Jupiter in 2022/23: Report no.3

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with results from the JUPOS team (2022 Oct.31)

Here we catch up on jovian developments since Report no.2 in July – although meanwhile, ground-based maps and brief updates have been included in our reports on Juno's perijoves: PJ43 (July 5), PJ44 (Aug.17) and PJ45 (Sep.29). There have not been major changes since Report no.2, except for the fading of the EZ colour, and the appearance of a new S. Tropical Band. Figures 1 & 2 are maps on July 20-21 and Sep.28-29; more images from around Sep.29 (the time of PJ45) are in Figure 3.

This interval includes Jupiter's very favourable opposition on Sep.26. Autumn oppositions are the closest (Jupiter will pass perihelion on 2023 Jan.21), and this was the closest for for 59 years past or 107 years future [Sky & Tel., 2022 Sep., p.48]. Some images of satellite transits near opposition are in Figure 4. More v-hi-res images, with some major ovals labelled, are in Figure 5.

The JUPOS team (Gianluigi Adamoli, Rob Bullen, Michel Jacquesson & Hans-Joerg Mettig) have produced their regular drift charts for all latitudes, and some of those have been adapted and annotated herein to show the motions of atmospheric features. Note that they are now produced in L3 (or L1), with east to the right, consistent with the other illustrations, which all use L3 and have north up.

Our PJ45 report also includes amateur maps of the north polar region (by Andy Casely): together with the JunoCam map, these show the structure and rotation of the methane-bright North Polar Hood.

N2 domain (Chart: Figure 6)

There are still three long-lived anticyclonic ovals in the NNTZ, little changed since July, though two of them have been elusive visually. Hi-res views of them are in Figure 5.
Their tracks are shown on the JUPOS chart (Figure 6), supplemented with measurements from methane-band images (esp. from P. Casquinha, A. Cidadao, M. Kardasis, P. Maxson, I, Miyazaki, G. Walker & M. Wong). NN-LRS-1 is brightest in methane, as usual; it is still distinctly red. WS-6 is also very bright in methane, and is still bright white. WS-4 has a methane-bright, white core, but this is small and so not conspicuous.

Most of the NNTB is pale and fawn-coloured, though there are some FFRs.

The JUPOS chart also includes many small, inconspicuous dark spots retrograding in the NNTZ. Those p. WS-4 (Figure 5, Aug.21 & 29) may have emerged from the FFR f. LRS-1.

There is still a widespread outbreak of dark spots on the NNTBs jet (Figure 2), also possibly arising from the FFRs.

N. Tropical domain (NTropZ & NEB)

Six barges and seven AWOs have persisted throughout, although all but one of the barges are faint (outlined by brown loops) and some of the AWOs have very low contrast (WS-A may be no more than a bay). Because of this, their tracks on the JUPOS chart (Figure 7) are incomplete, but they can be identified on most maps (Figures 1 & 2). White spot Z (WS-Z) is similar to some others in visible light, but is distinctively methane-bright (e.g. Figure 3).

The slow, partial revival of the NEB has proceeded, as disturbance and darkening is still gradually spreading northwards. On Oct.1-4, rifts from NEB(S) were interacting with a faded barge (Figure 8). But the barges are all still whitened, except for one dark one, which Juno imaged closely at PJ45.

All the vigorous activity is still in the NEB(S). The small, very bright outbreaks are now appearing around about half the circumference (Figure 9). This chart shows that they have the same retrograding drifts as before. One appeared on Aug.15, two days before PJ44, and was fortunately in JunoCam's close-up field of view – the third time such outbreak to be closely imaged, and the freshest one yet (see our PJ44 report). Another new outbreak appeared on Oct.1, just after PJ45 (green arrow in Figures 3 & 9; see our PJ45 report).

Equatorial region

NEBs:

There are now many NEBs dark formations (see maps in Figure 10), including some prominent ones, although most are rather oblique and difficult to track. Having arisen from the NEB(S) disturbances, they have a range of both positive and negative speeds close to System 1. The super-fast speeds have now almost disappeared, with just one or two tracks with DL1 = -32 in Sep., according to both the JUPOS and ALPO-Japan charts (Figure 9).

EZ:

The ochre colour faded rapidly during the spring and summer and is now very weak, amounting to a light fawn-coloured shading. However it is still quite dark in UV (e.g. recent images by Barry Adcock and Paul Maxson).

SEBn:

The flow of the SEBn jet is abundantly displayed on the JUPOS chart (Figure 11), though the speed (mean DL1 = -36 deg/30d) is much slower than usual. There is also an even slower-moving feature, appearing as a vacant band in the JUPOS chart, which is visually inconspicuous but displays the typical features of a weakly active South Equatorial Disturbance (SED), as was seen prior to 2010* (Figure 12A,B). We wait to find out whether this will become a large, long-lived SED. In detail:

The JUPOS chart (Figure 11) is filled with fast-moving tracks representing the so-called chevrons on the SEBn edge, moving with the SEBn jet. Their mean speed is DL1 = -36.1 (±6.1) deg/30d (N=16). This corresponds to the slower of two interspersed speed groups that we reported for 2021 (-42.3 (±11.3) and DL1 = -82.2 (±6.1); 2021 Report no.10). It is exceptionally slow for this jet. It is not obviously related to the possible new SED (see below) as the slow jet speed applies at all longitudes.*

The chart also shows a vacant band [grey arrows in chart] denoting a short gap in the chevrons, moving much more slowly: mean DL1 = +32 deg/30d. In maps (Figure 12A), this strip of SEBn tends to be associated with a very small rift at its p. end, and a very bright strip of EZ(S), and a dusky grey streak near the equator (Figure 12A). In all these properties it resembles the long-lived SED of 1999-2010 when it was in its quiescent phases.*

*References on the previous SED:

1. Rogers JH & Mettig H-J. (2008), 'Influence of Jupiter's South Equatorial Disturbance on jet-stream speed'. JBAA 118 (no.6), 326-334. *Available from:* https://britastro.org/jupiter/reference.htm

2. Simon-Miller AA, Rogers JH, Gierasch PJ, Choi D, Allison MD, Adamoli G, Mettig H-J (2012). 'Longitudinal variation and waves in Jupiter's south equatorial wind jet.' Icarus 218, 817–830. [doi:10.1016/j.icarus.2012.01.022]

3. Rogers J (2012) 'The life of the South Equatorial Disturbance, 1999-2010'
Available from: http://www.britastro.org/jupiter/icarus.htm
http://www.britastro.org/jupiter/2012_13/SED-1999-2010_Final-overview-to-post.doc

In mid-Oct., the SED appearance was reinforced as a bright white strip in northern SEBZ trailed behind the small rift (Figure 12B). However, this was a transient coincidence, as the SEBZ white strip had existed separately and the rift (DL1 = +51 deg/30d) was overtaking it.

The SEBZ white strip had developed by brightening of the usual northern SEBZ in the last days of August (Figure 14B) perhaps influenced by two phenomena in the previous days (Figure 14A): three new bright spots that erupted in the SEB rifted region f. the GRS; and a transient bright rift in the SEBn edge passing the GRS on Aug.22. The drift rate of the SEBZ white strip (Oct.2-19) was DL1 = +120 deg/30d for the p.end, +139 for the f. end; the latter is typical for white spots that frequent this latitude. [From JUPOS charts, they currently have mean DL1 = +144 (DL3 = -77; ±6.5), and in 2021 they had mean DL1 = +136 (DL3 = -85; ±9).] (Complex structure elsewhere in the northern SEBZ is seen in v-hi-res images in Figure 5.)

S. Tropical domain (SEB & STropZ)

The SEB has only shown modest changes in recent months, including development of bright white sectors of SEBZ in the north half (see above) and the south half (p. the GRS). The rifted region f. the GRS has mostly remained short, but was more extensive in August. The main change in this domain was the appearance of a new 'Hook' around the f. side of the GRS, in early July, which quickly gave rise to a new S. Tropical Band (STropB) extending from the p. side of the GRS.

GRS:

A few red flakes were observed, as in 2019, inside the curve of the Hook:

(1) 2022 Aug.3-6 (Figure 13): These maps show that a large SEBs ring entered the RSH on July 31, and a flake appeared on Aug.3 as pointed out by Isao Miyazaki and Amrit Seecharan; well shown by Gary Walker on Aug.6, inc. in methane. It was then visible at the p. end on Aug.8-11, while a smaller one followed it at the f. end. No more SEBs rings entered the RSH until Sep.26.

(2) Aug.27-30 (Figure 14B): At the p. end; no antecedent at the f. end.

(3) Oct.1-6 (Figure 15): A SEBs ring entered the RSH on Sep.26. The JunoCam inbound images on Sep.29 showed it connected to the GRS by the tenuous incipient flake. The red flake appeared at the GRS f. end on Sep.30, and was reported on Oct.1 by Johnny Hsieh (Taiwan) and confirmed by many Japanese observers -- as well as a small one at the p. end, of unknown origin. The latter was present again on Oct.3, and the former emerged at the p. end on Oct.5, persisting on Oct.6.

The GRS has now shrunk even more than before: the chart (Figure 16A) shows that it suddenly shrank in June and has had a mean length of ~11.5° since then.

Its drift rate, which had been faster (less positive) during 2021 (DL2 = +1.4, DL3 = +9.4 deg/30d), has been slower again during 2022 (DL2 = +1.8, DL3 = +9.8) (Figure 16B; the JUPOS chart agrees). The reason for these variations in unknown; they are not correlated with the presence of a Hook.

Meanwhile the 90-day oscillation continued like clockwork, and the rift or 'chimney' on the north edge of the RSH continued to appear and disappear in synchrony with it (Figure 16B).

SEBs, STropZ & STropB (Chart: Figure 17):

In the summer, there were many dark spots and streaks in northern STropZ with modestly retrograding speeds (DL2 = +29 to +53; DL3 = +37 to +61), and few rapidly retrograding SEBs rings; but recently the latter have become more numerous again on the SEBs jet.

The new 'Hook' developed around the f. side of the GRS, in early July, and quickly gave rise to a new S. Tropical Band (STropB) extending from the p. side of the GRS, as it always does. Shinji Mizumoto has posted an animation of maps showing this process, in which detailed dynamical events can be seen: http://alpo-j.sakura.ne.jp/Latest/j_Cylindrical_Maps/j22GRSanimL3n.htm (see also Figures 13 & 14). As with other such 'Hooks' in 2019 and 2021, in many respects it

resembled the S. Tropical Disturbance of 2018 as it streamed past the GRS. Three spots prograding on the STBn jet made a U-turn on the f. side of the Hook in July & August, to retrograde on the SEBs jet (purple points on Figure 17; marked in blue on Figure 13). The p. end of the STropB advanced with DL2 = -80 (DL3 = -72) deg/30d. The latitudes between the STropB and the STB (i.e. Segment A) were initially extremely turbulent (see animation link above), and remained so through Sep., although the sector closer to the GRS became clearer as STB Segment A prograded away.

In early Oct., the Hook appeared to be thinning and weakening; but by late Oct. it had revived, and the 'U-turn current' on the GRS f. side also appeared to be alive and well. The STropB rapidly became a major dark belt, and by Oct. it extended most of the way round the planet.

STBn jet:

A massive outbreak of dark spots on the STBn jet has continued, emerging p. STB segment G (see below) (Figures 1,2,4,5). Speeds are all close to DL2 = -77 (DL3 = -69) ±5 . The maps suggest that they have been drifting northwards as they prograded, as we have observed in previous outbreaks. As noted in our PJ42 report, they were emerging p. Segment G at ≤27.2°S (planetographic), but then mostly travelling at ~25.3°S. This is an unusually low latitude, north of the canonical STBn jet. We wondered whether this was because they were travelling along the longitudes of the former STB Spectre, but there are no hi-res JunoCam images of this sector to address this question.

Initially they covered a large range of longitude, but they could not survive past the GRS (esp. not after the Hook developed; see the animation link above, & Figures 13 & 14). So by Oct., as Segment G was drifting towards the GRS, they covered a much smaller range.

S. Temperate domain (Chart: Figure 18)

As previously described [PJ42 report & Report no.2], there is now some kind of dark STB around more than half the planet. Three segments of it are separated by major white ovals. In order of increasing longitude:

STB segment G (the descendent of Clyde's Spot/DS7) is a well-defined turbulent sector ~45° long (Figures 1,2,5,12B), extending to cyclonic oval WS6. Following WS6, there is a stretch of dusky STB that extends to oval BA. Following oval BA, STB segment A has stabilised at a length of ~80°. Its p. half appears turbulent and its f. half plain and dark, but JunoCam maps show all of it turbulent, up to the smaller STZ AWO which marks its f. end (Figures 1-3).

Following this AWO there is a long dark 'Sf. tail' along the STBs jet and STZ. In the summer it terminated at an even smaller AWO, adjacent to Spot 8, but now it tapers even further f.

Around the remaining longitudes, the STBn jet spots constitute a spotty STB(N). Spot 8 (or DS8) is confirmed as a dark brown oval (Figure 5).

The white ovals are a diverse collection:

Oval BA (the large AWO) is still off-white with a 'warm' tint due to a slightly reddish internal annulus. It still has a modestly dark grey-brown rim. It is still drifting quite fast (see below), with variations over a matter of months.

WS6 (the cyclonic white oval) is generally 'cold' white (relatively bluish), but sometimes appears to be resolved into different parts. For example, Antonio Cidadao on Sep.23 found that only the south part was dark in CH4 (as expected from a cyclonic feature), and it was redder. JunoCam imaged WS6 close-up at PJ44 and the oval had a 'yin-yang' shape, with the north part bluer.

Between BA and WS6, a small dark spot in the STZ latitude developed a bright centre in late May, turning into a small, dark-ringed AWO. Andy Casely tracked it and noted that in the methane band it was first visible by early July, grew brighter through August, and has been notably methane-bright since September. It's possible that the initial dark spot was the same as anticyclonic dark spot d1 in 2021 [2021-22 report no.10], which could

have squeezed past WS6 near solar conjunction; in fact it may have been doing so on April 9 in the JunoCam PJ41 map, though not clearly resolved.

The longer-established small AWO in the STZ is rimless and very bright. Curiously, it appears bright in blue & UV light while not very bright in methane (e.g. Paul Maxson & Todd Green, Oct.5) -- suggesting that its cloud cover has some similarity to cyclonic white ovals rather than to other AWOs.

Drift rates for these features are now quite uniform. From JUPOS data (July-Oct.), DL3 (DL2), deg/30d:
WS6: -9.7 (-17.7). BA: -8.7 (-16.7). AWO: -9.5 (-17.5) (variable). DS8: -8.5 (-16.5).

S2 domain (Chart: Figure 19)

There are still 7 long-lived AWOs, and two cyclonic white ovals (CWOs), p. AWOs A2 and A5.

Figures

Miniature figures are in a separate PDF, and full-size figures in a ZIP file.
