Juno at Perijove-4 (2017 Feb.2): What the JunoCam images show

--John Rogers (British Astronomical Association), 2017 Feb.24

Full-size copies of the figures are provided in a ZIP file, along with labelled sets of the late inbound and early outbound images covering the rest of the planet.

At PJ-4, JunoCam returned 15 colour images from pole to pole, plus one methane image over each pole. The quality was similar to PJ-3. Previous perijoves revealed an issue with artefactual colour banding, but this was solved by Mike Caplinger of the Juno team and by Gerald Eichstädt; at PJ-4, each of them rapidly produced a complete image set free from this artefact, and thus much easier to work with. In this report, I use some by Mike Caplinger, which are projected to reduce foreshortening near the horizon, and some by Gerald, which have larger scale. I have applied some enhancements to the images, but better versions of interesting regions have been posted by Gerald and some others on the JunoCam web site.

Figure 1 shows an amateur image taken just before perijove, with the intended targets labelled, and a map of it, on which the 'footprints' of the images have been overlaid.

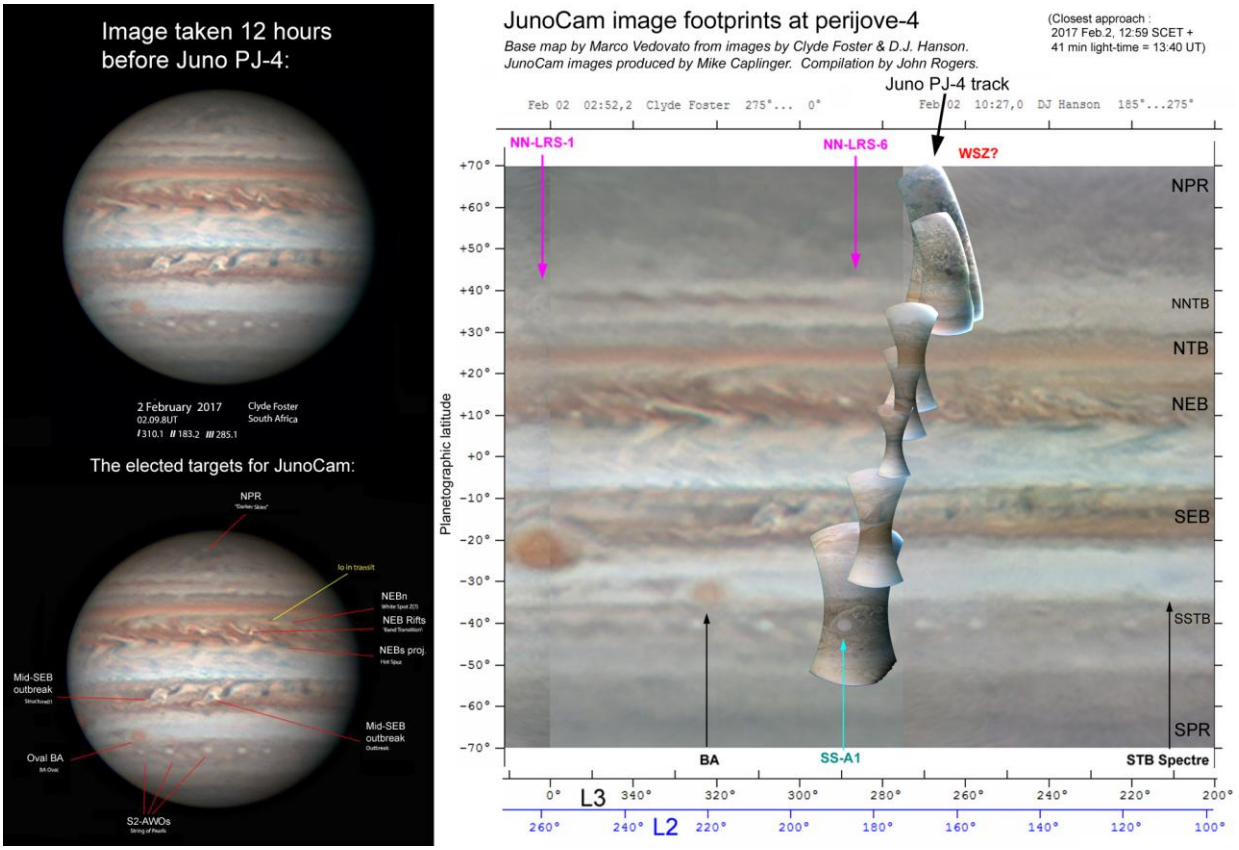


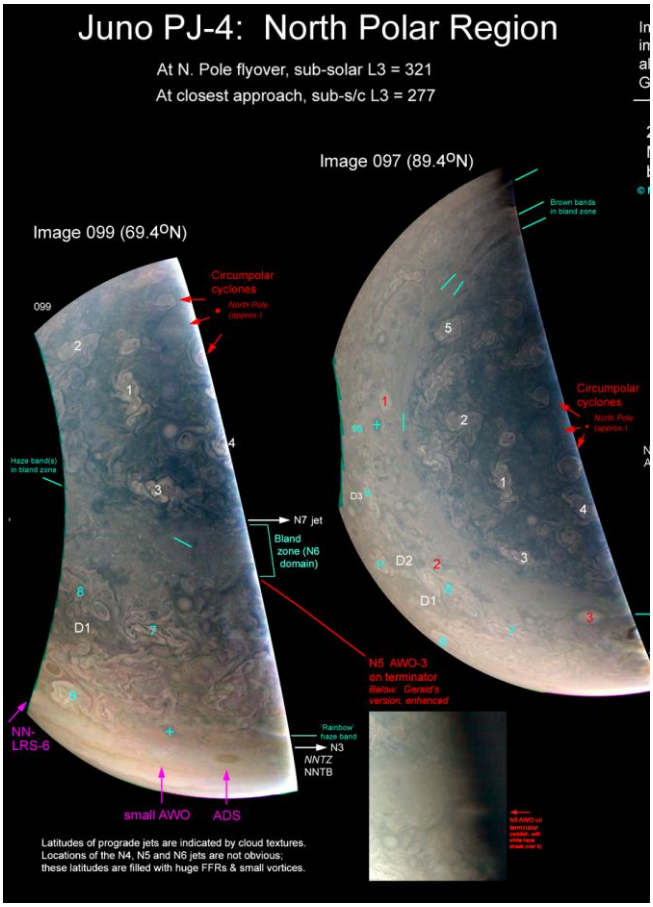
Figure 1.

North Polar Region

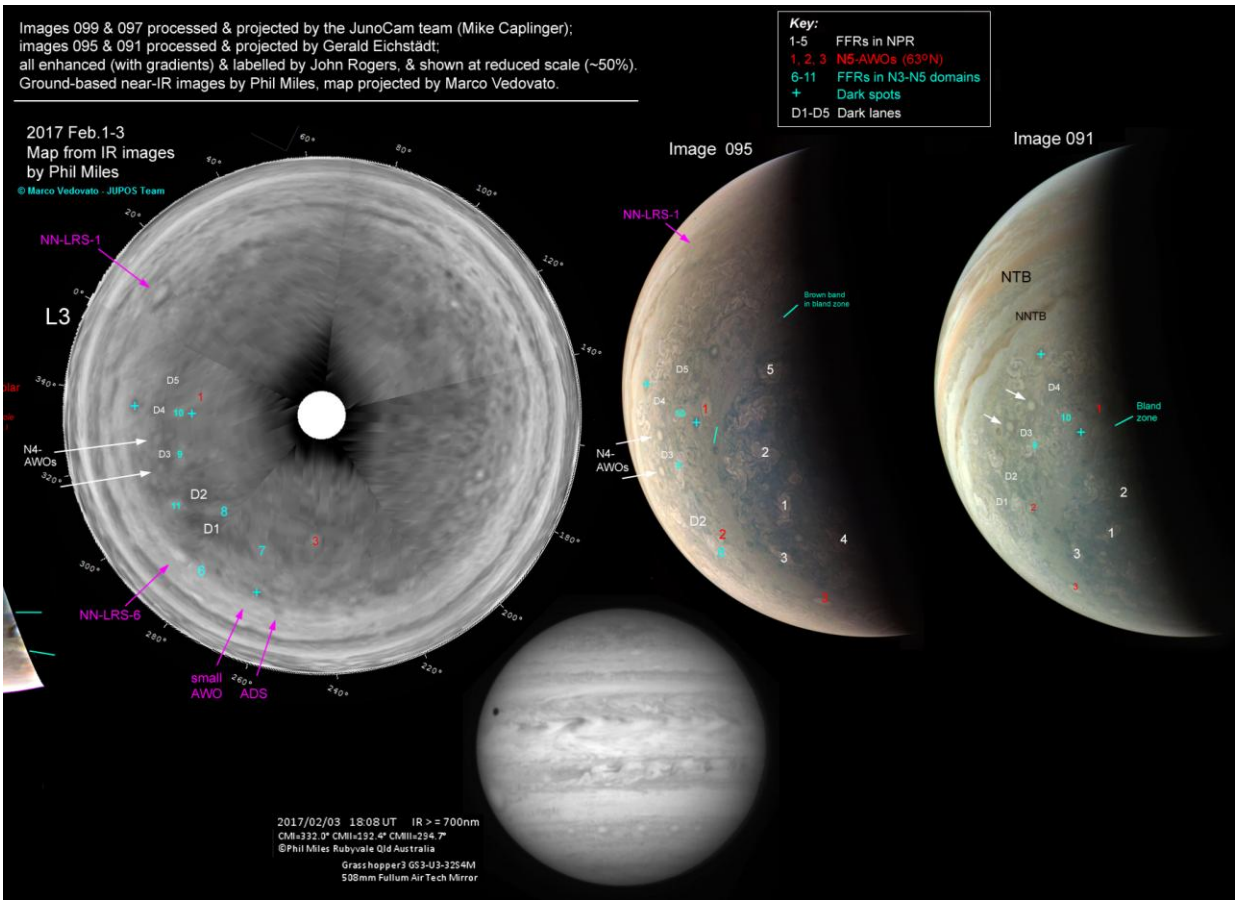
Figure 2 is a half-scale collection of images spanning the crossing of the pole. The images confirm that features discovered at previous perijoves are persistent:
--A cluster of circular spiral cyclones surrounds the pole;
--From there down to ~43ºN (the N3 jet), the north polar region is largely filled with chaotic FFRs (too chaotic for the jets to be clearly identifiable in single images), except:

--A bland zone occupies ~64-68ºN (between the N6 and N7 jets), and has one or more long narrow brown lanes within it, associated with high-level haze near the terminator;
--Narrow bands of haze, appearing white near the terminator or across it, are common over all the region.

Figure 2 is annotated to identify features seen in ground-based images of the north polar region, specifically the common dark streaks that are often seen in near-infrared images (~0.7—1.0 microns). As I previously supposed, FFRs can be identified as pale patches in the images by Phil Miles, and the IR-dark streaks (labelled D1-D5) are irregular dark spaces between them – although these spaces are not entirely calm, as there are small spots and eddies within them.



Right & below: **Figure 2.**



The long brown lanes in the bland zone again appear to be related to the high-level white bands; near the morning terminator, you can see a narrow white lane alongside a brown lane. It's clear that the brown lane is not a shadow as it is on the sunward side of the white lane. And the brown lanes are methane-dark (whereas none of the lanes are strongly methane-bright). Conversely at the evening terminator a broad white band, on the edge of the bland zone, lies directly across an AWO (at ~63ºN in the N5 domain).

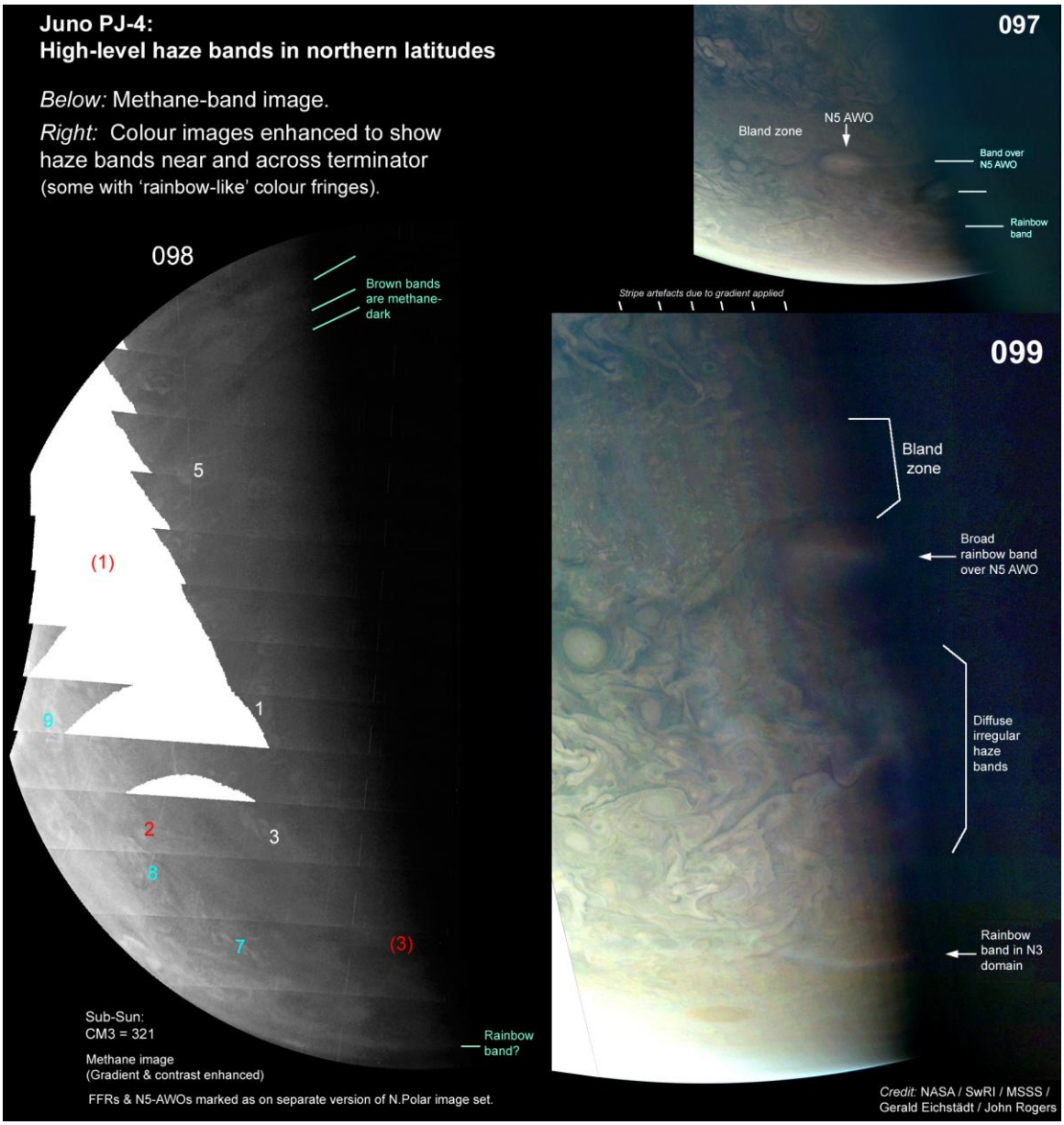


Figure 3.

Figure 3 is enhanced to display some of the high-level haze bands near and over the terminator. There is an extensive complex of them across the N3-N4-N5 domains. Most curious are 'rainbow bands' of haze. Images 097 and 099 show 3 examples, including one which lies over an anticyclonic white oval (AWO) in the N5 domain. From discussions with Gerald and with Mike Caplinger of the JunoCam team, it is still not clear if the colour fringing is real or not. Possible artefacts include scattered light in the camera, and residual colour gradients across the image strips (as seen on the dark side; this might explain the blue fringe in some cases), but I am not sure if these can explain all these 'rainbow bands'.

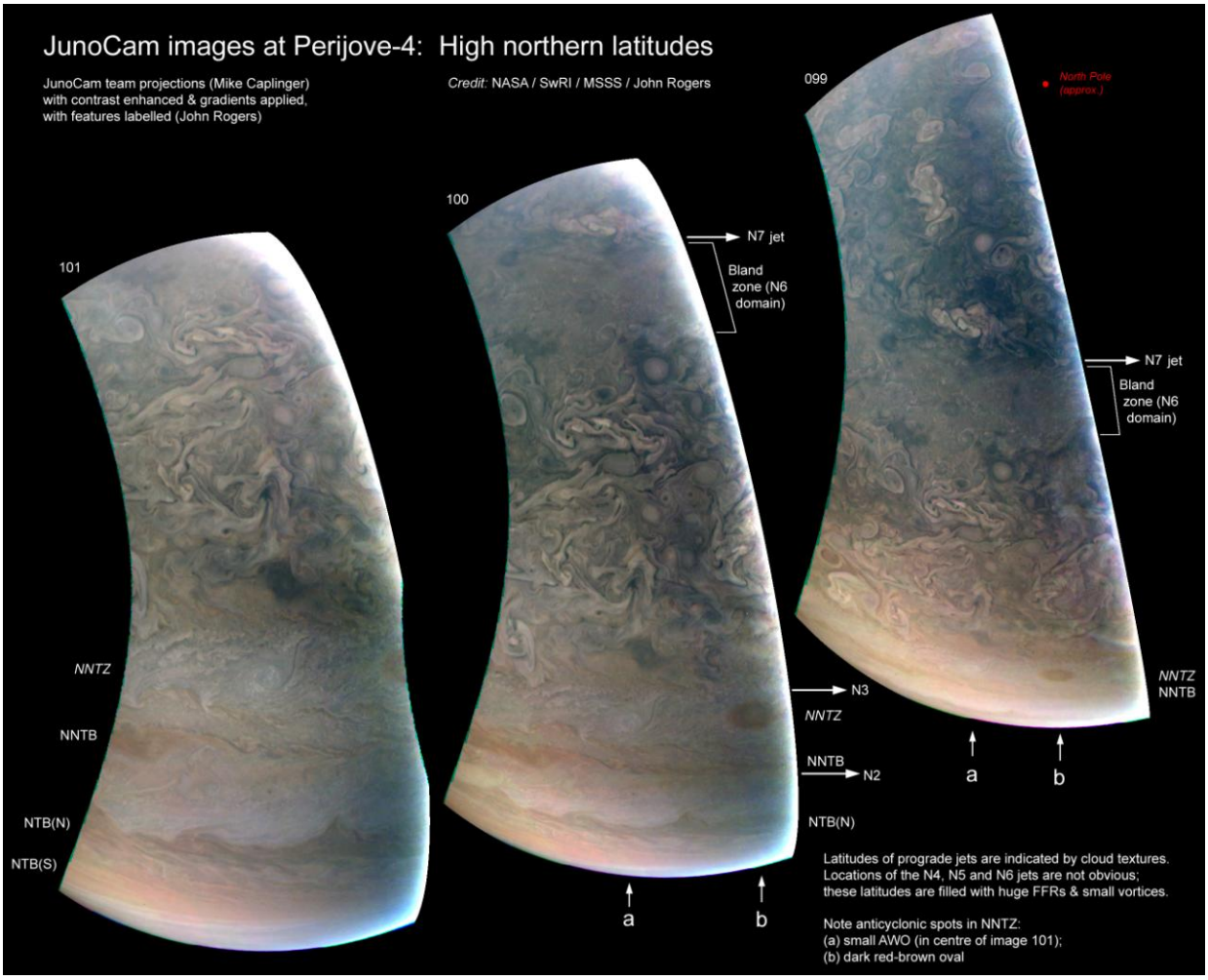


Figure 4.

Northern hemisphere

Figure 4 continues the coverage down to the NNTZ, where the images captured a small AWO and a dark red-brown oval (both also visible in amateur images, although we had not numbered them).

Figure 5 shows the 3 images covering the NTB and NEB, along with amateur images and an inbound Juno image which put them in context. (All 3 images appear slightly blurred, presumably due to the close range and high speed.) They can be compared with PJ-3 images 109-111, taken at almost the same latitudes, along with inbound and Earth-based images to show whether they changes seen are typical of other longitudes too.

The NTB (image 102) is maturing rapidly after the great outbreak last autumn initiated the revival of the belt, with contrasting NTB(South) (the "big red stripe") and NTB(North) (very turbulent and now dark grey). The edges are much better defined than at PJ-3, and the NTB(N) has darkened. In the N. Tropical Zone, there are still dramatic streaks of orange and dark grey and white.

In the NEB, these PJ-4 images captured dramatic views of some very active white 'rifts'. In image 102, where the brightest spot (presumably a convective plume) is captured near the horizon, there appear to be small-scale waves ahead of it. The NEB looked very different in the PJ-3 image because different parts of the rift systems were viewed.

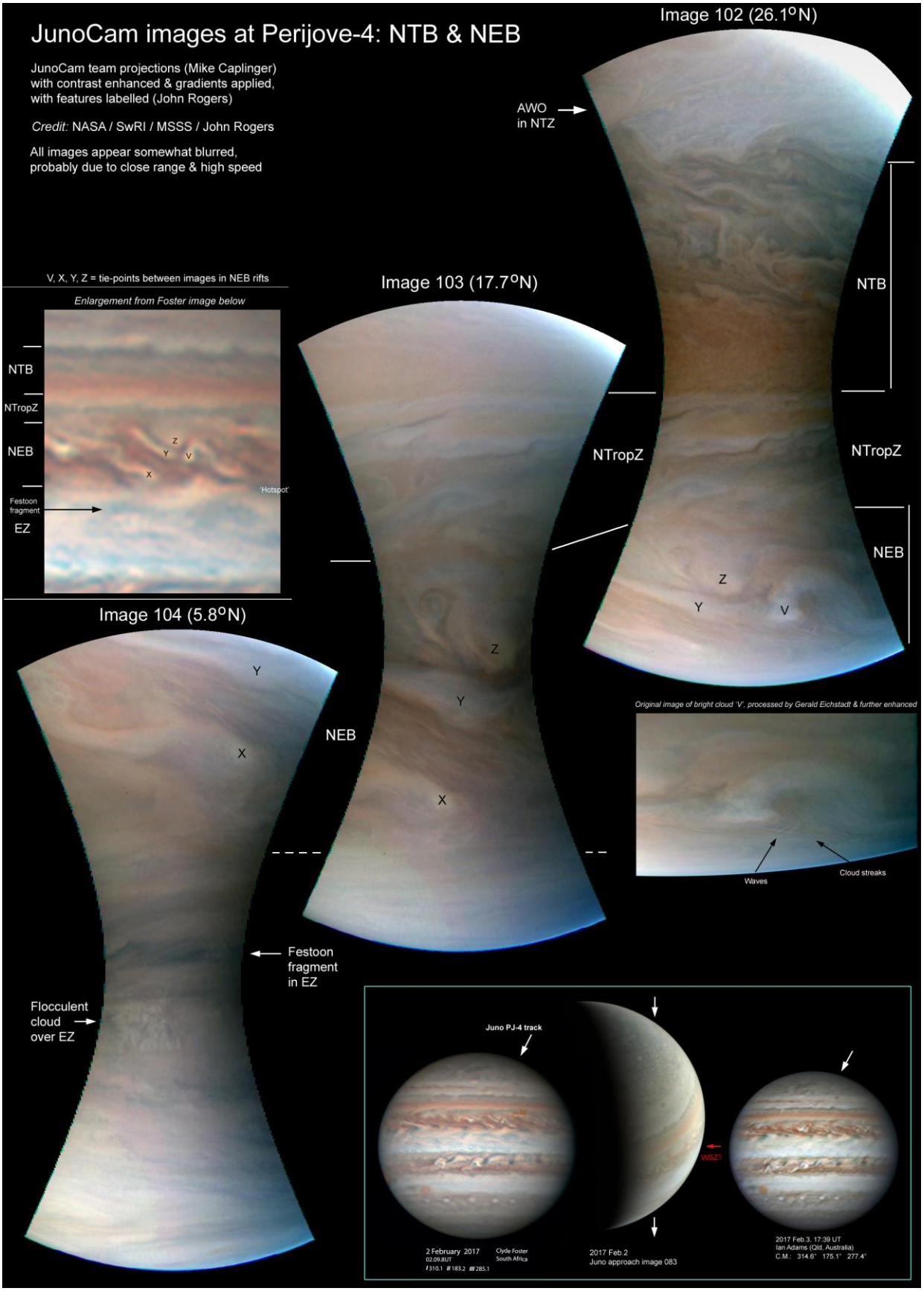

JunoCam images at Perijove-4: NTB & NEB
JunoCam team projections (Mike Caplinger) with contrast enhanced & gradients applied, with features labelled (John Rogers)
Credit: NASA / SwRI / MSSS / John Rogers
All images appear somewhat blurred, probably due to close range & high speed
Image 102 (26.1°N)
AWO in NTZ
NTB
NTropZ
NEB
Z
Y
V
V, X, Y, Z = tie-points between images in NEB rifts
Enlargement from Foster image below
NTB
NTropZ
NEB
Festoon fragment
EZ
'Hotspot'
Image 103 (17.7°N)
NTropZ
Z
Y
X
Image 104 (5.8°N)
Y
X
NEB
Festoon fragment in EZ
Flocculent cloud over EZ
Original image of bright cloud 'V', processed by Gerald Eichstadt & further enhanced
Waves
Cloud streaks
Juno PJ-4 track
2 February 2017
02.09.8UT
Clyde Foster
South Africa
2017 Feb.2
Juno approach image 083
2017 Feb.3, 17:39 UT
Ian Adams (Qld, Australia)
C.M.: 314.6° 175.1° 277.4°

Figure 5.

Image 104 targeted the NEB south edge, where 'hot spots' are located, but the context images show that there was no hot spot in the field of view; there was a dark blue-grey fragment of a festoon in the northern Equatorial Zone. South of this can be seen a patch of flocculent white clouds over the EZ; they appear to cast shadows.

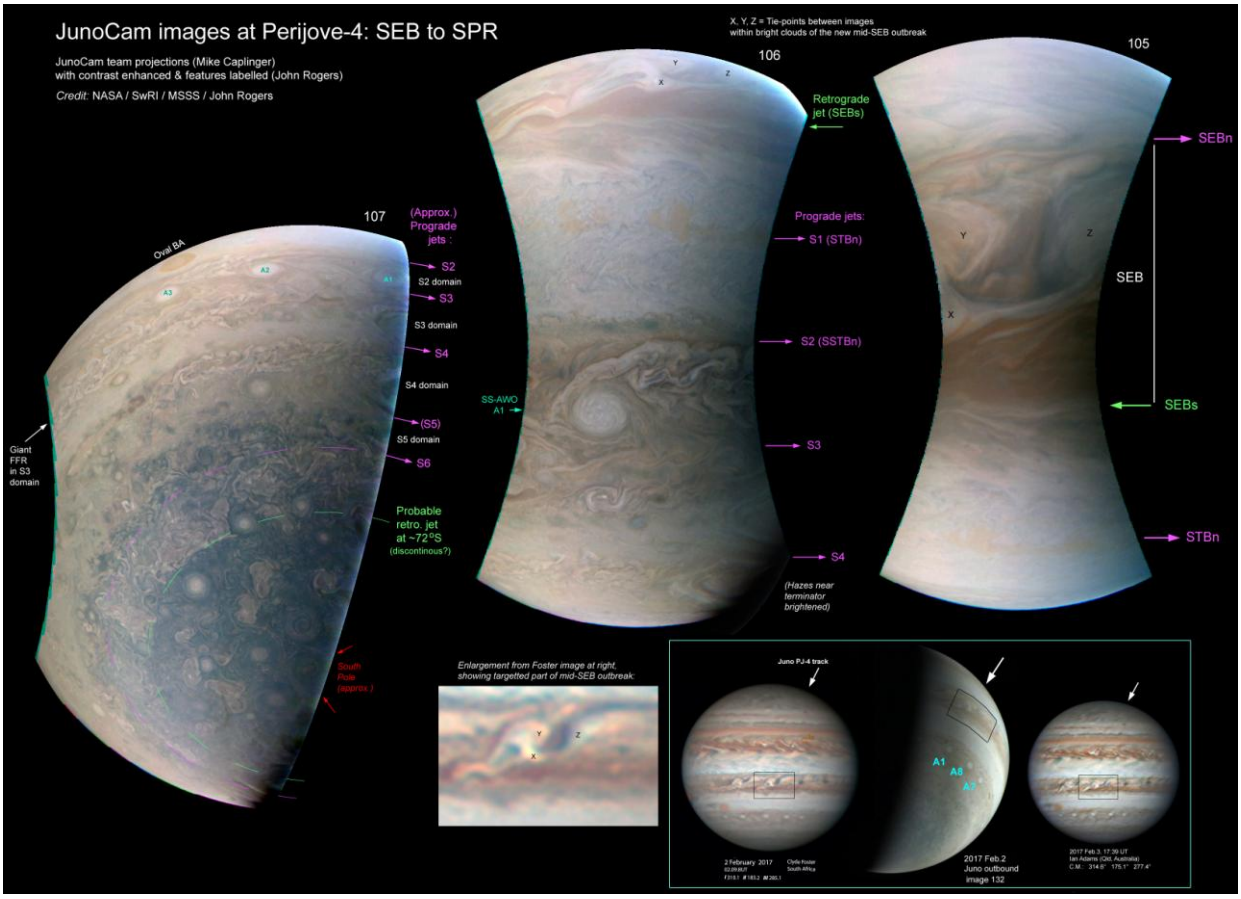


Figure 6.

Southern hemisphere

Figure 6 shows the 3 images covering the southern hemisphere, plus context images. The positions of the known circulations and jets are indicated. Most of the jets are evident from the cloud textures and adjacent cyclonic and anticyclonic structures, but this is not the case at all longitudes for the highest-latitude jets – prograde S5 and S6, and the suspected retrograde one at ~72ºS – so these jets might be discontinuous.

Part of the new mid-SEB outbreak (white 'rifts') was beautifully captured in image 105 and (near the horizon) in image 106. Not surprisingly, it looks somewhat similar to the rifted regions in the NEB (Figure 5) and in the SEB west of the GRS (at PJ-3).

On the SEBs, there was a low-amplitude undulation with wavelength ~5.4º, similar to wave-trains which we recently reported, and image 105 captured one wavelength of this as it approached the mid-SEB outbreak.

The STB is completely absent in this sector, and there is no sign of recirculation, but pale orange patches in the STBn latitude (with no evident vorticity) represent very subdued disturbance on the STBn jet.

As expected, image 106 did not cover oval BA, but it did capture a fine view of one of the S.S. Temperate anticyclonic white ovals (SS-AWOs or 'string of pearls'); this is number A1, with turbulent tendrils being twisted around it from an adjacent cyclonic FFR.

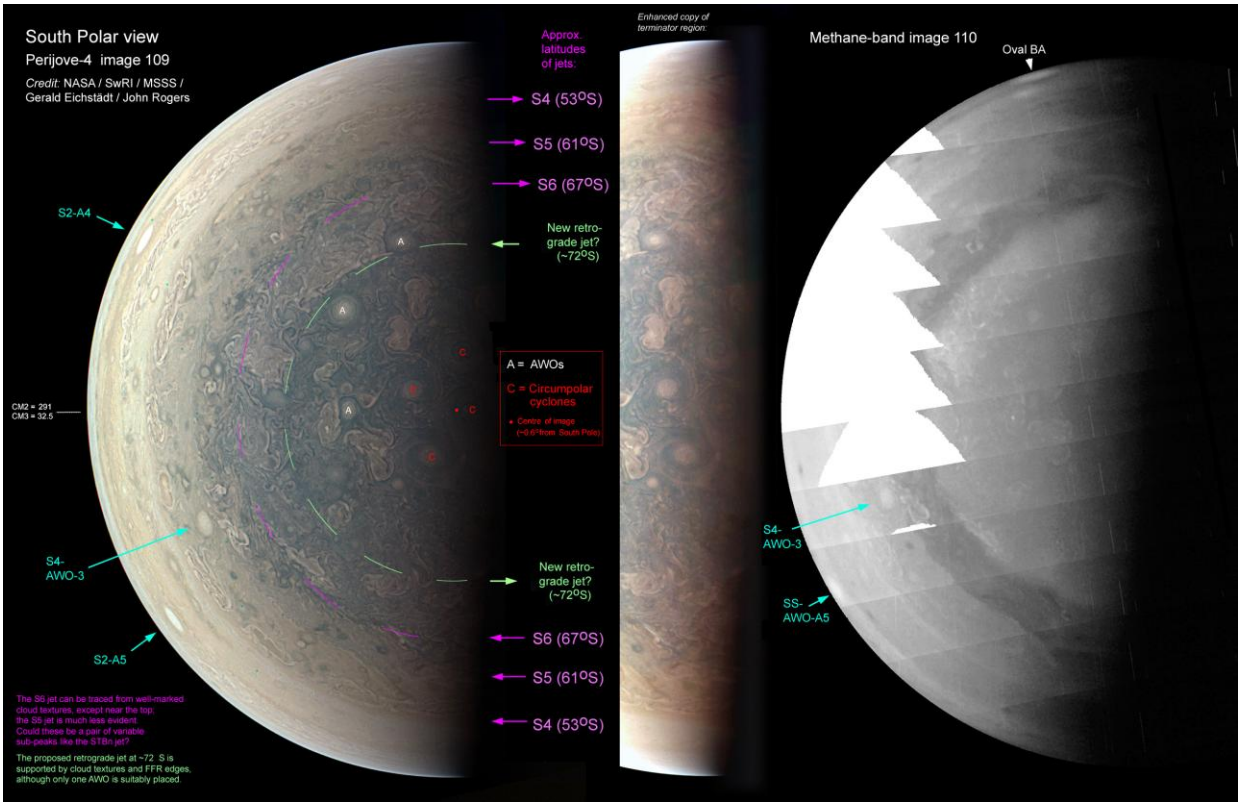


Figure 7.

South polar region

In Figure 6, image 107 extends up to the south pole, and shows dark and bright bands at the evening terminator, which probably represent thinner and thicker regions of a thin haze. They have a strikingly regular arrangement, with a <-shaped set of bands in each domain (S3, S4, S5), and probably also overlying the proposed 72ºS jet; thus, they approximately trace out the zonal wind profile of the underlying clouds. Note that this is not the South Polar Hood, which is a much more obvious haze above ~67ºS.

In Figure 7, the South Polar Hood is best shown in the methane-band image. Insofar as the jets can be located, the Hood has a well-defined edge at the S6 jet (~67ºS), surrounded by a methane-dark belt whose edge is at the S5 jet (~61ºS), just as at PJ-3. In colour images, the Hood can be discerned as a pale bluish haze over the whole region south of the S6 jet, e.g. in image 107 (Figure 6) and images 113 onwards (outbound images).

The most distinctive feature of the south pole is the cluster of circumpolar cyclones (Figure 7), just as at previous perijoves. Again they are surrounded by a chaos of cyclonic FFRs, with a few AWOs scattered between them. In Figure 7 the AWOs do not show a regular arrangement – however the outbound images (shown in a separate posting) revealed three more of them aligned with the proposed 72ºS jet as expected.