Jupiter's S2 (South South Temperate) domain, 2012-2023.

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Figures

Section 1

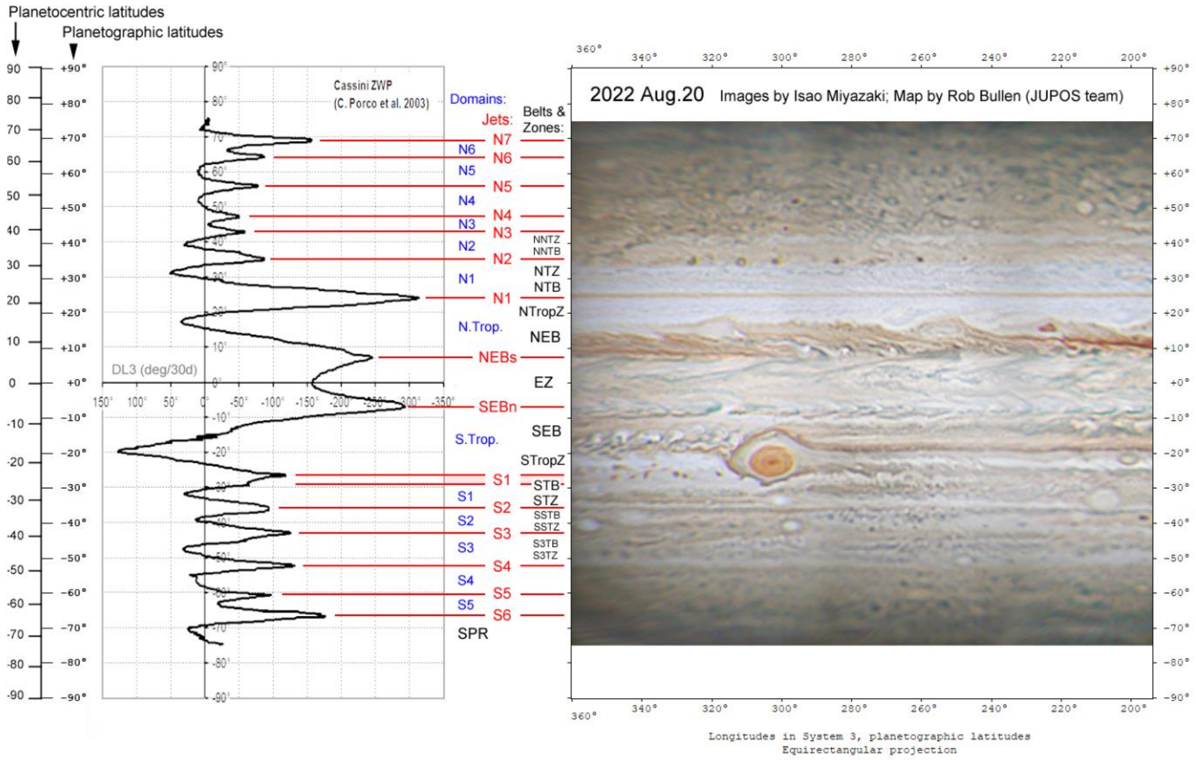


Figure 1. Jupiter's jets, domains, belts & zones, as defined in Ref.1 but shown with north up. (From Report 2022/23 no.8). The ZWP is from the Cassini flyby (Ref.22).

Figure 2. Images by Damian Peach in 2022 Sep., illustrating the best resolution that amateur observers can now achieve in this domain.

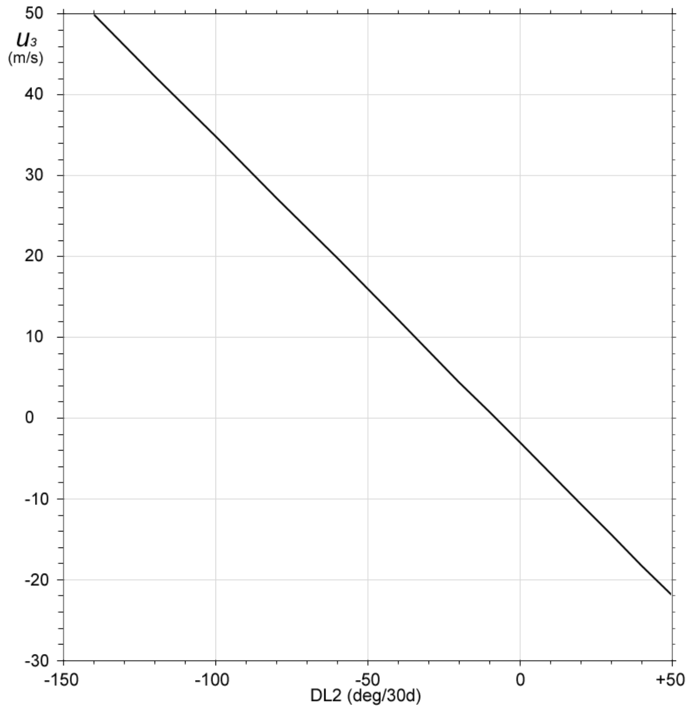


Figure 3. Relationship between DL2 vs u_3, for 40.0ºN (planetographic).

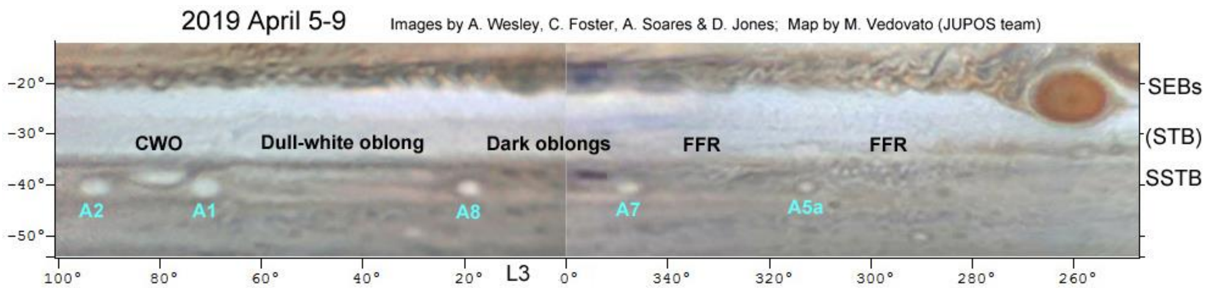


Figure 4. JUPOS map of part of the southern hemisphere with examples of typical S2 domain features labelled. 2016 April 5-9. Latitudes are planetographic.

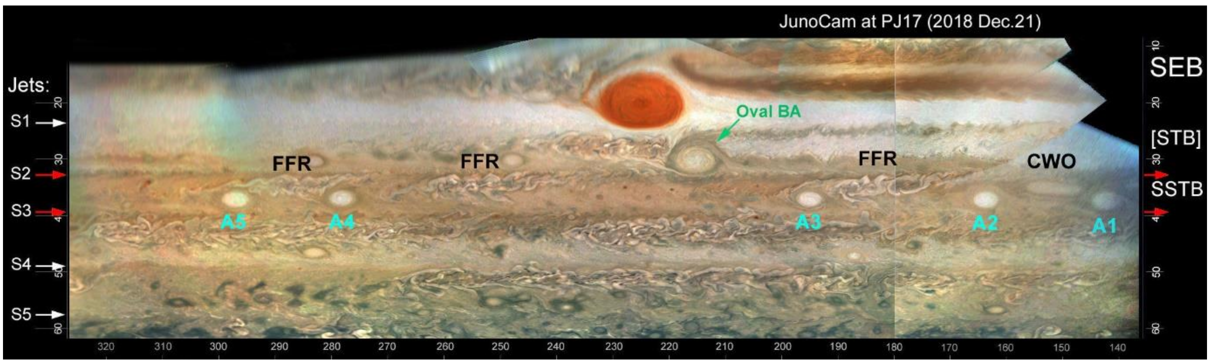
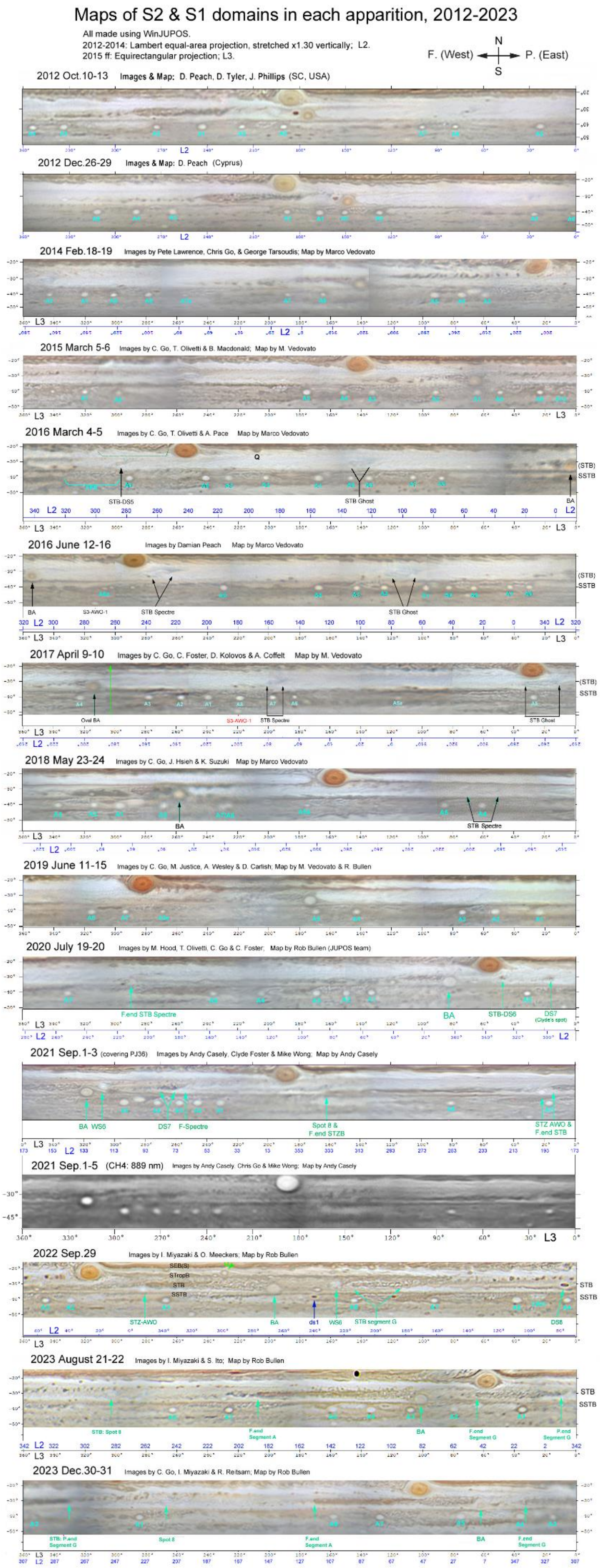


Figure 5. JunoCam map at PJ17, showing part of the southern hemisphere with examples of typical S2 domain features labelled, as well a the prograde jets. The S2 domain lies between the S2 and S3 jets (red arrows). Latitudes are planetocentric.

Figure 6. A selection of our ground-based maps covering the S1 and S2 domains – one of the best from each apparition, taken from our previously posted reports.



Sections 2 & 3

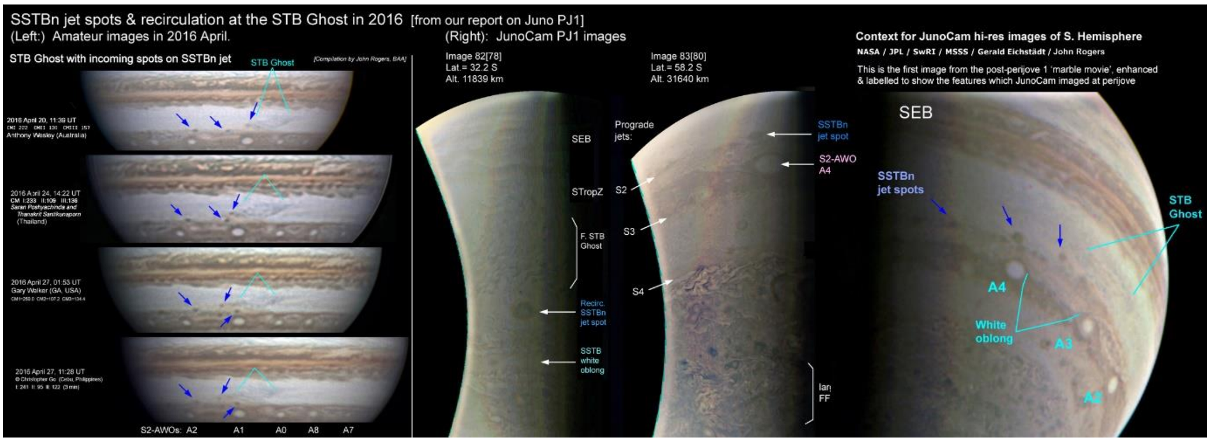
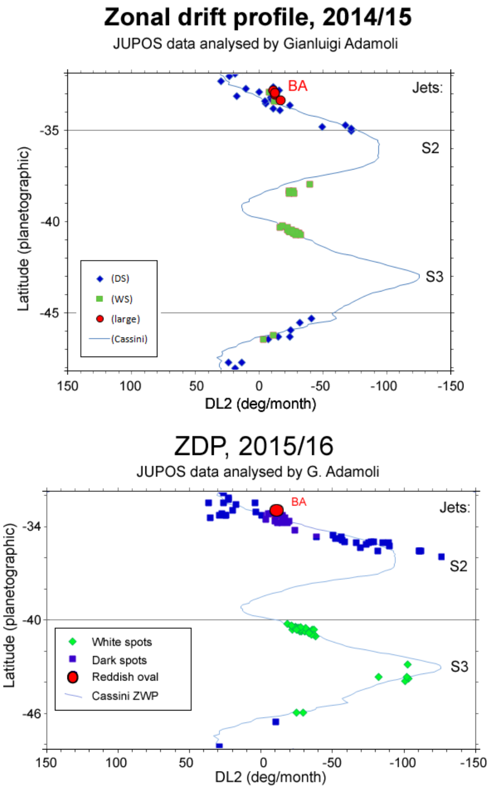


Figure 7. SSTBn jet spots in 2016, from ground-based images (2016 April) and Juno's first flyby (2016 August). These images are near the STB Ghost, where SSTBn jet spots were moving from prograde on the SSTBn to retrograde in the STZ via an anticyclonic 'recirculation loop' just f. the cyclonic Ghost. (Adapted from our PJ1 report; as these were mainly test images, the quality was not as good as subsequently.)



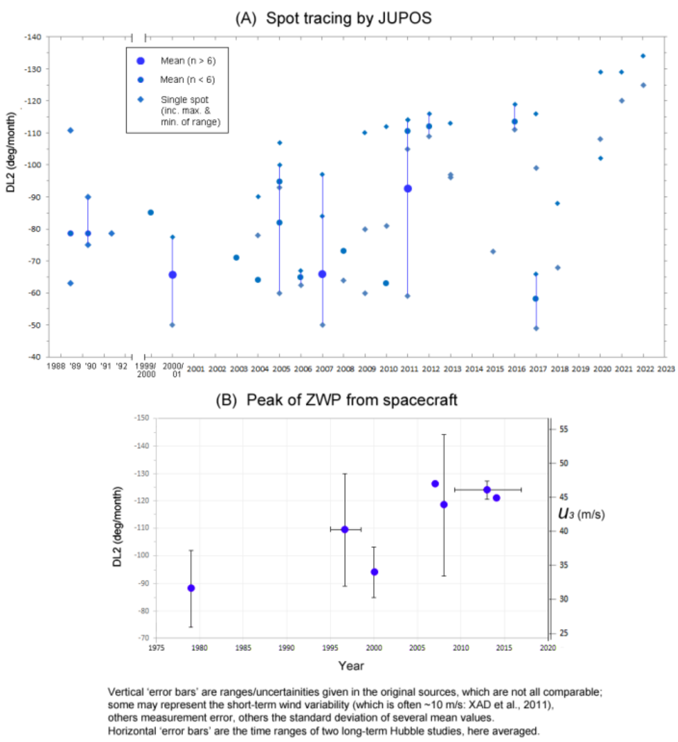


Figure 8 *(left)***.** Zonal drift profiles (ZDPs) from JUPOS data in 2014/15 and 2015/16, covering the S.Temperate Zone (STZ) up to the S2 jet. (Data for the rest of the S2 domain was not analysed in detail, apart from the AWOs, whose latitudes may be artificially constrained in the JUPOS data; but see Figure 12.)

Figure 9 *(right)***. Speed of the S2 jet.** (A) Spot tracking in amateur images, since the first detections in 1989 (including data from Ref.1). (B) Peak of ZWP from spacecraft, since Voyager in 1979. (See further comments on the figure.)

Figure 10. Speed of the S3 jet. (A) Spot tracking in amateur images, since the first detections in 2002 (including data from Ref.1).

(B) Peak of ZWP from spacecraft, since Voyager in 1979. (See further comments on Figure 9.)

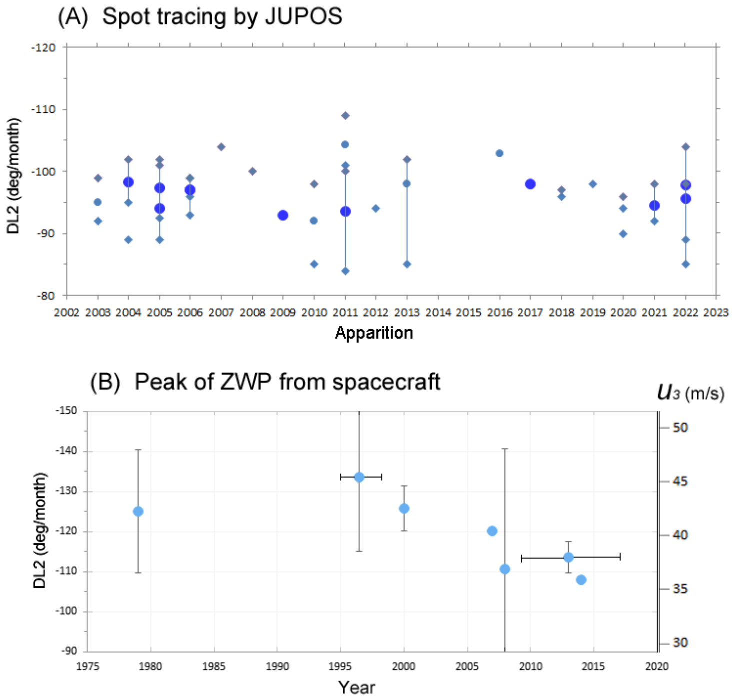
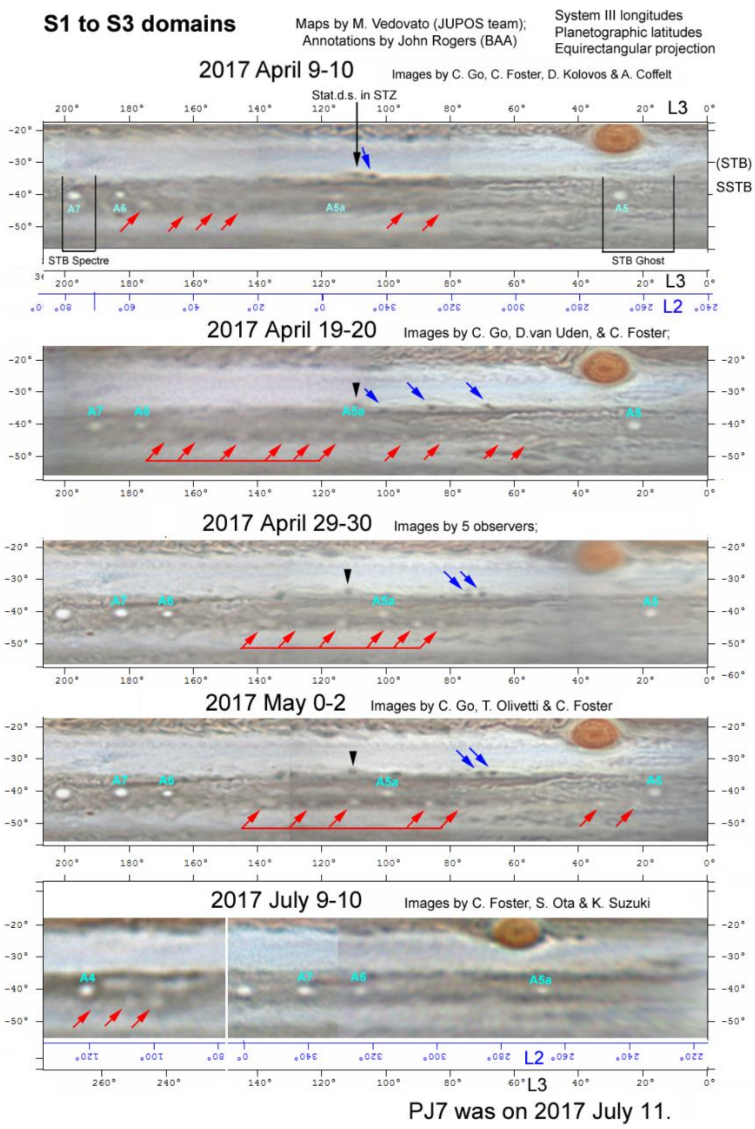


Figure 11. JUPOS maps of the S1 to S3 domains in 2017, showing prograding spots on the S2 jet (blue arrows, dark spots) and the S3 jet (red arrows, white spots, presumably cyclonic).

(By the time of Juno's PJ7 on July 11, the S3 spot chain had passed on p. the GRS. The chain can be seen in JunoCam maps from outbound images, but no closeups of it were obtained.)

The black arrowhead marks a near-stationary spot in southern STZ. These maps also show the sector from A5a to the large FFR p. A5, but the FFR appeared to be rather quiet during April, so no vortices were tracked f. it.



Section 4

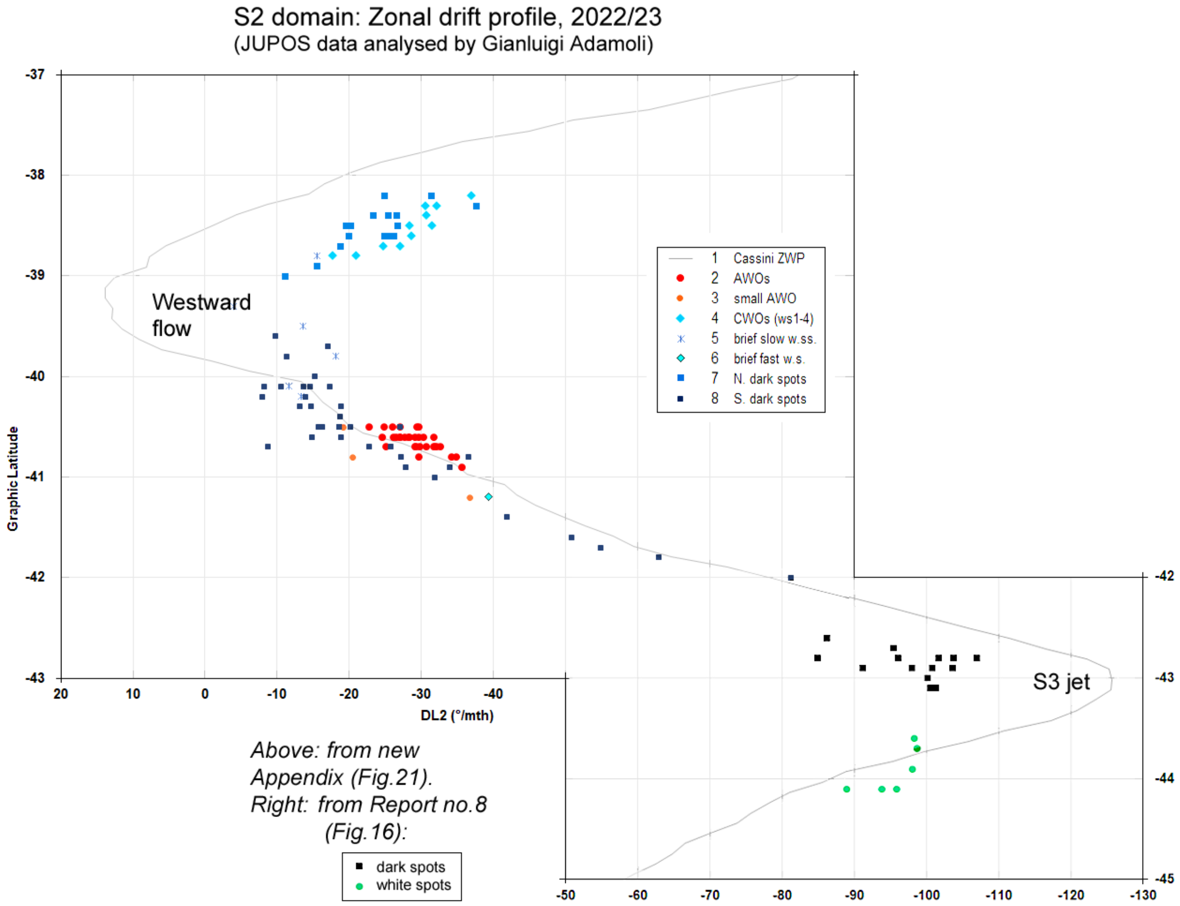


Figure 12. Zonal drift profile (ZDP) from JUPOS data for 2022/23. Adapted from Report 2022/23 no.8 with new Appendix. (q.v. for details).

There is little difference between dark and bright spots, or between longitude sectors. There may be a slight difference between large and small spots, but this could be an artefact. The JUPOS measurers sometimes use the AWOs in this domain as a latitude standard, checking that they are measured close to 40.5ºS, although their latitudes do vary. The AWOs on this chart (red points) show variations which parallel the ZWP, and suggest that the AWOs are at slightly lower latitude than smaller spots with the same drift rates -- consistent with what we have found for the S1 & N2 domains, due to large ovals deflecting the retrograde jet in the middle of the domain (Ref.9b Fig.11, & Ref.23). However, this could be an artefact of the adopted standard. The points for the other large feature, the cyclonic white oblong, also lie slightly off the mean ZDP, by ~0.2º.

Most of the smaller spots are slow-moving dark spots (*see section 7*). Many were in the A1-A2 sector, where there was a long pale fawn sector, though it did not clearly have a closed circulation. They were either on its S edge (anticyclonic) or in its interior (cyclonic). Both groups of spots had approximately the same drift rates (DL2 between -10 and -27). Those on the S edge corresponded to dark wave-like bulges; as at PJ26, these waves probably marked the track of the retrograde jet (see JunoCam images in Figure 16), and may have constrained spots on both N and S sides.

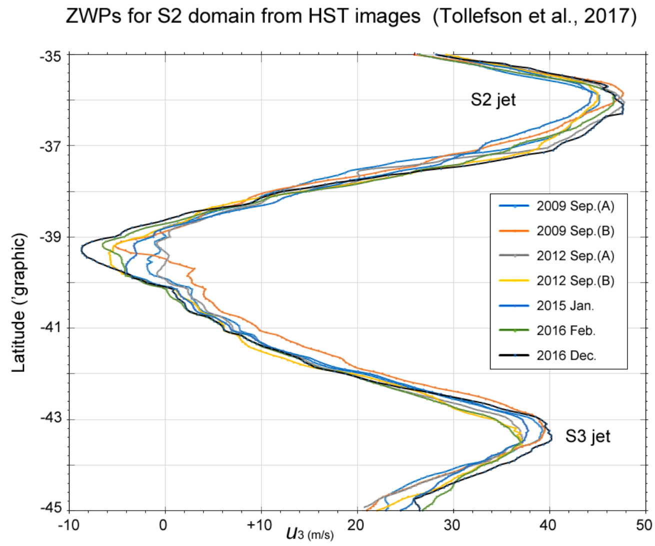


Figure 13. Zonal wind profiles (ZWPs) from Hubble images, from Ref.8a; also see Ref.8b. The data were kindly provided by Michael Wong. These ZWPs are also available on the WFCJ web site: https://archive.stsci.edu/hlsp/wfcj. Also see acknowledgement under Ref.7.

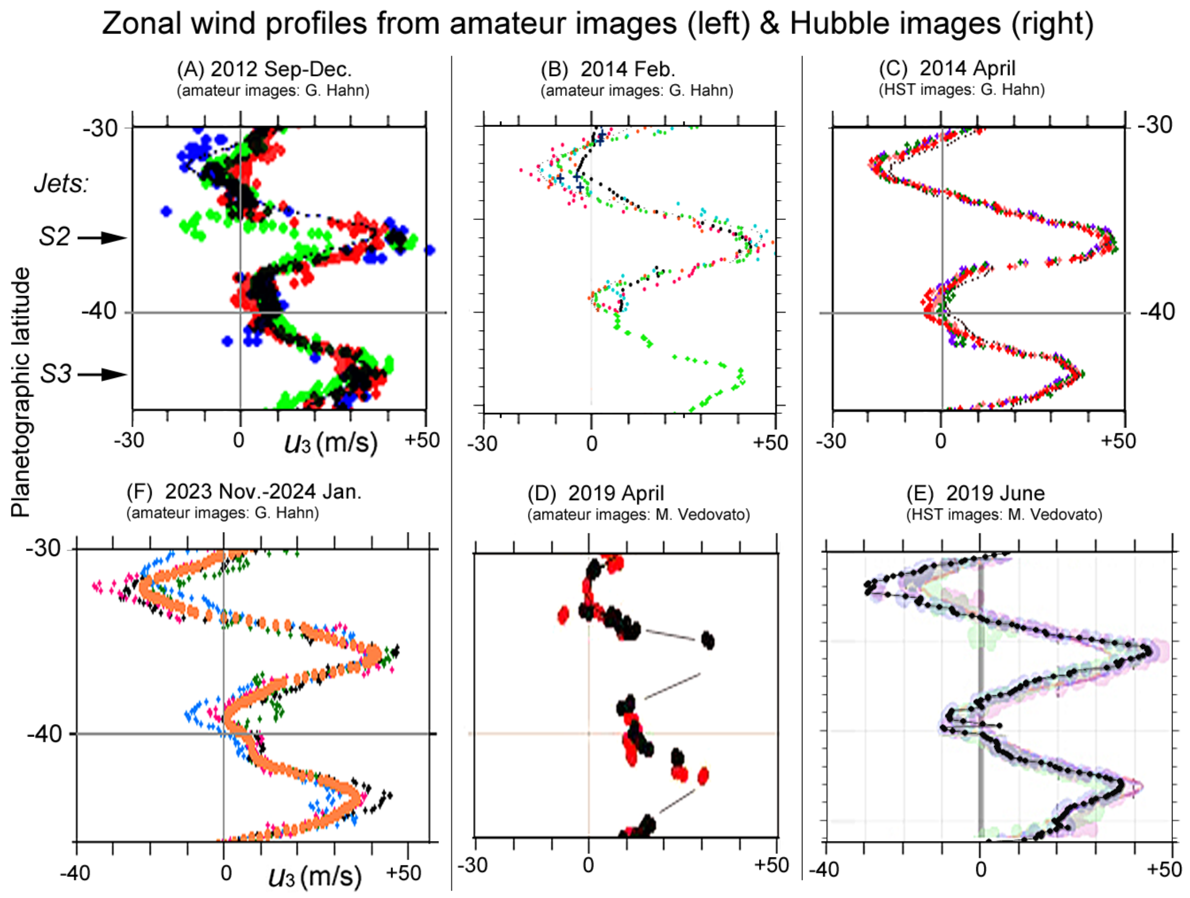


Figure 14. ZWPs made by JUPOS team members.
(A) 2012 Sep-Dec., by G. Hahn, several pairs of amateur images by W. Jaeschke, I. Sharp, D. Peach, D. Tyler, G. Walker, C.Go (with background curve from New Horizons). From report 2012/13 no.9 (Appendix 5).
(B) 2014 Feb., by G. Hahn, several pairs of amateur images by C. Go, D. Peach, B. Macdonald. From Ref.17 = report 2013/14 no.10.
(C) 2014 April 21, by G. Hahn, HST images (Ref.24). From Ref.17. *[Continues on next page]*

Figure 14 (continued):
(D) 2019 April, by M. Vedovato, two pairs of amateur images by C. Foster, T. Tranter, C. Go & T. Olivetti. From report 2019 no.4.
(E) 2019 June 26-27, by M. Vedovato, HST images. From report 2019 no.9, overlaid with a single ZWP close to the average of these data (data provided by Marco Vedovato).
(F) 2023 Nov.—2024 Jan., by G. Hahn, several pairs of amateur images by C. Go & E. Sussenbach. From report 2023/24 no.3 (Appendix 2).

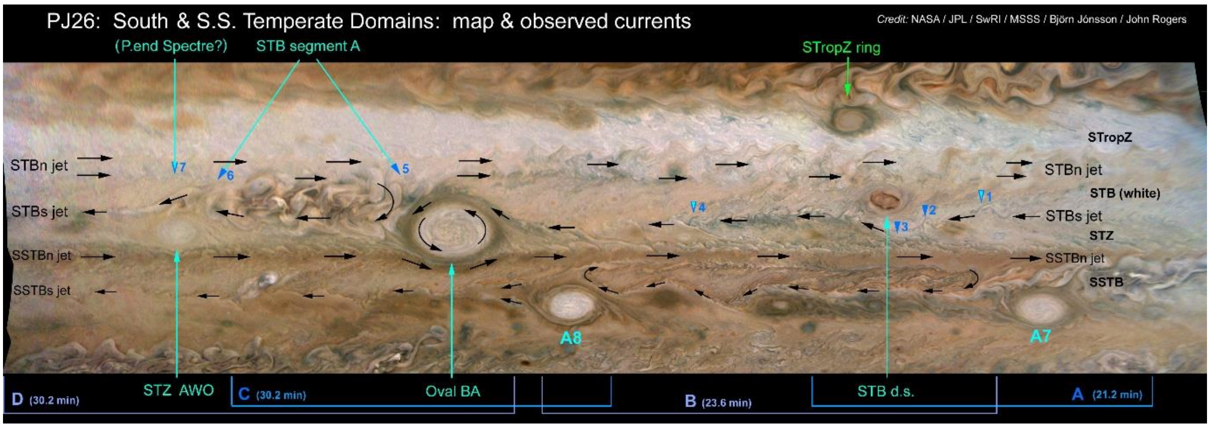


Figure 15. Map of the S1 & S2 domains from JunoCam images at PJ26 (2020 April 10), with arrows marking the currents visible by blinking maps of separate images. From our PJ26 report (Figure 12), which also included the animated blinks on which this is based. The underlying map was made by Björn Jónsson. (Annotations include some features not mentioned in the present report.) Note the long pale fawn oblong between A7-A8, with a rapid retrograde current along its wavy south edge (see section 4.1); also a very bright white spot at left (see section 6.3).

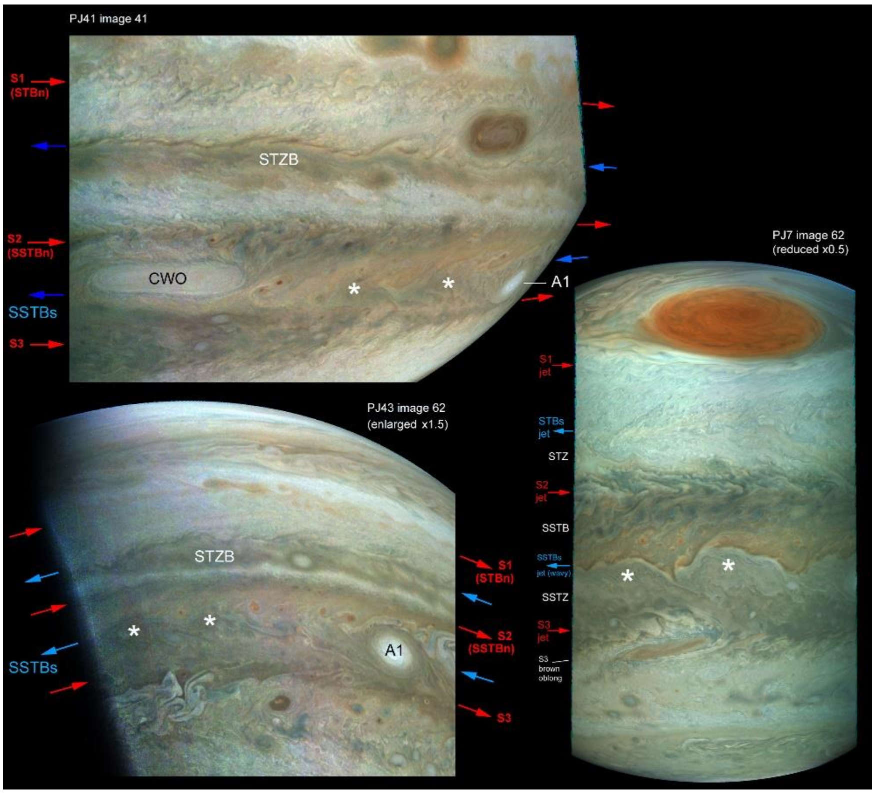


Figure 16. JunoCam images at PJ7 and PJ41/PJ43, showing high-amplitude waves along the S edge of light brown sectors of the SSTB, apparently representing waves in the retrograde SSTBs jet as at PJ26 (Figure 15). (Asterisks mark northward crests). JunoCam images processed by Gerald Eichstädt.

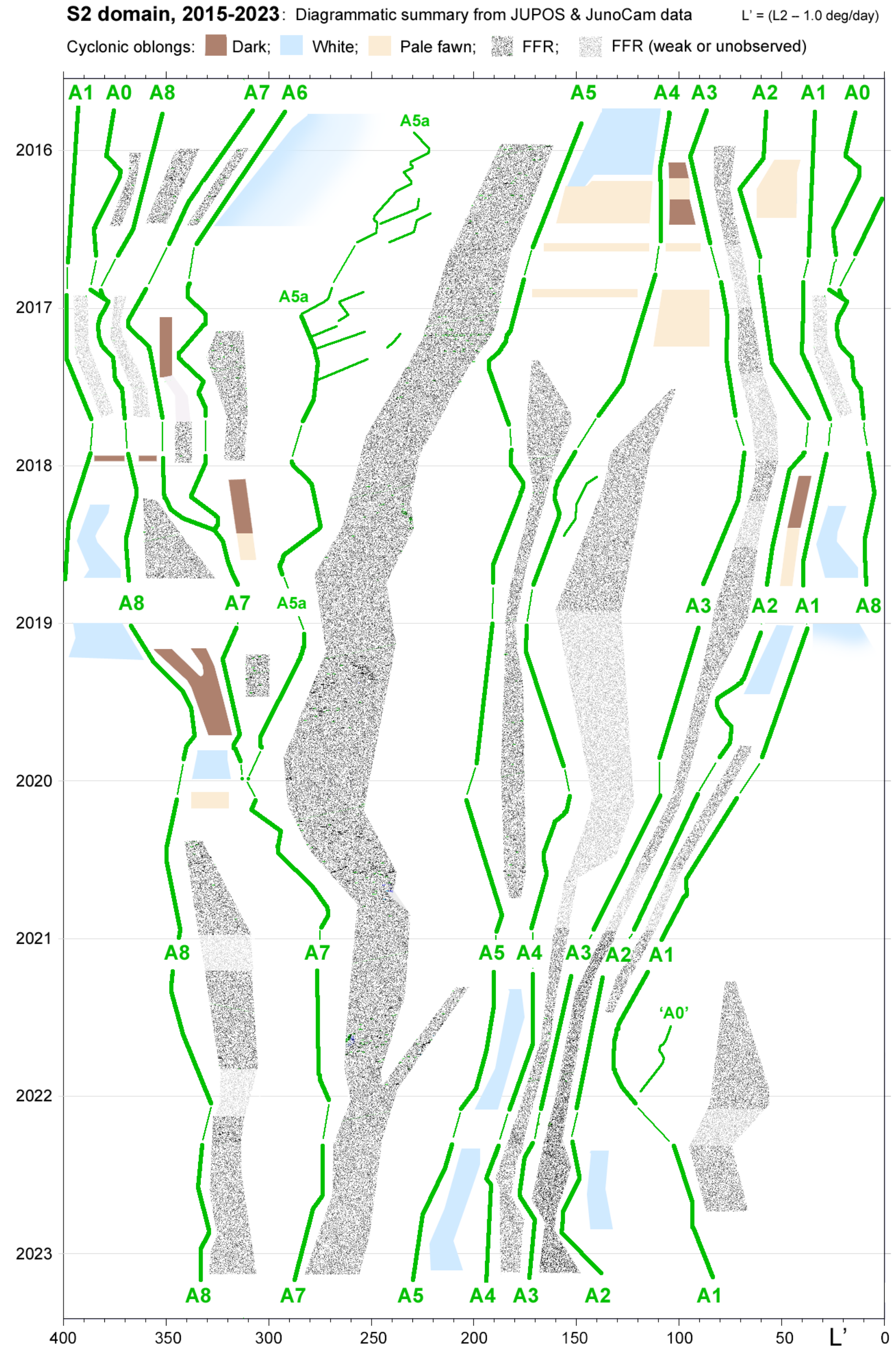


Figure 17. Chart showing diagrammatically the tracks of the AWOs and the presence of different types of cyclonic structure between them, from 2015-2023. It is derived from the JUPOS chart (**Appendix A**) at 1/4 vertical scale, with approximate tracks of FFRs represented by texturing. [Adapted from Ref.18 (EPSC Abstract), with some corrections and additions.]

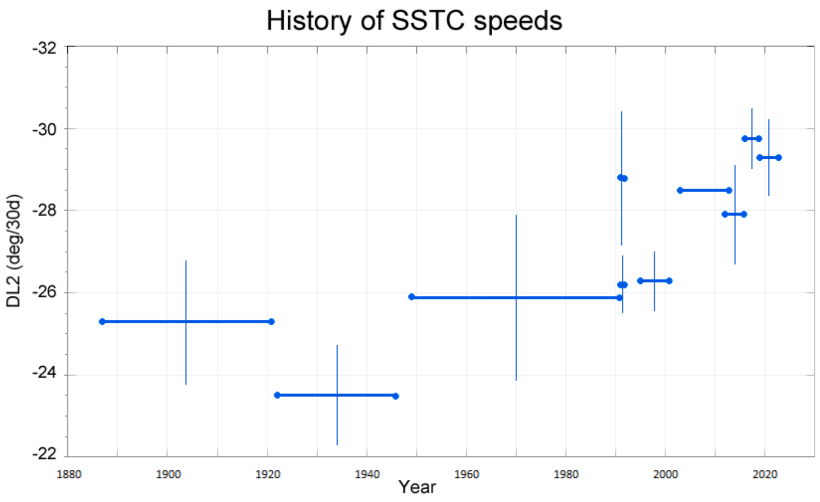


Figure 18. History of SSTC speeds. From Ref.2 (1887-1991), Ref.1 (1991-2013), and this work (2012-2023).

Section 5

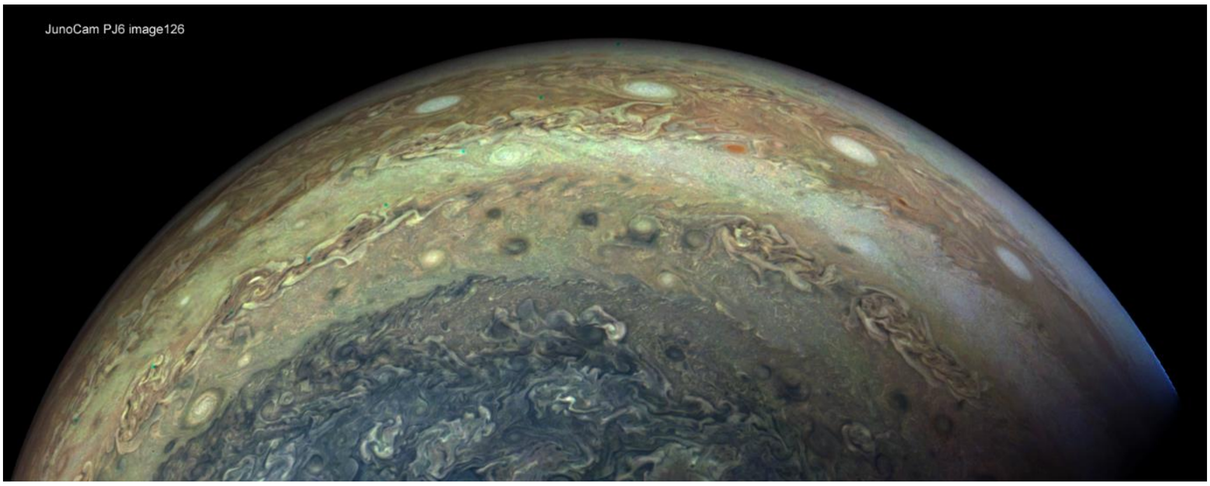


Figure 19. JunoCam view from over the south polar region towards the S2 domain with five AWOs visible, the "String of Pearls". Excerpt from PJ6 image 126 (Gerald).

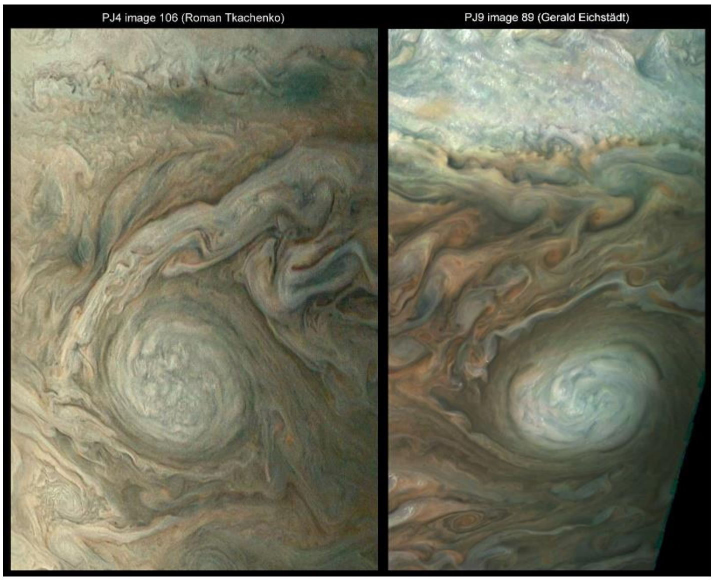


Figure 20. Two JunoCam closeups of S2 AWOs.

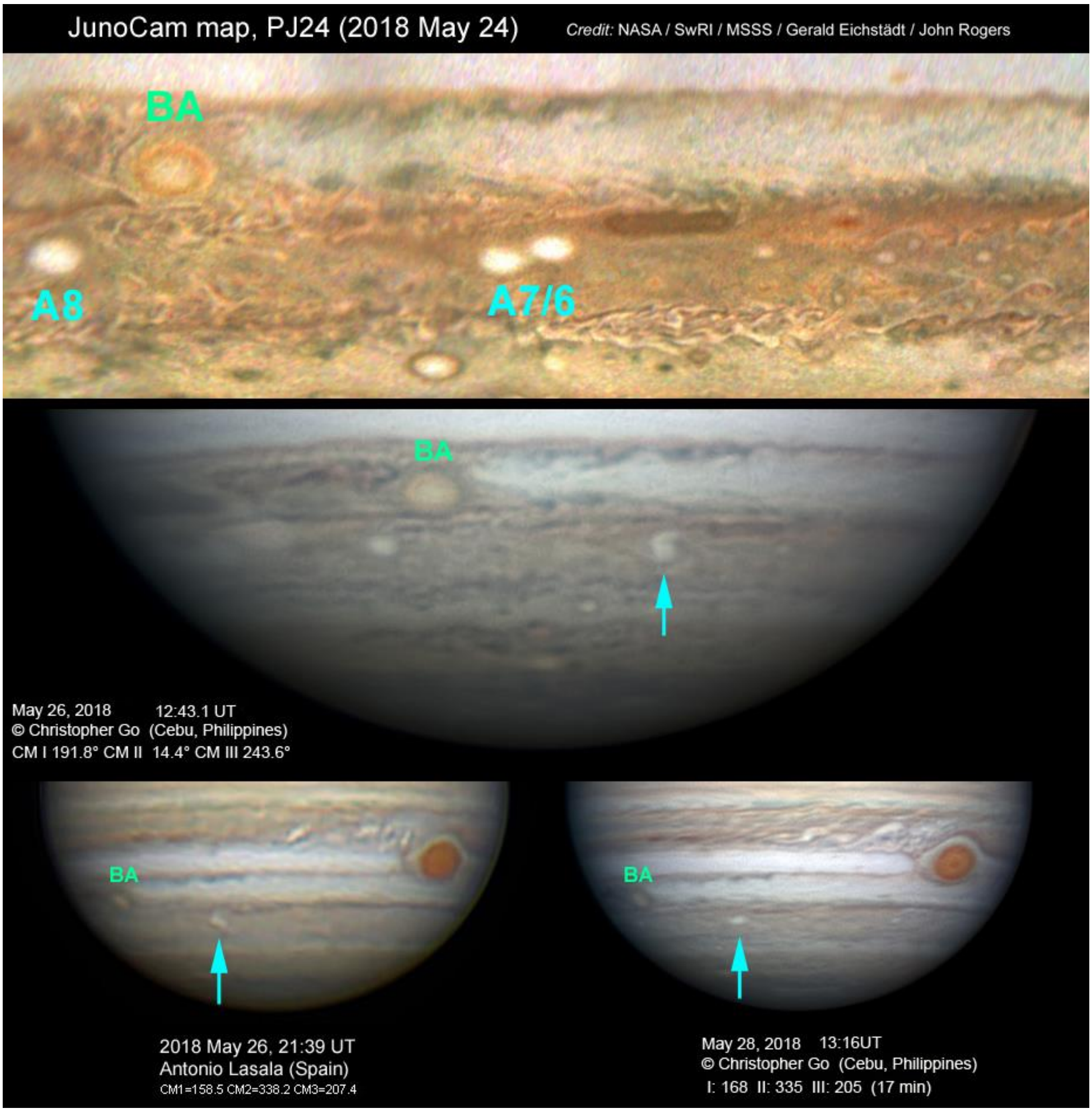


Figure 21. Merger of AWOs A6 & A7, 2018 May 24-28 (PJ13 map, May 24; Chris Go & A. Lasala, May 26 & 28).

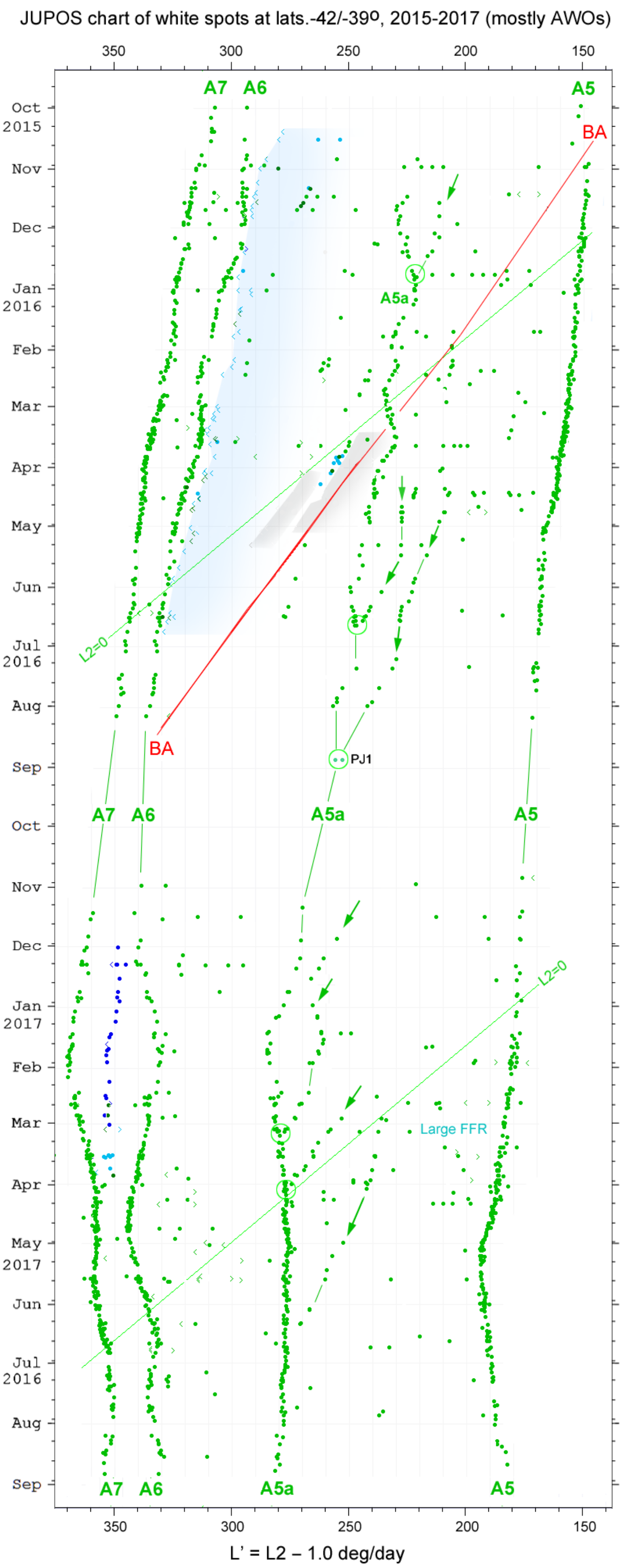


Figure 22. Excerpt from the full JUPOS chart (in **Appendix A**) in 2016-2017, highlighting the small slow-moving white spots (green arrows) which appear to have merged into oval A5a (mergers circled). Green points are white spots, mostly AWOs; for key to some other features, see the full chart in **Appendix A**.

Figures 23-29 show SSTBn jet spots at the 'recirculation loop' f. the STB Spectre (or Ghost), and the SSTB sector between oval A5a & the large FFR, with small vortices within it.

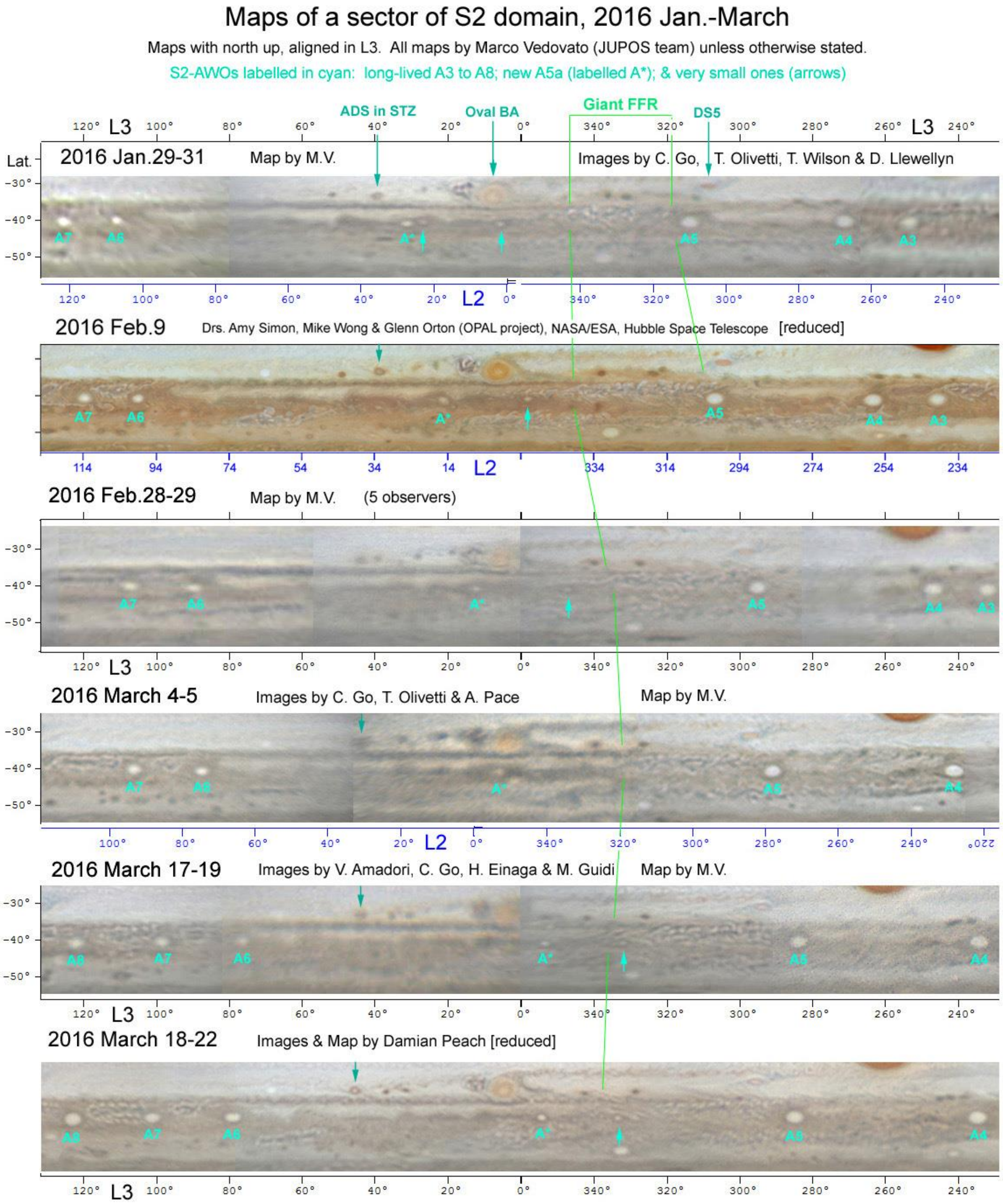


Figure 23. Maps of part of the S2 domain, 2016 Jan.-March, showing mini-AWOs in the sector p. A5a (labelled A*), f. the large FFR. Also shows a dark spot (STB DS5) evolving into the STB Spectre, alongside the FFR with SSTBn jet spots recirculating in Jan-Feb. and becoming near-stationary in the STZ. [From report 2016/17 no.8.]

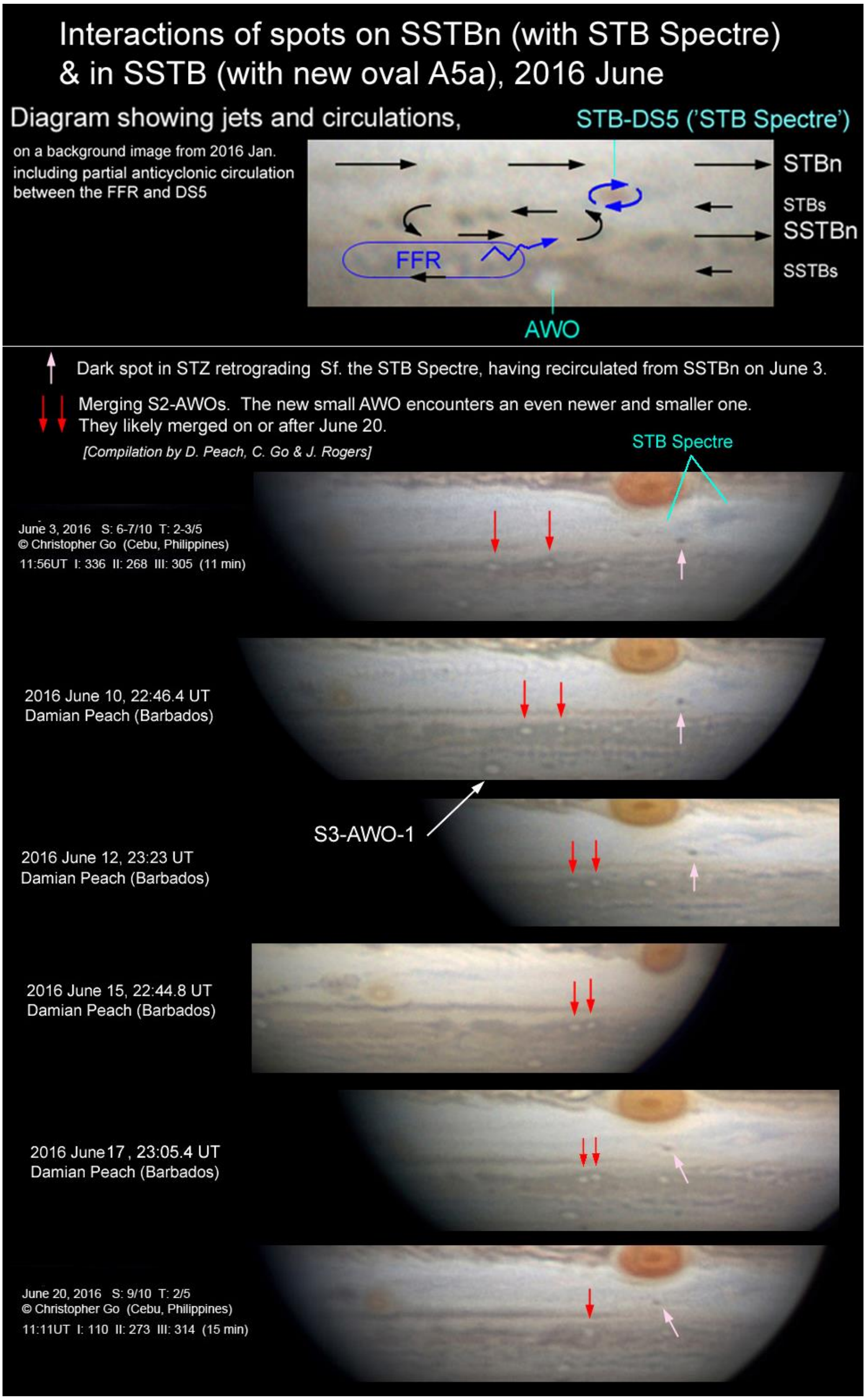


Figure 24. Amateur images, 2016 June, showing the sector from A5a to the large FFR, with mini-AWOs between them. Red arrows indicate A5a (left arrow) about to merge with a smaller mini-AWO (right arrow). Also shows the recirculation loop at the STB Spectre: pink arrow marks a dark spot retrograding f. the Spectre after recirculating. [Adapted from report 2015/16 no.13.]

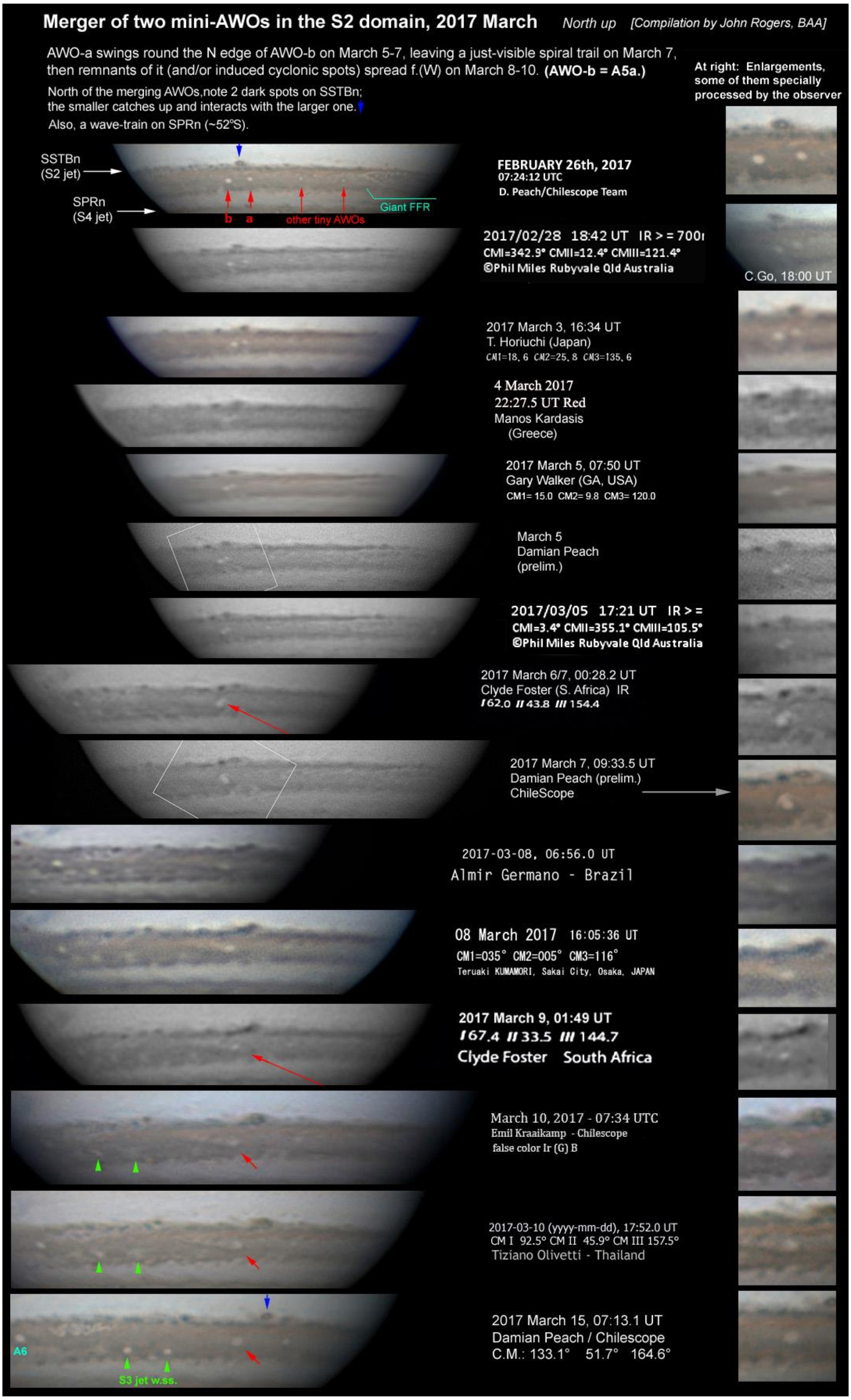


Figure 25. Amateur images, 2017 March, showing merger of A5a with another mini-AWO in 2017 March (the best documented example) [Figure from Report 2016/17 no.8]. There is also a very dark spot on SSTBn keeping pace with A5a, interacting with smaller, faster-moving SSTBn jet spots. (There is no recirculation loop in this sector.)

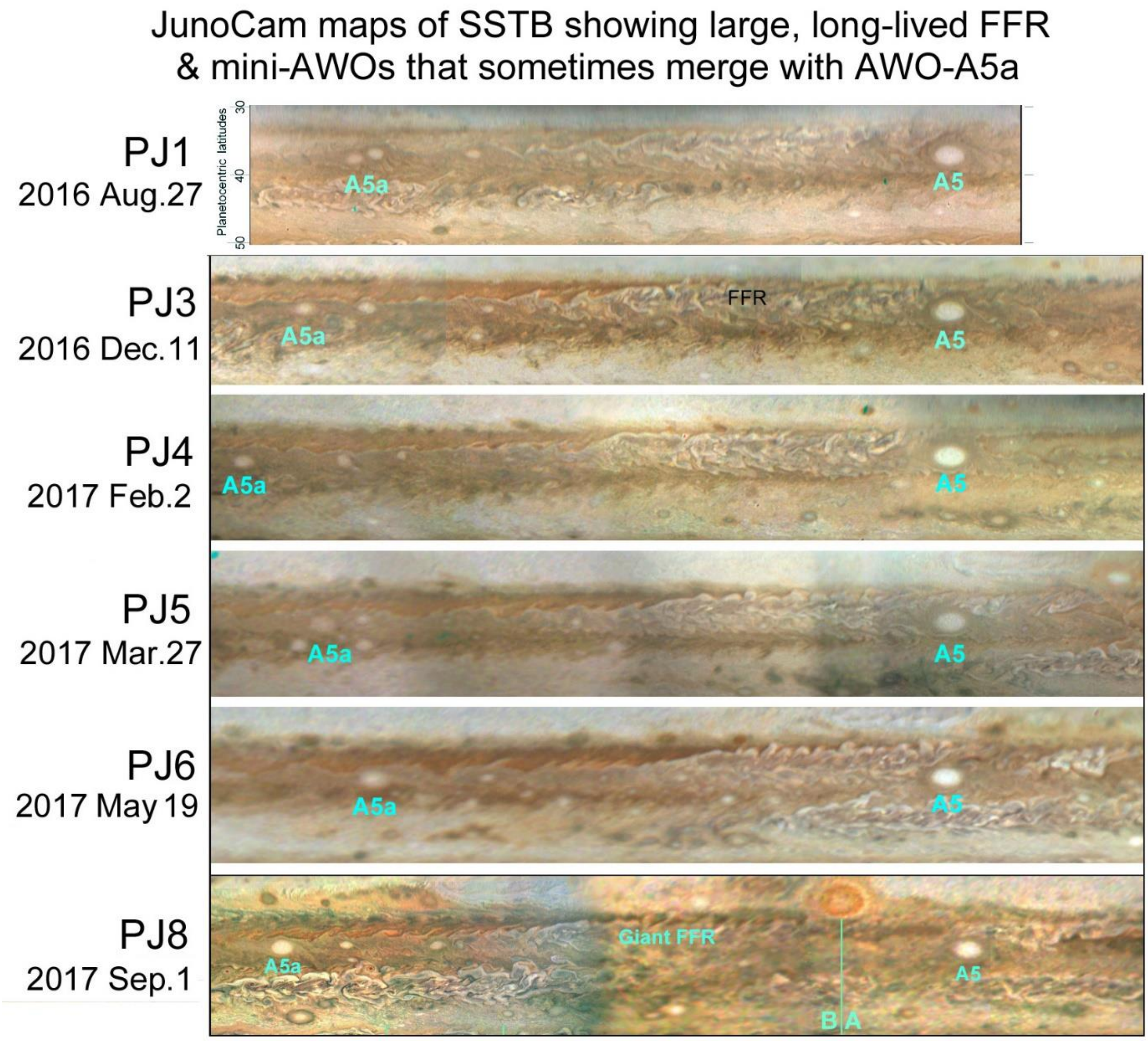


Figure 26. JunoCam maps of the sector from A5a through the large FFR, 2016 Aug—2017 Sep.

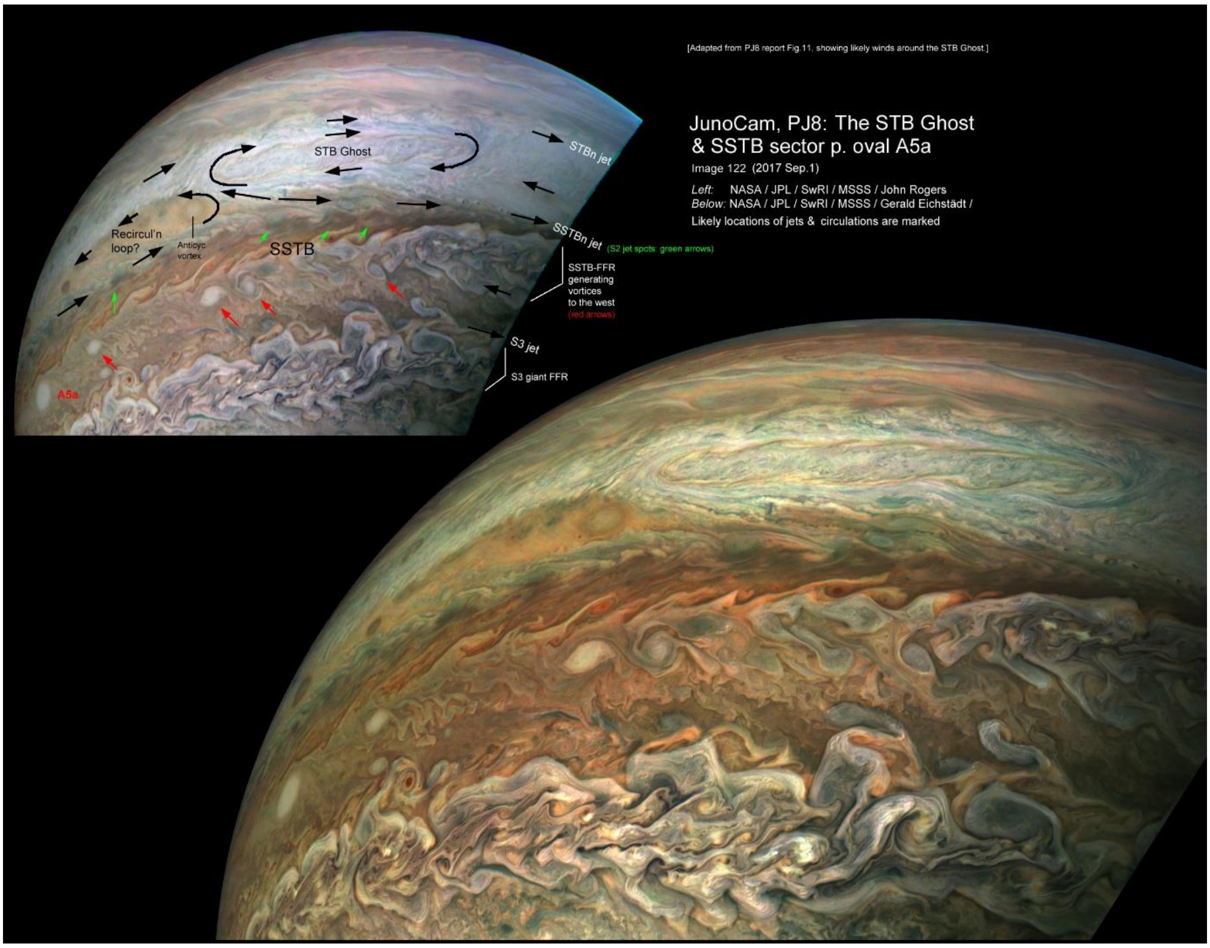


Figure 27. [From PJ8 report Fig.11]. Shows the orange-tinted recirculation loop f. the STB Ghost. SSTBn jet spots are indicated by green arrows. There are also several near the limb, caught in the 'recirculation loop' just f. the STB Ghost. Also shows the SSTB from A5a to the large FFR, with many vortices in that sector.

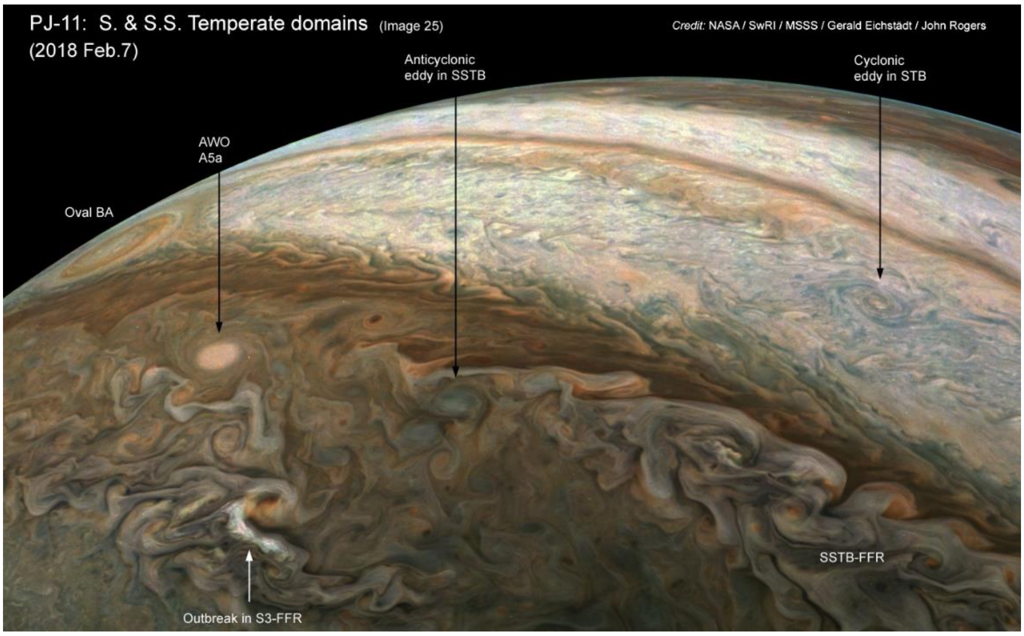


Figure 28. (PJ11 image 25, 2018 Feb.7). The large FFR now extends closer to A5a but an eddy is still visible between them. There are no obvious S2 jet disturbances in this sector p. BA.

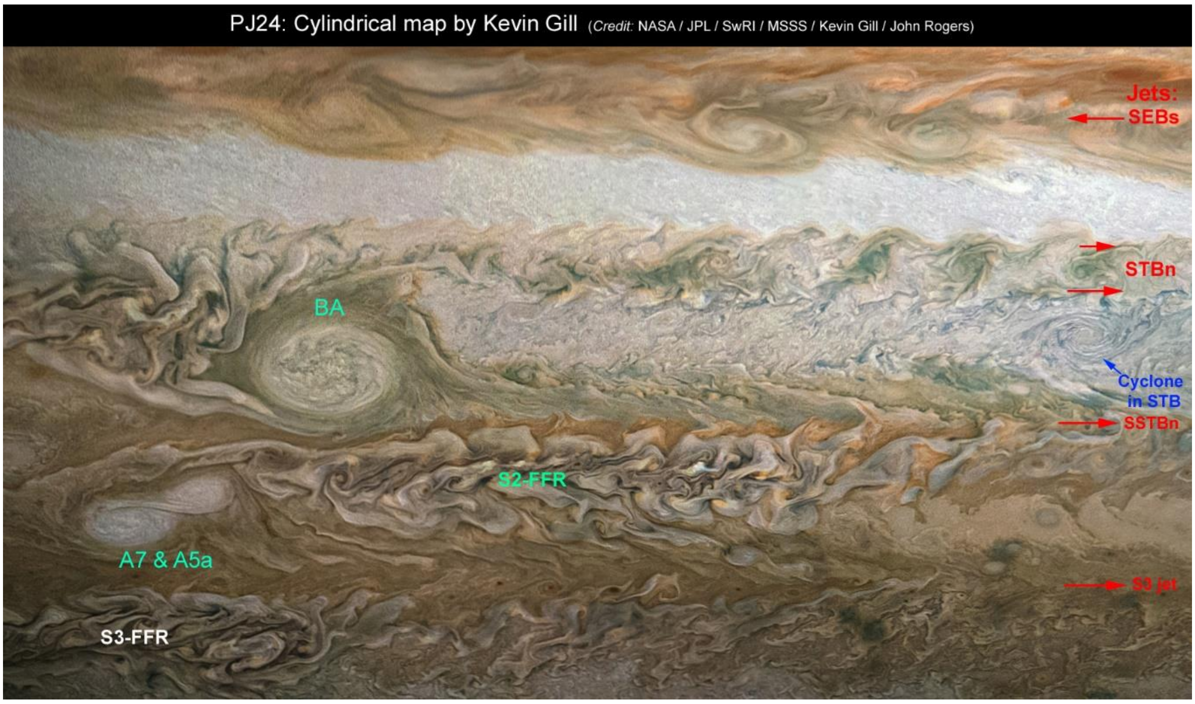


Figure 29. (PJ24, 2019 Dec.26: cylindrical map by Kevin Gill). Shows oval BA with ovals A7/A5a merging. The large FFR now extends up to A5a. There are no obvious S2 jet disturbances in this sector p. BA.

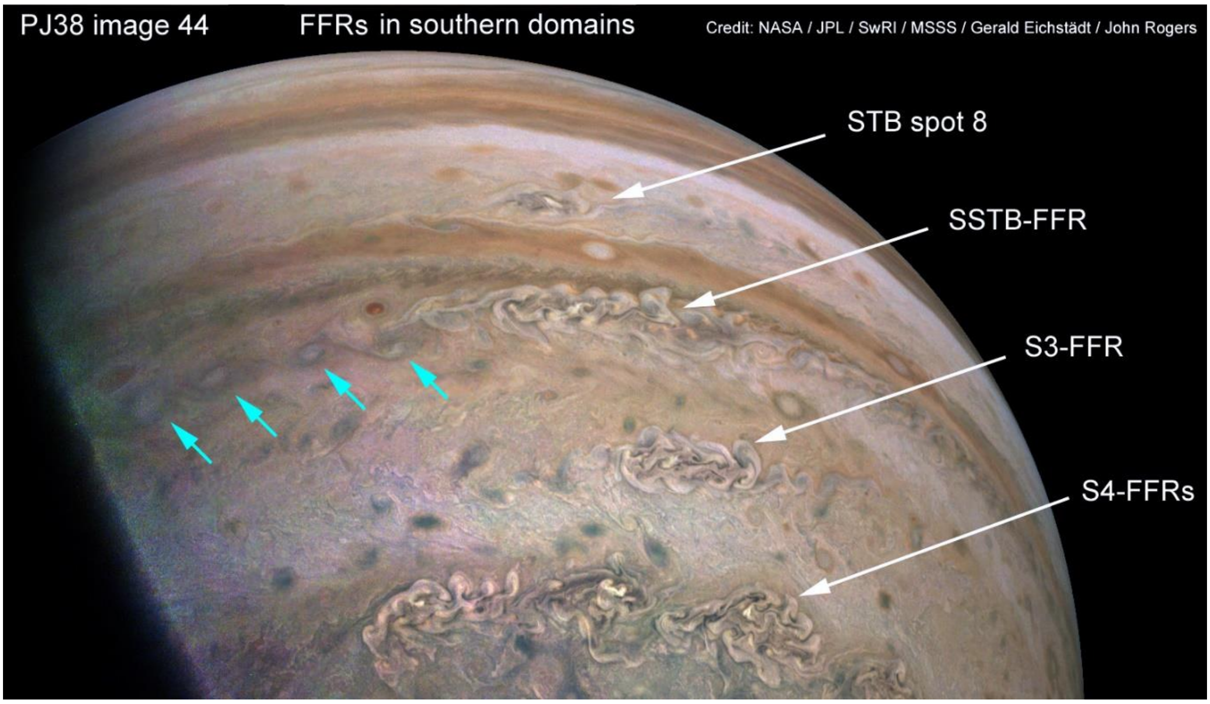


Figure 30. **(**PJ38 image, 2021 Nov.29). A chain of four anticyclonic vortices f. a FFR, apparently leading towards the new (short-lived) AWO 'A0' (beyond the terminator). [PJ38 report Fig.S1].

Section 6

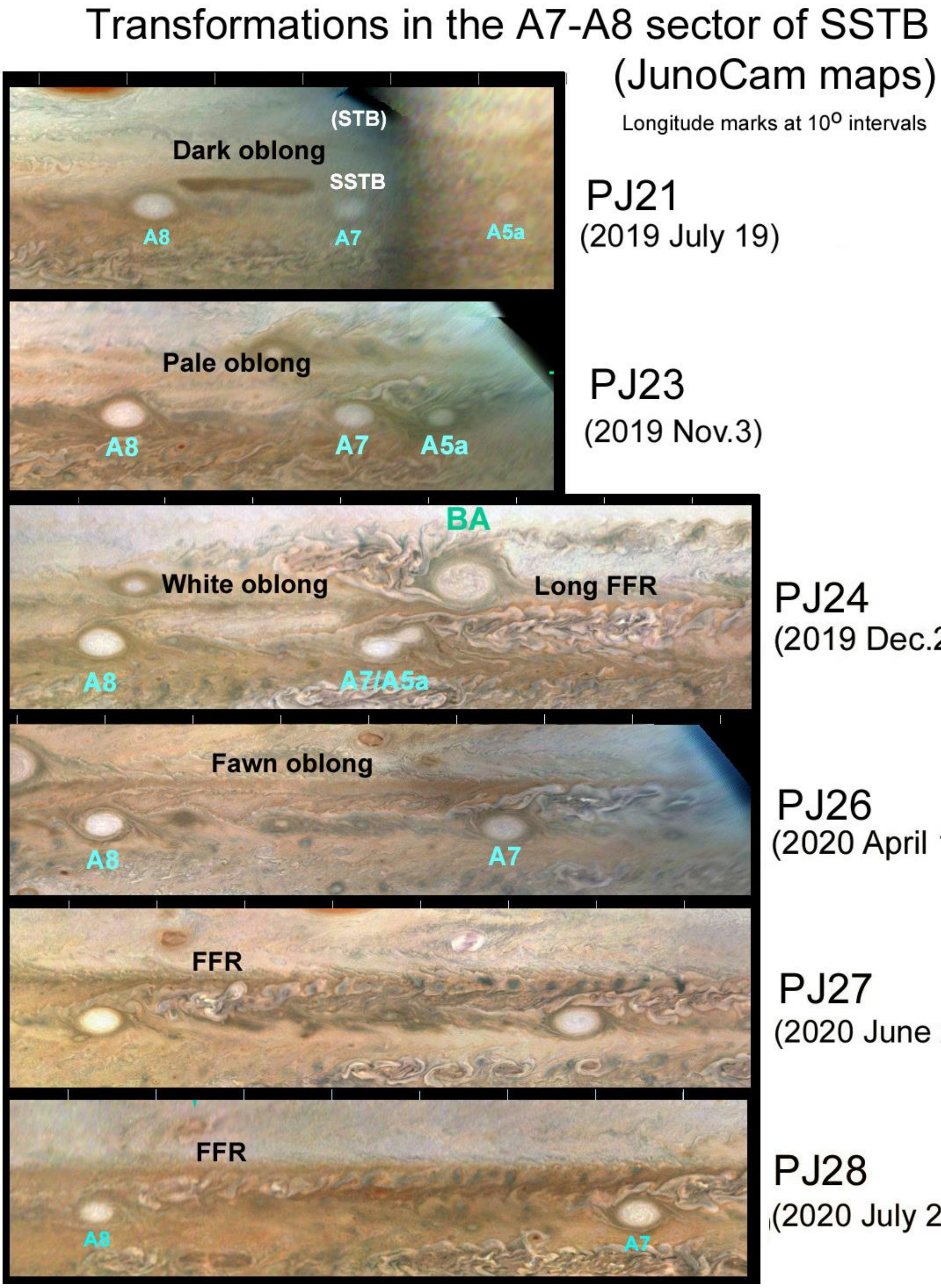


Figure 31. Excerpt from the series of JunoCam maps, showing one sector which successively transformed between the four cyclonic types.

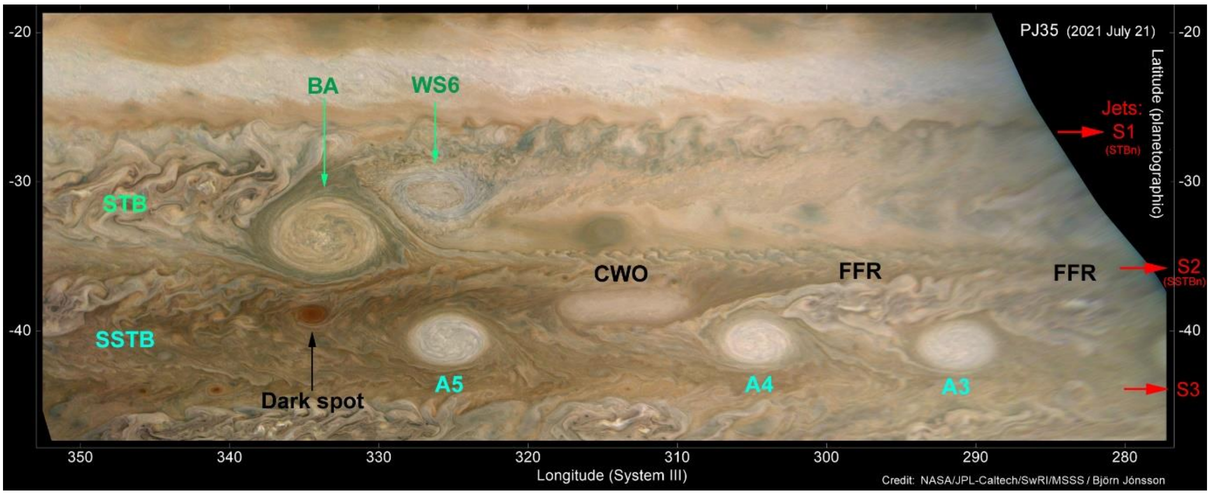


Figure 32. PJ35 (2021 July 21; cylindrical map by Björn Jónsson). Map of a sector of the S1 & S2 domains, showing examples of cyclonic structures, including the small dark spot adjacent to BA.

Figure 33. JunoCam image of a CWOb (PJ20).

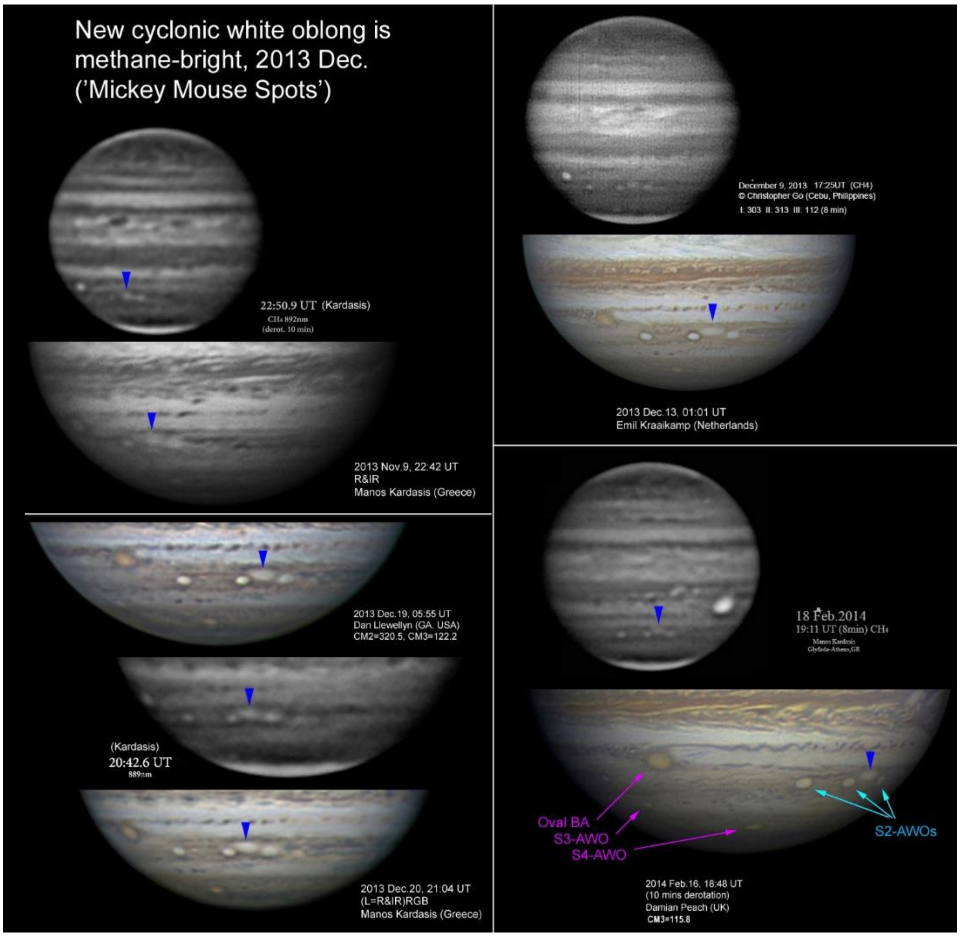


Figure 34. The "Mickey Mouse spots": a bright new CWO (dark blue arrowhead) between A3 & A4. [New figure]

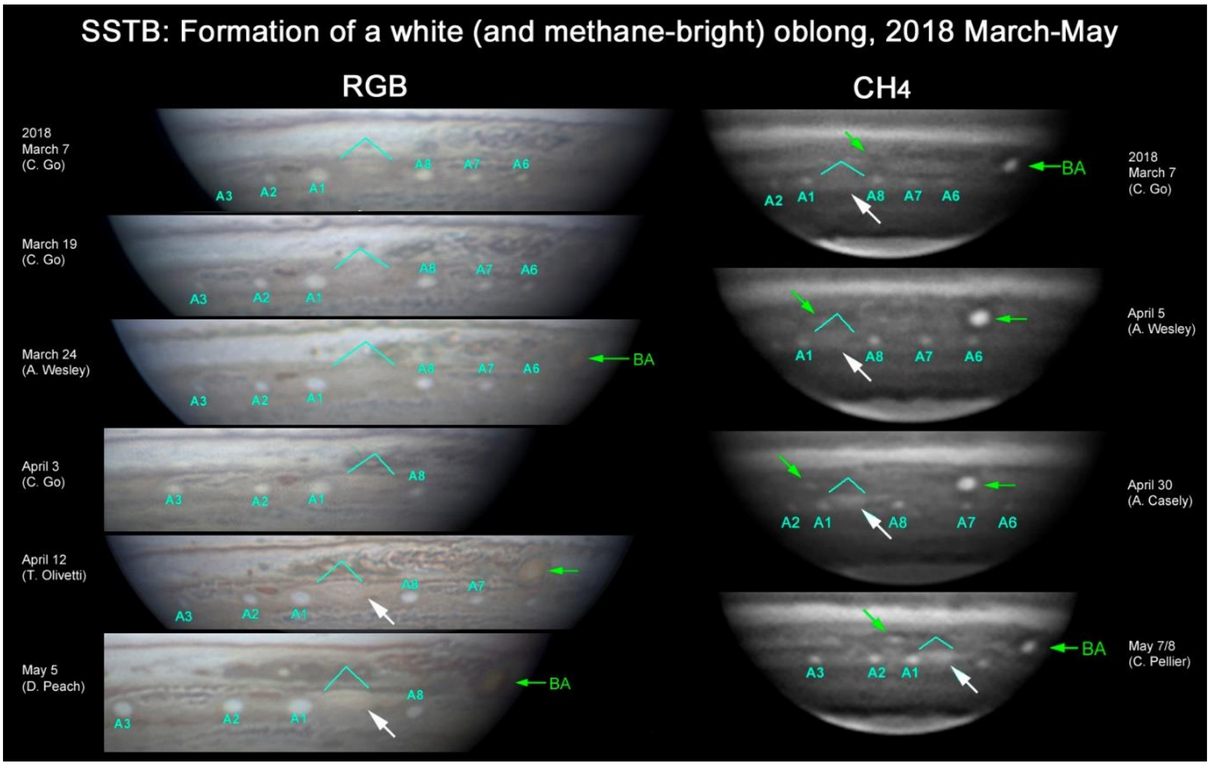


Figure 35. [From report 2018 no.6 Fig.12]. New CWO in 2018, brilliant white and methane-bright (bracketed).

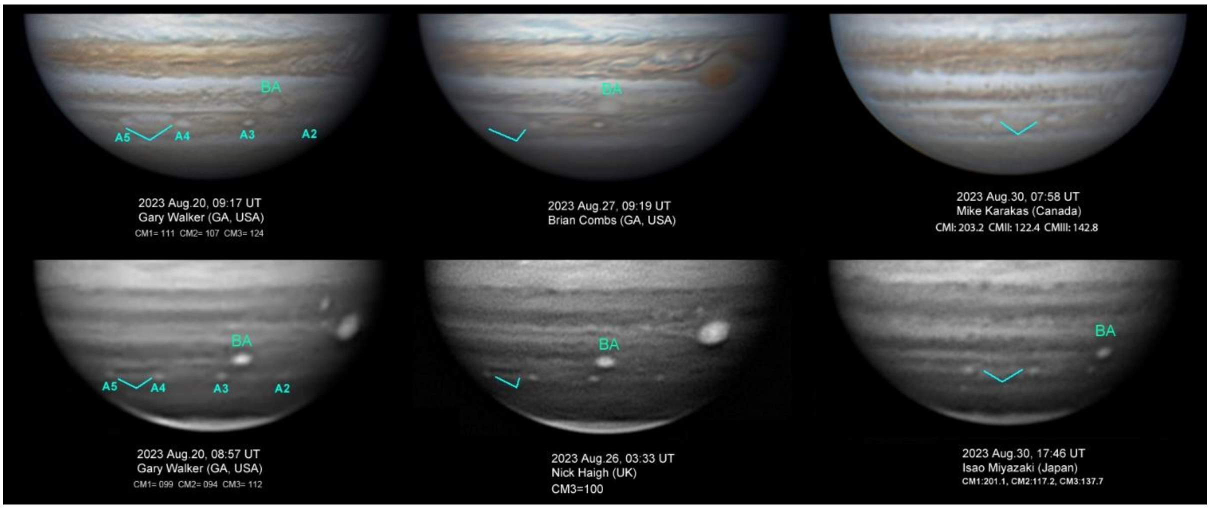


Figure 36 . CWOb (bracketed) between A4 & A5 in 2023; bright white but methane-dark as usual (esp. towards the limb) (like the STB Spectre, Figure 42). [New figure]

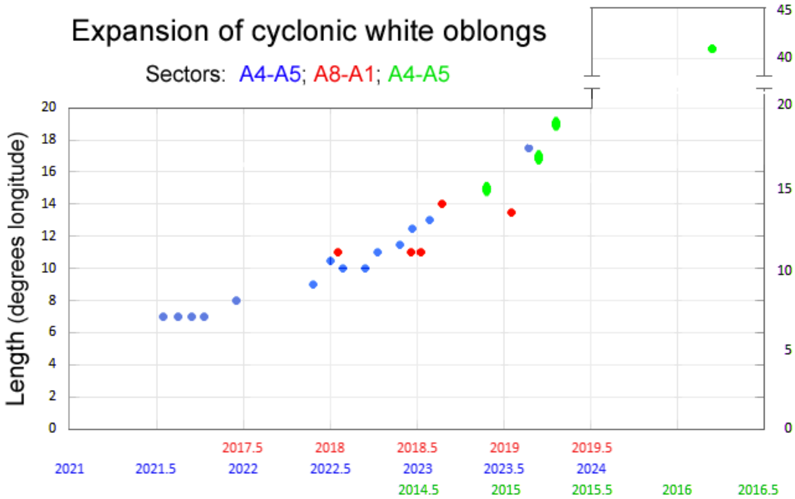


Figure 37. Chart showing the expansion rates of three CWOb's, measured from JUPOS maps.

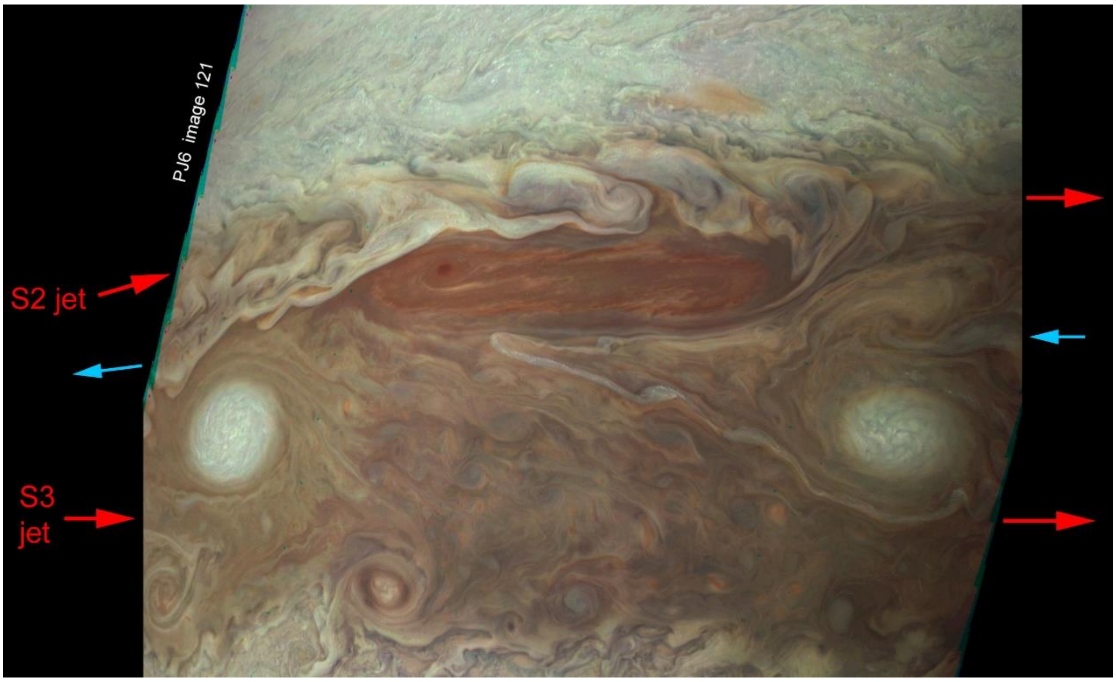


Figure 38. JunoCam image of a dark brown oblong (PJ6).

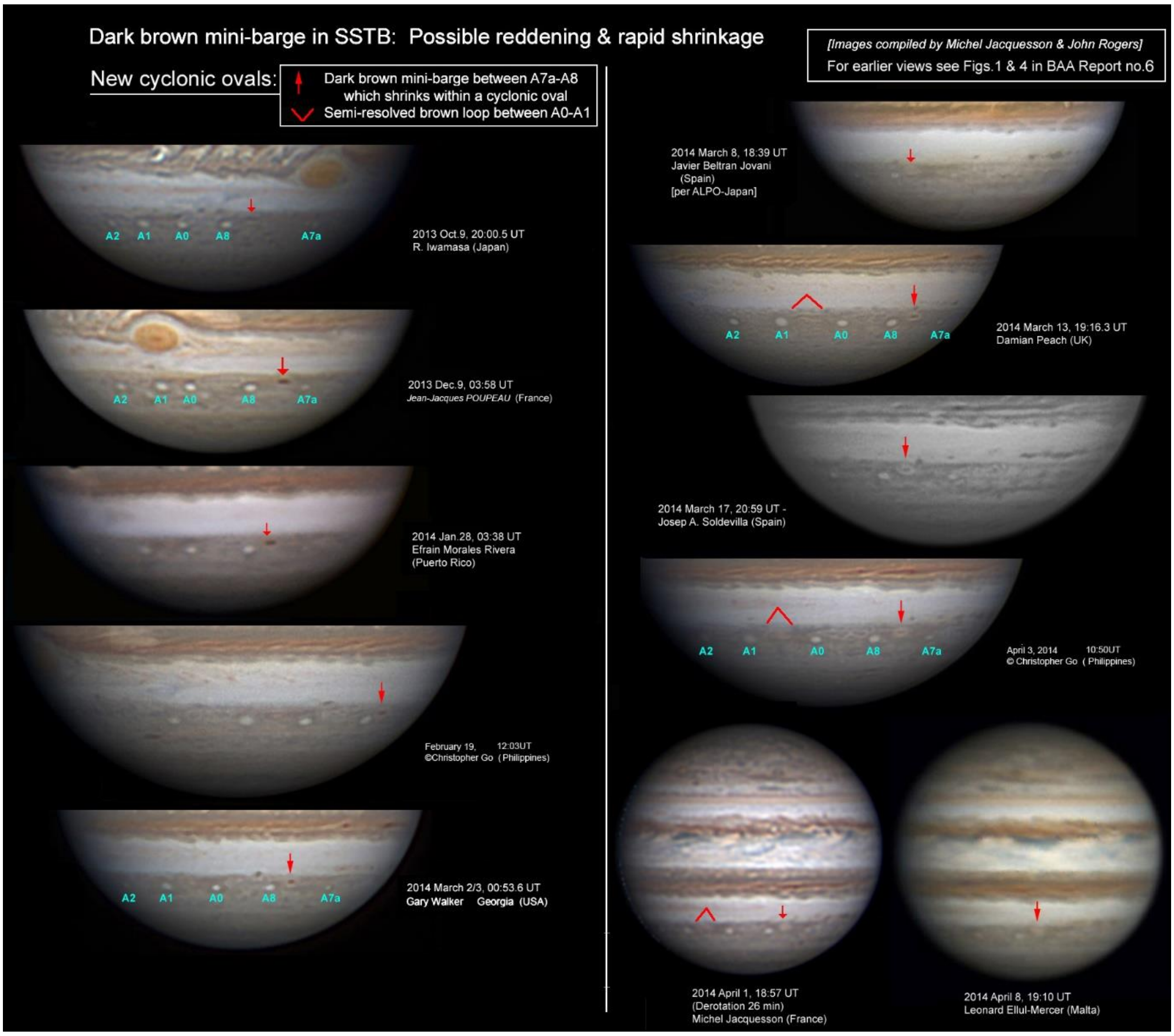


Figure 39. [Adapted from report 2013/14 no.8] A very dark 'mini-barge' between A7a-A8 becomes lighter brown and shrinks within a pale collar, then a brown streak between A0-A1 likewise shrinks, until both appear as light reddish ovals.

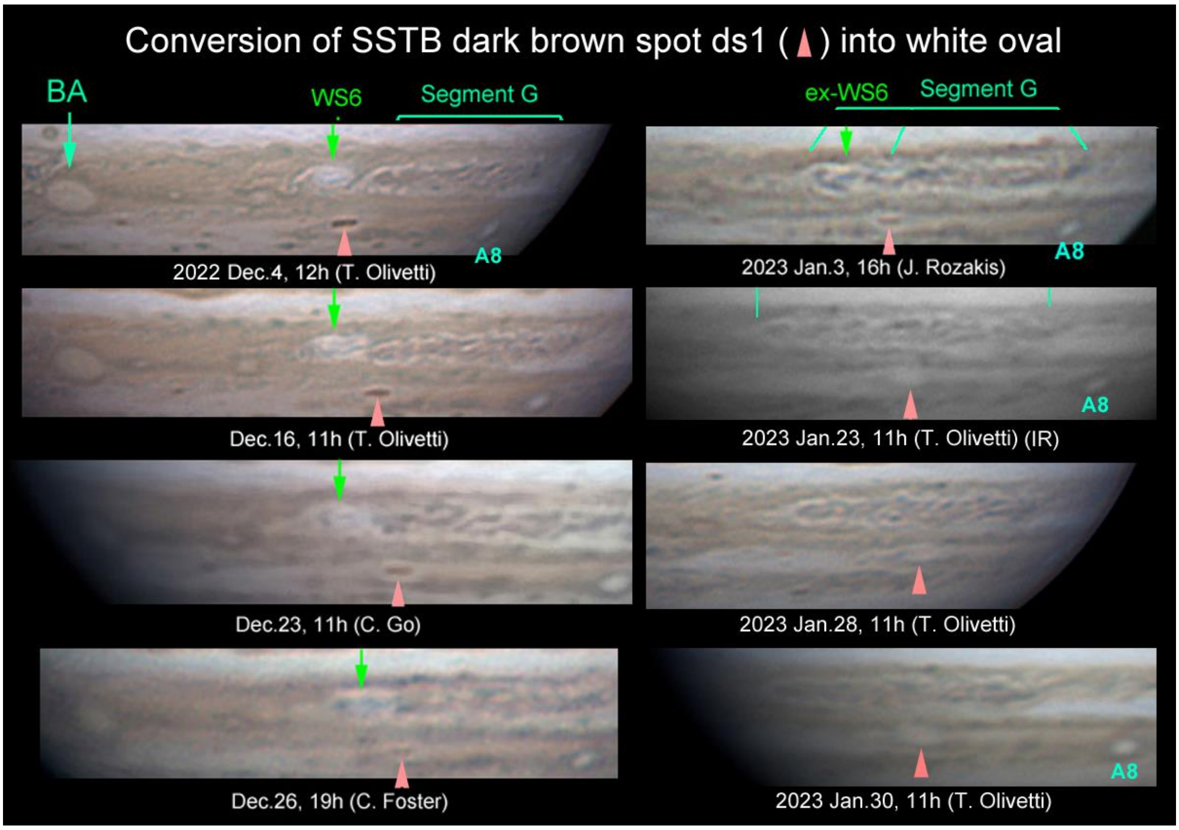


Figure 40. [Adapted from reports 2022/23 nos.5 & 8] In 2023 Jan., ds1 turned into a small light brown spot in a white collar. By late Jan. it was a dull white cyclonic oval, as also shown in the PJ49 map (March 1). So this was a typical example of a dark spot fading through reddish to white.

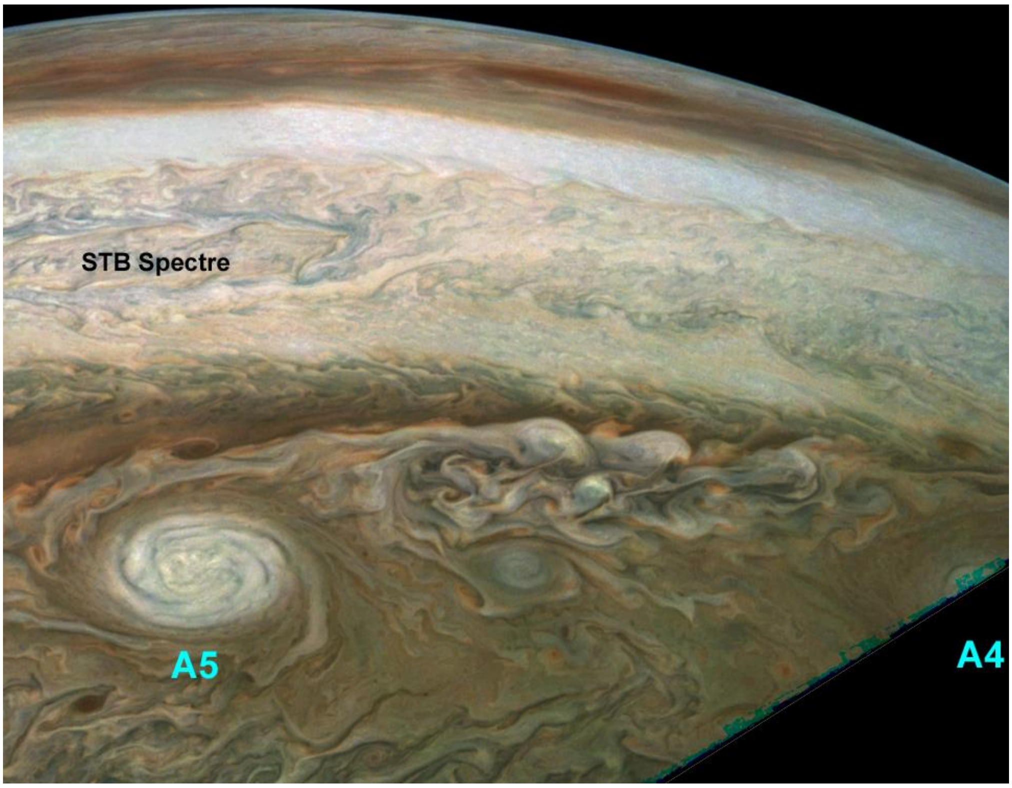


Figure 41. PJ15 image 37: Example of a small FFR.

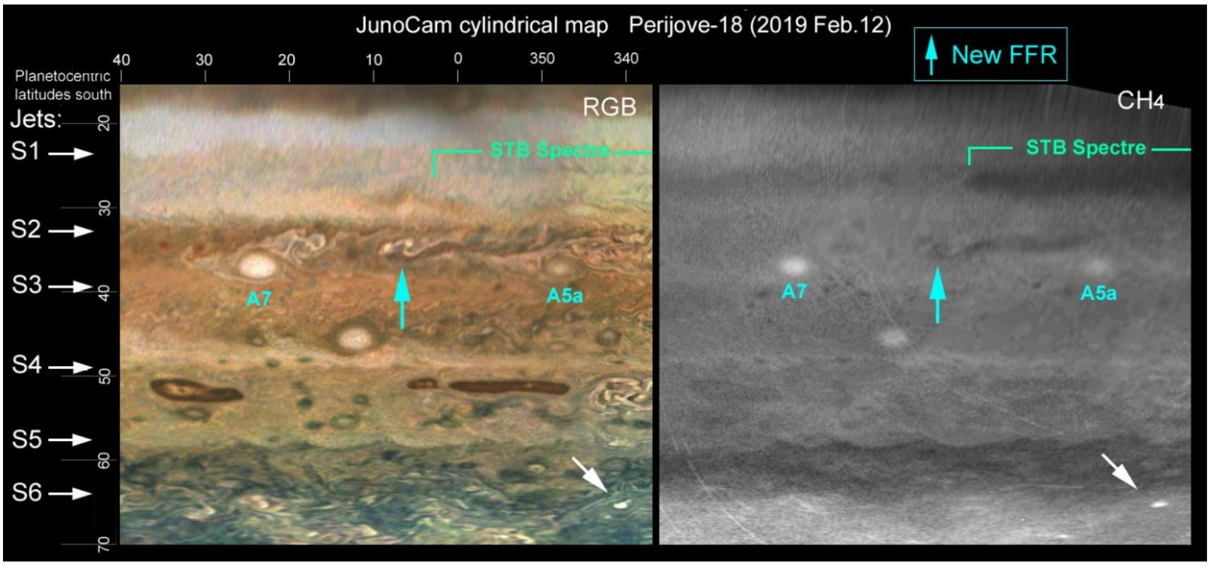


Figure 42. PJ18 cylindrical maps (by Gerald Eichstädt). A new FFR imaged at PJ18 (2019 Feb.12, arrowed blue), not methane-bright. In contrast, a much brighter point (convective outbreak, arrowed white) at lower right is very methane-bright. Note that the STB Spectre, like similar CWOb's in the SSTB, is methane-dark. [New figure.]

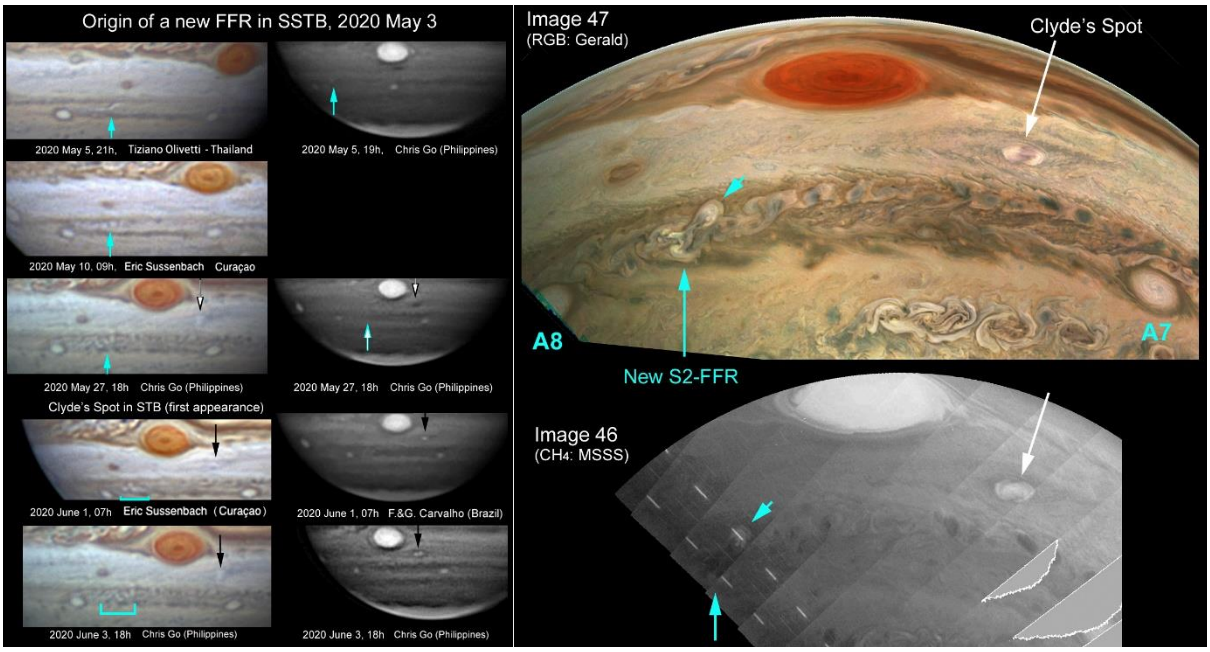


Figure 43. [Adapted from Report 2020 no.10] Origin of a new FFR in 2023 May, with a transient methane-bright plume, also viewed at PJ27, along with a similar but much greater eruption in the STB called 'Clyde's Spot'.

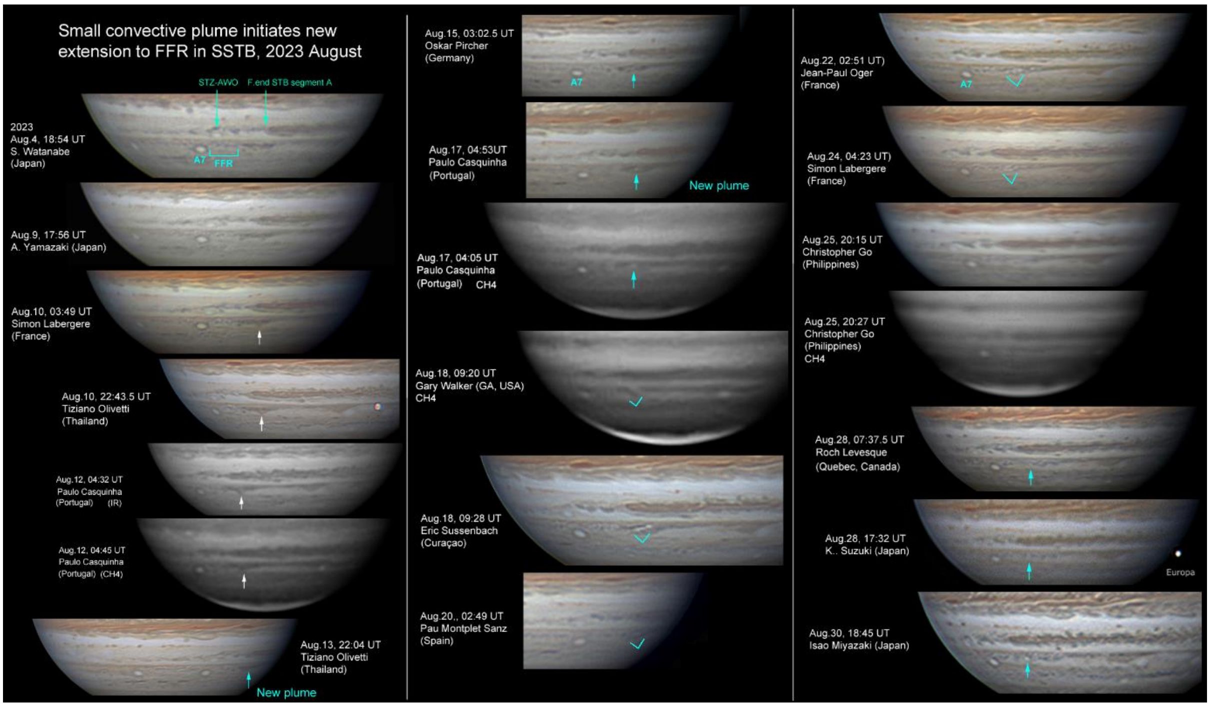


Figure 44. Origin of a new FFR in 2023 August, with a transient methane-bright plume.

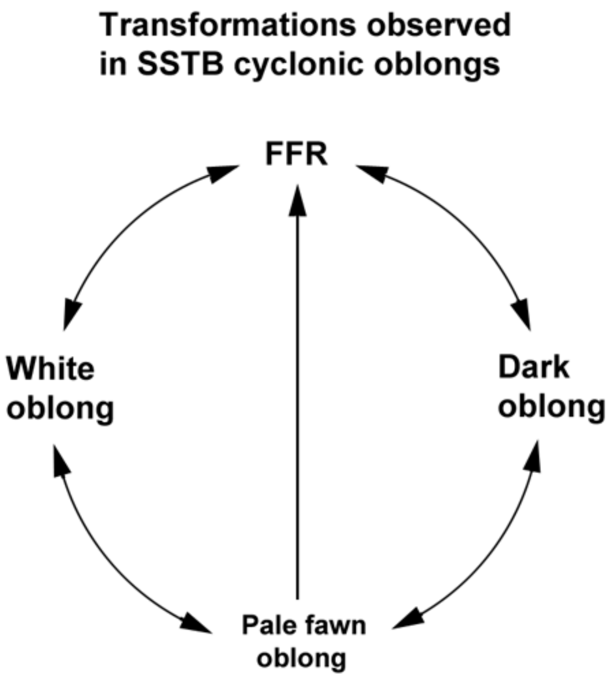


Figure 45. Diagram summarising the interconversions between the types of cyclonic features.