

JunoCam at Perijove-12 (2018 April 1): What the images show

John Rogers (2018 April 27)

Introduction and Summary

[please see Part I]

Part II: Middle and lower latitudes

Figure C1 is a map of the planet from ground-based amateur images on March 29-31 (& can be compared with my predictive map in our 2018 Report no.2). **Figure C2** is a set of amateur images covering the sub-spacecraft track before and after perijove on April 1, especially showing the interaction of the STropD and GRS. **Figure C3** is a small-scale composite of Gerald's cylindrical maps, putting the closeup images in context.

High northern & North Temperate domains

N3/N4/N5 domains: **Figure C4** shows some of the JunoCam team's images, labelled, and **Figure C5** shows details from two of Gerald's full-resolution versions. These images show the now-familiar awesome cloudscaapes. The later, closer ones resolve 'pop-up clouds', ranging from an isolated prominent one in a N5-AWO in image 82, to large rafts of them in FFRs in images 82 and 84. (The latter also appear methane-bright in image 83, but this may be merely proportional to their continuum reflectivity.)

Figure C5 (right) shows part of the N4 domain, with a multi-level FFR (top part) and an AWO (bottom half), each bearing popup clouds. We have recently shown that in N4 (unlike other domains), it is common for AWOs to stray into the low-latitude, cyclonic half of the domain, and this is a good example; note that it is distorted and has long 'arms' connecting to adjacent cyclonic FFRs.

NN-WS-4: This major AWO is splendidly shown in 3 closeup images (84-86) (e.g. **Figure C5**). It appears to be made up of spiral ridges of white clouds, with brilliant popup clouds scattered along their crests. Gerald has already provided reprojections of these images which, when stacked, show parallax of the brightest popup clouds, which will enable measurements of their heights. These reprojections have also been animated by Sean Doran to display the anticyclonic rotation of the oval over 8 minutes:

<https://www.missionjuno.swri.edu/junocam/processing?id=4360>.

NNTBs: A prominent volley of dark grey NNTBs jet spots had just passed this longitude (see image by Peach on March 30 in **Figure C2**), but only a small final one was passing on April 1, and it looks amorphous in images 84-86 (**Figure C4**).

NTB (**Figure C6**, image 87): As at PJ-11, the NTB(N) is pale and filled with dense small-scale turbulence, while NTB(S) is still orange. The southern half of NTB(S) also contains many popup clouds (tinted by the overlying orange haze); previously there were only a few here, but at PJ-11 they may have gone undetected because of the greater slant range.

North Equatorial Belt & Equatorial Zone (Images 88-90):

These are the best-ever closeups of the NEB and EZ, as the team used extra data volume to return the images at high quality; this is the first downward-pointing peri-jove at which this has been done. At previous peri-joves the subtle contrasts were partly obscured by compression artefacts, but now we see that the NEB is genuinely very diffuse at hi-res, whereas the central EZ displays a wealth of mesoscale waves. Image 88, of the NEB, was taken at closest approach, only 3493 km altitude. These images can be located in the ground-based images (Figures C1 & C2) and the JunoCam map (Figure C3).

North Equatorial Belt (Figure C6): The NEB closeup (image 88) shows a miniature barge. This was the mini-barge that I expected would be captured, but by April 1 it had shrunk to a barely-visible point in ground-based images. Nevertheless it is a well-defined orange vortex, with a white halo. This image also shows the **NEBn** cusp north of the mini-barge, with signs of anticyclonic circulation.

On the **NEBs** (image 89), the dark blue-grey band emerges from the p. (east) end of a typical NEBs dark formation ('hot spot'), seen just to the west in ground-based images (Figure C2), but it is not the dark formation itself.

Equatorial Zone: These images were taken to determine the extent of the 'mesoscale waves' (smallscale waves with wavelengths up to a few hundred km) on the EZ. Apart from one narrow white cloud lane in EZ(N), image 89 shows that there are no such waves in the northern EZ in this sector, but image 90 (shown at full resolution in Figure C7) shows waves over virtually the whole of the pale orange Equatorial Band (EB), and not elsewhere.

The pale orange EB has been obvious in recent JunoCam images although still not prominent in ground-based images. It extends from ~0 to 5°S, and is covered in mesoscale waves ranging from bands of clouds (white or pale orange, and partly overlying dark blue-grey streaks) to very subtle modulation of the otherwise featureless cloud deck. There is also a striking wave-train along a lane of very sharp-edged white clouds lying obliquely across the equator, which Gerald likens to terrestrial cirrus streaks. (There is a very high-contrast rendition of this image on the JunoCam web site by Kevin Gill.)

Great Red Spot (GRS) & S. Tropical Disturbance (STropD)

A unique bonus of PJ-12 was to fly only 10° p. the p. (east) end of the GRS, just as the p. part of the STropD was streaming past it [see our 2018 Report no.2]. Indeed, I predicted that the p. end of the STropD – recirculation from the SEBs jet to the STBn jet – might have re-formed p. the GRS by this time, as used to happen a century ago when the great STropD repeatedly passed the GRS. In the event, both ground-based and JunoCam images show that a large expanse of highly turbulent atmosphere from the STropD had swept round the GRS and expanded p. it across the latitudes of the STB and southern STropZ, but had not (yet) crossed the northern STropZ nor perturbed the SEBs jet. In ground-based images, this is still the case (up to April 24).

JunoCam took a series of images of this region, starting with closeups of the turbulence at the p. end of the GRS, and moving out to wide-field views taking in the whole GRS. It should be possible to obtain animations showing the dynamics on all scales: over 19 minutes from the JunoCam images, over 10 hours from Hubble images taken on the same date, and over several days from amateur images (Fig. C2). Figure C8 is a map from Cassini when the region was normal and undisturbed, for comparison with Figure C9, which is a composite map from the JunoCam images, made by Gerald (see Figure C3 for context). Figure C10 is a detail from image 92, showing the best resolution on this chaotic region.

From March 30 to April 5, the amateur images (Figure C2) showed a large white area gradually drifting north just p. the GRS, initially appearing as a white oval, but becoming duller and less regular after April 1. This was imaged by JunoCam, and it was not an oval but an irregular area between more

coherent streaks and eddies (Figures C9 & C10). The images show a chaotic scene, in which the STBn jet cannot be discerned and may be disrupted [animations are awaited], but there are many eddies on different scales. Most of them look cyclonic – which I had not expected, but is consistent with ground-based images over the preceding months which showed spots and eddies here mostly in the cyclonic (STB) domain. But there is a large anticyclonic eddy in contact with the p. end of the GRS, dark grey but evidently pulling orange streamers from the GRS around it. Note strong stream-lines in this region, including elevated ridges of white cloud, and streaks of different colours crossing each other, and much complex cloud texture. The edge and interior of the GRS has also been disturbed by this interaction. There is another dark grey anticyclonic spot further p. in the STropZ.

Discussion:

My expectations of this interaction were based on what was reported by the BAA over a century ago, when the Great STropD passed the GRS six times from 1902 to 1913. It was generally accepted that, when the p. end of the STropD ('p-STropD') arrived at the f. end of the Red Spot Hollow (RSH), dark material from it would stream rapidly round the south side of the GRS, then re-form p. the RSH. I have reviewed the accounts in the original BAA publications, and will post some excerpts in my next interim report on the present apparition (2018 Report no.3). To summarise the conclusions: the observations (all visual) were often incomplete, and very few good drawings were published. On the first passage of the p-STropD past the GRS, in 1902, it did indeed re-form p. the GRS within days or weeks. The second passage (1904) was not observable, but the next 4 passages (1906, 1908, 1910, 1913) all occurred in a more subtle and prolonged manner. The p-STropD was not actually observed for some weeks after it arrived at the RSH, then it only formed indistinctly, via vague ill-defined shadings. Although it did eventually reappear in its classic curved dark form, the idea that it had passed the GRS rapidly (taking only days or weeks) was only inferred by extrapolating its subsequent motion back to the RSH. In 1904 the p-STropD had not definitely completed its re-formation 2 months after the passage started, when the apparition ended; in 1910 it took nearly 3 months to do so.

In 2018, the p-STropD reached the RSH on Feb.4. We could say that vague ill-defined disturbance has been appearing p. the GRS since Feb., though by late April it still has not re-formed the p-STropD. So, apart from the fact that this disturbance is not obviously dark, it is not inconsistent with what used to happen a century ago.

This all reinforces my suspicion that if the p-STropD does re-form, it will be a stochastic process mediated by eddies in the STropZ which, sooner or later, trap the SEBs jet into the expected recirculation pattern. I suggest that this was what used to happen a century ago. Perhaps a new p-STropD will arise not from the old p-STropD itself, but from the extensive disturbance f. it which is still streaming around the GRS, and which may continue to disrupt the zonal wind profile p. the GRS until a new p-STropD forms there. Perhaps it is ideal that Juno obtained this snapshot of the GRS/STropD interaction at an intermediate stage, rather than showing the final result.

[The creation of a new STropD was observed by Voyager 2, as described in my book, but it occurred in a different way from the present one, by interactions of large anticyclonic vortices retrograding on the SEBs jet. There are no such vortices at present.]

High southern latitudes: S2/S3/S4 domains:

The usual splendid vistas of the high southern latitudes were further distinguished this time by including three long-lived anticyclonic ovals in successive domains: S2-A5, S3-AWO-1 (?)*, and S4-LRS-1. *(AWOs in the S3 domain have been difficult to track across solar conjunction due to their wildly varying speeds, but this may well be the largest and longest-lived of them, S3-AWO-1.)

Figure C11 shows (at left) the best resolution on all 3 ovals, from image 99. (Image 98 shows even better resolution on S3-AWO-1, which looks very like NN-WS-4). At right is image 100, which must be one of the most beautiful whole-disk images ever taken of Jupiter, spanning the globe from the GRS to the south polar cyclones.



Figure C1.

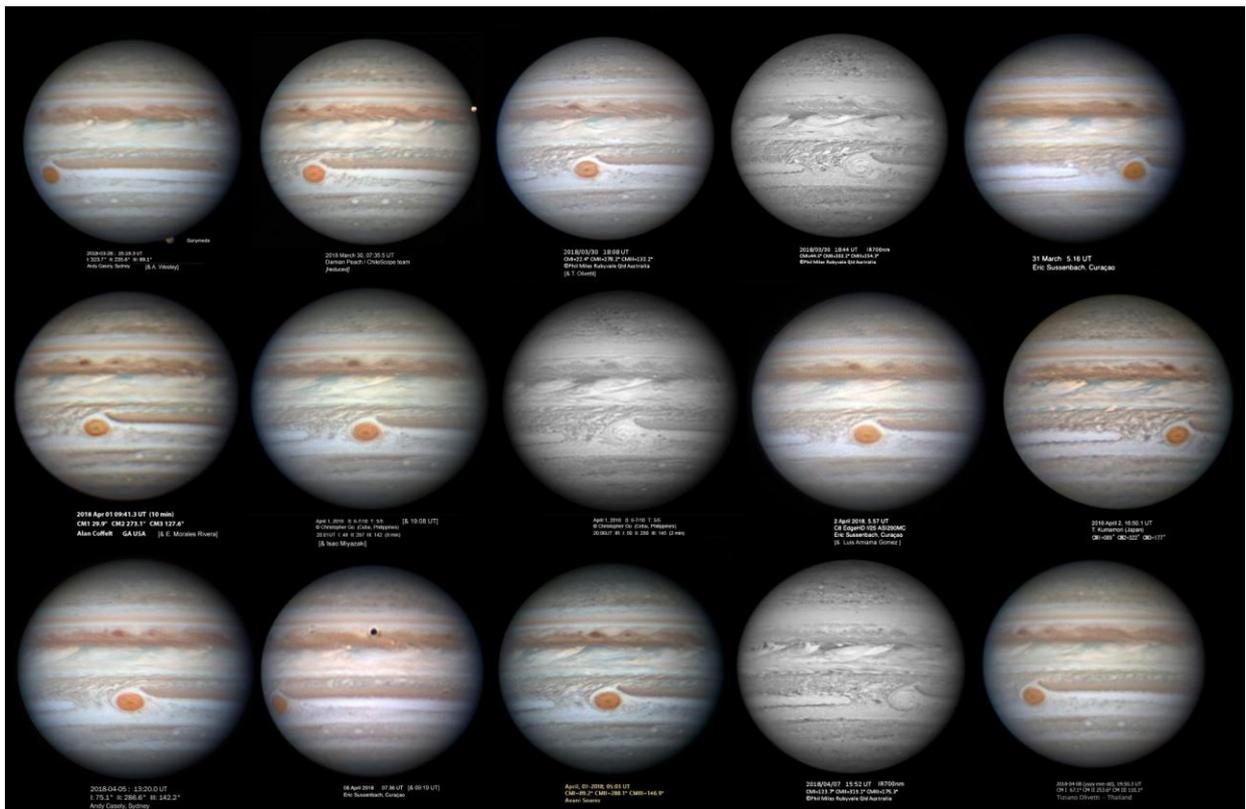


Figure C2.

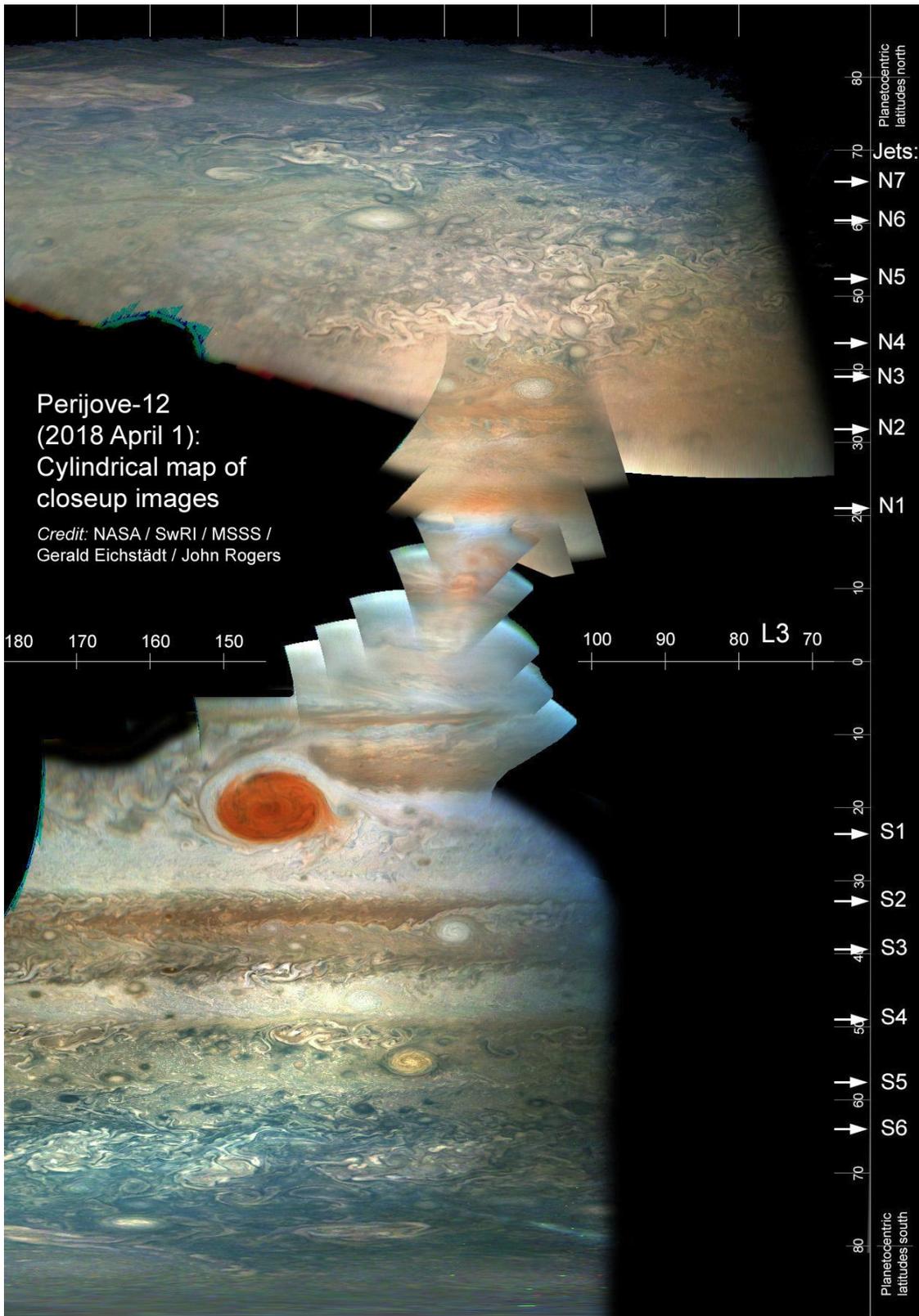


Figure C3.

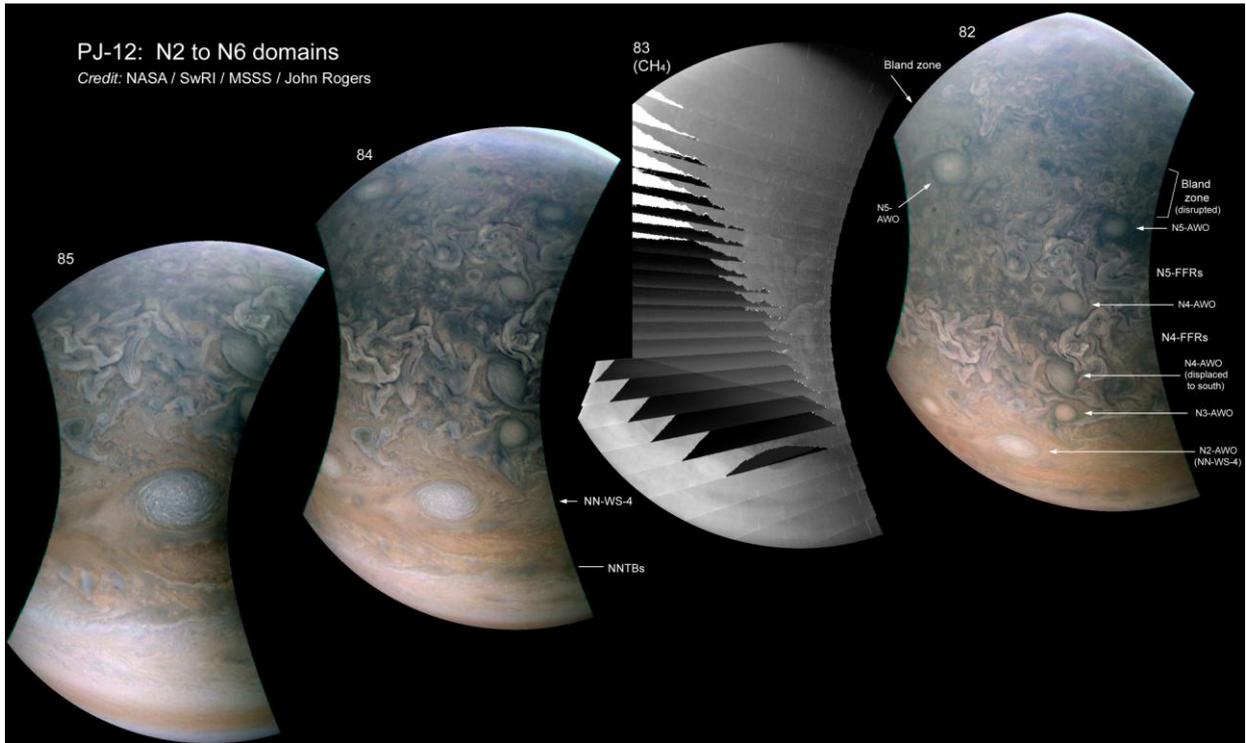


Figure C4.



Figure C5.

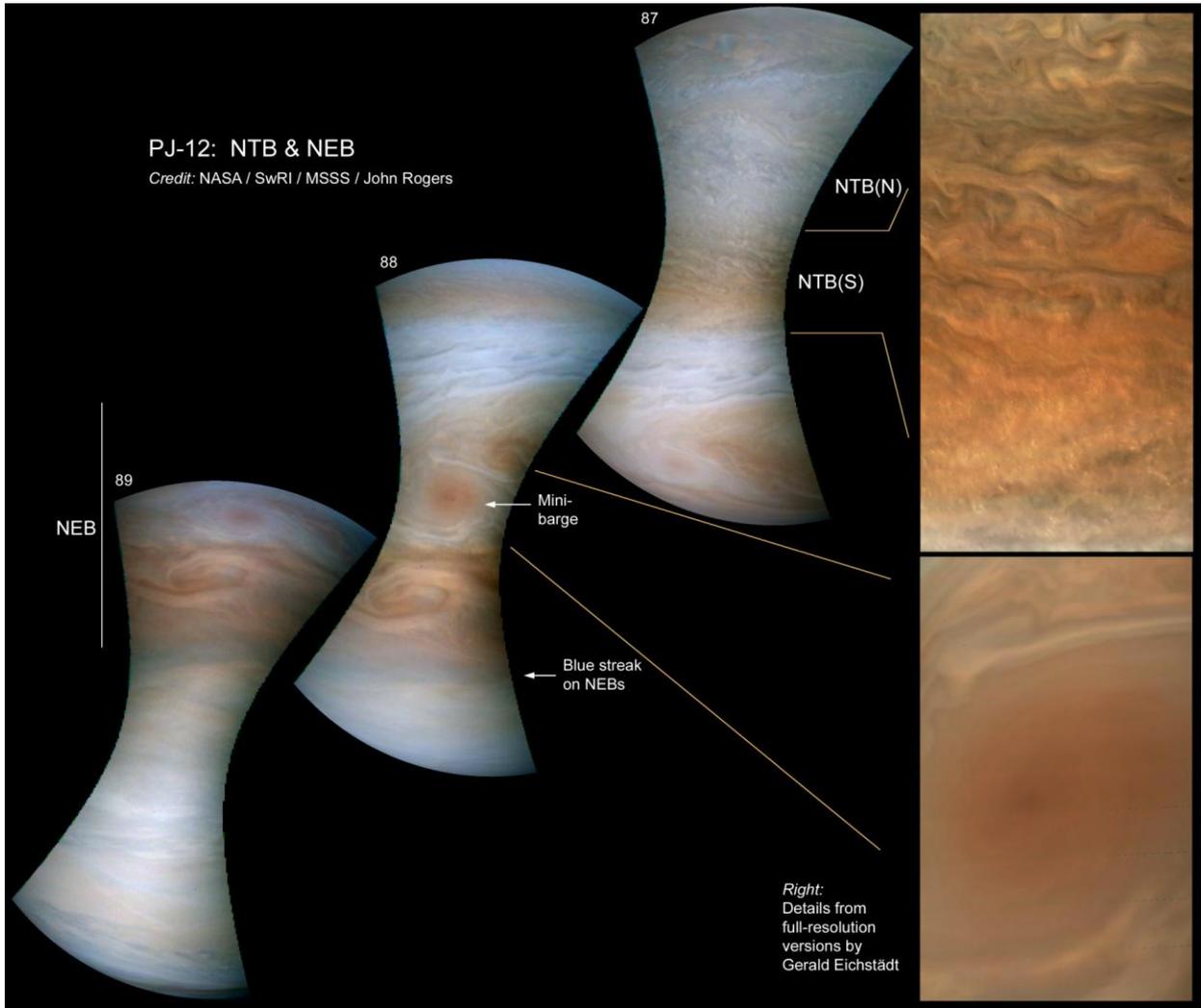


Figure C6.

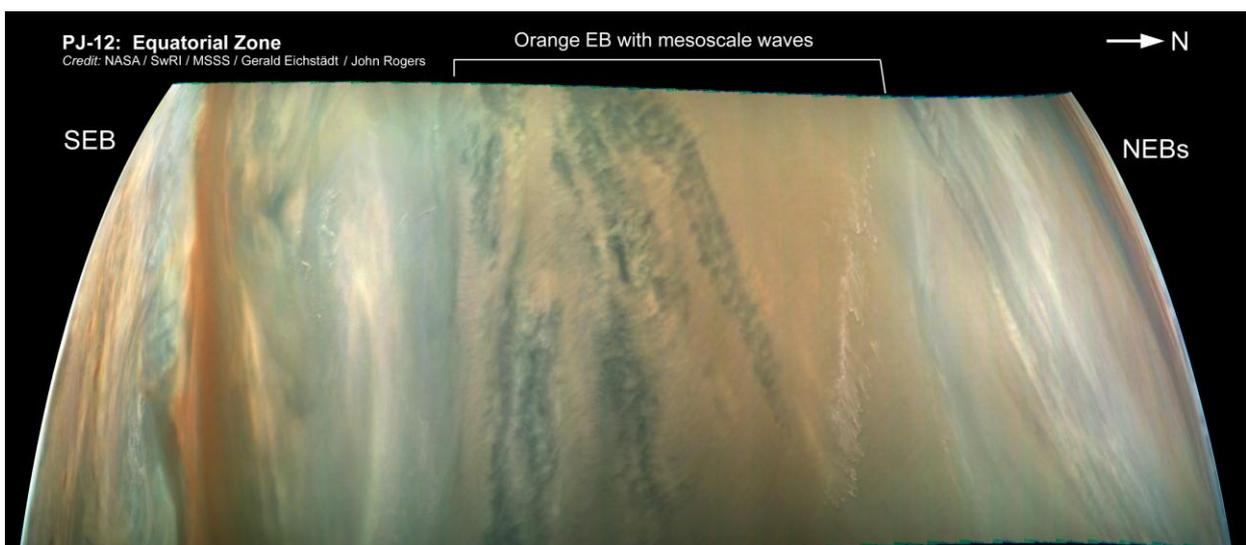


Figure C7.

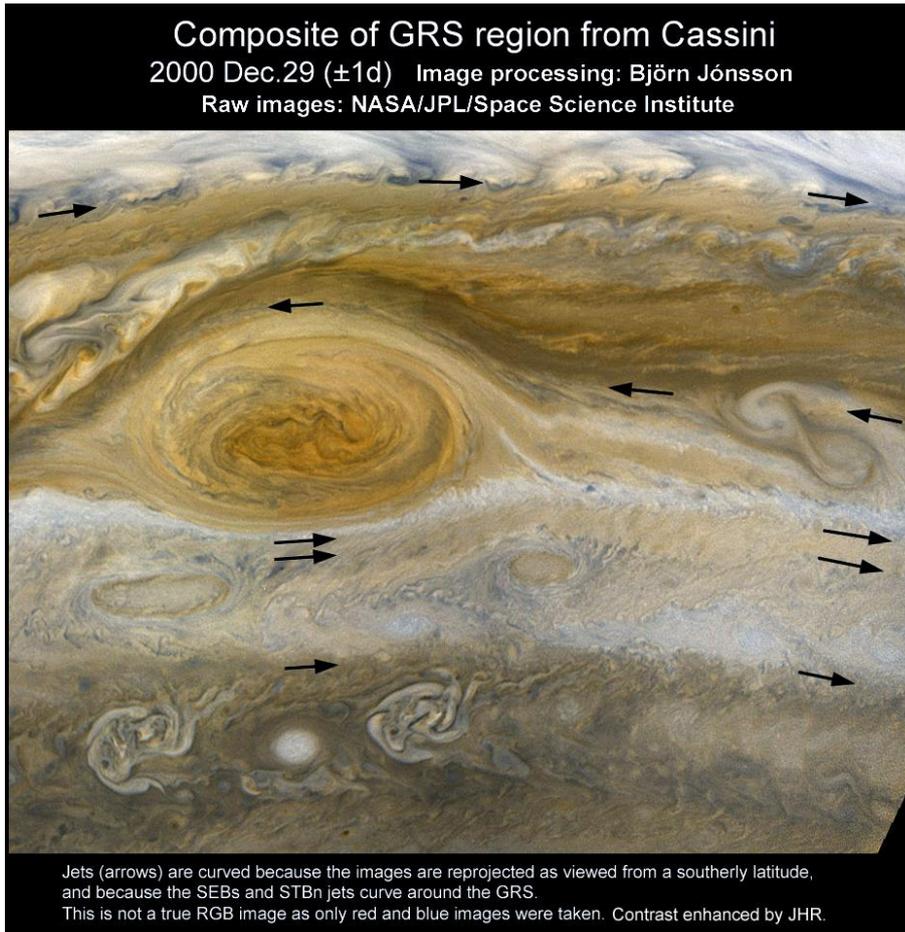


Figure C8.



Figure C9.



Figure C10.

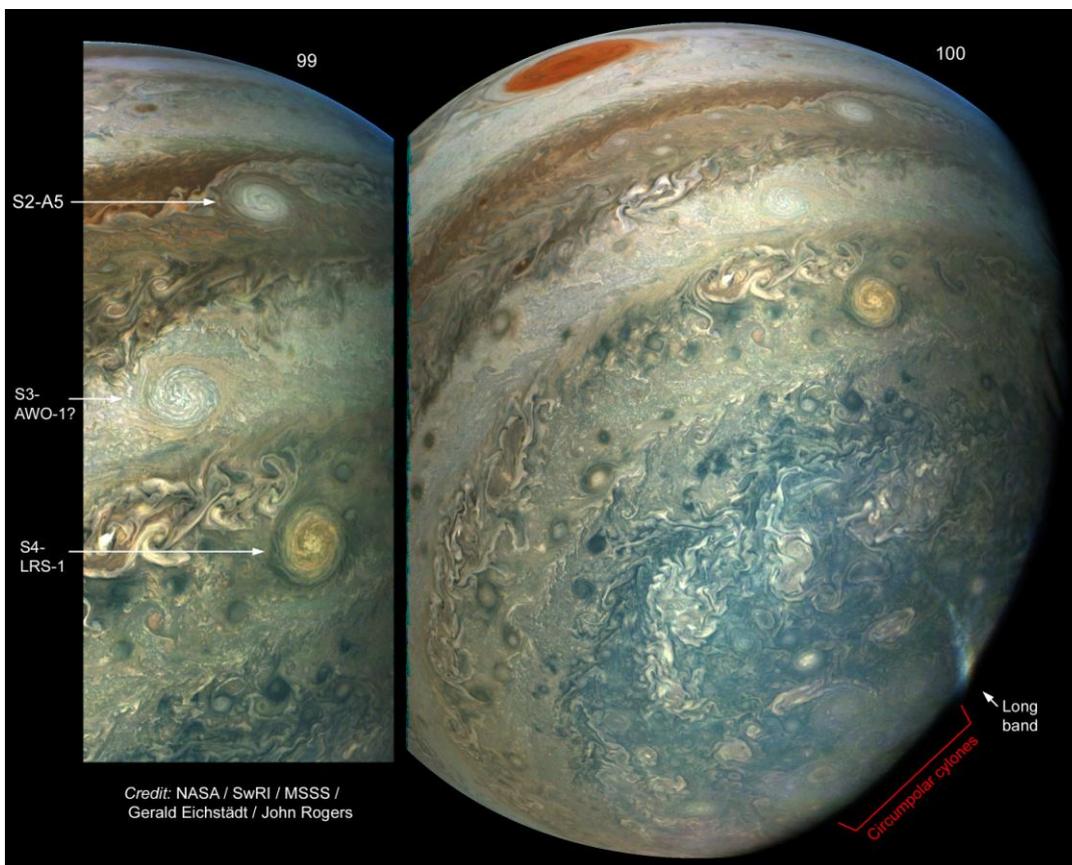


Figure C11.