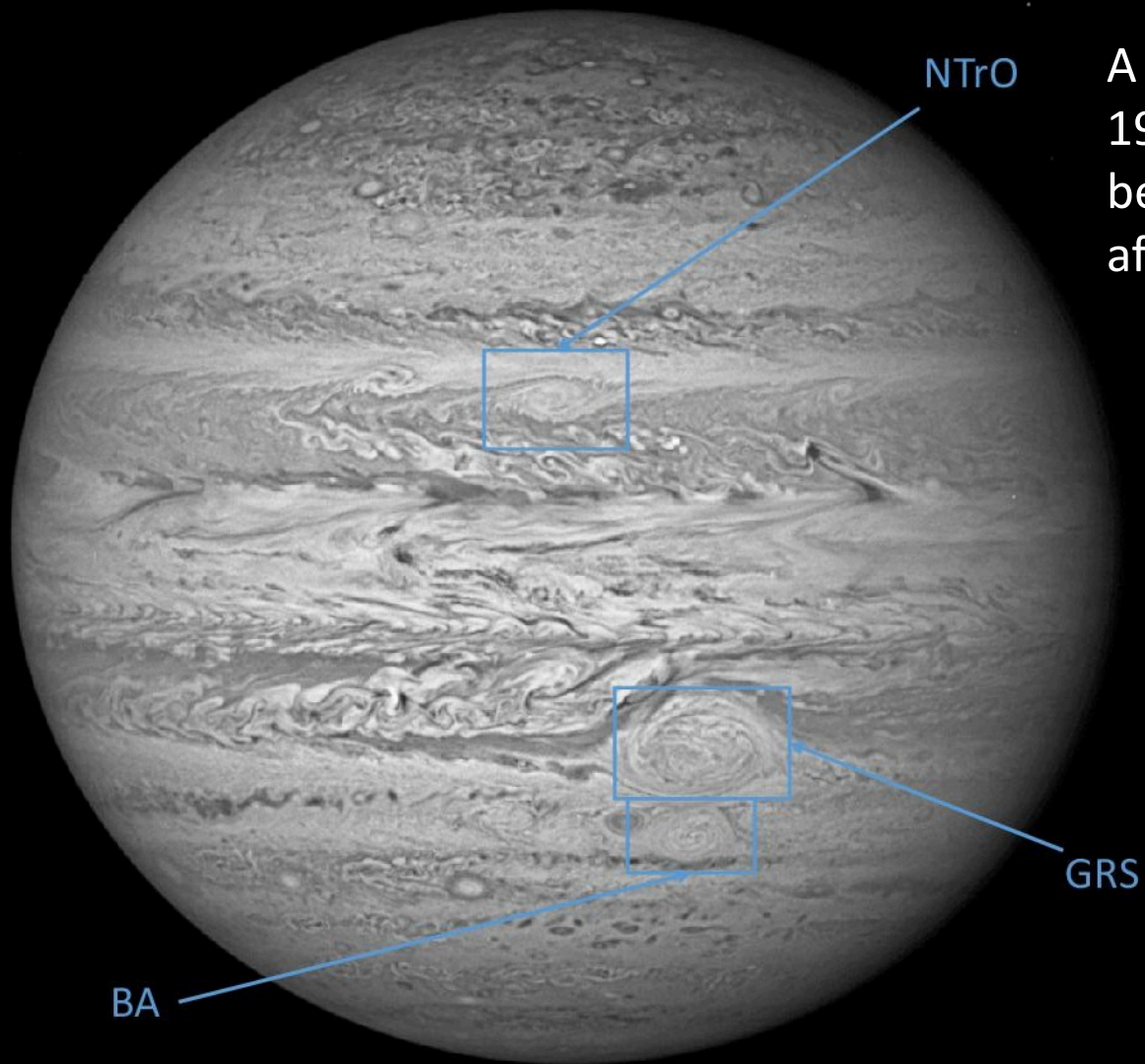
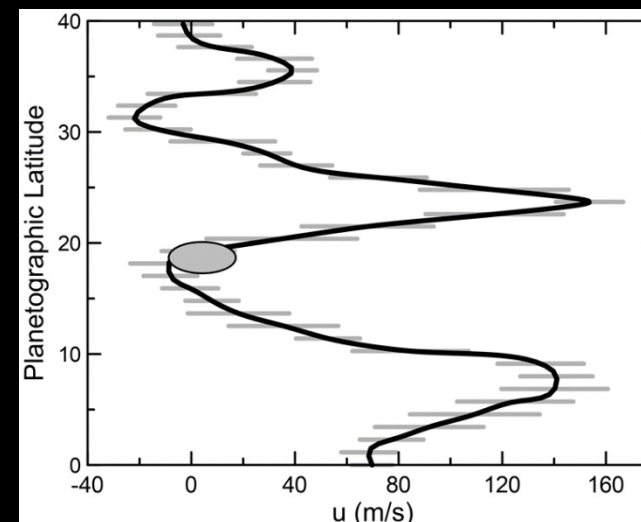


Color changes and dynamics of the third largest oval on Jupiter

N. Barrado-Izagirre, J. Legarreta, A. Sánchez-Lavega, S. Pérez-Hoyos, R. Hueso, P. Iñurriagarro, J. F. Rojas, I. Mendikoa, I. Ordoñez-Etxebarria

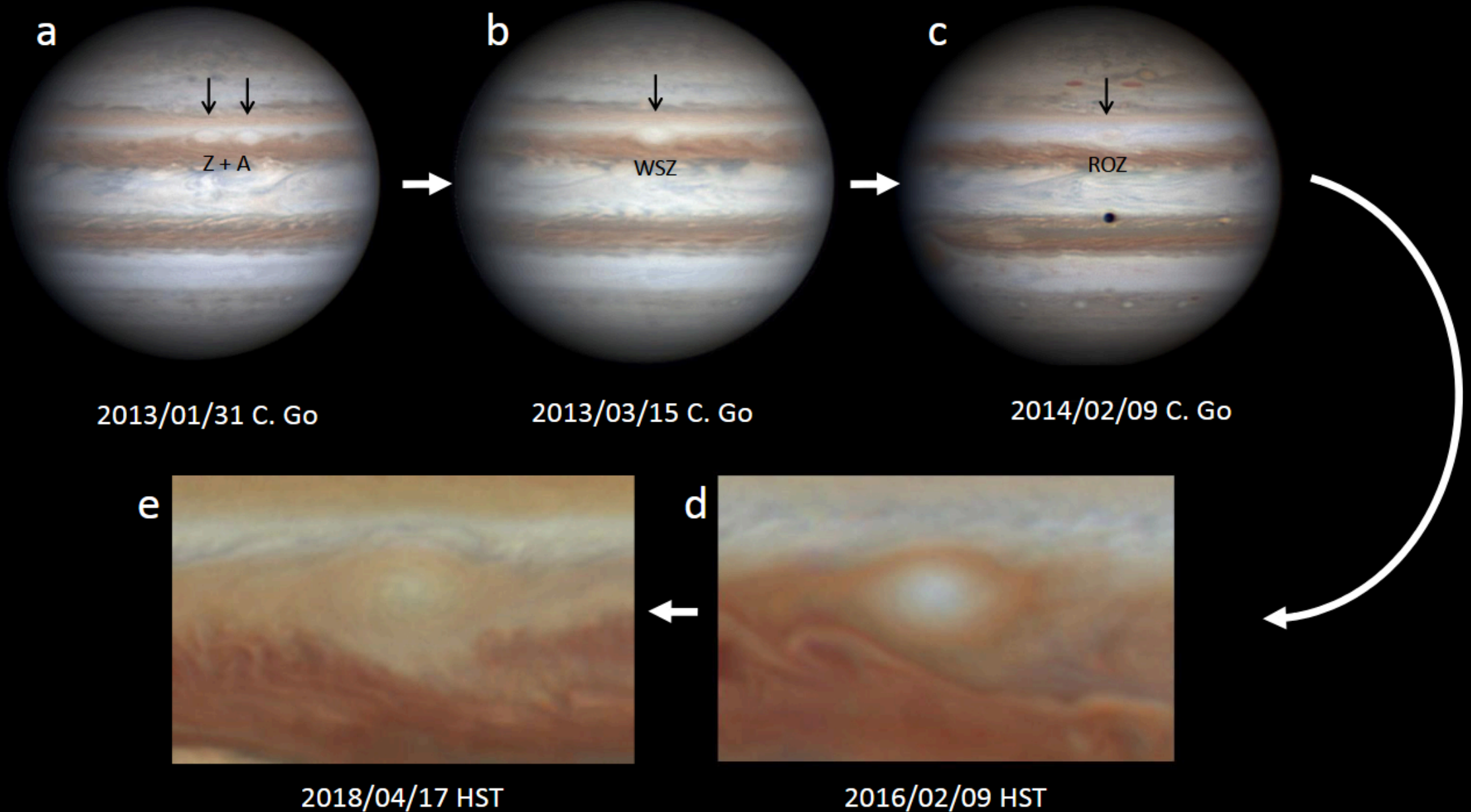


A large anticyclone, NTrO, at planetographic latitude 19°N persists there after a complex dynamic history, being possibly the third longest-lived oval in the planet after Jupiter's Great Red Spot and oval BA.

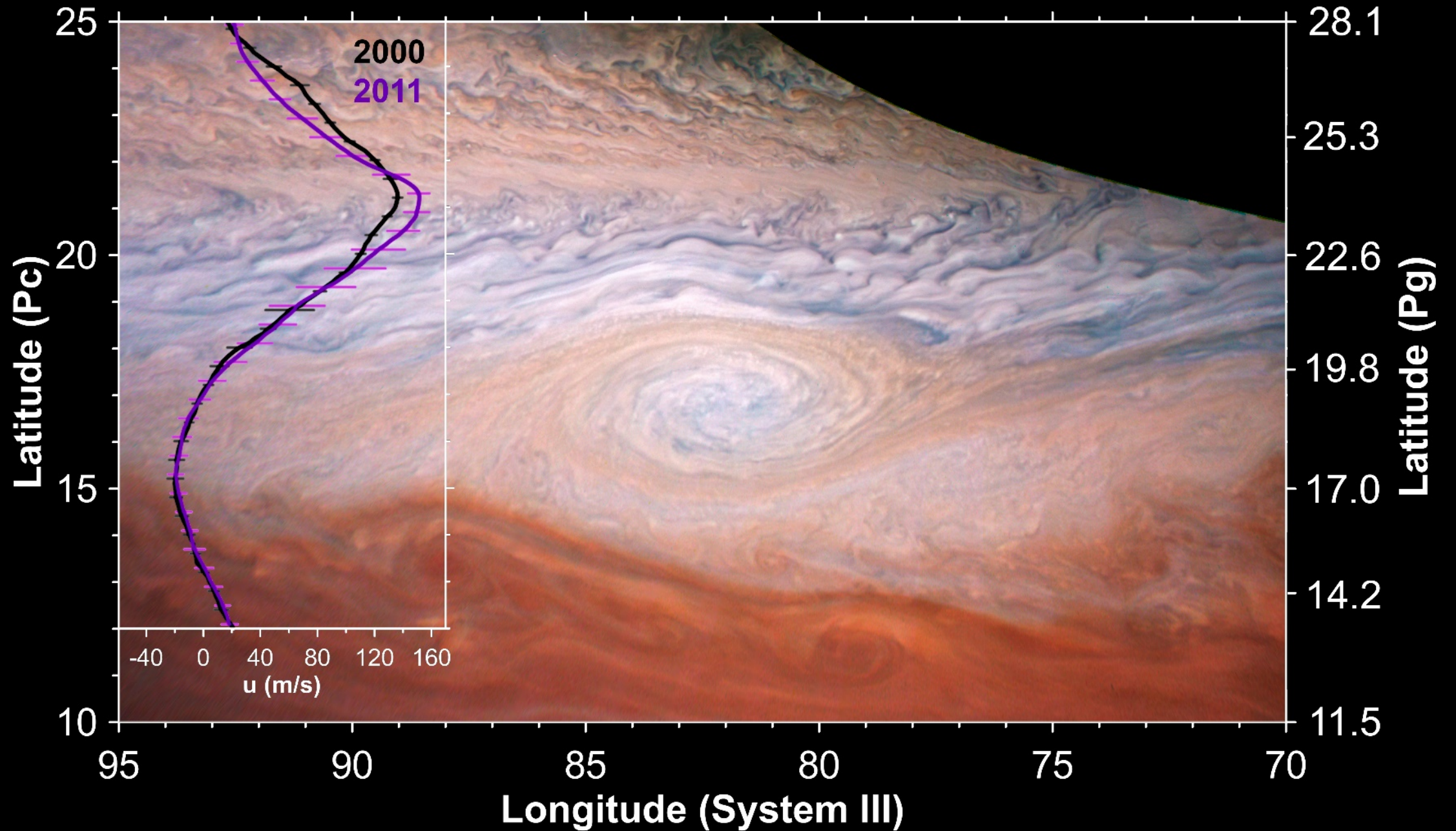


AT its position zonal winds are weak but have a strong latitudinal shear allowing the formation of cyclones and anticyclones that remain close in latitude.

Evolution an aspect of the oval in different periods of its lifetime



High resolution image of the NTrO from JunoCam observations



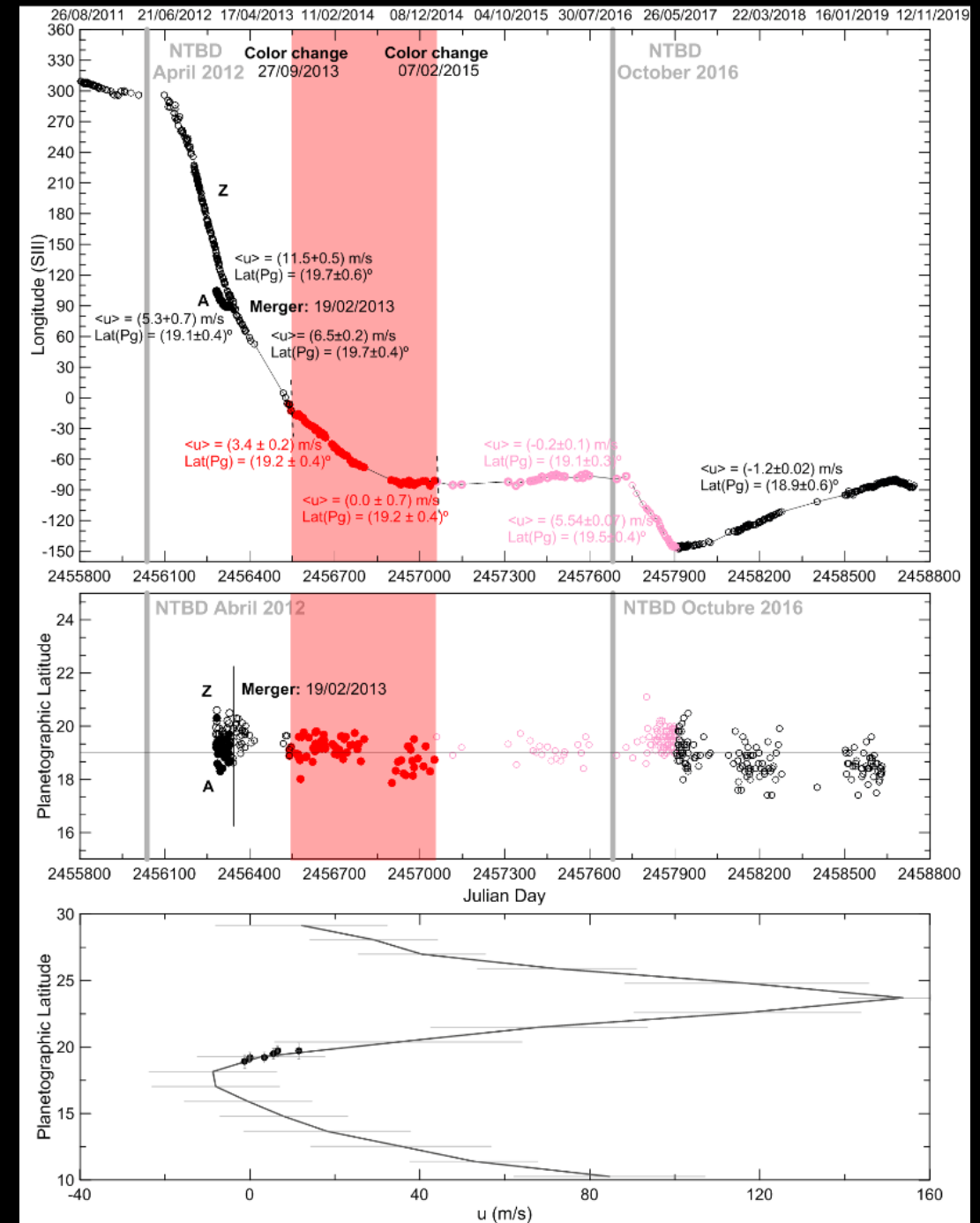
Tracking of the oval

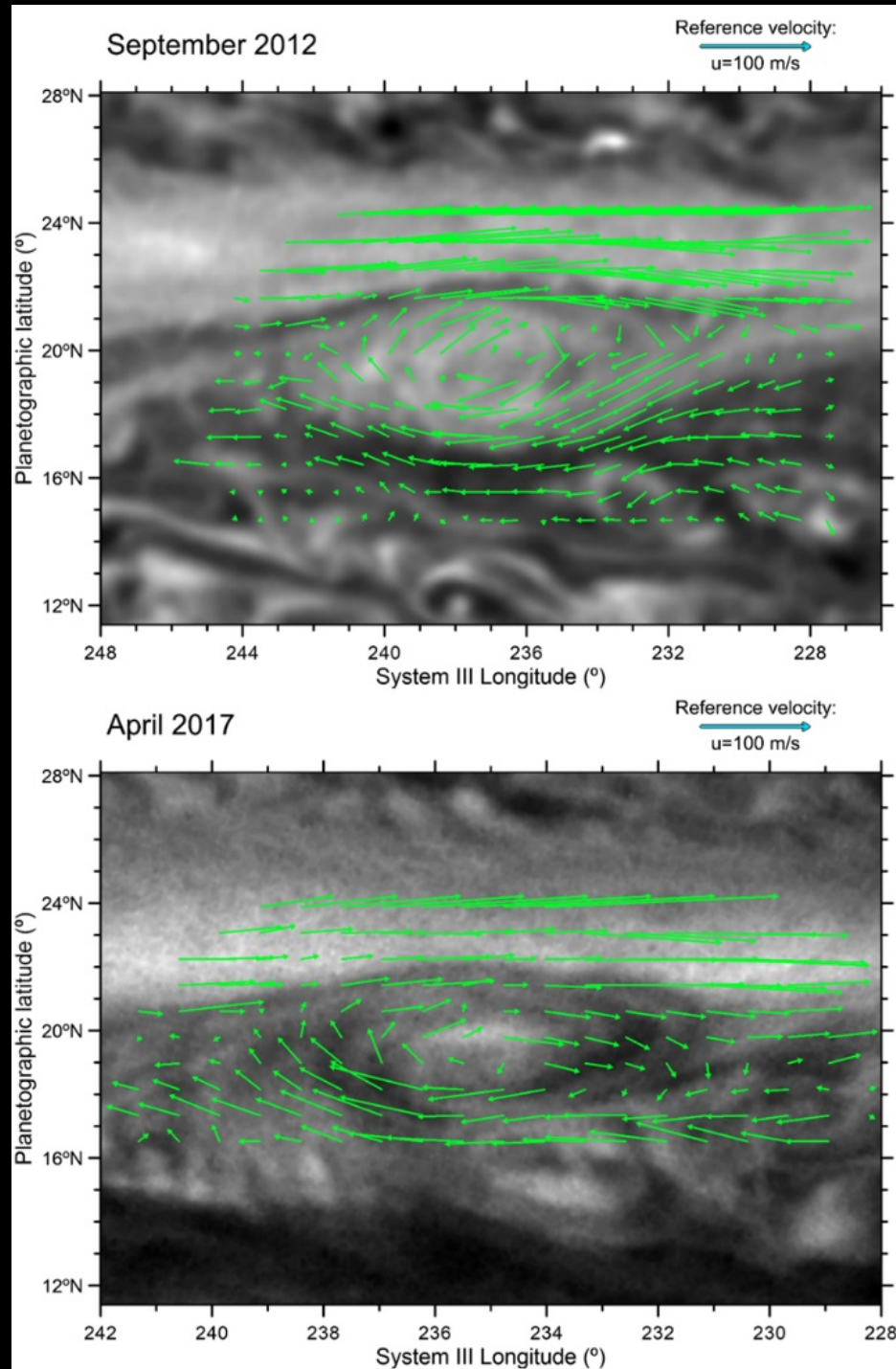
Changes in the slope (top panel) represent changes in the drift rate of the oval. Such changes are probably related to small changes in latitude (middle panel).

In February 2013, the NTrO or White Oval Z and the White Oval A merged. The oval underwent hardly any changes in appearance but a very subtle change in its position (latitude) that resulted in a small change in its drift rate.

Some months later, in September, the oval suffered a colour change and it remains red until February 2015, when it again turned White but with a pink ring around it.

In October 2016, an outburst of convective plumes in the NTB disturbed the area surrounding the oval (Sánchez-Lavega et al., 2017). The visual aspect of the oval didn't change but some days after the eruption the velocity increase from been nearly stationary to 5.5 m/s. Equivalent to what happened in 2012 eruption.





Rotation velocity and vorticity

Year	a (°)	b (°)	V_T (m/s)	ζ (s ⁻¹)
2012	4.9	2.4	-60±30	$(-3\pm1)\cdot10^{-5}$
2015	4.4	2.9	-35±20	$(-1.6\pm0.9)\cdot10^{-5}$
2016	3.2	2.1	-33±10	$(-2.1\pm0.7)\cdot10^{-5}$
2017	4.9	2.1	-34±20	$(-2\pm1)\cdot10^{-5}$
2018	4.0	3.0	-40±20	$(-1.9\pm0.9)\cdot10^{-5}$
2019 (*)	4.0	2.1	-	-

The relative vorticity has an average value of about $-2\cdot10^{-5}\text{s}^{-1}$. This is half the value of the GRS and BA, around $5\cdot10^{-5}\text{s}^{-1}$ and $4\cdot10^{-5}\text{s}^{-1}$ respectively.

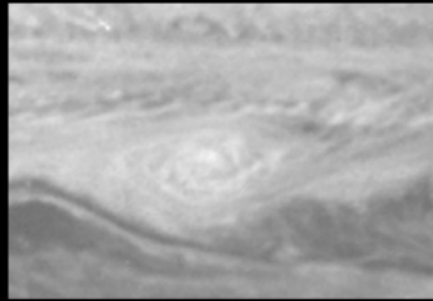
The ambient vorticity of the area where GRS and BA are located is lower than the oval's vorticity, of $1.5\cdot10^{-5}\text{s}^{-1}$ and $0.4\cdot10^{-5}\text{s}^{-1}$ respectively. However, the ambient vorticity of the NTrO's area is very similar to its relative vorticity.

Appearance of
the NTrO in
different filters
and time
periods

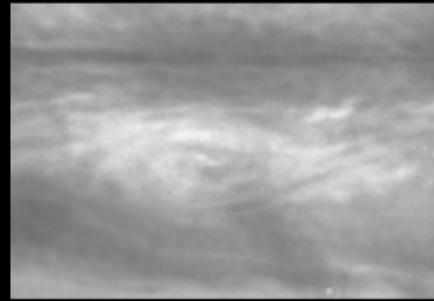
January 2015



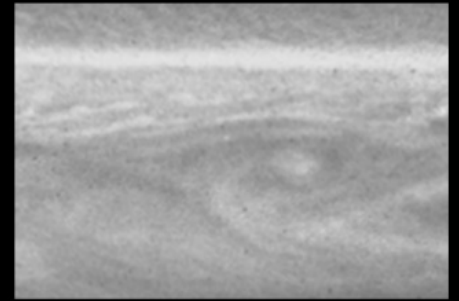
NIR



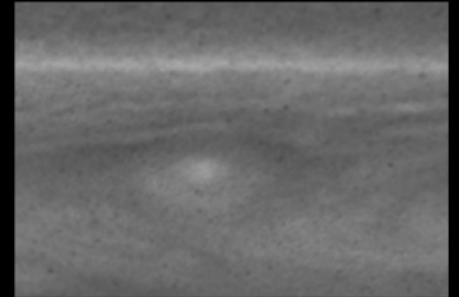
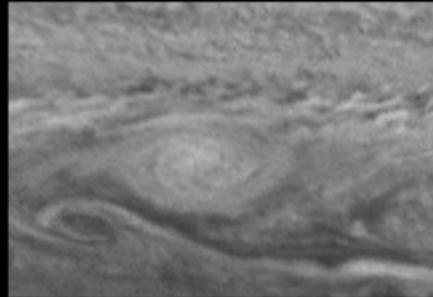
MT



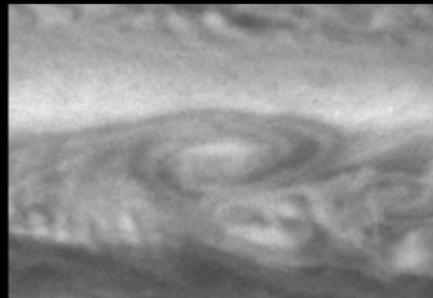
UV



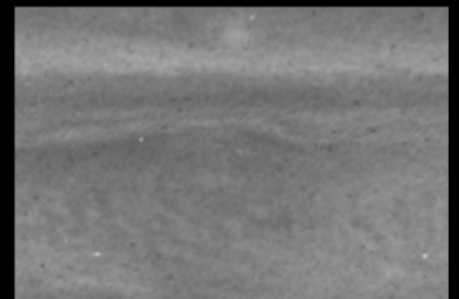
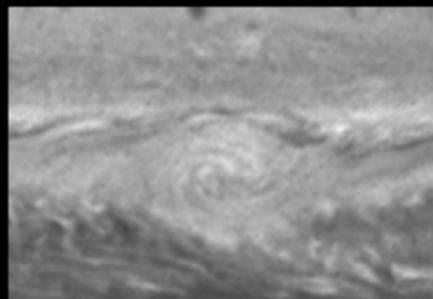
February 2016



April 2017



April 2018



We calculate two photometric indices: CI (Color index) y AOI (Altitude-opacity index) as described in Sánchez-Lavega et al. (2013).

Color index: sensitive to the color of a given detail.

$$CI_k = \frac{R_k(\lambda = 410 \text{ nm})}{R_k(\lambda = 673 \text{ nm})}$$

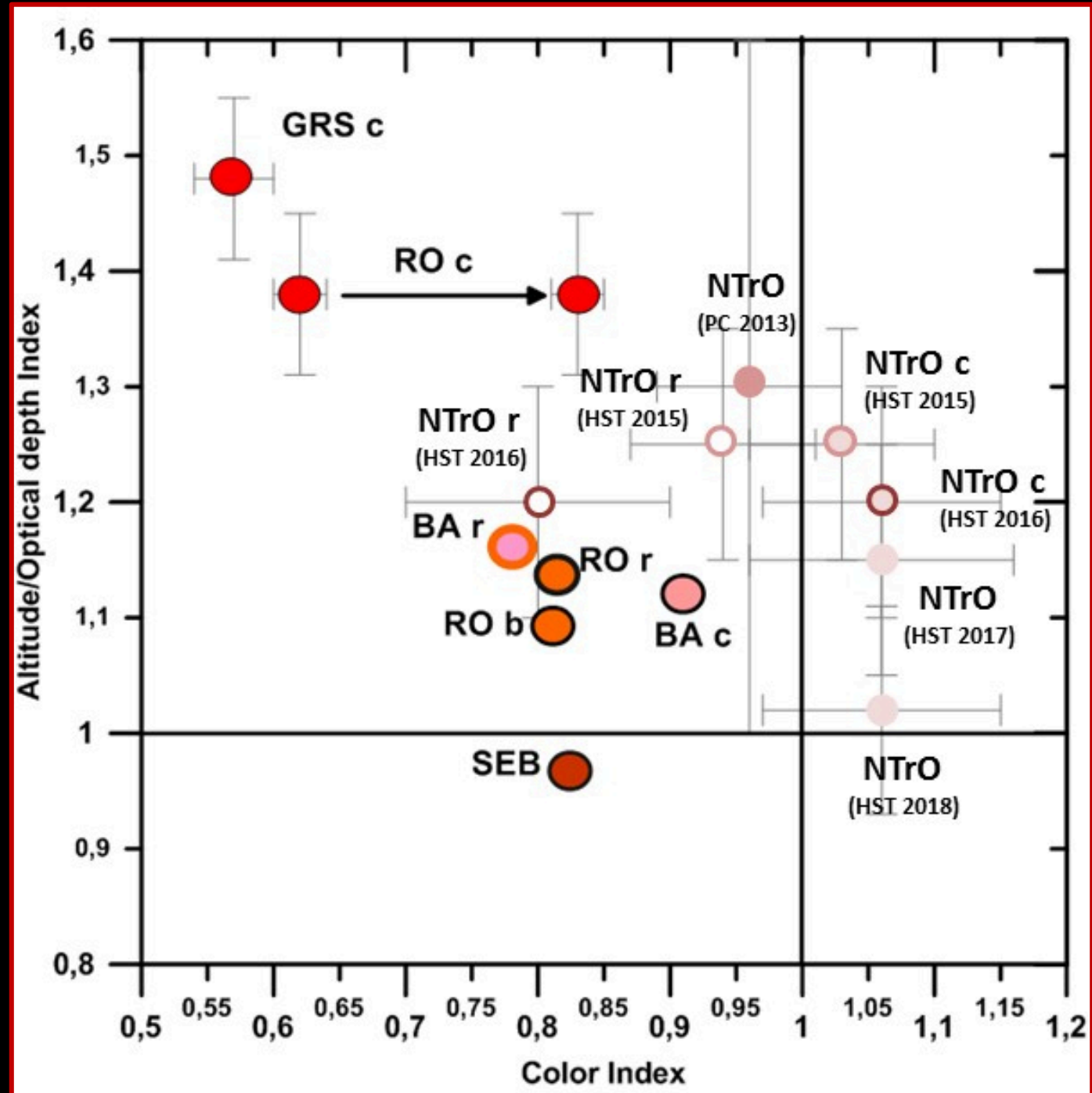
Altitude-opacity index: sensitive to the upper haze altitude optical depth and its ultraviolet opacity.

$$AOI_k = \frac{R_k(\lambda = 890 \text{ nm})}{R_k(\lambda = 255 \text{ nm})}$$

where

$$R_k = \frac{\langle DN(\lambda) \rangle_k / \mu_{0k}}{\langle DN(\lambda) \rangle_r / \mu_{0r}}$$

is the relative reflectivity.



Discussion and conclusions

- The NTRO is the third largest and longest-lived oval in Jupiter's atmosphere.
- It is half size of the second largest oval (BA).
- As oval BA has experienced mergers with other vortices and colour changes that comes together with changes in the vertical structure of the clouds.
- The NTrO is an anticyclone with a mean vorticity value of $-(2\pm1)\cdot10^{-5}\text{s}^{-1}$, which is very similar, within the error, to the vorticity of the zonal jet which value is $\sim-(2.3\pm0.8)\cdot10^{-5}\text{s}^{-1}$, contrarily to GRS and BA which have higher vorticity values than their corresponding ambient vorticity.
- The results suggests that NTrO must be sustained by the zonal jets confining it.
- Small changes in latitude seem to produce changes in its drift rate without significantly altering its size or vorticity.

Discussion and conclusions

- We quantified the color and the altitude-opacity indexes.
 - It seems to be more elevated than the reference area with a value of AOI higher than 1 in all the analyzed years.
 - In 2015, when the oval is white, it is less red than the reference area with values of CI between 1.0 ± 0.1 and 1.06 ± 0.07 .
 - In 2013 we obtain a 0.96 ± 0.07 value for the CI index which means it is redder than the reference but not as red as the GRS or the oval BA.

This work has been recently published in *Icarus* as:

Jupiter's third largest and longest-lived oval: Color changes and dynamics. N. Barrado-Izagirre, J. Legarreta, A. Sánchez-Lavega, S. Pérez-Hoyos, R. Hueso, P. Iñurriagarro, J.F. Rojas, I. Mendikoa, I. Ordonez-Etxeberria, IOPW Team. *Icarus*, **361**, 114394 (2021).