JUPITER IN 2007: FINAL NUMERICAL REPORT

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Part 3: South Tropical Region

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This region went through huge changes as part of the global upheaval. The STropZ had acquired two S. Tropical Disturbances (STrD-1 & 2). The SEBs jet-stream activity had ceased in 2006, and SEB internal convective activity ceased during solar conjunction, then the SEB started fading in 2007 March. The SEB Revival began on May 17, and the retrograding dark spots on SEBs recirculated at STrD-1 onto the STBn jet-stream. The whole SEB was largely restored by the end of the apparition.

First, though we describe activity on the STBn jet-stream that preceded the Circulating Current.

STBn jet, STropZ, SEBs jet, and the Circulating Current

As in several recent apparitions, there were a few small dark spots intrinsic to the ***STBn jet-stream***, before the Circulating Current got under way. Their speed and latitude (DL2 = -96, 28.2ºS) were typical, and very similar to those shown in 2006 (mean lat. 28.5ºS) (**Fig.13A**).

The two ***S. Tropical Disturbances*** were seen from the start of the apparition: STrD-1 from 2006 Dec.30 (Olivetti) and STrD-2 from 2007 Jan.10 (Wesley). They were well shown in the New Horizons images (Jan.9-21). Whereas STrD-2 remained compact throughout, STrD-1 became progressively longer.

Although a STrD was historically defined as a visibly dark structure spanning the STropZ (with prograding drift), its essential feature is thought to be the recirculation between SEBs and STBn jet-streams at its p. end (and possibly its f. end). This can only be observed if a SEBs jetstream outbreak is in progress, or if spacecraft produce v-hi-res images, so we were keen to search for such recirculation in 2007. Images from both New Horizons and HST showed continuous wavy lines connecting SEBs to STBn around both the p. and f. edges of the STrD's **(Fig. 11**: STrD-1), implying that recirculation was indeed occurring in both directions, although neither spacecraft had enough v-hi-res coverage to track actual features around the curves.

Recirculation has never actually been observed at the f. end of a STrD, from STBn to SEBs. A rare opportunity to look for it arose when a pair of STBn jet-stream spots (the 'set of 2' in Table 3) approached STrD-2 in June. Each one decelerated (to DL2 = -74) and moved north partly into the STrD (to 27.4ºS), but did not recirculate: instead they moved south and accelerated out of it again, still prograding on STBn.

Recirculation was not directly observed at the f. end of STrD-1 either, as no suitable spots impinged on it, but the NH and HST images showed the connection more distinctly here

(Figs. 11 & 12). Also, methane-band images (and IR images from New Horizons LEISA) showed STrD-1 as a dark feature **(Fig.12)**.

STrD-1 **(Figs. 11 & 12)** was initially a very large dark hump, but in January its f. edge split off as a separate feature which quickly became faint, although still distinct. This happened just as the p. edge of oval BA caught up with it, so it is possible that the change was triggered by the arrival of the weak sector of the STBn prograding jet alongside oval BA. However no other interaction between oval BA and STrD-1 was observed, as they very slowly passed each other during the year, so it is possible that the expansion of STrD-1 was entirely intrinsic – as is characteristic of STrD's. It continued to grow longer, with a f. end clearly distinct from the main column and p. end (see Table 3). The overall length was as follows:

2008	Images from:	Length
Jan.	New Horizons	8-15 deg.
March	Amateur & HST	25 deg.
April	Amateur	30 deg. (but see below for May)
June	Amateur	~40 deg.

By late April the f. end was a gradual slope, which became more oblique in May, and the outline suggesting recirculation had been lost (in ground-based images). However for a time in late May, a very distinct f. end re-formed only 20 deg. from the p. end (images by Peach and others and in methane band). This was probably a transient dynamical reconnection, which disappeared in early June, leaving only the increasingly oblique slope ~40 deg. from the p. end, which disappeared altogether by the end of June.

Recirculation at the p. end of STrD-1 occurred spectacularly as the conspicuous dark SEBs jet-stream spots, retrograding in the SEB Revival, arrived at it from July 1 onwards. This Circulating Current phenomenon has been thoroughly documented in our previous interim reports. Here we add the measured speeds and latitudes of the spots.

The spots retrograding on the ***SEBs jet-stream*** moved with a range of speeds **(Table 3B & Figs.13B, 15, 17)**, closely related to their size and their latitude **(Fig.14)**. Spots are labelled a to p in order of appearance, as shown on the previous image sets of the Circulating Current. In addition to the early values for spots d and e, other spots also started life with higher latitudes and lower speeds (DL2 ~+60 to +80), having been were injected from the source well into the STropZ, but these initial conditions were unstable and the spots soon accelerated.

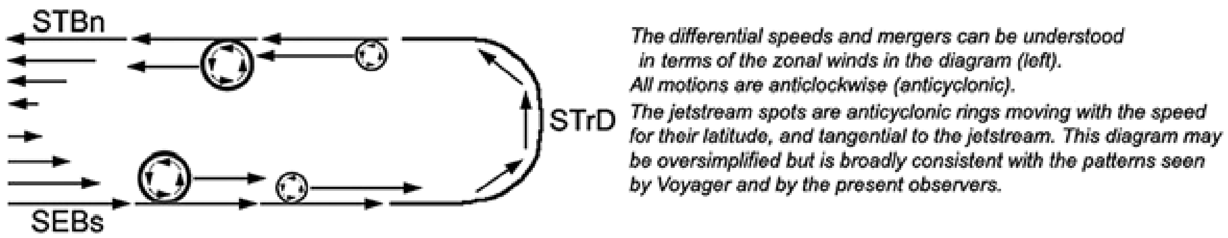


Fig.14. Diagram showing how the vortices move in the SEBs jet-stream and Circulating Current.

The situation is shown schematically in **Fig.14,** as discussed in the BOX (below). These jet-stream spots are anticyclonic vortices which 'roll' along the jet-stream, so the larger ones are centred further from the jet peak and have slower speeds. The mean SEBs speed in 2007 was DL2 = +114 (20.4ºS) for all spots, but +123 (20.0ºS) for smaller spots; the latter is thus our ground-based value for the speed of the jet. However the model in Fig. 14 implies that the peak speed of the jet is somewhat higher, so if we extrapolate to 19.5ºS (the peak according to spacecraft, and approx. latitude of the north edges of the jet-stream spots), we estimate a speed of ~+133 deg/mth. Indeed the New Horizons images in 2007 January gave a peak speed of exactly DL2 = +133 deg/mth at 19.5ºS [Cheng et al., 2008].

Our 2007 SEBs spots also fit well onto the Cassini zonal wind profile **(Fig.1)**. However it is notable in Fig.1 & Fig.13B that 4 of the 5 the earliest spots (a,b,d,e) fell below this zonal wind line: i.e. they were travelling unusually fast for their latitudes. This might indicate unusual behaviour for the earliest spots emitted in the SEB Revival.

After recirculation at STrD-1, the spots were prograding in the ***STBn jet-stream***, and again showed a range of speeds and correlated latitudes (**Table 3B; Figs.13A & 16**). The situation was complicated because the spots had a strong tendency to merge, whether before, during, or after their recirculation at STrD-1. This typically occurred as a spot moving fast, close to the jet peak, caught up with a slower-moving one centred further from the jet peak; sometimes, the anticyclonic vorticity of the merger could even be seen in amateur images. Thus we have categorised the spots as follows:
--'intrinsic' (intrinsic to STBn jet-stream, as described above);
--'recirculated - single';
--'merged' (after recirculation: these were all larger and lower-latitude and slower);
--'spinoff': much smaller spots which were spun off just-merged pairs, to higher
latitude and faster speed.
All these spots lie close to a well-defined line on the speed vs. latitude chart, except for the intrinsic spots, which lie about 1 deg. below that line, probably due to the normal flatness of the profile of this jet (see BOX below).

Effects of STrD's and SEB Revival on jet-streams?
This year's events gave an excellent opportunity to look for any such effects. It was previously shown that the SEBs jet tends to run faster when a STrD has been present in the preceding 6-12 months. Our ground-based SEBs speeds, which are the best to compare with historical observations, are near the upper end of the normal range for recent years when no STrD was present, but they do not confirm any acceleration. Conversely the SEBs jet speed from New Horizons (confirmed by our analysis above) is faster than any previous spacecraft value. However, the change may be more apparent than real (see BOX). If so, there has been little or no change in the speed of the jet.

Further discussion of this topic (see BOX) sets out three hypotheses:

1) That the true peak speed of the SEBs jet is slightly faster than the speed of jet-stream spots that are tracked from Earth, as is the case for prograding jets.
2) That the SEBs jet speeds up in the presence of a STrD only if there is also SEBs jet-stream spot activity.
3) That STrD's have now become a frequent accompaniment to the fading of the SEB.

BOX: ***The speeds of the SEBs and STBn jets*** ***(see Figs.13 & 14)***

After the Voyager flybys revealed the full pattern of Jupiter's permanent jets and the anticyclonic vorticity of the jet-stream spots, it appeared that the peak jet speeds were broadly the same as those historically recorded by amateur tracking of jet-stream spots during outbreaks. But now, with more spacecraft flybys and more-accurate ground-based data, it is known that the jet-stream spots actually move ~10 m/s (~20 deg/mth) slower than the true jet peak, as they 'roll' along the jet on the zone-ward side – at least on NTBs (Garcia-Melendo et al., 2000) and NNTBs (BAA data). We will explore this topic more thoroughly in a future paper for the JBAA. This year we show it is also true for the STBn jet, and for the retrograding SEBs jet.

The STBn jet has an exceptionally broad peak in spacecraft profiles: Voyager and NH found peak speeds (DL2 ~ -101 to -116) extending all the way from 27.0 to 29.0ºS. (Cassini found a sharper, faster peak: Fig.1.) In early 2007, the peak DL2 was -116 from NH, -96 from our images. The 'intrinsic' spots were within the flat peak, so it may be difficult to establish whether they 'roll'. But after the Circulating Current began, the fastest recirculated spots had similar DL2 but were ~1 deg. further N, (probably due simply to their different origin), and all the recirculated spots gave a well-defined speed gradient on the N side of the jet. The largest spots (the merged ones) were further from the jet peak with slower speeds, consistent with the spots 'rolling' along the jet.

The SEBs jet had the same speed in Voyager and ground-based data in 1979, but this may have been because the high density of jet-stream spots prevented Voyager from detecting the underlying peak speed. In 2007, we show clearly that the spots were rolling along the jet-stream (see main text), whose true peak speed was DL2 = +133 at 19.5ºS, as observed by NH. They also fit well onto the Cassini zonal wind profile (Fig.1). Indeed the SEBs jet structure was similar in 2000. Cassini found a peak speed of DL2 = +128 (19.7ºS), whereas the mean of our values was slower and further south: DL2 = +108 (20.8ºS). However the speeds in 2000 were quite diverse, and our values ranged up to DL2 = +127, almost the same as the Cassini peak. We have not analysed these in detail, but probably most spots rolled along the faster jet as in 2007, and only the smaller ones approached the true peak speed.

Did the SEBs jet speed up in 2007 after the appearance of the STrD's? The NH peak is the fastest recorded by any spacecraft, but only slightly faster than the Cassini value; and Voyager and HST might have missed the peak speed because it was masked by numerous spots. Thus it is possible that the true peak was close to DL2 = +133 in all these years, with little or no change. This hypothesis could be tested by a re-examination of the Voyager data.

The SEBs jet undoubtedly ran faster during the later years of the Great STrD and some others including the 'Voyager' STrD (see my book pp.163 & 262). However, I now suggest that it only speeds up if there is both a STrD and SEBs jet-stream spot activity. This would explain the failure to detect faster speeds in 1919/20, 1957/58, 1971, 1993, and perhaps 2007. In all these years, SEB Revivals started in the presence of STrD's which had not previously encountered SEBs jet-stream vortices.

Those years include 3 of the last 5 SEB Revivals, and I wonder whether STrD's have, in recent decades, become associated with the fading of the SEB. Wynn Wacker's (1995) original conception of a global upheaval included STrD activity, but at the time this did not seem to be a consistent element, nor one with any mechanistic connection. However the STrD's in these years may fit into a pattern: they all developed as the SEB faded, they were paler and shorter-lived than previous STrD's, and there were two of them in 1993 and in 2007. The STrD's of 2007 seem to have developed from a general tendency to eddying in the STropZ the previous year, which accompanied the cessation of SEBs jet-stream activity, and so may be part of the climatic change that comprises the SEB Fade. The typical behaviour of STrD's has been changing for more than a century, and this may be the latest habit that they have developed.

-- John Rogers

Following STrD-1:
As all the SEBs jet-stream spots were skimmed off by STrD-1, the SEB(S) f. it did not immediately darken, but in mid-July the first sign of darkening developed here, as a long elevated stretch of SEBs extended f. from STrD-1. A medium-sized dark spot [c'] formed around July 23 on its S edge and retrograded with DL2 = +114. [This was not spot c, which had disappeared in STrD-1, even though c' was on the same track.] The SEB(S) continued to darken progressively but insidiously f. STrD-1. Another pair of spots developed as low humps or tiny dark spots on this SEB(S) from Aug.23 onwards. All these SEBs spots tracked beyond STrD-1 had rapid speeds fitting the same latitudinal gradient as most of the other SEBs spots.

Later development:
By the end of August, 16 of the 17 spots produced on SEB(S) [the exception being small spot c which disappeared in STrD-1] had recirculated and merged to form just two dark spots in the prograding current. However these were not stable. On Sep.1-4 they had broken up again into strings of small spots.

Meanwhile large dark jet-stream spots were still coming round STrD-1 (spots S, T, U). But SEB(S) retrograding spots thereafter were smaller and less distinct, and there were long gaps between good images, so that it was not possible to track them thoroughly in September, although the Circulating Current may have still been operating: dark spots were still emerging from STrD-1 up to mid-Sept. By late Sept. a broad dark STB had formed p. STrD-1, extending p. oval BA – presumably formed largely from dark material of the recirculated spots. Its f. end detached from STrD-1 in October [**Fig.18**], possibly marking the end of the distinct recirculating spots, and prograded away from it. However STrD-1 remained prominent and dark as late as Nov.4 (the final view).

What happened to the recirculated spots and STrD's after August? This question is important because in 2008, they had all been replaced by two prograding anticyclonic ovals, one of them being a Little Red Spot. Measurements are shown in **Fig.16**. On 2007 Aug.28, all the recirculated spots from a to k had merged to form one big dark spot at L2 ~ 262, and although small fragments spun off Sp. from this, and others prograded past it (from the unstable merger of spots L to R, f. it), a spot remained stationary in mid-STropZ at L2 = 262 until mid-Sep. and possibly later. Meanwhile some of the spun-off fragments seem to have merged to become a faint 'bridge' at L2 = 228 in mid-Sep. It is possible that these two merged complexes, at L2 = 228 and 262, became ovals 1 and 2 by 2008 Feb., but we cannot be sure. Both became fainter after mid-Sep. From then until mid-Oct. there were only a few images, with modest resolution; they showed up to 6 spots or 'bridges' across this region, but one cannot resolve whether these were circulations in mid-STropZ or (blurred) spots still travelling on either side of it. It is quite possible that the same two features were seen as dark 'bridges' at L2 = 220 (Oct.10) and 262 (Oct.13); the latter was keeping alongside oval BA and may also be seen as a brown streak on Oct.29. So these may have become ovals 1 and 2 respectively. Even if they did not, other similar eddying fragments probably did, merging and stabilising in mid-STropZ to become the ovals.

STrD-2 was generally faint and indistinct after the SEB outbreak appeared next to it in May, (see below; **Fig.20**), but it did persist into August, and possibly as a small hump or wisp even up to Oct.

The Great Red Spot

When the SEB fades, the GRS normally becomes more conspicuous and redder, and develops a positive DL2. In 2007, the GRS appeared as a well-defined isolated orange oval (17º long) throughout. It may have appeared more conspicuous because of its isolation, but the images show no change in its darkness or colour; perhaps because there was not enough time for it to intensify. It did show unusually fast retrograding speed in 2007 (DL2 = +1.3) **(Fig.19C)**, greater than in the solar conjunction before (DL2 = +0.5) or after (DL2 = +0.1), so this must have been the effect of the SEB fading. It also showed the usual 90-day oscillation very clearly **(Fig.19C)**.

S. Equatorial Belt

Even while the SEB Revival developed f. the GRS, the fading continued in the rest of the SEB (Fig.2). By late July the fading was almost complete p. the GRS: SEB(S) had disappeared, and mid-SEB was a very pale pinkish colour. Also, in the SEB just Np. the GRS, a blue streak developed during July, which has been a distinctive (though usually faint) accompaniment of the faded SEB in other cycles. These aspects persisted until a diffuse reviving SEB(S) spread along these longitudes in late August.

Mini-barges:

With the SEB being quiet and then fading, a number of small dark spots became evident in its southern half. With their cyclonic latitude, dark red-brown colour, and slow positive DL2, they were clearly 'mini-barges', homologous to the better-known barges in the NEB. Their cyclonic sense was shown in the HST image on May 11 (**Fig.20A**).

They showed a clear gradient of speed and size with latitude (**Fig.1**), though retrograding less rapidly (esp. the larger mini-barges) than the Cassini gradient would indicate, consistent with the general rule that stable circulations move more slowly than the ambient zonal winds. The smallest ones, close to the SEBs (item no.1 in Table 3A), were rapidly retrograding from the edge of the GRS; the early ones in this series passed mini-barge no.2 then decelerated and merged with the larger barge no.5 (as did nos.3 and 4, earlier). (One of these mergers was taking place when HST imaged it on May 11 (**Fig.20A**). The later ones in the series were lost in the SEB outbreak.)

Barges no.5 (**Fig.20A**) and no.7 (**Figs.11&12**) were the largest and most northerly and slightly prograding, and absorbed all the retrograding mini-barges that encountered them.

The merger of nos.6 and 7 was shown in a montage of STrD-1 (July 1-6) (see previously posted interim report 13). No.6 had accelerated and moved S in June, then began merging with no.7 on July 1. As with mergers of barges in the NEB, no.6 slid to the far end of no.7, forming an oblique barge (July 3), before settling down as a longer normal barge (July 6), which maintained the same latitude and almost the same drift as no.7 previously.

The SEB Revival:

The SEB Revival always begins with an outbreak of bright and dark spots from a single source in the faded belt, usually a year or more after the fading begins. This time, it started prematurely, with the appearance of a tiny brilliant white spot in mini-barge no.2 on May 17, at L2 = 179, Lat. 18°S (**Fig.20A**). It must have begun within the mini-barge, just like a mid-SEB outbreak observed by Voyager 1. In Chris Go's image on May 17, the white spot was already double and overlapping the p. edge of the mini-barge, beginning the turbulent expansion to Np. that always characterises such outbreaks.

The very high spatial and temporal resolution of the present observations allowed us to document the origins of the SEB Revival in unprecedented detail. Not only did it confirm that such outbreaks can arise within mini-barges (as also suspected for Revivals in 1949 and 1993); it also allowed us to pinpoint the appearance of subsequent white spots. As usual, they appeared repeatedly at about the same L2 (**Fig.19B & 20B**). In fact the first five appeared very close to the extended track of minibarge no.2 (DL2 = +10), which of course was no longer visible as the outbreak developed, and all appeared at the same latitude: 17.9 (+/-0.5) ºS.

What caused these eruptions all to appear on the same track? Possibly they were recurring in a persistent cyclonic vortex, or possibly in a storm centre established by the first eruption. [Contrary to some older hypotheses, they were not controlled by any sub-surface source fixed in System 3. Moreover, the initial outbreak did not coincide with any of the hypothetical Reese sources, whose predicted positions were L2 = 318 (A), 133 (B), 27 (C).]

STrD-2 was immediately Sf. the source (**Fig.20**), and was briefly darkened by material from the outbreak (May 22-23 and 26-28 only), but then became faint and indistinct, buffetted by the adjacent turbulence (though it did persist into August, and possibly even as a small hump or wisp even up to October). It seems to have played no part in the further developments.

The progress of the outbreak has been described in our interim reports. In comparison with previous Revivals, it most resembled that of 1949, in its very early start before the SEB was fully faded, and its source in a mini-barge, and its initial slow development; and both Revivals were among the less spectacular ones by historical standards. Nevertheless, by early June it had developed the typical form of a SEB Revival outbreak, with bright and dark spots arising from the source and spreading out in both directions (**Figs.20B & 17**). To summarise the three main branches of such outbreaks:

1) Southern branch (dark spots retrograding in the SEBs jet-stream): This was the most impressive element of the 2007 Revival. These dark spots formed from May 29 onwards in a confused dark region Sf. the source, on the f. edge of STrD-2, and gradually emerged and accelerated westwards. The emergence of spots a to e was tracked in detail. Each of them started with speeds around DL2 ~ +60 to +80 (as did the next spot, not numbered, which was strikingly red on June 15-18 in contrast to the surrounding grey melee.) Spots a,b,c,e then gradually accelerated to DL2 ~ +120. The development of this branch was described above.

2) Northern branch (spots prograding rapidly towards or in the SEBn jet-stream): This failed to develop significantly. There was a prograding dark streak from May 27, picked up by the SED (great white spot) as it passed on May 29, but it faded or collapsed before getting far, as did some subsequent ones. Eventually a wedge of dark spots in northern SEB got to the Red Spot Hollow (RSH) on June 16, but never got past it. By June 23 a dark streak was spreading back (Sf.) up the RSH, and was very conspicuous on June 27-30. Also on those dates, the SEB(N) p. the RSH was broken into a series of small waves, no doubt representing disturbance from the SEB outbreak, but no actual spots got past it.

3) Central branch (bright and dark spots or rifts moving Np. within the SEB): This developed as usual, although there were not such large or such dark spots as in some Revivals. No drift rates were established because early bright spots were rapidly distorted or disappeared, and later ones were very small and transient, with much small-scale turbulence; and even the leading edge of the ensemble was very oblique. The envelope of the leading white spots, overall, advanced with DL2 ~ -16 in June and ~-40 in July, so by mid-July it had finally filled in the SEB down to the RSH with small-scale turbulent spots. In July, many white spots could be tracked with DL2 ~ -34 within this region. None of this disturbance penetrated p. the RSH.

SEB(N):

The SEB(N) remained a strong dark brown belt throughout, and its south edge was broken up into a series of dark projections or oblique streaks, covering a wide range of longitudes (outside the SEB Revival sector, and unrelated to the SED) (see **Fig.2**, esp. Peach's map). These features had a wide range of speeds, following the latitudinal gradient (**Fig.1**). ("F. ends" followed a gradient ~0.7 deg further south, as these were the Sf. ends of oblique streaks.)
The SEB(N) north edge was described fully in our Interm Report no.19, and will be summarised in the next part of this report.

TABLE 3 AND FIGURES ARE ON THE FOLLOWING PAGES.

In these tables:
Description: DS, dark spot; WS, white spot; bet., between.
L2(O): System II longitude at opposition on 2007 June 5.
Values in brackets are extrapolated.
DL2: Drift in L2 in degrees longitude per 30 days.
Values in brackets are imprecise or variable.
Lat.: Zenographic latitude.
SD: Standard deviation of latitude measurements.
All features were tracked with at least 5 positions, usually many more.

TABLE 3A.

2007: Positions and drift rates: S. Tropical region

Current/ Spot no.	Description	DL2: mean	--range	Lat.	(SD)	Dates	No. of spots
STBn jet							
Intrinsic jet-stream spots:		-96	-96 to -98	-28.2	0.5	Apr-July	n=9
From Circ. Current at STrD-1:							
	Recirc. (single)	-76.5	-61 to -94	-26.4	0.5	July-Sep.	n=9
	Merged	-32.5	-24 to -53	-24.9	0.5	July-Aug.	n=3
	Spinoff (late)	-41.3	-40 to -44	-26.0	0.7	Sep.1-14	n=3
	Spot O	0	0	-23.9	0.3	Sep.1-14	Merged spot at L2 = 262.
SEBs jet							
	All spots	114.3	+81 to 130	-20.4	0.6	June-Aug.	n=16
	Med/small spots	122.9	+118.5 to 130	-20.0	0.4	June-Aug.	n=7
	F. STrD-1	107.3	+90 to 118	-20.3	0.6	July-Sep.	n=3

	Description/Name	L2(O)	DL2	Lat.	(SD)	Dates	Notes
STropC							
STropZ	GRS	120	+1.3	[-22.4]	[assumed]	Jan-Sep.	Length 17 deg. Shows 90-d oscil'n.
	STrD-2	185	-13 --> -7.1			Jan-July	
	STrD-1: p. end	325	-7.1			Jan-Sep.	
	--main column	327	-7.1			Jan-Sep.	
	--f. end	(362)	-2.0			Jan-May	
SEB	'Mini-barges':	L2(May 1)					
1	Series of 11 v. small d.ss.	125-195 (range:)	mean +51 +41 to +56	-18.8	0.6	Apr-June	See text. n = 11
2	Small d.s.	174	+9	-17.1	0.5	Jan-May	Tracked from 2006. SEB outbreak appeared in it.
3, 4	2 small d.ss.	212, (238)	+11	-17.2	0.4	Feb-May	Merged with no.5 (March, May)
5	Larger d.s.	219	-0.5 (var.)	-16.8	0.4	Feb-Sep.	All p. it merged with it. Length = ~6 o in Apr-May, 7-11 o in July-Aug.
6	Small d.s.	318	7.7	-16.9	0.3	Feb-June	Merged with no.7 on July 1.
7	Larger d.s.	355	+11 -->	-17.3	0.4	Feb.	Tracked from 2006.
			-9 --> -4	-16.4	0.4	Mar-Aug.	
8	Small v.d.s.	83	+16 --> +7 (v)	-16.9	0.3	Jan-Aug.	Halted as it approached GRS in Aug
Mean	(nos.2-8)		+6.8	-17.0	0.3		

	Description	DL2: mean	--range	Lat.	(SD)	Dates	No. of spots
SEB: north half: White spots (in SEB Revival): L2 = 130-200,							
	White spots:	-34	-32 to -42	-13.7	0.9	July-Aug.	n=10
SEB: North half: Dark spots or projs. on SEB(N)s edge [quiet, not affected by Revival, all L2]						late May to mid August	
	Dark spots or projs:						
		-35	-30 to -41	-12.9	0.6		n=5
		-73, -86		-13.2	0.1		n=2
		-108	-89 to -129	-11.7	0.3		n=13
	Sf. ends streaks:	-111	-95 to -128	-12.1	0.6		n=10

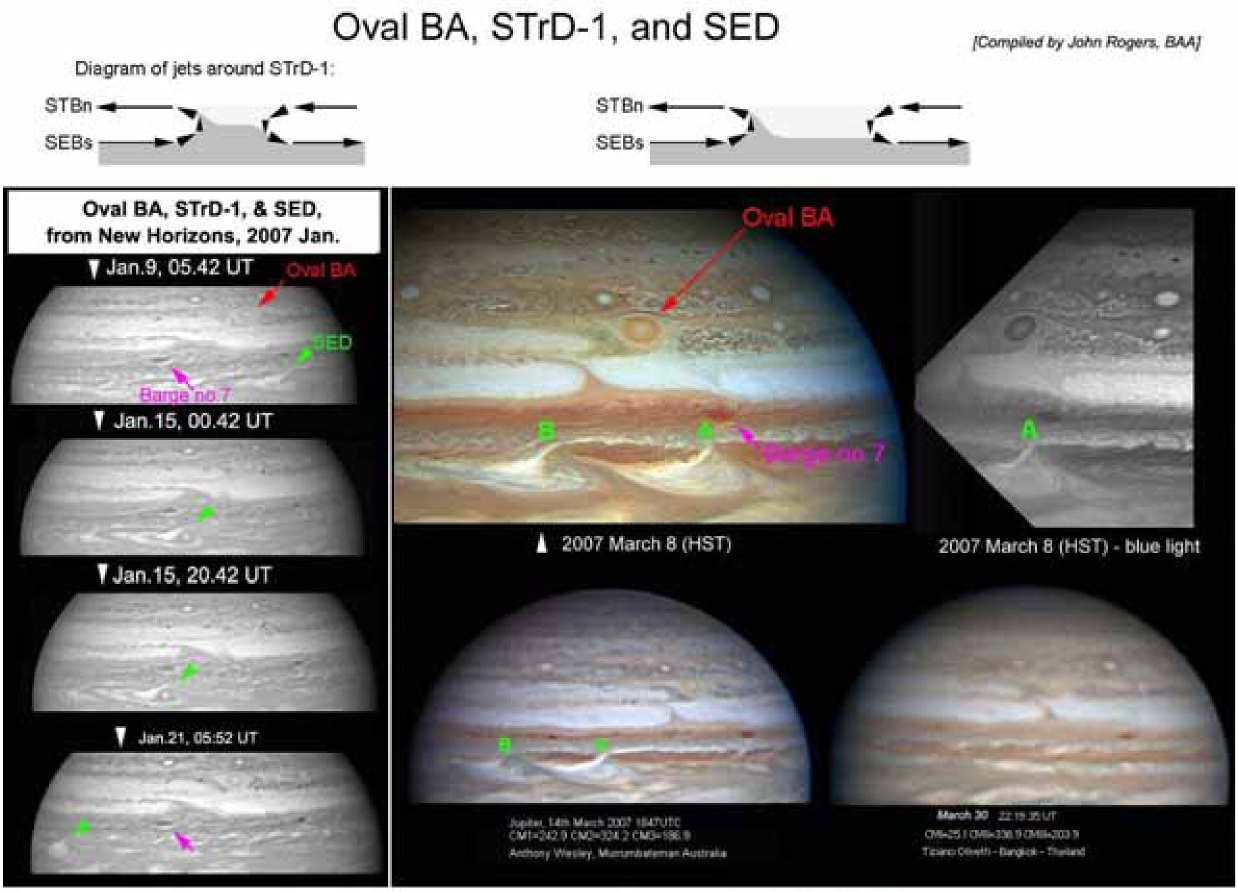
TABLE 3B.

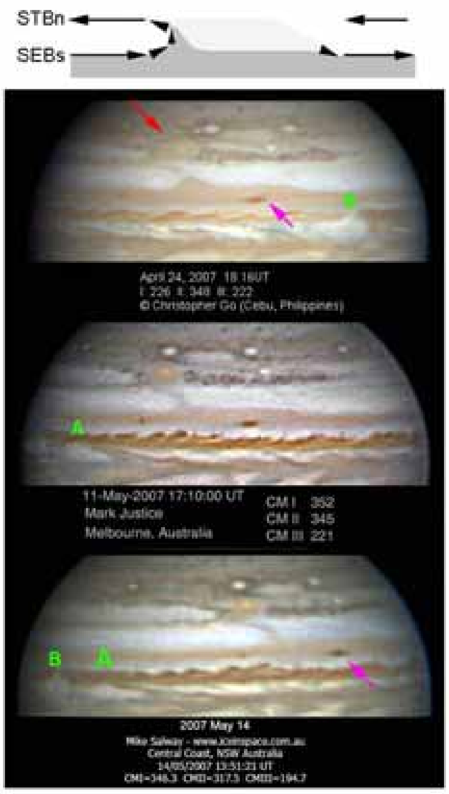
2007: Positions and drift rates: S. Tropical region
Details of groups of spots (averaged in table 3A):

STBn jet	Name	Type	DL2	Lat.	SD	Dates	
Intrinsic jet-stream spots:							
	set of 6	intrinsic	-96	-28.2	0.5	Apr-May	
	single	intrinsic	-97	-27.7	0.3	May-June	
	set of 2	intrinsic	-98	-28.3	0.5	June-July	
	-->	passing STrD-1	-74	-27.4	0.5	July	
From Circ. Current at STrD-1:							
	b'	spinoff	-73	-26.7	0.4	Jul.22-Sep.3	
	a	recirc.	-92	-26.6	0.2	July 6-13	
	b	recirc.	-94	-27.4	0.35	July 8-13	
	ab	merged	-53	-25.5		July18 -->	Steady decel'n and
	-->	merged	-26	-24.3		--Aug.11	northwards drift
	de	recirc.	-79	-25.6	0.3	July 18-23	
	-->	recirc.	-79	-26.2	0.5	Jul.25-Aug.1	
	fg	recirc.	-88	-26.5	0.3	Jul.25-Aug.1	
	defg	merged	-27	-24.7	0.5	Aug.4-14	
	h	recirc.	-70	-25.9	0.4	Jul.27-Aug.7	
	i	recirc.	-75	-26.7	0.4	Jul.30-Aug.7	
	dk	merged	-24	-25.0	0.4	Aug.18-23	
	jk	recirc.	-66	-26.2	0.6	Aug.6-20	
	S	recirc.	-61	-26.3	0.5	Sep.1-14	
	T	recirc.	-61	-26.6	0.5	Sep.1-14	
	x1	spinoff	-44	-25.2	0.5	Sep.1-14	
	x11	spinoff	-40	-26.6	0.75	Sep.1-14	
	x12	spinoff	-40	-26.1	0.5	Sep.1-14	

SEBs jet	Spot	Size	DL2	-Lat. (by spot size): Large	Med/small	Notes
	a	M	118.5		20.7	
	b	L	123.5	20.3		
	c	S	120		19.8	
	d	L	81	22.1		
	-->	L	100	20.5		
	e	L	105	21.4		
	-->	L	120	19.8		
	de	VL	112.5	20.6		Merged on July 3-4; imprecise speed, July 6-9
	f	S	119.5		20.0	
	g	L	116.5	20.0		
	h	L	114	20.3		
	i	M	123		19.8	
	j	M	130		19.9	
	k	L	104.5	20.6		
	-->	L	123.5	20		
	L	VL	105	20.7		
	m	M	125		19.9	Then merged with L
	n	M	124		19.9	*[formerly spot p on maps]*
	p	VL	106	20.5		*[formerly spot q on maps]*
	Mean:		114.3	20.6	20.0	
	SD:		11.7	0.6	0.32	
	Beyond STrD-1:					
		L2:	DL2	Lat.	SD	Dates
	c'	30 --> 97	114	19.7	0.3	Jul.28-Aug.14
	x	0 --> 34	118	20.3	0.25	Aug.23-31
	y	327 --> 11	90	20.8	0.55	Aug.24-Sep.7
			107.3	20.3	0.6	

Fig.11:





(Left): Fig.11 (cont.)

(Below): Fig.12.

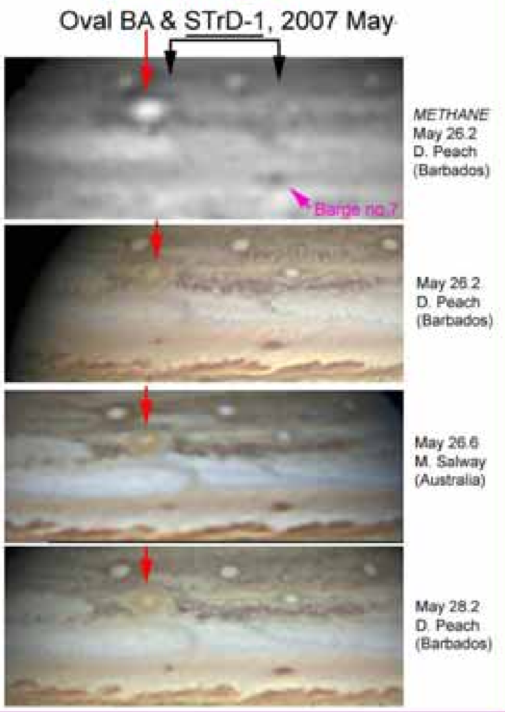


Fig.11 (ABOVE): Oval BA and STrD-1, 2007 Jan.-May. Diagrams at top show the extent and inferred wind patterns of STrD-1. The SED is also visible, passing by in Jan., March, and May; it becomes double in March (A and B). Images from New Horizons are from LORRI, credits: John Hopkins Univ Applied Physics Lab., Southwest Research Inst., and NASA. Images from HST are from WFPC-2, credits: Imke de Pater, Philip Marcus, Mike Wong, X. Asay-Davis, and Chris Go; UC-Berkeley, STScI, NASA & ESA.

Fig.12 (ABOVE): Oval BA & STrD-1, 2007 May. At this time a distinct f. end had re-formed temporarily. The top image is in the 890 nm methane band, showing that STrD-1 is all darker in methane than the rest of the STropZ.

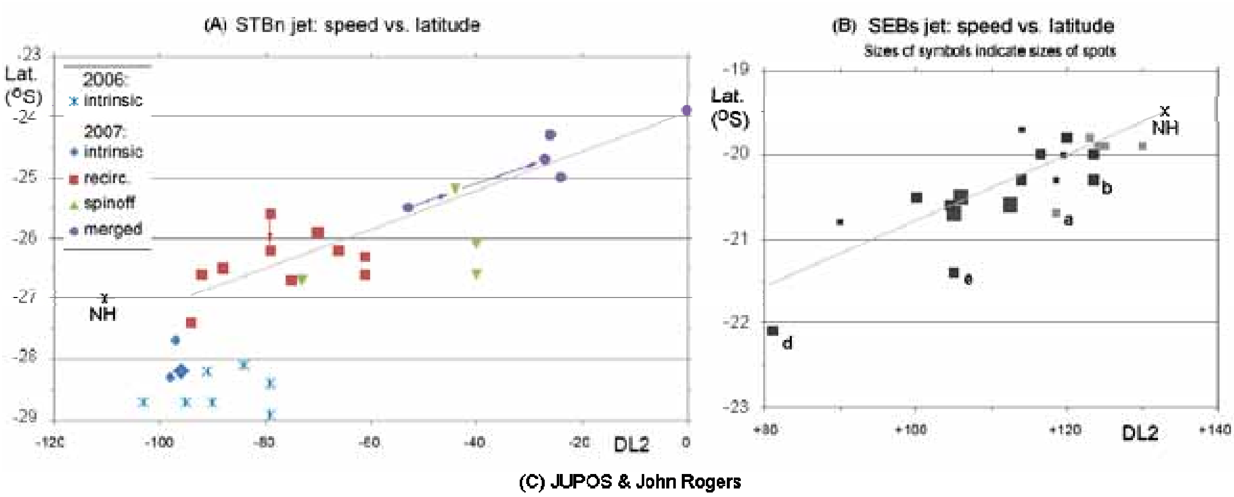


Fig.13. Zonal wind profiles for (A) STBn jet, (B) SEBs jet, before and during the Circulating Current. The charts show speed vs. latitude (enlarged from Fig.1), from data in Table 3B. See text for explanation. Arrows denote shifts of individual spots. X, peaks of jets observed by New Horizons [Cheng et al., 2008].

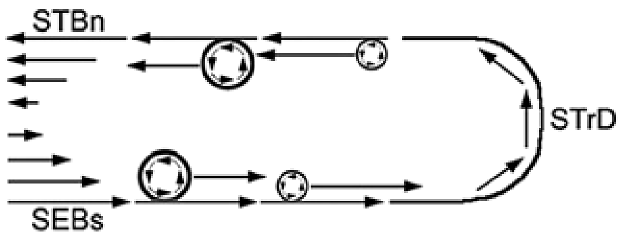


Fig.14. Diagram showing how the vortices move in the SEBs jet-stream and Circulating Current. The differential speeds and mergers of these spots can be understood in terms of the zonal wind gradient. All motions are anticlockwise (anticyclonic). The jet-stream spots are anticyclonic rings moving with the zonal speed for their latitude, and tangential to the jet-stream. Therefore smaller ones move faster, and catch up with larger ones and merge with them.

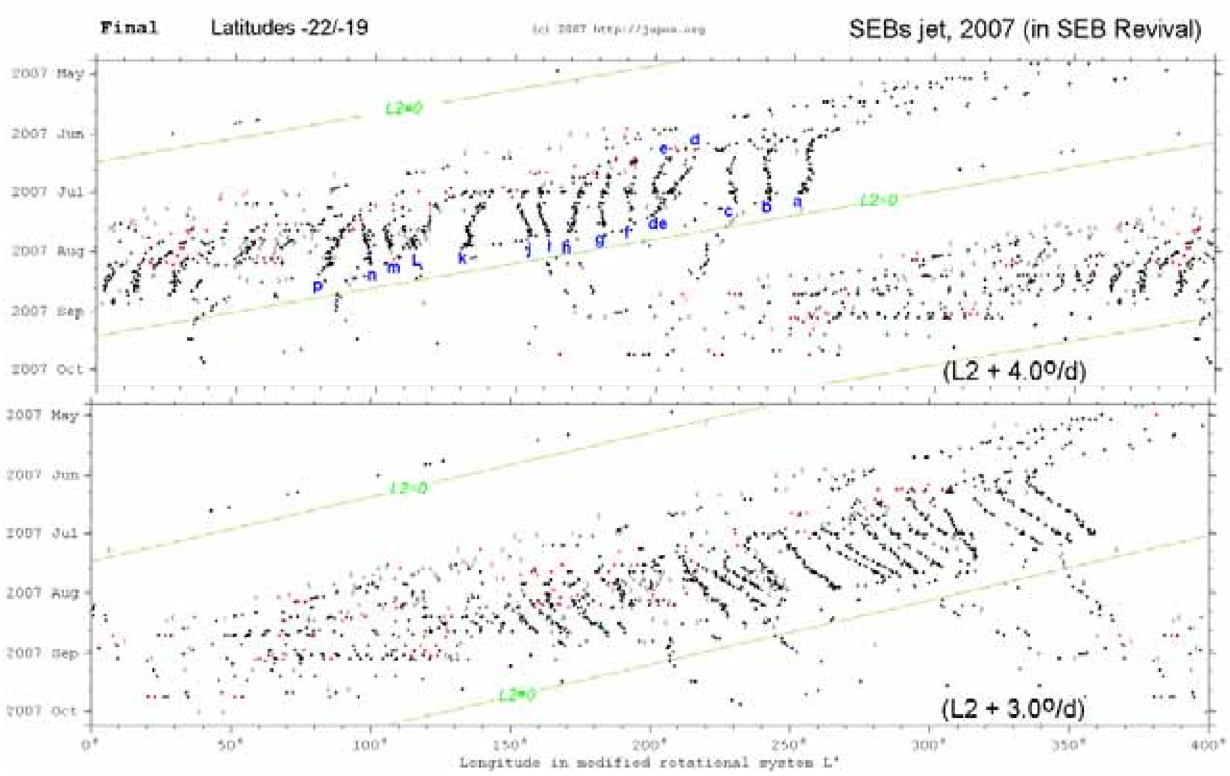


Fig.15. JUPOS charts for the SEBs jet-stream spots, in two different longitude systems: L2 + 4.0 deg/day (top), L2 + 3.0 deg/day (bottom).

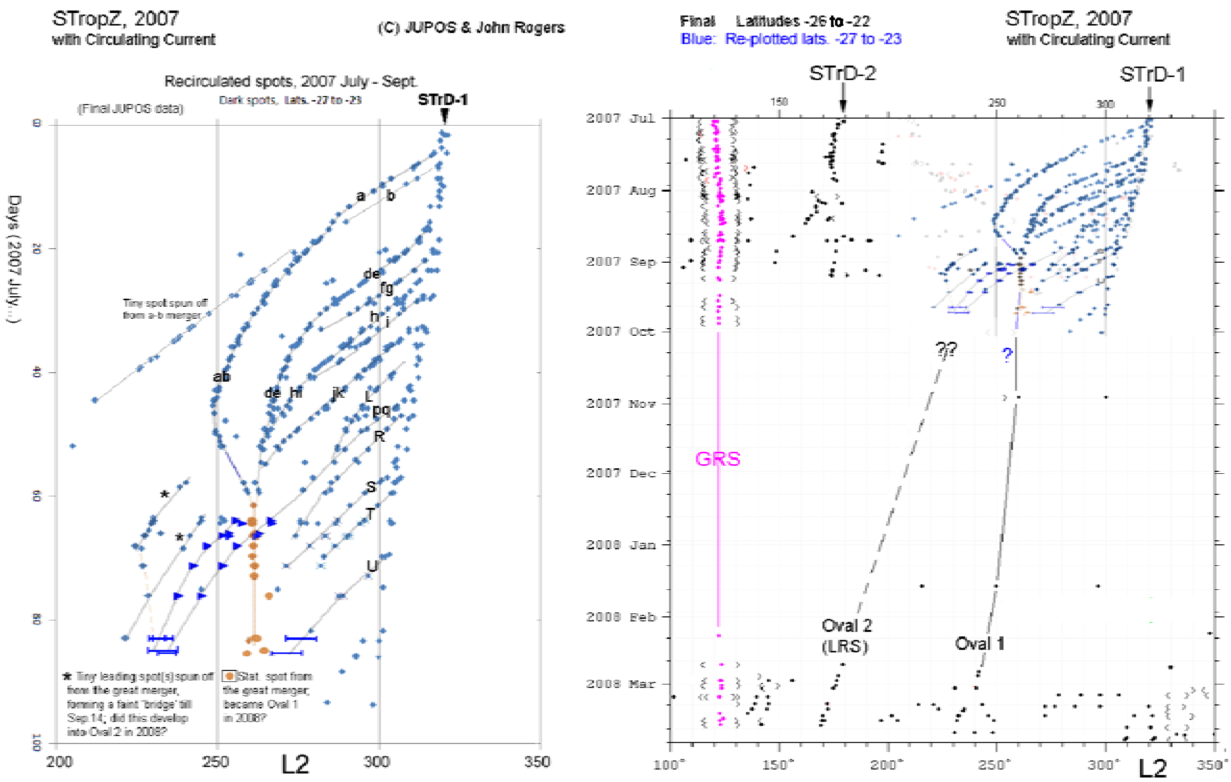


Fig.16. JUPOS charts for the spots recirculated in the Circulating Current, replotted in Excel. These charts include additional measurements of the later spots, by JHR and Michel Jacquesson. Blue points represent dark spots in southern STropZ in the STBn jet-stream. Some of these (marked *) were tiny fragments spun off preceding main spots that merged. Brown ovals represent the merged spot which formed in mid-STropZ, stationary at L2 = 262. These may have developed into Ovals 1 and 2 in the next apparition (right-hand panel).

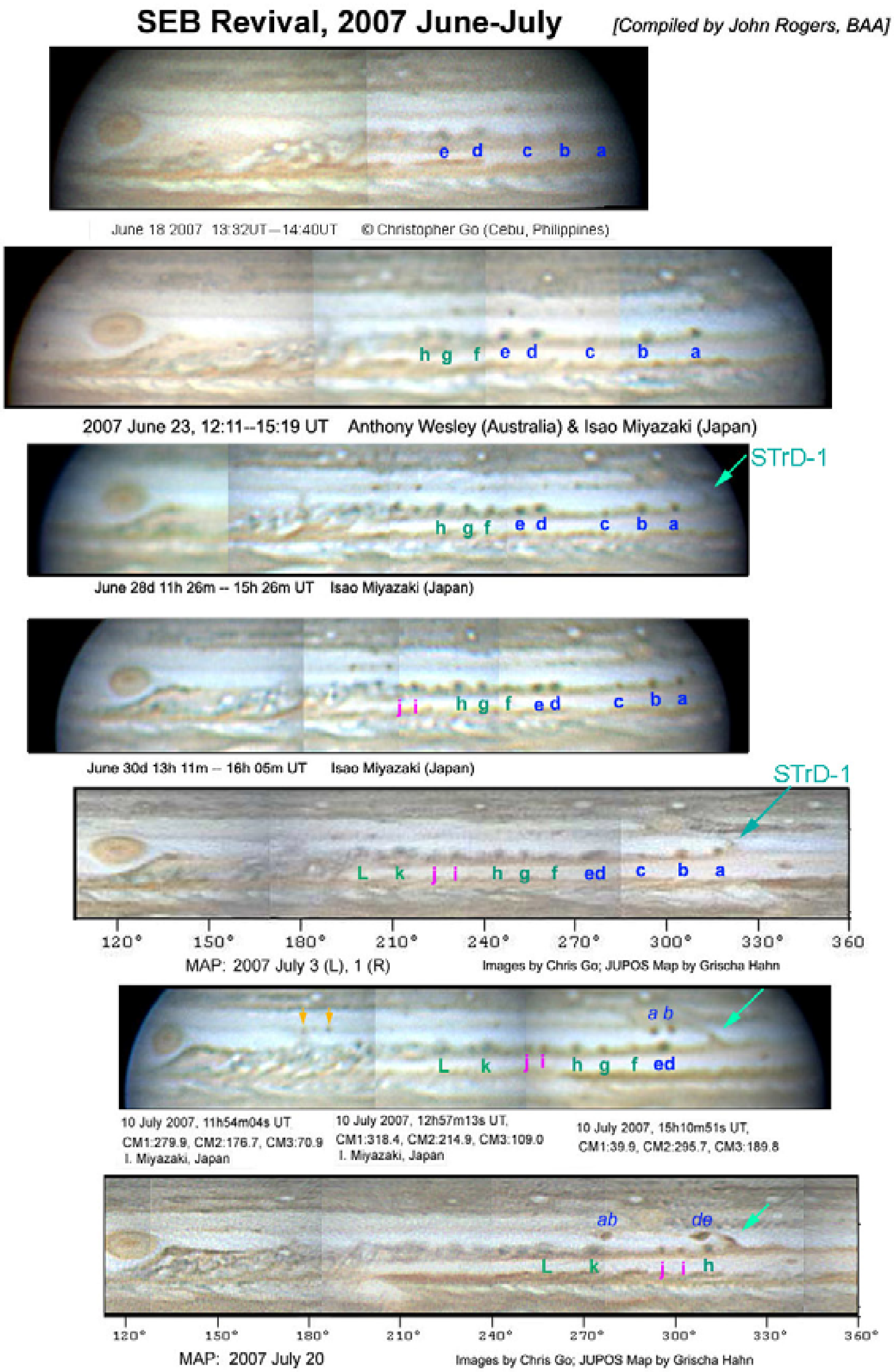


Fig.17. Strip-maps of the SEB Revival with SEBs jet-stream spots, June-July. They are assembled from unmodified images, except for July 1-3 and July 20 which are from cylindrical

projection maps in Fig.2. (For earlier stages, see Fig.20; also see figures in interim reports already posted.)

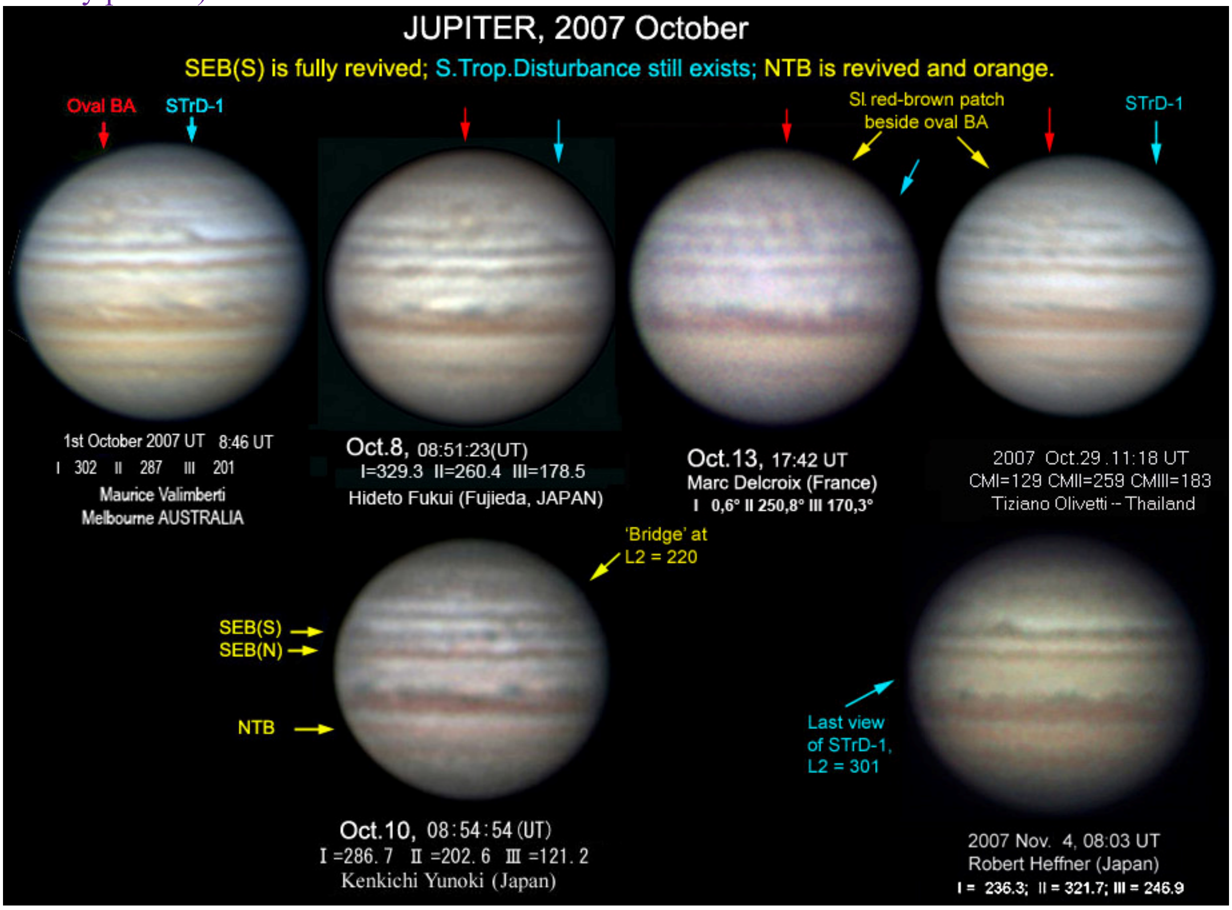


Fig.18. The last views of Oval BA, STrD-1 and the Circulating Current in 2007 Oct.-Nov.

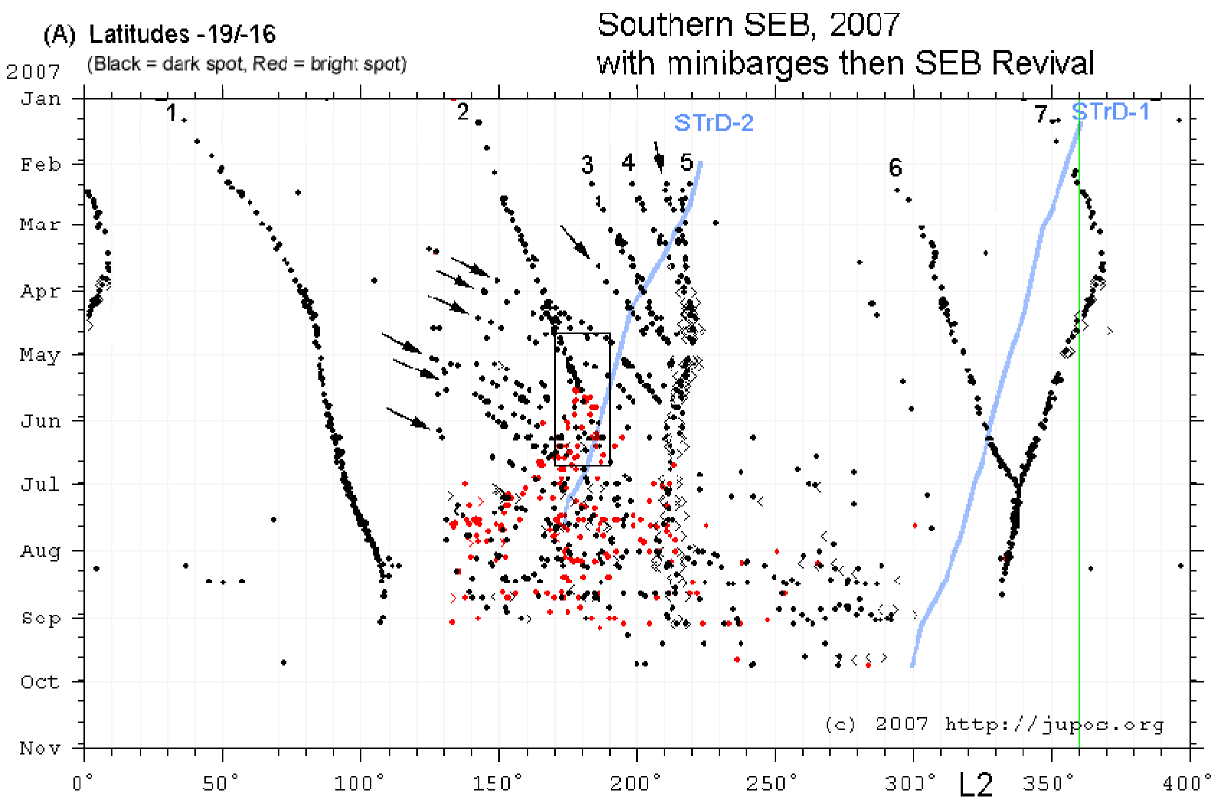


Fig.19 (A). JUPOS chart of the southern SEB, showing mini-barges (black points) the SEB Revival (red points are white spots). The boxed area is enlarged in (B).

Fig.19 (B). Enlargement showing that the first five white spots in the SEB Revival all appeared on the track of barge no.2. Barge no.2 [17.1 (+/-0.5) ºS] & new white spots in the outbreak [17.9 (+/-0.5) ºS] are re-plotted in Excel. Longitudes of the new white spots were as follows (see Fig. 20B):

2007	L2	Observer
May 17.7	177.6	Go
(double)	179.9	Go
May 25.2	182.4	Peach
May 27.2	185.9	Peach
June 2.5	183	Haese
June 6.1	187.5	Peach*
June18.2	178.6	Carvalho
(& 18.6)	177.5	Go

*This spot on June 6 was first seen in HST images on June 5d 18h, extremely bright at all wavelengths. [A. Sanchez-Lavega's group & NASA; C. Go et al., poster at DPS 2008].

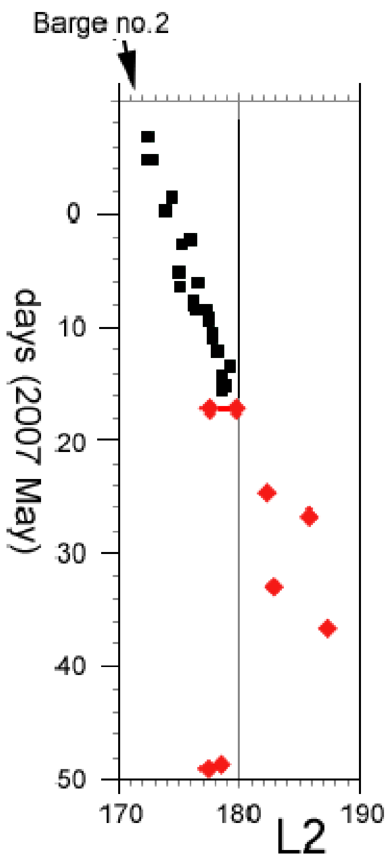
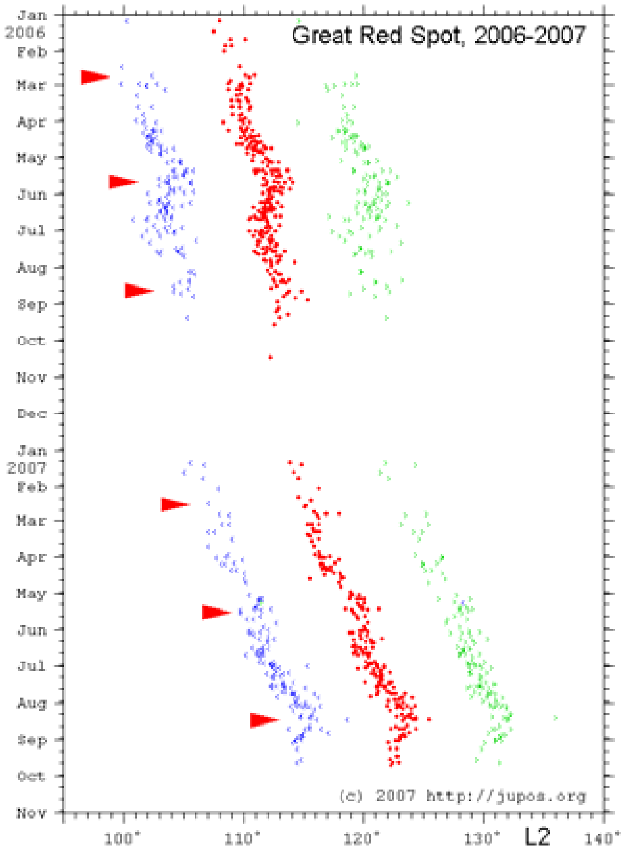


Fig.19 (C). JUPOS chart for the Great Red Spot, 2006-2007. Red arrowheads indicate maxima of the 90-day oscillation.



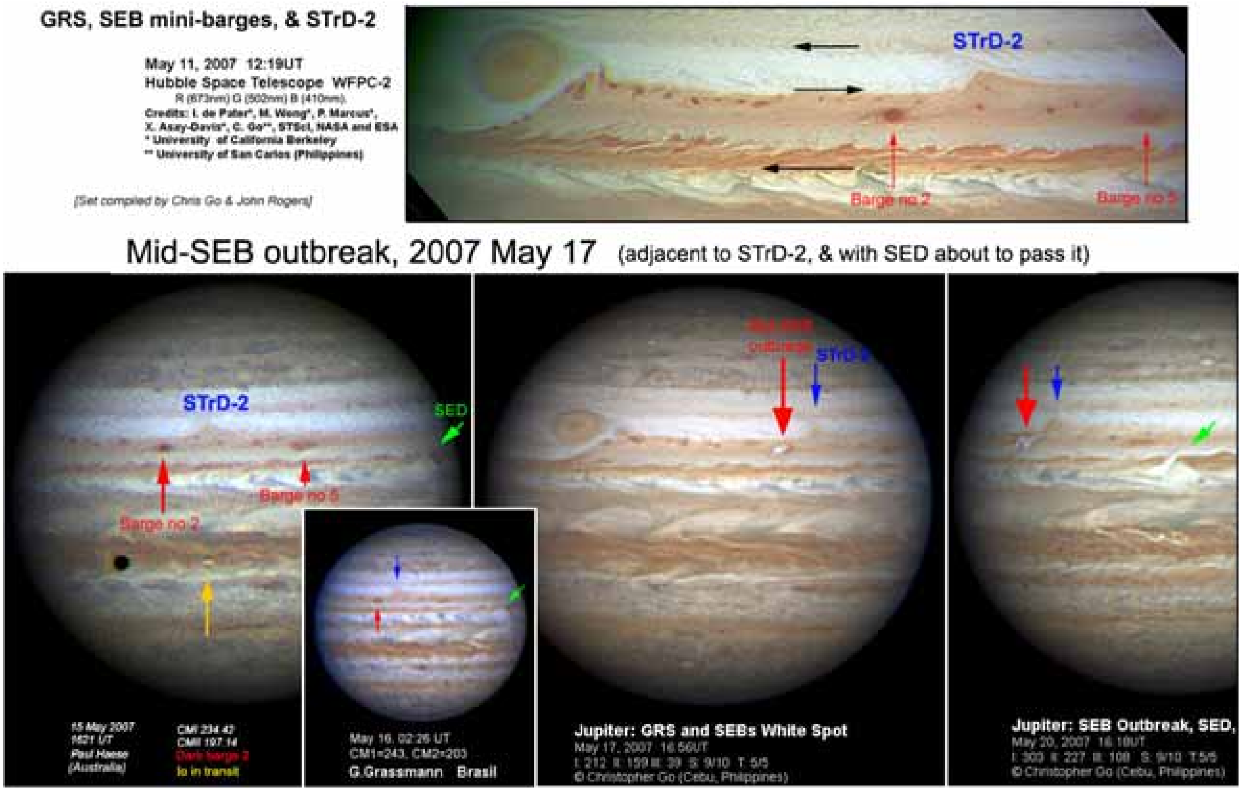


Fig.20(A). Origin of the SEB Revival oubreak. The HST image (May 11) shows STrD-2 and the mini-barges at high resolution; note the cyclonic circulation swirling of several mini-barges. The tiny red spot in barge no.2 was probably a normal cloud in the vortex; the white spot of the SEB Revival outbreak was still not visible from Earth on May 15, and was first recorded in Go's image on May 17, already expanding Np. out of the barge.

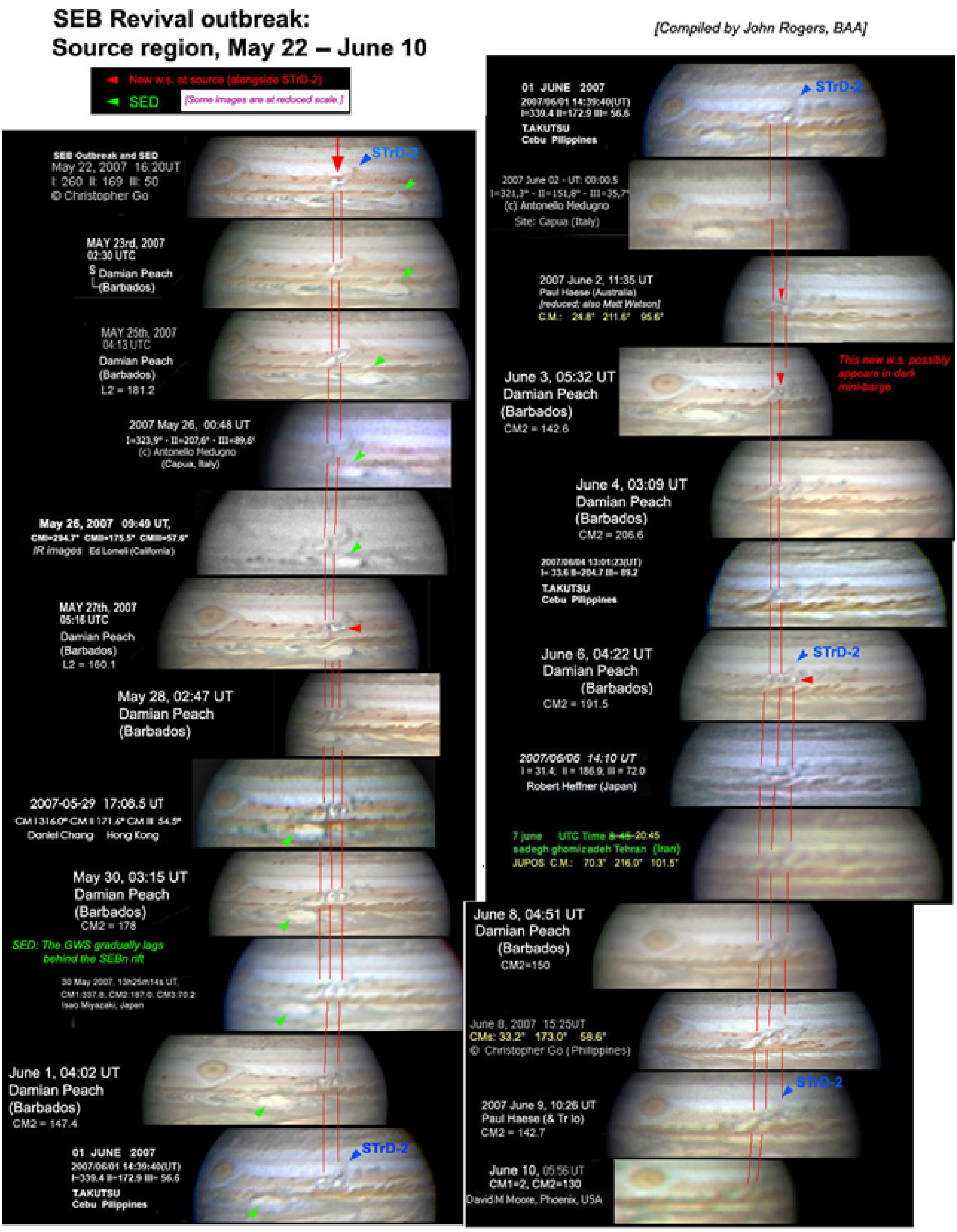


Fig.20(B). Development of the SEB Revival outbreak, May 22 – June 10. A hi-res image is shown for every rotation on which they were obtained. Red lines connect up the white spots, and the first appearance of each new white spot at the source is marked with a red arrowhead. They are all at about the same position, coinciding with the track of barge no.2 (Fig.19B). Also note the SED passing by. (For later views see Fig.17.)