# JunoCam at PJ43: What the pictures show

**John Rogers (BAA)** (2022 August 10)

Juno's perijove-43 (PJ43) was on 2022 July 5. Juno crossed the equator at L1=169, L2=59, L3=328.

This report, like all in this series, is due to the work of the NASA JunoCam team: Drs Candy Hansen (Principal Investigator), Glenn Orton, Tom Momary, and Mike Caplinger (of Malin Space Science Systems); and Gerald Eichstädt, who produces the complete sets of high-quality processed images and map projections. As usual, the JunoCam images have been presented (i) as initial versions posted by the JunoCam team (each projected as if from a point above Juno's track, but with reduced resolution); (ii) as full-scale, high-quality versions by Gerald Eichstädt (strips closer to Juno's actual perspective); and (iii) both cylindrical and polar map projections of all the images by Gerald, which I have combined into composite maps. Details were given in our PJ6 report. (For PJ43, Gerald has produced maps of all images but I have not compiled the methane maps for this report.)

Abbreviations and conventions are as in previous reports. P. = preceding (east), f. = following (west). AWO = anticyclonic white oval, FFR = (cyclonic) folded filamentary region. Latitudes are planetocentric. Longitudes are System 3 (L3).

On the approach, JunoCam got a prolonged look at Io over its north pole (Figure 1).

The inbound images now give good coverage from the NEB northwards, and this time they included methane-band as well as colour images (e.g. Figure 3).

## North polar region: Circumpolar cyclones (CPCs)

The lighting on the north pole continues to improve. Now we see 6 of the 8 CPCs (Figure 2) and the whole NPC. The NPC has moved slightly, now being only 0.5° from the pole. There is a large AWO north of CPC-4 – possibly the same one that was north of CPC-3 when last imaged at PJ40? The smaller AWO north of CPC-7 has dwindled to a small eddy.

## Bland Zone and haze bands

The inbound methane images show a well-defined wavy edge to the North Polar Hood (e.g. Figure 3), which becomes less distinct as the view becomes more vertical; however the edge is clearly shown in image 30, including a portion coinciding with a long linear band in the Bland Zone.

There is an extensive disturbed sector of the Bland Zone; but otherwise there are linear bands around much of this zone, including long ones visible under full sun as paired brown vs bright bluish bands (e.g. Figure 4).

The inbound RGB images also show haze bands over the N3 to N5 domains near the terminator (e.g. Figure 3).

High-altitude haze has also sometimes been visible as a distinct layer above the horizon, esp. over the N2 or N3 domains. Gerald notes an example in PJ43 image 31 (Figure 5), around 41.5(±3)°N, i.e. on the N edge of the N3 domain. This image was taken over the north pole so this is the first time a haze layer has been identified looking down from high latitude. There is also a haze layer visible in image 44 (Figure 5) (looking up from the NNTBs), estimated to be around 45.5(±2)°N, i.e. on the N4 domain. So both are at similar latitudes, but on opposite sides of the planet. These detached hazes may be the same as the fairly well-separated bands

that are sometimes seen on the terminator around this latitude, apparently the southernmost extensions of the North Polar Hood: e.g. in inbound image 26 (Fig.3, arrowed).

The higher-resolution imagery of the N3 to N5 domains now reveals not only popup clouds, but also examples of crisp-edged cloud rafts, small and irregular (Figure 6). They appear to be more extended versions of popup clouds, and likewise are methane-bright.

**NEB & EZ**

Figure 7 is the PJ43 global cylindrical map. Figure 8 shows a ground-based map near the time (Shinji Mizumoto) and another made 5-6 days later (Rob Bullen), for comparison.

The state of the NEB and EZ has not changed much since PJ42. Ground-based images show that there is still a single active sector of the NEB(S) containing tiny bright white outbreaks [J. Rogers & S. Mizumoto, 2022/23 Report no.2]. This sector is well shown in the inbound images [L3~110-170 in the map].

The perijove images [L3 ~310-330] show the edge of a faded barge, and a classic NEBs dark formation (NEDF). Ground-based images show this one as very dark bluish and moderately methane-dark, but it is not one of the very methane-dark NEDFs associated with the disturbed sector. There is also a string of white clouds in NEB(S) f. it.

Hi-res images of the NEB and EZ are unfortunately impaired by extensive artefactual 'contouring' due to the image compression with the low contrast and decreasing camera sensitivity in the green and blue channels. Efforts to improve this for future perijoves are under way.

**S. Temperate Domain**

The global map (Figure 7) agrees well with the ground-based maps (Figure 8), mostly at similar resolution. It confirms that WS6, DS7 (STB segment G), and DS8 (spot 8) appear as they did at PJ42, as well as the massive outbreak of dark spots continuing on the STBn jet. There is a small bright cyclone 25° p. DS8 (also visible as a white spot in Figure 8). Oval BA shows a distinctly reddish annulus; ground-based images show only a faint trace of this.

**South polar region**

Figure 9 is our composite map of the South Polar Region. The main features of the SPR are well shown, although now only two of the circumpolar cyclones are clearly visible: CPCs-2 & 3 [compare with Fig.S2 in our report on PJ40].

*Haze bands:*

As the mission progresses, haze bands are still prominent near the terminator, sometimes more so. Possibly the decreasing resolution is being offset by increased contrast due to the lighting and viewing angles – and there could be seasonal changes, now that the south pole is in darkness, although careful study would be needed to distinguish all these effects.

Figure 10 presents composite maps of the terminator regions at dusk and dawn. Characteristic patterns of haze bands in different latitudes, as discussed in our recent reports [see reports for PJ38-PJ40, though seen from PJ34 onwards, reported privately] can again be seen. It's notable that, in many regions, the dusk and dawn maps are almost negatives of each other: bands that are bright at dusk are dark or invisible at dawn, and vice versa. On the other hand, the haze bands show no substantial changes from one planetary rotation to the next, as we see now that the outbound imaging lasts for a full rotation period of 10 hours. The

contrast reversal and the 10-hour invariance are aspects that we have noted before but never so widely.

Another such aspect is that some of the haze bands increasingly look like edges of 3-dimensional 'slabs' of high-level cloud, whose edges shine in low sunlight or cast shadows; however, the interiors are at least partly translucent under higher sun. (We have noted examples of this from PJ38 onwards.) Figure 11 illustrates such features in two specially interesting parts of the South Polar Hood (SPH) under different lighting conditions; details are described in the caption. It's possible that some 'contrast-reversing' bands noted at previous perijoves could likewise be the edges of such 3D features, alternately illuminated and shadowed.

One thing that has changed is the 'Long Band', which from PJ33 to PJ41 was a conspicuous dark band visible across the sunlit disk, partially overlapping CPCs-4&5 or, latterly, 3&4. Now there is a similar band but at lower longitudes, tangential to CPC-3: it is part of complex B in Figure 11. The best comparison is with PJ40, when viewing conditions were similar; it's not clear whether the Long Band seen then has moved or disappeared.

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**Figure 1**. PJ43 images of Io, passing over the north pole, with synthetic maps of the first and last images. Processed by Björn Jónsson. A small bright projection on the terminator appears to be a mountain. Jason Perry reports that no plumes are visible.

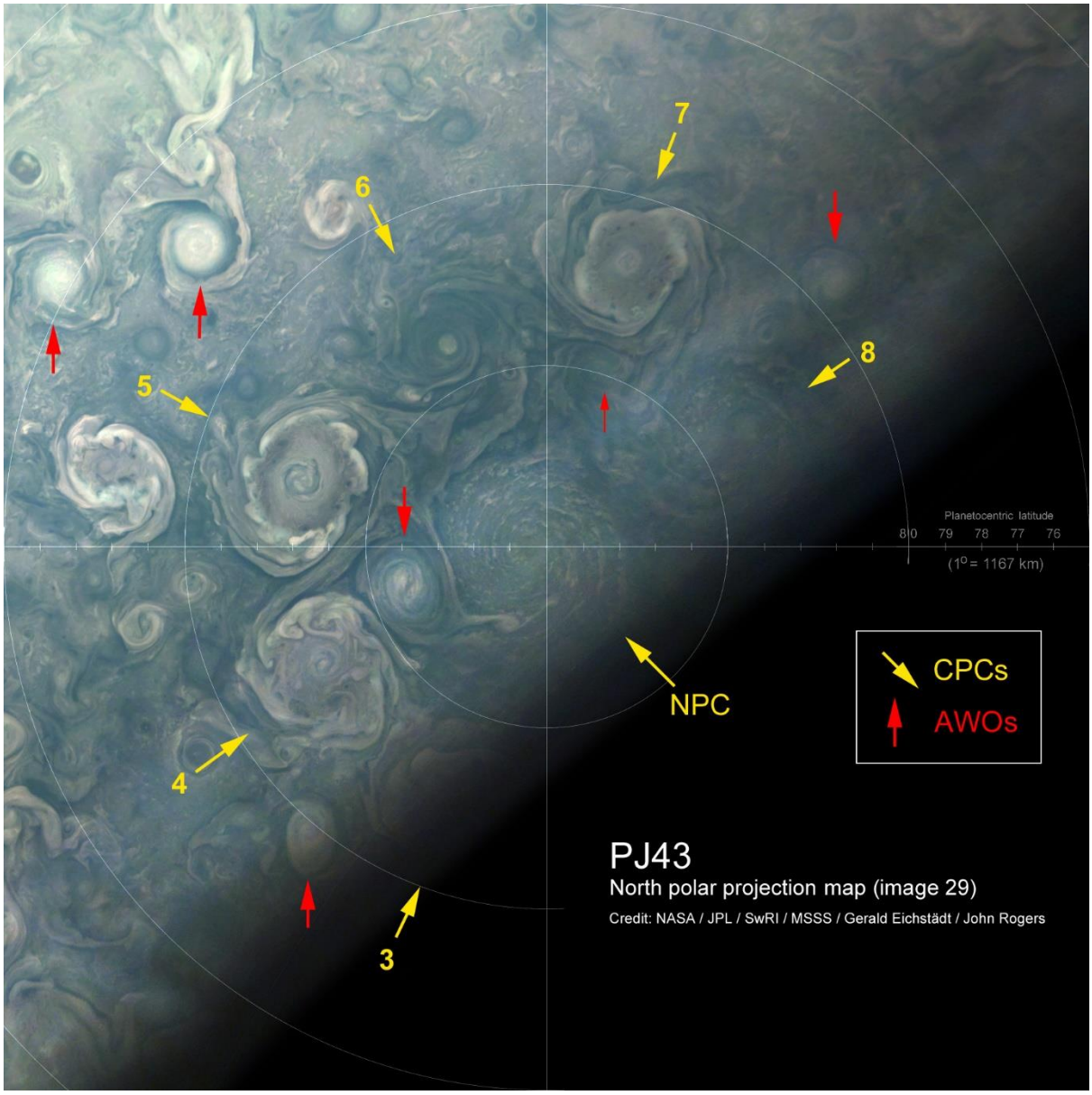


**Figure 2.** North polar projection map of the long-exposure image closest to the pole (image 27), down to 75°N at the edges. CPCs are numbered; red arrows indicate AWOs.

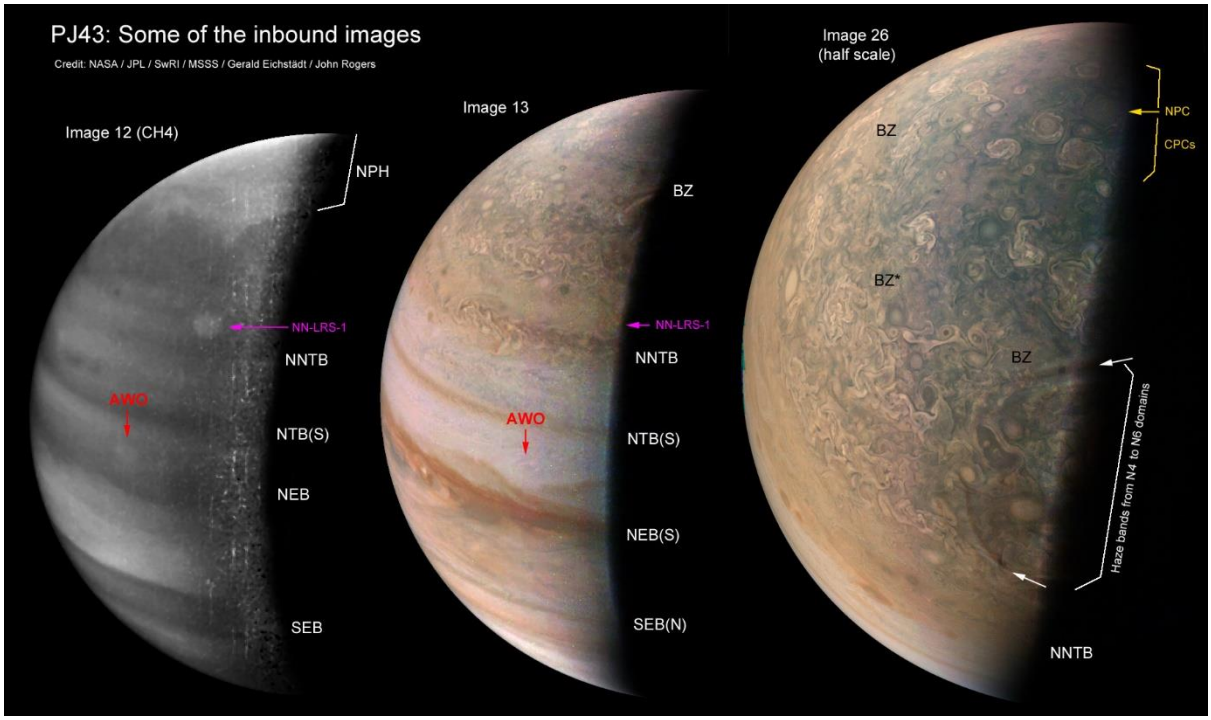


**Figure 3.** Examples of the inbound images.

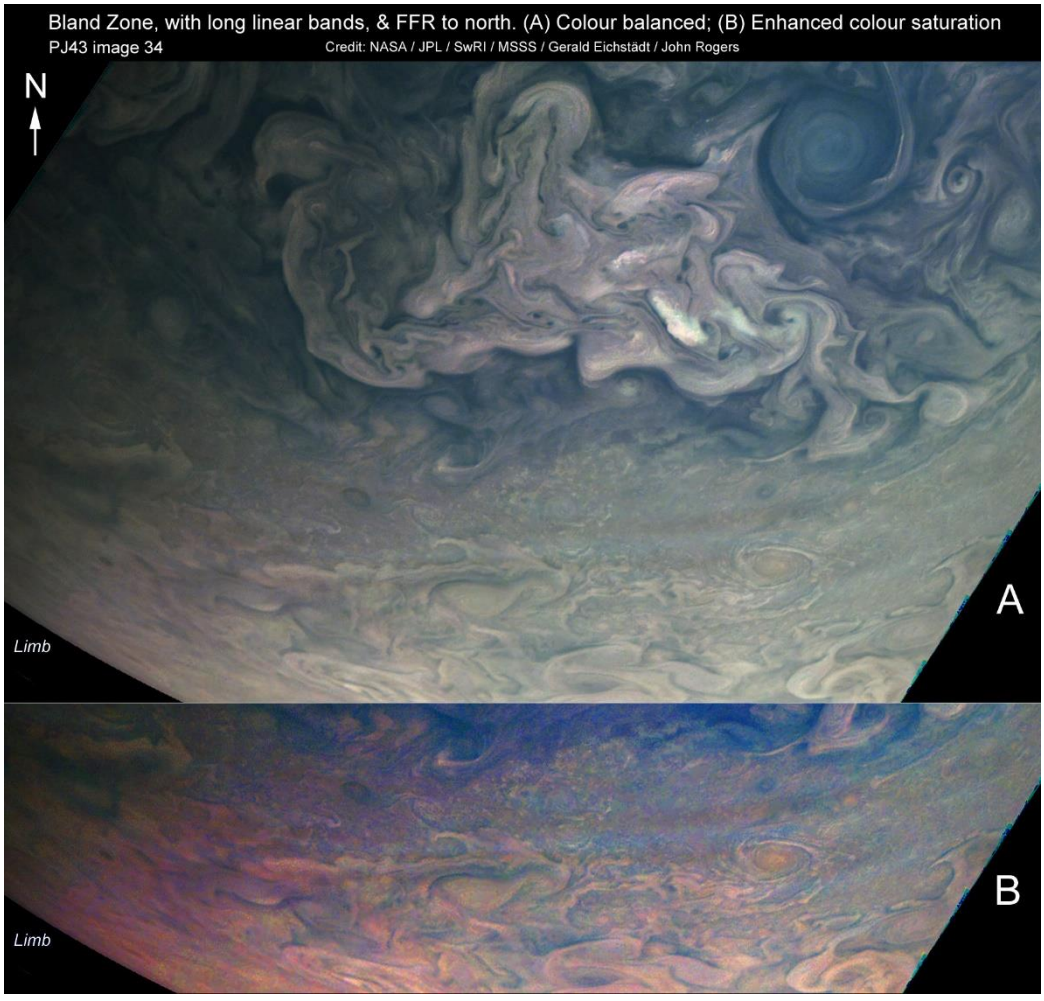


**Figure 4.** Closeup of the Bland Zone, showing the long linear bands under full sun, alternating brown and bluish-white.

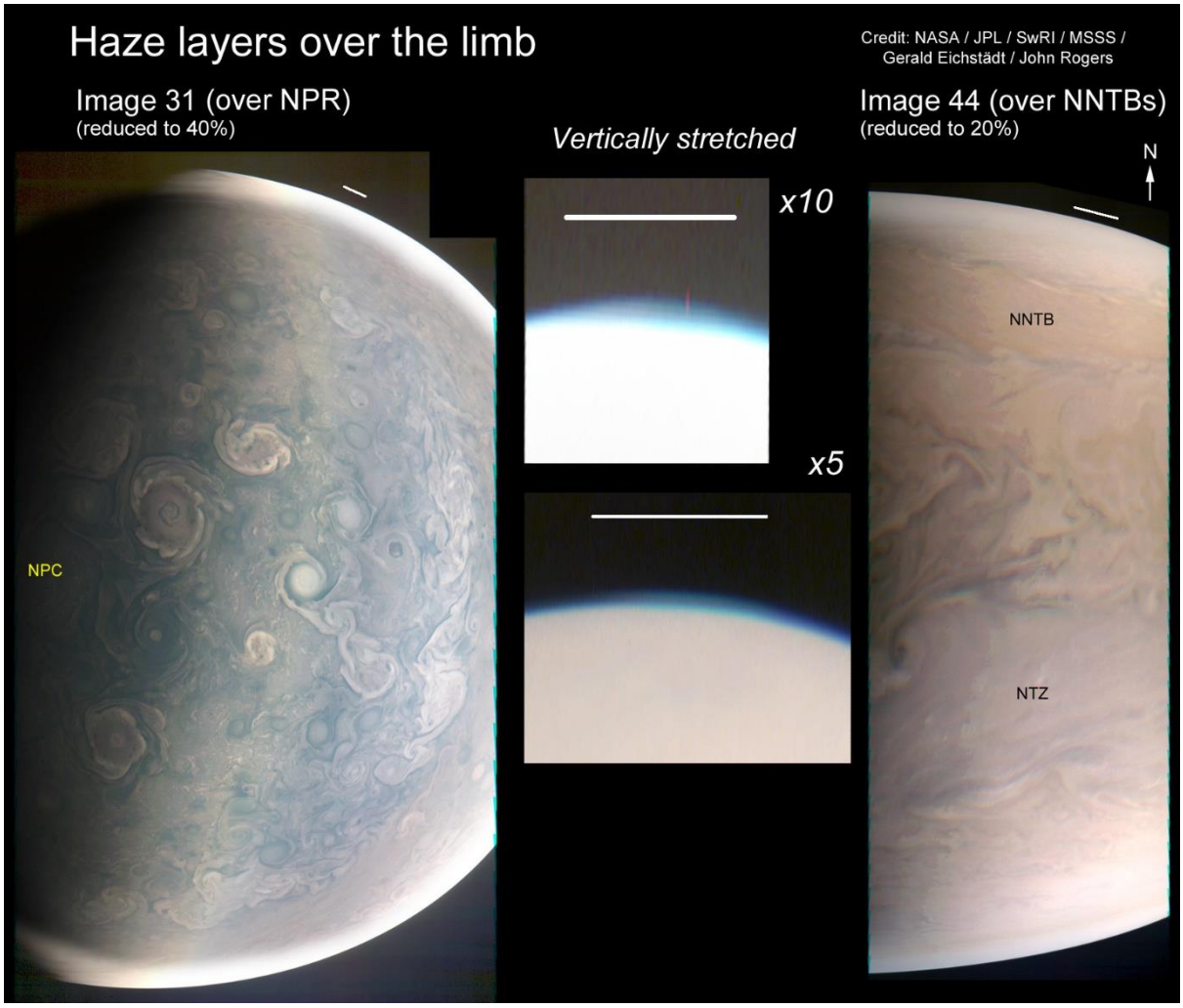


**Figure 5.** High-altitude haze layers above the horizon, in images 31 & 44. (These are Gerald's 'draft' images 32 & 44, with the limb brightened and the interior of the disk contrast-enhanced. White bars indicate the limb regions enlarged in central panels.)

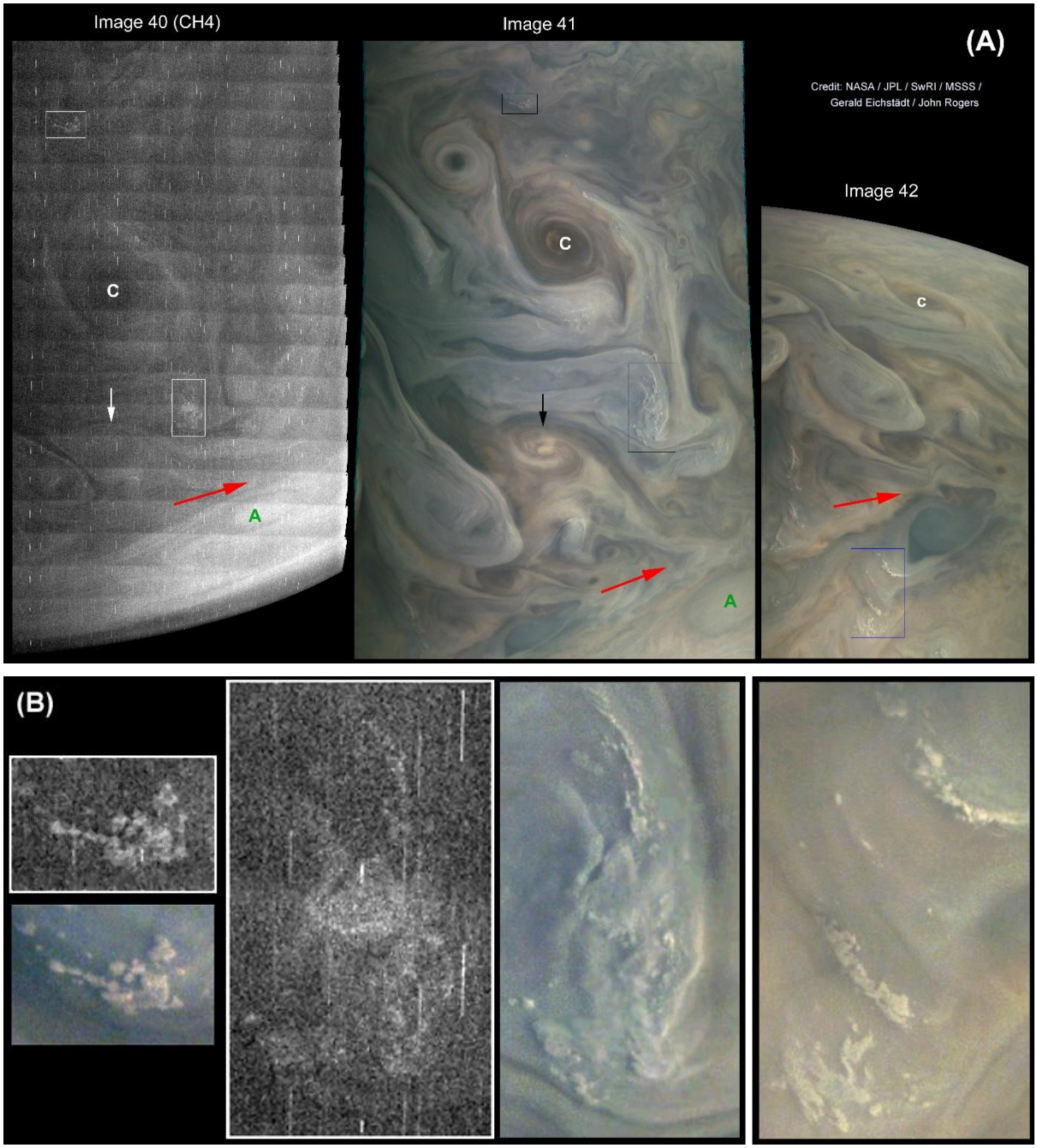


**Figure 6.** Hi-res views of the N4 domain, where white strips and swirls on the p. edge of a FFR are topped with popup clouds and similar but broader cloud rafts (examples are boxed); both are methane-bright. C, compact dark cyclonic vortex, very methane-dark; white or black arrow, lighter cyclonic vortex; red arrow, N4 jet (approx.); A, AWO in N3 domain (methane-bright).

Lower panels (B) show the boxed areas at full resolution; methane panels have been de-noised in Photoshop.

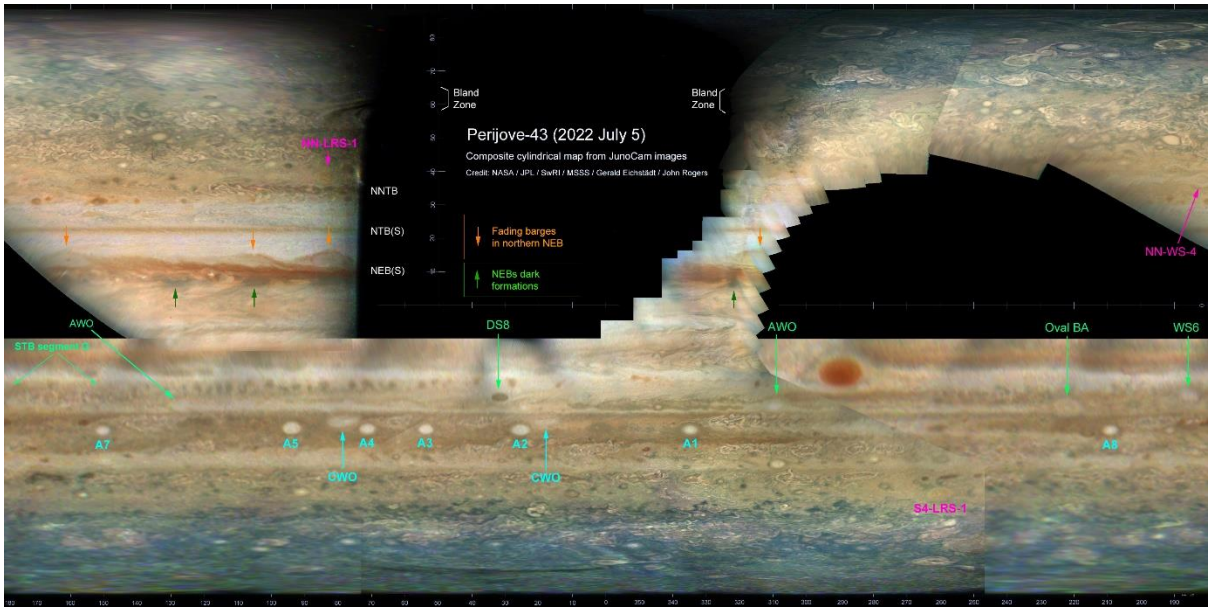


**Figure 7.** PJ43 composite global cylindrical map.

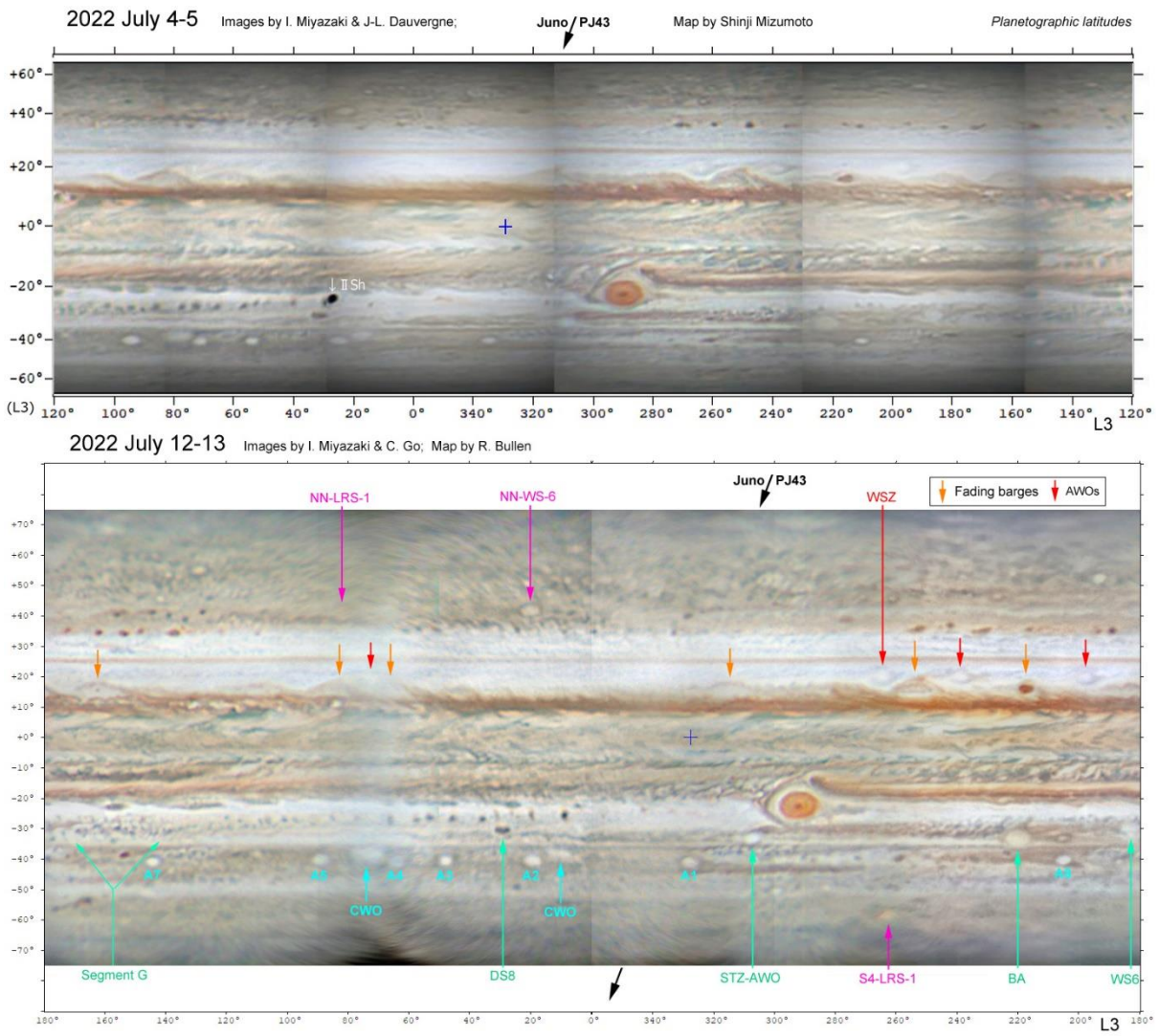


**Figure 8.** Two ground-based maps: (top) at PJ43 & previous day; (bottom) 5-6 days later.

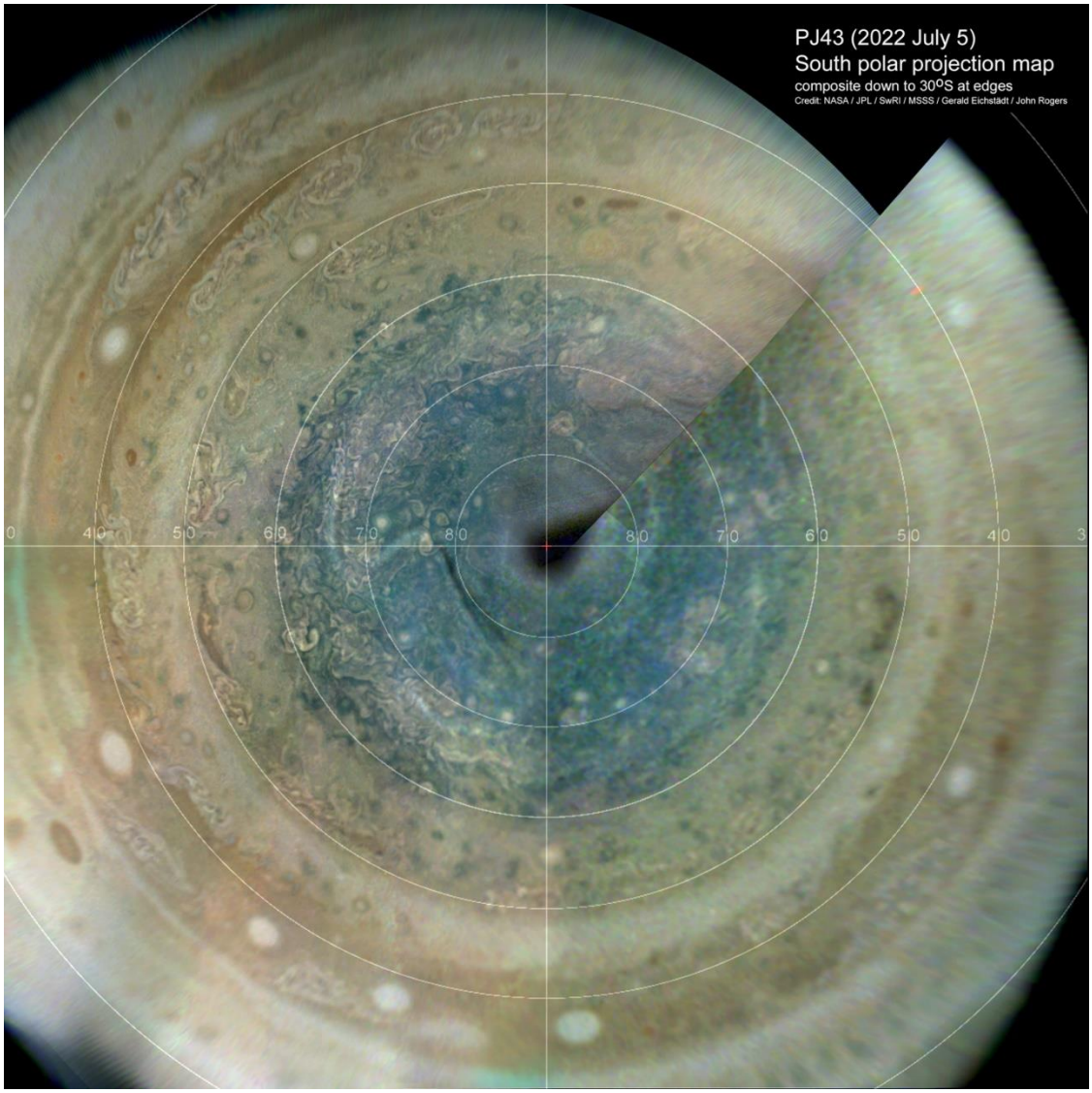


**Figure 9.** PJ43 composite map of the South Polar Region.

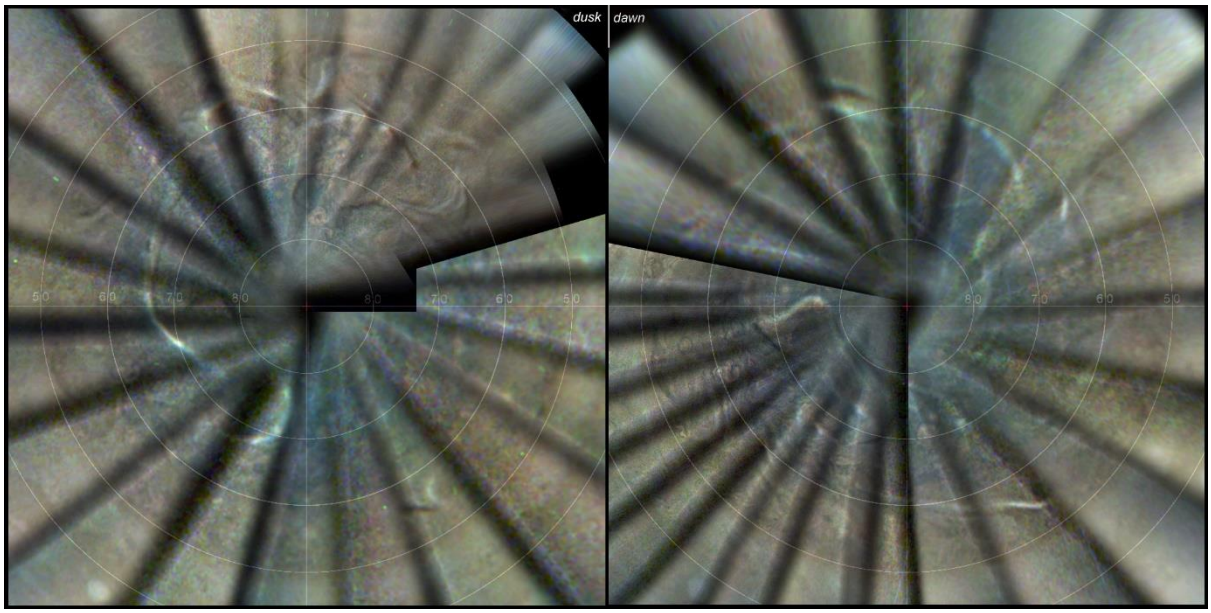


**Figure 10.** Composite south polar maps of the terminator regions at dusk (left) and dawn (right), from images 59-110, down to 45°N at the edges.

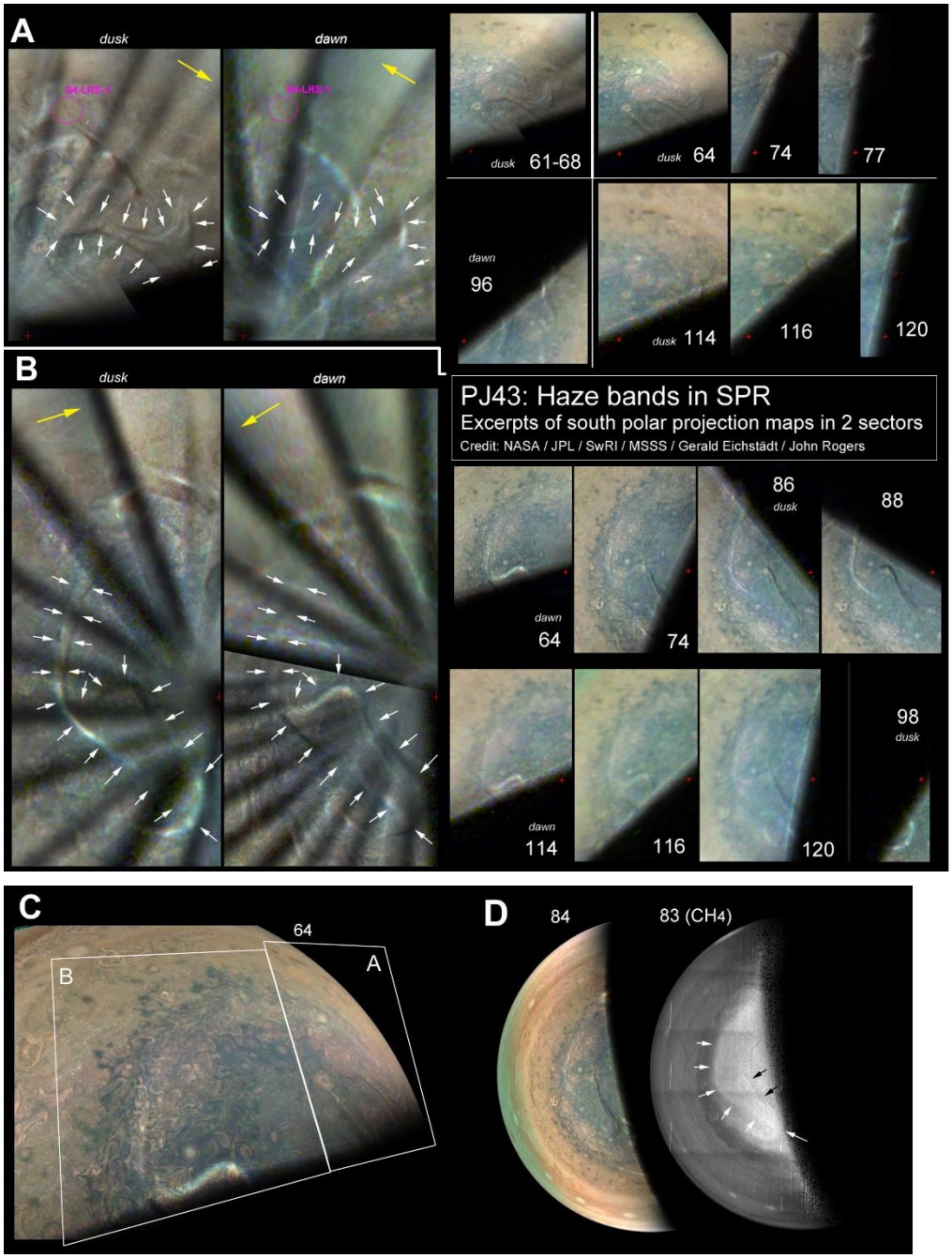


**Figure 11.** Haze bands in the SPR, viewed under the full range of lighting conditions.
This figure highlights two large complexes of haze bands, within the SPH, which appear to be irregular 'slabs' of high-level cloud (outlined with arrows in the left-hand panels) whose edges shine in low sunlight or cast shadows. There are also several other prominent haze bands that reverse contrast between dawn and dusk (not marked). Although these images are contrast-enhanced, the bands are also strongly visible in Gerald's 'draft' images without enhancement.
**(A, B)** Excerpts from south polar projection maps showing the two complexes. A red cross marks the south pole. *Left:* Composite terminator maps from dusk and dawn (from Figure 10). Yellow arrows indicate approximate direction of sunlight in corner of each map. White arrows outline the haze 'slabs'. In (A), also note a contrast-reversing band on the edge of S4-LRS-1. *Right* (at half scale): Maps from single images (numbered) under different illuminations. The appearance is repeated one rotation later: e.g. maps 64/114 (A&B), 77/120 (A), and 74/120 (B).
**(C)** Original image 64, outlining the areas shown in (A & B). Note that complex A is seen quite near the limb, enhancing its 3-dimensional appearance. Complex B includes a very bright sinuous 'rainbow band'on the terminator. **(D)** Original images 83 (methane band) & 84, taken on the outbound trajectory, showing that complex B is also visible in methane. Part of its low-latitude boundary forms the edge of the methane-bright SPH; elsewhere it is a brighter area within the SPH.