Jupiter in 2021-22: Report no. 9
N3 to N6 domains

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using information from the JUPOS team (Gianluigi Adamoli, Rob Bullen, Michel Jacquesson, José Luis Pereira & Hans-Jörg Mettig) and the JunoCam team (Candy Hansen, Glenn Orton, Tom Momary & Gerald Eichstädt)

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Summary & Conclusions

Movements of spots in the N6, N5, N4 & N3 domains are analysed from amateur images and JunoCam images. The JUPOS team have been able to track more spots in these domains than ever before, including several in the N6 domain.

The drift rates and latitudes all lie close to the zonal wind profiles known from spacecraft, and confirm that in both the N5 and N4 domains the broad retrograde flow represents the bulk motion of the FFRs as well as AWOs. All spots in N6 domain are rapidly prograding.

There were several notable interactions of AWOs. Two N5-AWOs (a & b) approached each other but then rebounded and exchanged their drifts and latitudes. The largest N5-AWO (e) suddenly reversed its drift when it approached a smaller white spot further north.

Most remarkably, we have one or (very likely) two examples of AWOs crossing prograde jets. N4-AWO-A swung rapidly southwards after it approached N4-AWO-B, and was last seen straddling the N4 jet and split into two lobes; the third time that this has been observed. Likewise, a N3-AWO swung southwards and crossed the N3 jet into the NNTZ – the first time that a spot has been seen to cross a prograde jet other than the N4 jet.

Both in N5 and in N4, AWOs can last for months or even years – in spite of many sudden shifts of latitude and drift rate – just as in the N2, S3 & S4 domains. V-hi-res tracking is needed to resolve these shifts, which can occur within less than a week. The largest N5-AWO (e) has probably lasted for years; some N4-AWOs may also have done (four of them lasted throughout this apparition) but cannot be identified from year to year because there were several of them with unpredictable track shifts. On the other hand, small AWOs in N5 and N4 have more rapid turnover than in lower-latitude domains. Within the timespan of our 2021 observations, some anticyclones in the N5 domain appeared and disappeared. Likewise, several in N4 probably lasted for only a few weeks or months.

Cyclonic features (FFRs or smaller cyclones) are evidently less stable than AWOs. Their JUPOS tracks are shorter, and may end because the features changed, or disappeared, or were unresolved after opposition. Many of the short-lived retrograding tracks that we measured from the JUPOS chart are probably FFRs in the body of the N5 and N4 domains, but most FFRs seen in JunoCam and Hubble maps are too ill-defined to be tracked in amateur images. However, almost all those from the N5 chart that we could identify at PJ36 were cyclones either at the northern edge of N5 or fully within the N6 domain. These tended to be isolated bright compact cyclones, rather than extended FFRs.

Introduction

Previous information about the N3, N4, N5 & N6 domains was given in our long-term report [ref.1] and our 2020 final report [ref.2]. Here we report on the behaviour of spots in these domains in 2021. Using amateur images, the JUPOS team have been able to track a large number of spots in these domains – even more than in 2020, even in the very obscure N6 domain; and we supplement and interpret these data by reference to images from Juno and Hubble. We can identify many of the spots in the maps from JunoCam (esp. at PJ36 on Sep.2 and PJ37 on Oct.16) and from Hubble (OPAL project [ref.3]: a pair of maps on Sep.4), close to opposition which was on Aug.19/20. Thus we can give an exceptionally full account of the behaviour of identified features.

JunoCam covers only about half the longitudes of the high northern domains at each perijove, so it was fortunate that Juno's perijoves in 2021 were at similar longitudes from PJ33-PJ35 (Fig.1), then in a different range of similar longitudes from PJ36-PJ39 (Fig.2).

Conventions in this report, unless otherwise specified: Latitudes are planetographic, but planetocentric in the JunoCam maps. Longitudes are plotted in L3, but drift rates are mostly given in L2 (DL2, deg/30d). DL3 = DL2 + 8.0 deg/30d. North is up in figures.

N5 & N6 domains

We discuss the N5 and N6 domains together. N6 is the northernmost complete domain, and is unusually narrow, with a velocity minimum but no retrograde jet between the N6 and N7 prograde jets [Cassini & Hubble data – ref.1]. It approximately coincides with a largely featureless zone in JunoCam images, which we call the Bland Zone, although some circulations do exist in it and there is sometimes a disturbed sector (see JunoCam maps, Figs.1 & 2). In N5, anticyclonic white ovals (AWOs) tend to lie near or at the northern edge of the domain, i.e. the N6 jet; this has often been seen in JunoCam closeups. In fact, they often straddle the mean latitude of this jet; but we have not yet established whether the jet is straight, and it may veer around the AWO (e.g. see our PJ38 report).

The JUPOS chart (Fig.3) shows a mixture of retrograding drifts and rapidly prograding drifts. The bright spots include both cyclonic folded filamentary regions (FFRs) and AWOs, as described below. The analysis of JUPOS data by G.A. is summarised in Fig.4. These data produce the zonal drift profile (ZDP) shown in Fig.4c. It is essentially the same as in our previous reports [refs.1 & 2], very close to the ZWP from Cassini, including the 'blunted' retrograde flow. We have argued that this is a steady zonal slow current (N5TC) that governs the drift of the major features of the N5 domain, esp. the FFRs, and this is now supported by observations of individual FFRs with drifts in this range (w1,w5). The same slow current applies to AWOs, other bright spots (most likely FFRs), and dark spots within the same latitude range. The mean speed of this current can be taken as the mean of all our measurements:

--from 59.1--61.9°N: Mean DL2 = +11.8 (±5.4) deg/30d, lat. 60.8 (±0.9)°N.

This agrees well with the long-term average of +13 deg/30d [ref.1]. More broadly:

--from 57.0--63.0°N: Mean DL2 = +5.3 (±9.8) deg/30d, lat. 60.4 (±1.6)°N.

North of this range, the ZWP & ZDP have a steep gradient of speed up to the N6 prograde jet at 64°N. All three long-lived N5-AWOs (here labelled a,b & e) were strongly influenced by this jet for parts of their tracks, moving up or down the anticyclonic gradient; and one bright spot (w2) had an unprecedented speed of DL2 = -76.6 deg/30d for over a month, in the jet peak. Even further north, three closely spaced, rapidly prograding tracks (w16, w17, w18; Fig.4b) represented bright spots in the N6 domain, which can be identified in the JunoCam and Hubble maps as cyclonic features in the middle of the domain (the Bland Zone).

The speeds and latitudes for the spots described individually below are listed in **Table 1**. Shorter tracks for bright spots on the JUPOS chart (Figs.3 & 4) last only ~1-3 weeks, all retrograding with the N5TC, and probably represent other cyclonic features such as FFRs.

The three best-documented tracks (a,b,e) were confirmed as AWOs by JunoCam images. The three named AWOs all changed rapidly between prograding and retrograding drifts (and accordingly latitudes):

(a & b) AWO-a was tracked from Aug.11; it could have existed earlier with a different drift rate. AWO-b was tracked from May and imaged at PJ34 (June).

They approached each other in late August (Fig.5). AWO-b was retrograding at ~61°N. AWO-a was prograding at higher latitude; in fact it soared from 63 to almost 66°N within a week, straying far into the N6 domain, then immediately came back again! It's possible that this excursion was unrelated to the interaction with b a week later; there does not seem to be a simple dynamical explanation of what happened. At first glance the chart suggests that the tracks of a and b simply crossed over, but close inspection indicates that they actually rebounded, exchanging latitudes and drifts (Fig.5). This is confirmed by the PJ36 closeup image (Sep.2) and the Hubble maps (Sep.4) (Figs.6 & 14). The JunoCam image caught them at the moment of closest approach, at virtually the same latitude, with a link between them. The Hubble maps two days later (which can be blinked – not shown here) show that a is moving southwards and b northwards, and they are separating in longitude.

After their encounter, AWO-a continued retrograding, and was imaged at PJ37 and PJ38 and PJ39, although its ground-based track between those perijoves is ambiguous. AWO-b reversed its drift suddenly again in late Sep., from prograde to retrograde, and was imaged at PJ37 (Fig.14).

(e) We identify the very large AWO imaged at PJ33, PJ34, & PJ39, with the well-established JUPOS track in between (when it was not imaged by JunoCam), despite the implied changes of speed. In ground-based images from Sep. to Nov. it was a conspicuous large AWO at 61°N (e.g. Figs.7-9). Its excursions can be watched in an animation that Rob Bullen has provided of his cylindrical maps throughout the apparition [not shown here].

Around Nov.1 it suddenly shifted north and reversed its drift from retrograde to prograde. Curiously, this happened when AWO-e (61.6°N) intersected the extrapolated track of a rapidly prograding spot [w2 – see below; 64.3°N]*. Fig.9 shows a subset of the best images around this time. w2 appears as a small white oval. It was not definitely recorded after Oct.23, but this is because of a lack of suitable images until Oct.28, when it would have been in conjunction with AWO-e.

> *We reported a very similar event in 2020 [ref.2]: The large N5 AWO "accelerated upon encountering a smaller, northerly, very fast-moving white spot in the N6 domain, probably a tiny AWO (66.1°N, DL2 = -39) which appeared to swerve north of it." In previous years we have observed other events in the N5 & N4 and also S3 domains, when a long-lived AWO changed its speed suddenly to match the extrapolated track of a smaller spot, but those were changes from prograde to retrograde, and we suggested they were caused by the AWO encountering a FFR [refs.1&2].

The new prograding track of (e) could be extended to a bright AWO imaged at PJ39 or, perhaps more likely though with slight deceleration, to the larger AWO labelled (e?) in Fig.2.

AWO-e may well be the same large AWO that was notable in 2019 and 2020, when it showed similar huge changes in drift rate [ref.2].

Several other AWOs in JunoCam images were not tracked in amateur images. The other tracked features that we can identify, in the JunoCam (PJ36) and Hubble maps near opposition (Fig.6), were cyclonic, as follows. It is notable that these very northerly cyclones were bright enough to be tracked in amateur images. The spacecraft images show most of them with more compact, near-circular shapes than typical FFRs.

(w1) This was a small FFR, tracked retrograding in N5 up to then.
(w2) At PJ36, this was near the terminator; the Hubble maps showed it to be a cyclone [see below].

(w5, w8) These, retrograding in the southern N5 domain, were FFR-like cyclones, although blinking the Hubble maps shows that their circulations were more complex.

(w16, w17, w18) These were rapidly prograding cyclones in the middle of the Bland Zone (N6 domain); the Hubble maps confirm that they were rapidly prograding.

w17 generally appeared irregular in ground-based images in late August, consistent with being a FFR. From July 16 to Sep.1 it drifted from 65.9 to 67.3°N, northwards across the N6 domain -- slowing temporarily as it crossed the velocity minimum. However, in the Hubble maps on Sep.4 it was at 65°N – possibly changing at the end of its life? [see below]. It cannot be tracked after Sep.4.

(w17, w18, w2) These three closely spaced, rapidly prograding tracks lead up to a close-packed cluster of six white spots at PJ36, mostly in the Bland Zone; some were in darkness to JunoCam, but the Hubble maps confirmed that the whole cluster was prograding. But it has been possible to resolve most of them using the JUPOS charts (Figs. 3 & 4), original images (Figs.7&8), and JunoCam and Hubble maps (Fig.6). In the N6 domain this constituted a chain of two AWOs (too small and northerly for ground-based tracking) and three FFR-like cyclones (w18, anon, & w17) – resembling the alternating cyclone-anticyclone chains sometimes seen in lower-latitude domains. (w18 and w17 were both tracked at 67°N, but w17 is at ~65°N in the Hubble map.) The sixth spot was w2, at 63°N, a cyclone on the N6 jet.

The cluster was identifiable in an image on Sep.4 [Fig.7] but not thereafter, and the tracks of w16 and w17 ended then. However, an AWO arose near this position (it could be north of w2, at 60°N, in the Sep.4 Hubble map, and could be the one on the same track at PJ35) and was tracked retrograding until it was imaged at PJ37.

Meanwhile, **w2** continued on the N6 jet. On Oct.5-23, ground-based maps showed it as a small white oval at 63-64°N (**Figs.8&9**): we can't tell whether it was still a bright cyclone, or had been replaced by an AWO on the same track. It maintained DL2 = -76.6 at 64.3°N, which is the fastest speed we have ever recorded on or near the N6 jet. In late Oct. it approached AWO-e, but the actual encounter was not well imaged; it apparently caused AWO-e to accelerate onto the extrapolated track of w2 (see above).

Table 1:

2021 N5 & N6 domains					
(JUPOS data - excerpt from GA analysis)					
This table lists the spots mentioned in the text.					
Red, lats.>63°N; pink, sparse data.					
spot	*time interval*	*DL2(°/30d)*	*U3(m/s)*	*Lat.(g)*	*N*
AWOs					
AWO-a	Aug 11 – 25	-51.8	9.5	64.7	12
	Aug 27 – Sep 6	-7.4	-0.1	62.5	6
	Sep 8 – 24	12.8	-5.0	61.8	6
AWO-b	May 15 – Jul 18	19.5	-6.8	60.4	17
	Aug 15 – 23	19.5	-6.8	60.9	5
	Aug 25 – Sep 2	0.5	-2.0	61.9	6
	Sep 4 - 9	-47.0	8.8	63.7	4
	Sep 20 -- Oct 8	22		61.5	5
AWO-e	May 14 – Jun 6	-9.5	0.4	62.3	7
	Jul 4 – 18	-6.2	-0.4	62.7	17
	Aug 4 – Oct 18	7.4	-3.7	61.6	74
	Nov 7 – Dec 8	-48.6	9.1	63.9	15
Cyclones & FFRs					
W1	Jul 12 – Aug 9	10.3	-4.6	60.4	9
	Aug 18 – Sep 9	18.8		61.2	8
W2	Aug 18 – Sep 15	-60.8	11.7	64.1	7
	Sep 18 – Oct 23	-76.6	15.1	64.3	11
W5	Aug 16 – Sep 9	8.4	-4.1	60.8	23
W8	Aug 25 – Sep 9	0.0	-1.8	62.8	12
W16	Aug 23 – Sep 8	-53.6	9.2	66.8	6
W17	Jul 16 - 28	-78		65.9	5
	Aug 9 – 24	-36.7	5.8	66.6	6
	Aug 27 - Sep 1	-52		67.3	5
W18	Aug 15 – Sep 8	-56.0	9.7	66.6	6

This apparition's results exceed our previous records for the largest number of features tracked in the N6 domain, and for the fastest spot tracked in or near the N6 jet
(DL2 = -77 for w2 at 64.3°N; less precisely, DL2 ~ -78 for w17 at 65.9°N). Also, w17 later reached 67.3°N (with DL2 = -52), which matches the highest-latitude spot that we have ever tracked, though not its still-unrivalled speed [67.3°N with DL2 = -91 deg/30d, in 2011/12]. Apart from these spots, both in 2021 and previously, other spots in N5 & N6 had speeds less than -60 deg/30d.

In Fig.9, we also note a well-observed large white area at 69°N, presumably one of the FFRs north of the N7 jet.

N4 domain

Part of this has already been posted in our PJ39 report, Appendix A (with DL3 and planetocentric latitudes).

Our data and analysis for the N4 domain are as comprehensive as for the N5 domain, and they generally reinforce our previous conclusions [refs.1 & 2], and are similar to the conclusions for the N5 domain.

Fig.10 shows the JUPOS chart of the N4 domain. Almost all the tracks are retrograding, except for some AWOs after mid-August. The ZDP derived from the JUPOS data is Fig.11. It closely resembles the N5 ZDP and previous N4 ZDPs. Most white spots and other features in the domain were retrograding:
DL2 = +6.5 (±3.3) deg/30d (mean of lats.50.5 to 53.4°N).
But the higher-latitude AWOs were rapidly prograding:
DL2 = -21 to -40 deg/30d (mean DL2 = -28.6 (±7.2) deg/30d from lats.54.1 to 55.2°N).
These speeds are entirely typical of the N4 domain [refs.1&2]. The retrograding speed is the zonal slow current for the domain (N4TC), and is likely to apply to the FFRs as well, although they have not been systematically tracked until now.

As in N5, long-lived white ovals in this domain are very likely to be anticyclonic (invariably so for high-latitude ones), and their identity as AWOs was confirmed whenever JunoCam imaged them. AWO-G could be arising from a FFR at PJ33 (Fig.1). Four AWOs (labelled A,B,E,G) were well tracked throughout the apparition, and several others for shorter periods, despite their large changes of speed. Almost all of the prograding white spots on the chart can be identified as AWOs, even very small ones. Of the retrograding non-AWO white spots, one at PJ36 (box near A in Fig.6 map) seems to be a pair of tiny cyclones, and one at PJ37 was a FFR. The latter FFR can be followed on the amateur images in Oct. in Fig.8, adjacent to AWO-G, with similar retrograding drift (Oct.4-16; light green oblique arrow). Dark spots can sometimes be identified on the JunoCam maps as amorphous dark areas.

All the AWOs with long retrograding tracks (A,B,D,E,G,H) showed substantial latitude variations without substantial change in their retrograding speeds, whether a gradual increase, or fluctuations, or a decrease – always above 50°N and below 54°N, in the range where the ZWP/ZDP is almost flat (Figure 12). This behaviour has been observed for other AWOs in the N4TC [refs.1&2].

Conversely, around the end of August, three consecutive AWOs (B, E, F) all changed from retrograde to prograde drift; and they all moved north then, to >53.5°N, again in accordance with the ZDP (Figs.10 & 12). We have noticed coordinated shifts like this in JUPOS data on many previous occasions, without any evident cause. One could speculate that an upsurge of activity in this sector of the domain forced the AWOs northward; but the global map made from Hubble (OPAL) images on Sep.4 does not show any obvious anomaly along this sector. Ground-based images of these major AWOs can be seen in Figures 7 (A,G), 8 (G) and 9 (E).

Ovals A and B were of special interest because of their interactions between PJ38 and PJ39, which apparently led to AWO-A moving north to straddle the N4 jet and splitting as it did so. Their tracks in longitude and latitude are shown in Fig.12.

AWO-A was steadily retrograding from May 5 to Oct.30, then around Oct.30, its drift suddenly slackened to DL2 = +2 deg/30d and its latitude increased slightly to 53.0°N (±0.5°; n=14; Oct.30 –Nov.21). Then from late Nov. its latitude rapidly decreased, to reach 49.3° by the New Year (±0.2°; n=3; Dec.30-Jan.11).

This rapid decrease in latitude was initiated in late Nov. when the tracks of A and B converged to bring them only 8° apart in longitude. So it may have been the anticyclonic flow around AWO-B that caused A to move south*. AWO-B paused, then accelerated again in early Dec. so as to pass A. Although the JUPOS chart does not show their interaction clearly, the original ground-based images in Dec. (Figure 13 = A2) show that AWO-B did prograde quickly past AWO-A (conjunction on Dec.16), so its identity in the JunoCam maps at PJ38 (Nov.29) and PJ39 (Jan.12) is confirmed.

*Earlier, AWO-A probably interacted with the cyclonic brown lozenge labelled C in the JunoCam maps (Fig.2) (as seen at PJ38; see our PJ38 & PJ39 reports), sending it south, before it converged on AWO-B. This feature C was not tracked by JUPOS.

A hi-res image by T. Olivetti on Jan.10 [Figure A3 in PJ39 report] was the last one showing both AWOs, as the apparition drew to a close; but the JunoCam PJ39 images (Jan,12) seem to show that AWO-A had continued to move south and become an hourglass-shaped double AWO, both lobes being methane-bright, straddling the N4 jet! [See our PJ39 report for further details. V-hi-res images of AWO-A are in our PJ38 and PJ39 reports.]

We have recorded exactly this behaviour -- i.e. an N4-AWO passing into the N3 domain -- on two previous occasions from amateur images, in 2011 Nov-Dec.[ref.1 & our 2011/12 final report] and in 2018 Feb-Mar. [ref. our 2017/18 report no.6] In the 2011 case, the AWO temporarily split into two connected lobes as it crossed the N4 jet, just as now. Other cases could have gone unrecorded, so the phenomenon may not be very rare. This is the only latitude in which there is any record of an anticyclonic oval directly crossing a prograde jet – except for one this year that crossed from the N3 to the N2 domain (see below)!

The other AWOs (D,F,H,J,K,L) were recorded for shorter times and some may have only existed for part of the year, although of course they could have been smaller anticyclonic vortices when they were not observable as AWOs. Thus:

AWOs D and F may have first appeared in August; F was not present earlier, at PJ34 nor PJ35 (Fig.1). [It is not w4.] We don't know what happened to D; it disappeared when in conjunction with AWO-B but they probably did not merge as they were at latitudes 50.6, 54.4, rply. F may have ended by merging with E (latitudes 54.5, 54.2, rply); its rapid approach can be seen in Fig.9; however, E then accelerated and they remained separate at least until Nov.9, so the outcome is unclear.

AWOs-K[w14] and M[w24] were small AWOs, probably also short-lived. They were imaged at PJ36 (K only) and by Hubble on Sep.4, and were tracked by JUPOS for 18 days and 34 days rply

AWOs H and L may have merged to create J; possibly just before or after PJ36, when a close pair of anticyclonic features is seen on the track. The PJ37 images may show AWO-J (at L3 = 3) being destroyed upon interacting with an FFR (Fig.2 & Fig.14).

N3 domain

The N3 domain contained a rather sparse array of small spots, as usual, but many of them were tracked by JUPOS (Fig.15), yielding the ZDP in Fig.16, which lies close to the ZWP from Cassini. All spots were prograding, representing the usual zonal slow current (N3TC). The mean drift rate was DL2 = -20.9 deg/30d (±6.4; N = 32 track segments for 16 spots, taking all spots between 43.5°N and 46.2°N that were tracked for >2 months).

There was one remarkable spot in N3, here called N3-w1, which moved from the N3 to the N2 domain in 2021 Sep – the first time this has ever been observed. The oval is shown in Figs.7 & 18 (green arrow). Its motion is plotted on the ZDP in Fig.16 and in detail in Fig.17.

This was a very bright white oval in the N3 domain, weakly methane-bright, which was definitely anticyclonic, as the ZDP shows it oscillating up and down the anticyclonic gradient in N3 before its movement south, and likewise in N2 afterwards (Fig.16). It began moving south as it skimmed past the north edge of NN-LRS-1 around Aug.4 (Fig.18A). It seems likely that the clockwise circulation of NN-LRS-1 initiated this movement, but we do not know why the AWO continued to drift steadily southward even as it was still prograding in the usual N3 current (N3TC) (Fig.17). As it moved south, it elongated meridionally, as shown in the HST maps on Sep.4 (Fig.6) and amateur images from Sep.7-12 (Fig.7). (Blinking the HST maps also shows it tilting anticyclonically despite being in the cyclonic domain; whether the N3 jet is present alongside the oval is not clear, although it is evident at most other longitudes.) As the oval crossed the N3 jet's mean latitude in mid-Sep. (Fig.17), its southward migration was still steady, even though it changed its longitudinal drift in partial, abrupt responses to the surrounding ZWP (Fig.16). Once it had entered the N2 domain, its drift and latitude oscillated within the NNTZ. It was still a very bright little AWO, between NN-LRS-1 and NN-WS-6 (Figs.8 & 18B). Its sudden acceleration around Oct.13 seems to have been due to encountering a small faint prograding spot that was traced up to Oct.13 (Fig.15 & Fig.18B). [This must be the orange cyclonic oval seen adjacent to the AWO in JunoCam's oblique view at PJ37 on Oct.16 (Fig.18C), and probably also seen in the HST map on Sep.4 (Fig.6, oblique cyan arrow)]. The translocated AWO w1 persisted into 2022 Jan., and we wait to see whether it will still be present in the next apparition.

References

Ref.1: Rogers J, Adamoli G, Jacquesson M, Vedovato M, & Mettig H-J (2017), 'Jupiter's high northern latitudes: patterns and dynamics of the N3 to N6 domains.' https://britastro.org/node/11328

Ref.2: Rogers J & Adamoli G (2021), 'Jupiter in 2020, Report no.9: Final report on northern hemisphere.' https://britastro.org/section_information_/jupiter-section-overview/jupiter-in-2020/jupiter-in-2020-report-no-9-final-report-on-northern-hemisphere

Ref.3: Hubble (OPAL) maps, 2021 Sep.4
The Hubble Space Telescope (HST) takes comprehensive sets of images once a year in the OPAL project [NASA / ESA / STScI / A. Simon, G. Orton & M. Wong]. "This work used data acquired from the NASA/ESA HST Space Telescope, associated with OPAL program (PI: Simon, GO13937), and archived by the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. All maps are available at http://dx.doi.org/10.17909/T9G593."
The maps are also posted here: https://archive.stsci.edu/prepds/opal/.

Figure legends

Figure 1. JunoCam maps from PJ33 to PJ35, covering the high northern domains. Labels are as in Fig.2.

Figure 2. JunoCam maps from PJ36 to PJ39. Boxes enclose disrupted sectors of the Bland Zone. Features are labelled as follows, as in the text: N5 AWOs (a,b,...); N4 AWOs (A,B,....). Feature C is a brown cyclonic lozenge in N4, which was not tracked by JUPOS, but could be the same feature at PJ37, PJ38 and PJ39. [This was Fig.7 of our PJ39 report.]

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N5 & N6 domains:

Figure 3. JUPOS chart of longitudes (L3) vs time for spots in the N5 & N6 domains.
The bright spots are a mixture of FFRs and AWOs. Some show retrograding drifts [down to left, green points, 56-63°N]; others, prograding drifts [down to right, blue points, >63°N]. Meaurements from the JunoCam maps are shown as larger symbols. (These charts are now in L3 with longitude increasing to the left, consistent with the format of the JunoCam maps, contrary to our previous conventions.)

Figure 4. Analysis of JUPOS data by G.A. (a) JUPOS chart like Fig.3, with tracked features highlighted and numbered. (b) Enlarged, revised tracks for prograding N5/N6 white spots around PJ36. (c) Zonal drift profile (ZDP).

Figure 5. Tracks of AWOs a & b, in latitude & longitude (L2), including the point when they rebounded from one another and exchanged tracks.

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Figure 6. The JunoCam map at PJ36, and one of the Hubble (OPAL) maps 2 days later. Features are labelled as follows: N5 AWOs (a,b,...); other tracked white spots in N5 & N6 (w1, w2,...; white in N6, blue in N5) and N4 (box in N4); N4 AWOs (A,B,....).

Figure 7. Ground-based images in Sep., covering the region shown in Fig.6 with N5 AWOs a&b and white spot w2.

Figure 8. Ground-based images in Oct., covering the same region as Figs.6 & 7, with the PJ37 map for comparison.

Figure 9. Ground-based images in Oct., covering longitudes from N5 white spot w2 to AWO-e.

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N4 domain:

Figure 10. JUPOS chart of the N4 domain.

Figure 11. Zonal drift profile for the N4 domain, from the JUPOS data.

Figure 12. JUPOS charts of longitude (L2) and latitude for six N4 AWOs.

Figure 13 [= Fig.A2 from PJ39 report]. Ground-based images in Dec. showing N4-AWO-B prograding past AWO-A.

Figure 14. Full-scale images from PJ36 and PJ37, possibly showing the origin and demise of N4-AWO-J, although we cannot be certain as these are snapshots of a very complex, dynamic region. At PJ36 there are two adjacent features which could be AWOs H and L about to merge to create J. At PJ37 AWO-J is interacting with a FFR. (Images processed by Gerald Eichstädt & JHR.)

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N3 domain:

Figure 15. JUPOS chart for the N3 domain.

Figure 16. ZDP for the N3 domain, from JUPOS data. The yellow symbols connected by a red dotted line denote AWO-w1, which moved from the N3 to the N2 domain.

Figure 17. Charts of longitude & latitude of N3-AWO-w1, from JUPOS records..

Figure 18. Images showing N3-AWO-w1.
(A) Early August, passing NN-LRS-1; its southward migration started at this time.
(B) October, after it had crossed the N3 jet. The oblique arrow indicates a small faint N3 spot prograding toward it, which must be the orange cyclonic oval shown in (C).
(C) JunoCam image from PJ37 on Oct.16.