JunoCam at PJ38: What the pictures show (Part II)

John Rogers (BAA) (2022 Feb.21)

Our initial report on PJ38 can now be supplemented with information from full-quality images and maps that Gerald Eichstädt has produced. Here we present composite maps of the planet in our usual style. (As usual, unlabelled TIF versions are available if needed.) Further discussion of some interesting aspects is deferred to our report on PJ39, which covers much the same longitudes and features.

North Polar Region

The map of the circumpolar cyclones (CPCs) is Figure N1. The distortion of the north polar octagon is unchanged: as always, CPC-7 is displaced away from the pole (now at 81.0°N), and the central cyclone is displaced in the opposite direction (now 1.0° from the pole).

Figure N2 shows the composite RGB map of the northern hemisphere, and the single CH_4 map to the same scale. On this occasion, haze bands were not impressive in RGB images near the terminator, but were widespread in CH_4 image near the limb, as seen in this map. Nevertheless, a linear haze band pair can be seen under high sun in the N5 domain in Figure 3 (white on N side, brown on S side: light blue arrowheads).

Figure N3 is a close-up showing part of the Bland Zone (BZ), interrupted by a disturbed sector at left, which comprises a remarkable crowd of closely-packed vortices of various kinds. These include a tightly wound grey cyclone (just upper left of centre). The N6 and N7 jets are indicated approximately from the cloud textures. At right is an AWO of the N5 domain; these are often so far north that they cover the mean latitude of the N6 jet, and here we can see cloud streaks suggesting how the N6 jet veers around the AWO. Clusters of small popup clouds can be seen in and around this AWO and some other circulations.

The eye-catching ovals in the N4 domain, shown in Figure 2 of Part I, will be discussed in our PJ39 report.

Figure N4 is our global cylindrical map for PJ38.

Equatorial Region: The NEB(S) outbreaks

With the NEB(S) being in a very unusual state and showing a wide range of drift rates, this is a very fortunate opportunity to study the variety of features close up. We described these NEB(S) outbreaks in our 2021 Reports no. 6 & 7, esp. those that Juno imaged at PJ38 and PJ39, but did not yet have complete maps of the JunoCam images. With those now available and the ground-based observations completed, we can establish exactly what features were shown in the JunoCam closeup images. An updated analysis of the ground-based images, with Shinji Mizumoto, is being posted as our 2021 Report no.7, Part II (revised) (https://britastro.org/node/26505).

Figure N5 is an enlargement of the map covering the NEB & EZ*. Figure N6 shows some of the original images.

*[*Footnote*: All along the faded northern NEB at ~12-15°N, note a faint pattern of near-vertical stripes, with a mean wavelength of 1.16 (±0.05) deg or 1400 (±60) km.]

In this map, the most striking feature is the very bright white convective outbreak, Plume 6 in Mizumoto's numbering. This had appeared 8 days earlier, and like all these outbreaks, it was initially retrograding in L1, then (the day before PJ38) moved south to the NEBs edge and reversed its drift. It was short-lived but its drift rates were apparently similar to others, changing from ~ +1-2 deg/day to –1-2 deg/day in L1. JunoCam caught it while it was still a bright plume. Its thick white clouds are partly overlaid by orange streaks, and are surrounded by thinner whitish veils. Other features are labelled as follows.

(a1, a2) Two long white streaks in the NEB: a2 may be a trace of the original (retrograding) plume 6 before it moved S; a1, possibly a trace of plume 5 (which is now in northern EZ, out of frame to the right).

(b) This dark blue-grey patch is moderately methane-dark (P. Maxson, Nov.28), but was not recorded earlier, and is probably a temporary feature associated with plume 6.

(c) This vague blue-grey patch coincides with the strongly methane-dark patch that was still retrograding from plume 5. (These remarkable methane-dark patches are intense hot spots at 5 microns, in an image obtained by Gordon Bjoraker at the NASA IRTF on Nov.27.)

(d) This small grey festoon curves around plume 7, and may have just formed in association with it; alternatively, it may be a super-fast feature just passing by. (Small projections and festoons with 'super-fast' speeds of DL1 ~ –1 to -2.5 deg/day were a feature of the quiescent NEBs at this time, and in ground-based images, poorly resolved ones could account for some variations in the NEBs edge and in the blue-grey formations corresponding to the methane-dark patches.) Note a narrow orange band running within the grey festoon.

(e) Another orange band, cutting across the whiter streaks that may be lower.

(f) A very oblique blue-grey festoon, most likely a super-fast feature that was not well tracked.

(g) This small blue-grey projection with festoon is a typical super-fast feature, tracked by the JUPOS and ALPO-Japan teams from mid-Nov. to Dec.5, with DL1 = -2.5 to -2.0 deg/day.

The blue-grey features often appear to be overlaid by orange or whitish hazes. This appears to be the case with the two methane-dark patches (b,c), although they were only viewed at low resolution close to the limb, as was the best-tracked super-fast feature (g). But the images are consistent with the hypothesis that both prograding and retrograding blue-grey features are all unusually deep.

Southern domains

The southern hemisphere displayed a beautiful sequence of FFRs in each of the domains from S1 to S4, if we include STB spot 8. Images showing these are in Figure S1, including the best image yet of spot 8. (It would look very different at PJ39.)
Another interesting feature in Figure S1 is the chain of anticyclonic eddies following the S2-FFR. These appear to be a specially clear example of vortices being emitted in the retrograde flow west of a FFR. The global map (Figure N4) shows that they lead up to a fifth, larger vortex that is just preceding AWO-A1, suggesting that these small vortices may end up merging into a larger vortex and perhaps into AWO-A1 itself. We followed just such a phenomenon in this domain a few years ago, which led to the formation of a medium-sized AWO that we called A5a, although it eventually broke up on encountering another FFR.

South Polar Region

Figure S2 is our composite map of the SPR (down to 45°S), showing the now-familiar features. The central part is enlarged in Figure S7 to show the CPCs and the Long Band. The Long Band, as at recent perijoves, is visible as a dark band right across the sunlit disk, tangential to some CPCs, and fraying into several strands at the f. end (see also Figs.S3-S5).

The northward drift of Juno's perijove means that, orbit by orbit, the spacecraft's course over the southern hemisphere is ever higher and slower. This means lower resolution but increased time of observation, and now JunoCam's outbound images allow some narrow parts of the SPR to be observed on two consecutive rotations. Interpretation is compromised by the low resolution and imprecise mapping (inevitable when the early and late images are taken from such very different viewing angles), but is still of interest:
--Figure S3 is a blinkable pairing of early images 45&46 with late images 85&87. At left we can see a complex FFR which shows the expected shear between the S6 prograde jet on its north side and the retrograde flow on its south side.
--Figure S4 compares the terminator regions of images 46&49 with images 87&91 – two pairs with almost the same subsolar longitudes. The main haze bands appear in much the same positions in early and late images, showing that they do not move or change enormously in 10 hours – although some changes may occur. This applies to the bright haze bands seen at the terminator, and to the dark strands that constitute the Long Band.

Therefore, our maps of the terminator regions at dawn and dusk, showing the high-altitude haze patterns, each cover a little more than one rotation, and we need 3 maps to display them. Figures S6A & B show the dawn and dusk terminators, respectively, omitting the late images; Figure S6C shows both dawn and dusk in the late images.

These maps have all been cropped to 45°S at the edges, as we do not see any haze bands below that latitude. JunoCam currently takes alternate high-quality and low-quality images during its outbound phase, to maximise coverage within the limits of data volume, and this is evident in the noise levels in the terminator maps.
The maps & images in this report, all processed by Gerald Eichstädt, have all been subsequently colour-adjusted, and the terminator has been enhanced separately. This brings out the artefactual green-and-magenta striping in the terminator regions, which is still present although I have reduced the saturation. As always, care must be taken in assessing colours near the terminator.

Haze features over the S4 & S5 domains:
We have reported a pattern of oblique bands over these domains – mostly at ~54-62°S, esp. in the dawn maps -- from PJ34 onwards. As we noted with the PJ35 maps:
"They generally confirm a dense pattern of streaks between ~50-60°S (as well as further south), particularly the linear, slightly oblique bands between 54-60°S in the dawn sector. They do not show any periodic pattern, unlike at PJ34. They are not so distinct in the dusk sector, but taking both dawn and dusk together, we can see that these bands are mostly part of a chevron-shaped series (>>>), which complements the underlying ZWP of the S4 domain, but the southern limb of the bands extends across the S5 jet into the S5 domain, like the linear bands in the northern hemisphere."
At PJ38, the maps confirm this picture.

The early images show a striking haze feature in the S4 domain as it rotates into sunlight (Figure S5). Actually we see a series of four haze bands with typical >-shaped orientations over the S4 domain, each of which fades as it rotated further onto the sunlit side:
(1) Narrow bright band casting a shadow in image 40.
(2 & 3) Together these bands form the apparently thick elevated wedge in images 40-42. As it becomes fully sunlit, the centre thins to reveal that the Sp. edge was a very bright rainbow band (2), while the Nf. edge appears principally as a dark band (3). But when the illumination is reversed at dusk (Fig.S6B -- see below), band 3 becomes bright and band 2 is dark (shadow). The wedge overlies two small anticyclonic rings, whereas its Np. end is aligned with a FFR, and these circulations could be responsible for its wedge shape. So the wedge is an elevated feature whose edges catch the sunlight or cast shadows; it is optically thick enough to obscure underlying features when illuminated at a low angle, but not when at a high angle.

(4) A long linear band, extending across the S5 jet, bright, with a dark band (shadow?) on its Sf. side; it overlies a small S4 AWO.

The wedge shown in Fig.S5 is seen both at dawn and dusk (Fig.S6A&B). A similar feature ~120° longitude away is seen in the dusk maps (both Fig.S6B&C, 10 hours apart; also see Fig.S4, which shows it projecting over the dusk terminator).

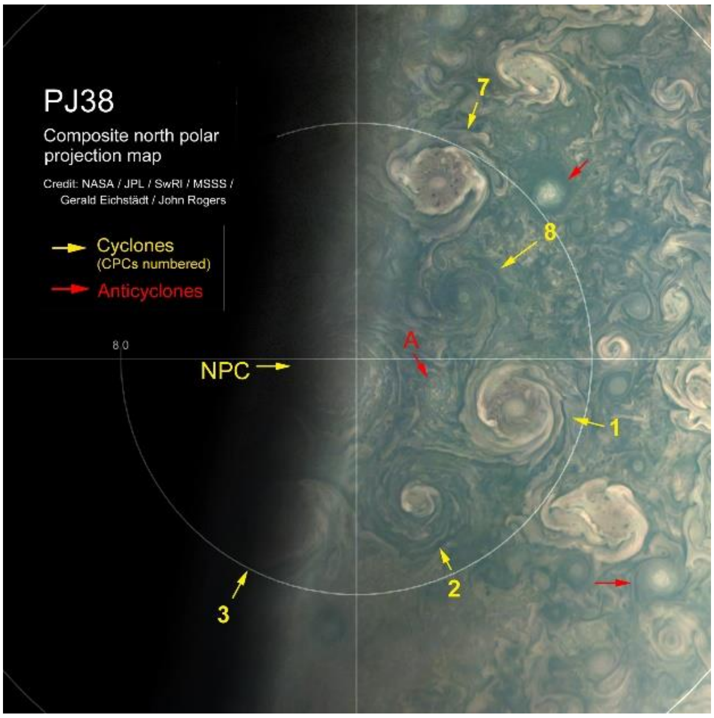
Haze features further south:
In the dusk terminators map (Fig.S6B), a striking feature is a sinuous bright band, extending ~110° longitude from 65°S to 72°S. It has a dark band or shadow in its S side, but does not appear dark under full sun (Fig.S2) – in fact it appears faintly bright, overlying the southernmost belt of FFRs [this region was close to the limb in the relevant images, hence its pinkish tone, so haze bands were more visible]. It is not clearly visible in the dawn map. This is distinct from the Long Band further south, but at its f. end it curves south and joins one of the splayed f. branches of that Long Band (Fig.S6B).
The long-lived Long Band itself is seen as a dark band under high sun (Fig.S2), but only weakly in the terminators maps.

Circumpolar cyclones (CPCs):
All 5 CPCs can be recognised, although their peripheries are no longer resolved so they are indicated speculatively on Figure S7. We note a curious brown pear-shaped structure, presumably cyclonic, intruding on the edge of CPC-5. The central cyclone is now in darkness.

On following pages:

Figures (miniature copies)

Figure N1. North polar map down to 75°N at the edges, showing the CPCs (numbered).



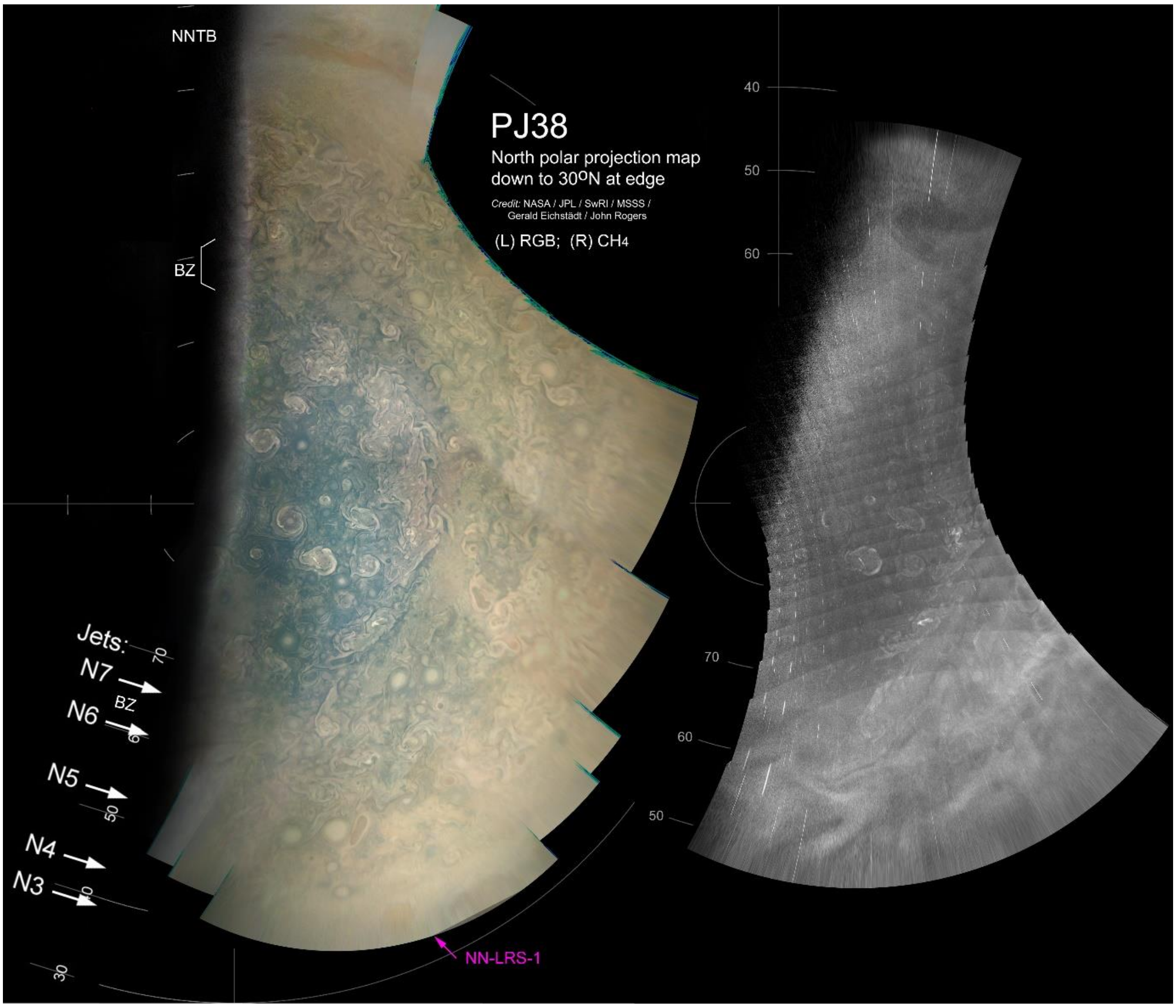


Figure N2. North polar projection maps down to 30°N at the edge: RGB (L) & CH_4 (R).

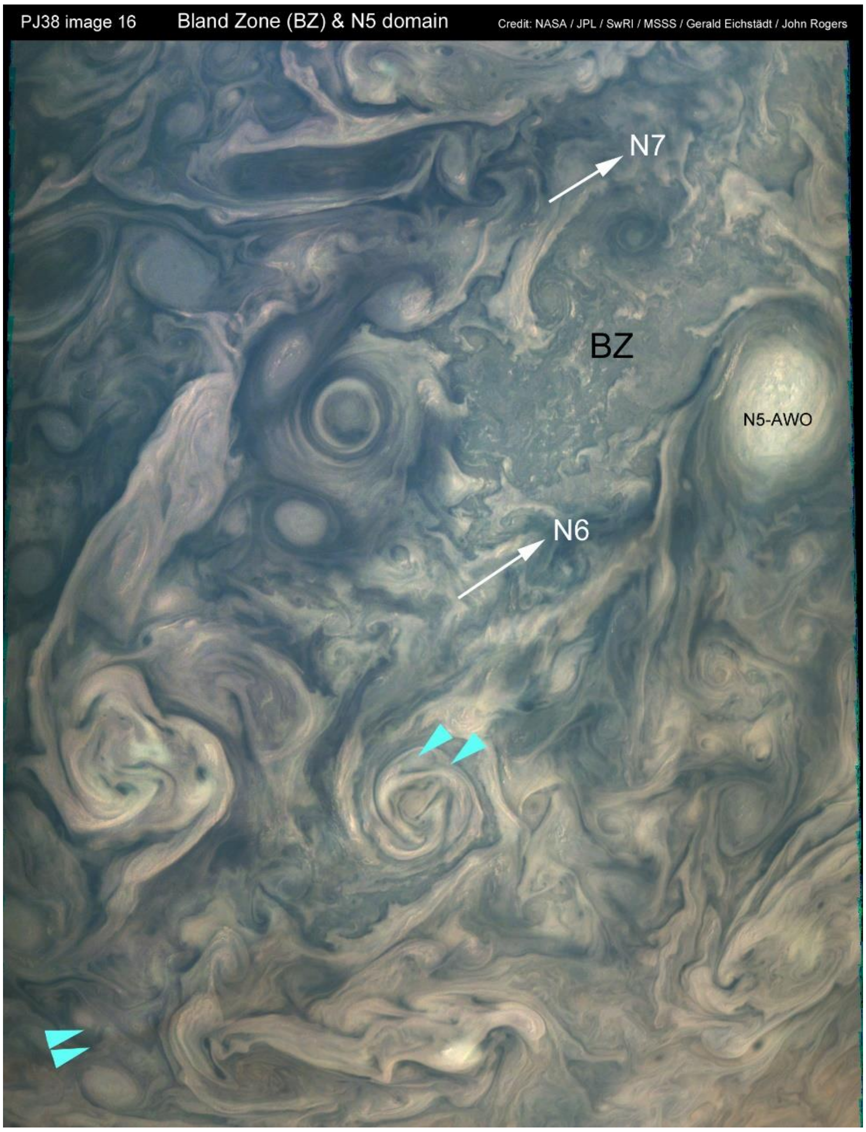


Figure N3. Image 16 showing part of the Bland Zone (BZ) & S5 domain.

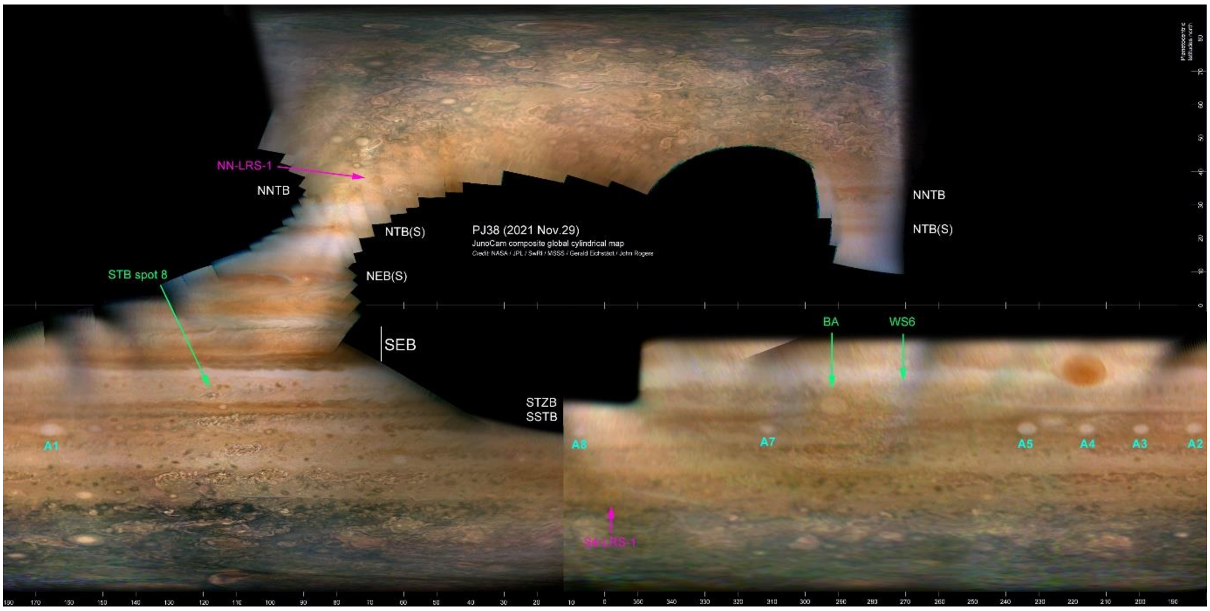


Figure N4. Global cylindrical map.

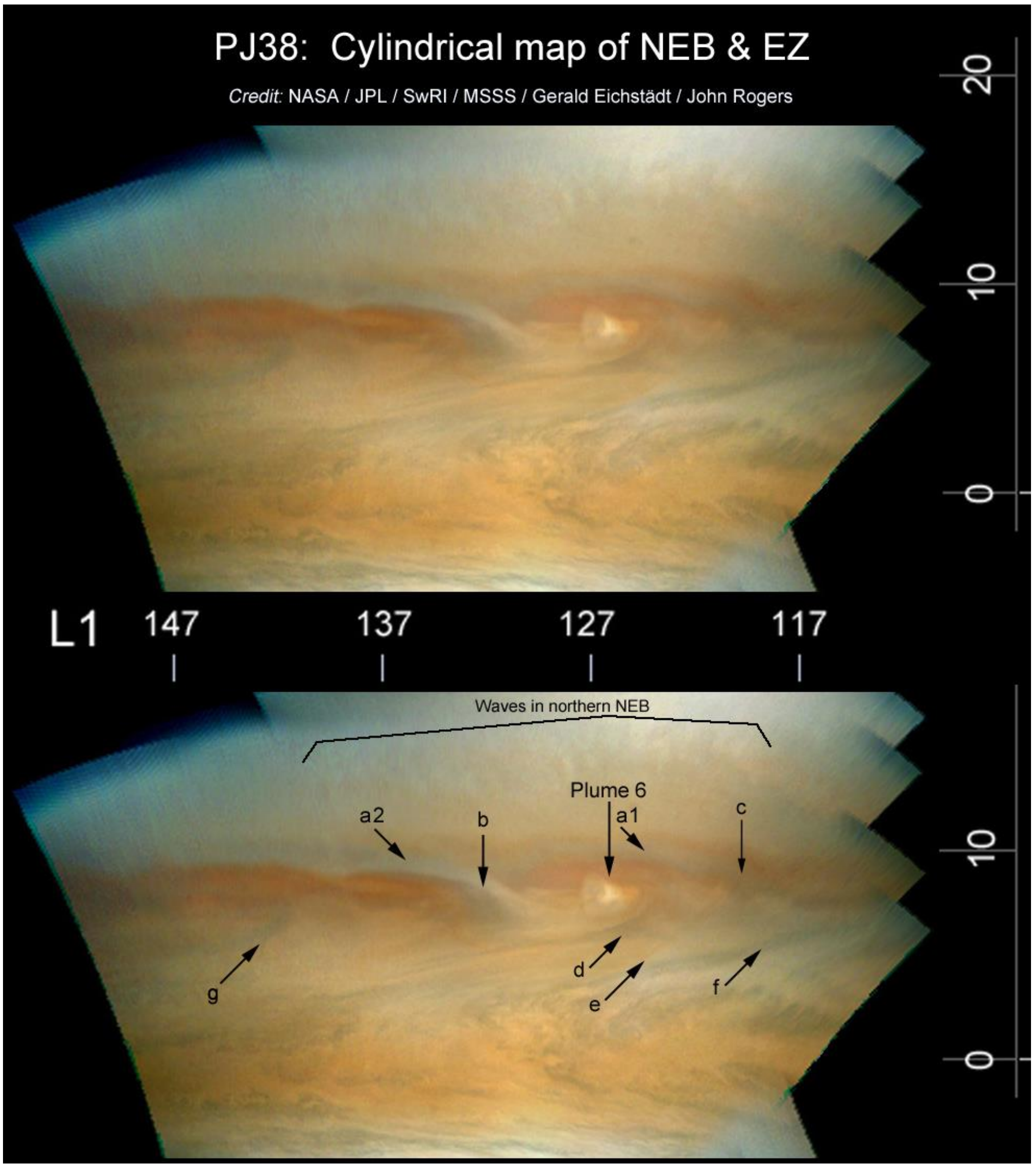


Figure N5. Part of the cylindrical map, covering the NEB & EZ. *Below:* Features of the NEB(S) outbreak are labelled (see main text), as well as a wave pattern in the faded northern NEB.

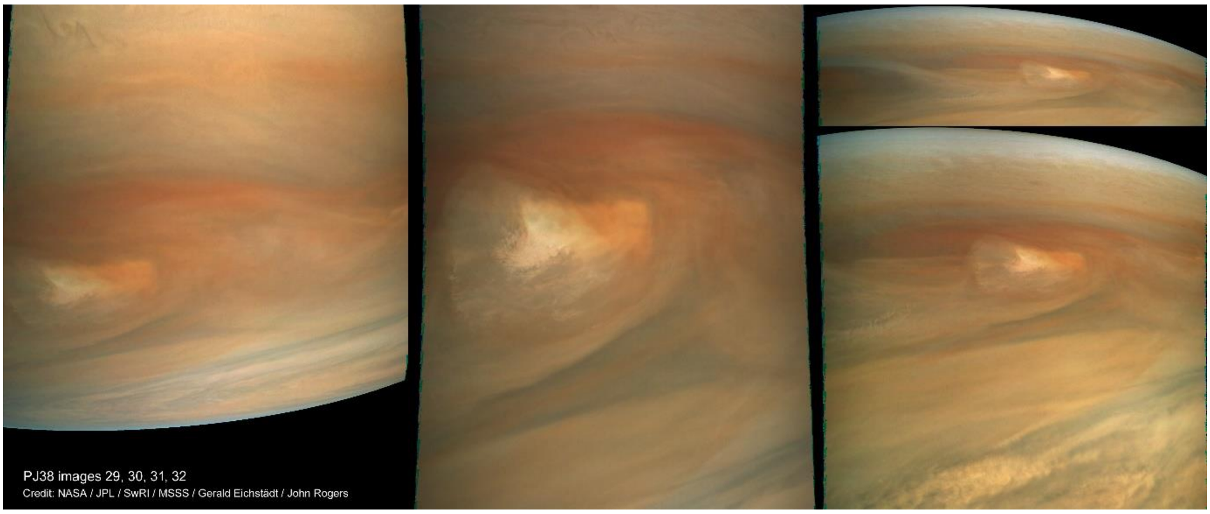


Figure N6. Original images of the NEB(S) outbreak.

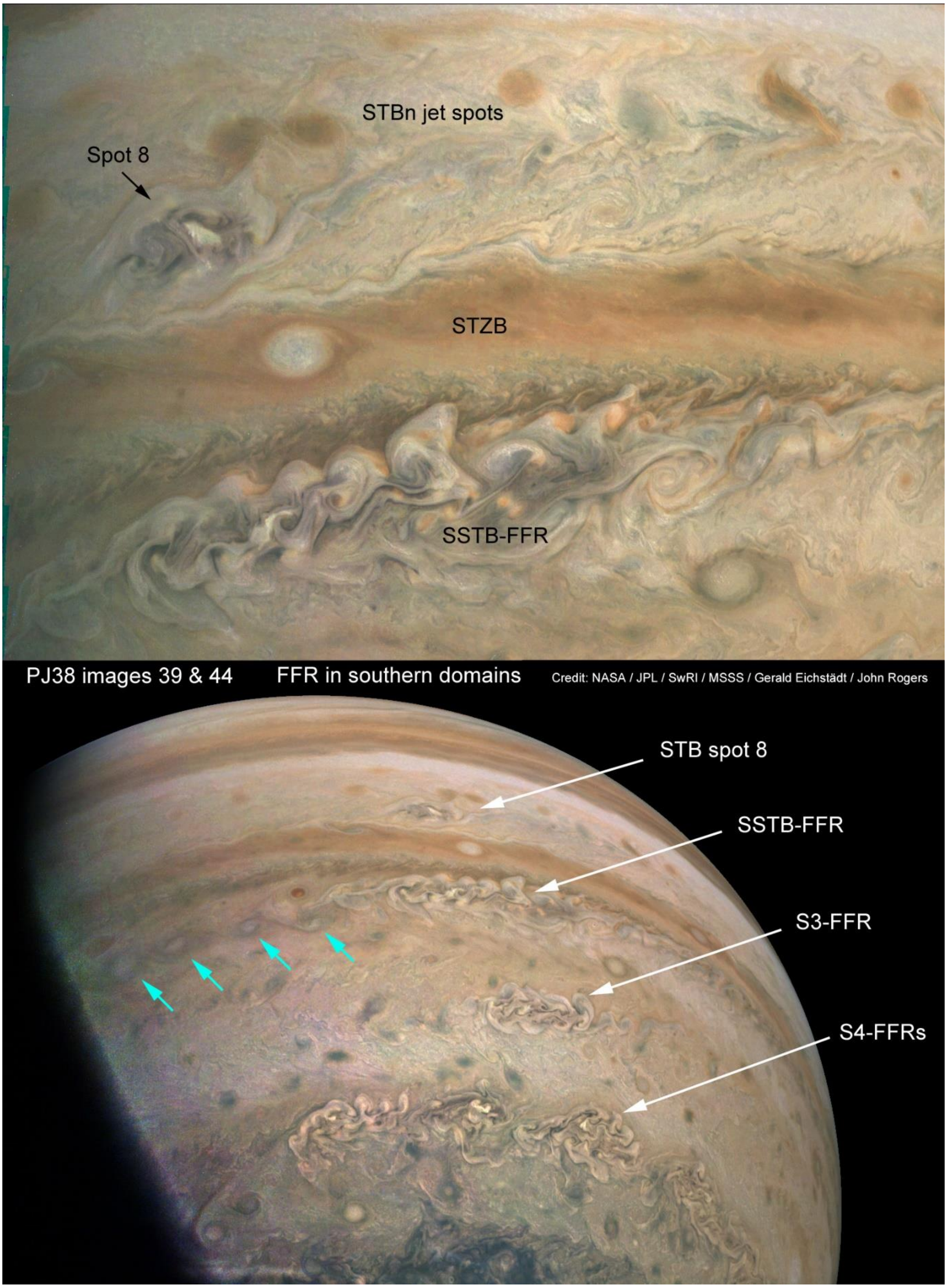


Figure S1. Original images showing the FFRs in domains S1 to S4, including STB spot 8.

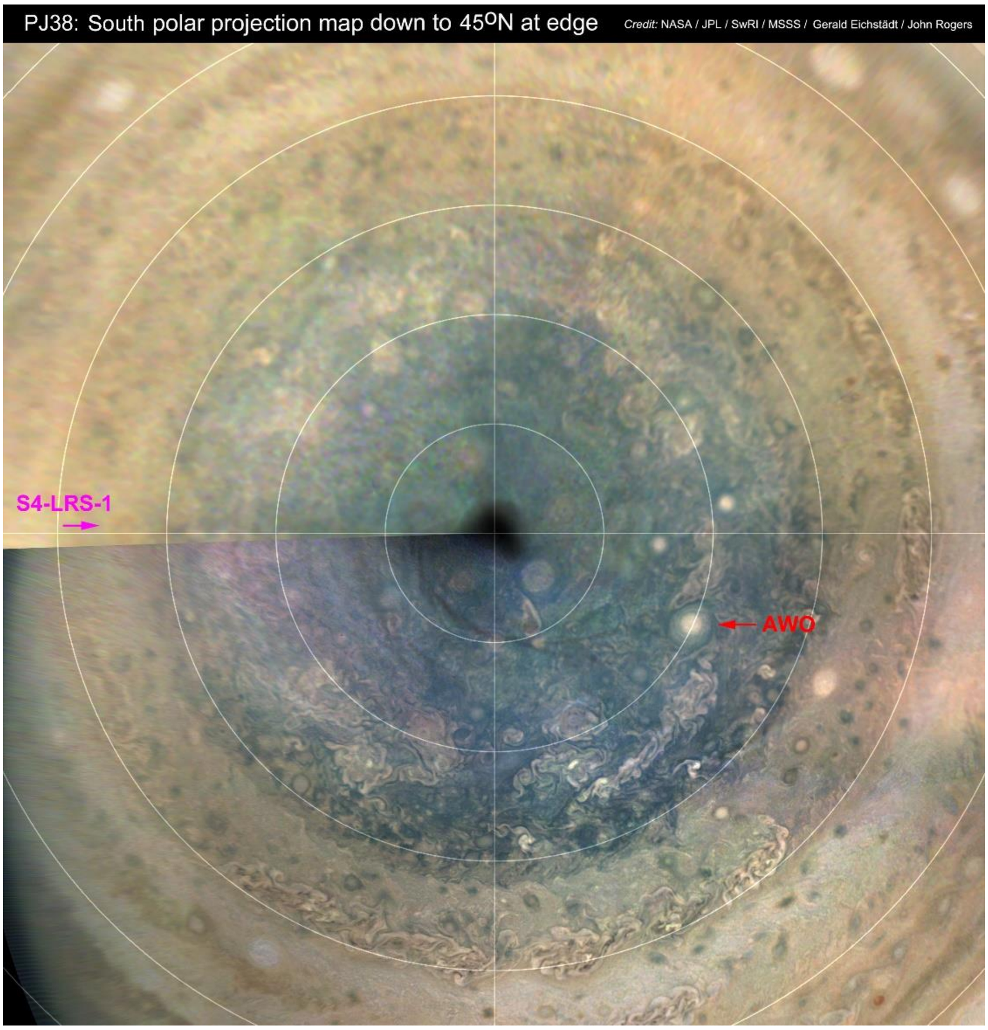


Figure S2. Composite south polar projection map of the South Polar Region.

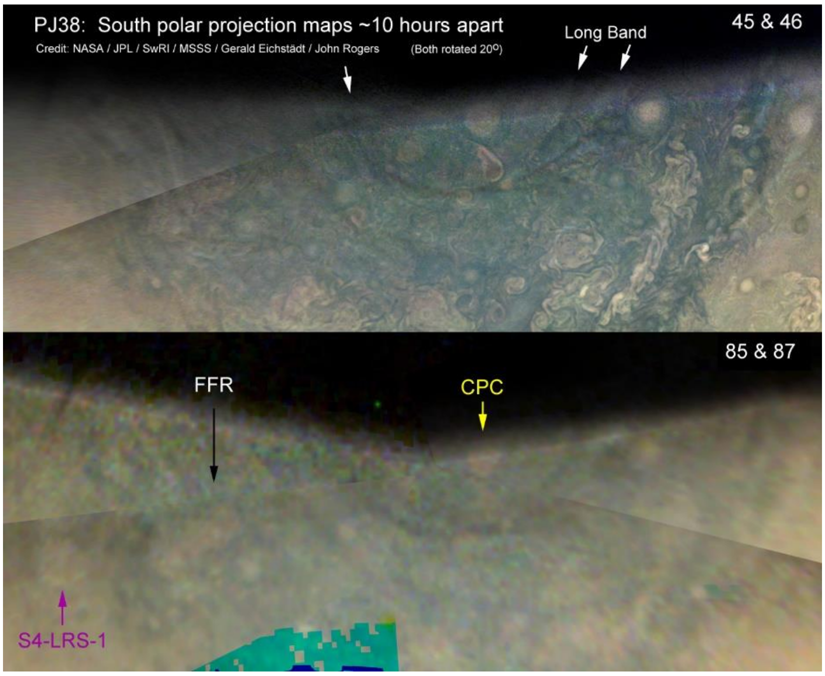


Figure S3. Paired south polar projection maps of early images 45&46 and late images 85&87. (They can be blinked.)

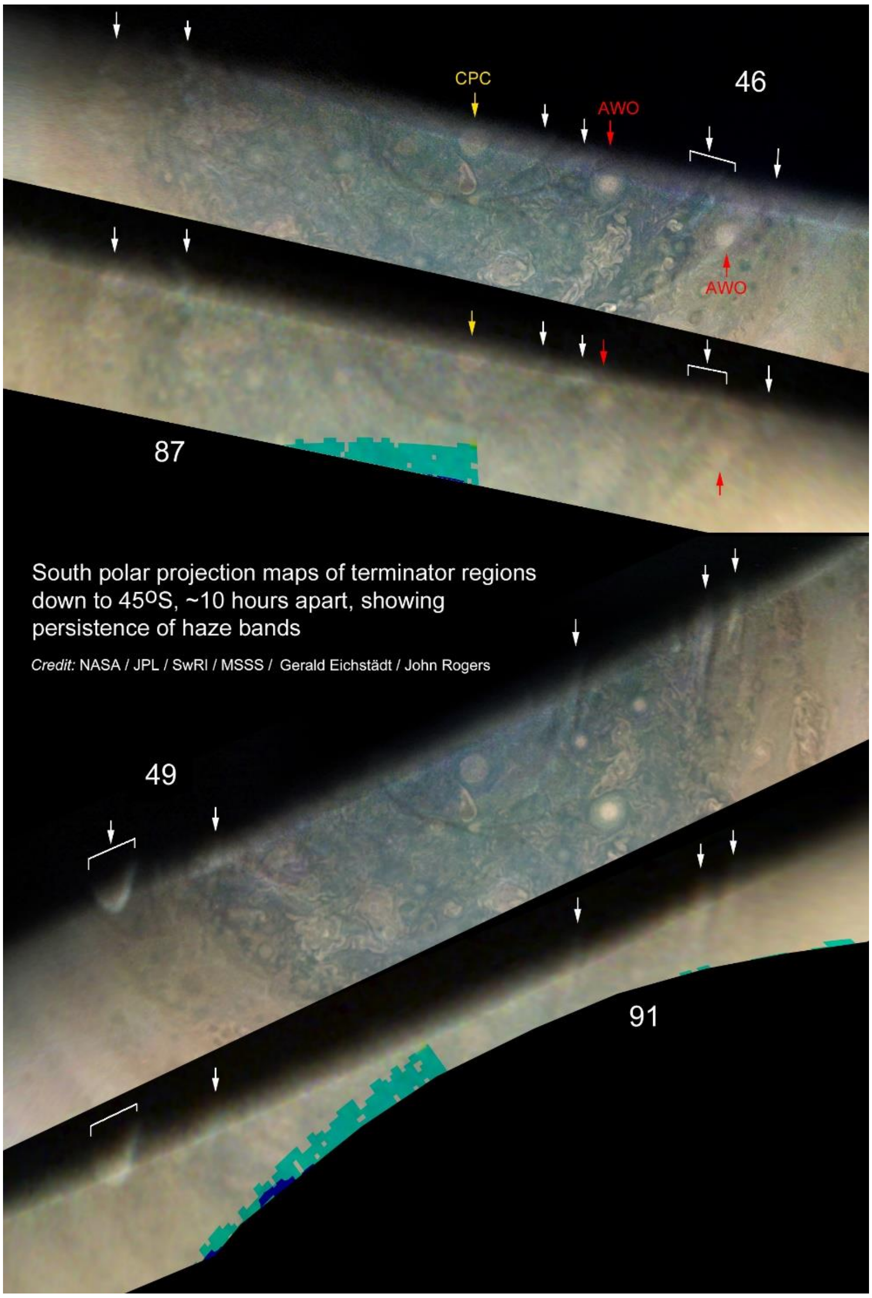


Figure S4. Paired south polar projection maps of the terminator regions of images 46&49 and images 87&91 – two pairs with almost the same subsolar longitudes, ~10 hours apart.

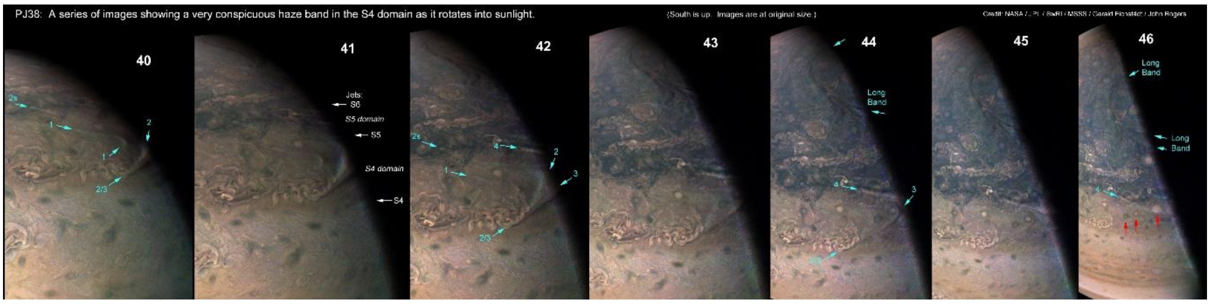


Figure S5. Series of images showing a striking haze feature in the S4 domain as it rotates into sunlight. Actually we see a series of four haze bands with typical >-shaped orientations over the S4 domain, each of which fades as it rotated further onto the sunlit side (see text for details). The dark Long Band around the south polar pentagon is also well shown in this series. *South is up.*

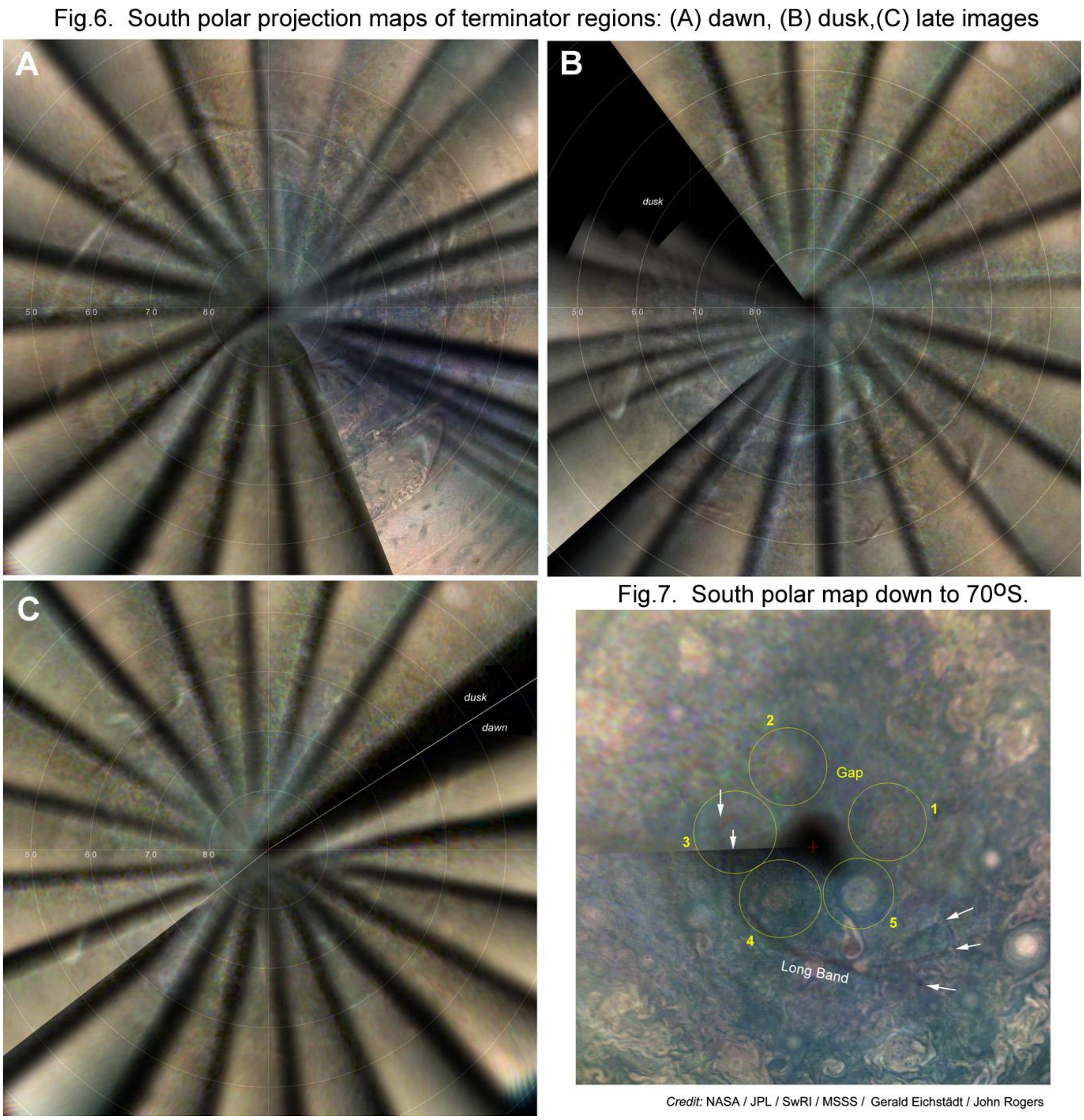


Figure S6. Composite south polar projection maps of the terminator regions.
(A) Dawn terminators; (B) dusk terminators; both omitting the late images. (C) Both dawn and dusk in the late, lo-res images.

Figure S7. Enlargement of the central part of Fig.S2, showing the CPCs (numbered, with boundaries speculatively marked) and the Long Band (arrowed).