Juno at Perijove 25: What the pictures show

John Rogers (2020 March 5)

Perijove-25 was on 2020 Feb.17. Juno's trajectory and orientation were similar to PJ23 and PJ24. Perijove altitude was 4700 km, at 23.5°N (all latitudes are planetocentric). Juno crossed the equator at L1=78, L2=116, L3=153.
This report is in the same style as our previous ones, which contain acknowledgements and explanations of the image sources and the abbreviations.

Galilean moons are shown in the first two inbound images (Figure 1). Image 1 shows Io with a probable volcanic plume seen faintly on the terminator. Image 2 shows Io entering eclipse, and another moon (not shown here).

North Polar Region

Circumpolar cyclones:
Figure 2 is a composite north polar projection map derived from Gerald Eichstädt's maps. Four of the circumpolar cyclones (CPCs) are nicely shown. Closer to the pole there is a large anticyclonic reddish oval; and traces of the central North Polar Cyclone can be seen around the pole itself, although not as regularly as at PJ24. The arrangement of the CPCs is the same as when this sector was last well imaged, at PJ23&PJ24 and at PJ17. Gerald has made an animation of hi-pass images, and points out that anticyclonic counter-rotation can be seen in the centres of two of the filled cyclones.

Composite views of north polar region:
Figure 3 presents composite north polar projection maps, in colour (A: RGB) and the methane band (B: CH4). Figure 4 presents composite, reprojected images of the NPR, also in RGB and CH4. Following the successful acquisition of methane images down to quite low latitudes at PJ24, more such images were taken at PJ25, and are presented here in extensively cleaned and reprojected versions (Figures 4 & 5).

Bland Zone & haze bands:
Long linear bands of bright haze are a striking feature in the PJ25 RGB images. These are normal features of the 'Bland Zone' at ~60-64°N, but it is unusual for them to appear bright all the way around the globe as they do here. They are also 2-3 times longer than usual. These linear bands are also visible in the methane images, and in some sectors they form a sharp southern edge to the methane-bright North Polar Hood. But surprisingly, overall the usual methane-bright North Polar Hood is not obvious. It is not clear if this is a real change, or due to the way the viewing angle varies across the globe.
There are also discrepancies in the features revealed in methane images at lower latitudes, perhaps due to differences in illumination. At ~43-58°N, where RGB images show irregular haze bands at the terminator, the methane images 13&16&19 (Fig.4) show diffuse, weakly methane-bright haze features near the terminator which do not match the underlying visible-light features (FFRs). But in methane images 23&26 (Fig.5) taken from lower latitudes and higher sun, the same and lower latitudes show no sign of overlying haze bands; instead, there is a tremendous amount of detail which generally correlates with the visible atmospheric features, including anticyclonic ovals methane-bright and cyclonic ones methane-dark (down to the NNTZ and NNTB).

The same regions are shown in Figure 6 as though from a single point on Juno's trajectory, in a fish-eye globe view made by Kevin Gill from his own projections of several images.

Global maps

PJ25 occurred early in the apparition for ground-based observers, so there were few good context images, but Phil Miles and Anthony Wesley in Australia managed to get remarkably good images at the same time as Juno's fly-over (Figure 7). A planet-wide map, from images taken a few days before, is in Figure 8.

Our usual global cylindrical map from JunoCam images is in Figure 9. Brian Swift has posted a higher-resolution composite cylindrical map, and an excerpt from it is shown in Figure 10, from the N3 domain down to the equator.

Mid-northern domains

N3 & N2 domains:

The closeup images of the N3 and N2 domains showed a remarkable panorama of diverse circulations, as shown in Gerald's reprojections in Figure 5B, and Kevin Gill's map in Figure 10, and also in high-quality reprojections posted by Kevin Gill and Bjorn Jonsson. Figure 5 shows that the features here follow the general rule that anticyclonic ovals are methane-bright and cyclonic features are methane-dark. The colour images are sufficiently hi-res to show pop-up clouds, clustered in ridges on the highly sheared streaks within NN-WS-4 and in the regions surrounding cyclonic circulations, though sparse within those circulations (Figure 11A).

The notable circulations are marked on Figure 10 (from top to bottom):

(1) In the N3 domain, a merging pair of cyclones. Beautiful orange cyclones are familiar in JunoCam images of this domain, so we can recognise the two mis-shapen features here as a pair of them caught in the act of merging.

(2) In the NNTZ, the great anticyclonic oval NN-WS-4 [see PJ21 report for list of previous closeups]. Its centre is slightly reddish and also the most methane-bright. (Last year it was sometimes quite reddish.)

(3) In the NNTBn latitude, a dark brown cyclonic oval which can be called a mini-barge.

(4) A closed, pale orange segment of NNTB, which is very likely the dark segment that was observed at L2~90-105 in 2019, which reddened then faded away in 2019 Sep. [2019 Report no.9]. Note its similarity to the STB Ghost & Spectre (PJ8, PJ10, PJ13, PJ15, PJ21) and to other closed pale cyclonic circulations such as one in the SSTB (e.g. PJ20 & PJ21).

Image 28 (Figure 11B) is the closest view of this NNTB segment, and also shows, at the limb, a detached haze layer over the NNTZ.

(5) NNTBs jet spots (dark rings); the anticyclonic vorticity is evident in some of them.

N1 (N. Temperate) domain:

In the NTB(N) we see a series of three small, very dark brown cyclonic spots or 'mini-barges' (Figure 10) – perhaps an indication that this belt is now developing a chain of very dark spots as it has sometimes done in the past.

Low latitudes

NEB:
This sector of NEB is especially colourful in ground-based images (Figures 8 & 9), and contains two AWOs persisting from 2019; the f. one is called WS-a, and the p. one here labelled WS-o. JunoCam image 31 (Figure 12) just includes both AWOs near the E and W horizons; but the main feature in this and other images, between the AWOs, is an impressive spiral circulation, which is cyclonic. It lies in the pale yellowish fringe north of the main NEB. In ground-based images it is only seen as a small irregular pale spot, which appeared in 2019 August within a brown bulge of the NEB.

EZ:
There are excellent oblique views of a NEBs dark formation and its festoon in the northern EZ, but no obvious mesoscale waves, perhaps due to the long slant range.

SEB:
This sector is all quiet, with just one small vortex on the S edge. Contrasting textures and colours in the clouds are evident (image 37-39: Figure 13): the very smooth texture of the light orange northern SEB, the streaky dark red-browns and greys of the southern SEB, and the numerous white flecks (presumably pop-up clouds) in the STropZ. Fringing the SEBs there is a remarkable long orange strip which is evidently a translucent haze band, enhancing the contrast of underlying cloud textures in the northern STropZ.

South Tropical and Temperate domains

Figure 9 includes our usual outbound southern hemisphere map.

The GRS was just captured in the final lo-res images (Figure 14). There are long complex streaks of red methane-bright material extending both p. and f. the GRS, presumably derived from recent flaking events; some flakes are still close to the GRS.

SEBs: After the three large rings that are closely approaching the GRS, there are no more for a long distance (Figure 9). Instead, there is a high-amplitude wave-train from L3=203-238, nine waves with a mean wavelength of 3.9°, perhaps the shortest that we have yet observed.

Oval BA is just visible on the limb; the dark segment of STB f. it is now short, but still turbulent, and its f. end abuts a small AWO in the STZ. Figure 15 is a hi-res map of the region.

STB Spectre: The p. end can now be seen, alongside the f. end of the turbulent STB segment f. oval BA, and adjacent to the small AWO there (Figure 15). It is not evident whether it is still a closed circulation there, as the p. end is tapered. As it is now in contact with the dark STB segment, there is the possibility of a sudden eruption and transformation of the Spectre, as happened with the STB Ghost in 2018. However, as the Spectre has elongated to an unprecedented degree, it may not behave in the same way. In the PJ25 map, the p. end is at L3~142 and the f. end at L3=305, a length of 163°. The f. end (Fig.9) is a fairly conspicuous dark feature, as also seen in recent ground-based images. The Spectre is still methane-dark in the JunoCam methane maps (Figure 17D) except possibly at the p. end, which does not appear dark in a ground-based methane image (Fig.7).

A typical view of the southern hemisphere is in Figure 16. South polar projection maps, in similar format to our reports for other recent perijoves, are in Figure 17.

South Polar Region

Haze structures:

The methane-band map (Figure 17C) shows the usual features, most obviously the methane-bright South Polar Hood, with its wavy outline, and methane-bright FFRs within it.

A map of near-terminator regions, to show hazes, shows unusually little for this perijove; haze bands are sparse and mostly inconspicuous, with low optical depth. A diagram of those detected is in Figure 17B. The bands largely have the typical orientations, and in the best-imaged sector (lower right) there is a series of the commonly observed ⊃-shaped bands, but not conspicuous; the deepest images also reveal extensive thin diffuse terminator hazes in this region. In the upper left sector, there is a 'rainbow band', and another haze band unusually close to the pole overlying a CPC (Figure 18B).

Circumpolar cyclones (CPCs):

The south polar polygon is currently of special interest, because at PJ23 the familiar pentagon of cyclones appeared to be transforming into a hexagon, as a small dark cyclone had moved into the gap between CPCs-1 & 2. At PJ24, this had been replaced by a larger but chaotic cyclonic region (FFR). Would there be a stable hexagon at PJ25? The answer is no: it has reverted to a pentagon, with the 5 cyclones more evenly spaced than they used to be! (Figures 17A&18A) (CPC-4 is not clearly visible, but is likely to be still present, as it is the furthest from the former gap, and arcs on one side of it can be seen.)

The centre of the south polar cyclone (SPC) has not moved much (Figure 18C). It is still oscillating to and fro in longitude, but has not changed its latitude significantly since PJ18.

FIGURES (miniature copies)

Full-size copies are in the attached ZIP file

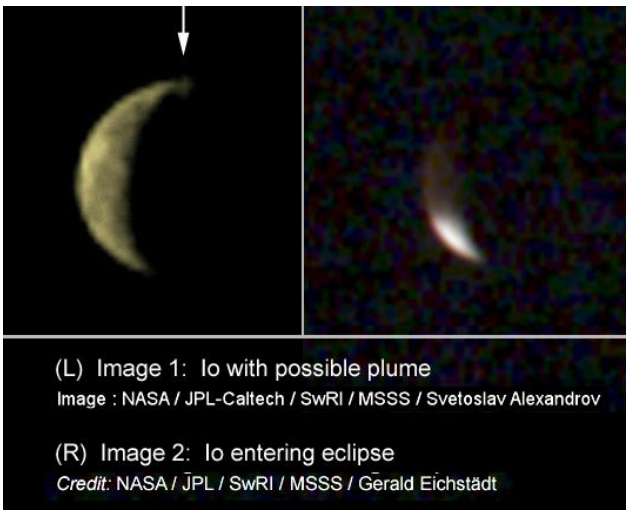


Figure 1. Views of Io. *Left*, showing a possible plume next to the upper cusp. *Right*, entering eclipse; the eclipsed part is brightened, and appears red like a lunar eclipse from Earth.

Figure 2. Composite north polar projection map derived from Gerald Eichstädt's maps, down to 75°N at edges. The red cross is the north pole.

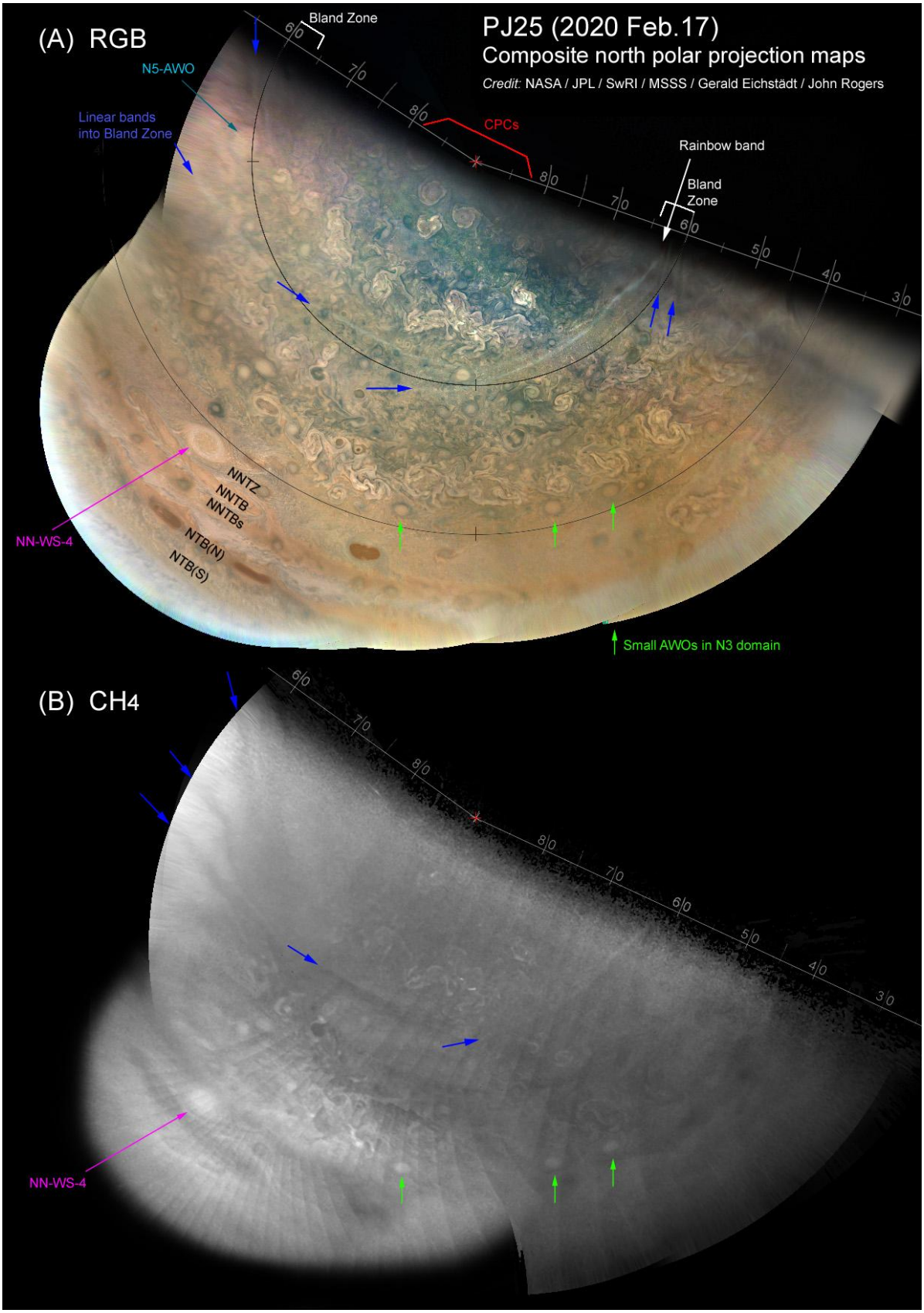


Figure 3. Composite north polar projection maps, in colour (A) and the methane band (B), covering the northern hemisphere.

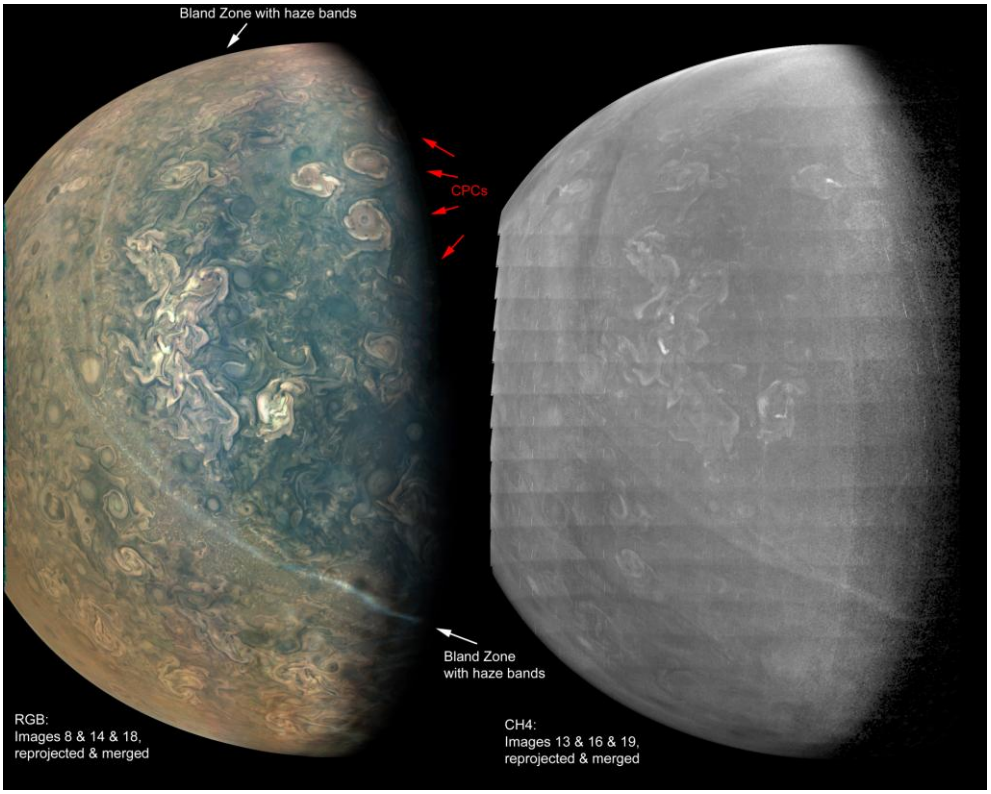


Figure 4. Composite views over the north polar region. Gerald Eichstädt processed the images and reprojected them all as from a common viewpoint. I have merged the sets of three images and adjusted the intensities so as to show enhance details including at the terminator. Several of the circumpolar cyclones are visible at upper right. (Left): Colour view derived from images 8 & 14 & 18. (Right): Methane-band view derived from images 13 & 16 & 19. Some pixel noisehas been removed. The small, very bright spots are convective clouds (thunderstorms) in the chaotic cyclonic regions (FFRs).

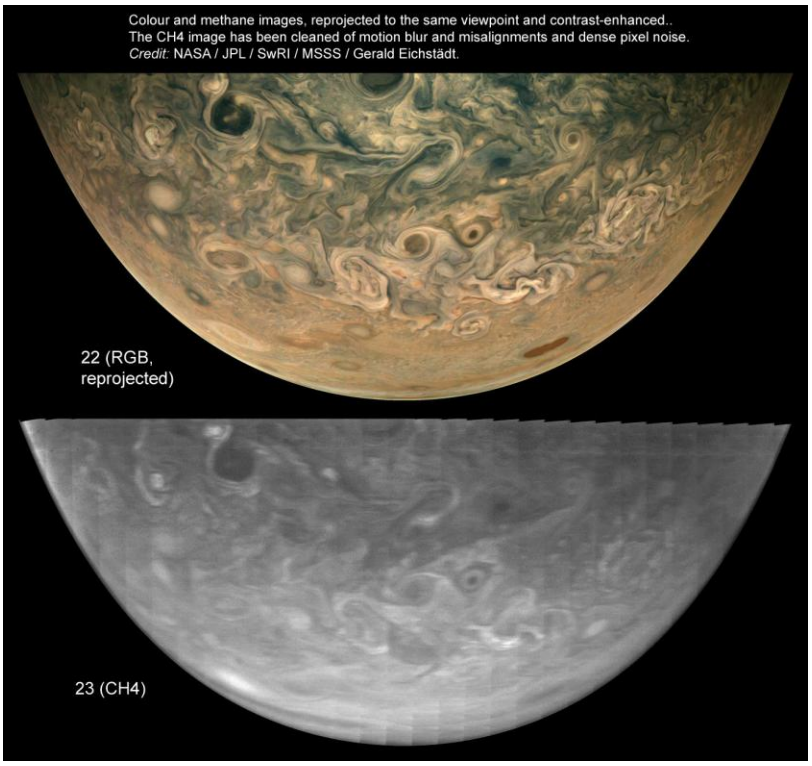


Figure 5A *[caption below]*

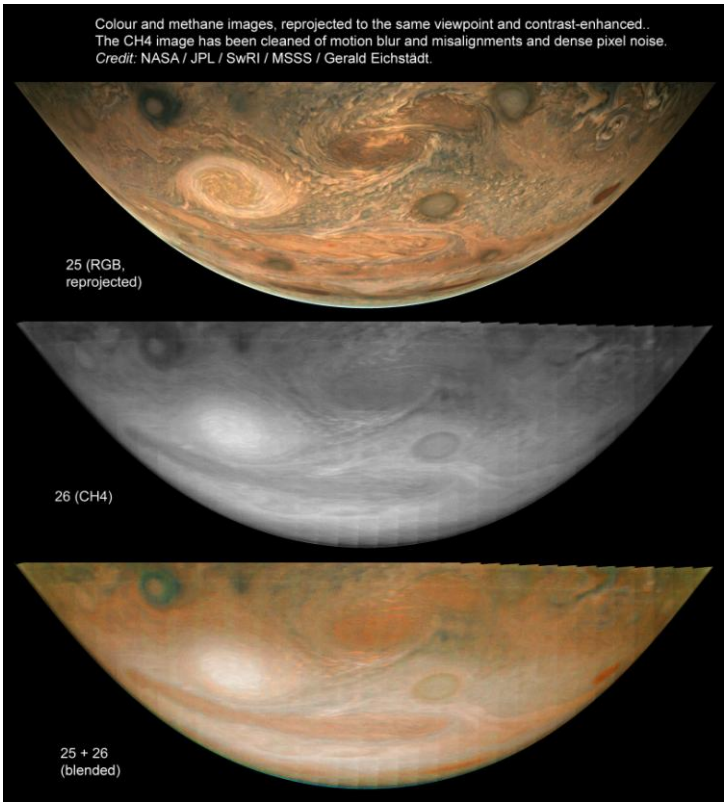


Figure 5. Colour and methane views, all by Gerald Eichstädt. The RGB images were reprojected to the same viewpoint as the CH4 images. The original CH4 images suffered from motion blur and misalignments and dense pixel noise, all of which have been minimised by Gerald's 'cleaning' processes. All images are contrast-enhanced. **(A)** Images 22 & 23, centred on the N4 domain. **(B)** Images 25 & 26, showing the N3 and N2 domains, including the merging cyclones in N3, NN-WS-4, a faded orange strip of NNTB; see Figure 10 for key.
(A & B): Top: RGB image, reprojected to same view point as CH4 image. Middle: Methane image. Bottom (only in B): Blend of RGB and methane images.

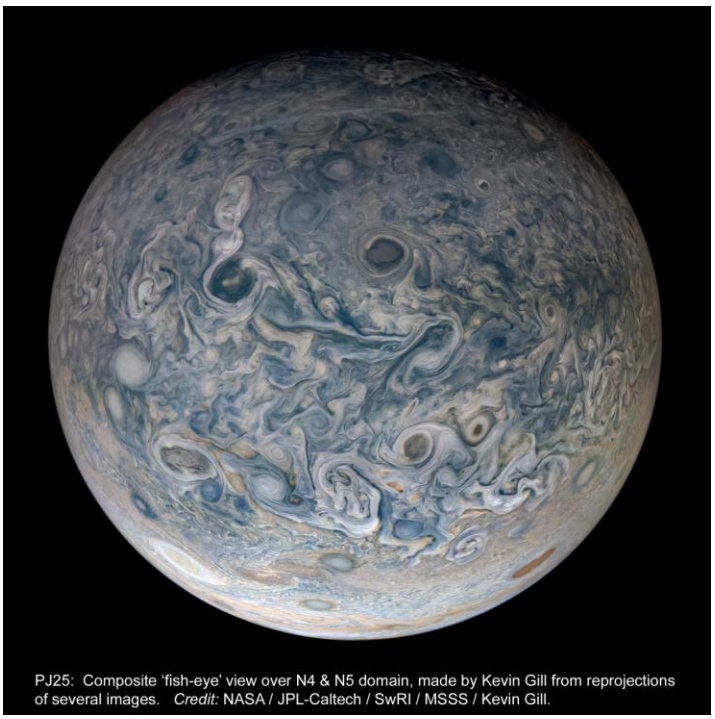


Figure 6.

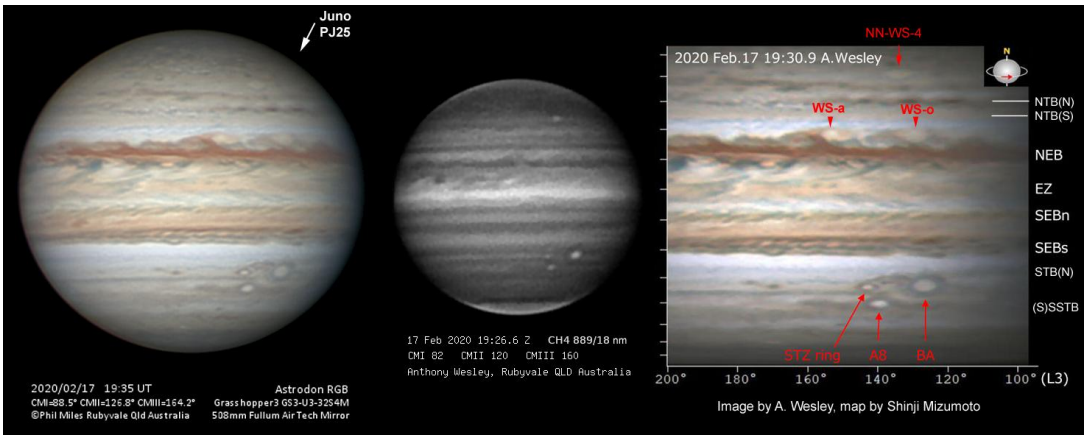


Figure 7. Ground-based images of Juno's track taken during PJ25, by Anthony Wesley and Phil Miles.

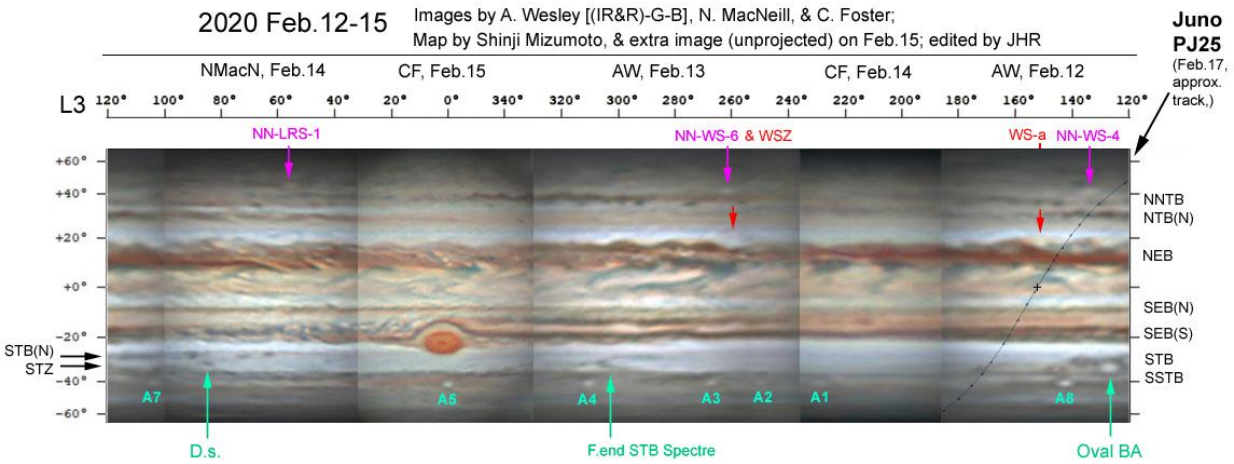


Figure 8. Map of ground-based images taken a few days before PJ25.

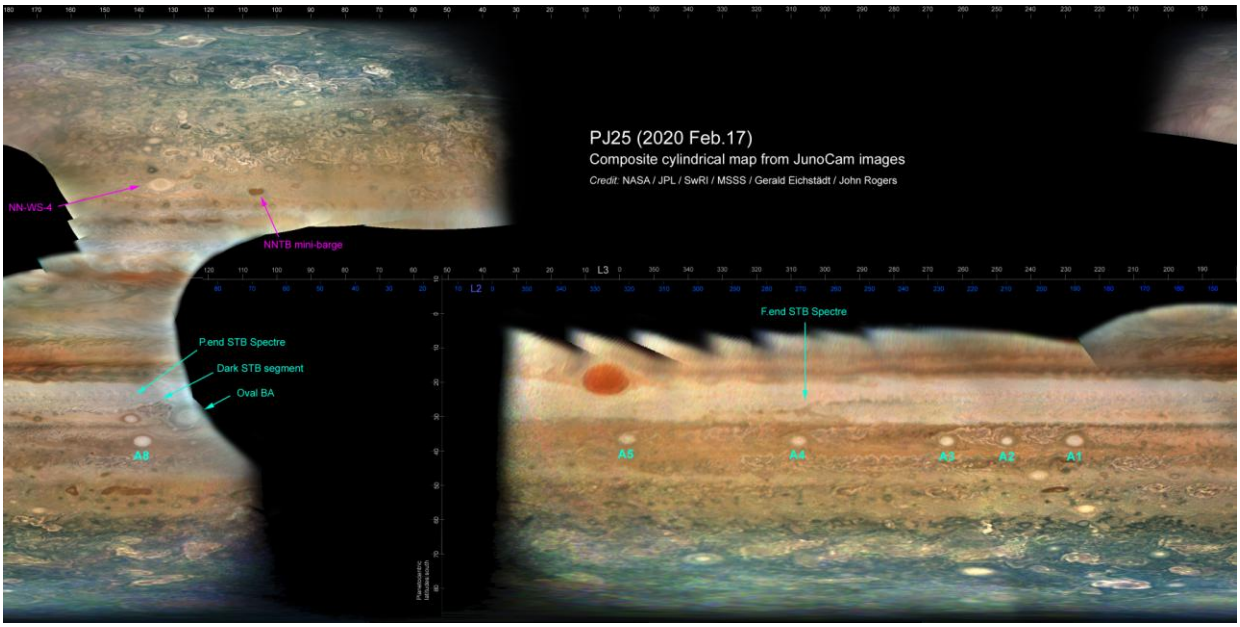


Figure 9. Map of JunoCam images from PJ25.

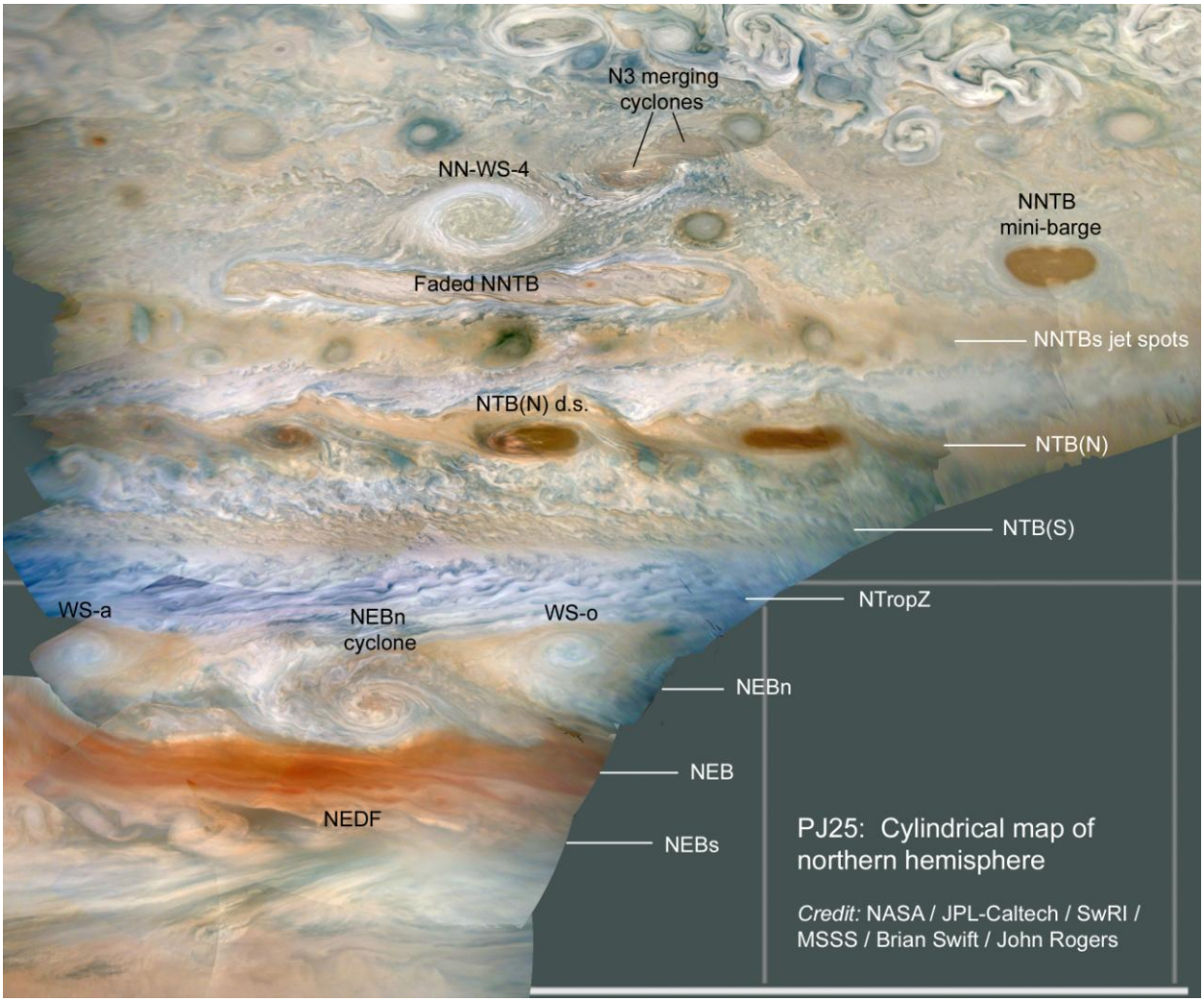


Figure 10. Cylindrical map from the N3 domain down to the equator: an excerpt from a larger map by Brian Swift, with some intensity adjustments and added labels. Black labels are above the indicated circulations. NEDF, NEBs dark formation.

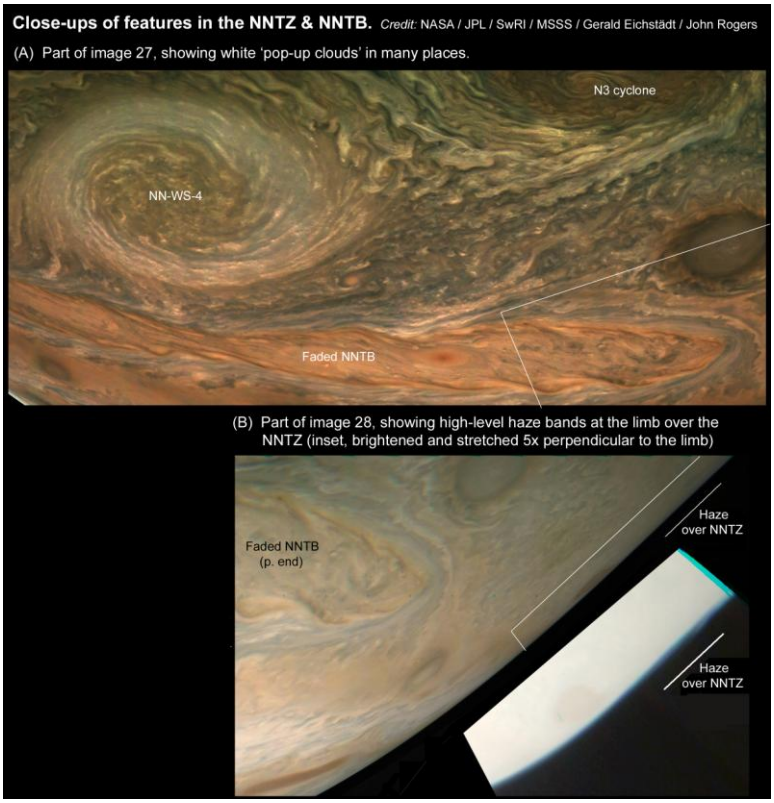


Figure 11.

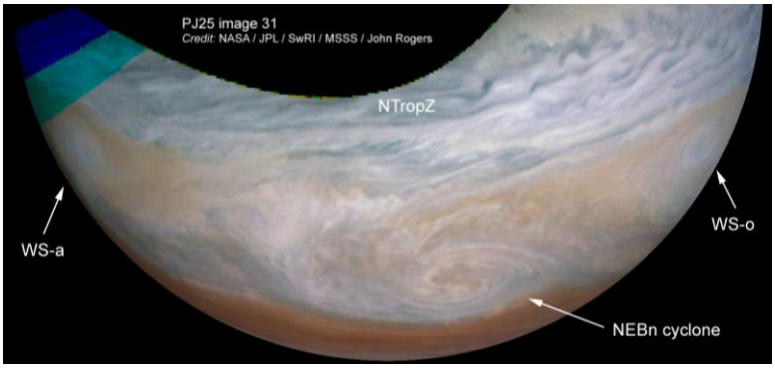


Figure 12.

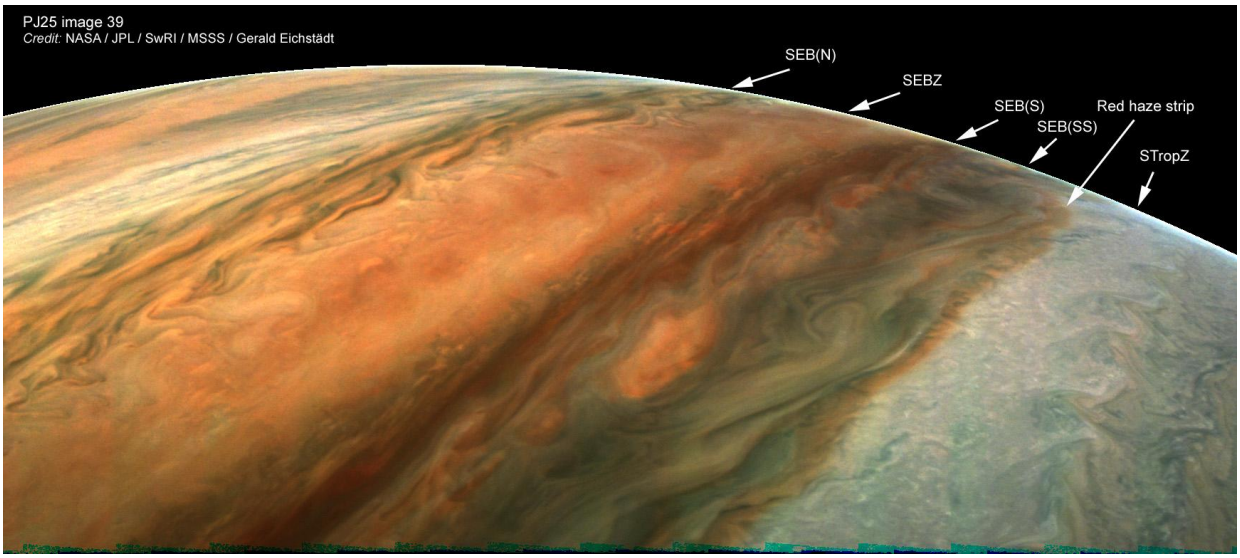


Figure 13.

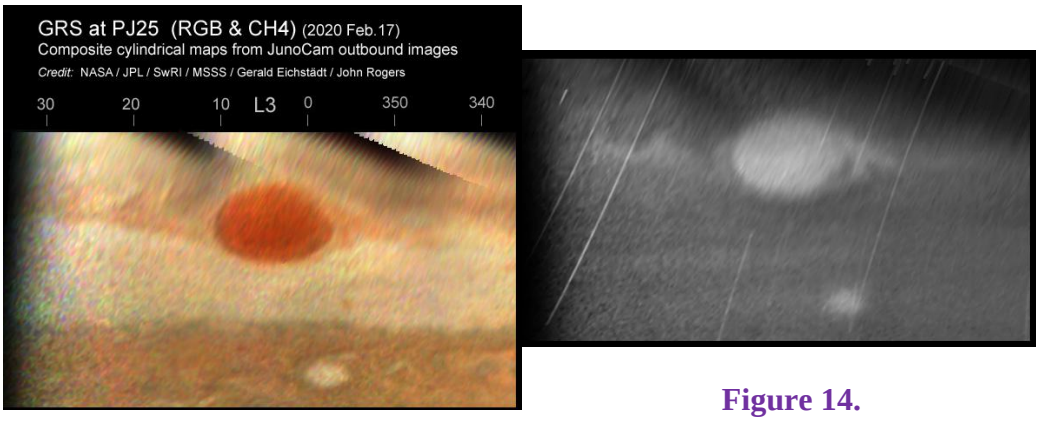


Figure 14.

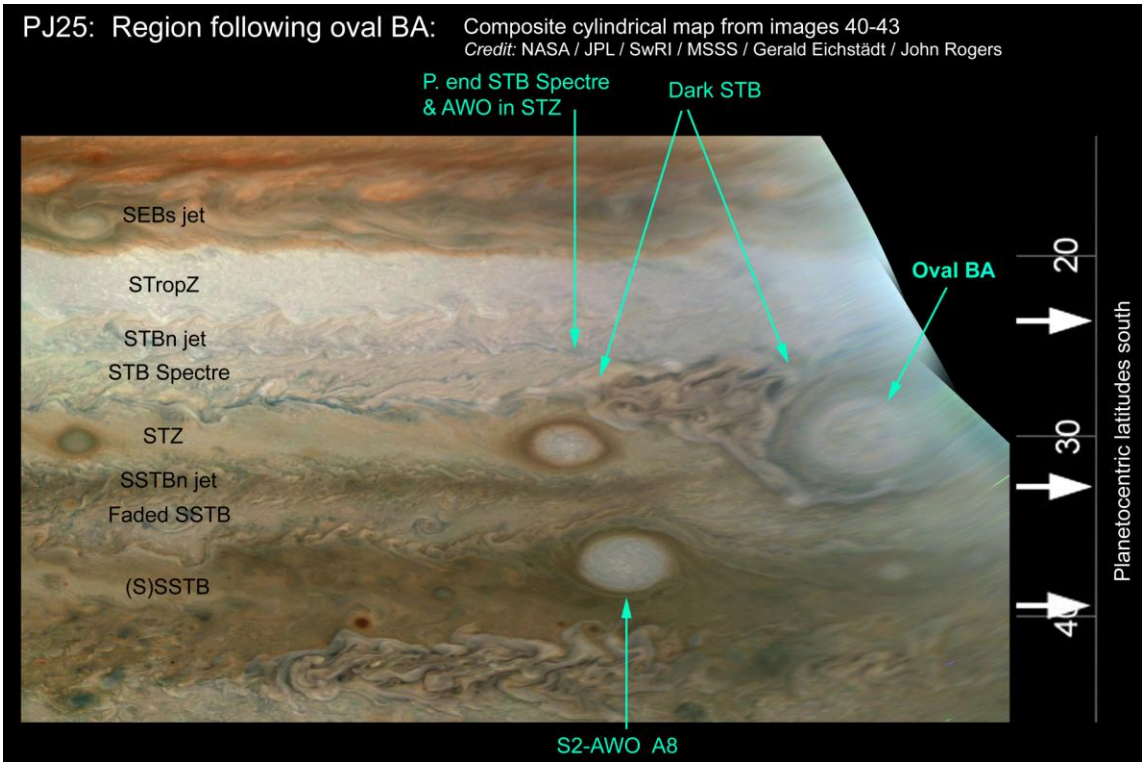


Figure 15.

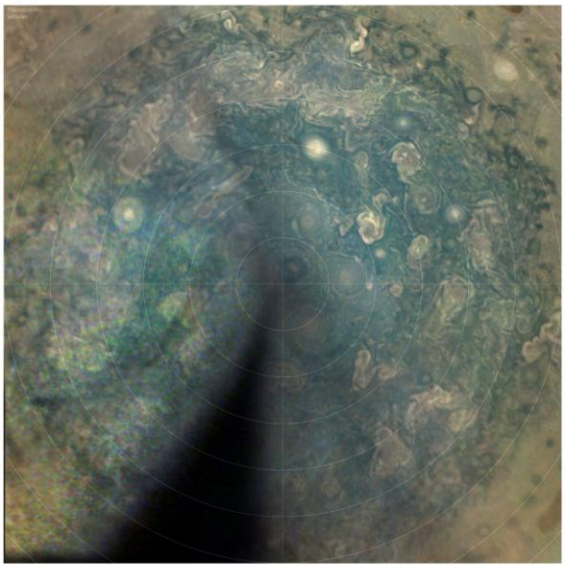
Figure 16.

NEXT PAGE: **Figures 17 & 18.**

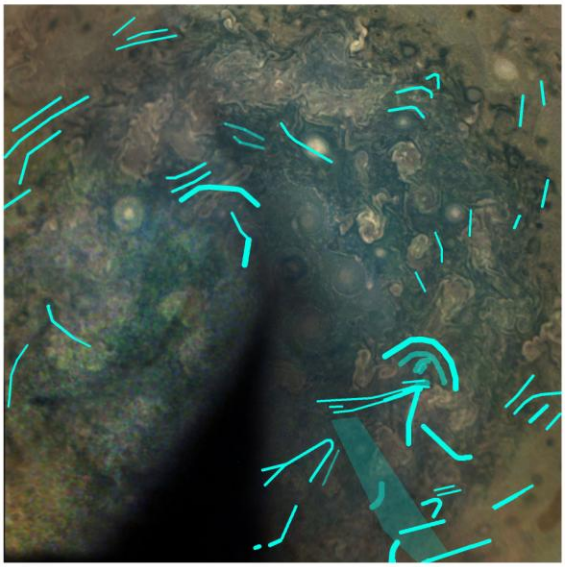
PJ25: Composite south polar projection maps.

Credit: NASA / SwRI / MSSS / Gerald Eichstädt / John Rogers

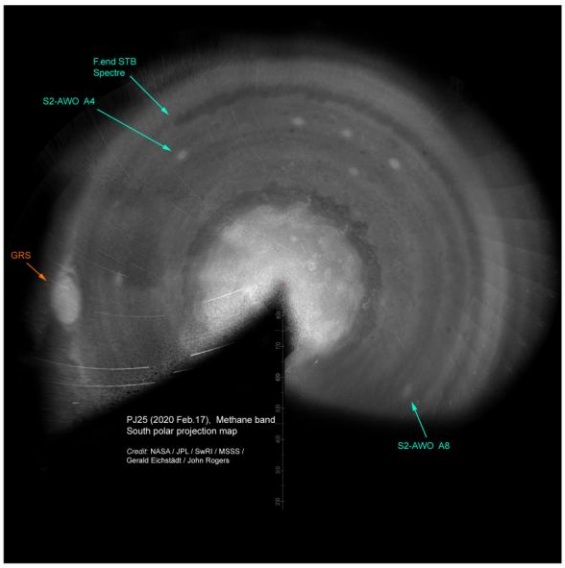
(A) Colour map (down to 60ºS at edges) Planetocentric latitudes. L3=0 to left.



(B) Haze bands, delineated from near-terminator composite maps



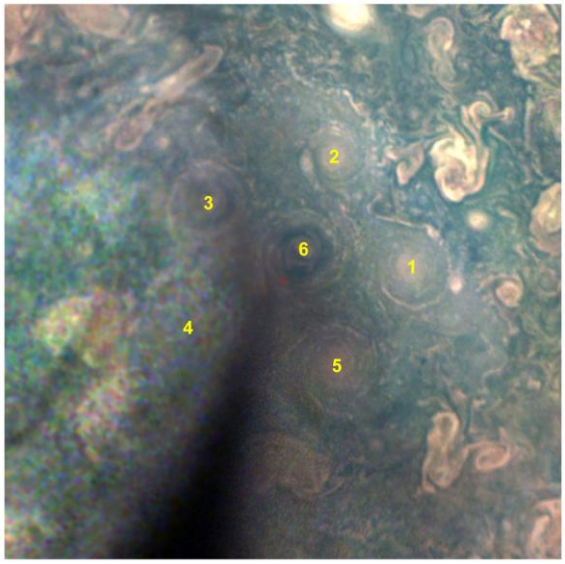
(C) Methane-band map (down to equator at edges)



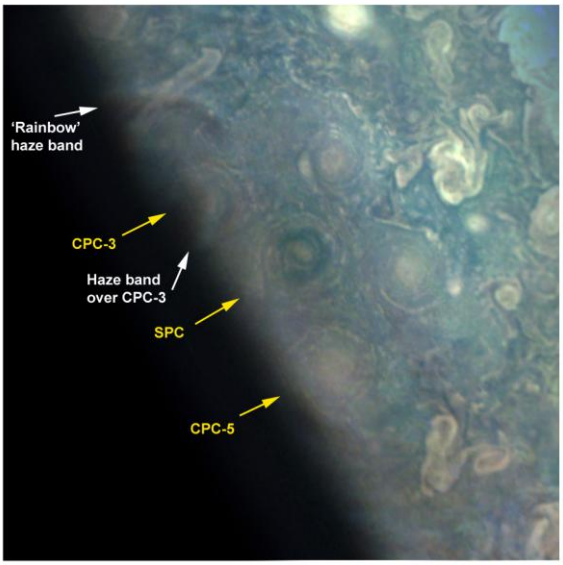
PJ25: Composite south polar projection maps.

Credit: NASA / SwRI / MSSS / Gerald Eichstädt / John Rogers

(A) Colour map (down to 75ºS at edges), showing the CPCs ['6' = SPC]



(B) Colour map of image 59 only



(C) Position of SPC w.r.t. South Pole: The centre of the SPC is marked at each perijove (black dots), on a background map from PJ25 & PJ21.