Jupiter's north polar region from Pioneer 11 to Juno

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Introduction & Summary

The main structural features of Jupiter's visible atmosphere are the eastward jets; their regular pattern was discovered by Voyager and has remained fixed since then. They divide the atmosphere into a series of 'domains' which we number [ref.4] as in Figure 1. Latitudes >60ºN, and especially, north of the uttermost jet (N7), were not well viewed by earlier spacecraft, but have been thoroughly mapped by images from Juno since 2016 [1].

We now look back at the map of the north polar region obtained by Cassini in 2000 [2], and the very first images of it by Pioneer 11 in 1974 [3], to see whether they recorded any of the features that are now familiar, and whether any changes can be inferred.

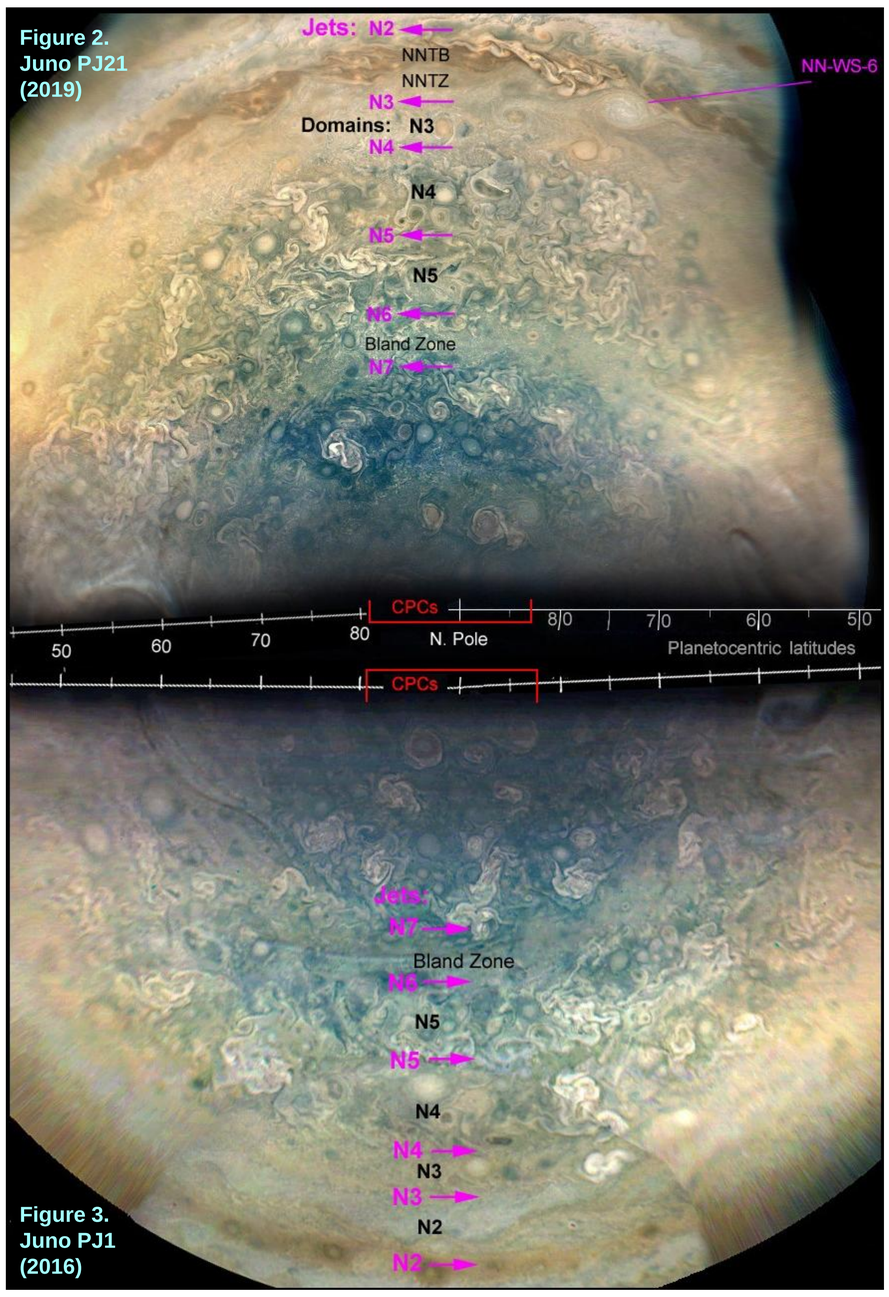


Figure 2. Juno PJ21 (2019)

Figure 3. Juno PJ1 (2016)

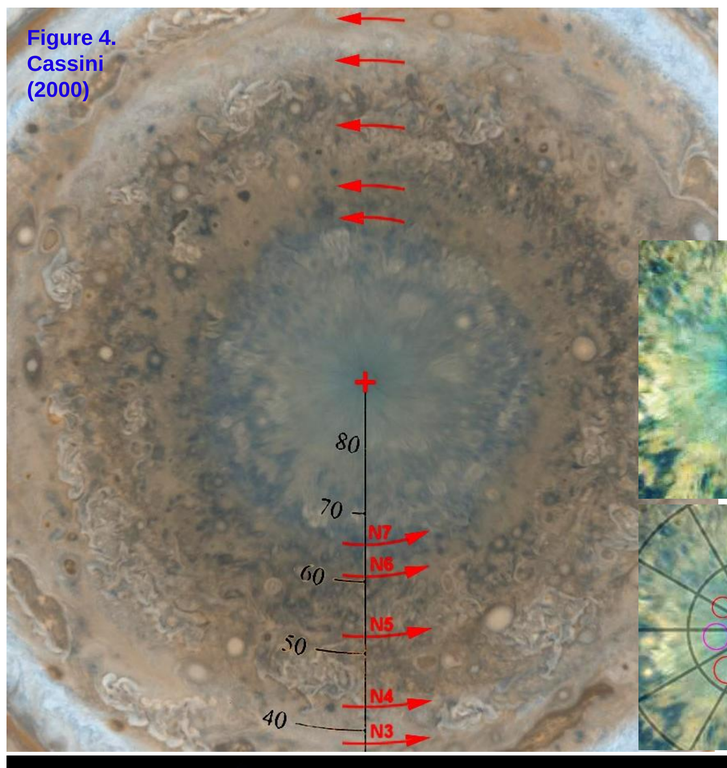
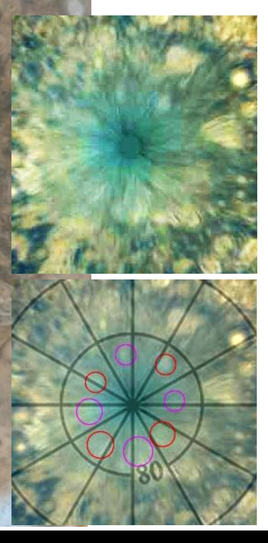


Figure 4. Cassini (2000)

Below: Polar region, enlarged & enhanced, with putative CPCs outlined.



1. Data sources

Juno: JunoCam images [1,7] are assembled and transformed into polar projection maps by algorithms specially created by G.E. These are then merged manually to create a polar projection map for each perijove (PJ) (e.g. Figures 2 & 3).

Cassini: North polar map in colour: PIA07783 (Figure 4) [2]. Animated north polar maps in near-infrared revealed the jet motions [2].

Pioneer 11: High-quality prints in [3] and original NASA prints: images D1 and D4. An approximate latitude grid was superimposed by reference to [3] (Figure 5). Latitudes and north pole position may be uncertain by a few degrees.

2. The N4 and N5 domains

Juno & Cassini: The N4 and N5 domains (47-64°N)* appear chaotic, being mostly filled with irregular stormy cyclonic patches called folded filamentary regions (FFRs), plus a few anticyclonic white ovals (AWOs) (e.g. Figure 6). Although the jets are not obvious from cloud textures in single images , animated maps from Cassini images [2] showed all the jets up to N7, and JunoCam has shown far more detail [ref.1, & reports on each perijove at: https://www.britastro.org/section_front/15].

Ground-based observations found a change in behaviour of AWOs in the N4 domain around 2012 [4]: their eastward drift rates were often slow up to 2012, but usually fast thereafter, suggesting that they were further north.

Pioneer 11: A narrow, largely featureless zone was imaged at ~52ºN or 55ºN, in the anticyclonic side of the N4 domain. No such zone is present in the Juno maps, so this suggests another systematic change in the behaviour of this domain.

**(Latitudes in the text and on the Pioneer images are planetographic, but those on Cassini and Juno maps are planetocentric.)*

3. The N6 domain and Bland Zone

Juno & Cassini: There is a visually bland zone at ~63 to 67-68ºN (e.g. Figure 6), approximately between the two northernmost prograde jets at 64 and 68ºN. Sometimes a sector of it appears disrupted, but otherwise it has been a permanent feature since Cassini. Juno images under low sun show a regular pattern of slightly oblique linear haze bands overlying it.

Pioneer 11: The Bland Zone is only doubtfully visible in the Pioneer images,but this may be because Pioneer happened to view a disrupted sector, as Juno sometimes does.

4. The Circumpolar Cyclones (CPCs)

Juno: JunoCam's first images revealed clusters of large spiral cyclones at each pole [1]. At the north pole they form an octagon, centred on a ninth cyclone now in darkness [5]. Due to Juno's orbit, it takes four orbits to image the whole octagon well illuminated. Nevertheless, it is evident that the pattern has not changed nor moved greatly [6] (Figure 7).

The octagon is a 'double square', with four CPCs whose central regions are filled with largely continuous reddish cloud decks, alternating with four CPCs with more chaotic or diverse structures. Individual CPCs have largely preserved their characteristic morphologies for nearly 3 years [6]. The 'filled' CPC-7 has drifted further from the pole, displaced by an AWO within the octagon, and yet the octagon has remained intact up to PJ21 (Figures 7 & 8).

Cassini: The polar map (Figure 4) shows a ring of white, roughly circular patches at 83-85ºN, similar to the present octagon. This may well be the same set of CPCs.

Pioneer 11: North of the Bland Zone, image D1 (Figure 5) shows some resolved FFRs and numerous smaller light patches, as in the Juno maps; and closest to the pole, at the terminator, are two roughly circular light patches at ~82.5ºN, which are likely to be two of the CPCs.

5. Conclusions

While the latitudes of the high-latitude jets have not shown definite variations since Voyager in 1979, the patterns of features in the N4 to N6 domains have shown some changes. The Bland Zone has existed at least since 2000, but its presence in the N4 to N6 domains have shown some changes. The Bland Zone has existed at least since 2000, but its presence in 1974 was unclear.

The cluster of northern CPCs has been largely unchanged from 2016 to 2019 (Juno), and probably also existed in 2000 (Cassini). The Pioneer 11 image is consistent with similar CPCs existing in 1974.

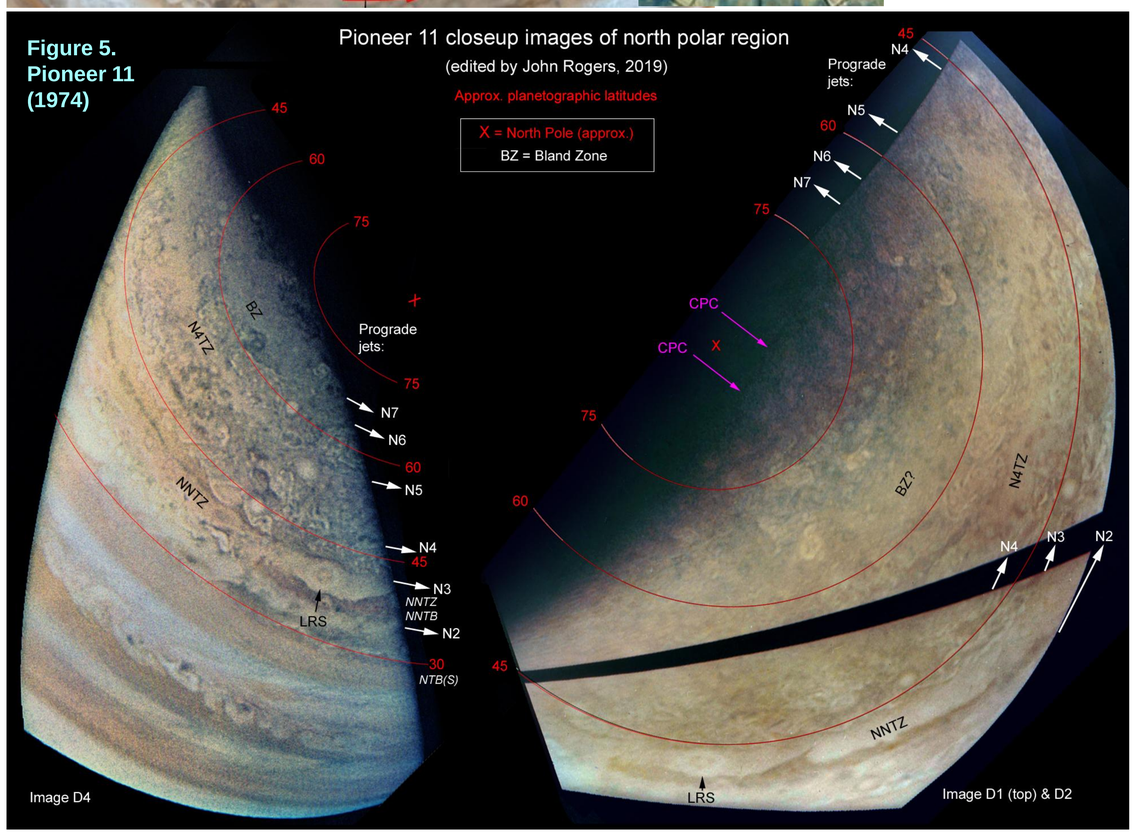
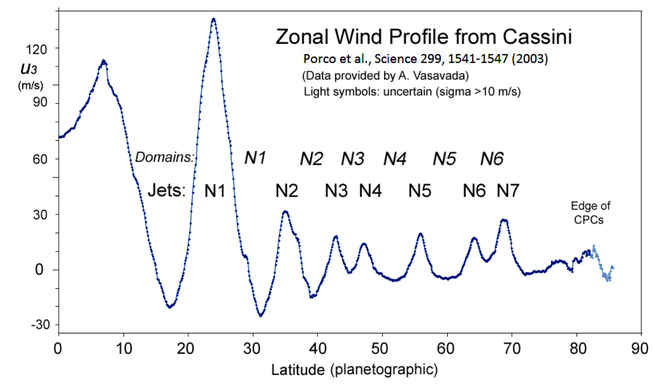


Figure 5. Pioneer 11 (1974)

Figure 1.



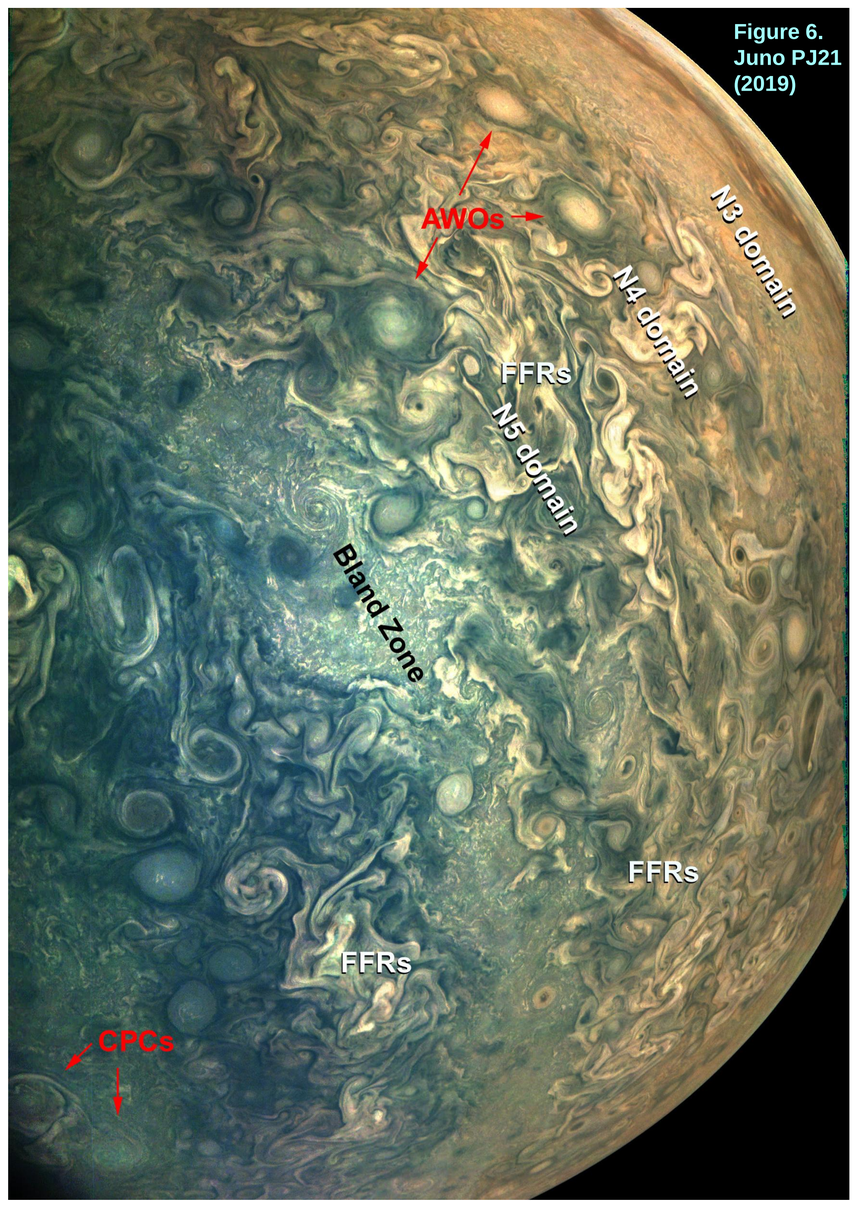


Figure 6. Juno PJ21 (2019)

Figure 7. Composite north polar projection maps (down to 75°N planetocentric at edges), showing the 8 CPCs (numbered as in [5]). L3=0 to left. Some maps have been slightly shifted or rotated, as noted, to optimise alignment of the CPCs.

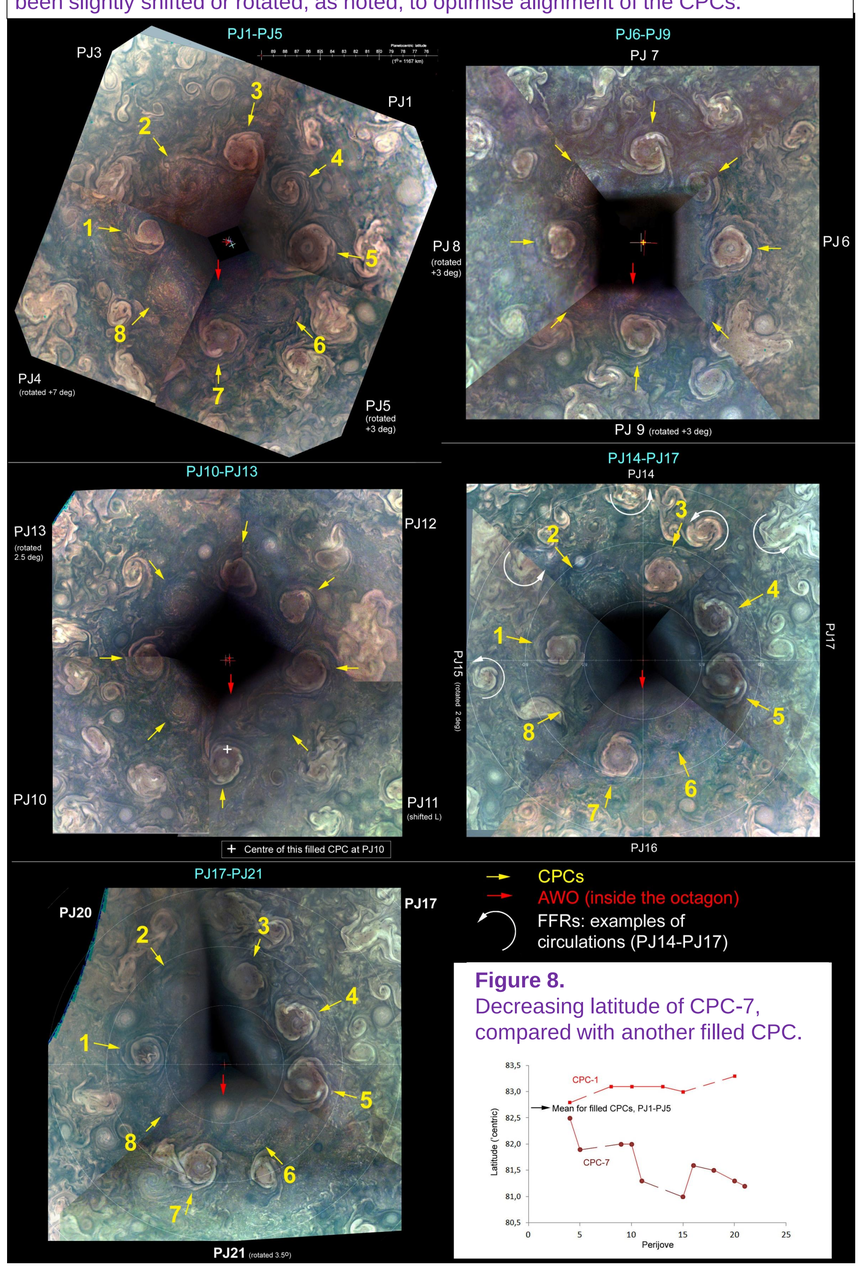


Figure 8.
Decreasing latitude of CPC-7, compared with another filled CPC.

Acknowledgements

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