National Aeronautics and Space Administration

Investigating the Color and Structure of the 2018-2022 Equatorial Zone Disturbance

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Equatorial Zone Disturbances – What causes these periodic, global storms?

- Jupiter's Equatorial Zone (EZ) undergoes quasi-periodic disturbances that both darken the normally white cloud tops and clear out the thick cloud layers every 6-8 or 12-14 years [1].
- The most recent disturbance began in 2018 and faded in 2022. The expected color change took place, but not the anticipated cloud-clearing. Fig. 1 illustrates the significant color change in the EZ between 2015 and 2019.
- The source of the periodicity of these major weather events and the exact dynamical mechanisms that alter cloud morphology and color in the EZ are yet unknown; if ID'd, measuring the degree of change they impart on the clouds can inform our understanding of Jupiter's bulk properties and energy budget.

To investigate these color changes and their causes, we conducted radiative transfer modeling of the EZ during quiet and disturbed periods. The degree of change between epochs can reveal clues as to what sort of mechanism (e.g. downwelling vs. upwelling) might be responsible for these changes.

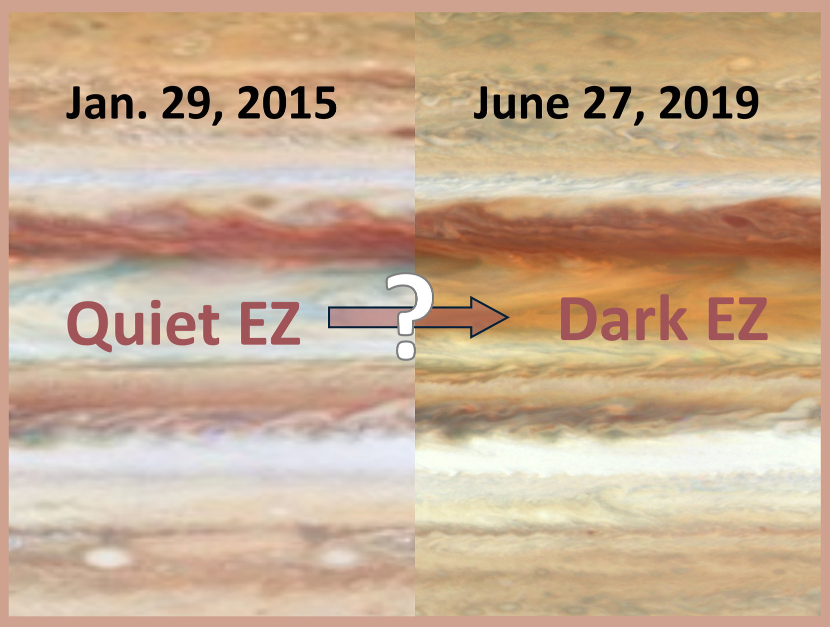

Fig. 1 – The color change undergone by Jupiter's Equatorial Zone between 2015 and 2019. Image credit: NASA / ESA / A. Simon (GSFC)

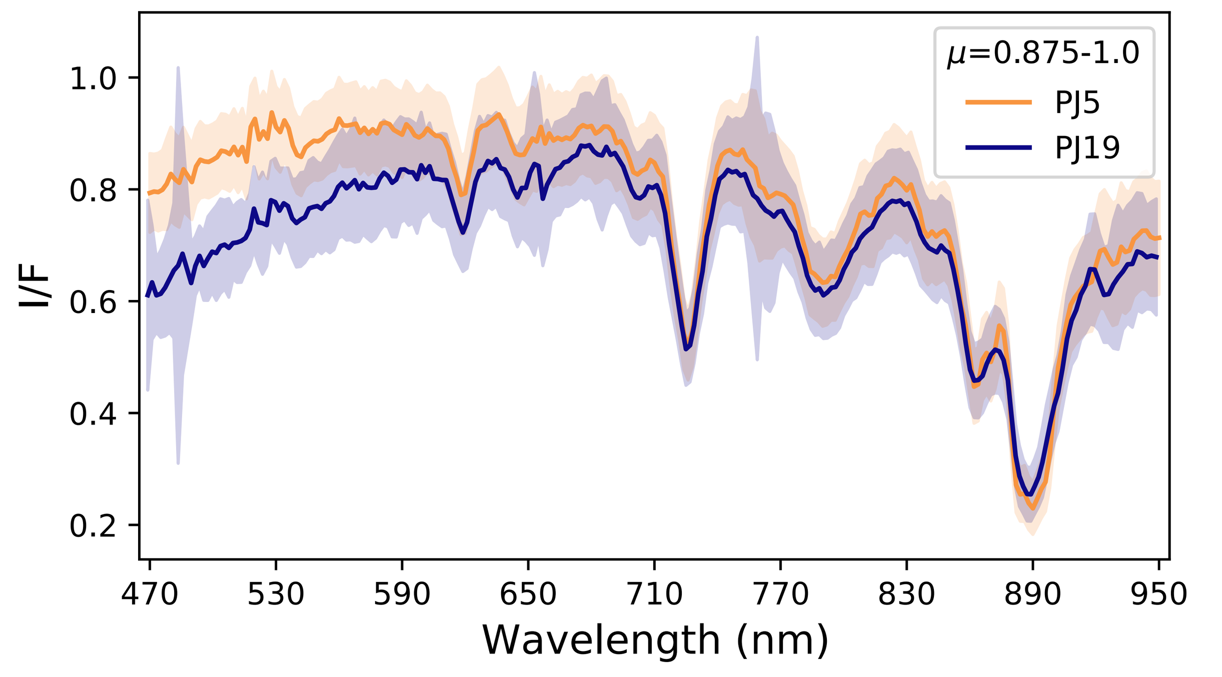

Fig. 2 – The color change undergone by Jupiter's Equatorial Zone between 2015 and 2019. Image credit: NASA / ESA / A. Simon (GSFC)

Observations

- Observations analyzed in this work were obtained with the NMSU Acousto-optic Imaging Camera at the 3.5-m telescope at Apache Point Observatory in Sunspot, NM in support of the *Juno* spacecraft's 5th and 19th perijove (PJ5 and PJ19) pass in March 2017 and April 2019, respectively
- Resulting hyperspectral image cubes cover 470-950 nm w/ an average λ/dλ of ~207
- Fig. 2 illustrates the difference in I/F, or absolute reflectivity, of the EZ when it was quiet in 2017 (during PJ5) and disturbed in 2019 (during PJ19)
- The disturbed EZ is darker at most wavelengths, and methane bands are shallower relative to the continuum; this reveals evidence of a haze layer that was redder and higher than in 2017

Modeling Methodology

- Using the NEMESIS radiative transfer software [2]
- Testing cloud parameterization that assumes a continuous colored haze above a tropospheric cloud; testing different combinations of assumptions on particle size and chromophore color
- Testing a variety of chromophore complex index of refraction spectra; running models with and without allowing those values to vary

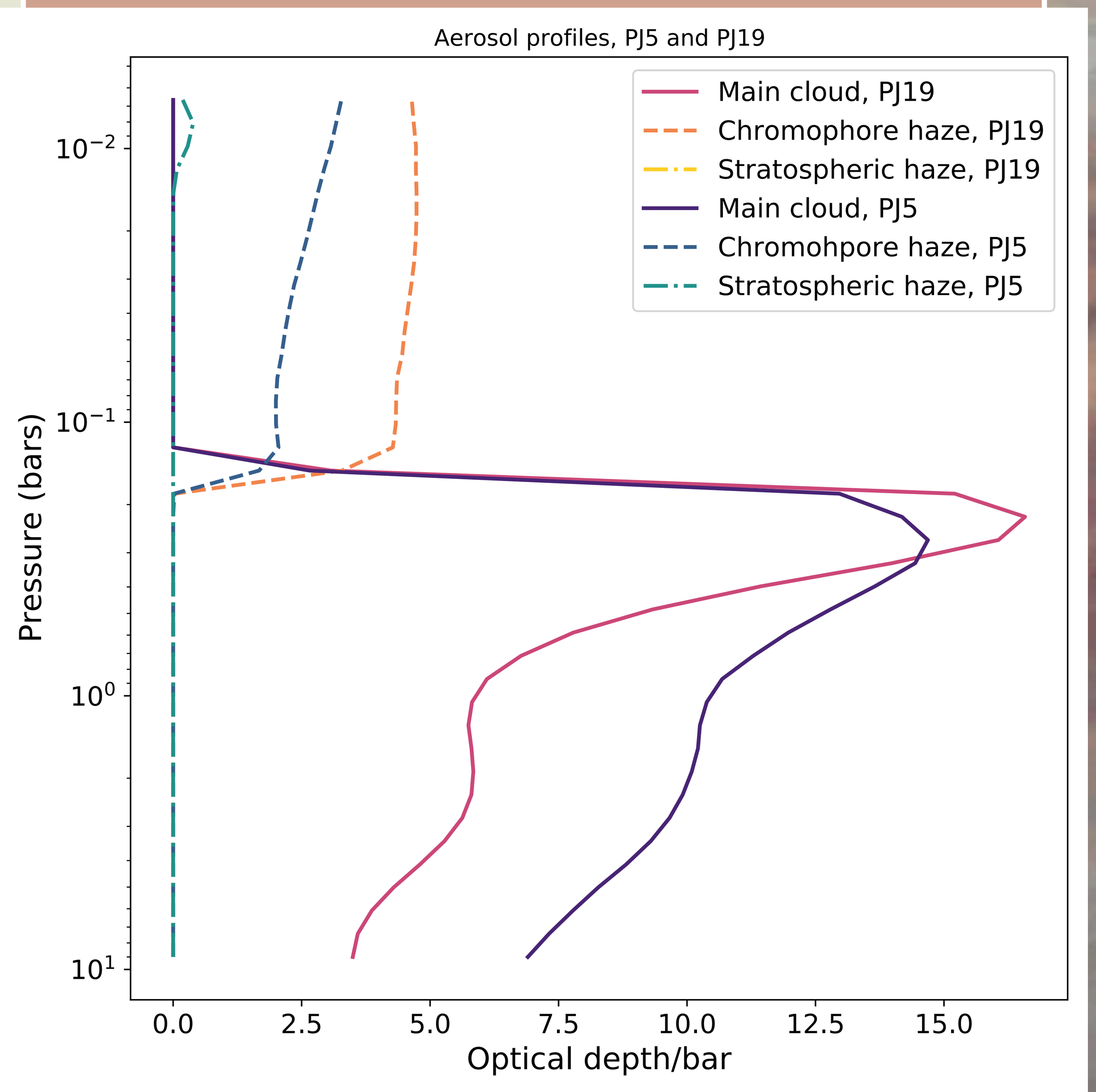

Fig. 3 – Retrieved aerosol profiles during PJ5 (pre-disturbance) and PJ19 (during the disturbance). Solid lines represent the main cloud layer, dashed lines the chromophore haze, and dot-dash lines the stratospheric haze layer.

Results: Increased opacity at higher altitudes → Uplifting?

- Best-fit retrieved values show a decrease in the integrated optical depth of the main cloud (τ_1) during the disturbance by 44% and an increase in the optical depth of the chromophore haze (τ_2) by 103%. The stratospheric haze also essentially vanished, with its optical depth (τ_3) dropping to essentially 0. Table 1 displays the values for these retrieved parameters. Retrieved values can be found in Table 1.
- The shapes of the aerosol layers (e.g. Fig. 3) also changed; while the main cloud decreased in overall opacity during the disturbance, it increased over the pre-disturbance clouds at higher altitudes near the cloud top.
- The color of the chromophore during the disturbance indicated an older, darker coloring agent by a factor of 2.
- ***All these results point to an uplifting dynamical mechanism!*** Something is lifting hazes to higher altitudes where they can be further photochemically processed.
- Identifying this uplifting mechanism will require measures of convective strength by pinpointing the aerosol load at altitude.

Table 1	PJ5	PJ19	Change
Cloud peak pressure	0.27 bar	0.22 bar	-18%
Main cloud τ_1 (total)	84	47	-44%
Chromophore τ_2 (total)	0.33	0.67	103%
Strato. haze τ_3 (total)	0.0016	~0	+0.0016
Chromophore exp. time	20 hrs	40 hrs	100%

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Publications:

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[2] Irwin, P. G. J., Teanby, N. A., de Kok, R., et al. 2008,Journal of Quantitative Spectroscopy and RadiativeTransfer, 109, 1136, doi: 10.1016/j.jqsrt.2007.11.006

Background image credit: NASA, ESA, and A. Simon (GSFC)