Juno at Perijove-5 (2017 March 27): What the JunoCam images show

--John Rogers (British Astronomical Association), 2017 April 15

Miniature copies of figures are shown here. Full-size copies are provided in a ZIP file.

JunoCam returned another set of fine images at PJ-5. This time, the majority of images were reserved for the polar regions, so that time-lapse animations of the circulations there are being produced by the JunoCam team. Five images were close-ups of the lower latitudes, as selected by the public, and fortunately they included our recommendations of the 'Big Red Stripe' and the STB Spectre, both of which were nicely imaged. The images nicely confirm many new features that were observed at previous perijoves. As usual, I indicate what features in the images are recognisable from ground-based tracking. These include white ovals at extremely high latitudes: one at ~72ºS which has been tracked for over a year, and a pair at ~60ºN which are now interacting.

Gerald Eichstädt is now producing true maps from all the images, in both polar and cylindrical projections, so for the high latitudes, I have created composites of the polar projections to cover the maximum range of longitudes. In addition to the hemispheric maps shown here, Gerald produced sets of hi-res maps of the polar region, which I have assembled into animated series to visualise the winds of the jets and circulations. Slight residual misalignments were minimised by shifting or stretching some maps by a few pixels. Jets have been located by their mean latitudes from previous spacecraft data.
A table is attached at the end, giving the mean latitudes of the jets, both planetocentric and planetographic. All latitudes in the map and in this report are given as planetocentric (indicated by suffix c); some are also given as planetographic (suffix g). These differ by up to 4º. The planetographic system is always used in our own work.
For lower latitude images, I use some by Mike Caplinger of the JunoCam team, 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.

Figure 1 *[not copied here]* shows a set of amateur images taken around the time of perijove, including colour, infrared, and methane-band images. Figure 2 shows some maps from amateur images, compared with a map of the JunoCam closeups (cylindrically projected by Gerald).

Figure 2:

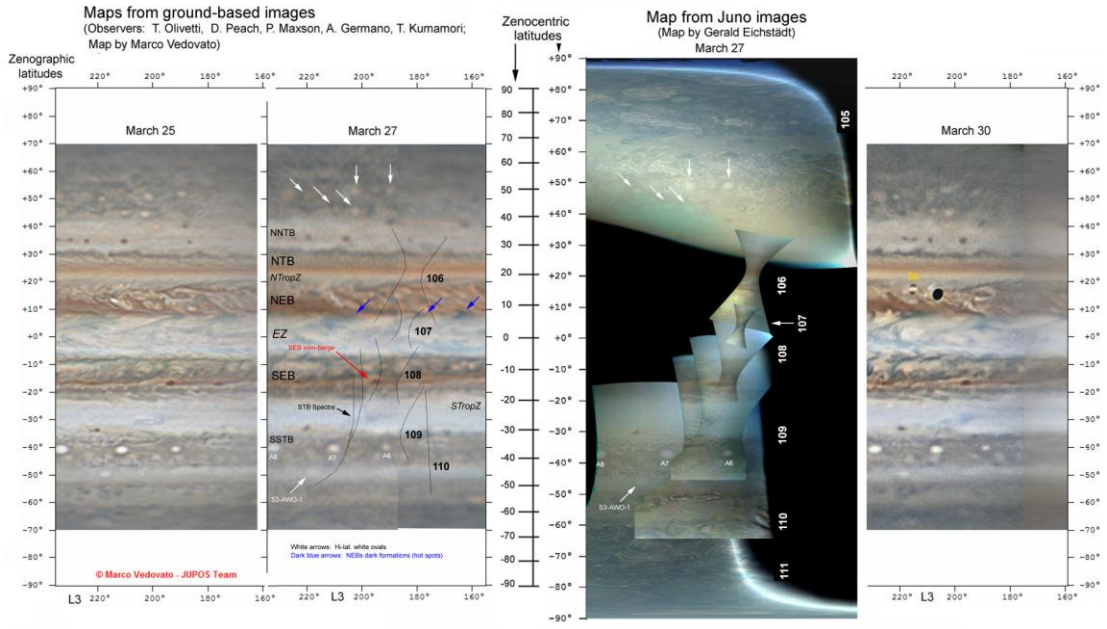


Figure 3:

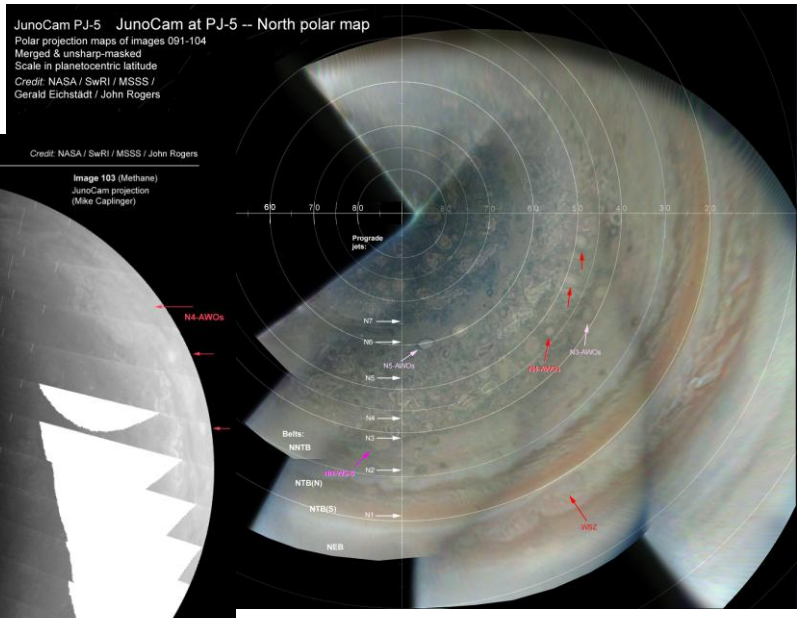
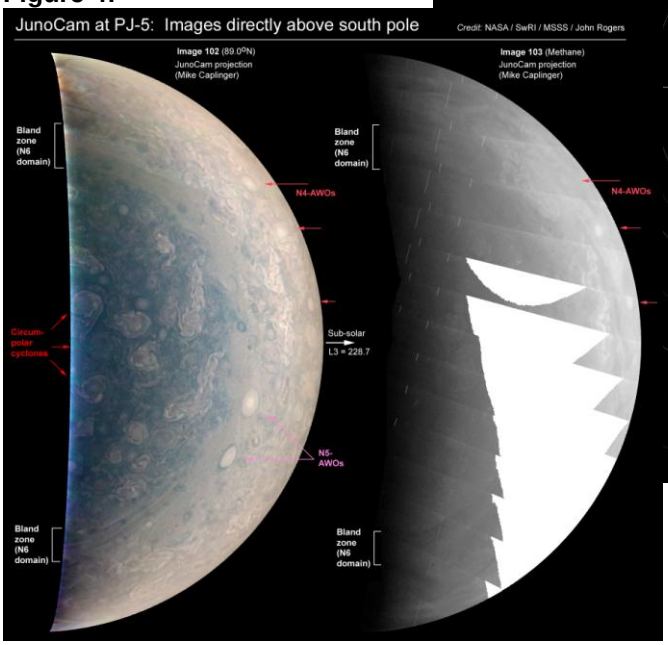


Figure 4:



North Polar Region

Figure 3 is a composite of polar projection maps (labelled and unlabelled versions); Figure 4 is the view from directly over the north pole (colour image and methane image). The images confirm the features previously discovered by JunoCam (see reports on previous perijoves):
--The circumpolar cluster of circumpolar cyclones (CPCs);
--Vast areas of chaotic cyclonic folded filamentary regions (FFRs), along with some anticyclonic white ovals (AWOs), filling most of the latitudes between the CPCs and the N3 jet, except:
--A bland zone occupies ~60-65ºNc (63-68ºNg; between the N6 and N7 jets), with long narrow lanes of haze within it.

By 'blinking' Gerald's hi-res polar projection maps, one can see the prograde motion of the N7 jet, immediately north of the bland zone – mainly along the south edges of FFRs. From the animations, and from the visible cloud textures, it appears that there are no jets and no organised structure between N7 (66ºNg) and the CPCs (80ºNc).

The bland zone has irregular edges at ~60 and 65ºNc (63 and 68ºNg, now accurately shown on the maps), within 1 degree of the N6 and N7 jets. As usual there are long narrow haze streaks within it, only approximately aligned in latitude. This time there are multiple parallel white streaks, again separated or flanked by brown streaks which are methane-dark (probably thinnings in the N. Polar Hood).

The maps show fairly close pairs of AWOs at 60ºNc (63ºNg; N5 domain), 48ºNc (52ºNg; N4 domain), and 41ºNc (45ºNg; N3 domain). These can be nicely traced from amateur images on Marco Vedovato's maps from March 19-30. His map from April 9-10 provides an update: the pair at 58-60ºNc (61-63ºNg) appear to be swinging round each other – are they merging? The pair at 48ºNc (52ºNg) are now very close, only 7º apart – will they likewise interact? But the pair at 40ºNc (44ºNg) are now difficult to recognise.

North Temperate Belt

The developing NTB has been nicely monitored by similar closeup images at PJ-3, -4 and -5. Figure 5 shows PJ-5 image 106. NTB(S) is the "Big Red Stripe" and NTB(N) is grey and very turbulent. It looks similar to PJ-4, although the images are consistent with a gradual evolution of the turbulence in NTB(N) towards smaller scale.

North Equatorial Belt/Equatorial Zone

Although there was no closeup of the NEB itself at PJ-5, image 107 (Figure 6) is a closeup of the NEBs edge, which can be compared with similar images at PJ-3 and -4. This is definitely the highest-resolution image ever taken of Jupiter, as the altitude was only 3422 km, much lower than previous perijoves at >4100 km! It shows no sharp features, which could be a consequence of the rapid spacecraft motion, or merely a characteristic of the diffuse cloud texture.
The main feature is very dark festoon in the northern EZ; contemporaneous amateur images (Figure 6) show that it extends from a NEBs dark formation ('hot spot') just out of the frame. There are flocculent white clouds on the east side of the festoon, as is common in v-hi-res images, but with no wave patterns.

Figure 5:

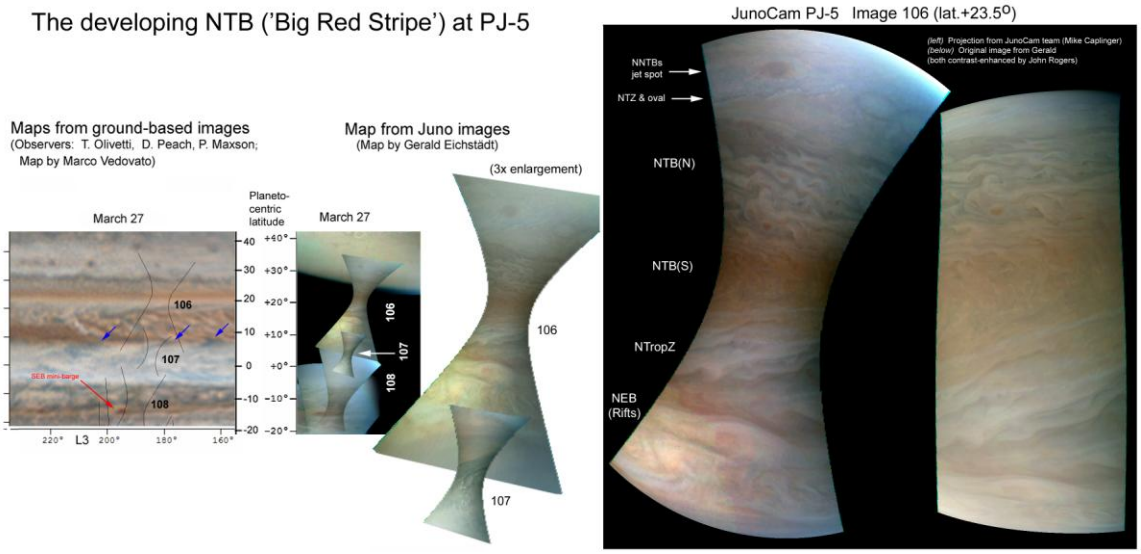


Figure 6:

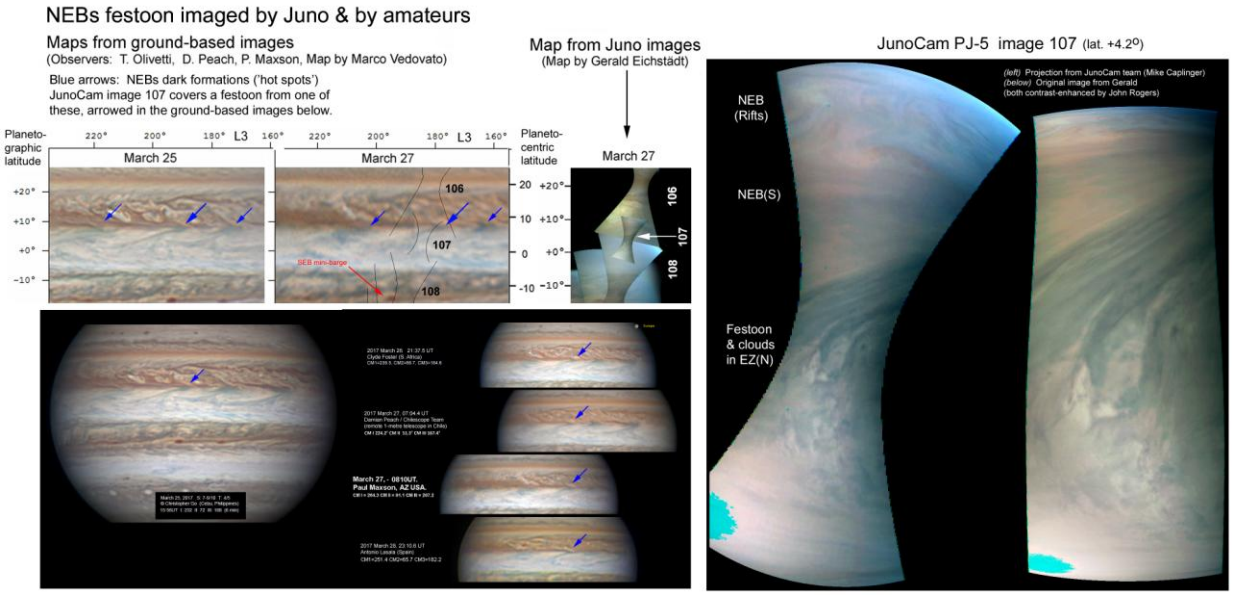
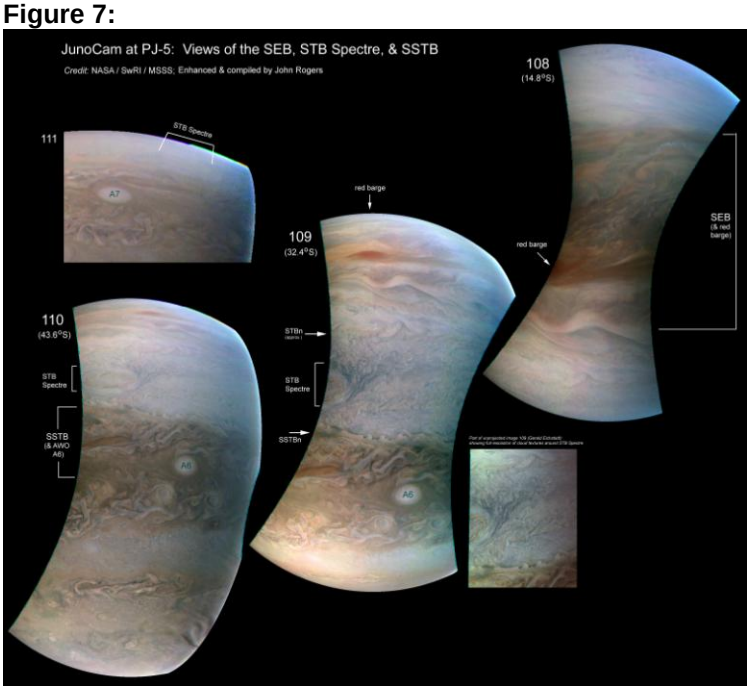


Figure 7:



Southern hemisphere

Figure 7 shows targetted images 108-110. The SEB was targetted in image 108. It shows a fairly quiet sector, which makes a nice comparison with the previous images of highly turbulent sectors. It includes a red mini-barge.

The STB Spectre was successfully captured (in part) in the targetted image 109, and more of it in the adjacent image 110 of the SSTB. (It can also be seen faintly near the horizon in image 111.) These beautiful closeups are shown in Figure 7. They show an impressive circulation pattern which clearly indicates the cyclonic circulation of its central oval; note that this is still reddish, in contrast to the surrounding blue streaks. The original images show many tiny, very bright clouds scattered across the lighter zones. We will be able to align this with images from previous perijoves to compare the textures of the whitened STB and S. Tropical Zone latitudes at different longitudes.

Images 109 and 110 also captured two of the AWOs in the SSTB ("String of pearls"), plus the surrounding turbulence. Image 111 shows the high southern latitudes, always beautiful and spectacular.

South Polar Region

Figure 8 is a composite of polar projection maps (labelled and unlabelled versions); Figure 9 is the view from directly over the south pole (colour image and methane image). The images confirm the features previously discovered by JunoCam, notably:
--The cluster of circumpolar cyclones (CPCs);
--Many diffuse streaks of haze which appear bright on the terminator, with familiar colour properties;
--Bright streaks in FFRs are also bright in the methane image (likewise in the north polar region);
--Evidence for a retrograde jet at ~71-72ºSc;
--The methane-dark South Polar Band and methane-bright South Polar Hood (SPH).

The domains and jets can be described more precisely now that we have polar projection maps. Labelled on the map are the long-lived AWOs, and the largest FFRs in the S2 and S3 domains. The S4 domain is the highest well-organised one, with cyclonic FFRs and brown oblongs at 50-53ºSc, and 2 known AWOs and some smaller rings at 55-57ºSc. The S5 and S6 jets, bounding the narrow S5 domain, are not obvious from morphology (but see below). To identify higher-latitude jets I 'blinked' several of the hi-

res polar projection maps. One can clearly see the prograde motion of the S6 jet, confirming that this is an especially fast jet, evident over ~180º of longitude. I cannot see any jet streams between S6 and the CPCs, not even the retrograde jet at 71-72ºSc, (except where it passes between a FFR and the largest AWO at 73ºSc, so this jet cannot be very fast. However its existence is again supported by a ring of large FFRs just north of this latitude, and a loose ring of AWOs near or just south of this latitude.

The largest AWO, at 72.5ºSc, is also visible in the ground-based JUPOS map from an image by Chris Go on April 10, and is almost certainly the same one that was imaged by Juno at PJ-4 and PJ-1, and was tracked by JUPOS in spring, 2016, at 69ºSc (71.3ºSg). This was probably the highest-latitude spot ever tracked in our data, and our final report for the apparition gave a drift equivalent to DL3 = +43º/53 days. Since PJ-1 its drift has been more modest but no more variable than other high-latitude ovals. So this retrograding AWO has now been tracked for over a year.

The retrograde jet at 71-72ºSc was probably recorded by Cassini, with DL3 = +60º/53d, at 67.9ºSc (70.4ºSg). This latitude is clearly lower than shown by the Juno images, but was probably inaccurate because in Cassini images the south pole was tilted away and features were largely obscured by the bright SPH.

Figure 8:

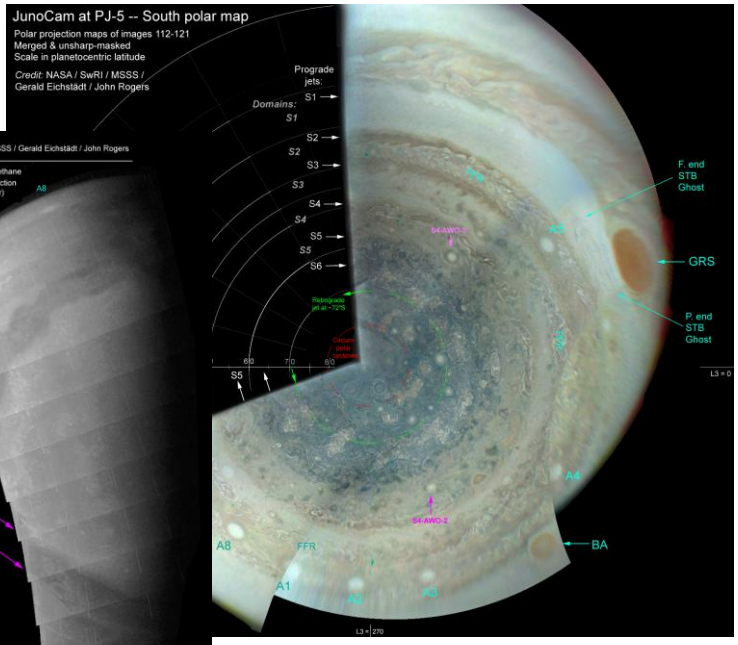
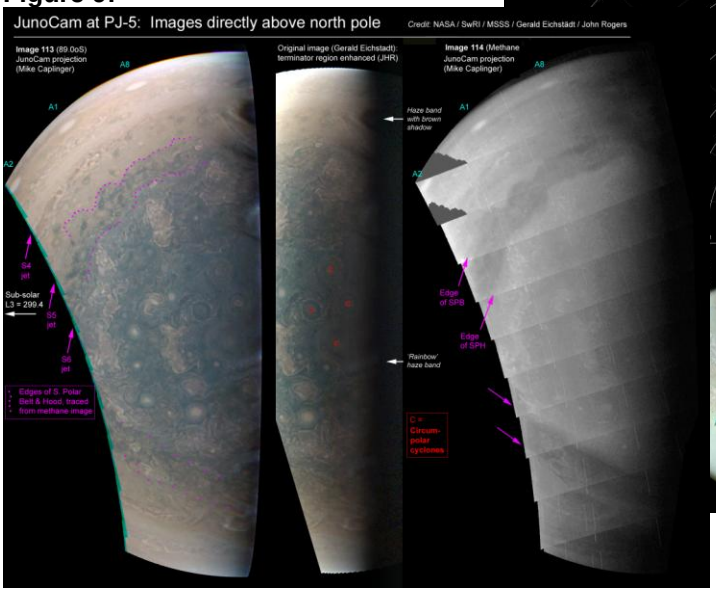


Figure 9:



The South Polar Hood (SPH) can be discerned as a pale blue haze over the dark south polar region in global colour images, but it is only well defined in methane images (Figure 9). This methane image again shows obvious waves in one sector, both in the edge of the SPB at ~57-59ºSc, and in the edge of the SPH at ~64ºSc; and again they align with underlying cloud interfaces which probably represent the S5 and S6 jets.

Many haze bands are seen at the terminator on Figure 9, both inside and outside the SPH. Some again have angles consistent with the flow of the jets, including a conspicuous C-shaped one near the top of the image which casts a deep brown shadow; others seem unrelated to the underlying features, including a 'rainbow band' overlying the edge of a large CPC. As at previous perijoves, these haze bands are only marginally visible in the methane image, which is still not understood.

Table: Names, latitudes and speeds of jets on Jupiter

Mean values from 4 spacecraft data sets (Voyager, Cassini, Hubble, New Horizons).
Data from 'Reference list of Jupiter's jets (Rogers, 2013), posted at:
http://www.britastro.org/jupiter/reference/jup_jets/ref_jets.htm
--with the addition of planetocentric latitudes.

	Lat. *graphic*	Lat. *centric*	u3 *(m/s)*
N7	68,4	65,7	31,1
N6	63,8	60,7	19,6
N5	55,8	52,2	20,6
N4	47,4	43,6	21,3
N3	42,7	39,0	22,3
NNTBn	*39,3*	*35,7*	*-17,8*
N2	35,1	31,7	37,3
NTBn	*31,1*	*27,9*	*-26,8*
N1	23,7	21,1	148,5
NEBn	*17,0*	*15,0*	*-21,5*
NEBs	7,2	6,3	108,7
SEBn	-7,2	-6,3	139,7
SEBs	*-19,5*	*-17,3*	*-58,6*
S1	-26,5	-23,6	49,0
STBs	*-32,3*	*-29,0*	*-16,4*
S2	-36,3	-32,8	38,2
S3	-43,1	-39,4	42,7
S4	-52,7	-49,0	41,1
S5	-61,0	-57,7	25,3
S6	-66,9	-64,1	29,4