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Tracking Temporal Changes below the Jovian Clouds using the VLA and Juno

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Abstract

In conjunction with Juno's closest approach to Jupiter, ground-based observers have observed Jupiter across many wavelengths from infrared to radio. We present Very Large Array (VLA) observations, that provide context for, and direct comparison with Juno MWR Channel 5 (10 GHz) observations [4]. The VLA observations in October 2016, December 2016 and January 2017 paint a picture of a highly dynamic planet. Longitude-resolved brightness-temperature maps that we correlate with changes in the underlying ammonia distribution, hinting at large changes in the underlying circulation, most notably: **(a)** an enhanced and expanded North Equatorial Belt below the cloud deck, a **(b)** highly disturbed South Equatorial Belt prior to the January 2017 storm outbreak, and lastly **(c)** a planetary-scale disturbance below the visible cloud deck during the October 2016 plume outbreak event first detected in the infrared [5].

1. Introduction

Ground-based observers have coordinated an observation campaign to provide context for the Juno perijove (PJ) passes and provide global maps in the infrared, visible and radio compared to the high-resolution but narrow field of view of the Juno instrument. Using the upgraded VLA in the A-configuration we obtain the highest-resolution spatial maps of Jupiter ever obtained at radio wavelengths from the ground; the 0.3" resolution (500 km) of the maps is comparable to the Juno footprints. For three epochs (October, December 2016 and January 2017) we obtained complete rotations of the planet, the basis for longitude-smeared and longitude-resolved maps [6]. Due to changes in Juno's orbit, only the December 2016 data have corresponding Juno measurements (PJ3).

The longitude-resolved maps show a myriad small-scale brightness-temperature variations showcasing the dynamic cloud morphology as seen in Figure 1.

1.1 Disturbed North Equatorial Belt

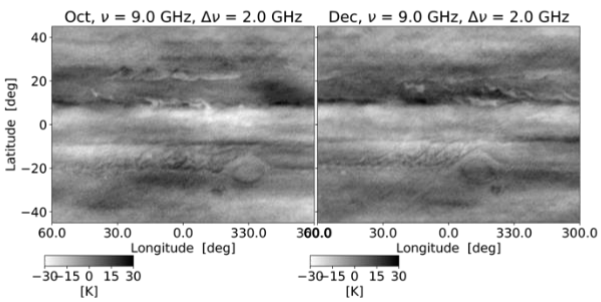
The resulting longitude-smeared maps show variations on a global scale, especially in the North and South Equatorial Belt (NEB, SEB). Compared to the 2014 zonal scans of the residual brightness temperature [2], we see a brightening of the NEB in conjunction with an expansion northward during all three epochs. This is especially interesting given that in the visible, the NEB expanded in late 2015, but returned towards a normal state around March 2016 [1]. We conclude that the lower troposphere (~2 bar) remains highly altered, even months after the clouds above the North Tropical Zone had been restored.

1.2 Planetary scale disturbance during the October 2016 outbreak

During October 2016, ground-based observers spotted 4 plumes in both the visible and infrared [6]. The longitude-resolved images show a large planetary-scale eruption already in place when the plumes broke through the cloud layer in the North Tropical Zone. This indicates that the disturbances took longer to build up and slowly propagated upwards through the atmosphere, instead of them just being rooted deep in the troposphere.

1.3 Temperature fluctuations in the South Equatorial Belt

In January 2017 the SEB saw the outbreak of a large-scale storm event [3] east of the Great Red Spot longitude. Observations in December showed no localized variations at the longitude of the outbreak. The zonally averaged brightness temperature at the corresponding latitude, however, shows large temperature (10K) fluctuations, indicating large-scale circulation changes. The outbreak itself can be seen clearly as a disturbance in the January 2017 VLA maps.



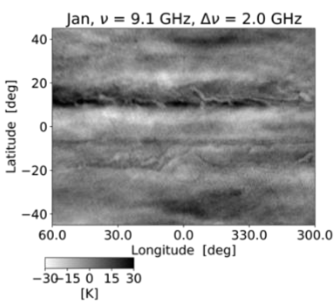


Figure 1:

Radio residuals maps showing variations in brightness-temperature across the planet.

The relevant observation details can be found below:

Table 1: Ground0based VLA observation campaign

	October	December	January
Date	10/19/2016	12/11/2016	01/11/2017
Frequency	8-10 GHz	8-10 GHz	8-12 GHz
VLA	A-config	A-config	A-config
Juno	No	Yes	No
IRTF	Yes	Yes	No
HST	No	Yes	Yes

2. Summary and Conclusions

Based on three separate observation campaigns we present changes of the Jovian dynamics below the cloud layer:

- The NEB remains highly disturbed below the cloud deck after the 2015 - 2016 expansion in the visible [1].
- Preceding the October 2016 plume eruptions [5], we can see a highly disturbed North Temperate Belt with a planetary-scale disturbance already in place by the time the plumes are detected in the infrared.
- The SEB shows large brightness temperature fluctuations prior to the January 2017 storm outbreak [2].

Acknowledgements

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