Jupiter in 2012/13: Interim report no.9 (2013 Jan.):

Interim report on Jupiter, 2012 Aug.-Dec.

John Rogers (British Astronomical Association),
including results from the JUPOS team
(Gianluigi Adamoli, Michel Jacquesson, Marco Vedovato, Hans-Joerg Mettig & Grischa Hahn)

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(For full-size images, see attached ZIP file.)

Appendix 1:
NNTZ: Anticyclonic ovals, 2008-2012

Gianluigi Adamoli & John Rogers

Here we update the history of the anticyclonic ovals in the NNTZ, as previously described in Ref. [3]. Their history is summarised in the JUPOS chart in Figs.A1 & A2 (presented in both L2 and L3). In Table A1 (below), we give brief notes on their appearance in hi-res images and in methane-band images (0.89 um).

In some cases the connections between apparitions are not certain (shown as dashed lines), because of changes in drift rate, but these connections appear likely, given that these are the only methane-bright spots, and that within apparitions they change drift rate much more often than they appear or disappear. The continuity of LRS-1 is beyond doubt because it is always the largest and most methane-bright.

As previously noted [ref.3], some of the white ovals are more methane-bright (MB) than others, but all are at least weakly MB in v-hi-res images. As the methane images have improved in recent years, this means that ovals are more often scored as 'weakly MB' now, which might have been non-MB earlier. For this interim report, we have not attempted a consistent survey. But it is still true that some ovals are more MB than others of the same size. Notably, in late 2012, LRS-b (probably former WS-7) is more MB than WS-6 (e.g. Fig.N1 in Appendix 2) although WS-6 is larger.

To summarise the history of each oval (see Table A1):
LRS-1 has been the largest oval and strongly MB throughout. Its visible colour has continued to fluctuate between strongly red (esp. when the NNTB was absent, in 2009 and 2012) and weakly reddish (same colour as its surroundings and so almost invisible, 2011).
WS-4 is a white oval, apparently increasingly MB until 2012 when it has shrunk.
WS-5 merged with LRS-1 in 2009 Sep. [ref.4].

WS-6 may have existed as a small, non-MB oval from 2008, but was first named in 2010 when it was small but very bright white. It has persisted, weakly MB, since then (see Fig.12).
WS-7 also appeared in 2010, and has always been small, but – if the continuity between apparitions is correct – it has become increasingly MB and, in 2012 Sep., changed from bright white to bright pink, so we here give it the provisional designation LRS-b (Fig.A3 & Fig.4).

Refs.

3. Rogers JH, Adamoli G & Mettig H-J (2011) 'Jupiter's high-latitude storms: A Little Red Spot tracked through a jovian year.' JBAA 121 (no.1), 19-29.

4. [2009 no.7] Jupiter in 2009: Interim Report, with new insights into the NTZ disturbance, NEB expansion, and SEB fading. http://www.britastro.org/jupiter/2009report07.htm

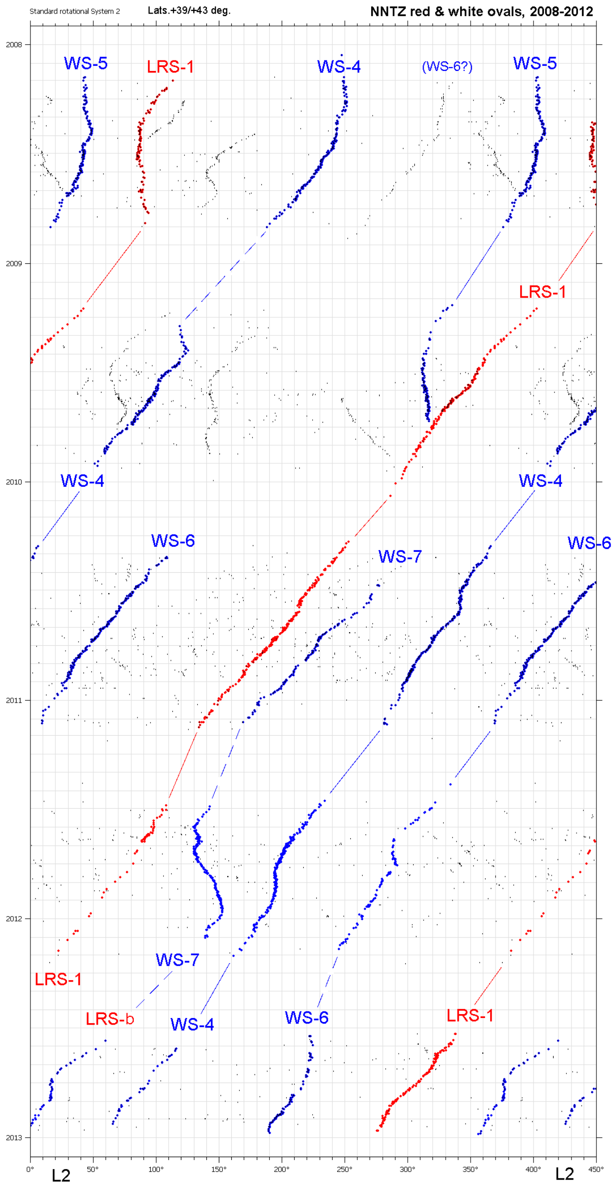

Fig.A1. JUPOS chart of the red and white ovals in NNTZ, 2008-2012, in System II longitude. In this chart (unlike other JUPOS charts in this report), only bright spots and LRS-1 are shown: LRS-1 by red points, long-lived white ovals by blue points, and smaller or short-lived white spots by small black points.

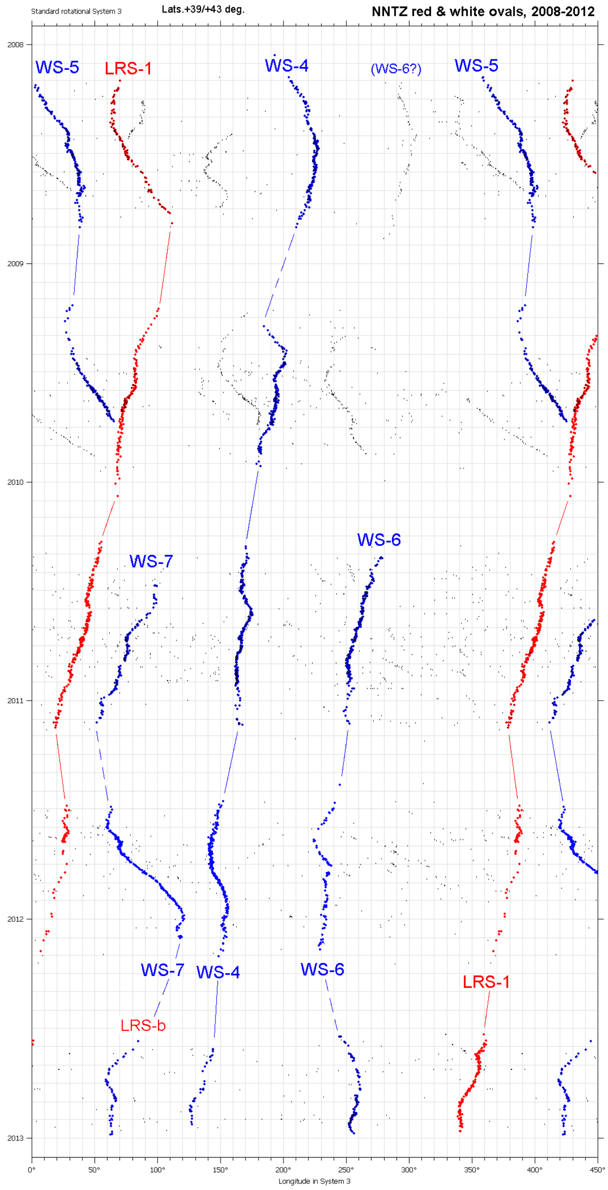

Fig. A2. The same as Fig.A1, presented in System III longitude.

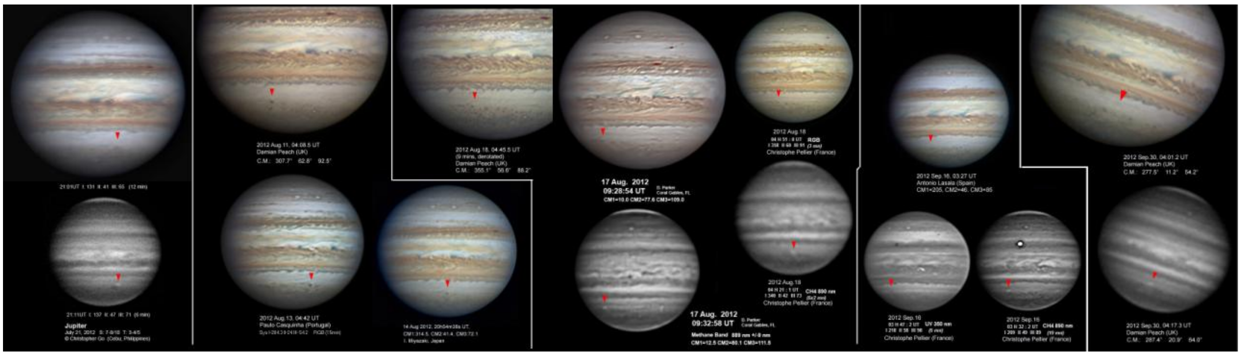

Fig. A3. Images in 2012 July-Sep. showing the tiny white oval (probably WS-7) which developed reddish colour in Sep., then being named LRS-b.

Table A1: NNTZ ovals, 2008-2012: Preliminary descriptive notes

	MB?	*Visible appearance*
LRS-1:		
2008	++	Dull reddish light oval, dark rim.
2009	++	early (NNTB absent): Dark red.
		later (NNTB restored): Red with dark rim.
2010	++	early: Central part strongly red.
		later: Weakening until only slightly reddish.
2011	++	Weakly reddish, rim disappeared, v. low contrast.
2012	++	(NNTB absent): Dark red.
WS-4:		
2008	-	White
2009	(+)	White
2010	(+)	White: large, with rim which later disappeared.
2011	+	White; quite large but shrinking; no rim
2012	(+)	White; small, v. low contrast.
WS-5:		
2008	-	White
2009	(+)	Merged with LRS-1 in Sep. [see our report]
WS-6:		
2010	(+)	White, v.bright, no rim
2011	(+)	White, no rim
2012	(+)	White, rim fading away
WS-7:		
2010	-	Smallest
2011	(+)	Small but bright white, dark rim
2012	+	V.small: white, rimless, becoming light pink **(LRS-2)**

Appendix 2:
NEBn: Dynamic interactions of spots

Figs.N1 to N5 present detailed alignments of images in five longitude sectors, to show these interactions of spots in the NEBn.

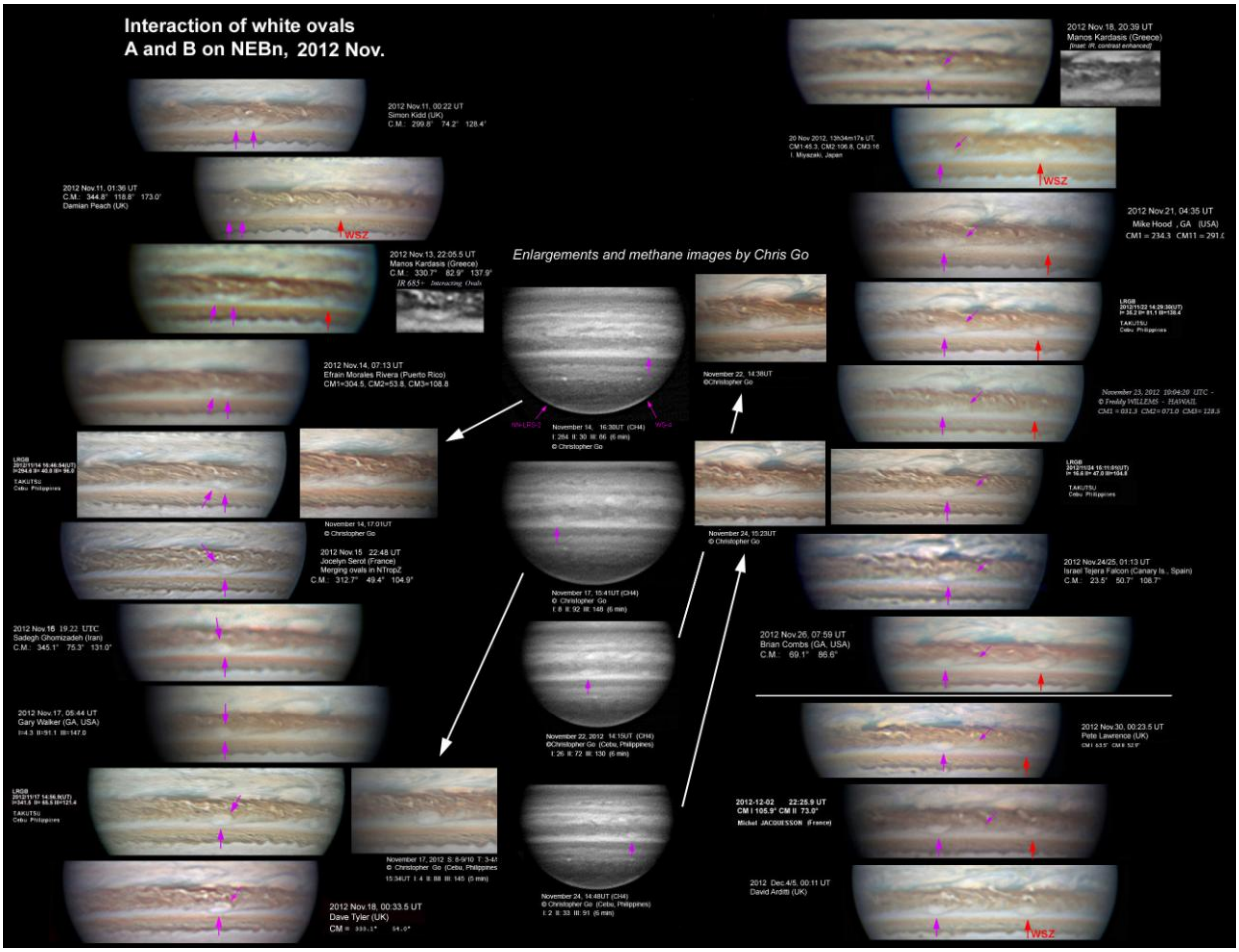

Fig.N1 (L2 ~ 70): Merger of anticyclonic white ovals A and B. (A nice alignment has also been posted by Tomio Akutsu from his own images, up to the start of merger.) These two large AWOs converged in mid-Nov., and the process was very similar to previous such encounters observed in this latitude [*see our web refs. below*]. The f. one (WSA), slightly more northerly, originally with DL2 = -28 deg/mth, accelerated towards WSB and contacted it on Nov.14. They visibly circled round in close contact over 4 days, appearing to merge, but a small fragment of WSA emerged from the embrace on Nov.18-20 travelling f. (smaller purple arrow), and dissipated around Dec.2. Given the large size and high prograding speed (DL2 = -22) of the resulting AWO, it seems likely that the main parts of the two ovals did merge, but as in all previous well-observed examples in this latitude, a small fragment of one oval escaped but did not last long.

White spot Z, now a fully white oval with DL2 = -42 (!), although sometimes showing signs of disturbance, is now converging on the merged oval so a similar interaction could take place in the coming months.

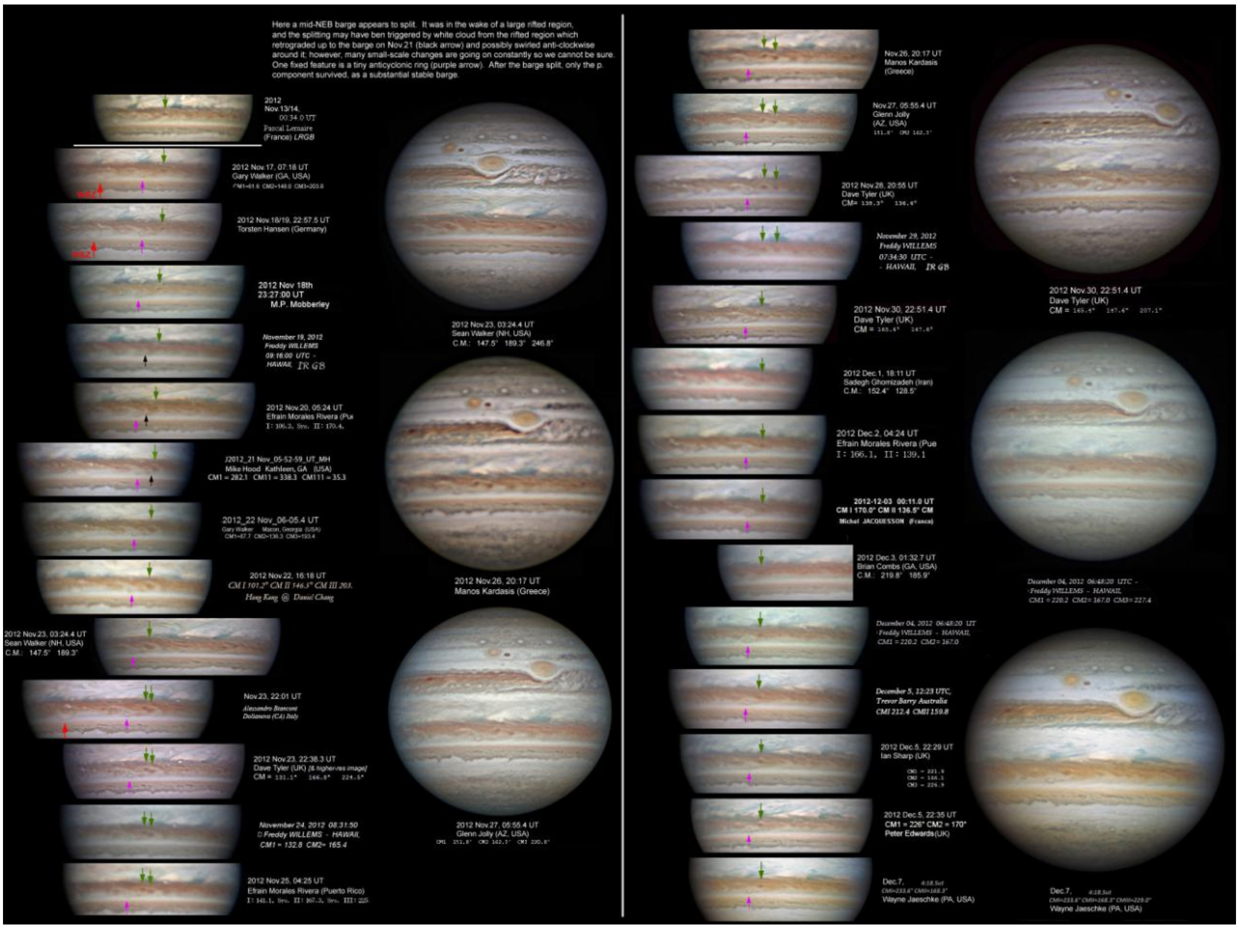

Fig.N2 (L2 ~ 160): Here a mid-NEB barge appears to split. The barge (green arrow) was in the wake of a large rifted region, and the splitting may have been triggered by white cloud from the rifted region which retrograded up to the barge on Nov.21 (black arrow) and possibly swirled anticlockwise around it; however, many small-scale changes were going on constantly so we cannot be sure. After the barge split, only one component survived, as a substantial stable barge.

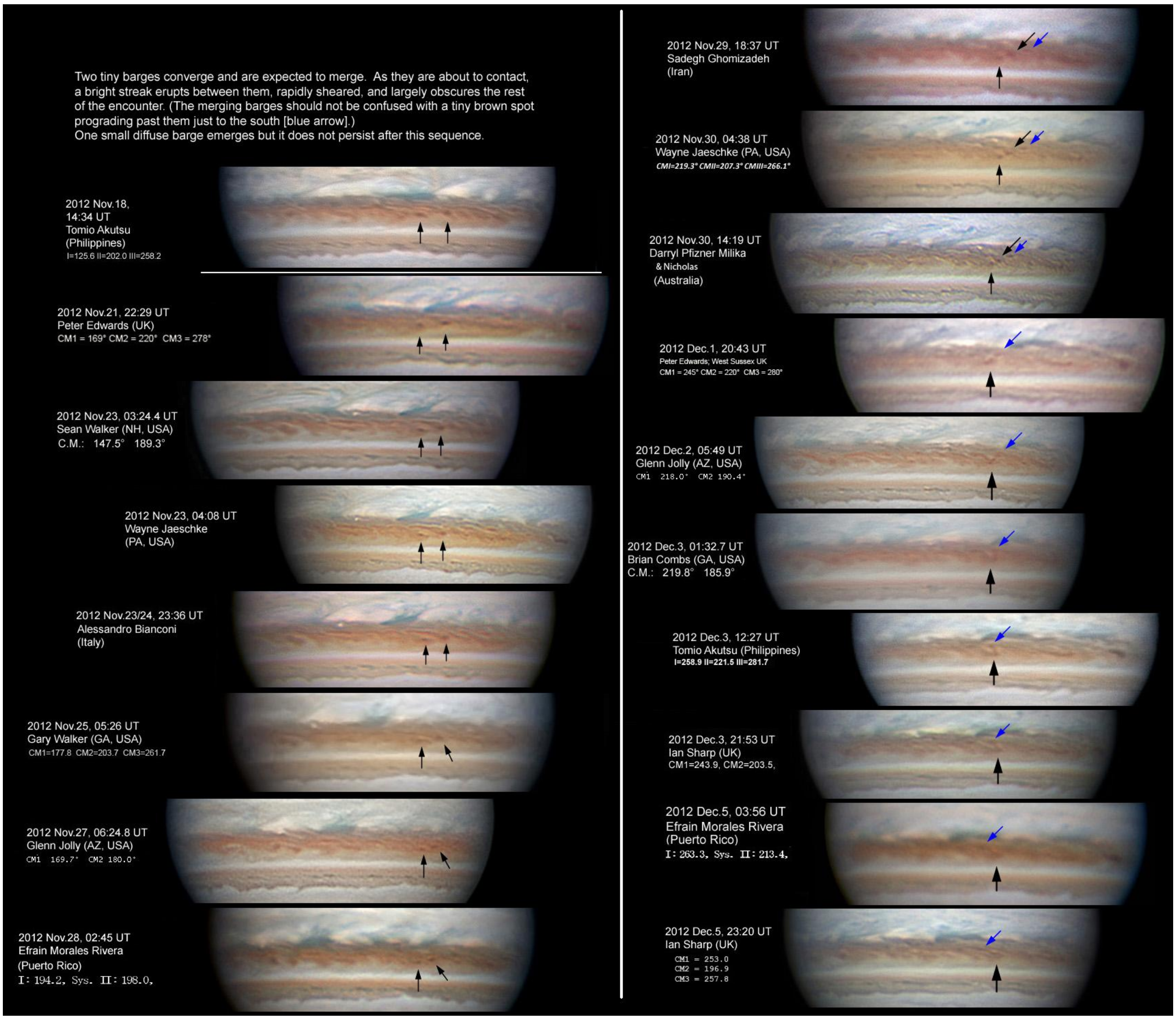

Fig.N3 (L2 ~ 220): Here, two tiny barges (black arrows) converge and seem about to merge. However, as they are acome into contact on Dec.3, a bright streak erupts between them, rapidly sheared, and largely obscures the climax of the encounter. One small diffuse barge emerges but does not persist.

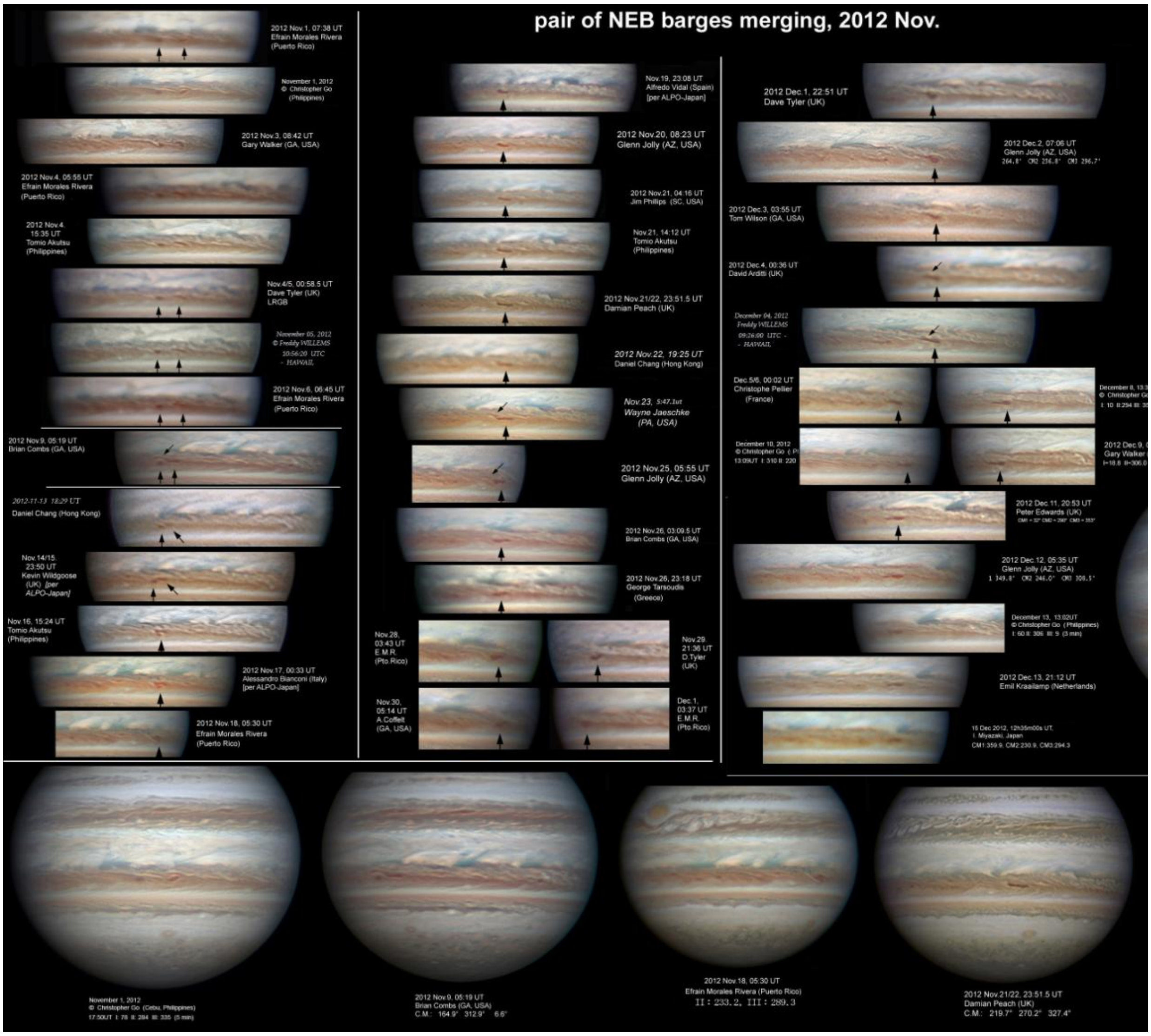

Fig.N4 (L2 ~ 270): Here, two barges merge (black arrows); the process is very similar to previous barge mergers which we have observed [ref.6 & web refs. below]. Mergers of these cyclonic barges are more common and smooth and complete than mergers of AWOs; the barges merge as soon as they come into contact, but evidence of the two partners sometimes persists for some time as they continue on their courses within a common envelope before settling down. In this case the barges accelerated towards each other, and the f. barge elongated towards the p. one so much that it emitted a small fragment on Nov.6 (small black arrow), which streaked S of the p. barge on Nov.9. The main part of the f. barge encountered the p. one on Nov.14; a small bright cloud appeared between them but they rapidly merged, forming a conspicuous longer barge. Evidence of the two partners, circulating anticlockwise within a single envelope, persisted in the tilting and twisting of the merged barge. It was elongated Sp-Nf. from Nov.19-22, then a small streak detached from it to Sp. (small black arrow), and the remaining barge tilted Np-Sf. from Nov.26-29. At this time it rolled up, before unrolling around Dec.2-3 with a Sp-Nf. alignments and emission of another long streak to Sp., indicating that the merged barge had undergone a complete revolution since mid-November. It then tilted back to p-f. alignment around Dec.8, indicating that the circulation had still not fully stabilised.

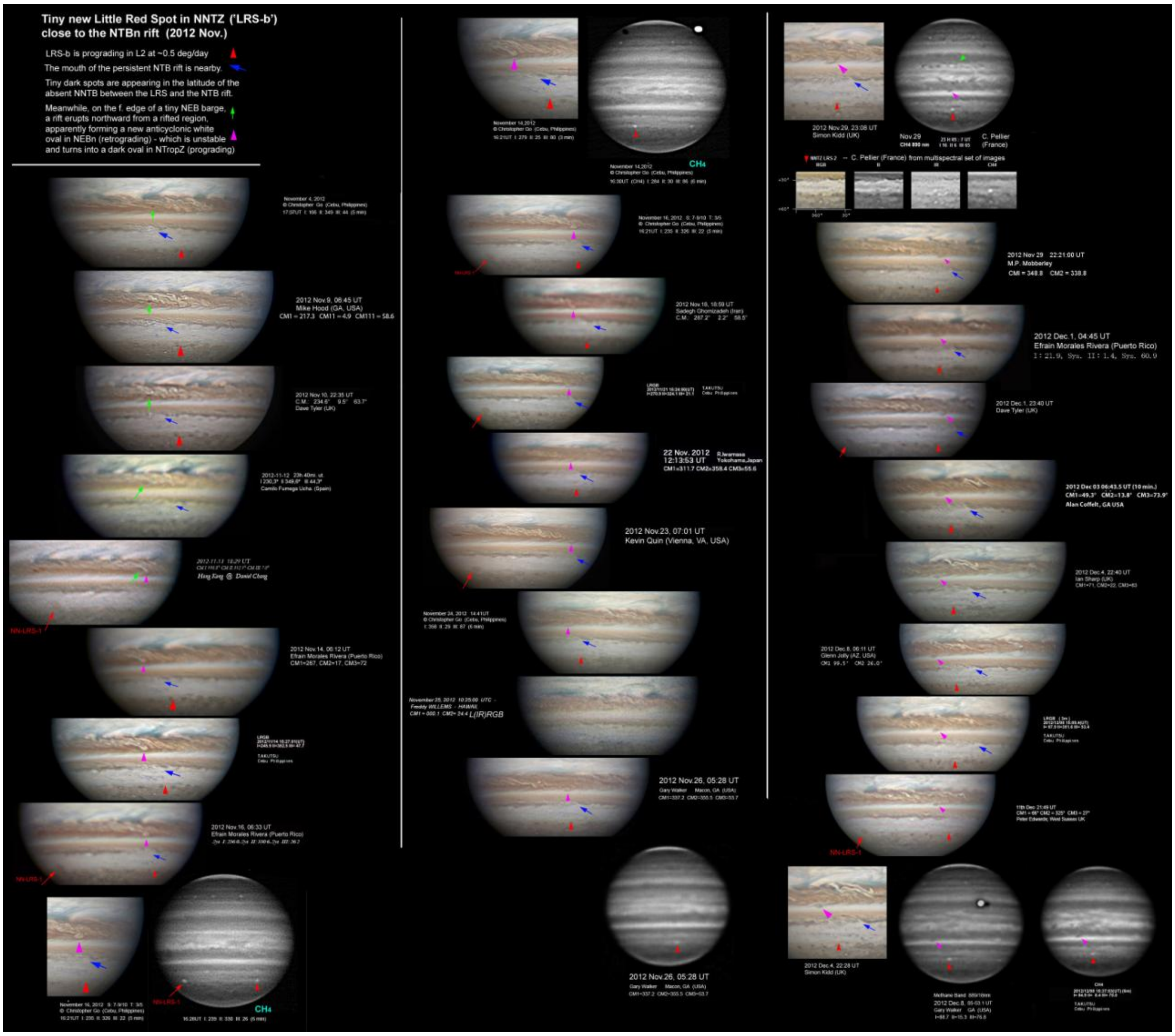

Fig.N5 (L2 ~ 350): Interaction between a mid-NEB rift and a small barge generates a new spot in the NTropZ. On the f. edge of a tiny barge (green arrow), a rift erupts northward from a rifted region. (Surprisingly, it thrusts due N, contrary to the presumed circulation of the barge – similar to the way we have seen dark spots form in NTropZ in the early stages of NEB expansion events – see our 2009 reports.) The barge does not survive, and the rift transiently forms a new white oval in NEBn, which retrogrades from Nov.14-20. But this is unstable and turns into a small dark oval in NTropZ, rapidly prograding (DL2 ~ -46 deg/mth), which is also very dark in methane images.

Our previous reports of mergers in NEBn:

Barges:

2001 Nov., 2002 Dec., 2005 May -- [Ref.6]

2006 Feb: http://www.britastro.org/jupiter/2006report02.htm
[2] SEB and NEB activity

2008 April & May (4 mergers of barges, two well observed):
http://www.britastro.org/jupiter/2008report02.htm
[2] Detailed Interim Report.
& http://www.britastro.org/jupiter/2008report06.htm
[6] Jupiter in 2008: Full Interim Report. (Figs.8&9)

2009 Oct: http://www.britastro.org/jupiter/2009report07.htm
[7] Jupiter in 2009: Interim Report, with new insights into the NTZ disturbance, NEB expansion, and SEB fading.

AWOs:

2006 June http://www.britastro.org/jupiter/2006report10.htm
[10] NEBn: The enigmatic encounter with white spot Z

2006 Sep. (end of apparition, not fully covered)
2007 Feb. (start of apparition, not fully covered)

2008 April: http://www.britastro.org/jupiter/2008report02.htm
[2] Detailed Interim Report.

2010 Aug. http://www.britastro.org/jupiter/2010report09.htm
[9] Jupiter in 2010: Interim report: Northern hemisphere

2010 Sep. http://www.britastro.org/jupiter/2010report11.htm
[11] NEBn: Second merger of Anticyclonic white ovals

<u>**Appendix 3**</u>
<u>**Equatorial Band: Tracking the f. end**</u>

Here I present a set of images of the f. end of the orange EB, which was the most well-defined part of it, from Aug.21 to Nov.10. The f. end was fixed at L1 = 355 in Aug., then started to move in increasing L1, with DL1 = +16 deg/mth from mid-Sep. to mid-Nov. This f. end appeared to be an irregular whitish cloud stably positioned south of a NEBs projection – a typical location for such clouds, although this one was unusually conspicuous (and esp. bright in early Nov.). It showed rapid short-term changes in shape, but no overall motion, even while the adjacent NEBs projection interacted strongly with passing rifts in the NEB (from Sep.11 until late Oct.). (Because of this variability, this NEBs projection/festoon does not show up very clearly on the JUPOS chart in Fig.8.)

A second f. end of the EB was visible in Oct. at L1 = 54 --> 58. This too was formed by a very bright and dynamic white cloud lying south of a NEBs dark projection and festoon, probably associated with it. This f. end and white cloud broke up in early Nov., but other such features could sometimes be seen at other longitudes.

Dark streaks on the EB south edge could occasionally be seen moving more slowly (more positive DL1) than the f. end of the EB, perhaps representing the usual slow wind speed at the equator (as in Fig.14), but there was no distinct motion of the orange material itself. Further scrutiny of the images, especially from animated map projections, might reveal more.

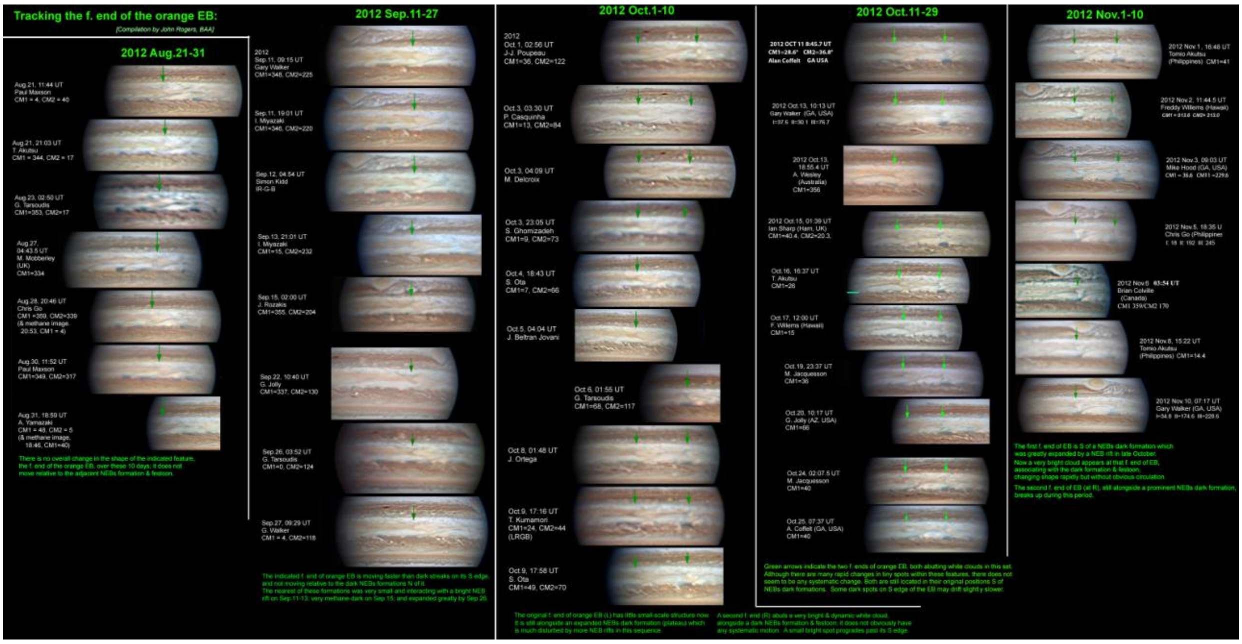

Fig.EB1. Images of the f. end of the orange EB, from Aug.21 to Nov.10. (For hi-res versions and methane images, in Aug-Sep. see Fig.10, and in Nov. see Fig.EB2.)

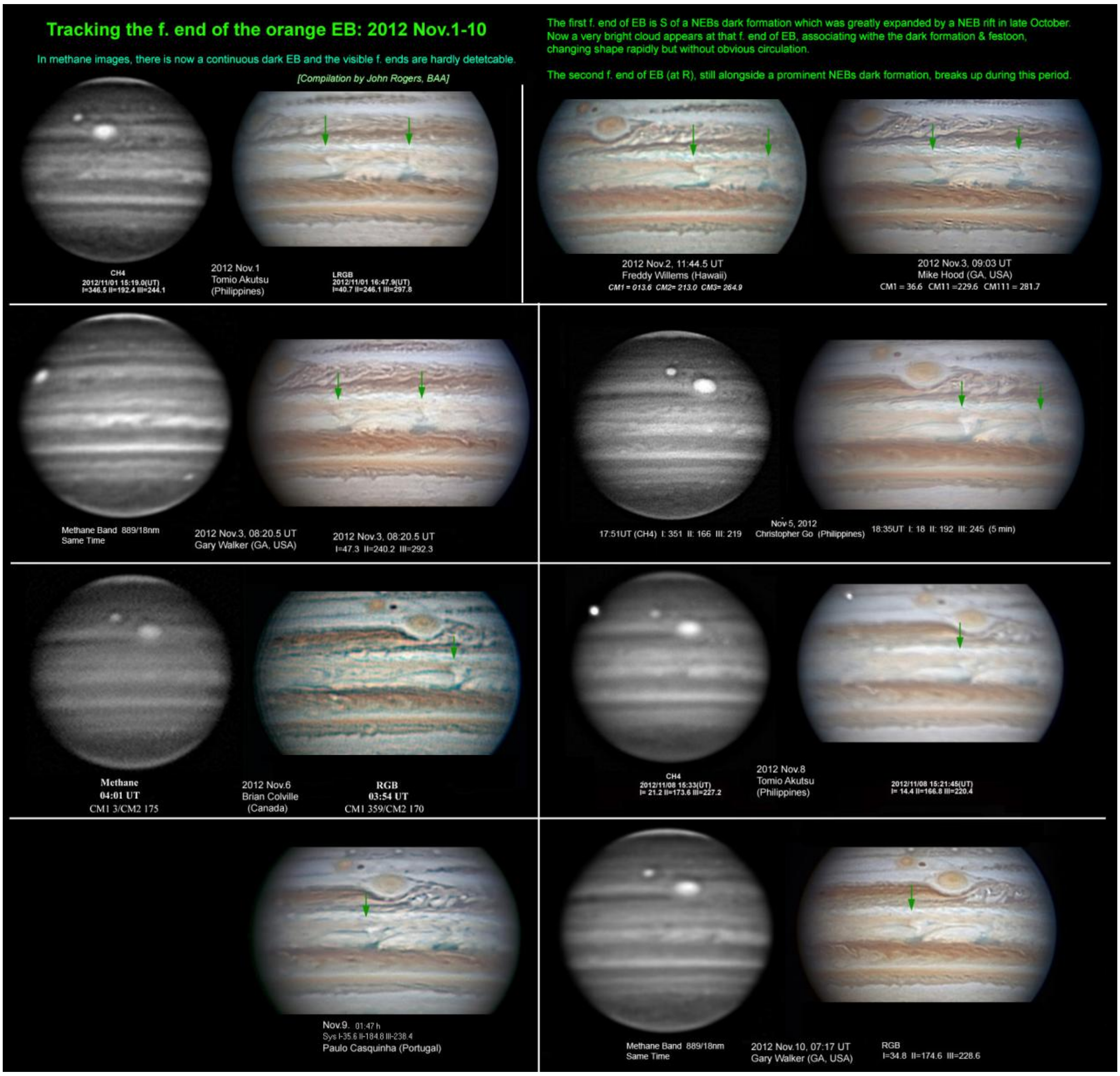

Fig.EB2. Images of the dual f. ends of the orange EB, Nov.1-10, with companion methane images of the whole disk.

Appendix 4:
SEBn: A new SED?

There is strong evidence that a new S. Equatorial Disturbance (SED) is forming. The main evidence is from the JUPOS chart (Fig.S1a). Since 2012 Aug. it has shown the familiar dynamical signature of a SED, that is, a band of low spot density, moving with positive DL1 (~ +24 deg/mth), which represents the SED itself, and a gradient of speed for the chevrons, whose speed increases eastward from the SED. Fig.S2 shows this gradient; in general it is similar to the gradients observed in previous years with a conspicuous SED, with speeds increasing from minimum -1.0 deg/day just p. the SED to -3.4 deg/day just f. it; although there is more scatter, due to the presence of speeds in the range DL1 = -2.4 to -3.3 deg/day at most longitudes.

The previous SED, which existed from 1999 to 2009 or possibly 2010, showed this dynamical signature whenever it was visually conspicuous, as we have reported in a series of papers [refs. S1-S4, below]. The history of that SED is summarised in our website report [ref.S5]. It disappeared in late 2009 or mid-2010, during the SEB Fade. In retrospect, the new feature may have originated in summer 2011, as the JUPOS chart (Fig.S1b) shows three low-density bands with DL1 ~+26 deg/mth throughout the 2011 apparition, one of which aligns exactly with the putative SED track in 2012. However, no speed gradient was evident in 2011, nor was there any visible SED.

We therefore examined maps and images (Figs.S3, S4) to look for a visible SED at the longitude implied by the chart in 2012. A SED-like feature has occasionally been visible (notably around Sep.29 and Nov.15) but has not been a constant feature, lasting for only a few days at a time. In the images from Nov-Dec., green arrowheads label features in the relevant region which could be the SED – because there either is a rift in the SEBn, or a bright spot in EZ(S) -- but each one is transient and is soon replaced by another one ~10-30 deg. f. it.

In methane images, likewise, there are distinct dark features just p. the putative SED, but not yet the characteristic methane-dark 'step' at the SED itself.

Thus, the appearance in images would not at present be clear evidence for a SED. However, the situation is consistent with the early stages of the previous SED and with a model of it as a wave. In the early months of the previous SED in 1999, likewise, it was usually inconspicuous and variable, and the visible rift several times shifted ~10 deg. f., and the typical methane-dark appearance only developed after several months [ref.S1]. Some of the features indicated with green arrowheads in Figs.S3 & S4 may be not the SED itself, but chevron-like disturbances at its p. end, arising in the stormy sector that often manifests p. the SED. The SED itself may be a wave that has not yet fully appeared at the surface, manifested mainly as a quiet chevron-free stretch, within which little rifts repeatedly open up. The wave may be dynamically strong, but not yet fully visible. I propose that there is an incipient SED, 'struggling to be born', and that it will develop into a classical SED over the coming months.

The new feature looked more like a classical SED as it approached the GRS in late Dec. (Fig.S4). It passed the GRS on Dec.27, so I suggested that it might open up as a conspicuous SED soon thereafter. Indeed, on Jan.5 Chris Go reported that this feature had developed a rift in the SEBn and so looked like a classical SED (also seen in Luis Campos' image on Jan.3). We will have to wait and see whether this will last.

SED refs:
S1. Rogers J, Mettig H-J, Peach D & Foulkes M (2003), JBAA 113 (no.1), 10-31. Jupiter in 1999/2000, Part I: Visible wavelengths.
S2. Rogers JH, Cidadão A, Akutsu T, Mettig H-J, Peach D, Orton GS, JBAA 115 (no.2), 70-78 (2005). Jupiter in 2000/2001: Part III: The South Equatorial Disturbance: A large-scale wave in a prograde jet.
S3. Rogers JH & Mettig H-J. (2008), 'Influence of Jupiter's South Equatorial Disturbance on jet-stream speed'. JBAA 118 (no.6), 326-334.
S4. 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]
S5. Rogers J (2012) 'The life of the South Equatorial Disturbance, 1999-2010' --see link from: http://www.britastro.org/jupiter/icarus.htm

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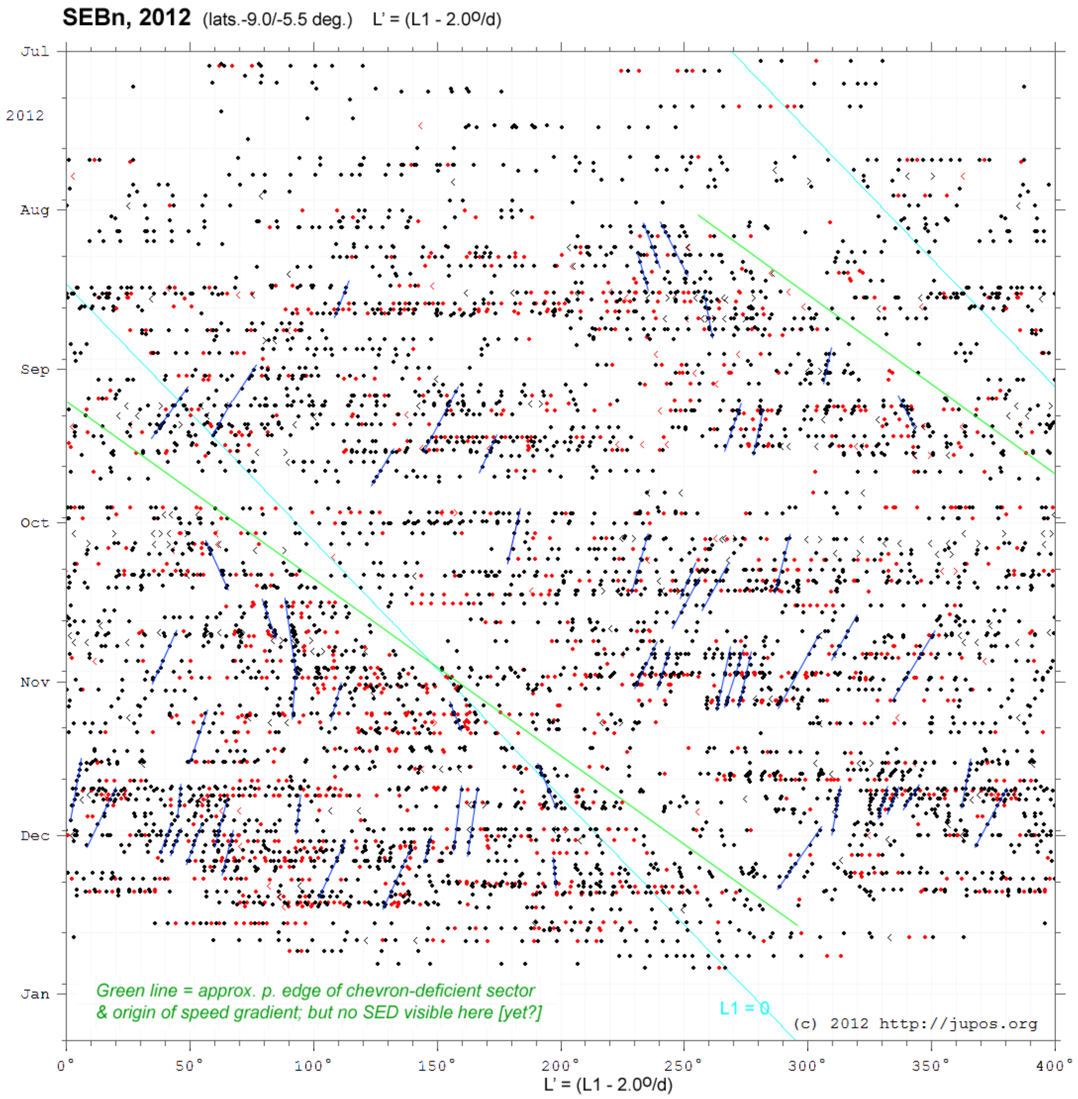

Fig.S1. JUPOS charts of the SEBn in 2012:
(a) 2012 Jul-Dec.. The green line marks the approximate p. edge of the chevron-deficient sector with DL1 ~ +26 deg/mth. Blue lines mark the tracks of individual chevrons.

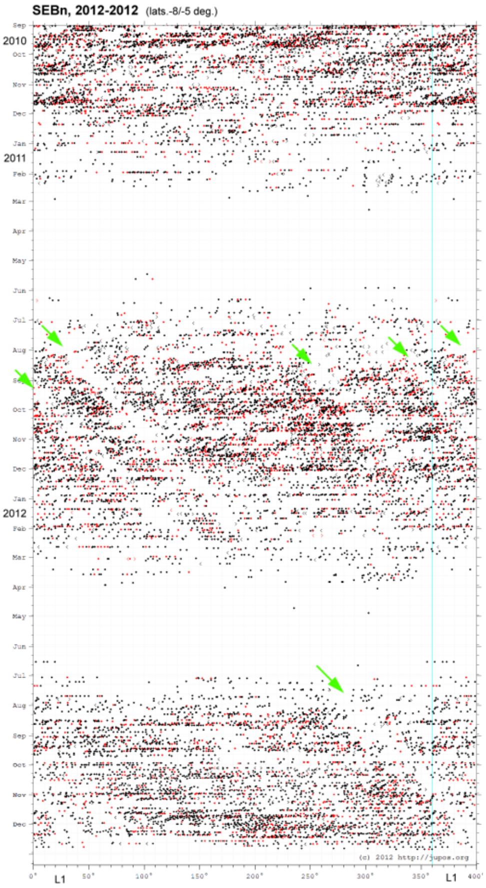

Fig.S1. JUPOS charts of the SEBn in 2012: (b) 2010-2012. Green arrows mark slow-moving chevron-deficient bands in 2011, one of which aligns with the similar band in 2012.

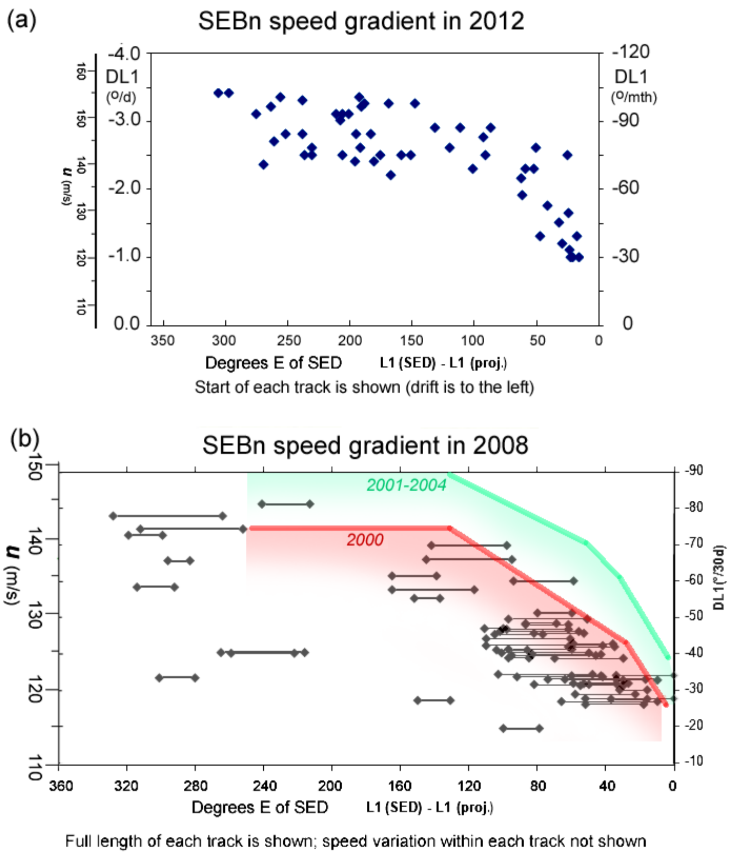

Fig.S2. SEBn speed gradient in 2012 (a), compared with results from previous years when the SED was present (b). In 2012, measurements are for the tracks marked in Fig.S1a, and because the SED is not consistently visible, distances are measured from the green line marking the chevron-deficient sector. In previous years this approximately coincided with the SED.

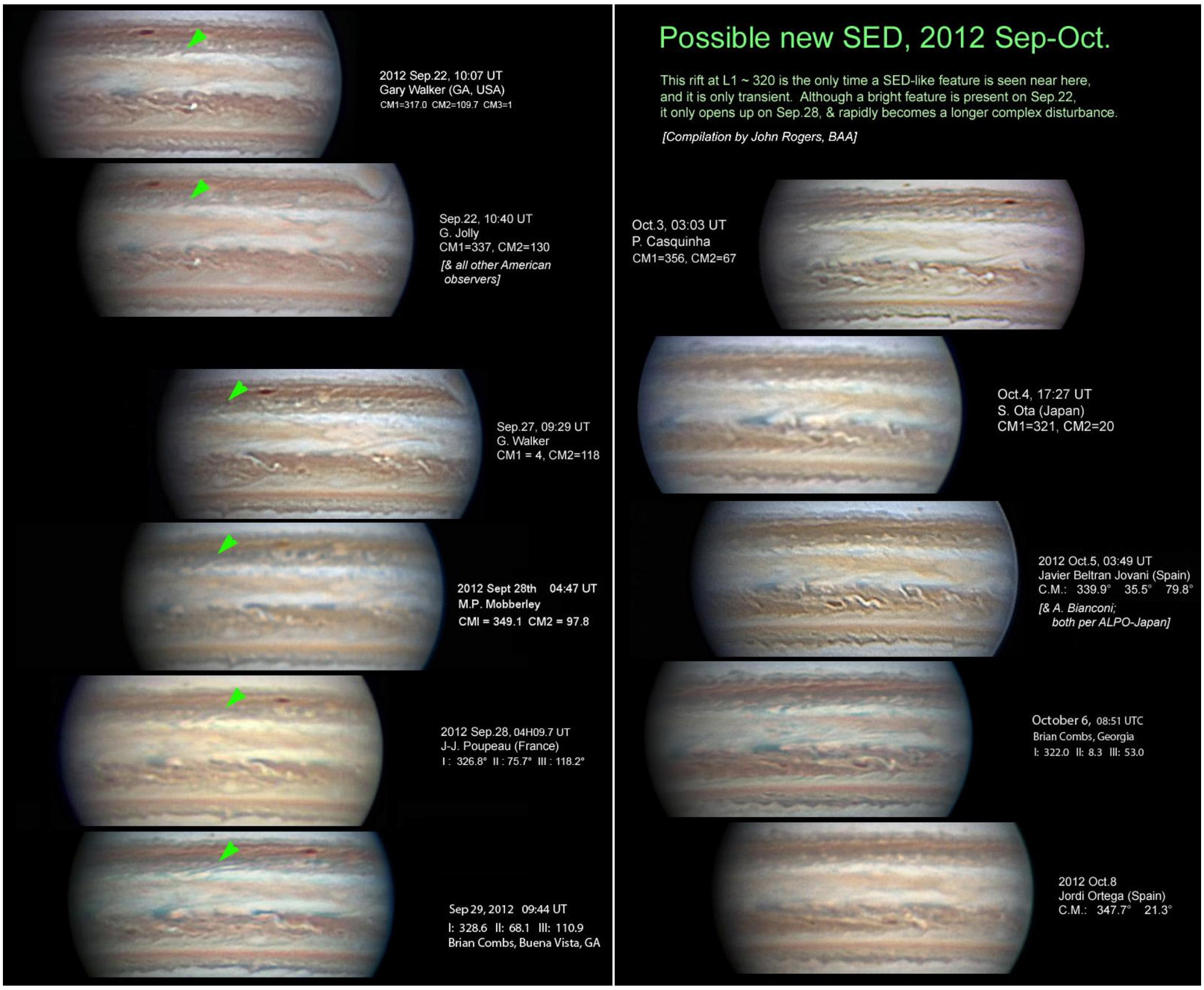

Fig. S3. Images of the putative SED region, 2012 Sep.20-Oct.10. A rift opens up on Sep.28 (green arrowhead), producing a SED-like appearance in the expected position at the p. edge of the chevron-deficient sector, but it only lasts a few days.

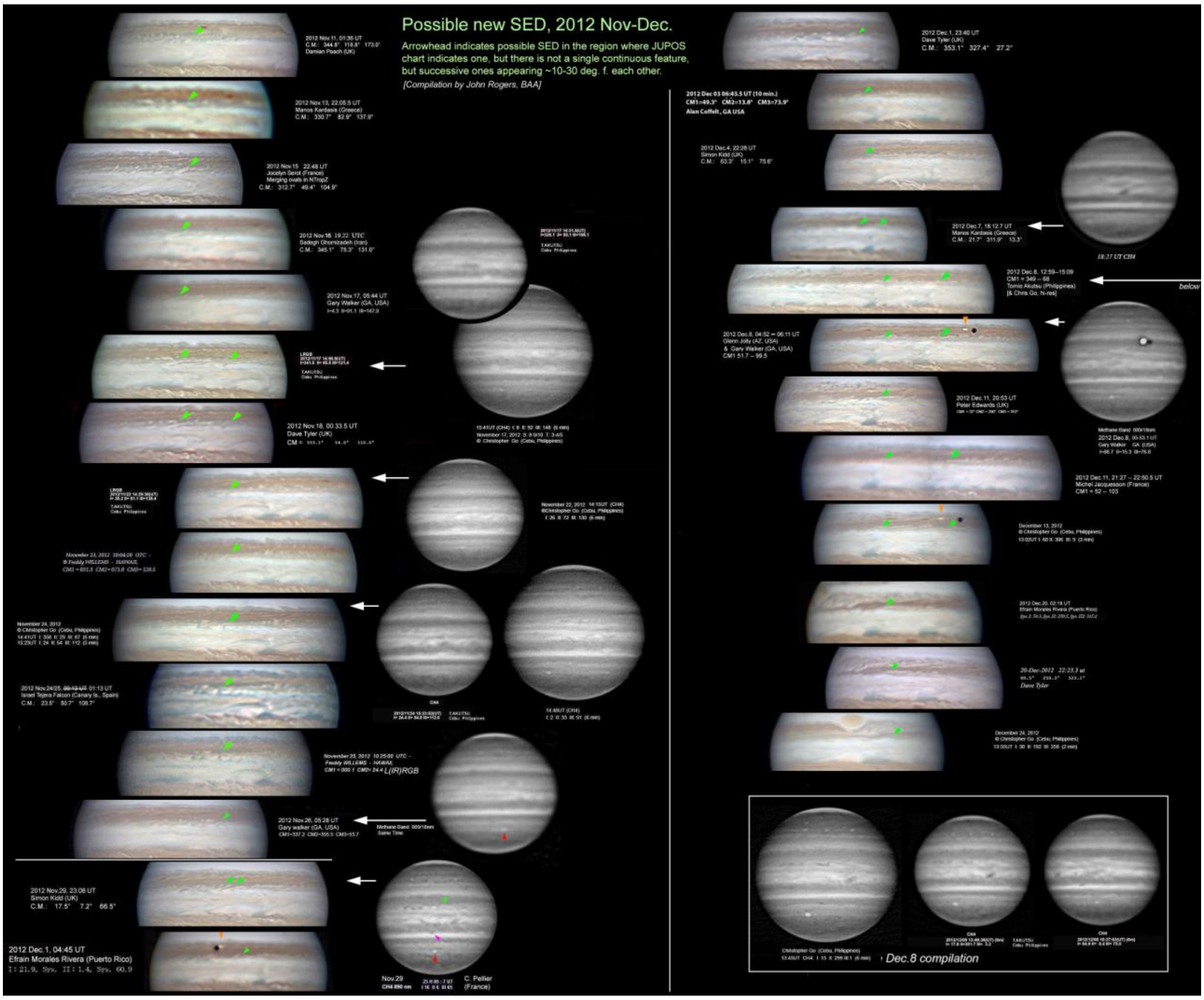

Fig. S4. Images of the putative SED region, 2012 Nov.15-Dec.24. SED-like features are repeatedly seen in the expected position, but there is not a single continuous feature, rather, successive ones appearing ~10-30 deg. f. each other.

Appendix 5
Zonal wind profiles
(results from Grischa Hahn)

Because of the high resolution of modern images, it is now possible to extract not just the drifts of distinct spots, but the east-west wind speeds across most latitudes (zonal wind profile), using the routine for correlating cylindrical projection maps made 10 or 20 hours apart, which Grischa Hahn recently created within WinJUPOS (http://jupos.org). Hahn has produced zonal wind profile from sets of images in Sep., Nov., and Dec., as shown in Fig.14. Note the very good agreement between the three profiles. The most substantial difference, in the SEB at latitudes 11-15 S, may be due to the fact that the 'green' profile includes the GRS and flanking regions, while the others do not; the same difference is also commonly seen within profiles from spacecraft.

In general, these are all very similar to previous profiles from spacecraft, confirming that the NEB and NTB Revivals have not altered the zonal wind profiles. They deviate from the New Horizons profile within the equatorial region, but agree much better with the Cassini profile (not shown), presumably due to real variations at cloud-top level from year to year.

All the jets are well defined, even those which carry no visible spots at present. Mean peak wind speeds and latitudes for the major jets from the 2012 profiles are as follows (mostly +/-4 m/s, +/-0.5 deg):

	u3	*Lat.*		*DL2*	*DL1*	
SEBs	-52 m/s	19.5 S		+106		deg/mth
SEBn	+145 m/s	7 S			-83	deg/mth
(Eq.)	+68 m/s	0 N			+80	deg/mth
NEBs	+98 m/s	7.5 N	(Sep,Nov.)		+16	deg/mth
	~+120 m/s	7 N	(Dec.)		-29	deg/mth
NEBn	-19 m/s	17 N		+33		deg/mth
NTBs	+145 m/s	24 N			-106	deg/mth
NTBn	~-20 m/s	31 N		+40		deg/mth

The value for SEBn agrees well with feature tracking (Appendix 4).
The value for NEBs in Sep-Nov. is the speed of the large dark 'projections. However the faster value in Dec. corresponds to the speed of smaller features as recorded in some recent years, but not visible in the JUPOS charts this apparition, indicating that a faster wind speed is present in spite of the apparent dominance of the large dark projections.
The value for NTBs is interesting as it is intermediate between the 'normal' and 'super-fast' levels, as in 2005 and late 2007 [ref.9], before and after the super-fast outbreak in 2007. We should wait to see if it accelerates further in the next year or two, which would be predictive of another super-fast outbreak to come.

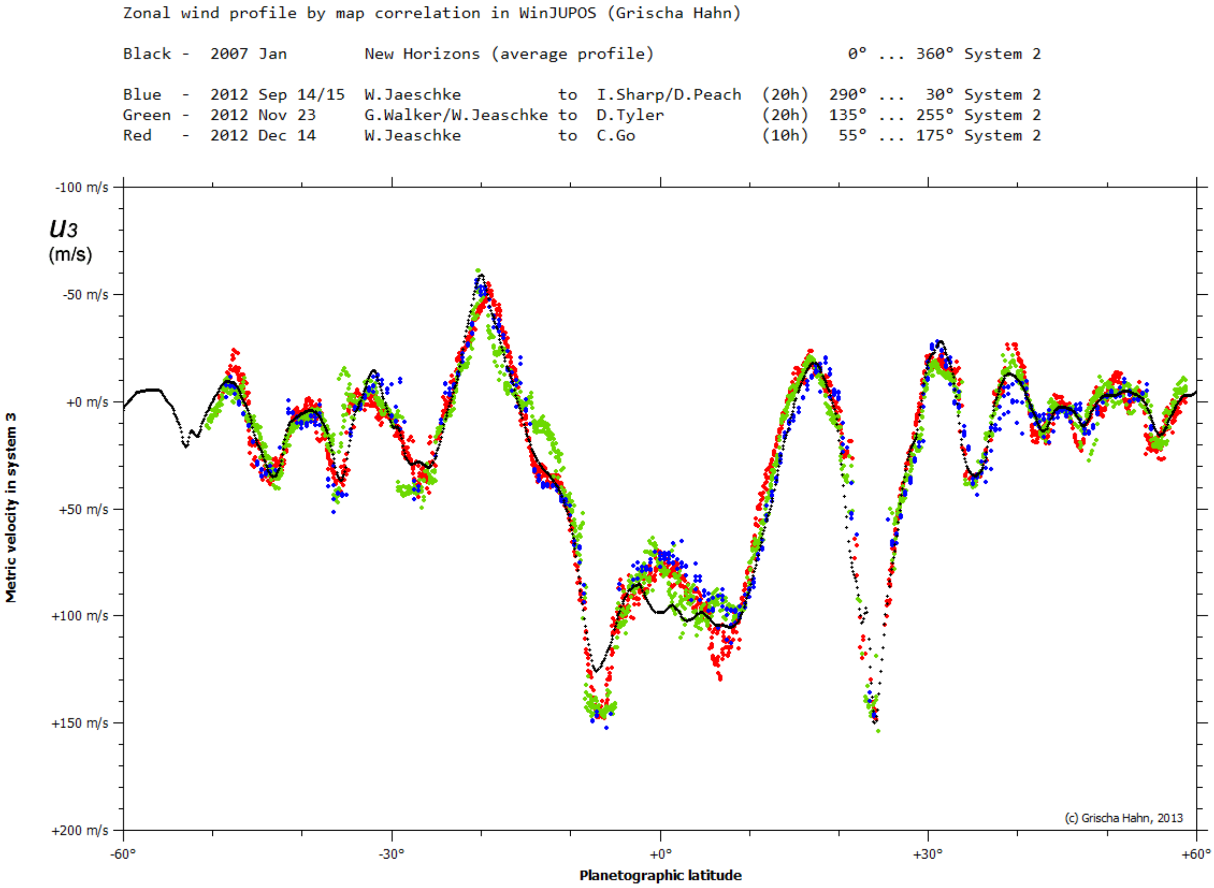

Fig.14. Zonal wind profiles produced by G. Hahn from the indicated sets of images. The thin continuous line is the profile from New Horizons in 2007 for comparison. Because these speeds are very sensitive to slight inaccuracies in timing or registration of the images, the three profiles from 2012 have each been adjusted for optimum fit by adding or subtracting a speed increment across the whole profile.

Appendix 6:
Fireballs on Jupiter

A bright fireball was recorded on 2012 Sep.10 -- the third such event to be recorded by amateurs [ref.8]:

[2012 no.5] 'Fireball on Jupiter, 2012 Sep.10.'
http://www.britastro.org/jupiter/2012_13report05.htm

Such events only last 1-2 seconds, and up to now, their detection has been limited by the requirement that someone is actually looking at the planet or at the video that they have taken of it. Now, Dr Ricardo Hueso has posted freely accessible software to scan webcam videos of Jupiter automatically for such flashes. His message is reproduced below, and serious imagers are encouraged to make use of this opportunity, so as to search for more impacts and establish their frequency.

From: Ricardo Hueso <ricardo.hueso@ehu.es>
Date: Tue, 23 Oct 2012 15:59:58 +0200
Subject: Jupiter impacts detection software available on PVOL-IOPW

Jupiter observation by amateur astronomers has steadily increased over the last years in number of observers and quality of the observations. The International Outer Planets Watch and its database of visual observations PVOL (http://www.pvol.ehu.es) store observations by many of you that have largely contributed to our advances in our knowledge of the dynamics of the jovian atmosphere. We have posted a software tool able to detect fireball impacts in Jupiter that could interest your attention. You can find this software on the PVOL webpage
http://www.pvol.ehu.es/software
or through the links in the PVOL webpage
http://www.pvol.ehu.es/

We warmfull acknowledge helpfull discussions and ideas shared with Emil Kraaikamp, Marc Delcroix and John H. Rogers. We hope the software will be helpfull to those of you interested in finding this type of Jupiter impacts.

Best regards,
Dr. Ricardo Hueso.
Ricardo Hueso Alonso
Física Aplicada I
Escuela Técnica Superior de Ingeniería
Alda. Urquijo s/n, 48903, Bilbao