JunoCam at PJ47: What the pictures show

John Rogers (BAA) (2023 Jan.22)

Juno's Perijove-47 was on 2022 Dec.15 (Dec.14 in America). Perijove was at latitude 39.1°N, then the spacecraft crossed the equator 15 min later, at L1=130, L2=218, L3=170.

The downlink of data to Earth was disrupted; according to the NASA press release, this was "most likely caused by a radiation spike as Juno flew through a radiation-intensive portion of Jupiter's magnetosphere". Mission controllers successfully rebooted the computer and put the spacecraft into 'safe mode' (i.e., mostly switched off) for several days. But the science data were intact and download resumed a week after perijove. So far as I know, this was the mission's first significant adverse event since Perijove-2; Juno has proved remarkably reliable and resilient. Almost all the JunoCam images were fully recovered, except for the lo-res outbound sequence after south pole crossing.

Before the flyby of Jupiter, Juno again flew over Io's north pole, at a moderate distance of 63700 km – the closest yet. JunoCam's images showed a similar view to PJ43, with slightly higher resolution (e.g. Figure 1). The small bright projections at the terminator appear to be mountains rather than plumes. Notable features include Loki Patera (the giant caldera whose central 'island' is still present after 43 years) and Acala Fluctus (an area of volcanic flows and white deposits, which was apparently detected by Damian Peach in a ground-based image on Oct.2).

On the inbound leg on Dec.14-15, as at PJ46, JunoCam took a full series of images (e.g. Figure 2) covering the whole of the northern hemisphere and part of the southern. A map from these images, assembled automatically by Gerald, is shown in Figure 3. Figure 4 shows some ground-based maps for comparison.

North Polar Region

Circumpolar cyclones (CPCs):
PJ47 produced another excellent view of the northern CPCs (Figure 5), which was opposite to the side viewed at PJ46, so the two image sets can be combined to make a composite map (Figure 6). The PJ47 view (Figure 5) can be compared to that at PJ44. We note:
i) CPC-1, a filled cyclone, is much more disturbed internally than it was at PJ44; it now contains about 6 weakly *anticyclonic*, off-white eddies, and a bright white cloud apparenetly being pulled into the central *anticyclonic* vortex.
ii) CPCs 3 & 4 are not only in contact with each other and with the AWO just N of them (as usual), but appear to be interacting closely. This could be a transient configuration as they jostle to and fro within the polygon.
iii) There are three well-defined but non-circular cyclonic features flanking the polygon (below it in the image). There were two here at PJ45, and two at PJ44: different shapes but possibly related to each other and to the small cyclones that sometimes associate with the polygon? Also, two small AWOs S of CPCs 3 & 4 could be the same two that were there at PJ45.
iv) Image 88 is a good methane image of the CPCs.

Bland Zone and adjacent regions:
Figure 7 is our larger map of the NPR at PJ47. On this occasion, the inbound and over-the-pole images do not show much haze structure near the terminator, although Figure 7 does show some rather subdued linear bands in the Bland Zone, and subtle, largely amorphous

hazes flanking it. In a closeup methane image (Figure 8), the Bland Zone is almost feature-less, although the edge of the N. Polar Hood (black arrow) is clearly visible just N of it.

JunoCam is getting ever better views of the Bland Zone and the band of FFRs just north of it that is labelled in Figure 7 as the 'northernmost belt' (NB). This cyclonic belt at ~65-71°N is homologous to the southernmost belt in the S. Polar Region. One of the FFRs in it is shown in detail in Figure 8 (boxed & enlarged on right side). Typically, it contains very bright pop-up clouds, which are flanked by greenish haze, and appear methane-bright (although near the limb). Figure 9 is a stereo pair of this FFR. To my eyes, it appears to be higher than the dark mottled area to the right of it, but precise measurements will be needed to decide whether this is significant.

Also marked in Figure 8 are an anticyclone near the N edge of the Bland Zone (red arrow) which is whitish on the S side but very dark grey on the N side, suggesting that it is overlaid by dark grey haze; and a cyclone-anticyclone pair in the N5 domain (boxed & enlarged at left) which shows clear signs of shadowing.

Figure 10 is a pole-to-pole map from the perijove flyby.

North Equatorial Belt (NEB) & Equatorial Zone (EB)
(Images 98 and 106 were losslessly encoded.)

In the NEB, no major circulations were covered. As usual, the interior of the belt appeared diffuse, although the high resolution of the images was confirmed by the appearance of small crisp-edged cloud clusters overlying a dark blue streak on the NEBs edge in image 104 (Figure 11: box).

JunoCam yet again had the good fortune to capture a fresh convective outbreak in the NEB (Figure 11). This one had started on Dec.14, and was further north than the recent ones in the NEB(S); it was the first such outbreak in mid-NEB since the NEB fading started in 2021. (Details and images are in our newly-posted 2022/23 Report no.5.) This time JunoCam did not get a direct vertical view of it, but it was seen looking back near the limb in the highest-quality image (106); the mottled appearance of the bright white cloud mass and the extensive whitish haze expanding around it look very similar to the NEB(S) outbreaks viewed previously. JunoCam also obtained methane images of the region. Inbound on Dec.14 (Figure 3B) the oubreak was not visible in methane; during the perijove pass, methane image 107 (not shown here, though it is the best so far of the NEB & EZ) only hints at its presence in the noise near the terminator. This outbreak was also not strongly methane-bright in ground-based images.

Just S of the outbreak, on the NEB(S), there is a striking array of curved 'ripples' (Figure 11), possibly casting shadows. These suggest that a super-fast NEBs feature may have been passing by, although by December no such features were recorded in ground-based images. [From the displacement of the dark blue streak S of the outbreak on Figures 3A & 10 (maps of images approx. 5.6 hours apart), I estimate a speed of DL1 ~ -1.4 (±2.2) deg/day, suggesting that it was probably (but not definitely) in the super-fast range.]

In the EZ, image 106 only shows one or two localised mesoscale wave-trains, and none near the terminator despite the opportunity for shadowing.

South Equatorial Belt (SEB)

This was a rather featureless brown sector of SEB. Nevertheless, there were quite extensive mesoscale waves in the SEB(S) in images 109, 110, 111 [not shown here].

S. Temperate domain

Oval BA was beautifully imaged as it emerged from the terminator (Figure 12). No shadows are visible in it, probably because of the now-reduced resolution of southern hemisphere images. (Note that pop-up clouds are no longer recorded in the STropZ.)

S. Polar region

The last RGB images returned were nos.120&122, shown in map projection in Figure 13.
The prominent haze band (labelled) is close to the position of a similar band at PJ46.
The CPCs are not discernible.

Figures (small copies):

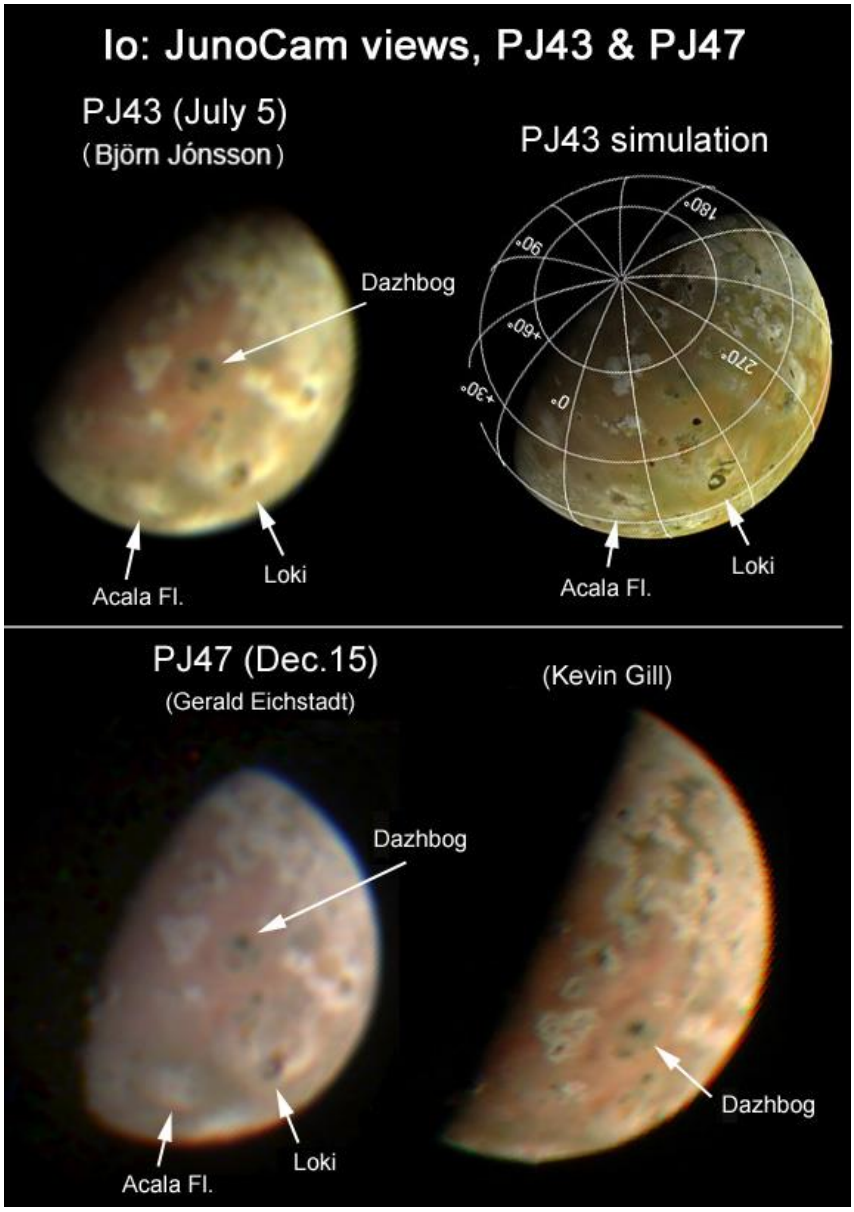

Figure 1. JunoCam views of Io at PJ43 and PJ47.

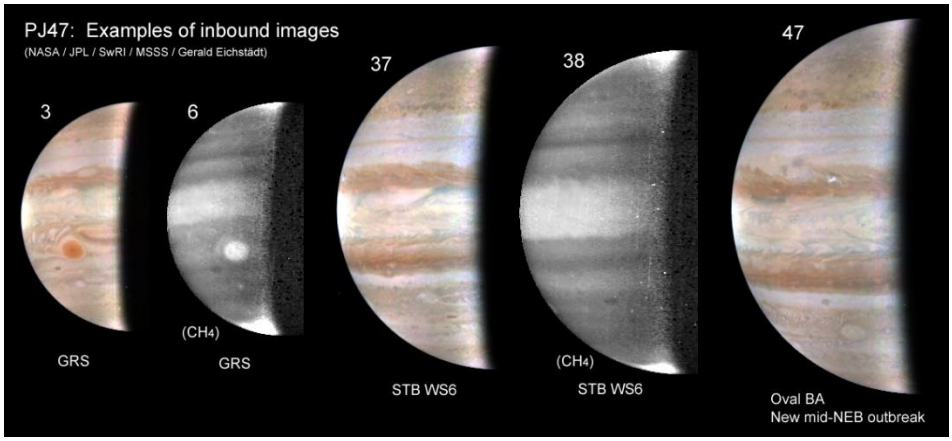

Figure 2. Examples of the inbound images, before the Io flyby. Image 47 includes the track of the perijove flyby ~5.6 hours later.

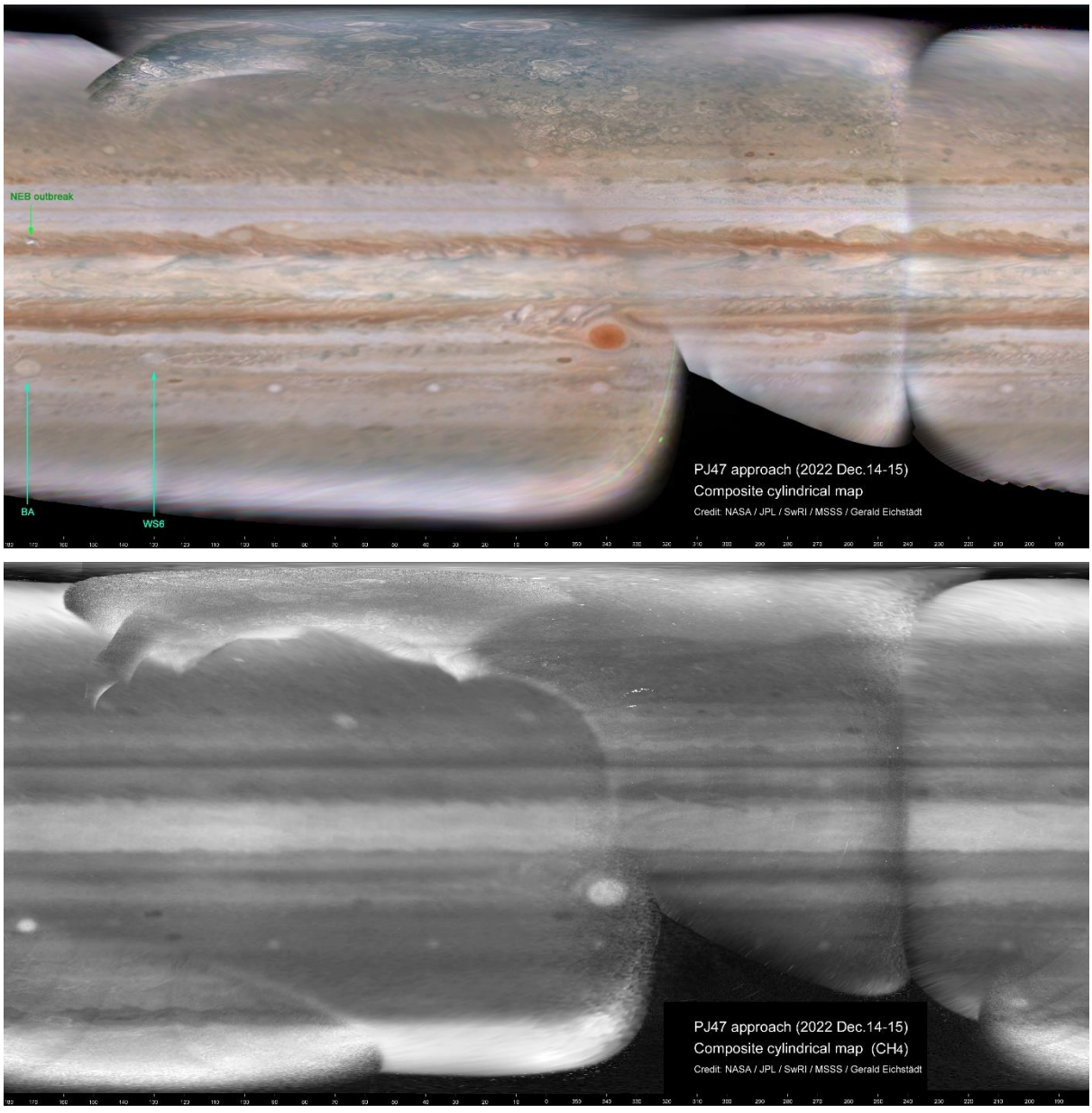

Figure 3. Global maps assembled automatically by Gerald from the inbound images: (A) RGB, (B) CH4. Some features near the Juno track are labelled; see our 2022/23 Report no.5 for a more throroughly labelled ground-based map soon after.

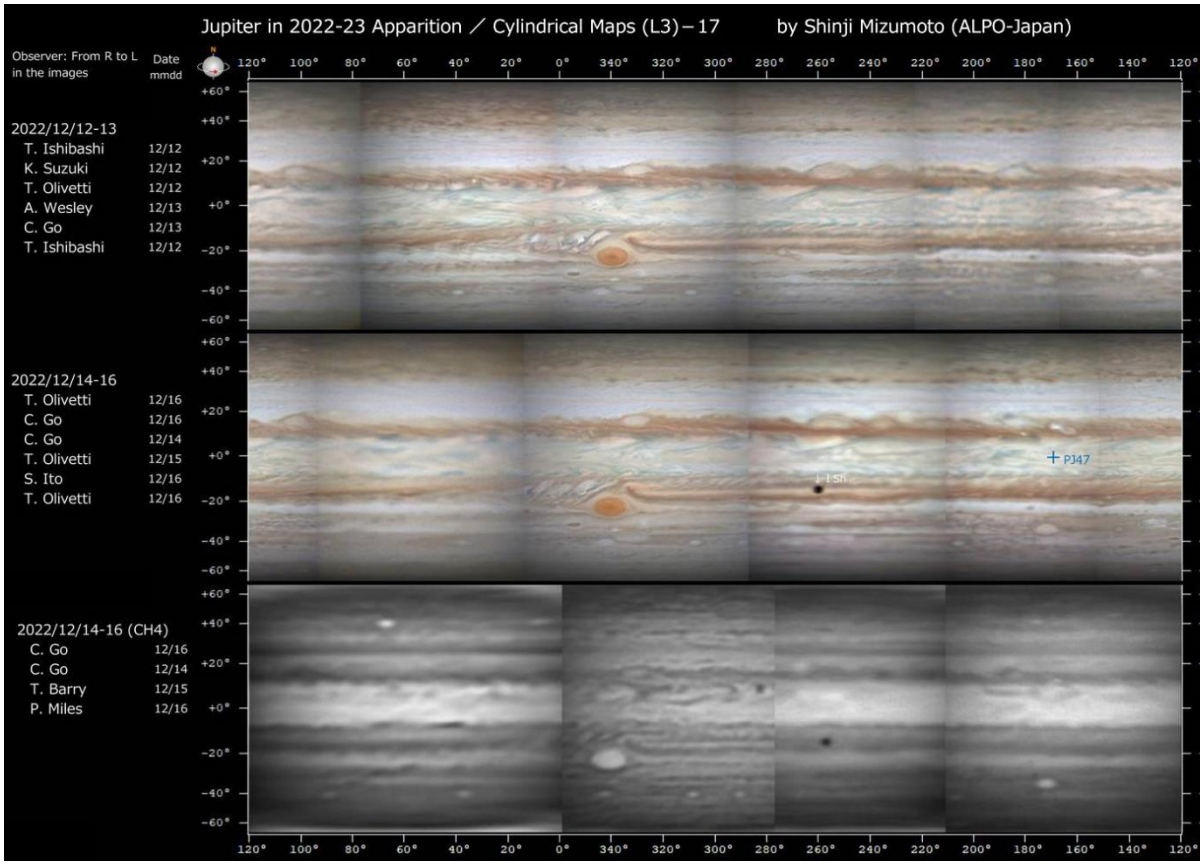

Figure 4. Ground-based maps assembled by Shinji Mizumoto.

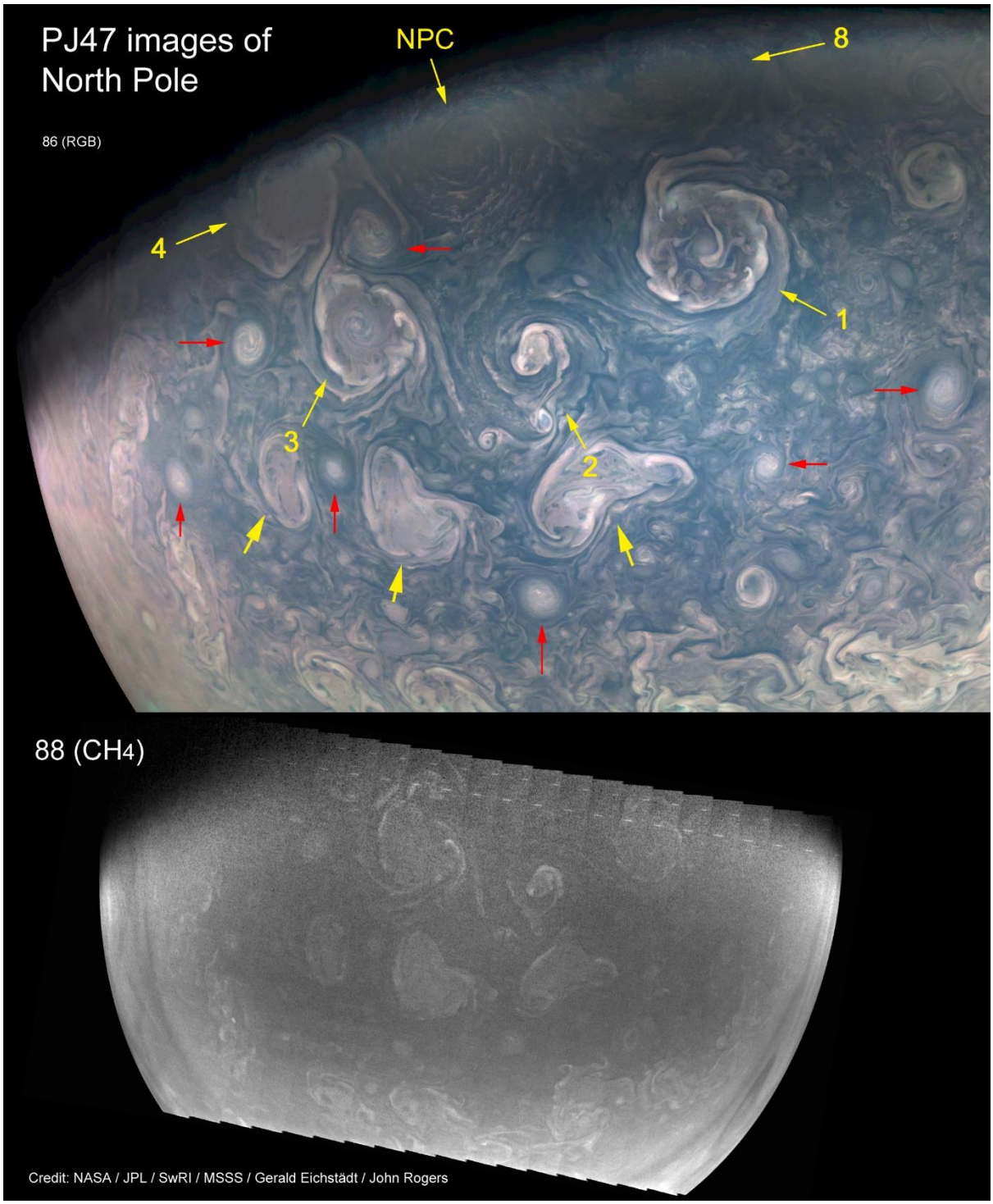

Figure 5. Images showing the northern CPCs at PJ47 (RGB & CH4). The CPCs are labelled; unlabelled yellow arrows indicate cyclonic features that may be related to the 'extra cyclones' previously seen adjacent to the polygon of CPCs. Red arrows indicate small AWOs.

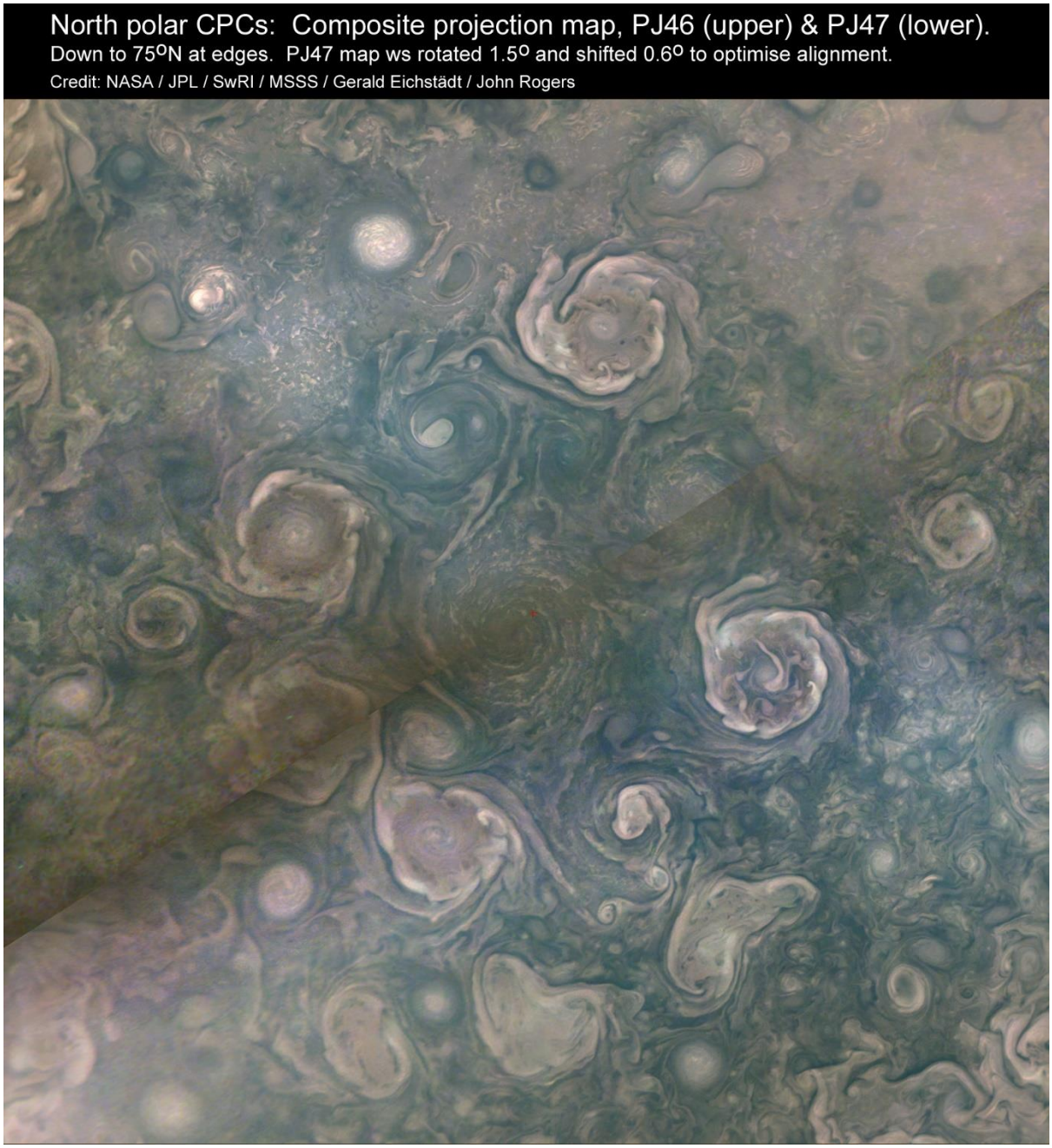

Figure 6. Composite map of the northern CPCs at PJ46 & PJ47, down to 75°N at the edges. The PJ47 map has been rotated by 1.5° and shifted by 0.6° to optimise the alignment.

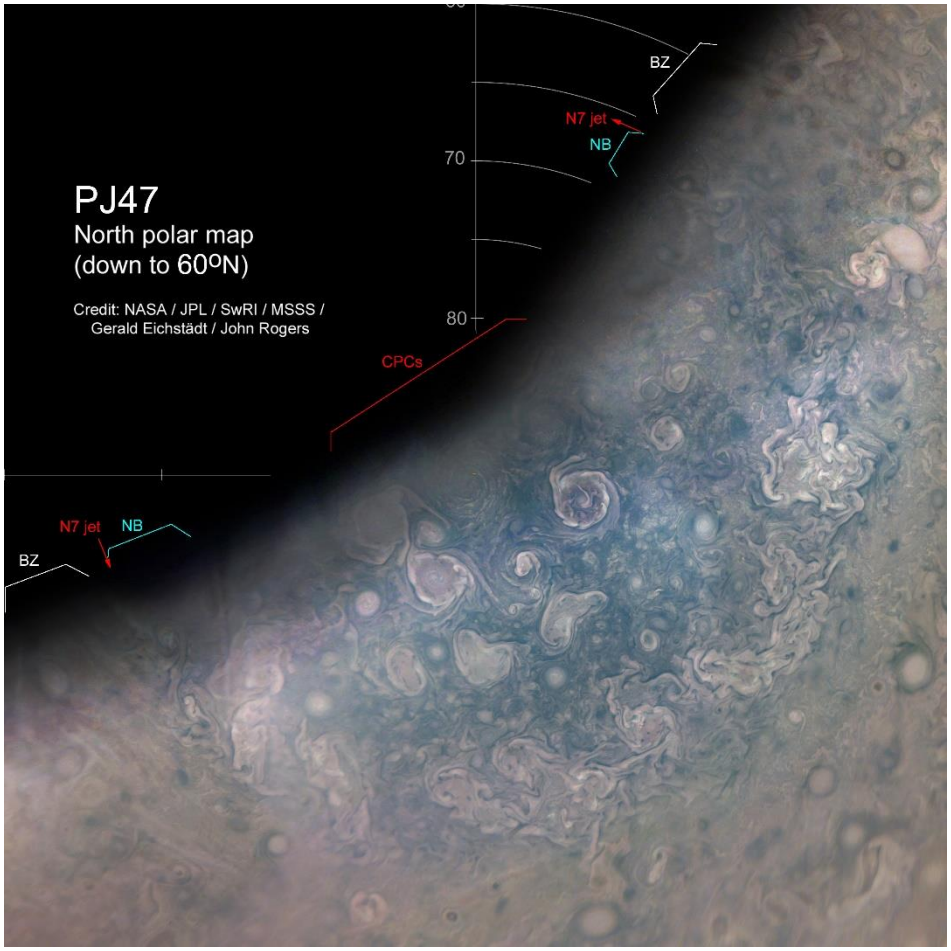

Figure 7. Composite map of the NPR at PJ47, down to 60°N at the edges. BZ, Bland Zone; NB, northernmost belt of FFRs.

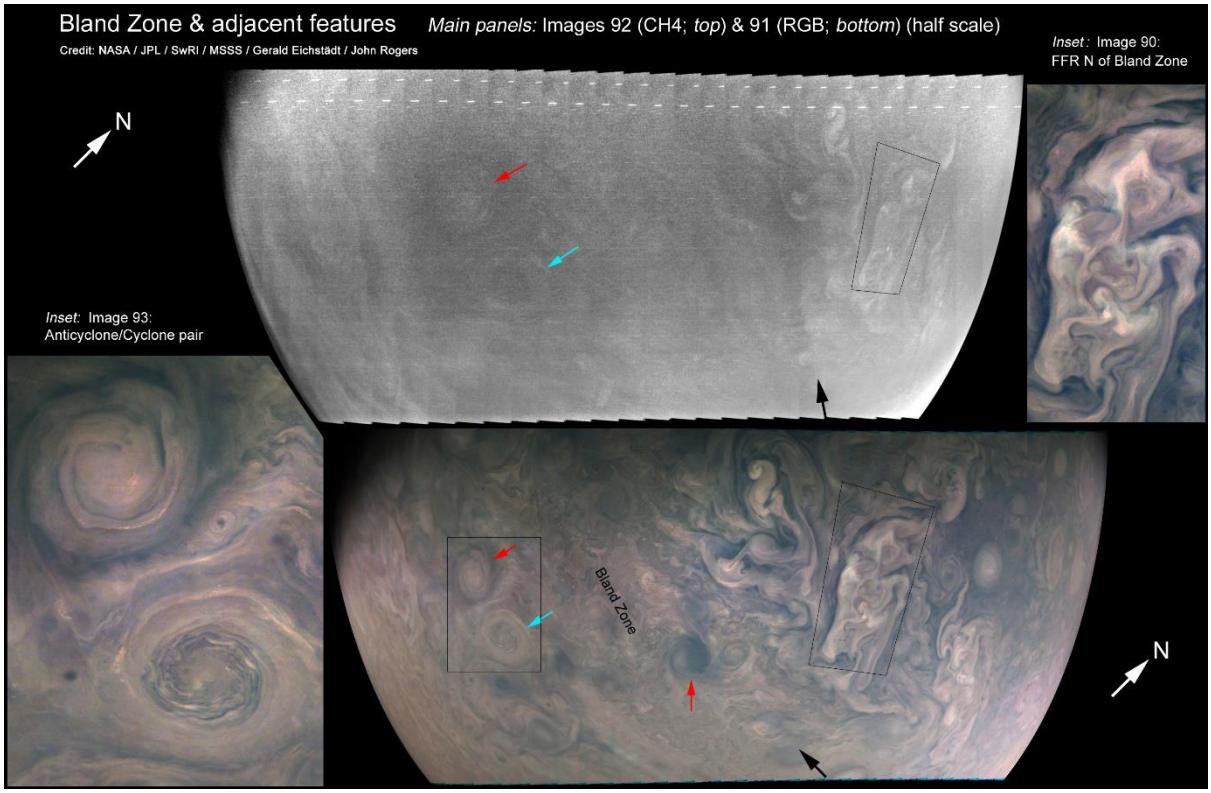

Figure 8. Hi-res images of the Bland Zone and flanking regions... *[continued on next page]*

Figure 8. Hi-res images of the Bland Zone and flanking regions, including: FFRs in the 'northernmost belt', at right; the edge of the N. Polar Hood (black arrow); a two-toned anticyclone that may be partly overlaid by dark grey haze; and a cyclone-anticyclone pair in the N5 domain (red & cyan arrows, boxed & enlarged, at left).

Figure 9. A stereo pair of the same FFR, posted by Brian Swift, reprojected from images 89 & 91. If you view the L and R images with your L and R eyes respectively, allowing the images to superimpose, you should see the view in 3 dimensions.

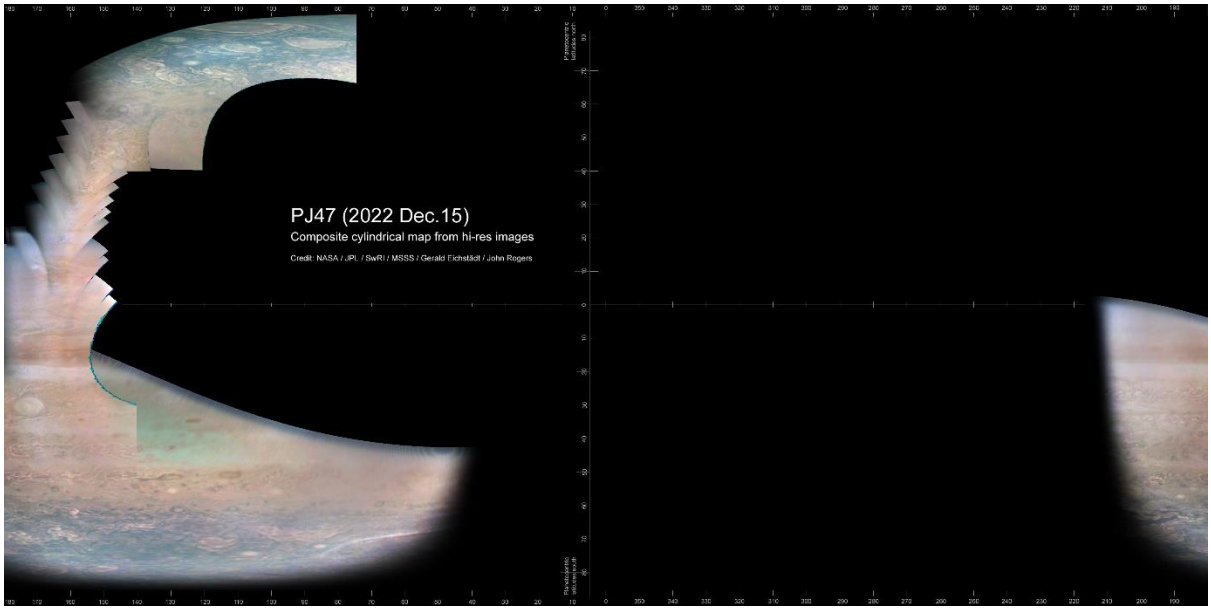

Figure 10. Cylindrical pole-to-pole map from the perijove flyby images.

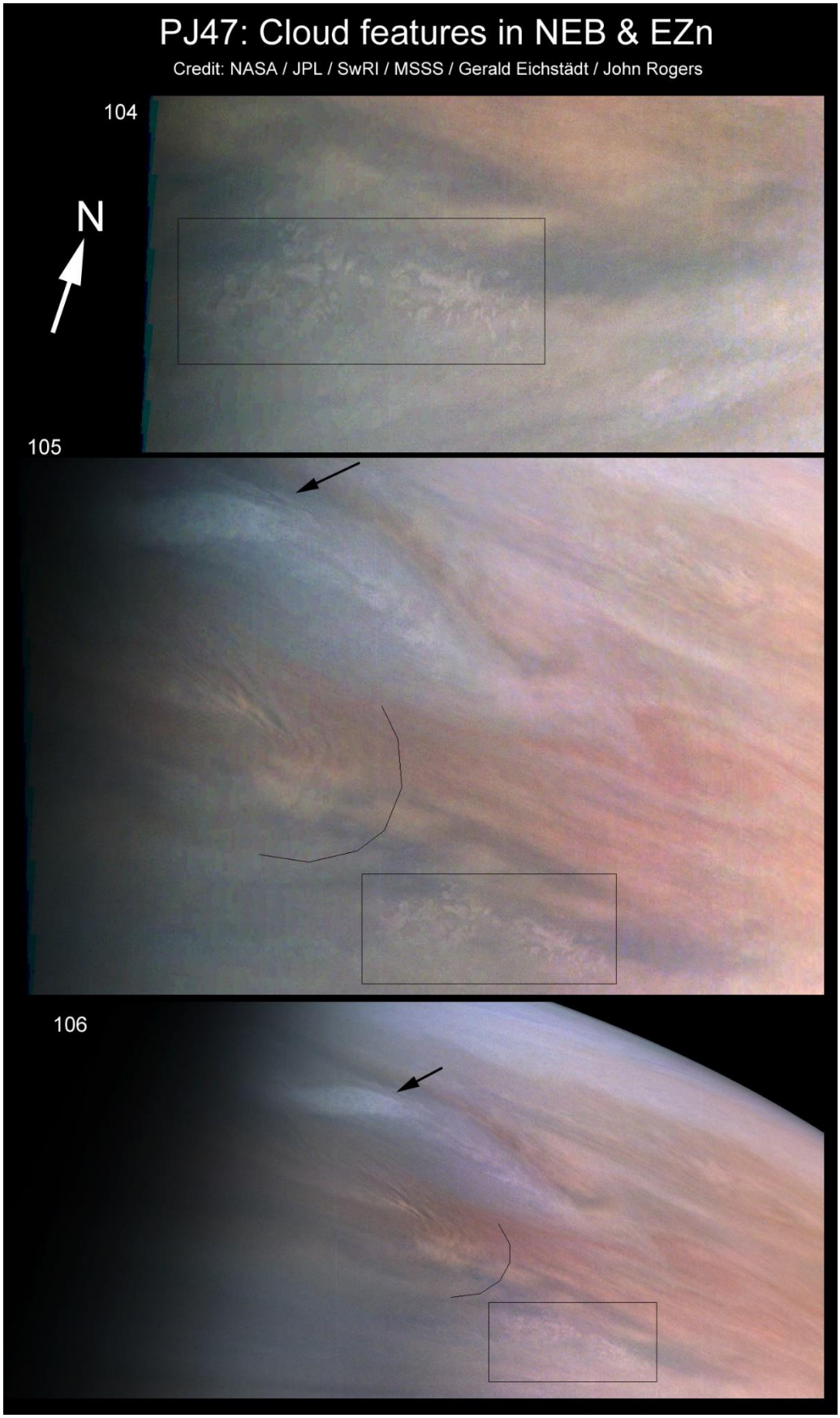

Figure 11. Portions of images showing cloud features in the NEB & EZn. Images 104 and 105 are marred by compression artefacts but textures are well shown in lossless image 106. Box: Small crisp-edged cloud rafts overlying a dark blue-grey streak on NEBs. Curved line: P. edge of a series of 'ripples' on NEB(S). Arrow: The bright white NEB outbreak, just emerging from the terminator.

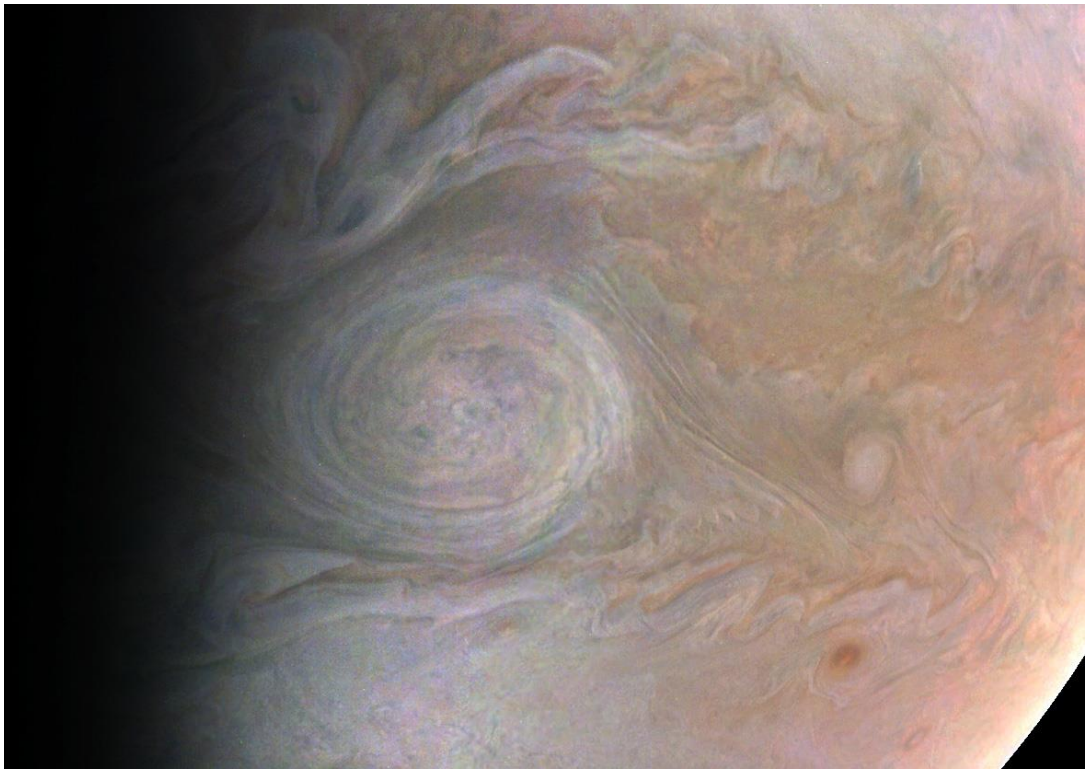

Figure 12. Oval BA, emerging from the morning terminator. Part of image 112, processed by Gerald Eichstädt and further enhanced. North is up.

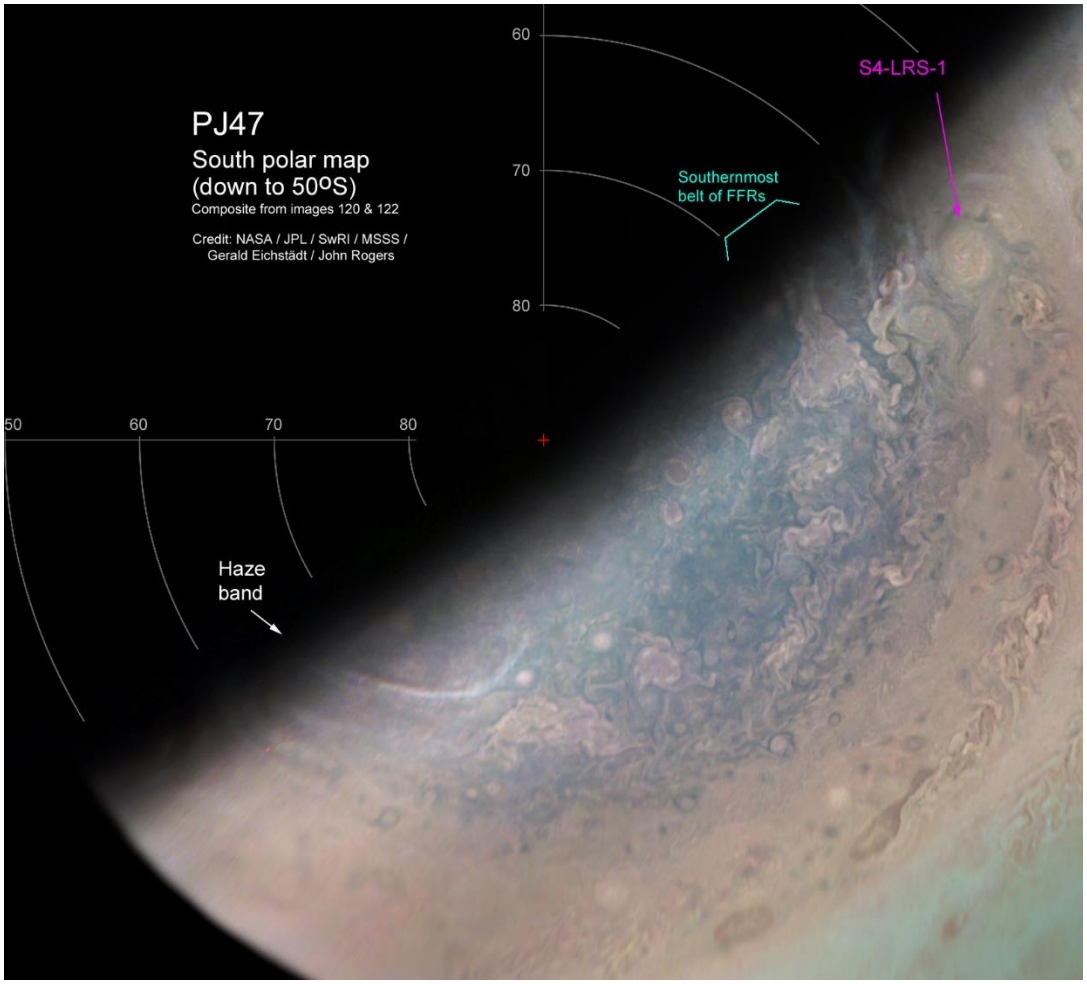

Figure 13. South polar projection map.