JUPITER IN 2007: FINAL NUMERICAL REPORT

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Part 4: Equatorial Region

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The whole EZ was much darker than usual, apparently as a part of the global upheaval, although it was unusual that the darkening was largely grey-brown, rather than the usual yellow or reddish colour. (Yellow-brown shadings had been present when this darkening began in 2006.)

This darkening made the major features very conspicuous, but we have no evidence that it affected their behaviour. We report wide ranges of speeds for different features and compare these with results from previous apparitions, particularly as they bear on the supposed wave-like nature of the SED and the NEBs dark projections.

SEBn/EZ(S) and the S. Equatorial Disturbance

*[The full report, with illustrations, is already on our web site as **Interim Report no.19**; it is summarised here:]*

The SED had been inconspicuous until summer 2006 when the EZ darkened and the SED main complex became visible as a great white spot. In 2007 it was conspicuous for most of the time, and had an impressive 'stormy sector' p. it, with numerous, very-high-contrast 'chevrons' at most longitudes. Very-hi-res images revealed dynamic activity in the main complex and elsewhere.

The main complex generally had the classical structure of an oblique rift in SEB(N) with a bright area in EZ(S) at its mouth, with variable blue-grey shading just f. this. New Horizons images confirmed that these areas comprised an anticyclonic oval. Sometimes the whole oval appeared as a brilliant Great White Spot (GWS). Its mean drift was DL1 = +31.3 (+/- 0.4) deg/mth. However it underwent a remarkable duplication just after it passed the GRS in mid-Feb.: a new main complex (B) developed 30 deg. p. the existing one (A), and took over from it in March-April, but in May-June the GWS at the new main complex expanded to the f. side until it eventually returned to its original track.

Preceding it, there were large dark blue-grey streaks in EZ(S) which showed very diverse drifts (DL1 ~ +30 to -60), because of several co-existing speeds affecting them. Prominent dark spots slightly further p. moved rather faster (DL1 ~ -27 to -44), whereas the small dark projections that appeared to be connected to them moved faster still (DL1 ~ -42 to -71). These speed ranges were largely the same as in previous years.

Further p. there were many small dark blue-grey projections ('chevrons'), and bright spots or streaks between them. Their speeds (DL1) ranged from -42 to -84 deg/mth. These are similar to values recorded in earlier years when the SED was highly active, when the speeds formed a clear gradient with longitude p. the main complex [see our paper in press in JBAA]. In 2007 the speeds did not clearly confirm this gradient, apparently for two reasons: the gradient was rather flattened (as also during the Cassini flyby), and speeds close to the SED were unusually diverse (fast). Nevertheless, the slowest speeds were p. the main complex and the fastest speeds were f. it, as usual.

NEBs/EZ(N)

The dark projections and festoons were very prominent, dark blue-grey, linked to the very dark brown Equatorial Band. All these features (including the EB) gradually faded to moderate darkness during the summer. There were about 12 well-defined projections, but they were quite variable in appearance and drift, with a number of mergers, splittings, and new appearances during the year. We present evidence that there were two concurrent sets – one set of compact projections with zero or slightly negative DL1, and a set of longer, more widely spaced projections described as 'plateaux' with positive DL1 – and these were probably superimposed in the manner of wave-trains showing interference.

To track these rather large and complex features adequately, it is best to examine the JUPOS charts in conjunction with strip-maps, as shown in **Figs. 21-23**. Fig.21 is the raw JUPOS chart; Fig.22 is a higher-resolution version with the tracks of dark projections labelled.

At first sight (Fig.21) the chart is dominated by ~11 continuous tracks with DL1 ~ 0, but with irregular variations in drift; these have been denoted by lower-case letters a to k (Fig.22). Indeed, in the sector L1 ~ 140-280, there were 6 such near-stationary projections (f,g,h,i,j,k), from Feb. to July. They were conspicuous, large and dark, with festoons in EZ(S), mostly DL1 = -4 to +2, and quite stable in spite of passing NEB rifts.

However in the other sector, L1 ~ 330-120, there were initially (Feb.) four conspicuous long dark blue plateaux with DL1 ~ +11. (We label the long retrograding plateaux with capital letters corresponding to the more compact projections which they morphed into or, later, expanded out of; thus these four are labelled N,A,D,E. Preceding them, proj.L was another huge dark plateau from March onwards.) Each in turn was disrupted by the passage of the major region of mid-NEB rifts (see below), from proj.N in late Feb. to proj.E in late March. Proj.D disappeared for several weeks. Conversely, sometimes these plateaux became briefly very large, 'inflated' by rifts, and in this inflated state proj.A split into two near-stationary major projections, a and b, in late March. Proj.b later repeated the process, while hugely inflated by another major rift system in late April/early May, to create proj.c. In a comparable interaction, plateau E merged with proj.f in late March, but the passage of rifts then split the merged plateau again to re-form projs. e and f (moderate-sized but very distinct projections with white plumes).

The medium-to-large projections resulting from these interactions (b,c,d,e,f) were stable with DL1 ~ -5 for 1-2 months. (After April, the rifted regions in NEB, although very extensive, had only modest effects on NEBs projections when they passed.) However, there seemed to be a tendency to re-establish long retrograding plateaux. Thus the re-formed long plateau N merged with projs. a and b in turn, while proj. d also expanded to become a large very dark retrograding plateau (D"), as proj.e disappeared ahead of it.

From July onwards, some projections in the other sector (L1 ~ 140-280) also succumbed to the 'expansionist tendency': projections f,e,i, in turn disappeared as large retrograding plateaux approached them, and g and h themselves expanded into large plateaux (G and H). So at the end of the apparition, there was again a sector of long dark retrograding plateaux (now labeled L,N,D",G,H).

Discussion: NEBs projections as wave-trains and their superposition:

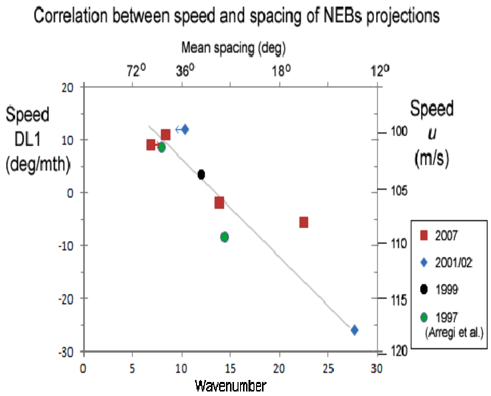
To quote from our just-published report for 2001/02:

"It is thought likely that the dark NEBs projections are Rossby waves whose phase speed (the observed drift) is much less than the underlying wind speed. If so, their phase speed should vary with their spacing, and this appears to be so [Ortiz et al., 1998; Arregi et al., 2006]. In 2001/02 we recorded two concurrent sets of NEBs projections which extend this relationship to even more extreme values: the large slow projections (DL1 = +12, or 99.7 m/s, spacings of >=35 deg.), and small rapid projections (DL1 = -26, or 117.9 m/s, spacing ~13 deg.). These values are consistent with the correlation established by Arregi et al.(2006)..."

In 2007 we again had two concurrent sets of projections with different speeds and spacings, which can be interpreted as wave-trains with different wavelengths, and these agree with this correlation (**Fig.24**).

Data in Fig.24 (from Table 4):

Large plateaux:	Dates 2007	Mean spacing (deg.)	DL1 (deg/mth)	u (m/s)
N,A,D,E	Feb-Mar.	43	+11	100.2
L,N,D",G,H	Sep.	< 52.5*	+9	101.2
More compact projs:				
a,b,c,d	May-June	16	(-5.5)	(108)
f,g,h,i,j,k	May-June	26	-1.8	106.3



*This value might be lower, as additional retrograding plateaux may have been developing in the longer gaps.

Indeed, the chart suggests **(Fig.22)** that the two wave-trains were more persistent than was initially apparent, and cut across one another, surviving the intersections and showing positive and negative interference! This hypothesis is illustrated by the grey lines drawn in **Fig.22,** to mark the boundaries of five persistent loci that encompassed the long retrograding plateaux and had steady drifts throughout the apparition: L; N; A-(b,c,d')-D"; D-(e')-G; E-(f,g)-H. (Dashed lines indicate proposed continuity between A and D".) After plateaux A, D, and E were each disrupted by the rifted region, the resulting projections belonged to the more compact, faster-moving set (a to f), but these tended to be longer and/or slower-moving while within the extrapolated tracks of A,D,E, indicating constructive interference. Conversely the retrograding plateaux did sometimes disappear when between the tracks of the faster-moving set, indicating destructive interference. We believe this chart is strong evidence for wave-like behaviour by the NEBs projections.

A very similar interpretation of the 1997 observations was proposed independently by Arregi et al.(2006) [J.Geophys.Res. 111, E09010] (see Fig.24). The present observations are more complete and show more extensive wave interference. The fact that independent analyses of the 1997 and 2007 data have produced an identical model strengthens our confidence that this model is correct.

Smaller, faster-moving projections:

In 2001/02, we also reported numerous small projections and bright spots with exceptionally fast drifts, DL1 range -14 to -36 (mean -26). The JUPOS analysis has revealed similar speeds

in most apparitions since then (unpublished data). In 2007 we again find several examples, including:
i) Proj. b itself had DL1 = -18 for intervals of ~1-3 weeks in four consecutive months.
ii) 'Proj. m' denotes a succession of 6 fast-moving projections/festoons with DL1 ranging from -17 to -37, approx. one per month. They appeared between plateaux L and N and usually merged with L. (They were in the same latitude as the other, more normal projections.)
iii) A white spot with DL1 = -47 for one week.

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TABLE 4.

2007: Positions and drift rates: Equatorial Region

South Equatorial Current (SEBn jet)	*DL1*		*Lat.*		*Dates*	*Deg.p.*	*No. of*
	mean	*range*		*SD*		*SED*	*spots*
SED main complex	+31.3	+26 to +42	nd		Jan-Sep.	0	1 (2)
Stormy sector:							
(dark streaks & large spots)	(0)	-30 to +30	-6.9	0.6	May-June	20-40	3(6)
	(-36)	-27 to -44	-7.2	0.5	May	30-50	3
Small SEBn projs.	-66	-42 to -84	-7.0	0.55	May-Aug.	20-340	36
(& white spots, not measured)							

North Equatorial Current (NEBs jet)

Note: The values for NEBs large plateaux are organised according to the alignment of tracks in the chart in Fig.22.

NEBs dark projections:	*DL1*		*Lat.*		*Dates*	*Mean spacing*	*No. of*
Large retrograding plateaux:	*mean*	*SD*		*SD*		*(deg.)*	*values*
N,A,D,E	+11	2.3			Feb-Mar.	43	4
L,N,D",G,H — See note	+9	2.1			Sep.	<= 52.5	4
mean (all values)	+9.8	2.3	7.5	(charts)			8
mean (whole-year values):	+9.9	2.5					5
More compact & faster projections:							
a,b,c,d	(-5.5)	1.3			May-June	16	3
f,g,h,i,j,k	-1.8	3.6			May-June	26	11
mean (all values)	-2.6	3.4	7.0	(charts)			15
Smaller faster features:*	*mean*	*range*					
b Proj.(segments of track)	-18		n.d.				4
m Series of projs.	-25	-17 to -37	7.2	0.4	May-Sep.		3
y Proj.	-21		7.6	0.3	Aug.		1
X WS	-47		7.9	0.3	May		1
Retrograding dark spots in southern NEB							
(within rifted region A1: L1 ~ 280-30)	+22		8.5	0.5	Aug-Sep.		3

*[DL1 for these short-lived faster features is generally +/- 2 deg/mth.]

FIGS. 21-24 ARE ON THE FOLLOWING PAGES:

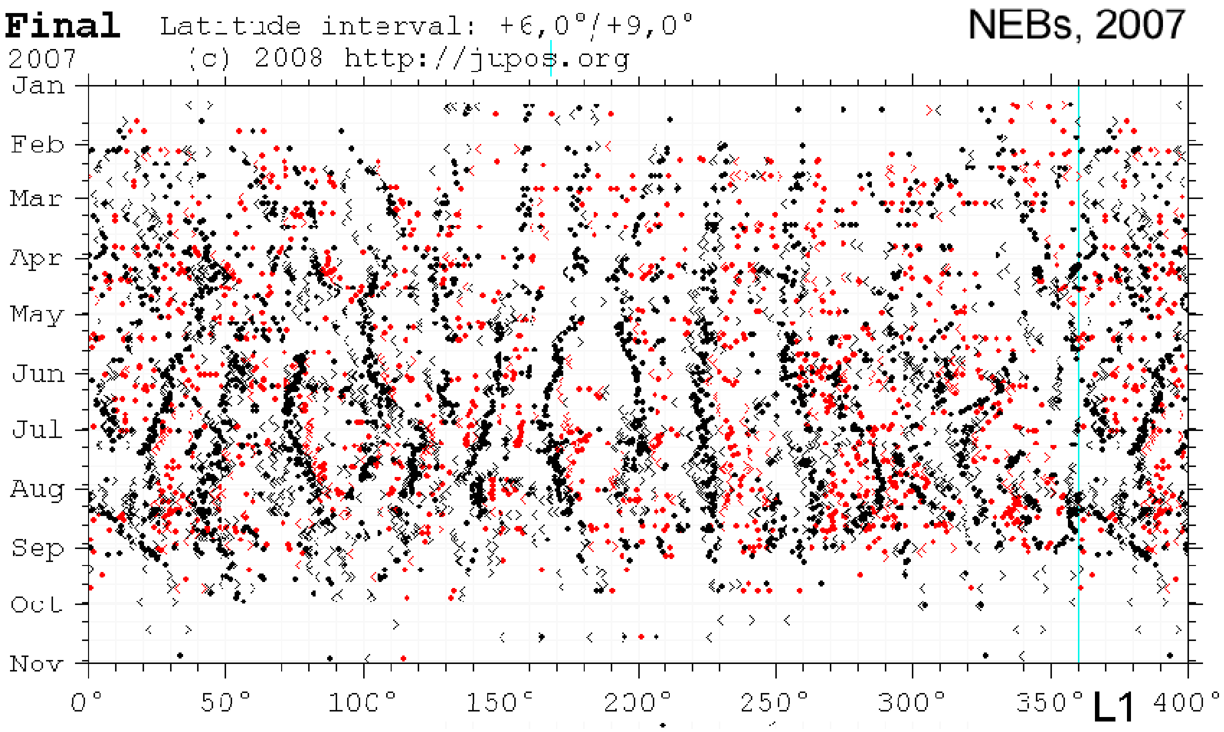

Fig.21. JUPOS chart of the NEBs features (unlabelled): L1 vs. time As in all JUPOS charts, red = bright spots, black = dark spots (here, NEBs projections); < > denote long features (here, NEBs plateaux).

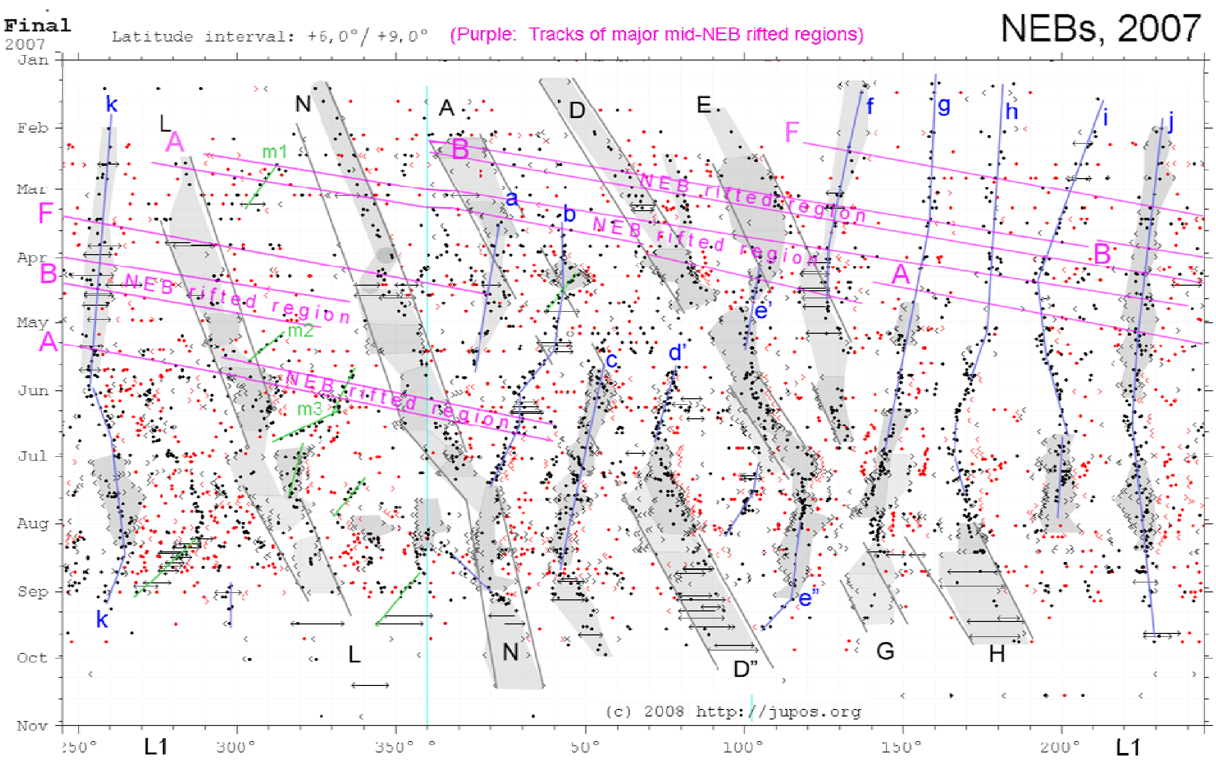

Fig.22. JUPOS chart of the NEBs features: as in Fig.21 but at double resolution, fully labelled, plus NEB rifts and double-wavetrain interpretation. Plateaux are denoted <——> and tracks of persistent features are shaded grey. Projections (including plateaux) are labelled with capital letters (long, slow-moving ones) or lower-case letters (more compact, faster-moving ones), such that A and a (for example) refer to a continuous track with variable speed. Tracks of the long, slow projections are outlined and interpolated to show how they persisted throughout the apparition in spite of interference from the shorter, faster projections. Tracks of small projections moving even faster are indicated by green lines. Purple lines and labels indicate mid-NEB rifted regions (see next part of this report): their names A, B, F are unrelated to the names of the NEBs projections.

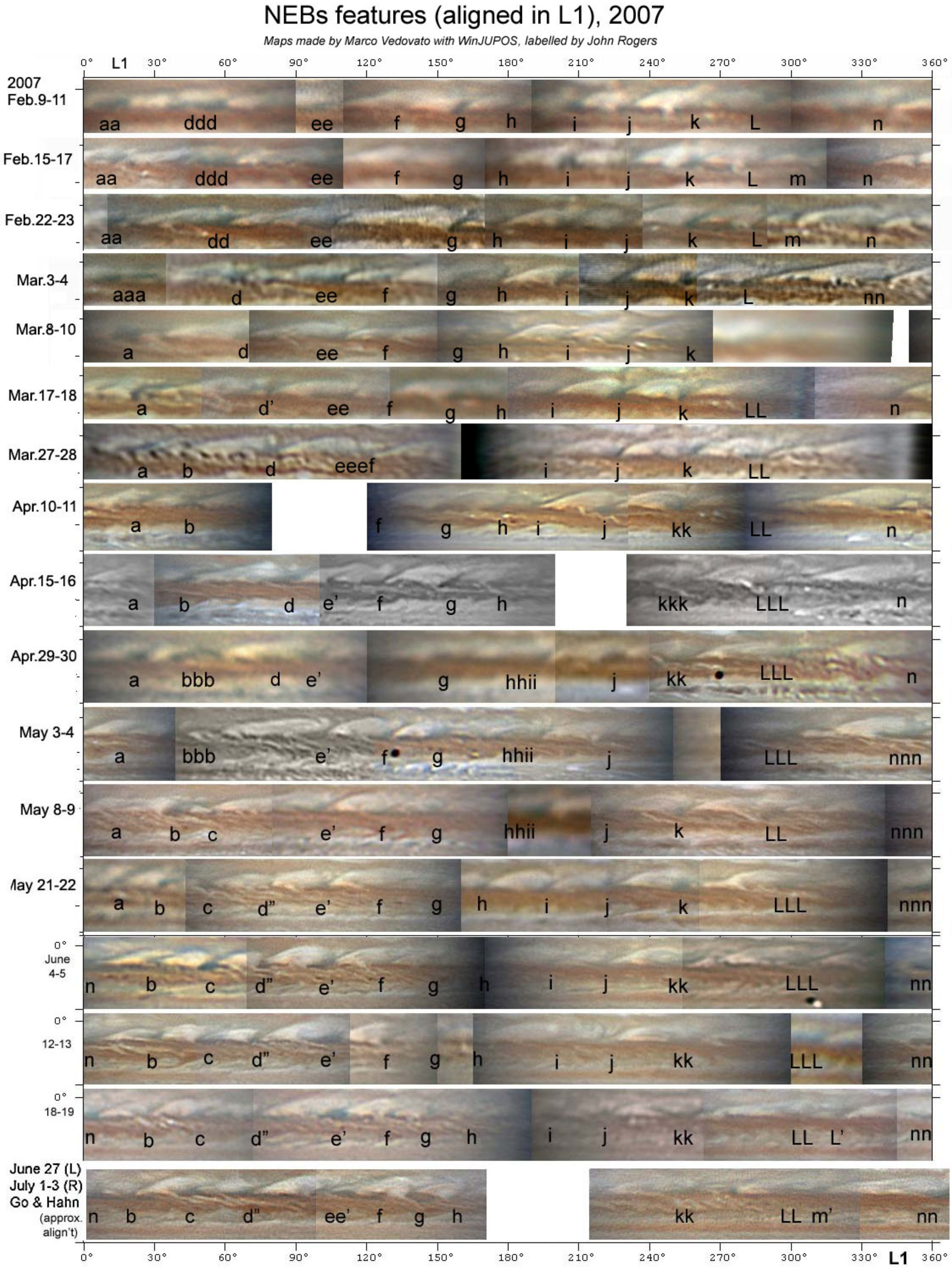

Fig.23(A). Maps of the EZ(N) & NEB, approx. once a week from from 2007 Feb. to Sep. *[Legend continues below.]*

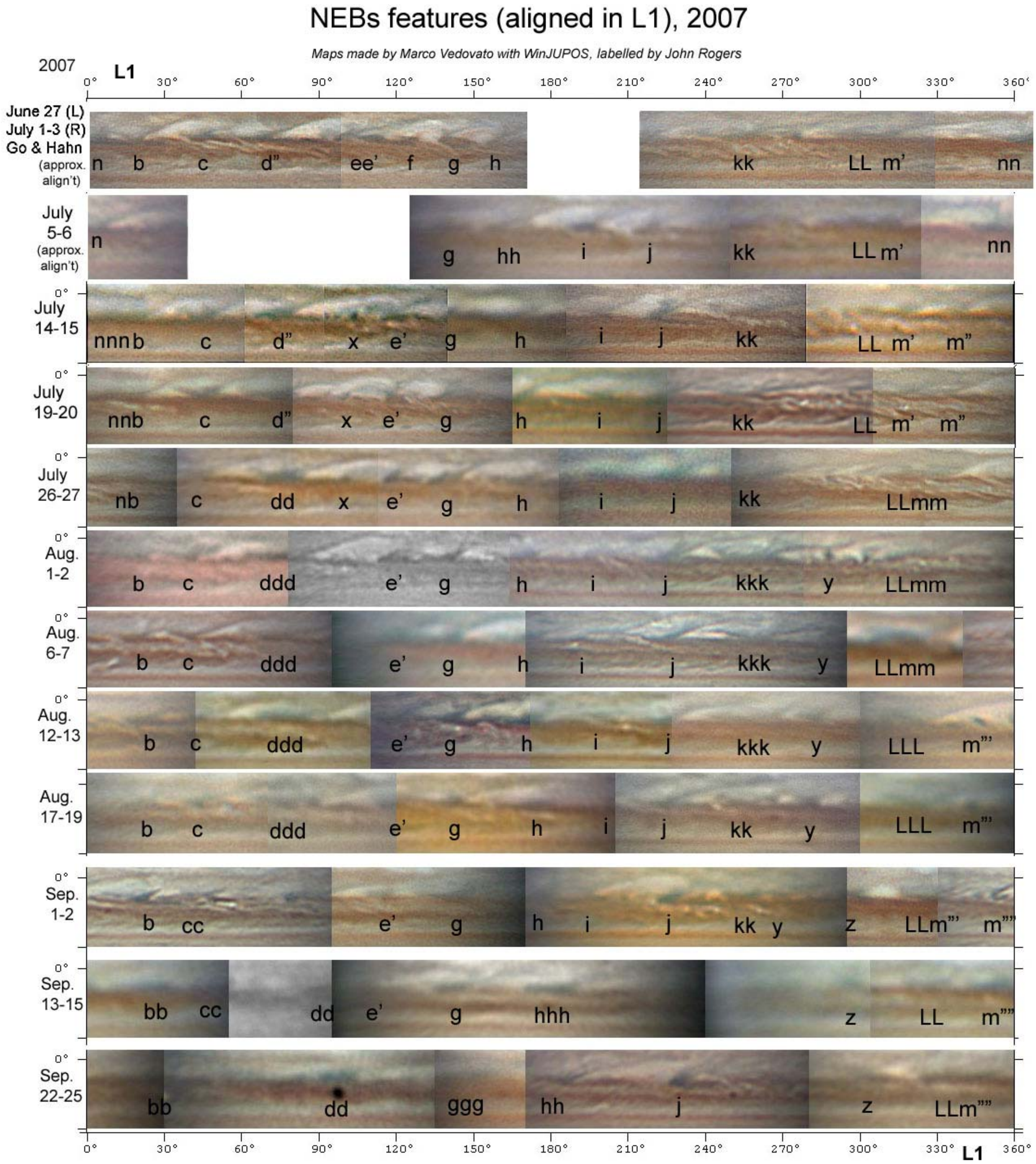

Fig.23(B). Maps of the EZ(N) & NEB, approx. once a week from from 2007 Feb. to Sep. All maps were made by Marco Vedovato, using WinJUPOS, with images from various observers; except for the one by Chris Go & Grischa Hahn. NEBs projections are labelled. (This is a working compilation and labels may differ slightly from those adopted in Fig.22. Label such as **aaa** indicates a long dark plateau denoted **A** in Fig.22.)

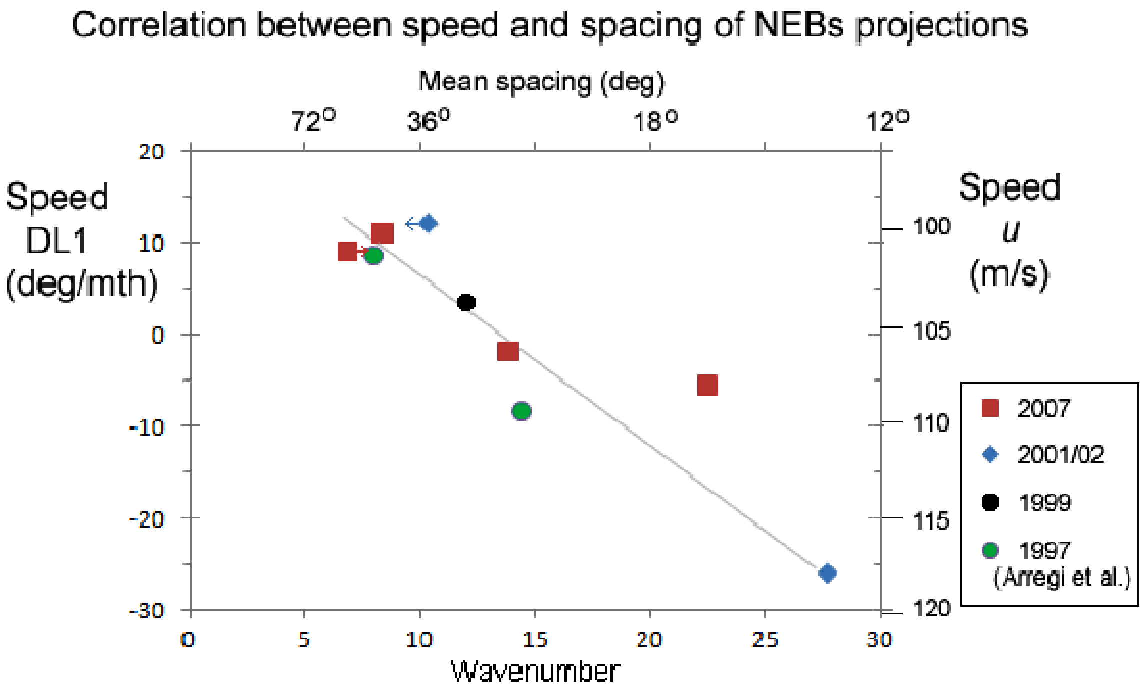

Fig.24. Correlation between speed and spacing of NEBs projections, for 2007 and several other apparitions where extensive arrays of persistent projections showed regular spacing or 'wavelength'. (Wavenumber = 360º / wavelength.) Note that judgement often has to be made in deciding how to calculate the 'wavelength'. Thus the mean spacing of 52.5º in 2007 is a maximum value, as additional retrograding plateaux may have been developing in the longer gaps. Conversely 35º in 2001/02 is a minimum value. Values for 1997 are from Arregi et al.(2006) [J.Geophys.Res. 111, E09010], and are consistent with our chart for that year.