes. We compare polar maps of the planet at a variety of deeply penetrating image filters showing vortices up to ±73 deg latitudes and methane absorption bands showing polar waves in the upper hazes [9]. These global maps of the polar regions, together with the rest of the analysis presented, can provide a global context to JunoCam observations of the planet [10].

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References

[1] Hueso et al.: Jupiter cloud morphology and zonal winds from ground-based observations before and during Juno's first perijove, Geophys. Res. Lett., 44, doi:10.1002/2017GL073444 (in press).

[2] Fletcher et al.: Jupiter's North Equatorial Belt expansion and thermal wave activity ahead of Juno's arrival, Geophys. Res. Lett., 44, doi:10.1002/2017GL073421 (in press).

[3] Sánchez-Lavega et al.: A planetary-scale disturbance in the most intense Jovian atmospheric jet from JunoCam and ground-based observations, Geophys. Res. Lett. (in press).

[4] Simon et al.: First results from the Hubble OPAL Program: Jupiter in 2015, ApJL, 812(1), id55, 8 (2015).

[5] Sánchez-Lavega et al.: PlanetCam UPV/EHU: A simultaneous visible and near infrared lucky-imaging camera to study solar system objects, Proc. of SPIE, 8446, 84467X-1-84467-X-9 (2012).

[6] Mendikoa, I.: PlanetCam UPV/EHU: A Two-channel Lucky Imaging Camera for Solar System Studies in the Spectral Range 0.38-1.74 μm, PASP, 128 (961), 0350002 (2016).

[7] Hueso et al.: The Planetary Virtual Observatory and Laboratory (PVOL) and its integration into the Virtual European Solar and Planetary Access (VESPA), PSS (in press).

[8] Ordonez-Etxeberria et al.: Spatial distribution of Jovian clouds, hazes and colors from Cassini ISS multi-spectral images, Icarus, 267, 34-50 (2016).

[9] Sánchez-Lavega et al.: A system of circumpolar waves in Jupiter's stratosphere, Geophys. Res. Lett., 25, 4043-4046 (1998).

[10] Orton et al.: The first close-up images of Jupiter's polar regions: Results from the Juno mission JunoCam instrument, Geophys. Res. Lett., 44, doi:10.1002/2016GL072443 (in press).