

*Final, 2013 July 12*

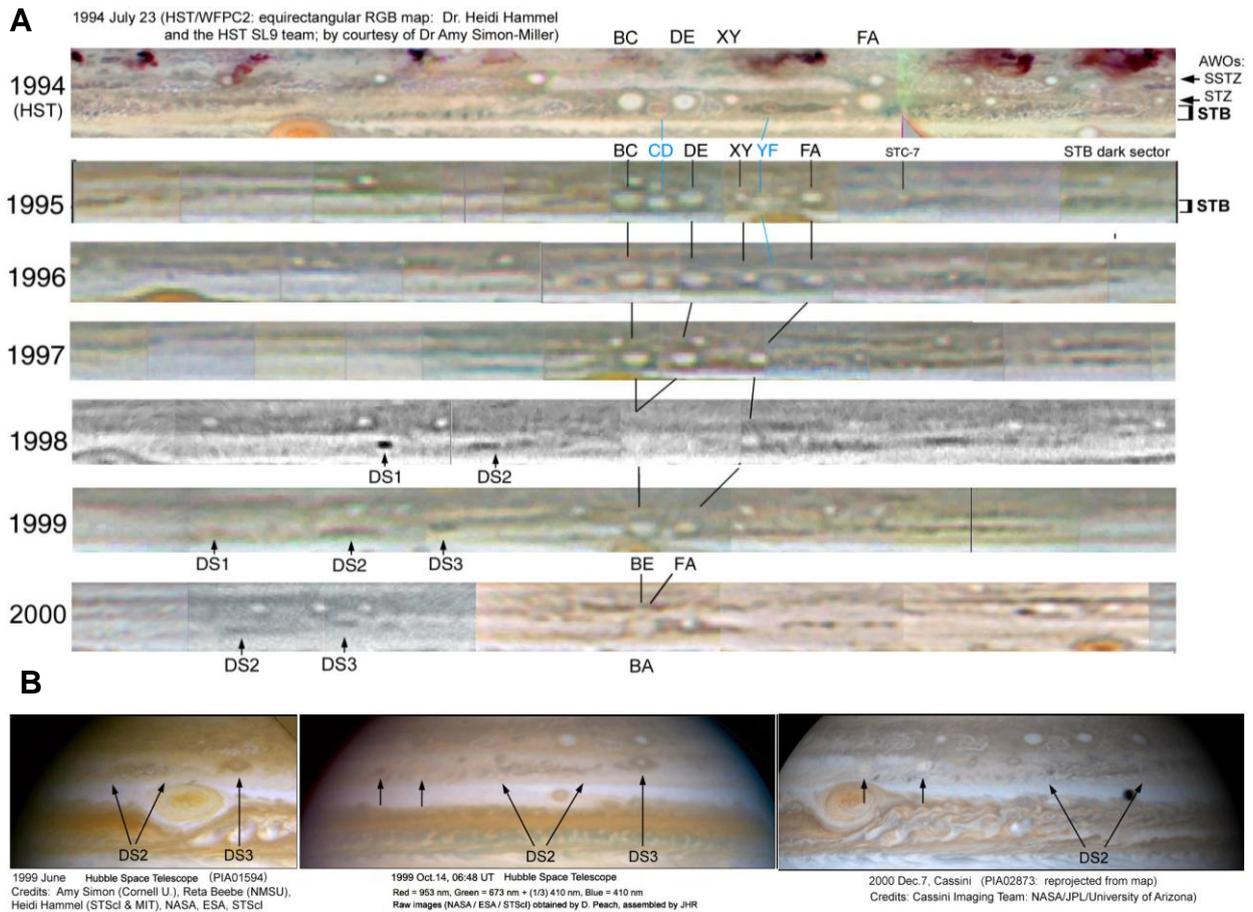
**Jupiter's South Temperate domain: Behaviour of long-lived features and jets, 2001-2012**

John Rogers , Gianluigi Adamoli, Grisca Hahn, Michel Jacquesson, Marco Vedovato, & Hans-Jörg Mettig

**FIGURE LEGENDS & MINIATURES**

*South is up in all figures.*

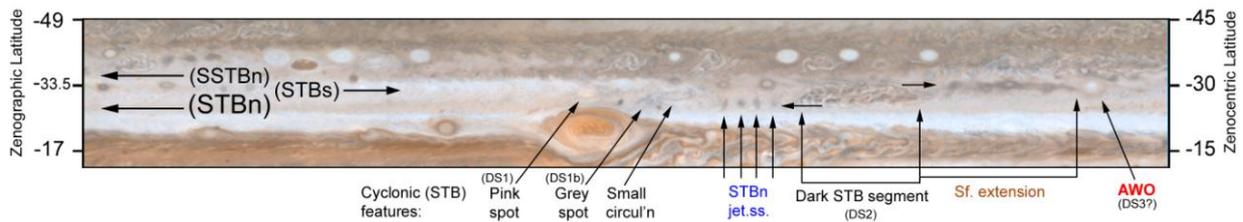
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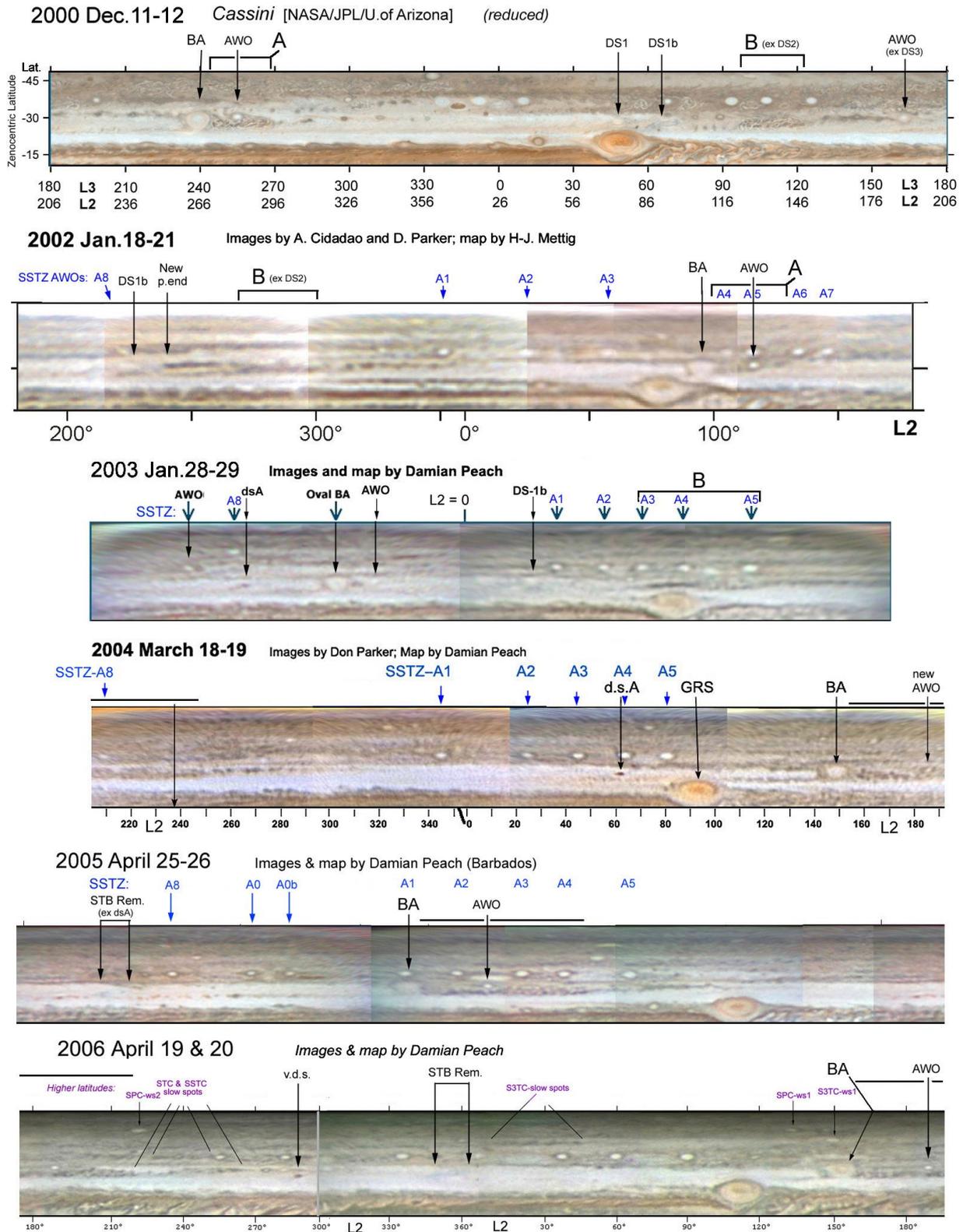
**Figure 1. The S. Temperate domain, 1994-2000.**

**(A) Maps in each apparition, 1994-2000.** All are cylindrical projection maps, published in our reports in the *Journal of the BAA*, except the HST map in 1994 (see credits on figure). South is up. Maps are aligned on oval BC/BE/BA. CD and YF were cyclonic ovals: YF was designated the ‘Morphing Spot’ because of extraordinary changes in its colour and appearance (Appendix 1).

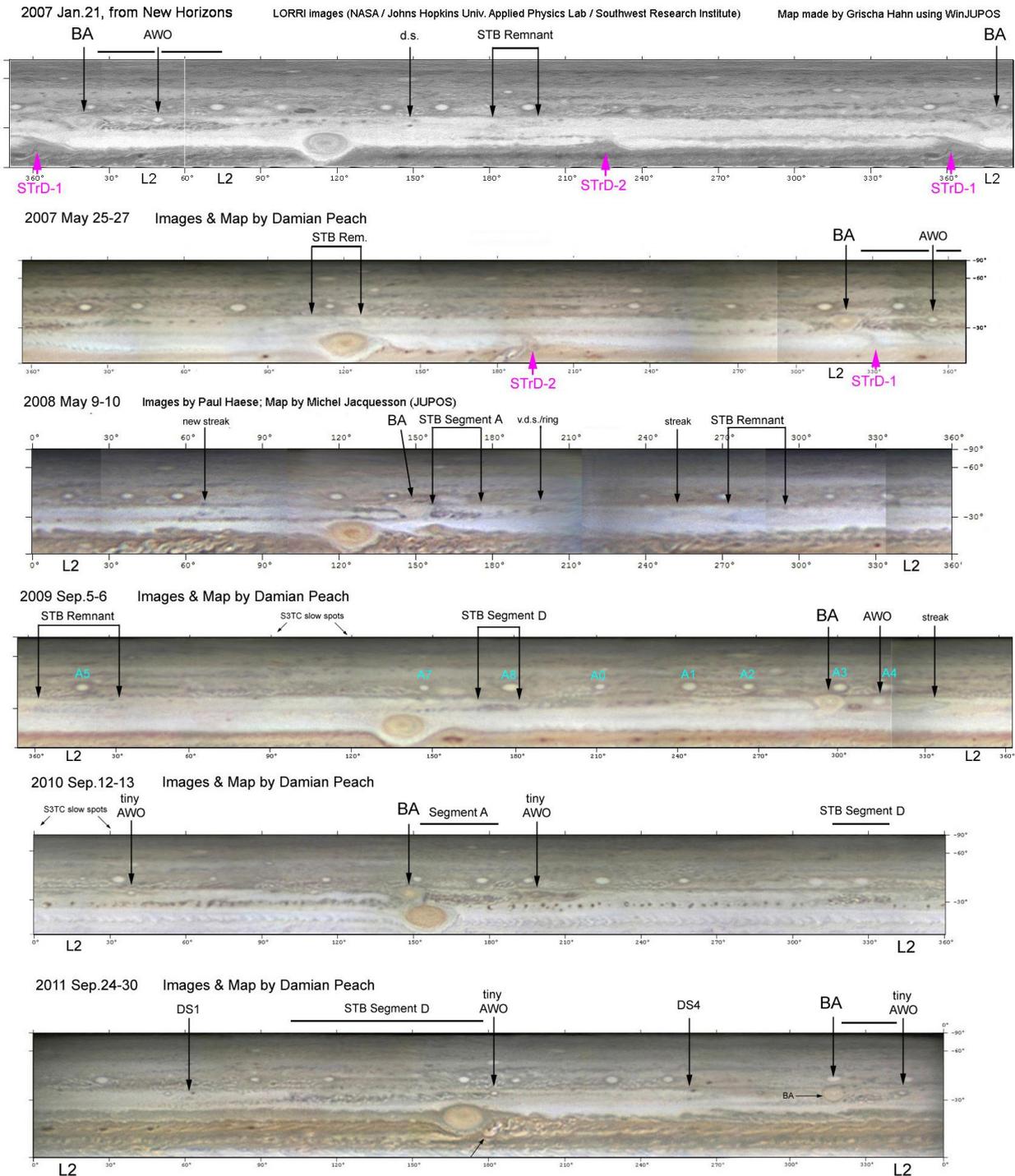
**(B) Spacecraft images of the new structured STB sector, in 1999 June & Oct. (from Hubble Space Telescope) and 2000 Dec. (from Cassini).** The main features are the new dark STB segment (DS2) and the small, very dark anticyclonic oval Sf. it (DS3). Shorter arrows indicate two small cyclonic spots (probably DS1 and DS1b). Credits on figure. (More spacecraft close-ups of these spots are shown in our reports [refs.2 & 3] and in **Fig.2.**)



**Figure 2. Part of the Cassini map on 2000 Dec.11-12, showing details of a typical STB structured sector (right half), compared with an undisturbed sector (left half), on which the approximate jet latitudes are marked.** (Credit NASA/JPL/University of Arizona). This map is used as it has an equirectangular projection which does not distort high-latitude features excessively.



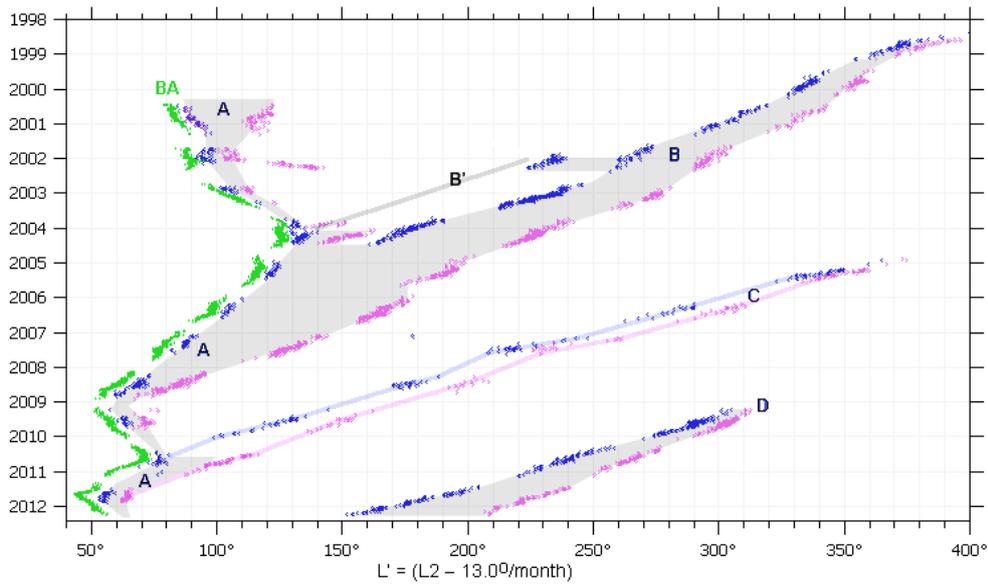
**Figure 3. Maps in each apparition, 2000-2011.** One of the best available maps for each apparition is shown, covering latitudes from the south pole down to mid-SEB, with the S. Temperate features labelled. Black bars above mark the extent of STB structured sectors, including STB dark segments A and B as labelled in the early maps. On some maps the S.S.Temperate AWOs are also indicated (labels in blue). All maps use cylindrical projection and System II longitude (L2), and were made using WinJUPOS, except the Cassini map which uses equirectangular projection.



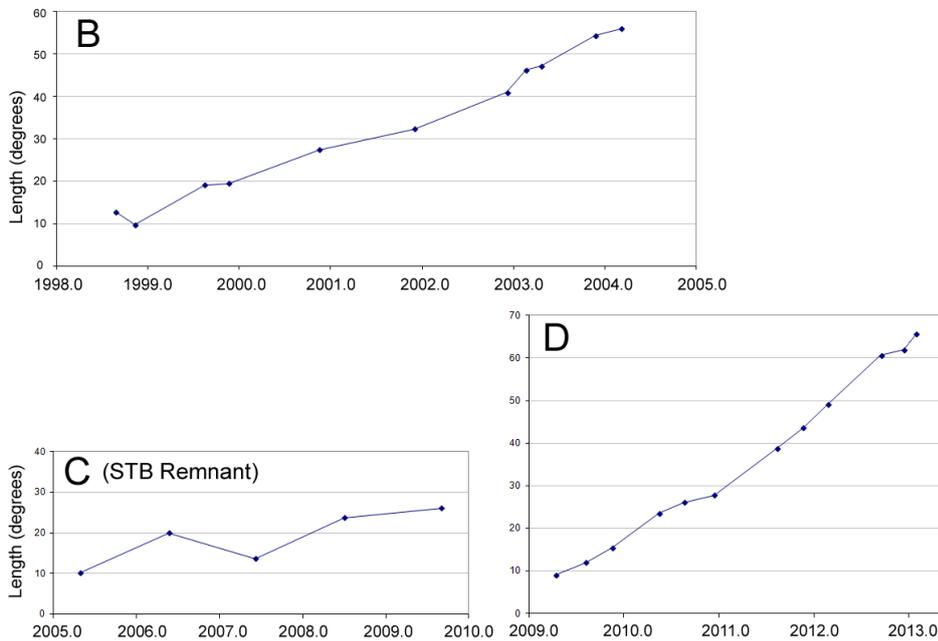
**Figure 3 (cont.).**

**NEXT PAGE:** Figure 4. JUPOS charts for the S. Temperate domain. (A,B) Charts of longitude vs. time, for 29-34°S. Longitude is plotted in System III ( $L3 = L2 - 0.266 \text{ deg/day}$ ); oblique pale blue line marks  $L2 = 0$ . Black points, dark features (31-34°S); green points, oval BA (31-34°S); red points, bright features (31-34°S, mostly small AWOs); grey points, dark features (29-31°S, i.e. belonging to cyclonic STB or to the edge of the STBn jetstream). Oblique pink line is the track of the GRS. < > indicate p. and f. ends of dark sectors; some dark STB segments are highlighted by grey shading. The track of the STB Remnant was not always clear from the JUPOS chart, because of its irregular extended nature, but has been plotted from inspection of images.

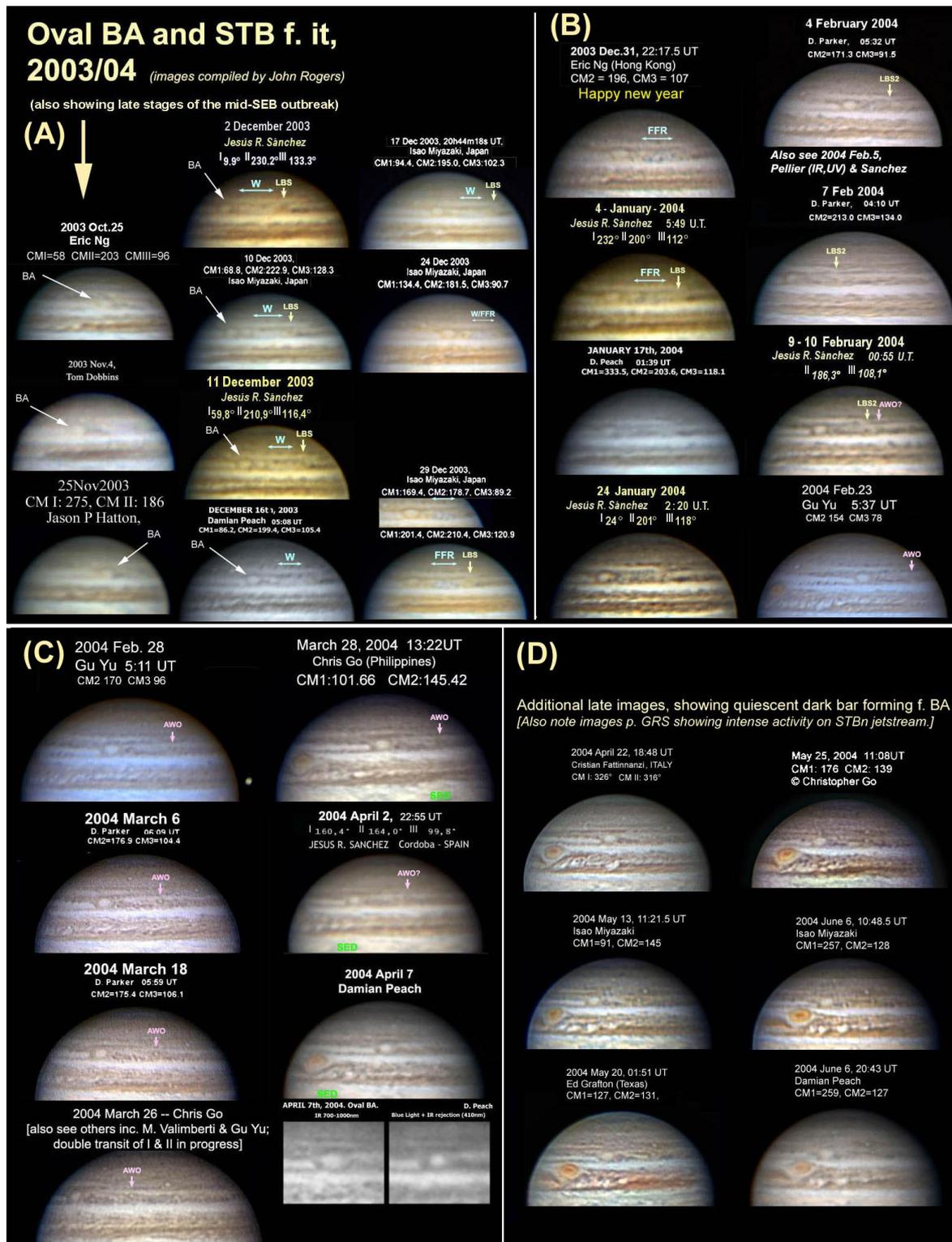




**Figure 4(C) Summary chart.** Longitude =  $L2 - 13.0 \text{ deg/mth}$ .  
 Grey shadings indicate dark STB segments.  
 Green, oval BA; blue, p. end of structured sector; purple, f. end;  
 B', small feature (DS1b) p. main part of sector B.

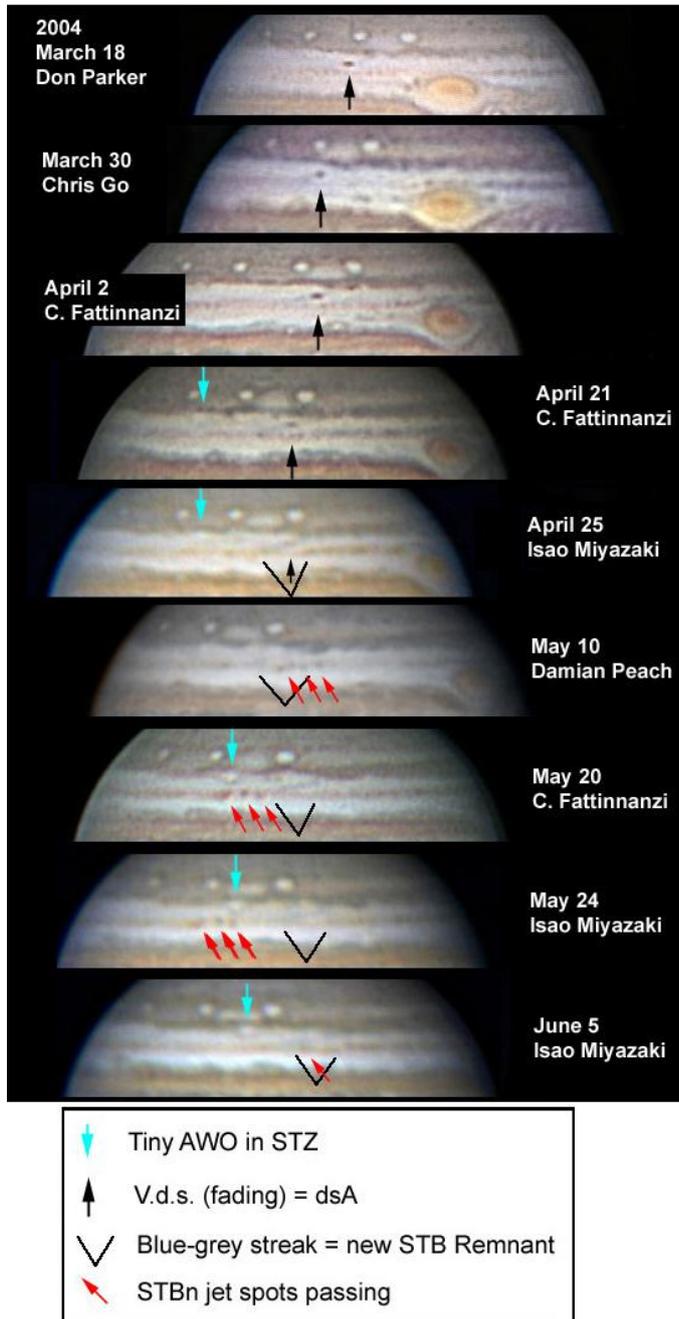


**Figure 5.** Growth of the three new STB structured sectors, shown in charts of length (in degrees longitude) vs time. The two dark segments steadily increased in length: segment B at a rate of 0.6 deg/mth increasing to 1.0 deg/mth; segment D at a rate of 1.1 deg/mth increasing to 1.6 deg/mth. In contrast, segment C (the STB Remnant) only showed modest and inconsistent growth.



**Figure 6. Images showing oval BA and the STB f. it in 2003/04, when rapid changes took place due to the impact of small cyclonic region DS1b followed by the large dark STB segment B. See text for details. 'FFR', folded filamentary region (turbulent sector of STB).**

**STBs dark spot A, 2004, fading as it moves  
p. GRS, & converting to 'STB Remnant'**



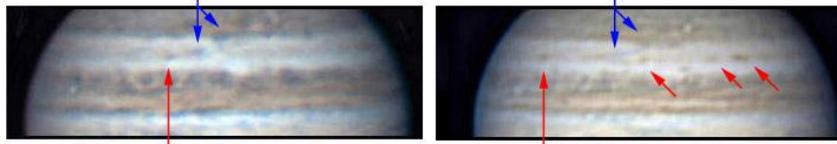
**Figure 7. Image sets showing early stages of the STB Remnant and a similar feature.**

**(A) Origin of the STB Remnant from a v.d.s. (dsA) in spring, 2004.**

# 'STB Remnant', 2005 April-May

(Montage by John Rogers, BAA)

Blue arrows: STB Remnant, connected to small dark projection on SSTBn



Red arrows: STBn jetstream spots, prograding on STB(N)

2005  
April 21,  
11:41 UT, CM2=189  
Isao Miyazaki  
(Okinawa, Japan)



April 21  
22:03 UT, CM2=205  
Dave Tyler (UK)



April 23, 14:15 UT  
CM2=223  
Daniel Chang,  
Hong Kong



April 23/24  
23:03 UT, CM2=182  
Dave Tyler (UK)



April 25/26  
00:45 UT, CM2=185  
Jesus R. Sanchez  
(Spain)



April 28  
12:42 UT, CM2=198  
Isao Miyazaki  
(Okinawa, Japan)



2005  
April 30,  
14:33 UT  
CM2= 207  
Isao Miyazaki



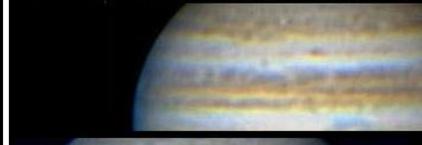
May 0/1, 00:27 UT  
CM2=205.5  
Ralf Vandebergh  
(Netherlands)



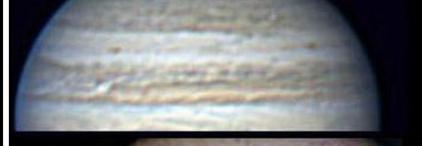
May 1,  
10:05 UT, CM2=195  
M. Valimberti  
(Australia)



May 3, 02:43 UT  
Jim Phillips, USA



May 3, 11:26 UT,  
CM2=185  
Isao Miyazaki  
(Okinawa, Japan)

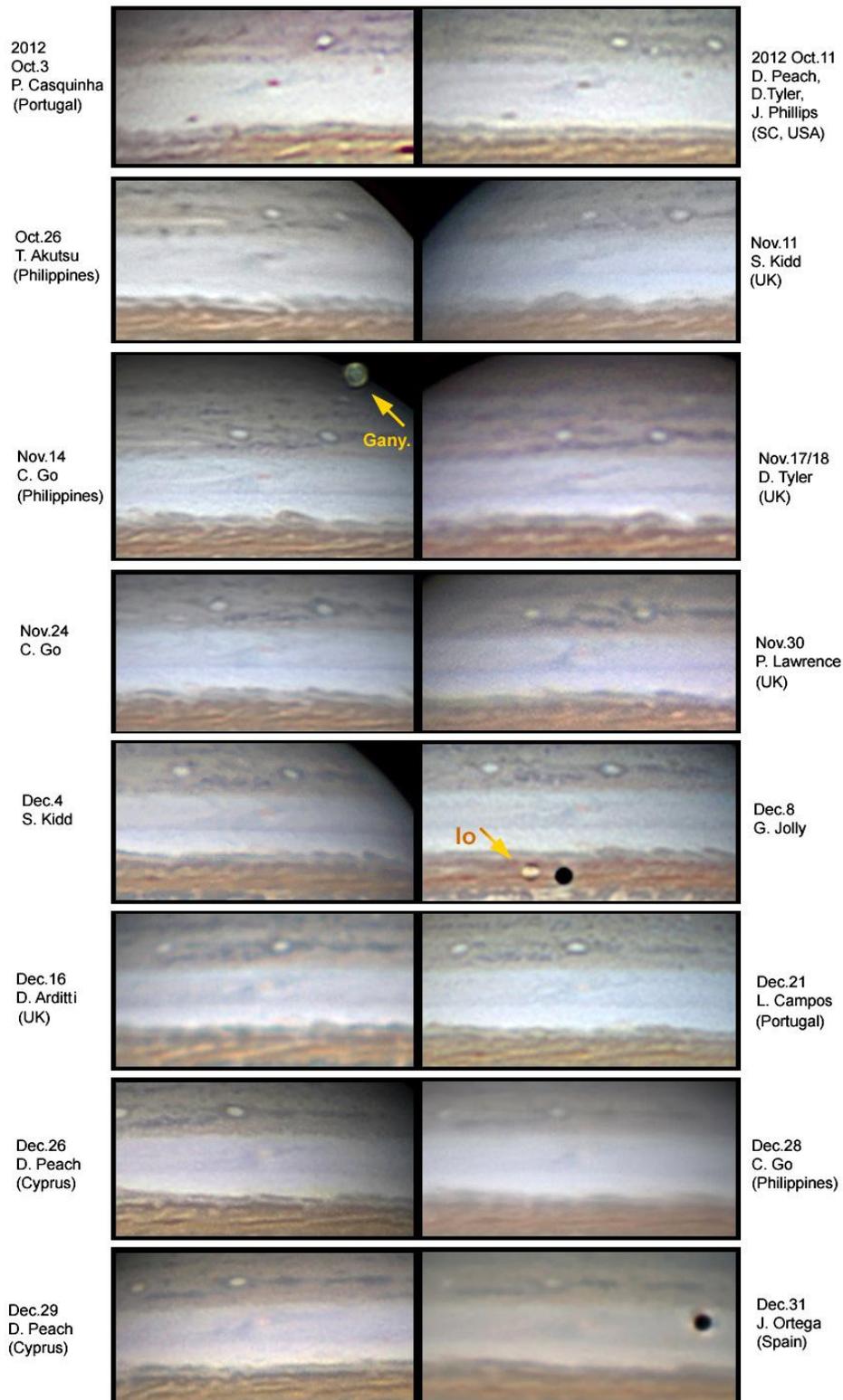


May 5, 13:40 UT,  
CM2=206  
Chris Go  
(Philippines)



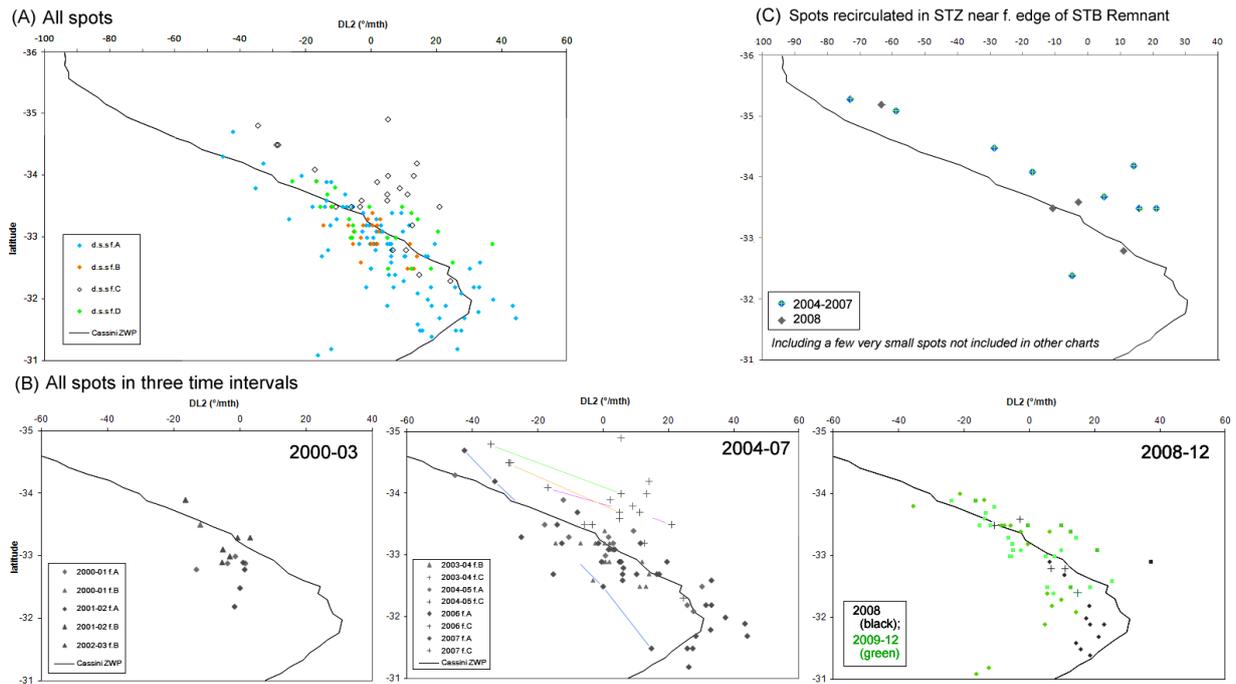
**Figure 7. Image sets showing early stages of the STB Remnant and a similar feature. (B) The STB Remnant in 2005.**

## STB dark spot 4 turns white, 2012

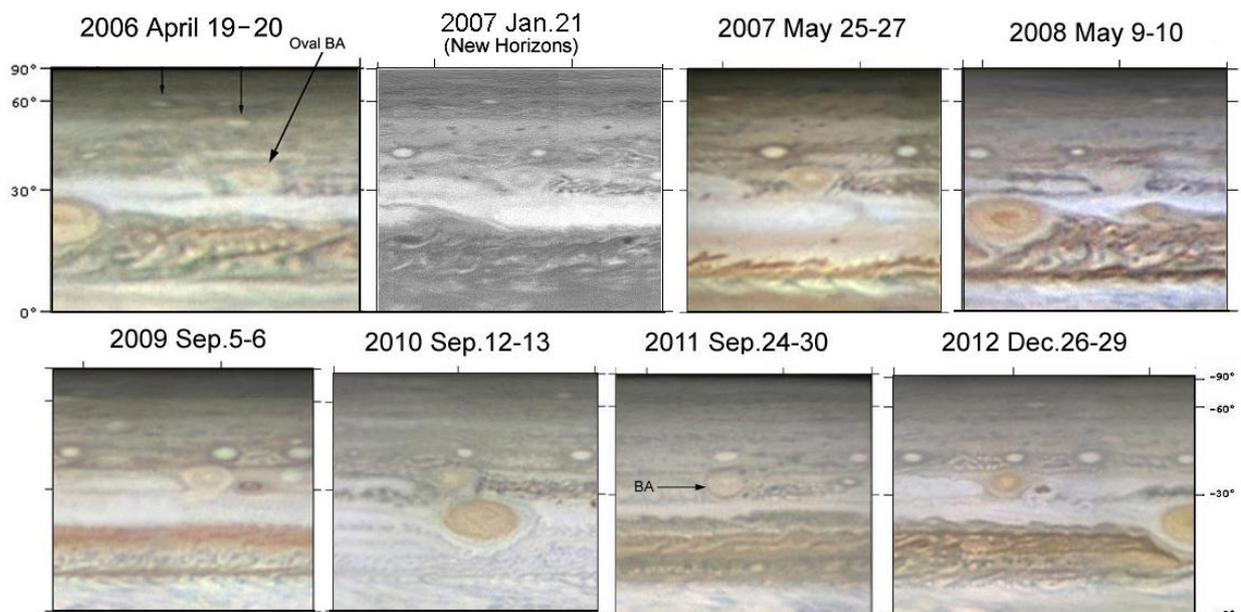


**Figure 7. Image sets showing early stages of the STB Remnant and a similar feature.**

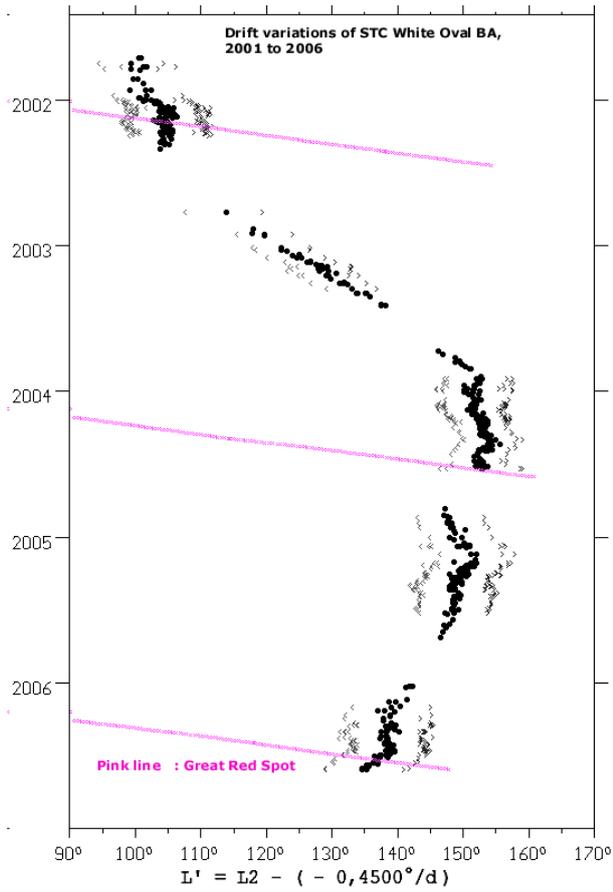
(C) A cyclonic very dark spot (DS4) fading in 2012 autumn, within a blue-grey streak, which could be the origin of a new structured sector similar to the former STB Remnant. The spot becomes reddish as it fades to pink. By 2013 Jan. it was a small white oval within the faint blue-grey streak.



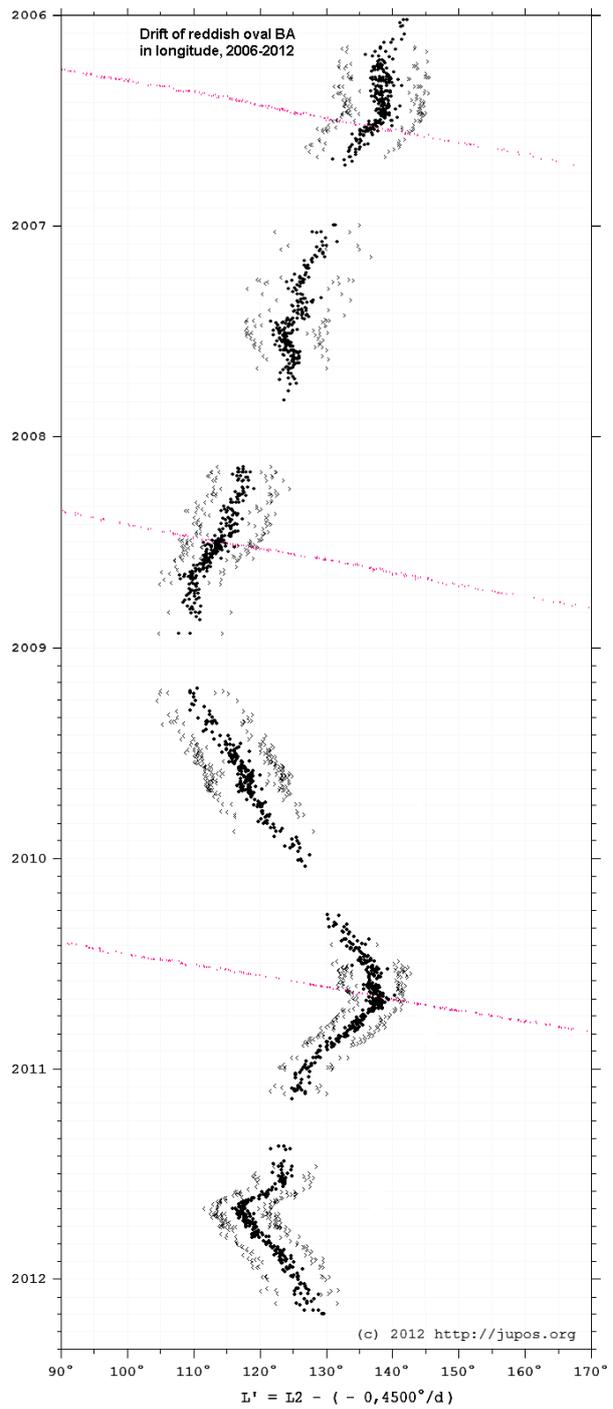
**Figure 8.** Charts of speed vs latitude for dark spots in the Sf. extensions of STB segments, from JUPOS data, with the Cassini ZWP for comparison, covering the STZ and the retrograding STBs jet at 32°S. (A) All spots, 2000-2012. The large scatter is resolved into multiple ZDPs in the following panels. (B) All spots in 3 time intervals. Spots mostly lie close to the Cassini ZWP, except for two groups: (i) Spots at 32°S reached the full retrograding jet speed only in 2004-2007, but not in other years. (ii) Spots f. the STB Remnant (segment C) in 2005-2007 lay south of the Cassini ZWP. They are marked +; coloured lines indicate changing speed/latitude for individual spots. Most of the spots in group (ii) had been recirculated from the SSTBn prograde jet at the f. edge of the STB Remnant, and all such spots are shown in (C), including a few very small spots not included in the previous charts. (Analysis by G. Adamoli)

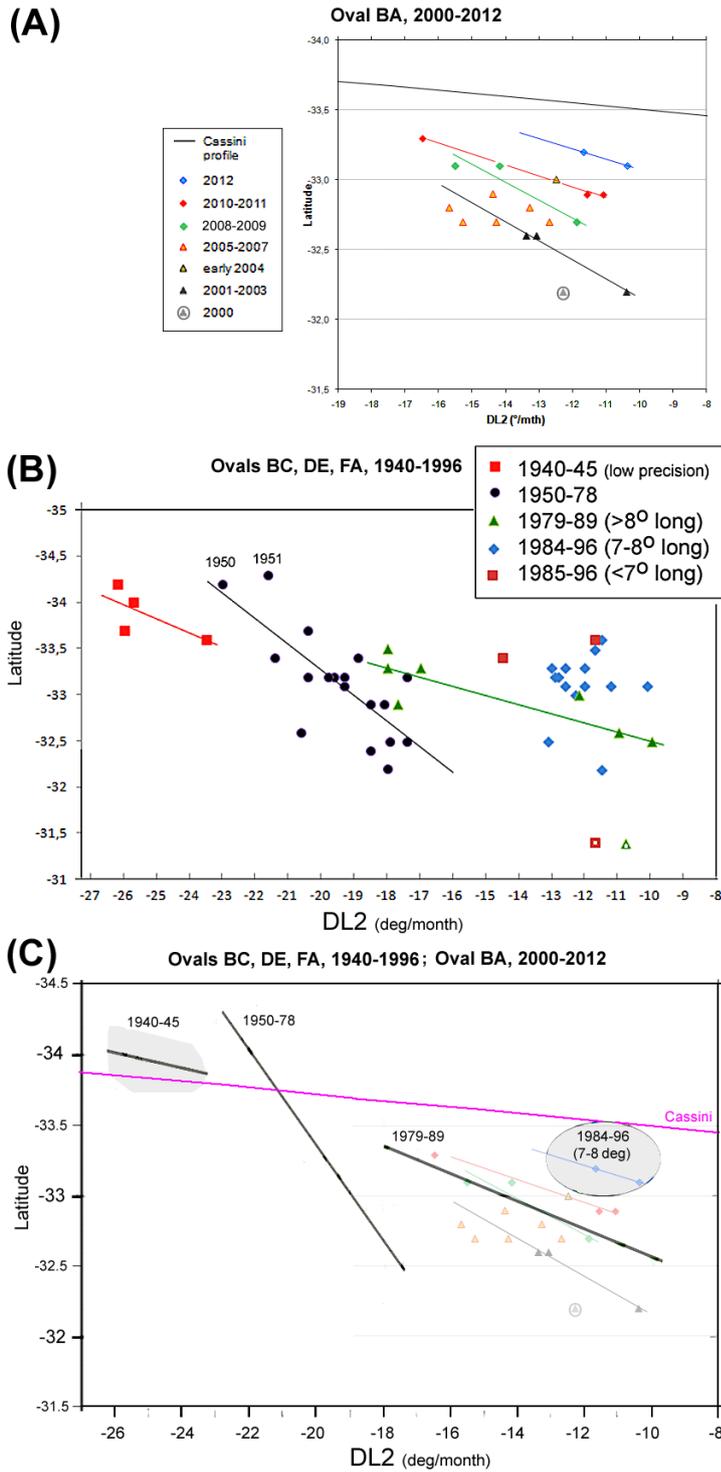


**Figure 9.** Views of oval BA from 2006 to 2012, in cylindrical projection maps from Fig.3.



**Figure 10. JUPOS charts for oval BA, 2001-2012.** Longitude =  $L2 - 0.45$  deg/day. Pink line is track of GRS.





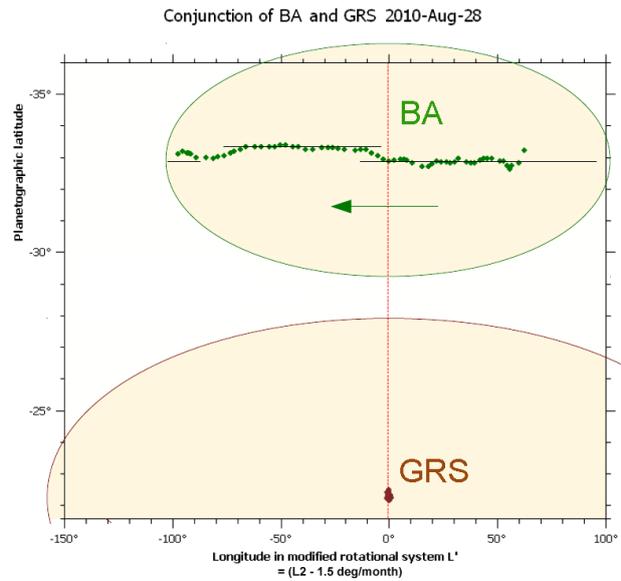
**Figure 11. Zonal drift profiles for oval BA and its predecessors.**

(A) Speed versus latitude for oval BA, year by year, 2000-2012.

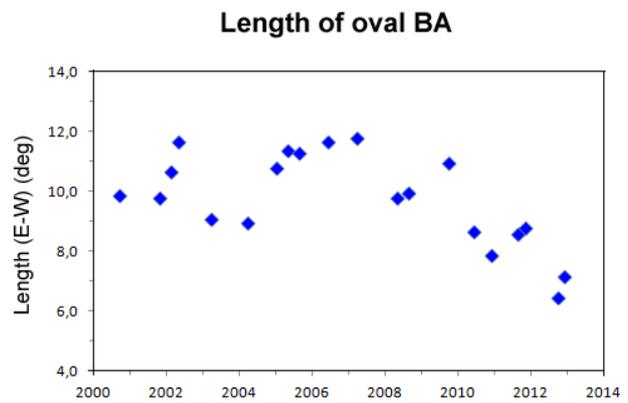
(B) Speed versus latitude for the previous 3 long-lived ovals. Data for 1940-45 and 1950-78 were published in [ref.13, & ref.1 p.227]. For subsequent years, the data have been re-examined and sorted by the lengths of the individual ovals.

(C) Trend lines from (B) overlaid on (A), showing that the ZDPs are identical when the ovals have similar sizes. The shaded area marks the locus of most points for 1984-96 when the ovals were 7-8° long; there was too little variation to establish a gradient. (The few points for lengths <7° were scattered and are not shown.)

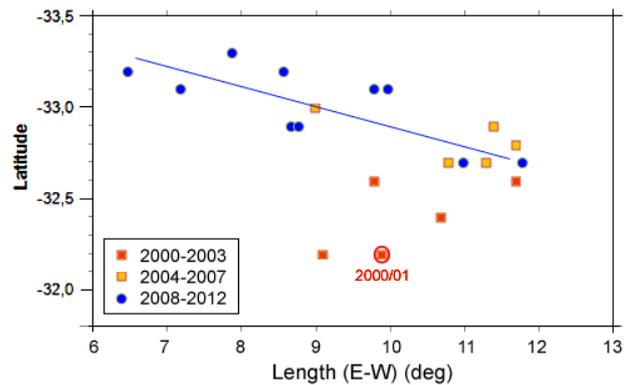
**Figure 12. Passage of oval BA past the GRS in 2010.** The position of BA is plotted to scale in latitude, relative to the GRS, showing how it suddenly shifted in latitude from 32.9 to 33.3°S, when it also accelerated, exactly at conjunction. (Oval outlines are shown diagrammatically; note that longitude scale is compressed.)



**Figure 13. Length of oval BA.** (A) Length of oval BA throughout its lifetime, from the data in Table 3 (white-light images). There was little change from 2000-2007, but significant shrinkage since 2007.

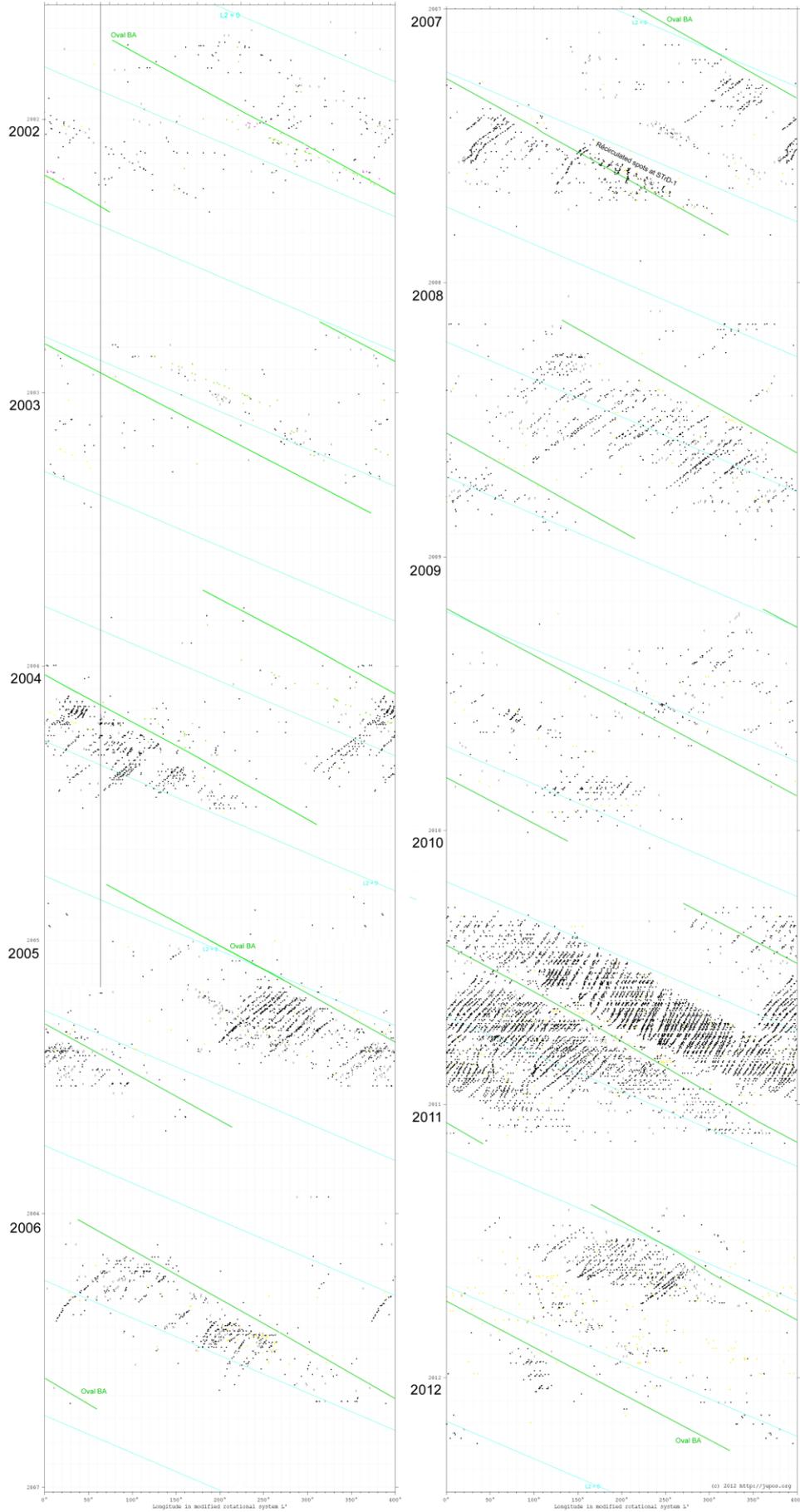


(B) Chart of length vs latitude. Since 2007 there has been a significant correlation, consistent with the hypothesis that the southward shift of BA's ZDP is due to its shrinkage. Latitudes before 2004 were anomalously low, probably because of the asymmetric shape of the 'oval'.



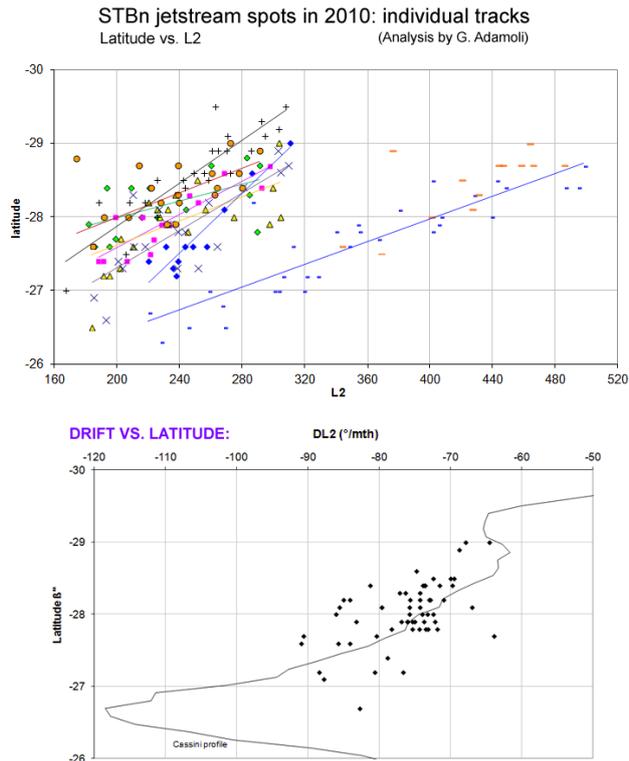
**NEXT PAGE; Figure 14. JUPOS chart for the STBn jetstream, 2001-2012** (dark spots only, latitudes 26-29°S; longitude =  $L2 - 2.00 \text{ deg/day}$ ). Oblique green line marks the track of oval BA. The density of points has increased over the years due to better imaging, but there were also real increases, most notably in 2003/04 and 2010.

STBn jet, 2001-2012 (Lat-29/-26)  $L' = (L2 - 2.0^\circ/d)$



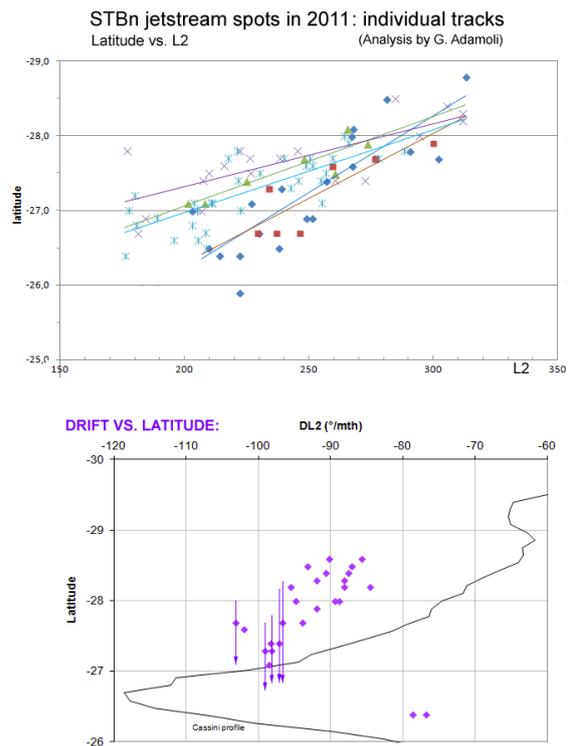


**Figure 15. Measurements of the STB latitudes in 2006 and 2010**, from images by Italian observers (UAI, by G. Adamoli). Grey bands highlight the STB sectors. Note that the STB(N) trends north for ~80-180° p. oval BA.



**Figure 16. Drifts of STBn jetstream spots in 2010.**

(A) Tracks of individual STBn jetstream spots in 2010 which moved north during their lives. Each colour/symbol denotes one spot.  
 (B) Chart of speed vs mean latitude for all STBn jetstream spots measured in 2010, compared with the ZWP from Cassini. Data in these charts were from Italian observers, and the results were published in [ref.17], which stated: "The numerous spots of the STBn (...) jetstream lay in agreement with the local wind profile as measured by spacecraft. Some spots of the STBn jetstream, born near the p. edge of one of the dark sectors of the STB, had their latitude progressively diminishing during their eastward motion. That may be linked to the latitude variation of the belt, which the spots adhered to."

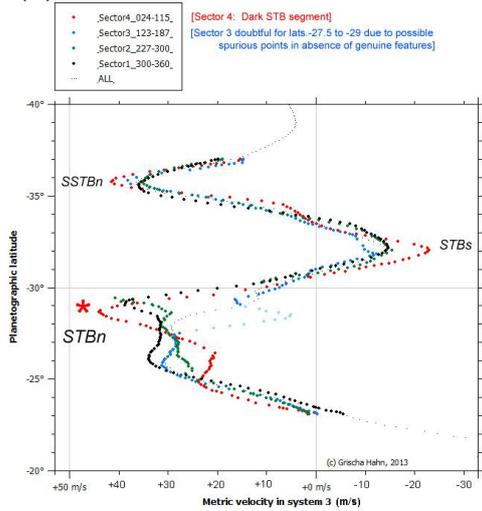


**Figure 17. Drifts of STBn jetstream spots in 2011.**

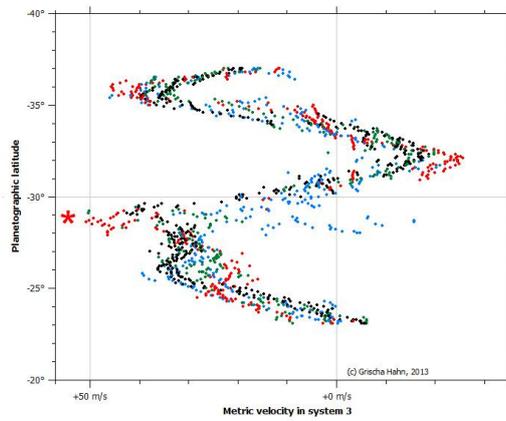
(A) Tracks of individual STBn jetstream spots in 2011 which moved north during their lives.  
 (B) Chart of speed vs mean latitude for all STBn jetstream spots measured in 2011, compared with the ZWP from Cassini. Five spots moved north during their lives through a latitude range indicated by vertical lines. (JUPOS data.)

Zonal wind profiles, 2007 Jan, using images from New Horizons (LORRI)

(A) (averages Jan 8/10 + 14/15 + 20/22)

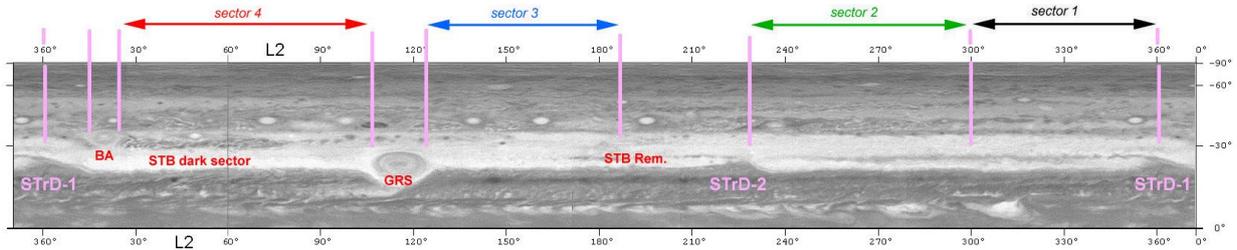


(B) (Results for each date-pair separately)



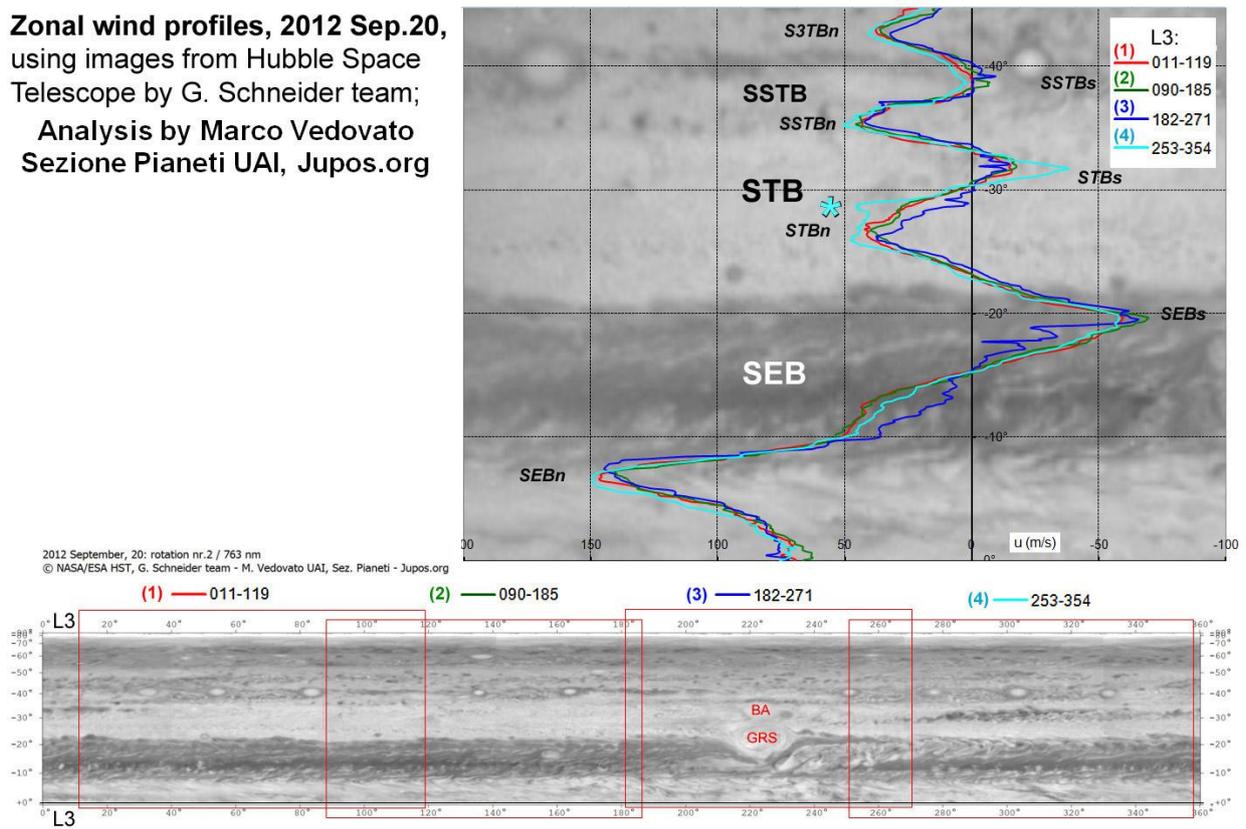
Jupiter, 2007 Jan.21, from New Horizons  
LORRI images (NASA / Johns Hopkins Univ. Applied Physics Lab / Southwest Research Institute)

Map made by Grischa Hahn using WinJUPOS



**Figure 18.** Zonal wind profiles and map from New Horizons images in 2007 Jan. (analysis by Grischa Hahn). [See refs.18 & 19.] The ZWPs were obtained by correlation between maps made from sets of images two rotations apart, taken on 2007 Jan.8-10, 14-15, and 20-22, in white light. (A) ZWPs in 4 sectors (defined as in the map below): averages for all dates. Asterisk marks the STBn jet sub-peak at 29°S, strongest in the structured sector. (B) The same with data from individual dates plotted. (C) A representative map, defining the 4 sectors. Also note the presence of two South Tropical Disturbances, although these do not appear to have perturbed the intrinsic flow of the STBn jet south of 26 S.

**Zonal wind profiles, 2012 Sep.20,**  
 using images from Hubble Space  
 Telescope by G. Schneider team;  
**Analysis by Marco Vedovato**  
 Sezione Pianeti UAI, Jupos.org

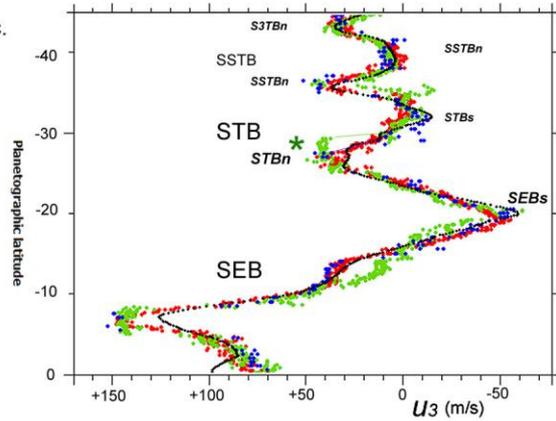


**Figure 19.** Zonal wind profile and map from Hubble Space Telescope images on 2012 Sep.20 (analysis by Marco Vedovato). [See refs.20 & 21.] The ZWPs were obtained by correlation between maps made from sets of images one rotation apart, in near-infrared light. Asterisk marks the STBn jet sub-peak at 29°S, strongest in the structured sector. ZWPs are shown in 4 sectors, defined as in the map below.

Zonal wind profiles from amateur images, 2012 Sep-Dec.  
(Analysis by Grischa Hahn)

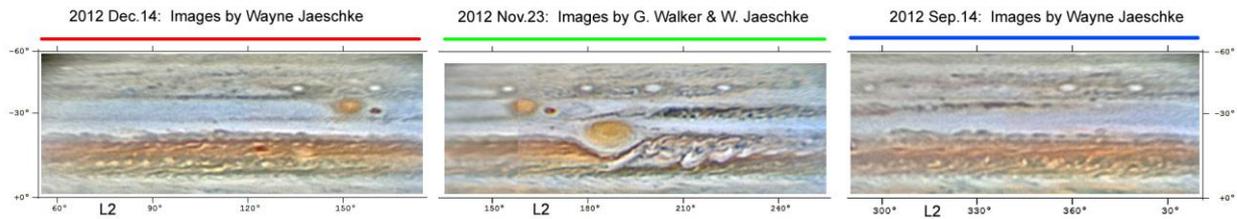
Colour:	Date:	Observers:	Interval:	L2 range:
Blue	- 2012 Sep 14/15	W.Jaeschke to I.Sharp/D.Peach	(20h)	290° - 30°
Green	- 2012 Nov 23	G.Walker/W.Jaeschke to D.Tyler	(20h)	135° - 255°
Red	- 2012 Dec 14	W.Jaeschke to C.Go	(10h)	55° - 175°
Black	- 2007 Jan	New Horizons (average profile)		

\* Faster component at 29°S alongside dark STB segment

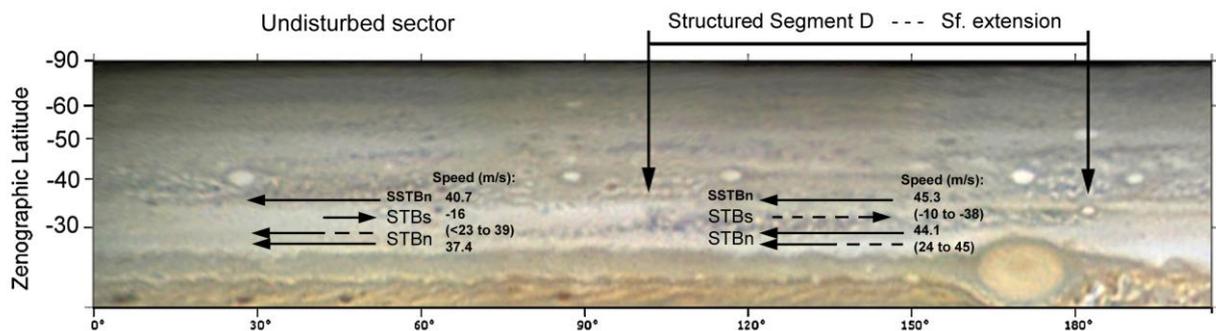


Maps showing the sectors analysed for zonal wind profiles by Grischa Hahn

All maps by Grischa Hahn



**Figure 20.** Zonal wind profiles from amateur images in 2012 Sep-Dec.; at bottom is one map from each pair. (Analysis by Grischa Hahn; image dates and observers as listed on the figure). It is more difficult to extract an absolute ZWP from ground-based images than from spacecraft images, because of possible errors in timing and limb-fitting, so empirical global offset has been applied to some profiles to optimise the fit. Nevertheless, the profiles agree well with each other and with spacecraft ZWPs, and the STBn jet sub-peak at 29°S (asterisk) is a notable difference between the structured and undisturbed sectors.



**Figure 21.** Summary of the mean parameters of the jets in the structured and undisturbed sectors. This is an updated version of **Fig. 2**, showing the true relative speeds of the jets in different sectors, with data derived from **Figs.18-20 (Table 6)**. The base map is from 2011 Sep.24-30 by Damian Peach.