Juno at Perijove-15 (2018 Sep.7): What the pictures show

--John Rogers

Perijove-15 (PJ15) was on 2018 Sep.7, with equator crossing at 01:14 (UT at spacecraft) over L1 = 335, L2 = 88, L3 = 344.5.
Seen from Earth, Jupiter's apparition is drawing to a close, so the only good images of the track were those in Figure 1 taken a few days before perijove by Clyde Foster (S. Africa) and Andy Casely (Australia). A map of the whole planet from their images on Sep.4-5 is in Figure 2.
For background information, please see our 2018 reports, esp. no.6 (https://www.britastro.org/node/12200).

As usual, this report will be illustrated with some JunoCam images in the preliminary versions released by the JunoCam (MSSS) team, and some in the full-res versions and maps produced by Gerald Eichstädt. There is now a third way of viewing all the images, projected onto a 3D globe of the planet: the Juno Observer system, created by Matt Brealey. This excellent and easy-to-use tool is at: https://juno.observer/
Figure 3 shows a few of the PJ15 images projected in Juno Observer (they can also be enlarged and rotated to any viewpoint). These show clearly how the JunoCam field of view is constrained now on the routine 'Gravity' orbits, i.e. most perijoves from PJ10 onwards including PJ15. Nothing is seen until the spacecraft passes over the north pole, which appears in a narrow strip; descending to lower latitudes, the view becomes broader but oblique, looking to the midday horizon; then the spacecraft rises higher again towards the south pole and gets good views of the southern hemisphere as it recedes.

North polar region:
Figure 4 shows the circumpolar cyclones. Strangely, there appear to be five of them strung out along the terminator! Those marked 4, 5, 6 are in their usual positions in the octagon (ditetragon), but no.7 has moved to progressively lower latitude this year; has it been ejected from the octagon? The cyclone marked X does not belong to the octagon. Also on this map, bright and dark bands of haze are evident running obliquely across the terminator.
As the north polar images are now narrow slivers, Figure 5 shows composite maps made from Gerald's projections of multiple images, in colour and in the methane band.
There is a nice series of closeups of the 'bland zone' (~60-64ºN), shown in Figure 6. In some panels, labels indicate whether vortices are cyclonic (C) or anticyclonic (A). As is often the case, there is a close pair of anticyclonic white ovals (AWOs) of the N5 domain on the south edge of the bland zone. But smaller ovals are more scattered, including an adjacent cyclonic/anticyclonic pair which must constitute a distortion or interruption in the N6 jet at this latitude. This pair is shown at full resolution in the first panel in Figure 7.

High northern domains:
Small, well-defined cyclones are sometimes seen in JunoCam images of the N3 to N6 domains, and Figure 7 shows five particularly nice ones. They typically have an orange central region, which often appears to be at a lower level than the surroundings, and the tightly wound spiral arms give a clear impression of a 3D vortex (reminiscent of water going down a plug-hole). The smallest of these five cyclones is partly overridden by a much larger AWO.

The major domains:
NNTB (Figure 8 & inset): The images captured a very dark brown belt segment which appears just like a barge, evidently a cyclonic circulation. Its brown depths are all diffuse. By contrast,

it is embedded in a FFR, whose bright streaks are well-defined and carry ‘squall lines’ of popup clouds.

NTB (Figure 8 & inset): The NTB now consists of well-separated N and S components, both pale orange. The NTB(N) is very pale with a largely featureless surface. By contrast, small cyclones N and S of it are well defined, and the NTB(S) again carries some popup clouds.

NEB (Figure 9 & inset): As usual, the NEB has impressive large-scale texture but is diffuse at the smallest scale – except for a bright anticyclonic eddy on its N edge which has popup clouds and mesoscale waves in its spiral arms (see inset). (Similar mesoscale waves were imaged in satellite views of the spiral arms of Earth’s recent Hurricane Florence and Typhoon Mangkhut.)

EZ/EB (Figure 9): In the EZ(N), the images show probably the largest NEBs dark formation (‘hot spot’) yet imaged by Juno, though it is near the limb.
The orange-and-grey Equatorial Band now spans a large fraction of the Equatorial Zone. It only shows mesoscale waves in a restricted band of brighter cloud streaks within it (image 29).

The EZ(N) and SEBn show unusually conspicuous and colourful features that look like a South Equatorial Disturbance (SED). (This is puzzling as I had just reviewed the ground-based data up to August and decided that, in spite of velocity patterns suggestive of a SED, no SED could be seen [Report no.6].)
Hi-res image 30 (inset in Figure 9) also shows a scattering of numerous small, crisp white clouds on the p. side of the ‘SED’, which do not look like popup clouds (albeit they are viewed under high sun). The more northerly ones show influences of mesoscale waves, and there are also much fainter mesoscale waves to the north on the edge of the EB. But the more southerly white clouds look different and seem to confirm the reality of a strange feature seen on Voyager image C1638035, in exactly the same latitude: see Björn Jonsson’s post at:
http://www.unmannedspaceflight.com/index.php?showtopic=6705&st=30&p=163825&#entry163825

SEB (Figure 9 & inset): The mid-SEB is pale, but still shows fantastical swirling cloud patterns. The most obvious feature in southern SEB is a barge (one of three that now exist). Its cyclonic circulation is evident, and there are mesoscale waves along a white cloud band on the southern edge of the barge (again, reminiscent of those terrestrial cyclones).
The S. Tropical Zone is full of popup clouds.

STB Spectre (Figure 10): Images 33-39 comprise an excellent set of views of the STB Spectre, confirming that this large cyclonic circulation has survived its involvement with the S. Tropical Disturbance (it has been hard to define in ground-based images for most of 2018). It is much longer than it was before, but just as well-defined, and these images will enable animation and wind speed measurements. Vortices visible to its south suggest that a recirculation loop is again present there, although we have not had the opportunity to track anything there recently.

S. Temperate domain in outbound images:
Juno gets a prolonged view of the southern hemisphere outbound, sufficient to create a global map of it (Figure 11), which shows features that are no longer resolvable from Earth.
The S. Tropical Disturbance has now disappeared except for the last trace of its f. end, visible as a slight bulge on STBn at L3 = 118.
The map shows oval BA and the dark turbulent STB segment f. it, and the dark sector of STZ f. it, which is now very long and includes two small AWOs.
The sector tens of degrees p. oval BA is of interest because I am expecting a new structured sector to arise there, typically in the form of a cyclonic circulation. A small eddy noted at PJ11

could not be tracked further. However, ground-based images revealed some spots and streaks in southern STZ/SSTBn in this sector from April onwards (see our 2018 Report no.6), and similar anomalous features can be seen in the P15 images (Figure 12), so this region – now passing the GRS -- deserves monitoring.

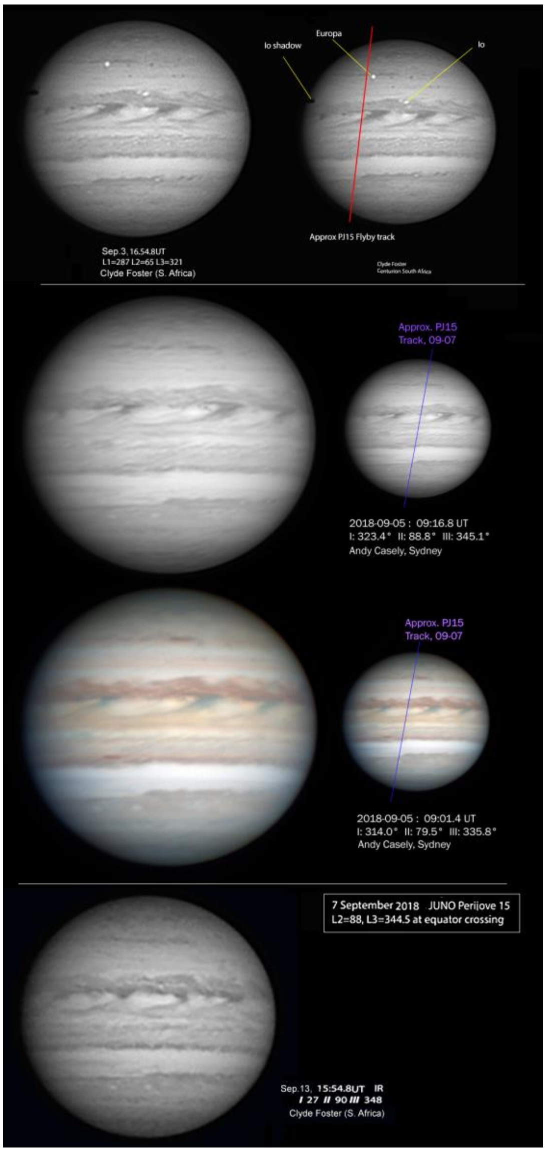
S4 domain in outbound images:
There was great interest in the convergence of two ovals, LRS-1 and AWO-2. They were tracked particularly by Andy Casely and Clyde Foster, and Casely's chart of them is shown in Figure 13. They were converging so rapidly that it seemed likely that they would be merging at the time of PJ15. However, in the few days leading up to PJ15 they suddenly stopped converging and rebounded without merging.
At PJ15 they came across the dawn terminator shortly after south pole crossing, as expected, so they were well imaged (Figure 12). They were visibly interacting and still had almost minimum separation, which was less than the radius of either.
I suspect the reason they did not merge is that the adjacent large FFR confined them in latitude so they could not swing round each other. In contrast, when AWO-2 was imaged at PJ11 just after it apparently merged with AWO-3, there was no FFR alongside it. I suspect that many of the speed changes shown by AWOs in the high-latitude domains are due to interactions with FFRs which often cannot be resolved by amateur images: specifically, that high-latitude AWOs naturally drift fast, but can be blocked by encounters with slow-moving FFRs [see our recent long-term report on the N3-N6 domains, https://www.britastro.org/node/11328]. This encounter may have been a variation on this theme.
Figure 15 (posted as a separate GIF file) is an animation of 2 images of these two ovals as reprojected by Gerald. It shows the internal rotation of S4-LRS-1, and of FFRs in various latitudes, and the motion of the S4 and S6 jets nearby.
In the methane band (image 66, not shown here), it is again notable that LRS-1 is methane-bright while AWO-2 is barely detectable.

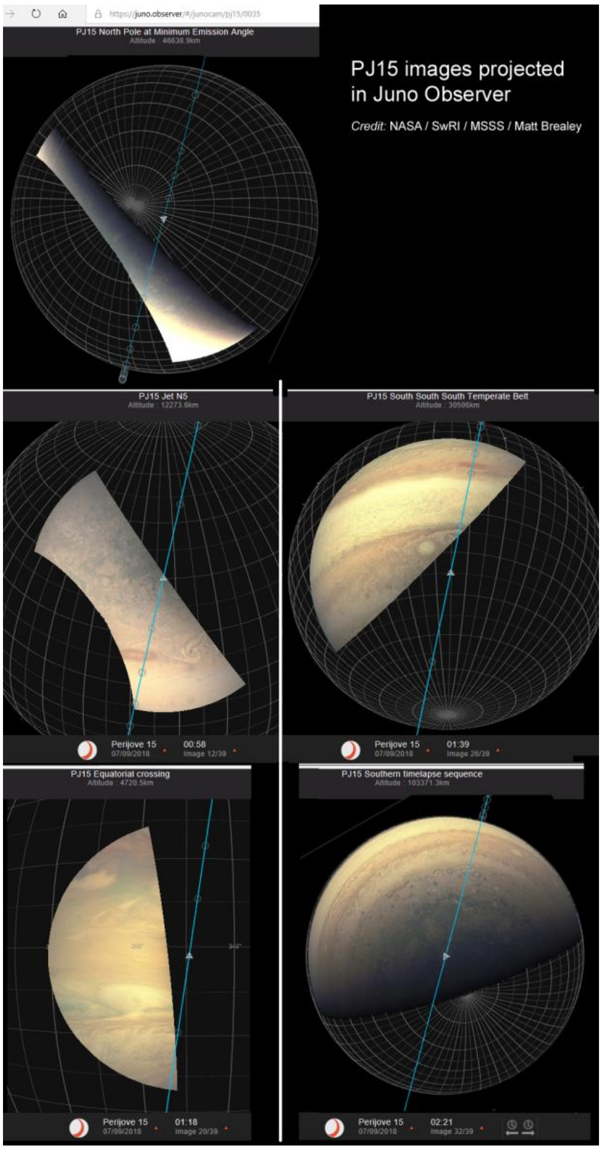
South polar region:
Figure 14 shows a colour and a methane image taken close to the time of south pole crossing, with the now-familiar features of the south polar region. South polar projection maps (in preparation) show that the complete pentagon of cyclones is still present, with little if any gap, but that the long band of haze, which lay alongside the pentagon from PJ5 to PJ12, is still absent, whereas there are multiple bands of haze at lower latitudes (some visible in Figure 14 near the terminator).

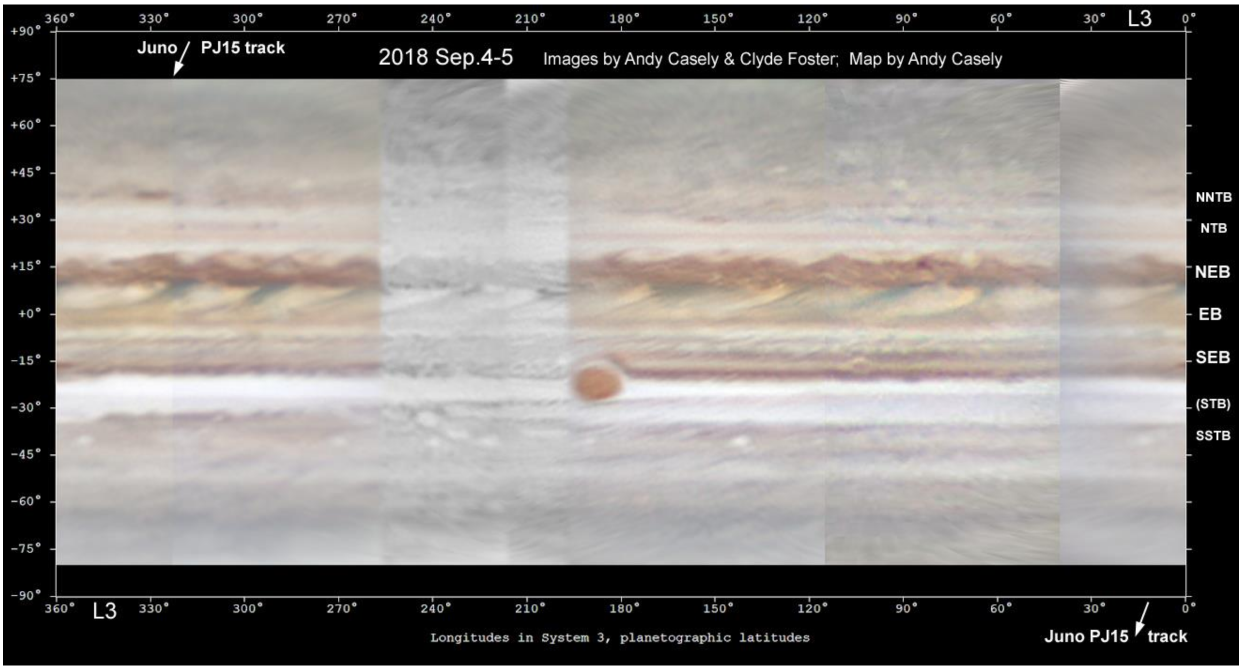
Figures

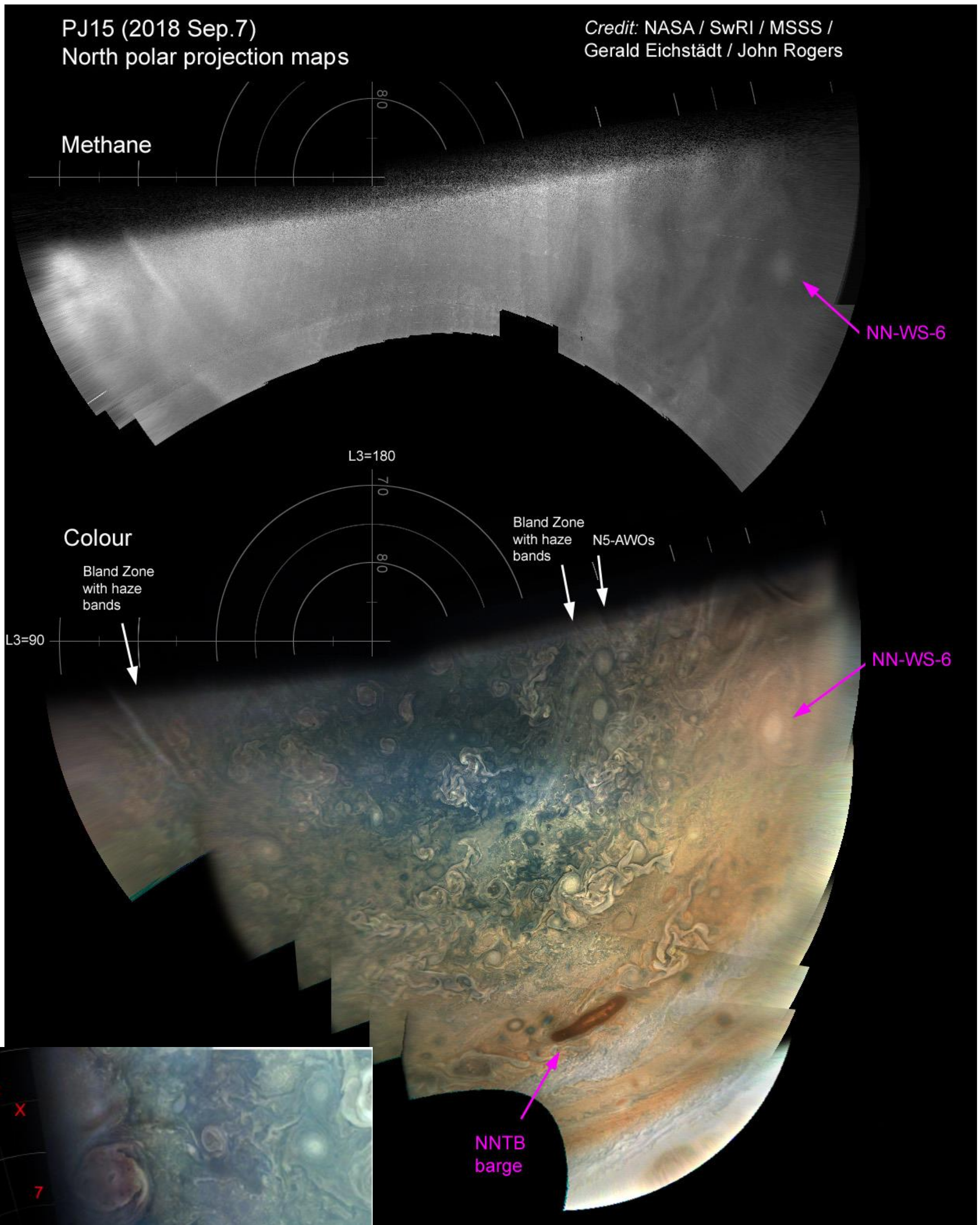
(miniature copies: full-size versions are in ZIP file)

Next page: **Figures 1-3**


Io shadow
Europa
Io
Sep.3. 16.54.8UT
L1=287 L2=65 L3=321
Clyde Foster (S. Africa)
Approx PJ15 Flyby track
Approx. PJ15
Track, 09-07
2018-09-05 : 09:16.8 UT
I: 323.4° II: 88.8° III: 345.1°
Andy Casely, Sydney
Approx. PJ15
Track, 09-07
2018-09-05 : 09:01.4 UT
I: 314.0° II: 79.5° III: 335.8°
Andy Casely, Sydney
7 September 2018 JUNO Perijove 15
L2=88, L3=344.5 at equator crossing
Sep.13, 15:54.8UT IR
I 27 II 90 III 348
Clyde Foster (S. Africa)


PJ15 images projected
in Juno Observer
Credit: NASA / SwRI / MSSS / Matt Brealey
PJ15 North Pole at Minimum Emission Angle
PJ15 Jet N5
PJ15 South South South Temperate Belt
Perijove 15
PJ15 Equatorial crossing
PJ15 Southern timelapse sequence
Perijove 15


Juno PJ15 track
2018 Sep.4-5
Images by Andy Casely & Clyde Foster; Map by Andy Casely
L3
360° 330° 300° 270° 240° 210° 180° 150° 120° 90° 60° 30° 0°
+90° +75° +60° +45° +30° +15° +0° -15° -30° -45° -60° -75° -90°
NNTB
NTB
NEB
EB
SEB
(STB)
SSTB
Longitudes in System 3, planetographic latitudes
Juno PJ15 track



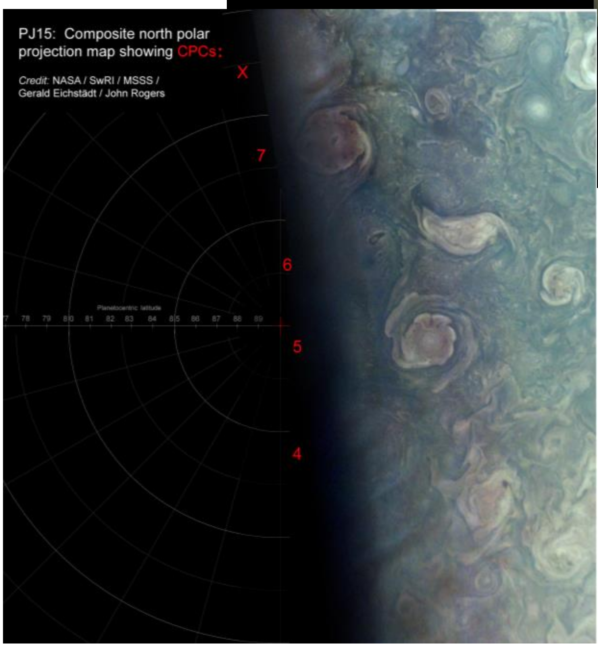


Figure 4 (left). **Figure 5 (above).**

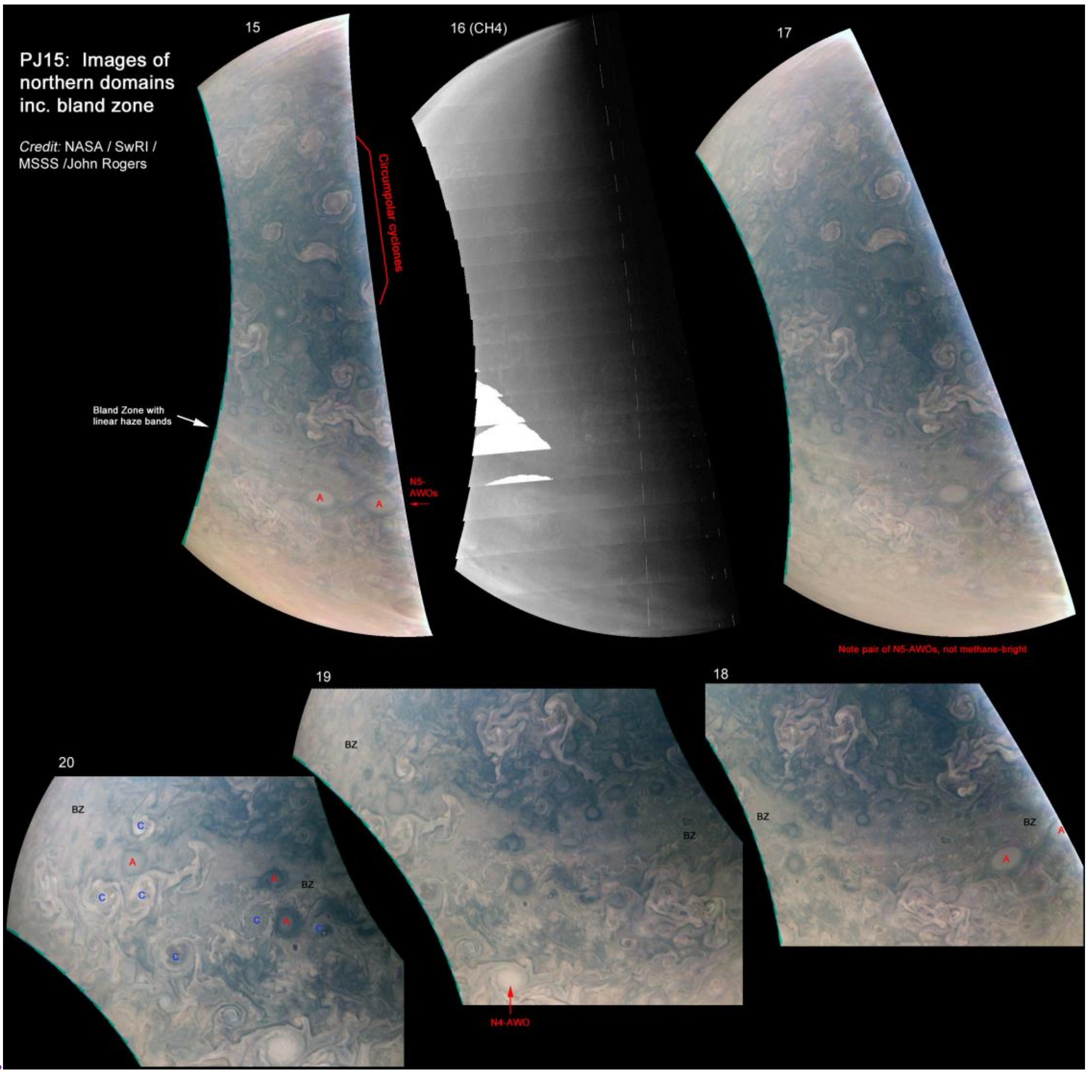

PJ15: Images of northern domains inc. bland zone
Credit: NASA / SwRI / MSSS /John Rogers
15
16 (CH4)
17
Circumpolar cyclones
Bland Zone with linear haze bands
N5-AWOs
A
Note pair of N5-AWOs, not methane-bright
20
19
18
BZ
C
N4-AWO

Fig. 6 .

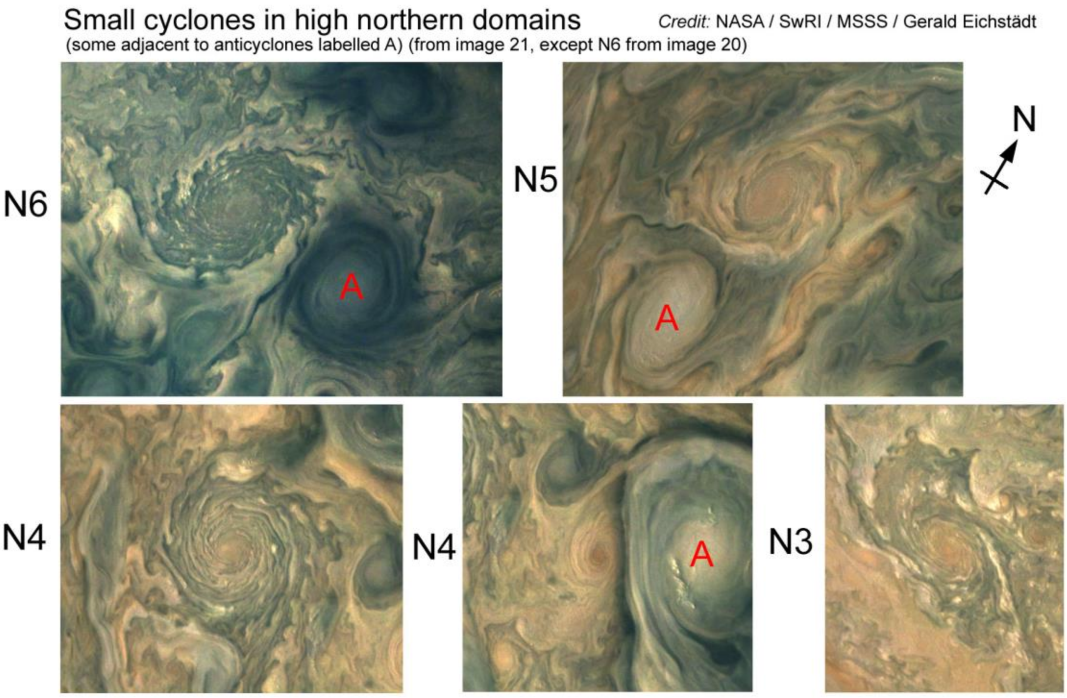

Small cyclones in high northern domains
Credit: NASA / SwRI / MSSS / Gerald Eichstädt
(some adjacent to anticyclones labelled A) (from image 21, except N6 from image 20)
N6
A
N5
A
N
N4
N4
A
N3

Fig. 7

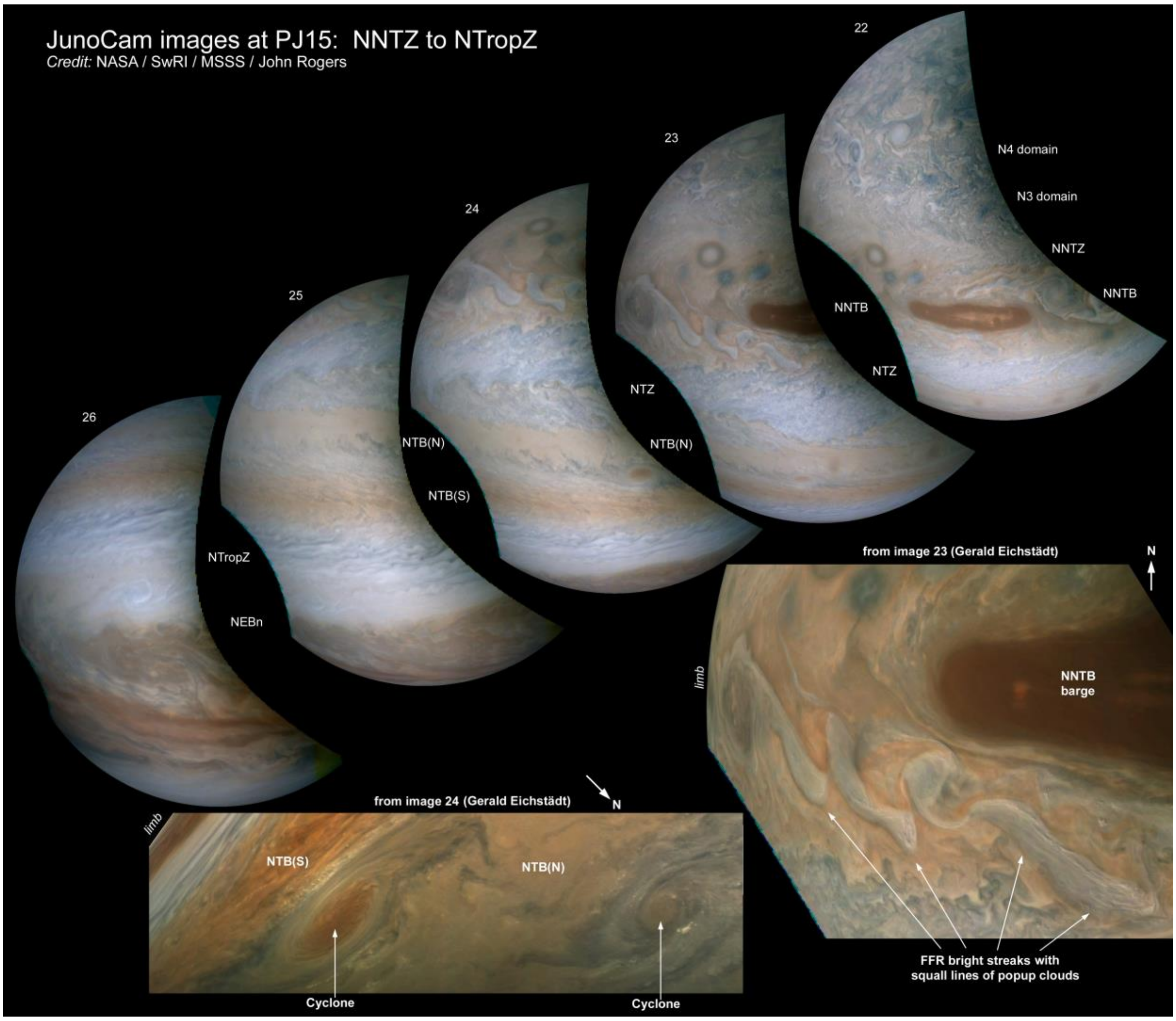
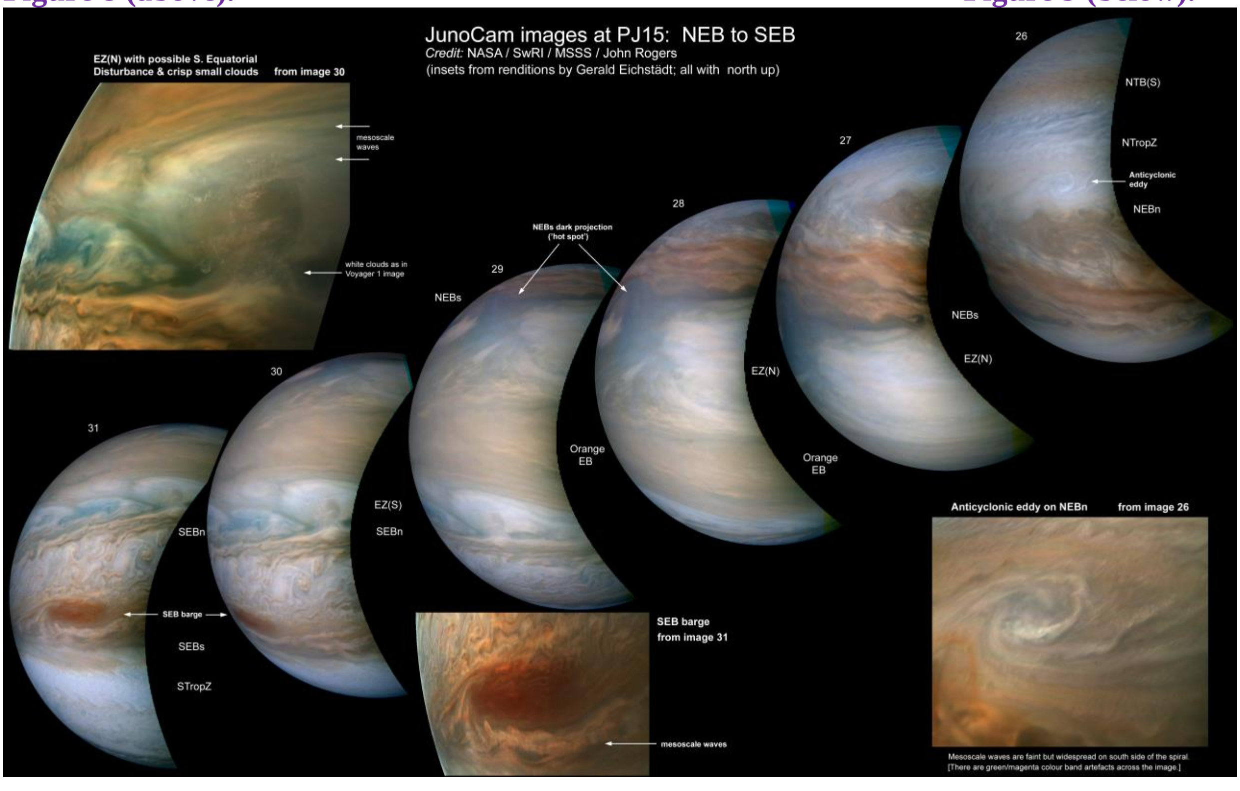


Figure 8 (above).

Figure 9 (below).



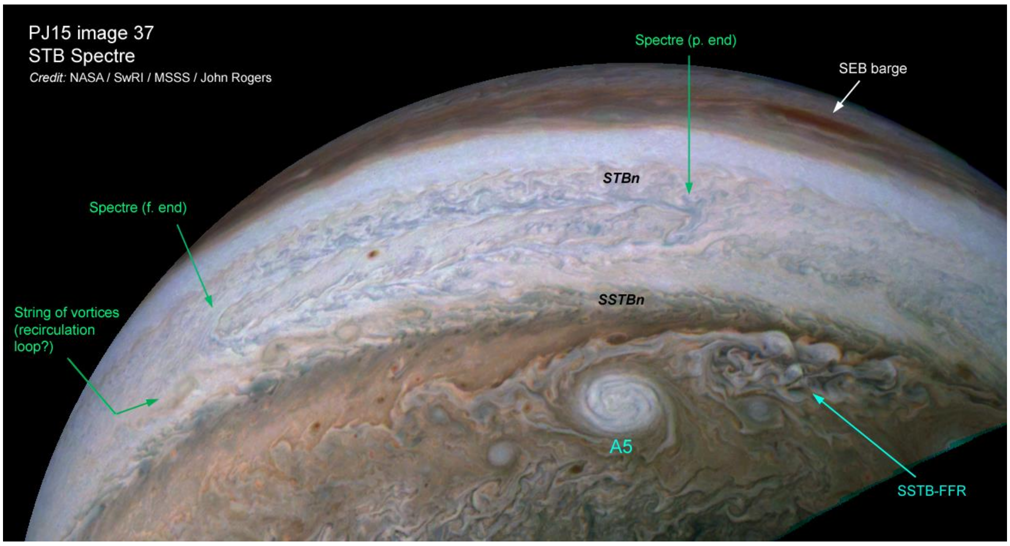


Fig.10

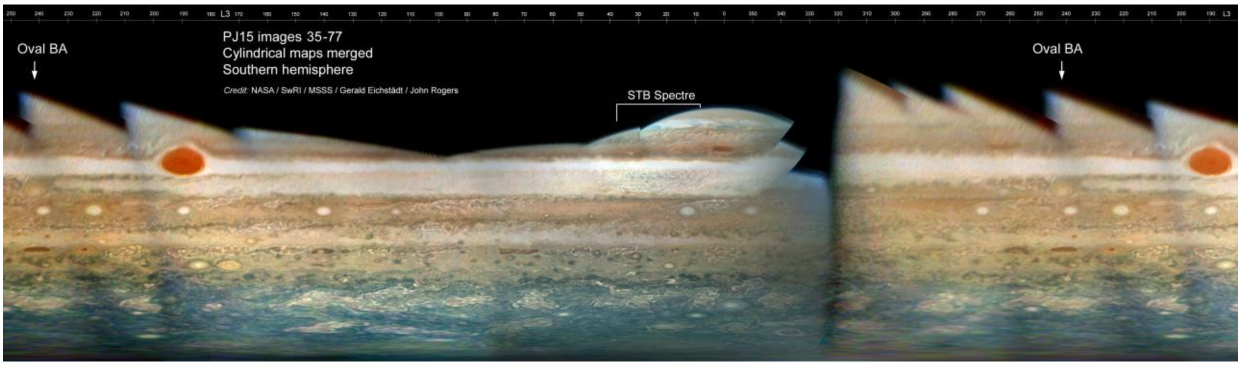
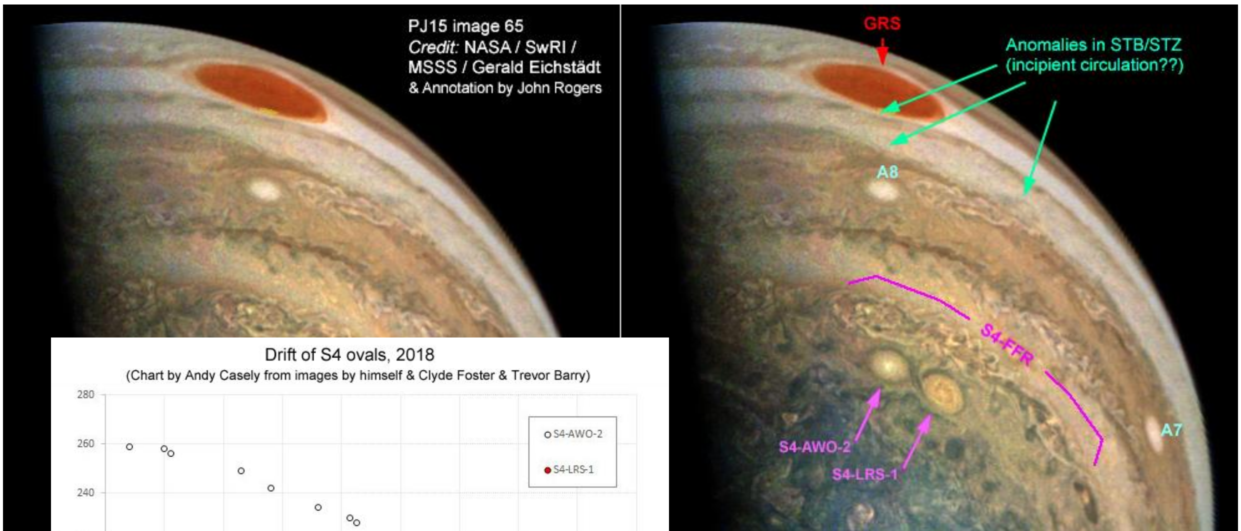


Fig.11



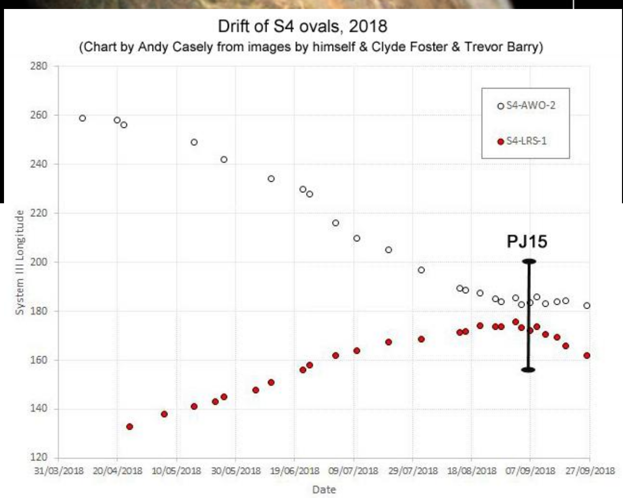


Fig.12 (above)

Fig.13 (left)

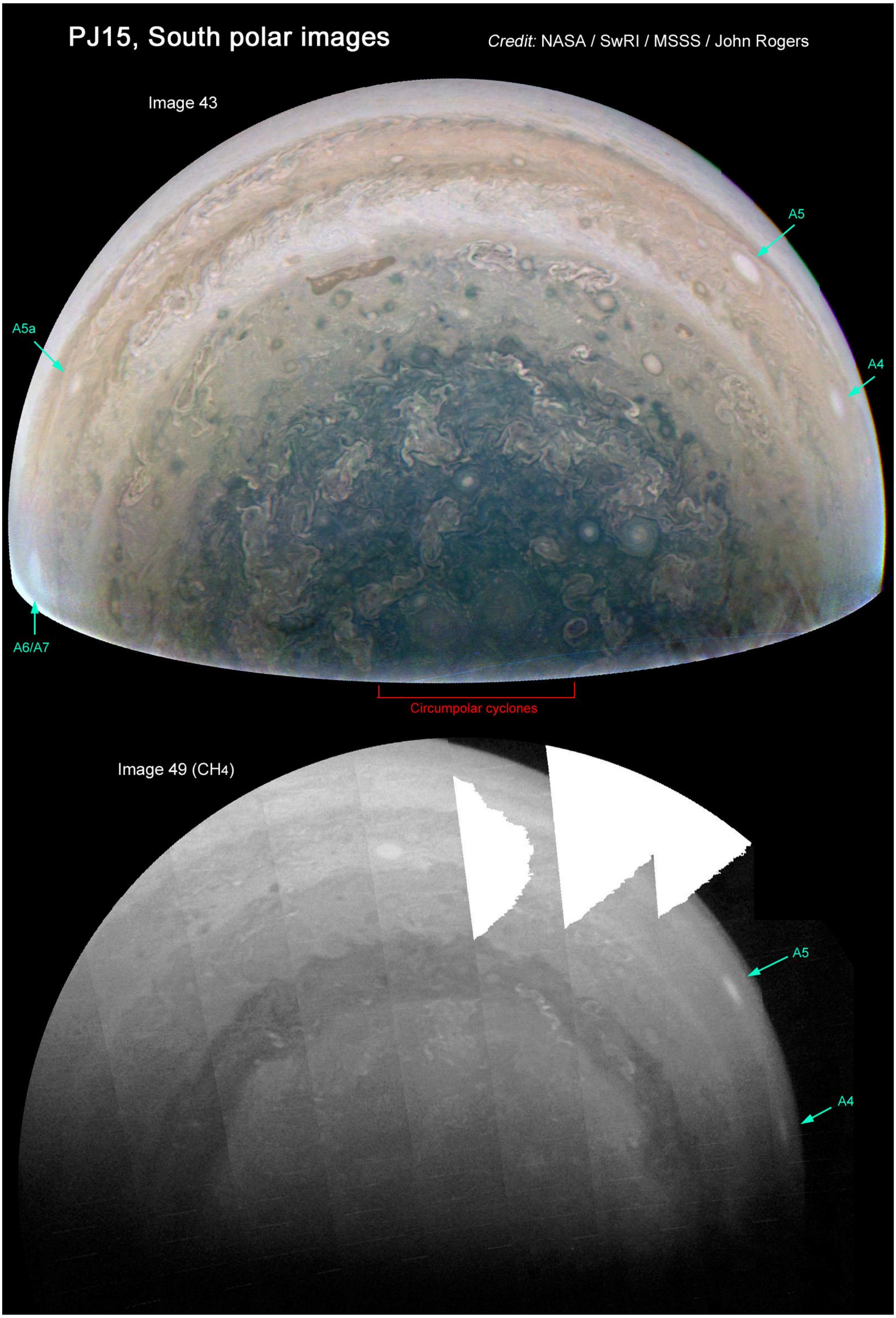

PJ15, South polar images
Credit: NASA / SwRI / MSSS / John Rogers
Image 43
A5
A5a
A4
A6/A7
Circumpolar cyclones
Image 49 (CH4)
A5
A4

Fig.14