JunoCam at PJ23: What the pictures show

John Rogers (2019 Nov.27)

Perijove 23 (PJ23) was on 2019 Nov.3. Perijove was at 22.5°N, 3500 km above the NTB; but because of Jupiter's oblateness, minimum altitude was 3369 km, a few minutes later. Juno crossed the equator at L1=63, L2=189, L3=198.

On Oct.1, a month before perijove, Juno performed a manoeuvre to adjust the orbit so that it would not pass through Jupiter's shadow before PJ23. Now that it has 'jumped over' Jupiter's shadow, it crosses the equator just before local noon, and perijove will continue shifting towards the morning side for the remainder of the mission. Another consequence of the manoeuvre is that the orbital inclination has reduced from 78.9° (PJ22) to 74.3° (PJ23), so Juno no longer passes directly over the poles.

At all current perijoves, Juno is pointed towards the Earth and Sun, so when near the equator the camera just scans the horizon. However, the low-latitude images are still surprisingly good, for several reasons: (i) The sub-spacecraft track is imaged obliquely as Juno descends over the north, looking forward, and as it ascends over the south, looking backward. (ii) The images are 58 deg wide, and with Juno's low altitude, this is enough to see the planet near the horizon; indeed, PJ23 image 28 captured the horizon around 360°! (Figure 5). (iii) Although the low-latitude images should now show progressively more of the view to the east, those at PJ23 were still tilted slightly towards the west as at previous perijoves; I suspect this was because the spacecraft was pointed towards the Earth which was several degrees away from the Sun.

Ground-based imaging was difficult as the planet was slipping into the evening twilight, but Clyde Foster in S. Africa was able to get pre-sunset images of the track, which showed the main features covered by JunoCam (Figure 1). JunoCam's own images enabled cylindrical maps to be made by ourselves (Figure 2) and in hi-res by Brian Swift (see JunoCam web site). Kevin Gill rendered several sets of consecutive images into realistic but spectacular 'fish-eye' views of how Jupiter would have appeared to Juno at single moments on its trajectory; small copies of four of these are shown in Figure 3.
This report (Part I) covers everything except the polar regions, which will be described in Part II, to follow.

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 (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 ('v01') 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 by Gerald. Details were given in our PJ6 report. Abbreviations and conventions are as in previous reports. P. = east, f. = west. Latitudes are planetocentric.

High northern domains

The images of the northern domains are shown in Figure 4, with domains and major features labelled. In the N5 domain, there is a closeup of a large AWO (Fig.4A); it had been tracked by the JUPOS team from ground-based images throughout 2019, with a fairly steady retrograding drift. There are also many haze bands in this region, which will be illustrated and discussed in Part II.

The N5 and N4 domains are full of FFRs and other chaos as usual. Given the lower altitude of the spacecraft over the northern hemisphere now, we can see popup clouds to higher latitudes than before. Some are just visible even in the N5 AWO (Fig.4A), and long lines of them are seen in a N4 FFR (Fig.4B). This FFR is surrounded by anticyclonic eddies (possibly spun off from it). Bright white cloud strips in the FFR are truncated at these eddies, but not because they are over-ridden; instead, they appear to be held back from the eddies by some unidentified meteorology.

In the N3 domain, two beautiful cyclones are seen (the larger one is in Fig.4C).

In the N2 domain, long-lived NN-WS-4 is seen near the limb; this AWO appears remarkably reddish. The view of the domain is dominated by a grand FFR, with diffuse orange haze patches over many of the cyclonic eddies within it (Fig.4D). Orange patches like these were prominent in Voyager images. In Juno images, they have not often been an obvious feature before now, although some were present in similar views of this or another NNTB-FFR at PJs-6, 11, 13, 14, 20 & 21. The present image (Fig.4D) must be the most striking view of them so far.

N. Temperate (N1) domain

The images cover the f. end of the N. Temperate Disturbance (NTD). It was not very dark at the time (Fig.1), but can be identified as a large wave-like feature protruding from NTBn at L2=188, L3=197 (Fig.2), seen near the limb (Fig.4, bottom left).
The NTB proper is very pale although still highly textured.

Equatorial Region

As described above and shown in Figure 2, the whole of the sub-spacecraft track was imaged from various oblique angles, even the EZ, although when passing over the equator, JunoCam could only view the horizon -- which it did in every direction (Figure 5). Given the large slant range, limited detail is visible, although images 27-33 do show traces of previously observed varieties of cloud and wave patterns in the EZ.

South Equatorial Belt (SEB)

The images show several interesting features in the SEB (Fig.6A&B):

1) The SEB(N) – specifically, some of the dark streaks that constitute it – has a relatively greenish tint that has also been noticed by ground-based observers. This may actually be grey, but contrasting with the dark bluish streaks in EZ(S) and the reddish SEB.

2) In the chain of variously-shaped light spots between the SEB(N) and SEB(C) components, one especially bright white spot is clearly anticyclonic, despite being in a cyclonic belt!

3) A large 'white barge' – one of two that we have been tracking in ground-based images – is seen close up. It clearly shows a cyclonic circulation pattern at the p. end, though not at the f. end.

4) The SEBs edge is obviously undulating, deformed almost continuously by wave-trains with wavelengths 4.2° to 4.5° longitude (5000-5300 km). These appear to be the same type of waves that we have reported from ground-based observations in recent years; they are waves in the retrograde jet, with phase speeds less than the jet speed. Images 36-38 are the best views ever obtained. The streaks aligned with the waves support our conclusion that the jet itself is undulating.

5) Just south of the SEBs edge, we can see two of the retrograding rings (SEBs jet spots) and the ring in the STropZ; all are anticyclonic vortices that have been tracked in ground-based data.

S. Temperate (S1) domain

The whole of the STB Spectre is imaged; it is now 120° long! (Figures 2 & 6B) – confirming that it has elongated rapidly throughout 2019, even though the p. end has rarely been distinct. The p. end is here seen alongside the anticyclonic dark ring in the STZ; the ground-based data [see our forthcoming 2019 Report no.8] suggests that they have been together since late July, still approaching oval BA.

High southern domains

The images of the souther hemisphere have lower resolution than they did earlier in the mission, because of the northward drift of perijove, but they are still very impressive. Major features are labelled in Figure 2. The polar region, with polar projection and methane-band maps, will be presented in Part II.

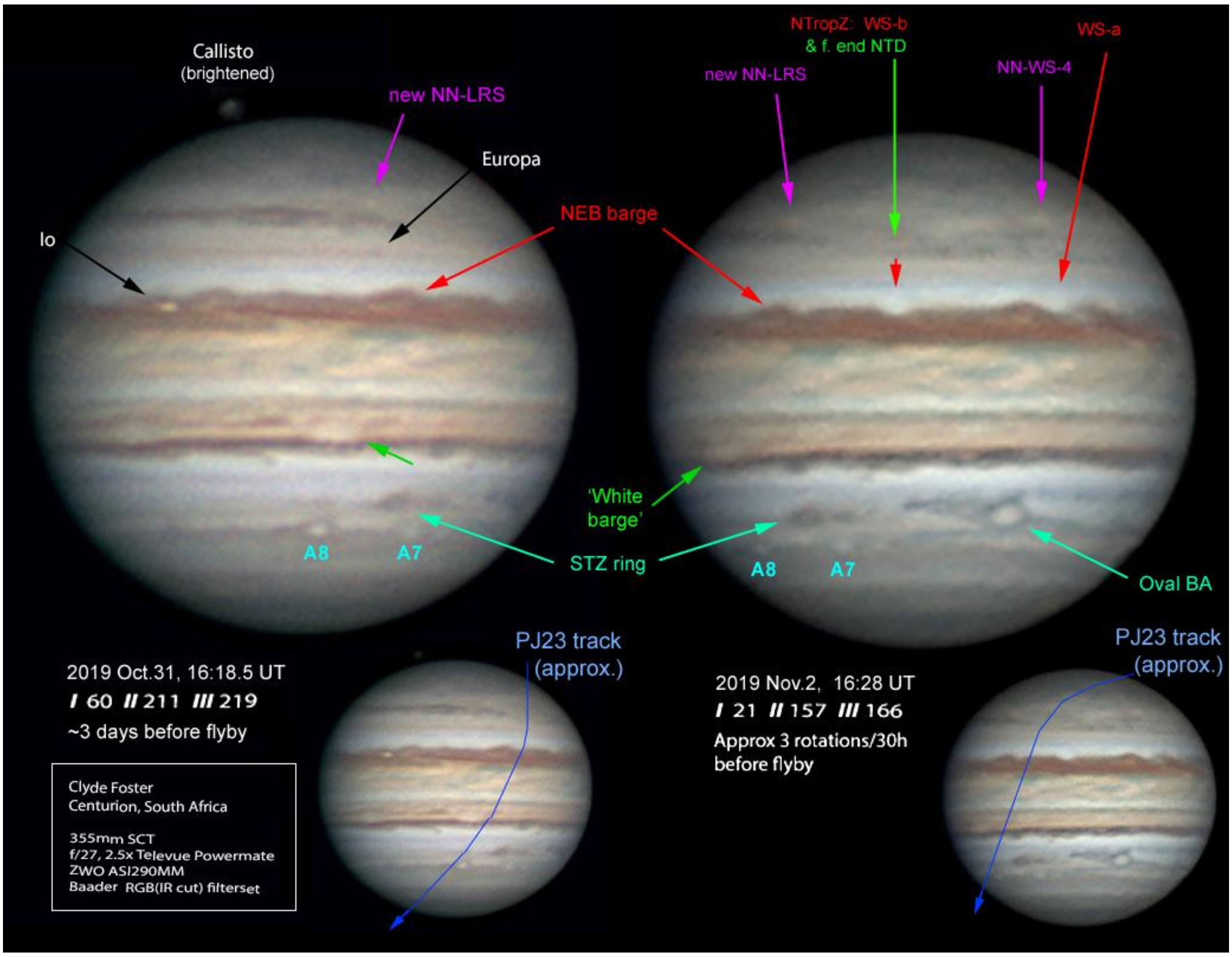


Figure 1. Ground-based images by Clyde Foster in S. Africa, ~3 days and 3 hours before the flyby. On the small copies, the sub-spacecraft track has been approximately drawn in. It actually forms a complex curve on such an image, due to the reduced inclination and the rotation of the planet. Labelling by JHR. (The Oct.31 image also recorded 3 of the moons; shortly afterwards, Callisto also moved partly in front of the planet to complete a rare triple transit.)

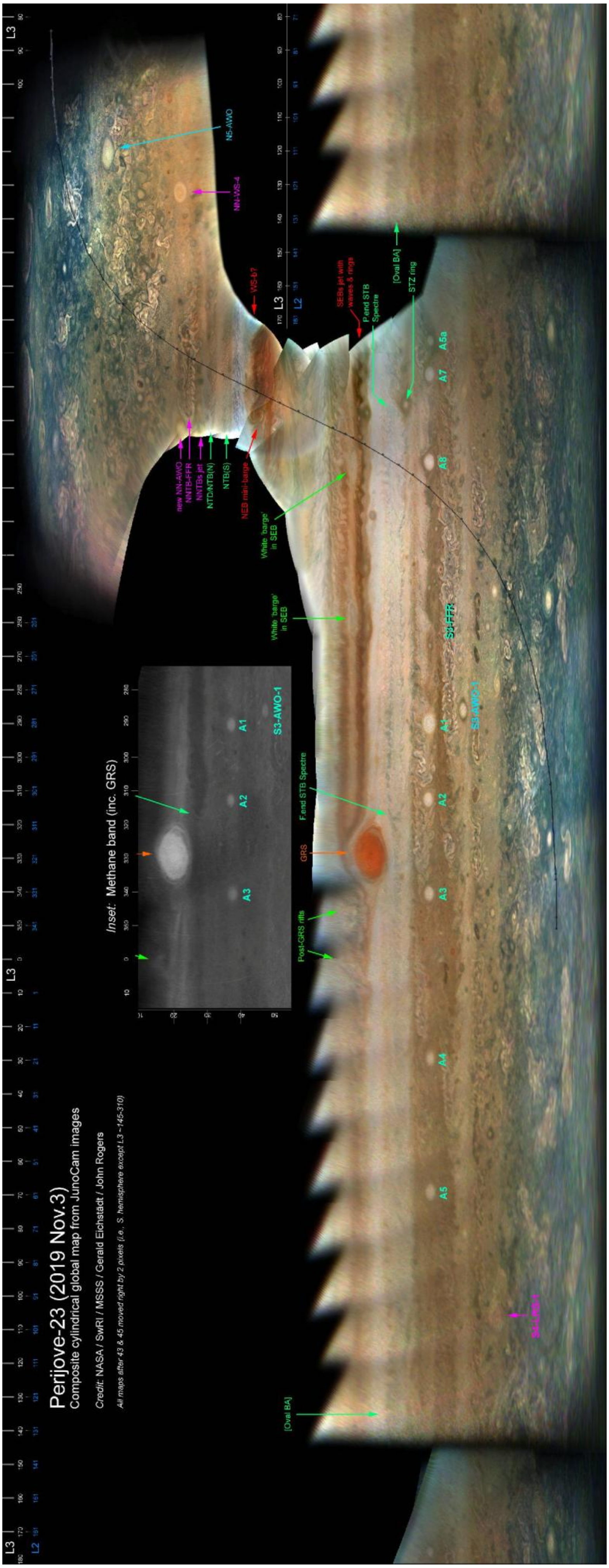


Figure 2.
Global cylindrical map, compiled from maps of individual images made by Gerald Eichstädt. The sub-spacecraft track is plotted from the actual coordinates recorded for the JunoCam images during this flyby.

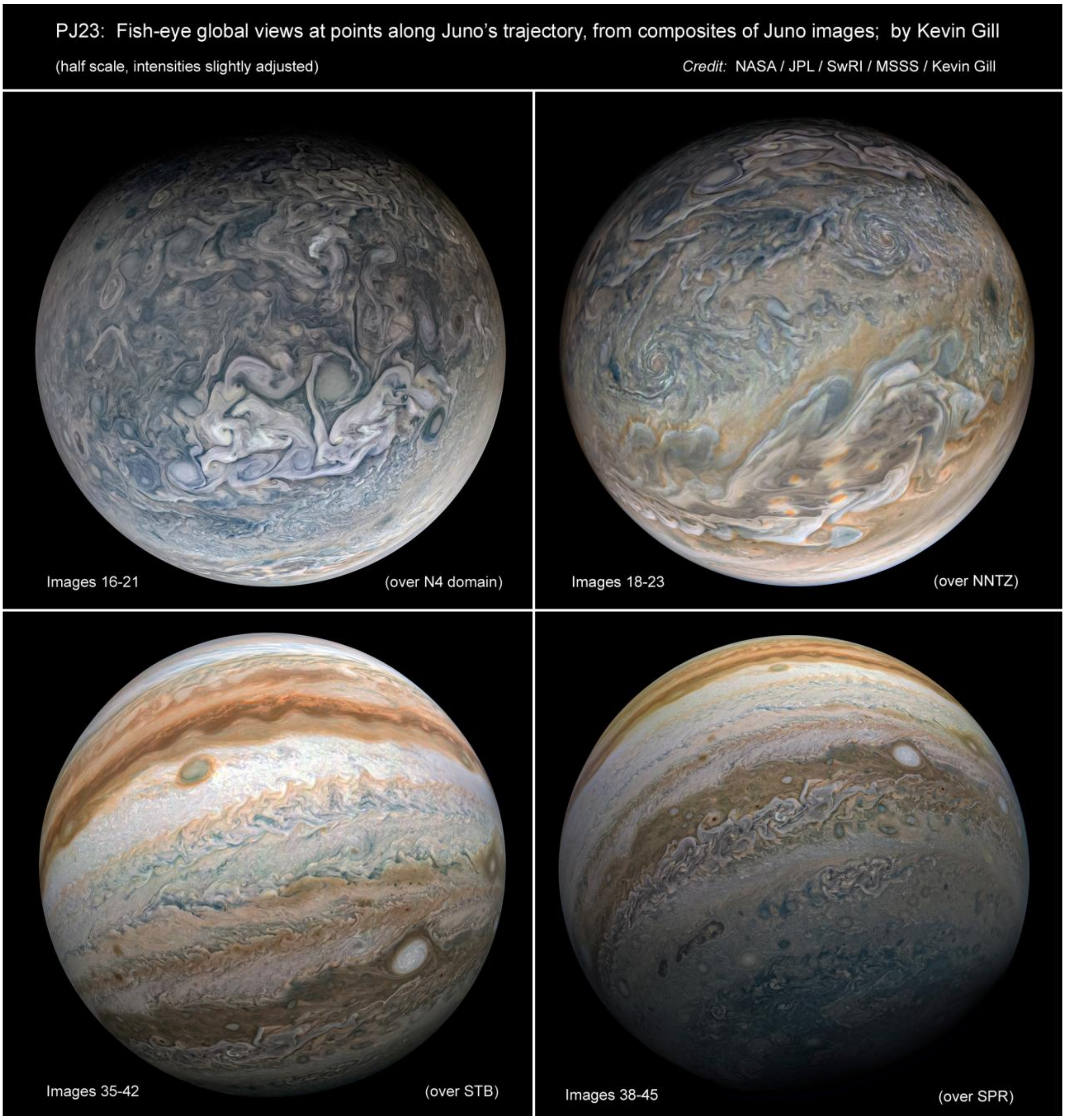
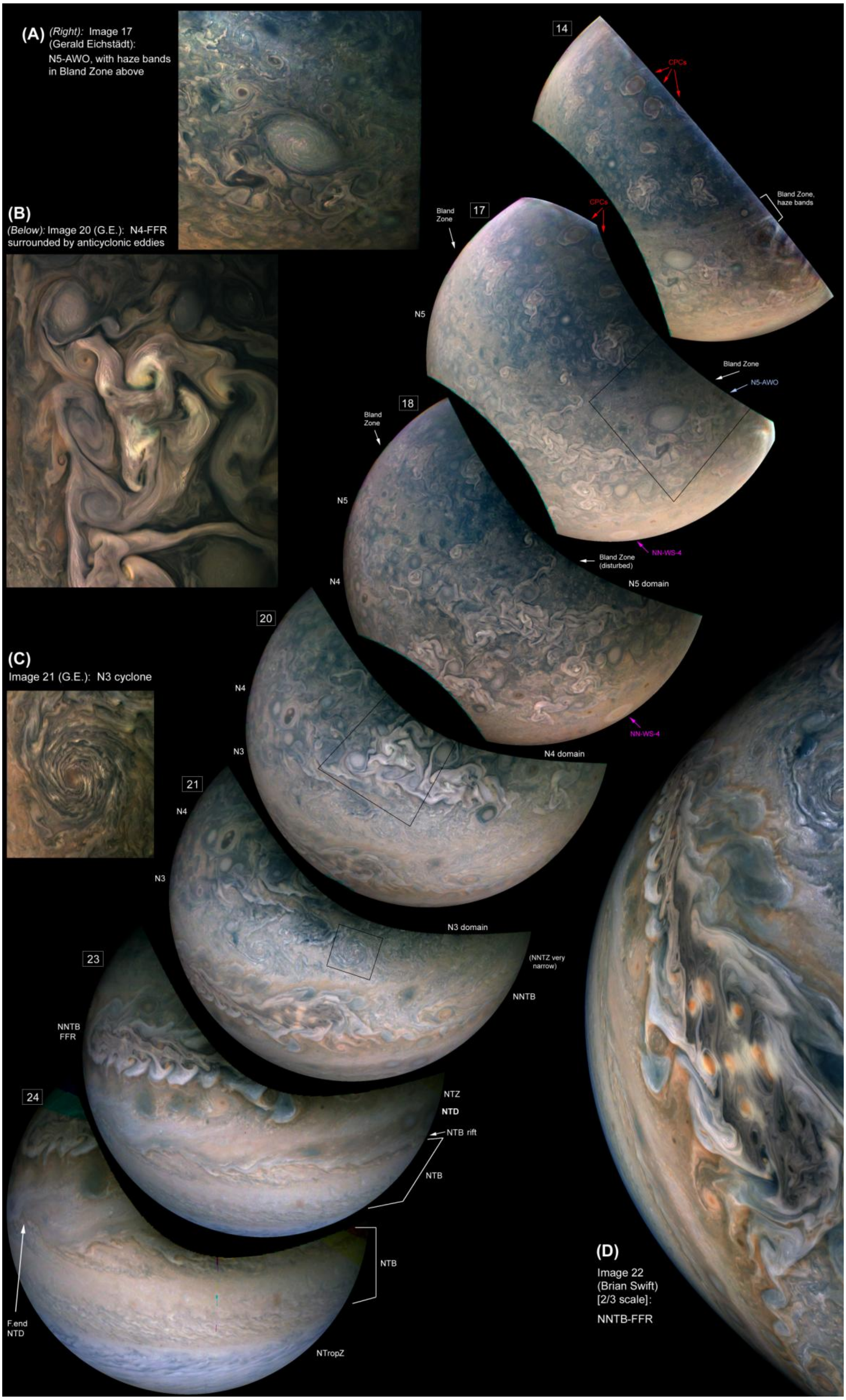


Figure 3. 'Fish-eye' views of how Jupiter would have appeared to Juno at single moments on its trajectory, compiled by Kevin Gill from his own projections of the raw images. Shown at half scale, with contrast adjusted.

Figure 4 ***[next page].*** Images from NPR to NTB. The main series of images are the 'v01' index images posted by the JunoCam team, labelled. North is up. At top left, insets (A-C) are excerpts from full-scale images processed by Gerald Eichstädt. At bottom right, inset (D) is image 22 processed by Brian Swift, from the JunoCam web site. In (A-D), north is to top right. Contrast has been adjusted in all images.


(A) (Right): Image 17
(Gerald Eichstädt):
N5-AWO, with haze bands
in Bland Zone above
(B)
(Below): Image 20 (G.E.): N4-FFR
surrounded by anticyclonic eddies
(C)
Image 21 (G.E.): N3 cyclone
14
CPCs
Bland Zone,
haze bands
17
Bland
Zone
CPCs
N5
Bland Zone
N5-AWO
18
Bland
Zone
N5
NN-WS-4
Bland Zone
(disturbed)
N5 domain
N4
20
N4
NN-WS-4
N3
N4 domain
21
N4
N3
N3 domain
(NNTZ very
narrow)
NNTB
23
NNTB
FFR
24
NTZ
NTD
NTB rift
NTB
NTB
F.end
NTD
NTropZ
(D)
Image 22
(Brian Swift)
[2/3 scale]:
NNTB-FFR

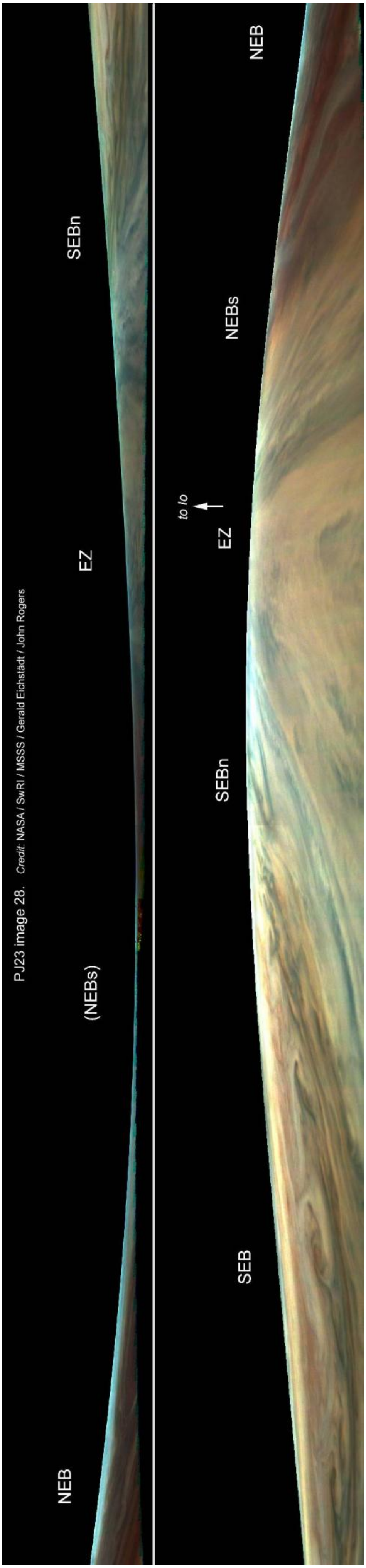
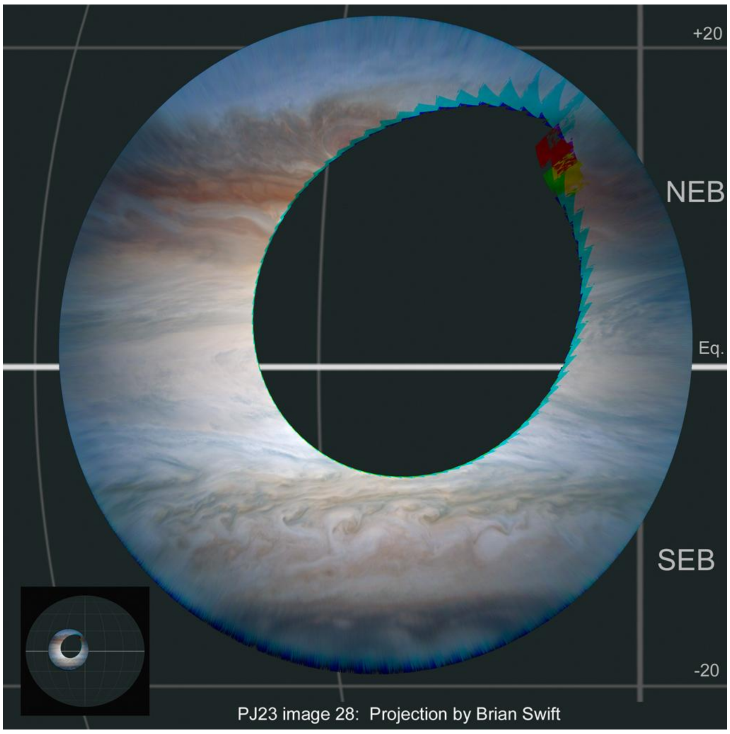


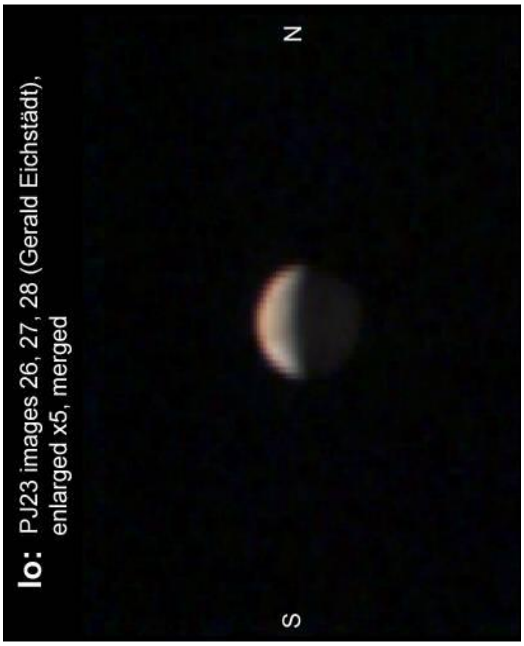
Figure 5: Image 28, taken over a complete 30-second rotation of the spacecraft, above latitude 2°N.

(A) Actual image (in 2 sections) Gerald Eichstädt);

(B) Cylindrical map (annular!) (Brian Swift);



(C) Io.
(Io was present in all of images 26-29; this panel shows a composite from images 26-28, as processed by Gerald and stacked by JHR). The dark side is illuminated by Jupiter-shine, but no volcanic plumes are visible.



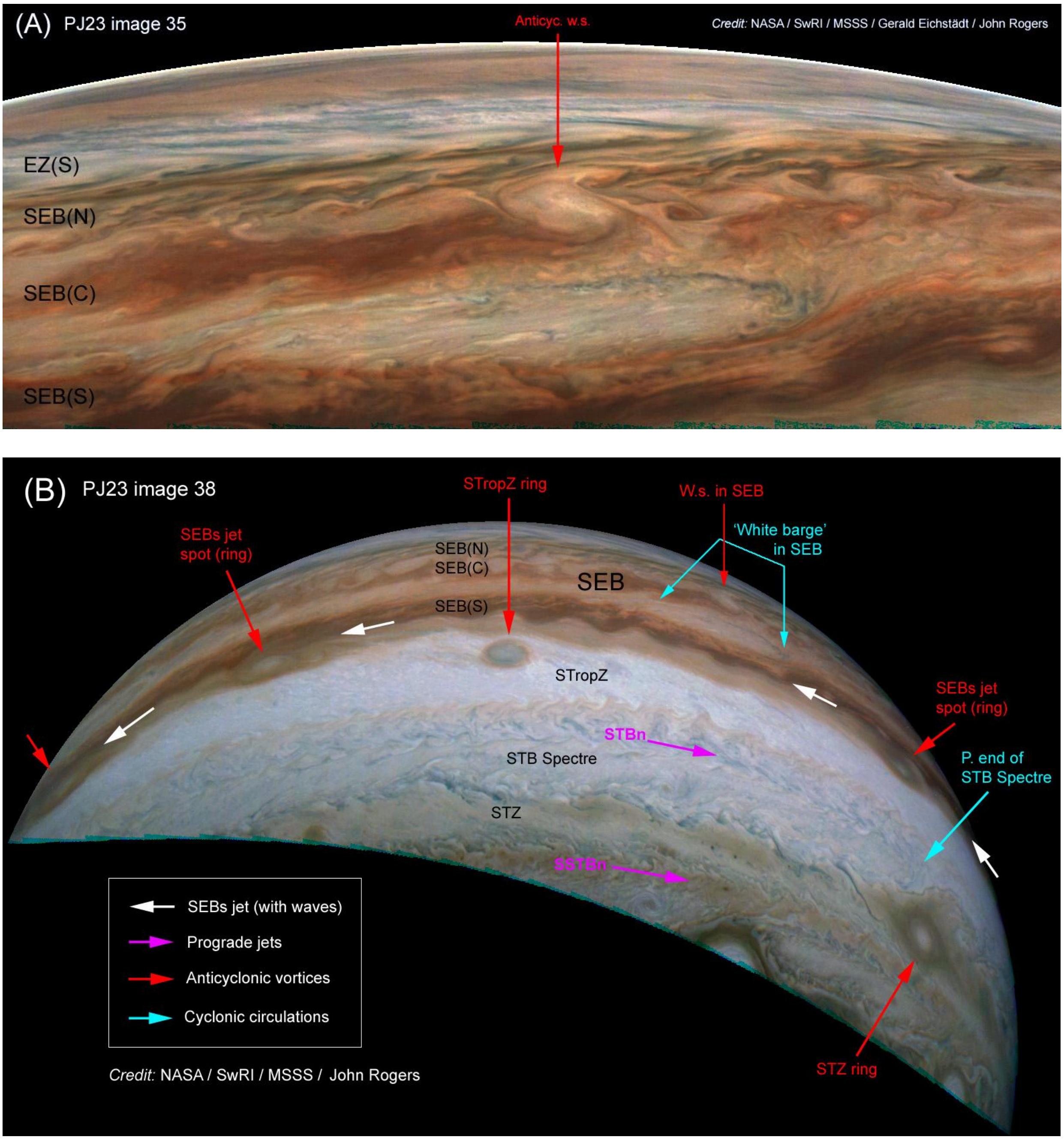


Figure 6. Features of the SEB etc. (A) Image 35, processed by Gerald; the 'white barge' is in the lower half, and ~1½ of the SEBs waves are visible at bottom right. (B) Image 38, with features labelled.