JunoCam at Perijove-PJ17 (2018 Dec.21): What the pictures show

John Rogers (2019 Feb.8)

PJ17, on 2018 Dec.21, came just at the start of the new apparition, so amateurs had been able to take only a few, lo-res ground-based images by that date. Even in 2019 Jan., the better images only showed longitudes preceding or following the PJ17 track, but they did give an idea of the global context (Figure 1). (This figure and more information are in our 2018 report no.1: https://britastro.org/node/17158). Thus, the JunoCam images themselves were vital for characterising the atmospheric features. Like PJ15, this was a Gravity orbit, with the spacecraft pointing towards Earth and Sun, which limited the coverage by JunoCam. Nevertheless, a full set of images was taken from pole to pole. A global cylindrical map, compiled from Gerald's map projections, is Figure 2. Juno crossed the equator at L2=240, L3=164.5. (This report does not describe the polar regions, which will be covered in a later supplement.)

As always, this report describes images produced by the JunoCam team: Candy Hansen, Glenn Orton, Tom Momary, Mike Ravine, Mike Caplinger, and Gerald Eichstädt.

In addition to the JunoCam web site, many of the best processed versions of JunoCam images at each flyby (including those by Björn Jónsson and Gerald Eichstädt and Seán Doran, and animations, and comments on any moons visible) can be found on **unmannedspaceflight.com** (UMSF) at: http://www.unmannedspaceflight.com/index.php?showforum=82

Views of moons and shadow

Inbound images 2 to 6 show moons, including a view of Io with a sunlit plume in the centre (Figure 3). This was caught just before Io entered Jupiter's shadow. During that eclipse, Io was also imaged by JIRAM (showing numerous volcanic hot spots in infrared) and by the Stellar Reference Unit (a hi-res, low-light camera, which recorded several glowing volcanic hot spots on a disk dimly lit by reflected light from Europa). Juno was looking down at high northern latitudes. The images and details are in this NASA press release:
https://www.swri.org/press-release/juno-mission-captures-images-of-volcanic-plumes-jupiters-moon-io
According to Io expert Jason Perry, on UMSF, the visible plume is from a volcano in Chalybes Regio which first appeared in 2008 and has been erupting since then.
Outbound image 49 also showed two moons along with Jupiter.

Also, two images at perijove (see below) show the shadow of Amalthea in the EZ(N) (for the second time – it was also imaged at PJ8). But a second very dark dot, on the NEBn, cannot be a satellite shadow.

Figures 1 *[not shown here]*

Figure 2 *[next page]*

Figure 3 (right): Io, with the plume of an erupting volcano projecting above the terminator near centre.

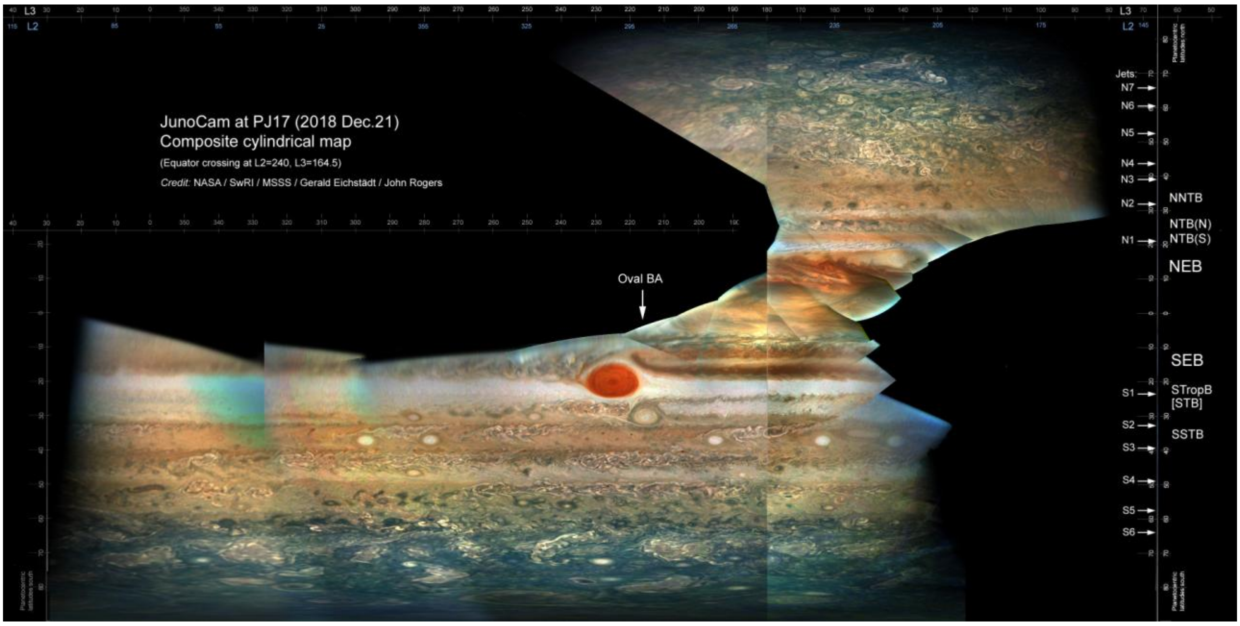


Figure 2.

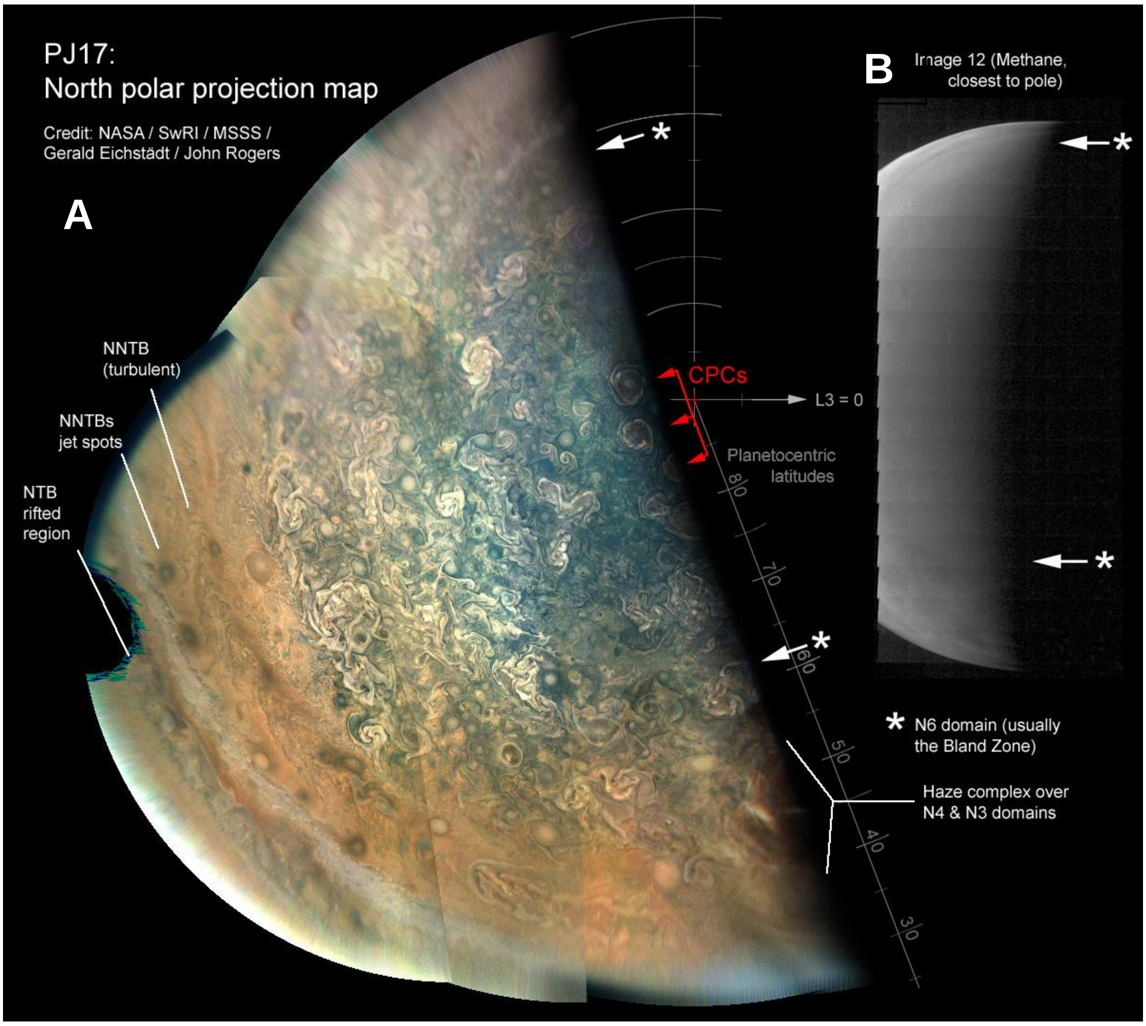


Figure 4.

[Figure 5-10 are at end of document]

High northern domains

Figure 4A is a north polar projection map covering a wider latitude range. The methane image (Figure 4B) is largely featureless because, now that over-the-north-pole images are taken from a low altitude, it merely shows the densest part of the polar hood -- except around the edges, where substantial bands can be seen in the haze as usual.
The Bland Zone is difficult to make out in these images; it is totally disrupted at most longitudes covered. However, this may well be just one abnormal sector. In the lower part of the map (Figure 4A), there is a typical stretch of Bland Zone, and in the upper part, there are typical haze bands aligned with it, both white (at top near terminator) and brown (under full sun, better seen in individual images or Figure 2).

Near the terminator further south, there is a complex tangle of prominent haze bands, overlying the N3 and N4 domains. They include a very bright 'rainbow band' and an extensive 'brown shadow', as seen in an enhancement of Björn Jónsson's processed image 13 (Figure 5A).

Further south still, where Juno views the brightly sunlit horizon from low altitude, a high-altitude haze layer can be seen side-on, as seen in an Björn's processed image 21 (Figure 5B). It is most prominent in a band over the NTB north edge, on or beyond the rifted region, with a fainter extension northwards over the NTZ. Another prominent band is seen further north, perhaps over the N3 or N4 domain. Although these do not coincide with the NNTB as in two previous perijoves, they are all likely to be the same kind of haze bands that we also see near the terminator.

Figure 6 shows hi-res views of some of the magnificent storms in these northern domains. (Seán Doran has posted even better versions of these on UMSF.)

Figure 7 shows some of the views over the northern temperate regions. *The NNTB* is mostly pale, but filled with highly textured clouds and some small orange cyclones. In contrast, the *NNTBs (N2) jet* is covered with a largely featureless cloud deck, within which are a series of conspicuous anticyclonic spots (A), alternating with small cyclones (C). The anticyclonic spots are typical 'jetstream spots', both white and dark. It is notable that the dark ones appear diffuse, both in extent and in their spiral structure (hi-res view in Figure 8), like other dark grey structures that we have noticed in the N2 domain at previous perijoves. It is possible that the dark grey colour is a haze at or above cloud-top level, although the high sun angle at PJ17 precludes a 3D impression.

Juno passed over the *NTB rifted region*, shown extensively in Figures 2, 7 & 8. Within it there are many examples of whitish or pale orange cloud streaks crossing over other cloud structures which are presumably at different altitude (white arrows). Further west, a high-altitude haze layer is seen above the horizon (Figure 5B).

North Tropical Domain and Equatorial Zone

The last ground-based observations of 2018 showed that the northern extension of the NEB had faded to a pale fawn colour, leaving the main NEB dark brown with a sharp, wavy NEBn edge. The new images in 2019 Jan. (Figure 1 & 2018 report no.1) show a similar aspect, but with almost no trace of the residual northern extension.

The PJ17 images span a sector of NEB between an AWO at L3 = 142 and a barge at L3 = 175 (Figure 2). JunoCam does show ochre colour still in the residual northern extension of the NEB. A wealth of beautiful structure is seen in the NEB, although as usual it is diffuse at the highest resolution (Figure 9, images 24 & 25). (Any visual impression of 3D topography in the cloud bands is probably an illusion, as the sun is nearly overhead.)

These images show two notable, tiny, very dark dots, spotted by Justin Cowart and Gerald. One, on the EZ(N) in images 22 & 23, is the shadow of Amalthea. The other, on the NEBn in images 22-24, cannot be a satellite shadow, given its latitude (provisionally, 14.3ºN), and it is very dark brown, and has a circular light reddish halo (Figure 9, image 24). It's close to the retrograde jet.
I hesitate to say (given how often that 'impacts' are suggested by people who have just noticed a dark spot) but perhaps it could be a scar from one of those small impacts that are occasionally imaged as flashes? Or perhaps it could be a tiny vortex? (These can be extremely dark, as we see in the S2 & S3 domains, for example, in unenhanced versions of image 36 by both Gerald and Björn; also Daniel Macháček on UMSF noted a similar tiny round spot in a Voyager 2 closeup of the faded NNTB, but it was generally agreed to be a cyclonic vortex.) But this is the only such feature seen in the NEBn.

In the EZ, ground-based images (Figure 1) show that the ochre or dull orange coloration is still strong, and now covers most of the zone at varying intensity, leaving only a narrow strip of white EZ(S). The JunoCam images show the EZ as an intricate mixture of ochre and grey streaks. (Note that the JunoCam images have strong colour enhancement, which also brings out residual colour banding due to the scan strips.) Within this, in the EZ(N), there is one large raft of mesoscale waves (Figure 9, image 26).

The SEBn edge has a distinctive, high-contrast appearance, viz. a long series of the disturbances termed 'chevrons' (Figure 9, image 27), as well as wave-like features within the SEB north component.

South Tropical and Temperate Domains

In ground-based images (Figure 1 & 2018 report no.1) the SEB has not changed much since October: it still has a broad, very dark south component, so it has not generally faded, but it still has a 'SEB Zone' (SEBZ) within it, broad and very light f. the GRS (as imaged at PJ16), and narrower and light ochre p. the GRS (as imaged at PJ17). There are still one or two bright white spots just f. the GRS (as imaged at PJ17 near the limb: Figure 2), so the convective and turbulent activity here still continues, at a low level.

The northern part of the SEB shows striking high-contrast patterns, whereas the SEBZ appears bland and almost white. The SEBs edge has a long series of undulations, of wavelengths 3.8 to 4.7 deg. longitude (Figures 2 & 10). These must be the same type of waves that we discovered a few years ago, also mainly at times when the SEB was largely quiescent, and the PJ17 images give the best-ever view of them.

As Juno climbed higher over the southern latitudes, it had a striking view of the GRS and oval BA rising over the limb (e.g. Figure 10). This was JunoCam's first good view of oval BA. Its usual orange colour has faded away during solar conjunction, leaving only a faint tint (remember that colour is enhanced in the JunoCam images). Indeed, ground-based images showed the oval BA's colour fading in 2018 July [our 2018 report no.6], almost white in October [images in report no.9], and white now (Figure 1).

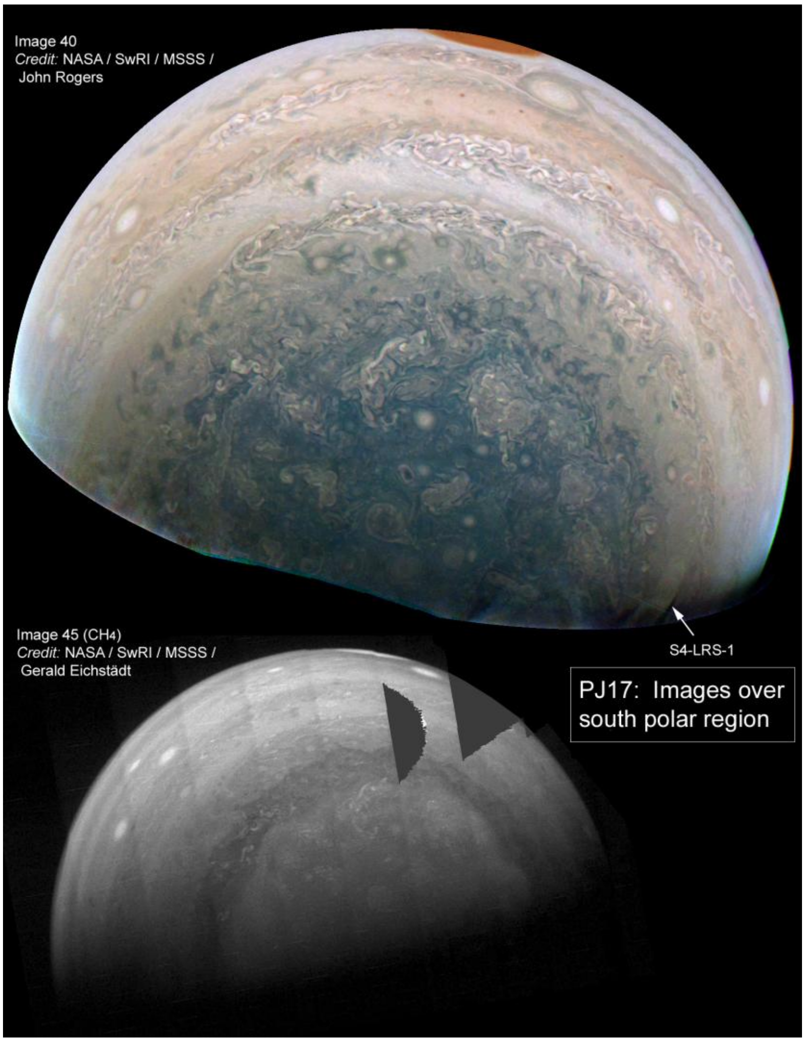
Gerald and Sean made animations of the PJ17 projected images of the GRS and BA, posted on the JunoCam web pages and UMSF:
http://www.unmannedspaceflight.com/index.php?showtopic=8443&st=45
The anticyclonic rotation of both ovals is clearly shown, esp. BA as it was further from the limb. I have measured wind speeds within BA from these maps: the fastest winds are in the formerly-orange annulus, averaging 109 (±8) m/s in the north and 142 (±8) m/s in the south. The speeds could be up to 18% higher at the outer edge of this annulus. Details will be given in a supplemental report, and Gerald is working on measurements using an independent technique.

Following oval BA, the turbulent STB segment is still well defined, and f. that in the STZ, there are still two small AWOs and several small dark grey spots. However, the very dark grey 'tail' seen at PJ16 has largely disappeared. Preceding oval BA, I am still looking out for any new cyclonic circulation, but so far there are only small vortices which could be ephemeral.

High southern domains

Images close to the south pole (though not directly over it), in RGB & methane, are shown in Figure 11. A reddish oval at 57ºS, dimly seen at the terminator with some overlying haze, is probably S4-LRS-1 (approx. L2=210, L3=135). This had a close encounter with S4-AWO-2 at PJ15 [see 2018 Report no.7], and it must have been rapidly prograding since then; as there is no sign of f. it, they probably merged during solar conjunction, although this needs to be confirmed by future observations.

Figure 11 (right):



Attached is an **animation** of the first and last of Gerald's south polar maps (similar to one posted in our report on PJ16). We see not only the rapid circulation in the circumpolar cyclones and FFRs, and the S6 jet, but also a weaker prograde jet or stream at 76-77ºS, not previously noticed; this could be only a temporary flow. The S6 jet is obvious, and preliminary wind tracing by Gerald (data not shown) shows (as we have long suspected) that it does have a sinuous flow aligned with the wave pattern around the edge of the methane-bright South Polar Hood, which largely winds around the edges of the FFRs to the south.

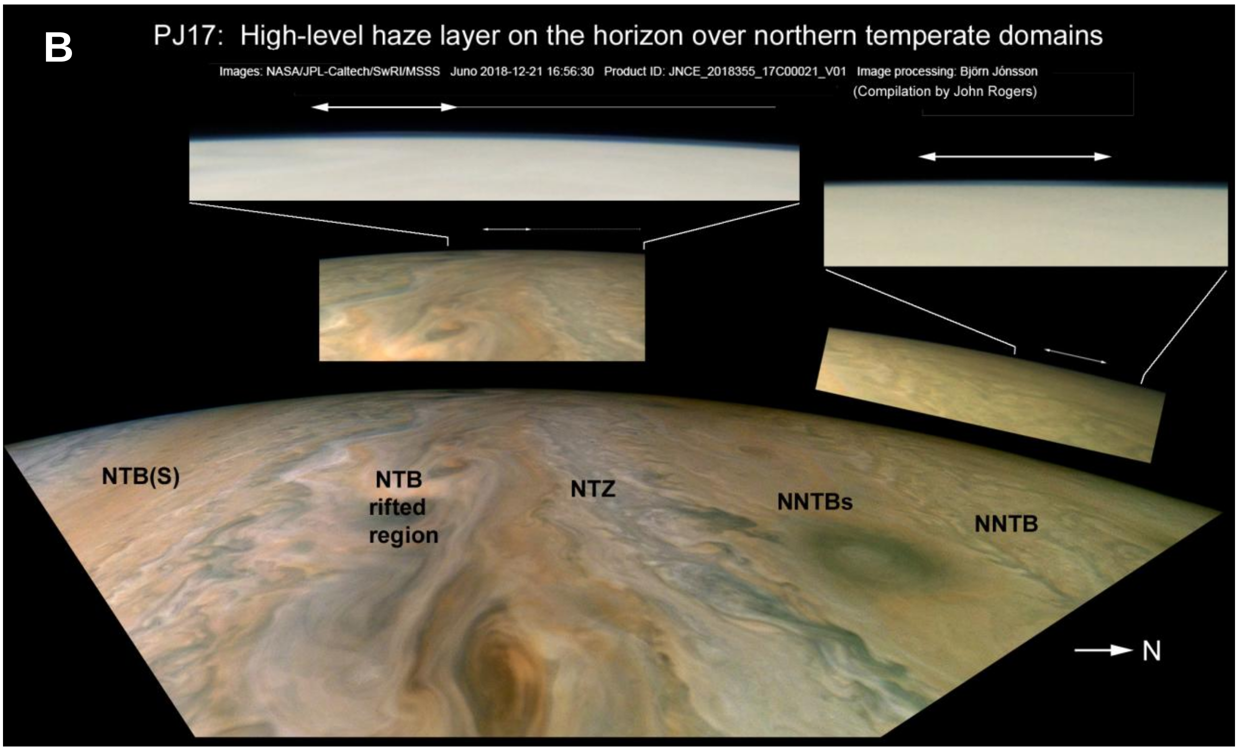


Figure 5 (A & B, above):
Hazes over northern domains.

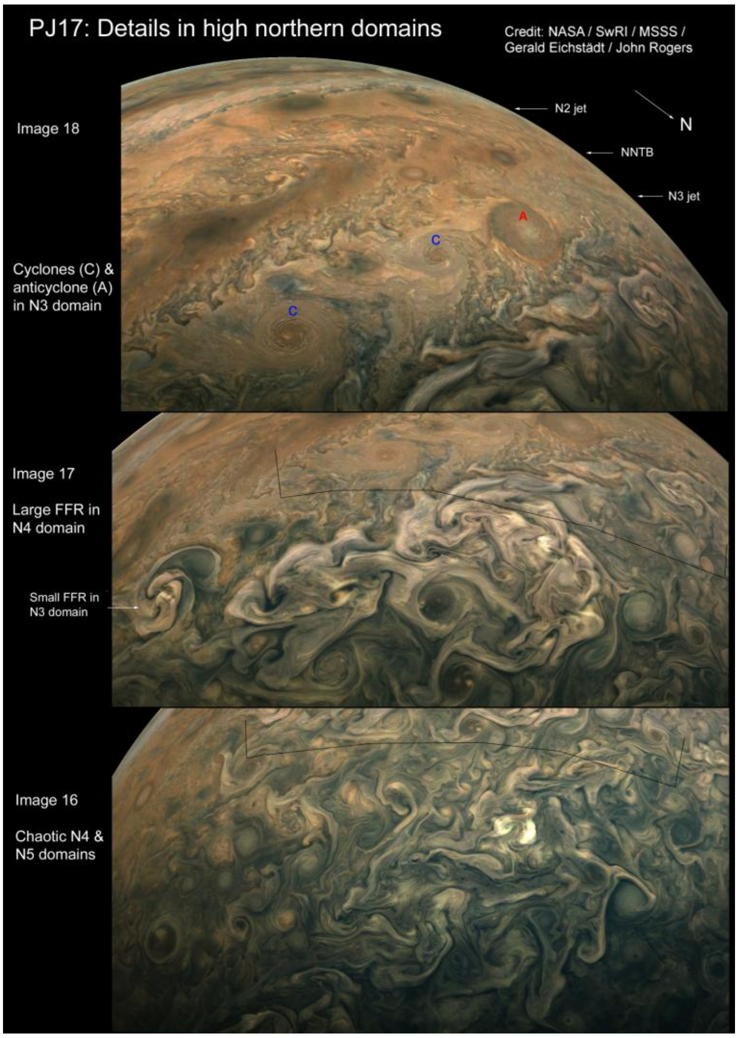


Figure 6 (right):

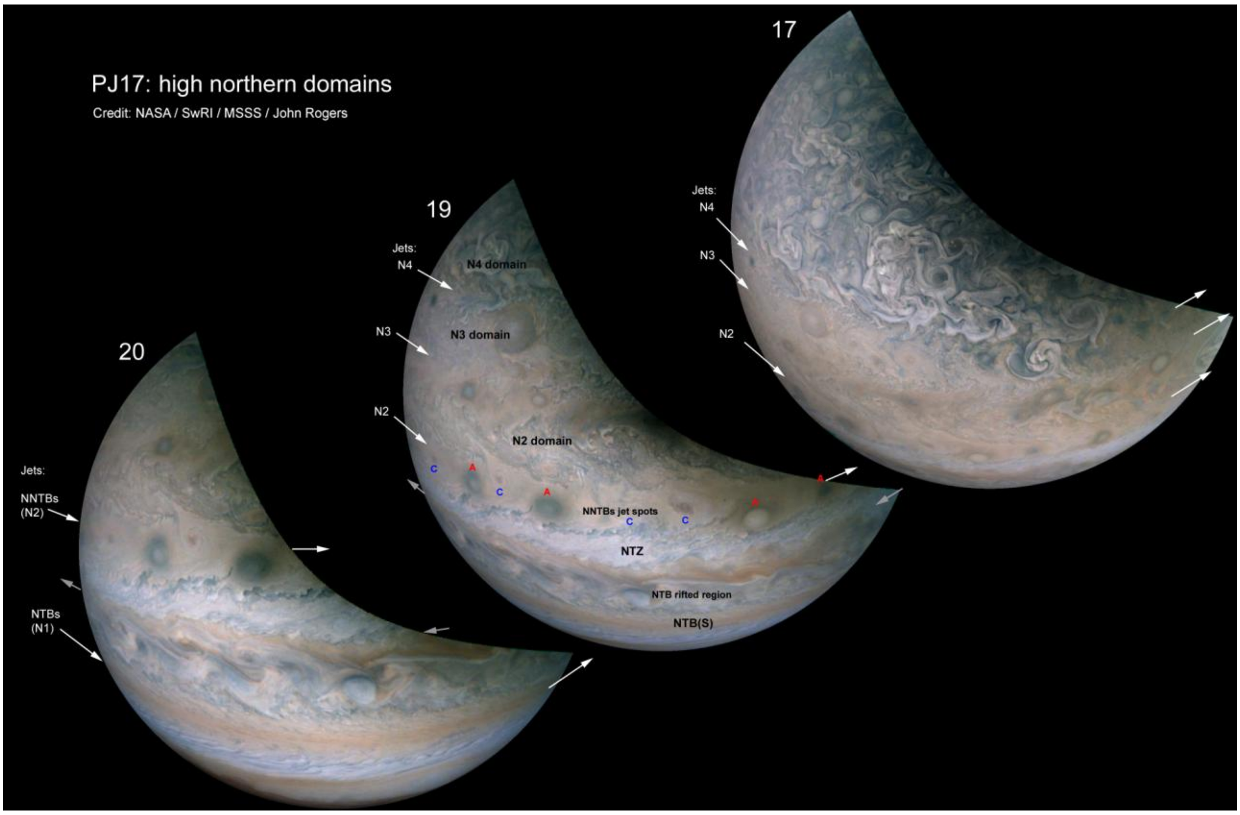


Figure 7.

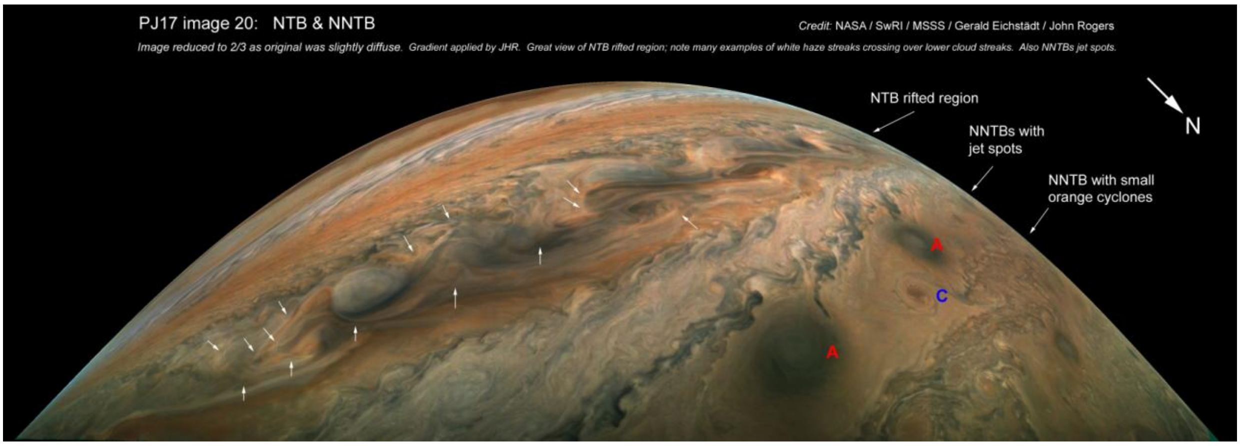


Figure 8.

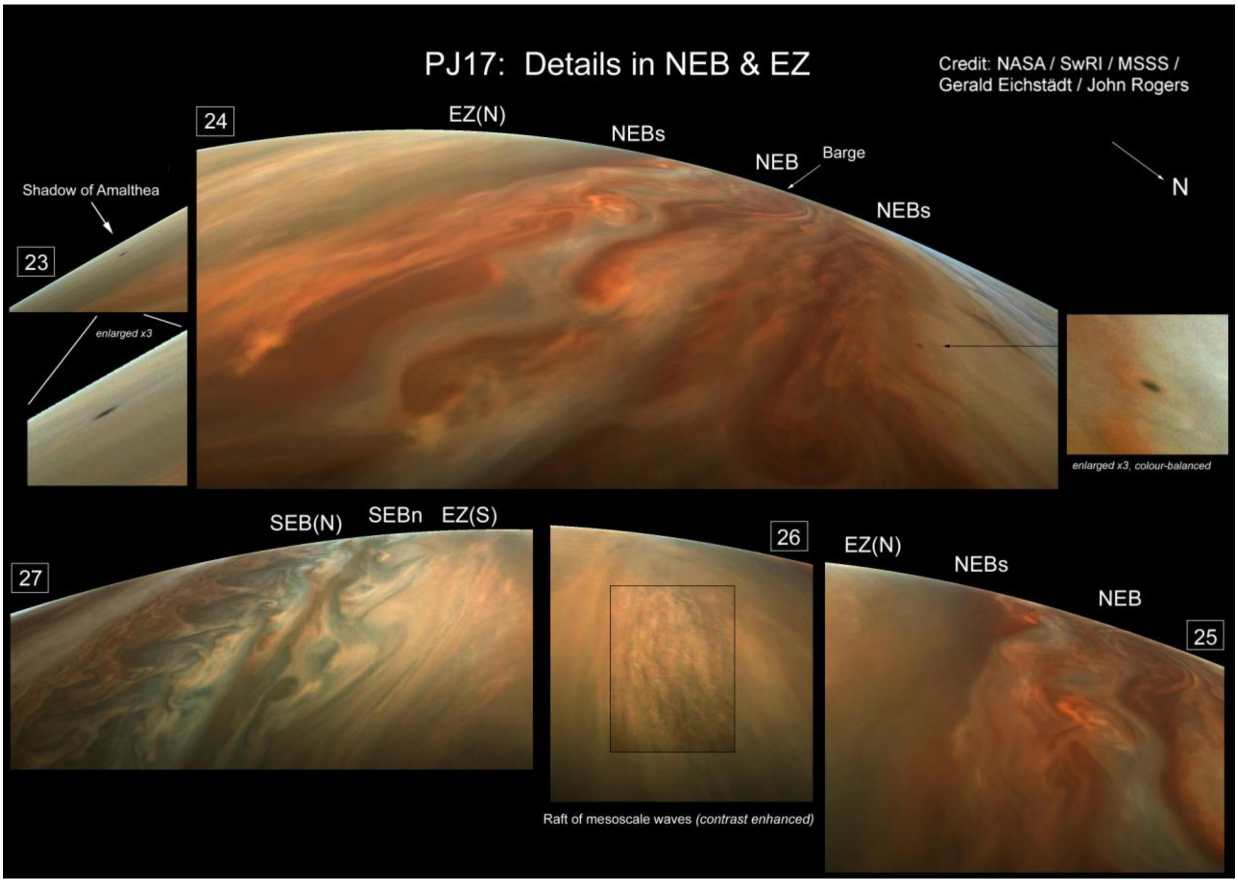


Figure 9.

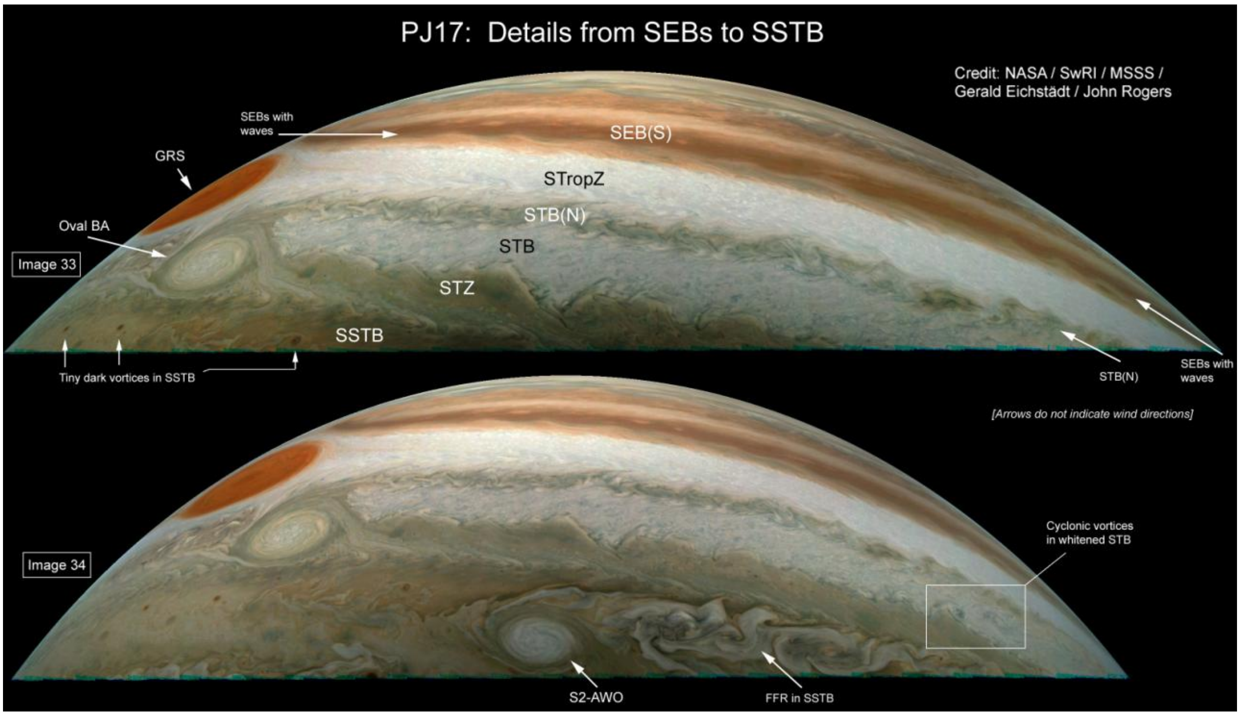


Figure 10.