

JunoCam at PJ23: Part II: Polar regions

--John Rogers

North polar region

Circumpolar cyclones (CPCs):

Figure N1 shows the hi-res map of the CPCs that form the octagon around the north pole, at PJ23 and at some previous perijoves for comparison. The hi-res view covers similar longitudes to PJ1 and PJ17, but the longitude range is now limited because of the orbital evolution: the crossing of the NPR is now fast and low (altitude when at highest latitude was 38,700 km at PJ23 versus 73,000 km at PJ1). Also, the highest sub-spacecraft latitude was only 75.4°N. Nevertheless, the CPCs were well imaged.

The map (Figure N1B&C) shows three adjacent ‘filled’ CPCs, and, faintly, part of a ‘chaotic’ one (CPC-6) on the terminator. So the octagonal shape is quite regular in this sector (unlike PJ21). But the pattern is no longer strictly ditetragonal: CPC-4, formerly a chaotic cyclone with partially filled central region, has gradually evolved until it is now indistinguishable from the previous filled cyclones. There is a small AWO inside the octagon (also seen at PJ17).

An anticyclonic counter-spiral is evident in the central white disk of CPC-4, but not in CPC-3 nor -5. Blinking maps of images 9 and 12 shows cyclonic rotation in two of these CPCs.

Most notably, *we can now see part of the North Polar Cyclone (NPC) for the first time!* Although this cyclone on the north pole had been revealed by JIRAM data, it is only now becoming visible as sunlight gradually creeps towards the pole. Our previous best view towards the north pole was at PJ1 (20 months before the winter solstice), but the cloud arc imaged then had a radius of ~4.4° latitude (with respect to the pole) and probably marked the outer edge of the zone surrounding the NPC. At PJ23 (18 months after the solstice) we see two cloud arcs of the NPC itself, one of radius 2.3-2.8° (an outer spiral) and one of 1.7°. A whitish haze band partially overlies the NPC.

There is a perceptible ‘bland zone’ around the outside of the octagon (as at PJ21 but not PJ17). A haze band that apparently casts a dark brown shadow lies over the periphery of CPC-6, probably enhanced by the very oblique viewing angle.

The Bland Zone and haze bands:

Figure N2 shows images of the NPR in colour and methane band (images 14-16, by Gerald). This is one of JunoCam’s best-ever methane images of these regions. Curiously, the blue NPR (which normally coincides with the densest part of the methane-bright North Polar Hood (NPH)) is less methane-bright than the surrounding regions – as we also observed at PJ21 – and this is the case across the whole image so it does not appear to be due to viewing angles. Can it be truly variable?

These images cover the blue NPR with its large FFRs; the Bland Zone, with a conspicuous set of its characteristic long linear haze bands; and the N5 domain, with further conspicuous haze bands at various angles, on the typically chaotic background. The haze bands in visible light show up well in the methane image, but there are also other diffuse methane-bright patches. The large white oval is an AWO in the N5 domain, which has been tracked by the JUPOS team from ground-based images throughout 2019, with a fairly steady retrograding drift. In the methane image it is almost invisible, being embedded in a generally methane-bright region. All these aspects of the NPR have been recorded at many previous perijoves but are specially well documented in these images.

One of the longest linear bands across the Bland Zone was identified by Björn Jónsson under high sun in his projection of image 18 (Figure N3). That band covers at least 50° longitude, as does another such band illuminated closer to the terminator. As he notes, the bright band appears slightly bluer/whiter than the surrounding areas, while a dark band on its north side looks like a brownish shadow cast by the bright band. The frame is located in Figure N4, which shows composite north polar projection maps in RGB and methane band.

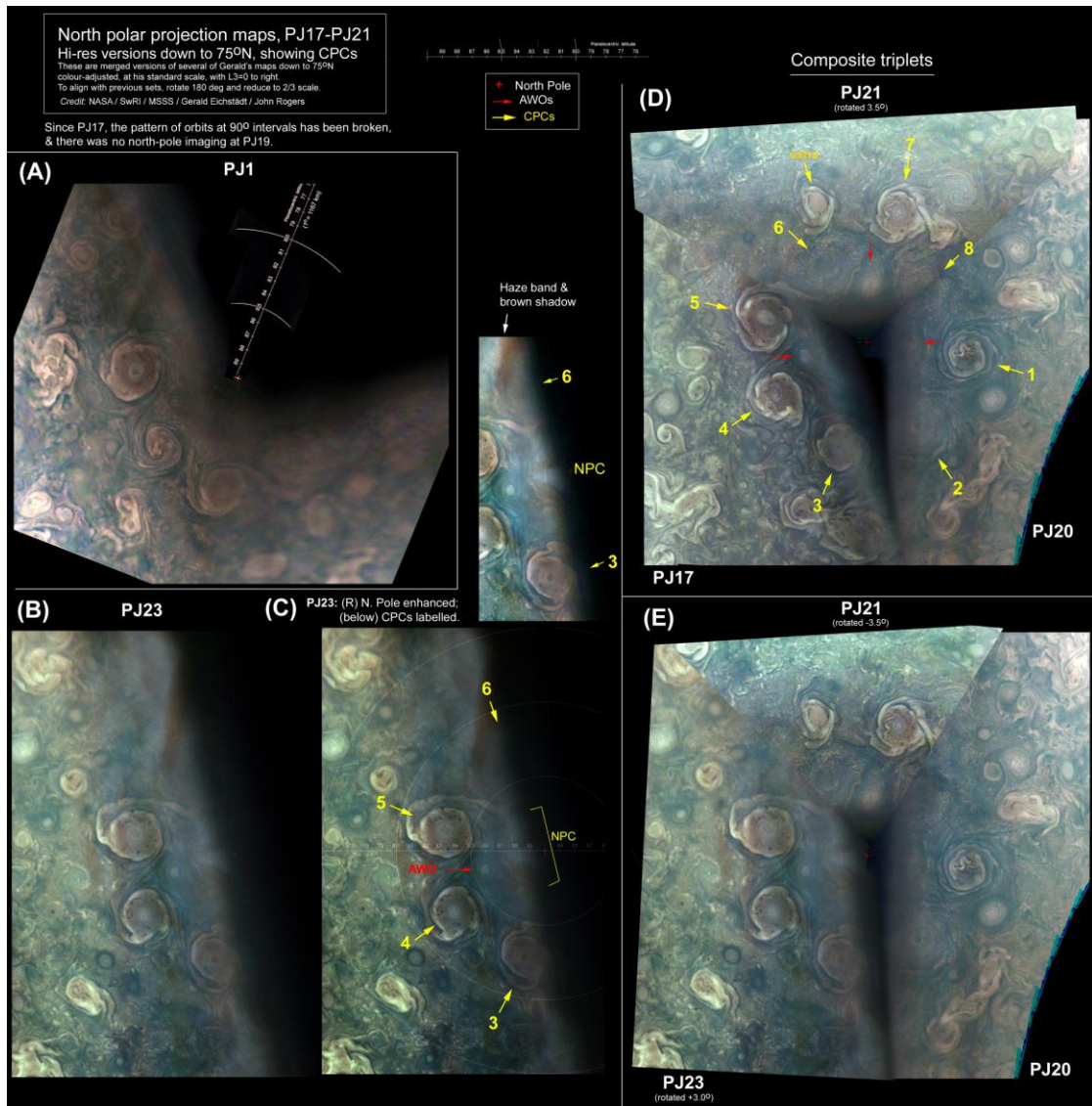


Figure N1. (For description see main text.)

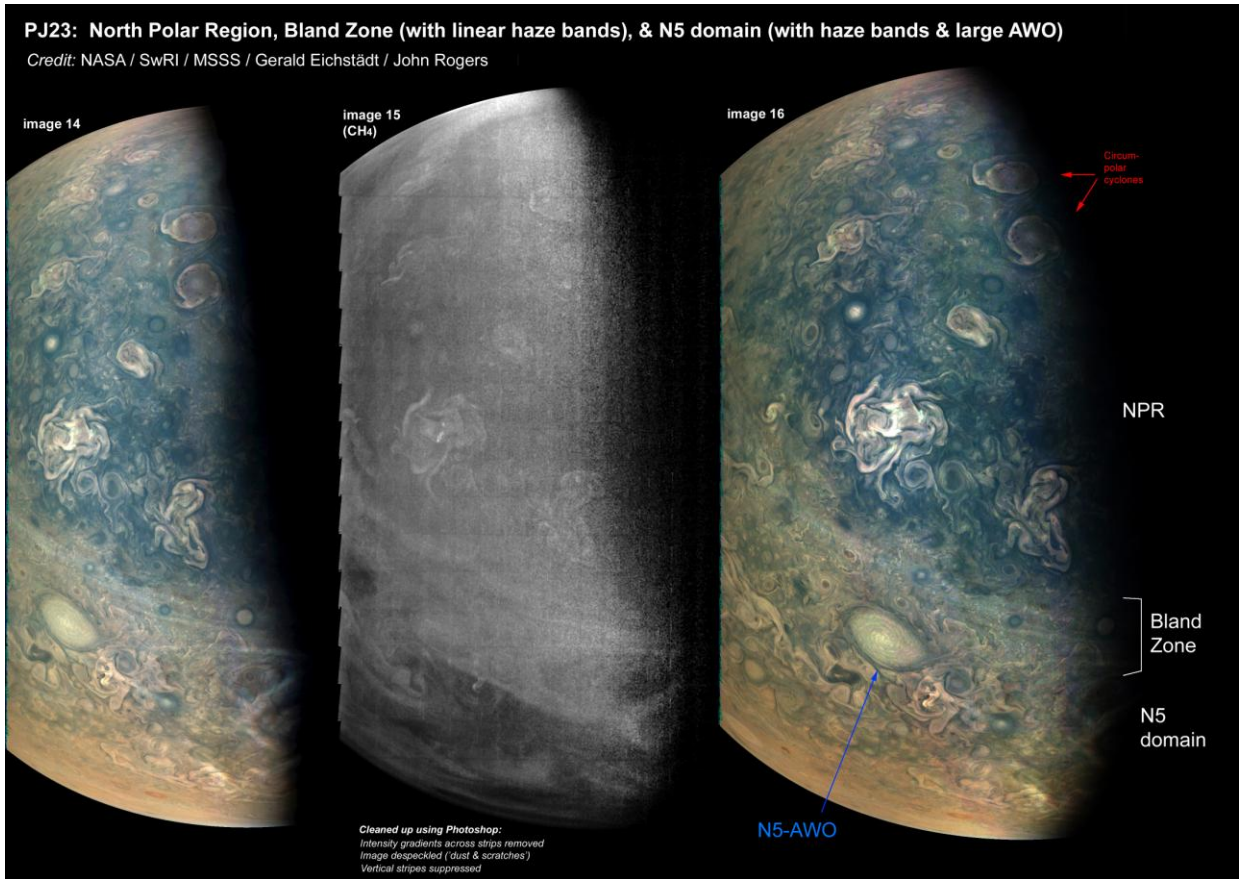


Figure N2. (For description see main text.)

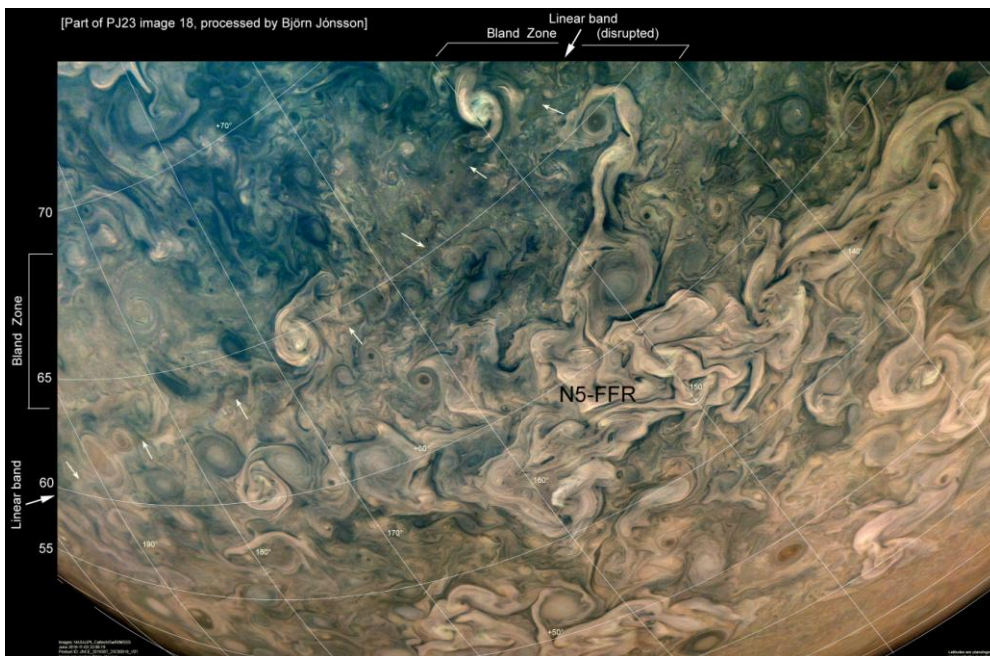


Figure N3. Part of image 18, processed from the raw data by Björn Jónsson who also added the grid. He comments: “The image is heavily processed to more clearly reveal various subtle features, in particular a haze band. The band itself appears slightly brighter and bluer/whiter than the surrounding areas. The arrows indicate what is apparently a brownish shadow cast by the haze band. Latitudes are planetographic and longitudes in system 3.” (This is one of the linear bands across the Bland Zone, although that zone is interrupted by a chaotic sector in the centre of this view.)

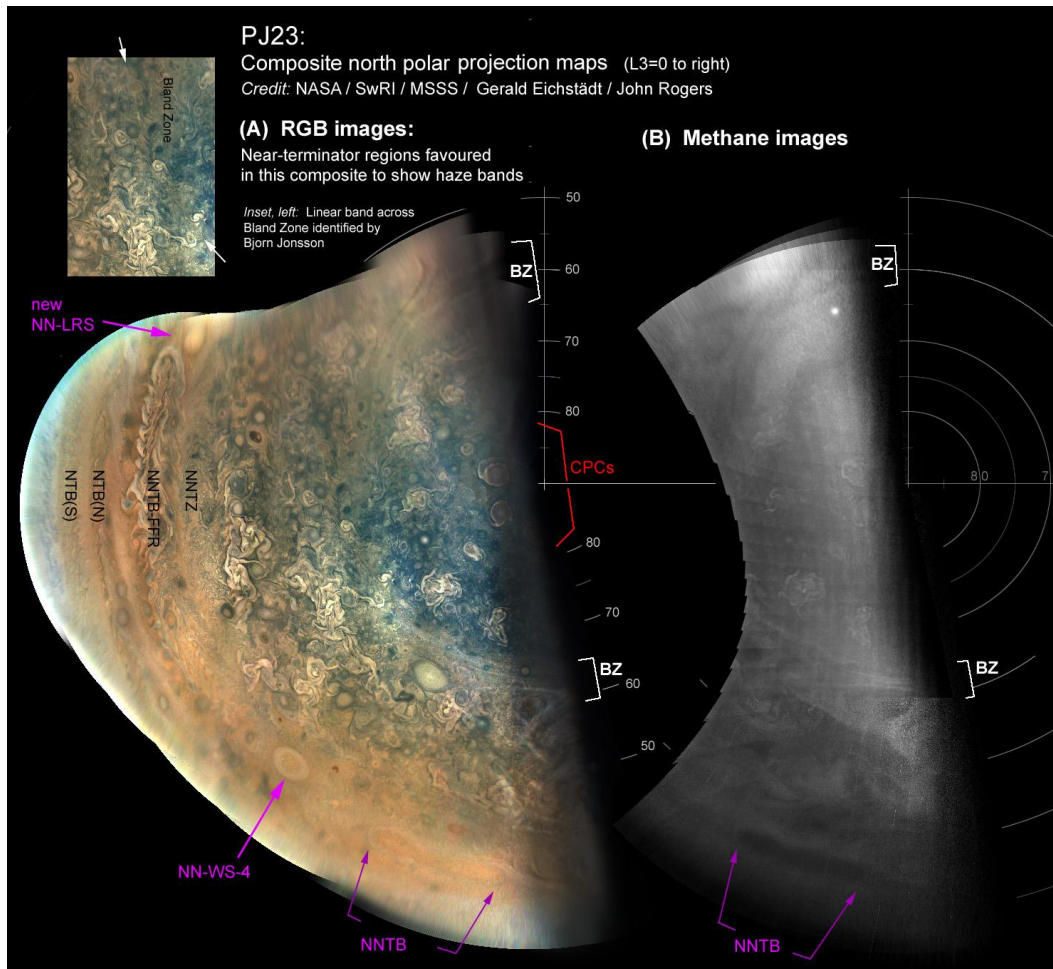


Figure N4. Composite north polar projection maps. (A) RGB composite; this version favours near-terminator regions so as to emphasize haze bands, though this makes little difference (except at top right) as the range of terminator longitudes was small. (B) Methane-band composite. BZ, Bland Zone (with linear haze bands).

South polar region

Figure S1 presents six composite polar projection maps, in similar format to those in our PJ21 and PJ22 reports. The images now have noticeably lower resolution than earlier in the mission, as the altitude at highest latitude (MEA) has almost doubled from 92,500 km (at PJ1) to 173,000 km (at PJ23); but spiral structure in the CPCs is still clearly resolved. Blinking of maps shows the usual rapid motions in the S6 jet, the FFRs, and some of the CPCs.

In our PJ21 and PJ22 reports, we noted two large AWOs at 73°S. They are still present, at ~73°S, having retrograded by 22° and 30° respectively in L3 since PJ22.

Haze bands and South Polar Hood (SPH):

Maps of near-terminator hazes have been prepared as usual; here I just show them diagrammatically (Figure S1B). There are numerous haze bands, densely packed in parallel bands all round the south polar region, but they are mostly narrow and/or tenuous. The bands may be more visible now due to the more oblique viewing angle,. They are not identical to the

bluish, methane-bright South Polar Hood (SPH), as they are still abundant outside it. Most bands have the usual orientations with reversals near 64°S and 70°S in accordance with the ZWP, but there are also several instances of intersecting bands.

The visible haze map can be compared with methane-band maps (Figure S1C&D). Unusually, the boundary of the methane-bright SPH seems to be double around much of its circumference, with several linear methane-bright haze bands (see below) marking the inner boundary.

Two classes of linear haze bands stand out, visible both in RGB and (unusually) in methane. They are visible in RGB (sometimes even under full sun) as single narrow bright bluish bands with a dark band on the poleward side, possibly a brown shadow. They are marked in green on the haze diagram (Figure S1B) and most are visible in the image taken at highest latitude (Figure S2C). One of them is a very long band running across the upper half of the map; in the methane map it marks a boundary between a bright part of the SPH and a darker part (Figure S1D). It thus resembles the 'Long Band' which used to run alongside CPCs on the opposite side of the pole, but that band has not reappeared.

The bands of the other class are of medium length, all at ~66-69°S with similar slightly oblique orientations, and also divide brighter from darker areas of SPH, thus forming an inner boundary to it. We have not noticed bands of this class at previous perijoves, and they could be more visible now due to the quality of the methane map; but further checking would be worthwhile.

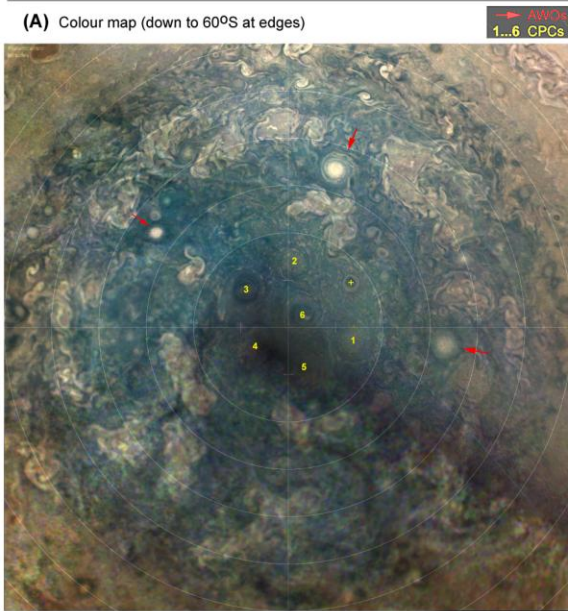
Circumpolar cyclones (CPCs):

Figures S1E&F and S2C show the hi-res map of the CPCs that form the polygon around the south pole. It is still centred on the South Polar Cyclone (SPC), which is still displaced from the pole (see below). However, *the pentagon may be transforming into a hexagon!* In the hitherto permanent gap between CPC-1 and -2, there is now a small sharp-rimmed very dark cyclonic oval (labelled + in Figure S1A). One or more similar very dark ovals, probably small cyclones, have been present in or near the gap at recent perijoves, but this one is now symmetrically placed with the five previous CPCs to form a hexagon. Its bright rim shows narrow cyclonic spiral structure and rotates cyclonically. However, its surroundings do not show clear spiral structure and do not show systematic cyclonic rotation; on the contrary, as Gerald points out, there is retrograde flow around it (Figure S1F). So it remains to be seen whether there is now a stable hexagon, or whether the small dark cyclone will drift away again to leave the gap as before.

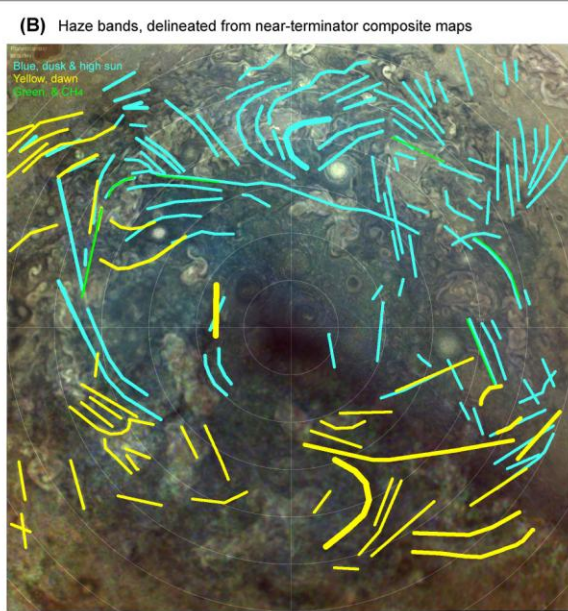
Blinking of maps shows the cyclonic rotation in CPCs-2 and -3 and the SPC. The centre of the SPC contains a bright sub-radial streak which rotates by 19° ($\pm 7^\circ$) in 46.7 min (images 44 to 55), i.e. 0.41 (± 0.15) deg/min. This is similar to the rapid rotation here that we reported from images at PJ1 to PJ4: 0.35 to 0.51 deg/min.

The SPC has moved a small distance since PJ21 in longitude, but not in latitude (Figure S2B). The strong oscillation in latitude that occurred earlier in the mission seems to have ceased. It is still centred 1.9° latitude from the pole, suggesting that the vorticity of the hexagonal configuration is not (yet) symmetrical.

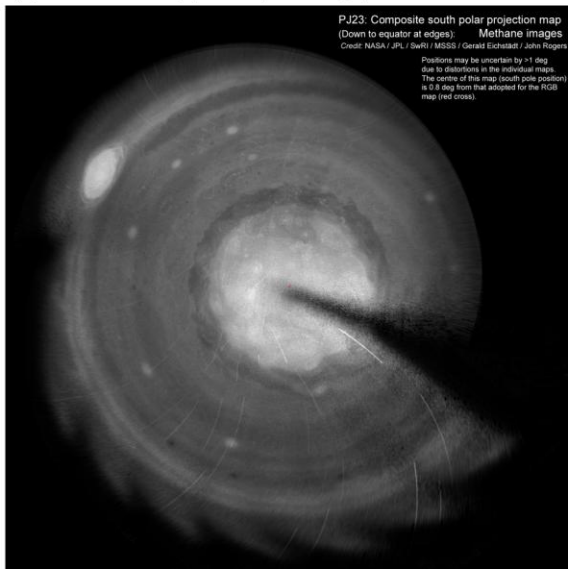
(A) Colour map (down to 60°S at edges)



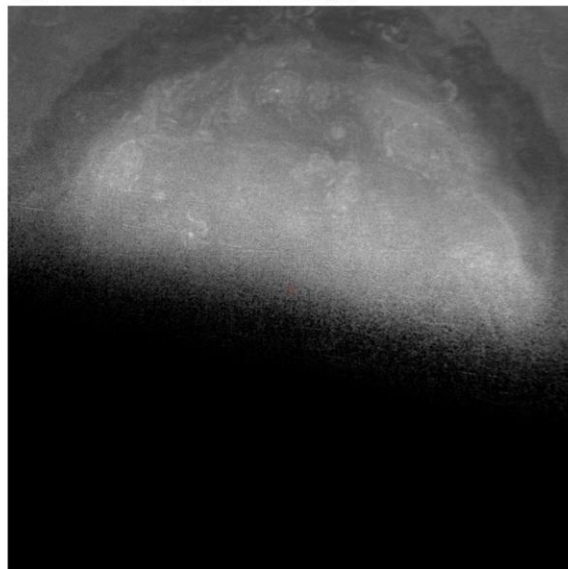
(B) Haze bands, delineated from near-terminator composite maps



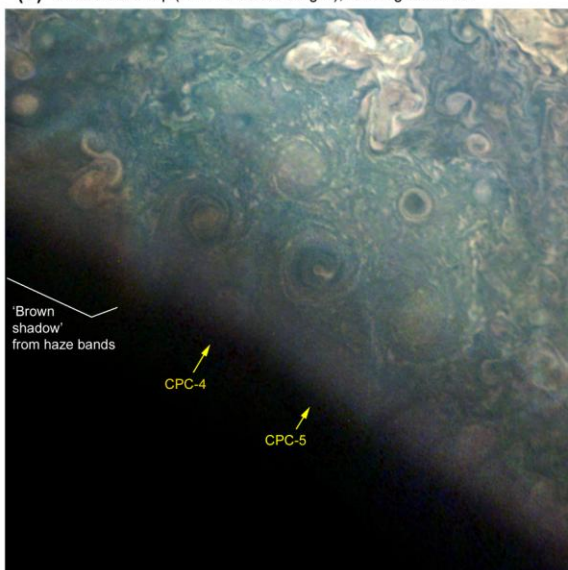
(C) Methane-band map (down to equator at edges)



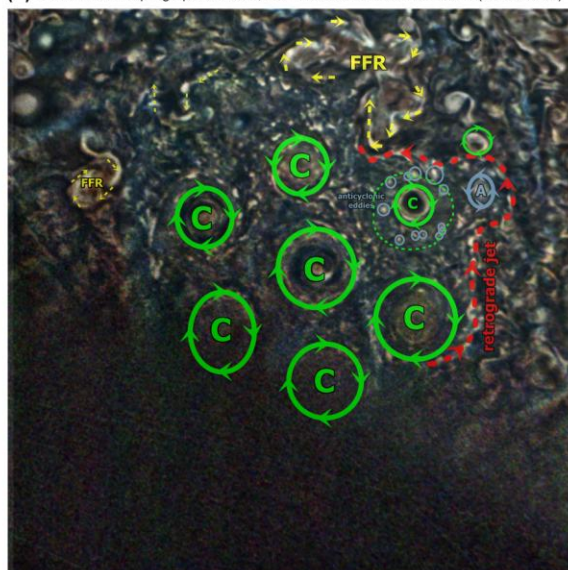
(D) Methane-band map (down to 60°S at edges)



(E) Hi-res colour map (down to 75°S at edges), showing the CPCs

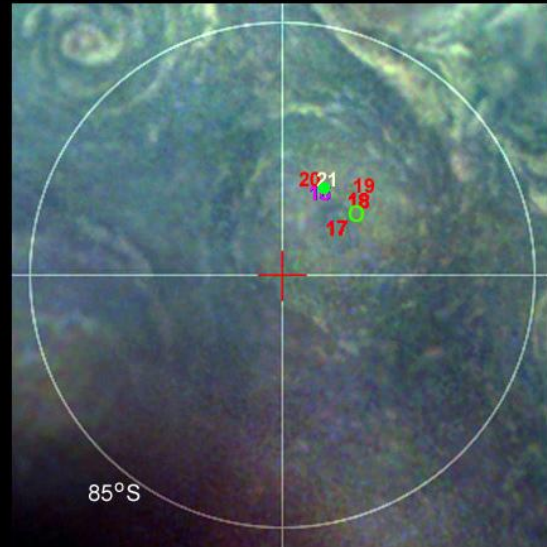
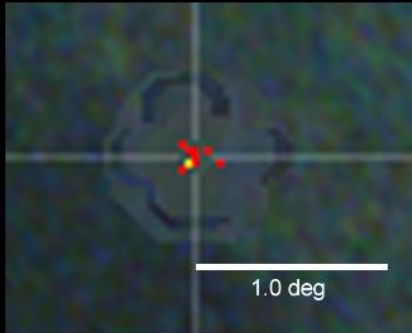


(F) Hi-res colour map high-pass-filtered, with observed circulations marked (G. Eichstädt)



Above: **Figure S1.** Below: **Figure S2.**

- (A) S. Pole position from 8 maps, images 44-61 (red dots). (Enlarged x5)
All pole positions are within 0.14 deg of centre=average=consensus position.
(Yellow dot = position adopted for merged global maps, slightly off the average.)



- (B) **Position of SPC w.r.t. South Pole**

The centre of the SPC is marked at each perijove
(Enlarged x1.33 w.r.t. standard map)

- PJ22 (same as PJ16/21)
- PJ23

- (C) Map from image 51 (highest latitude) (down to 60°S at edges; half size)

