Jupiter in 2024/25, Report no.5: The NTBs outbreak

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(1) BAA; (2) ALPO-Japan; (3) JUPOS team

Figures & Tables

[The full-size figures are in a separate ZIP file.]

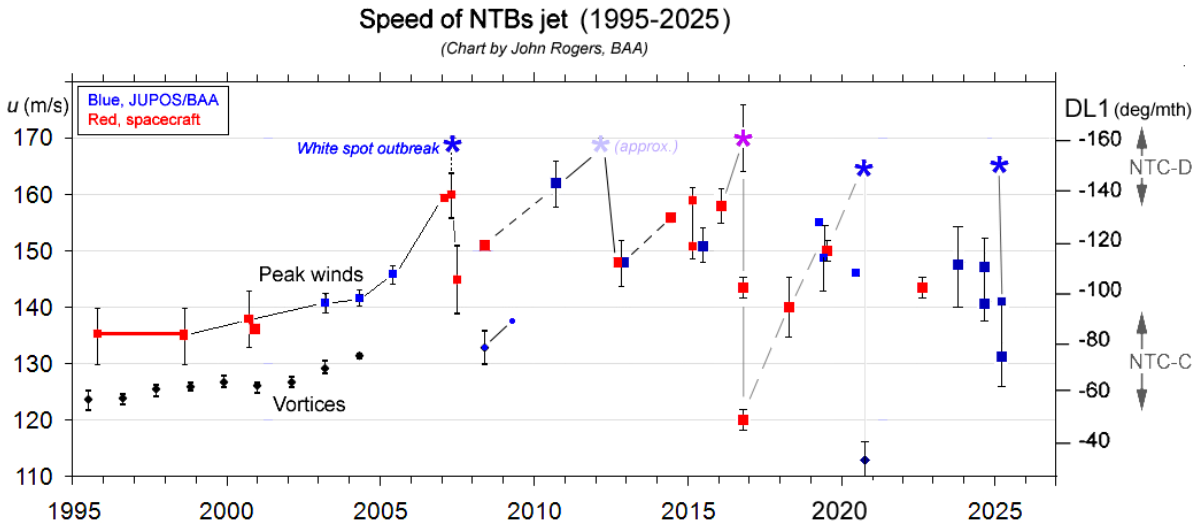

Figure 1. Speed of the NTBs jet from 1995 until now. This is the latest version of a chart which we have been posting since 2008, including in ref.4. It includes conversion between u_3 (m/s) and DL1 (deg/30d) Large asterisks denote the outbreak plumes; those in 2020 and 2025 were slightly slower than in previous outbreaks. In the well-observed outbreaks of 1975 and 1990, most plumes had DL1 ranging from -159 to -165 deg/30d (-5.3 to -5.5 deg/day) (ref.1).

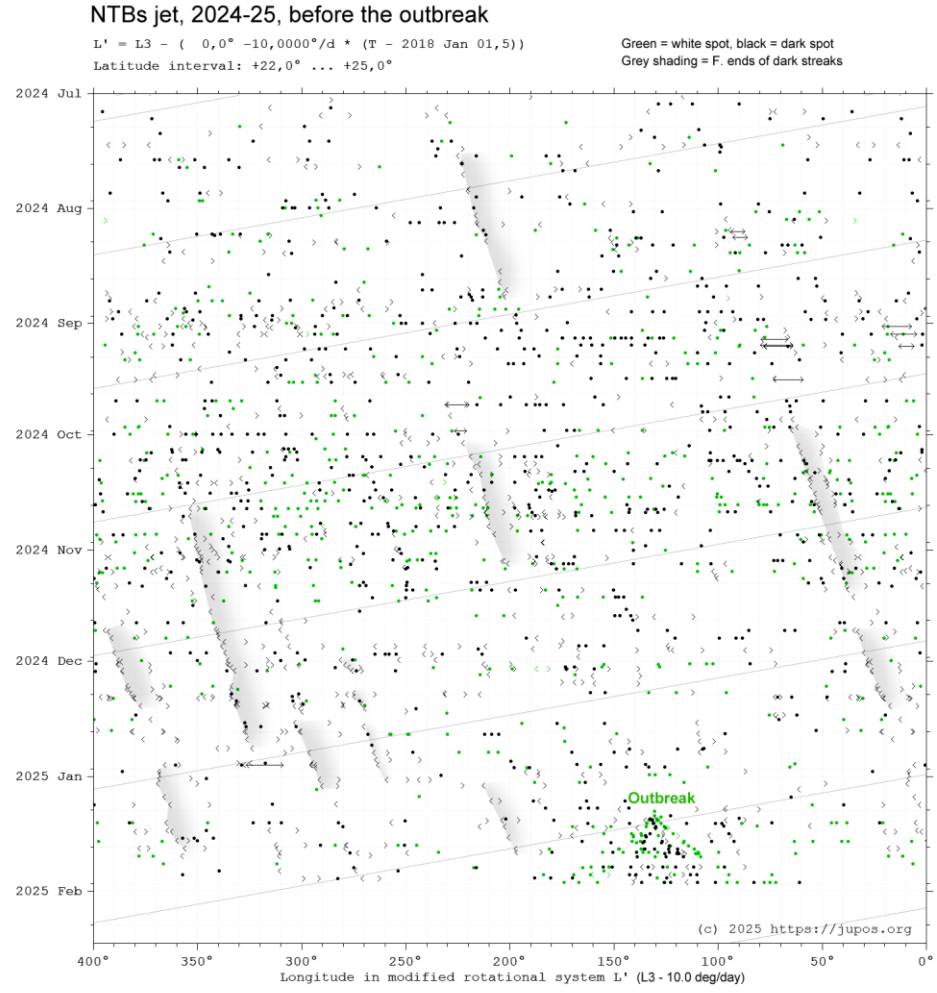

Figure 2: JUPOS chart of the NTBs before the outbreak, in a longitude system moving with L3 – 10.0 deg/day.

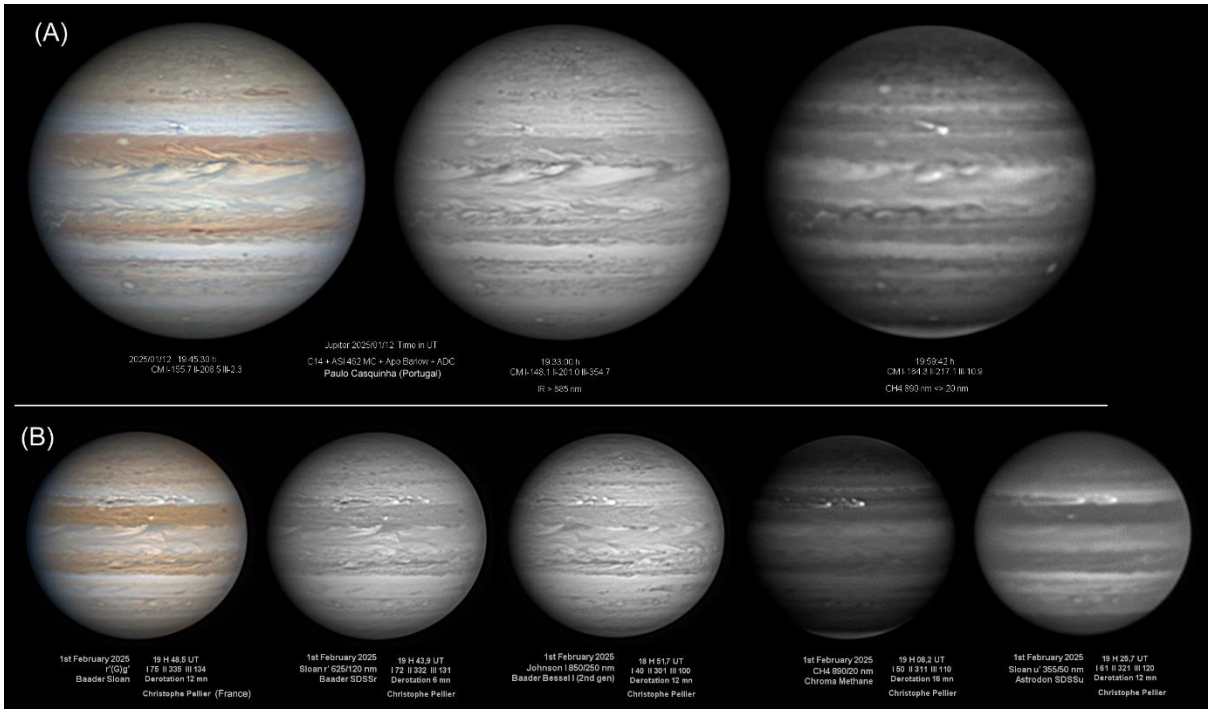

Figure 3. Multispectral image sets showing the plumes. (A) Paulo Casquinha's images on Jan.12, when plume 1 was 2 days old. (B) C. Pellier's set on Feb.1, with plumes 1 & 2.

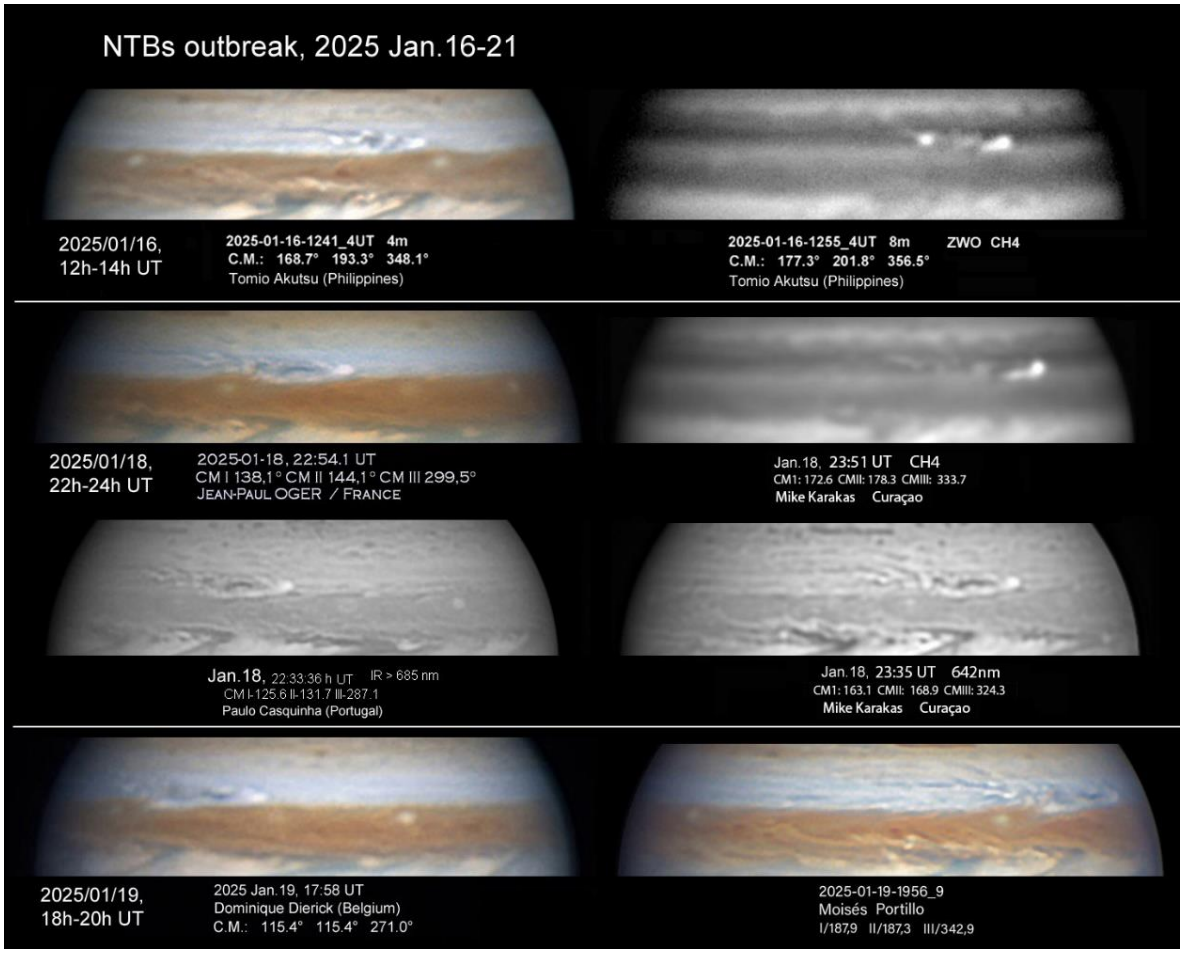

Figure 4. Selected good images of plume 1 from Jan.16-19. The series is continued in Fig.11.

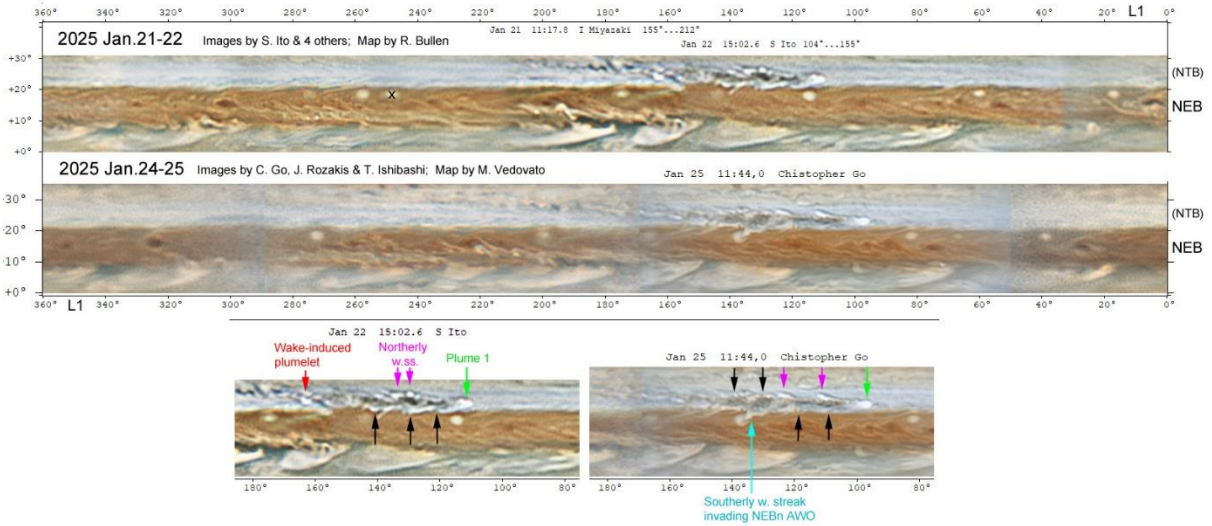

Figure 5. Maps of the whole NTBs and NEB on Jan.21-22 and 24-25. On Jan.21-22, X marks an AWO (near-stationary in L3) that was duplicated because images from different rotations were combined in L1. Below are copies indicating Plume 1 and various spots in its wake. Black arrows mark the large dark patches.

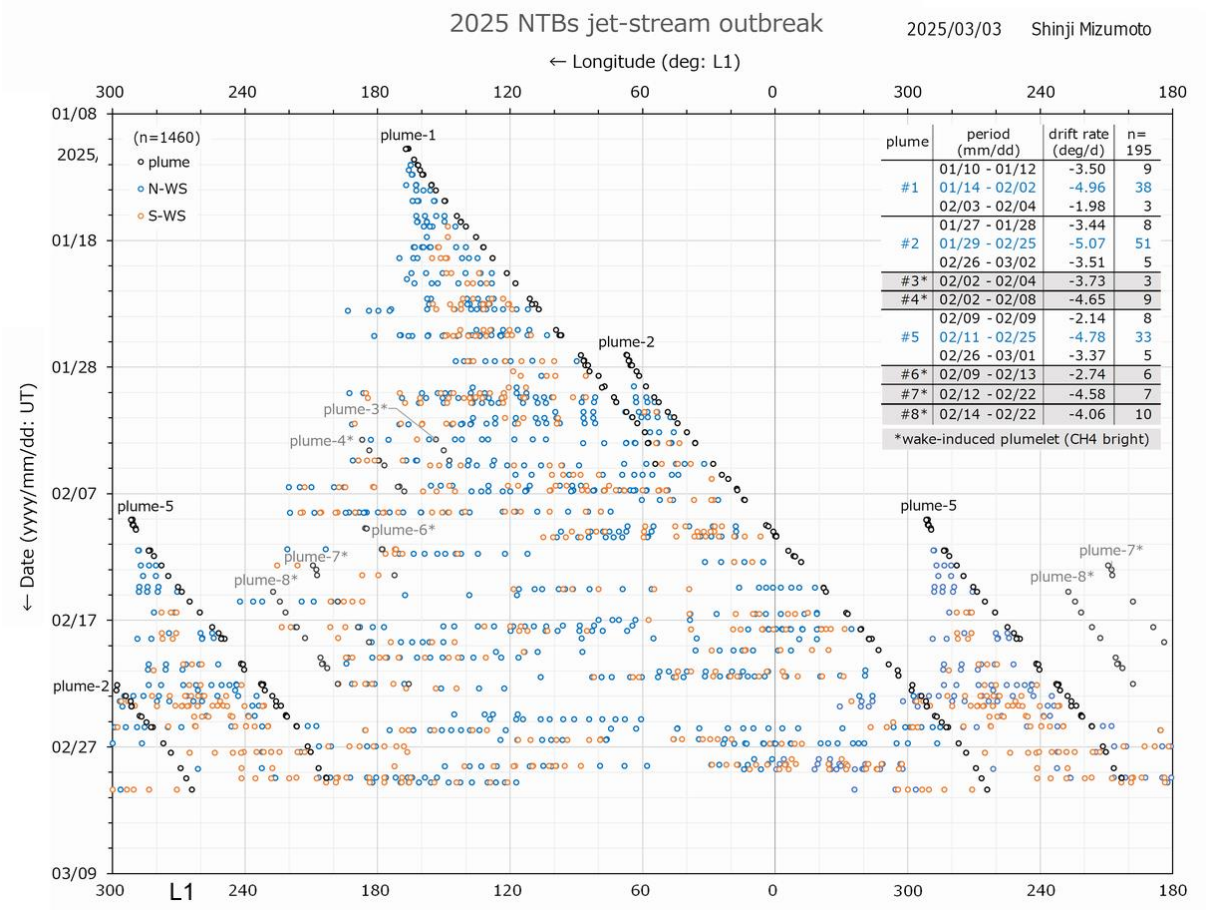

Figure 6. Drift chart of all the white spots in the outbreak, by S.M., up to March 2. Different colours indicate plumes (including plumelets), and northerly and southerly white spots in the wake. *Inset:* Measured drift rates in L1.

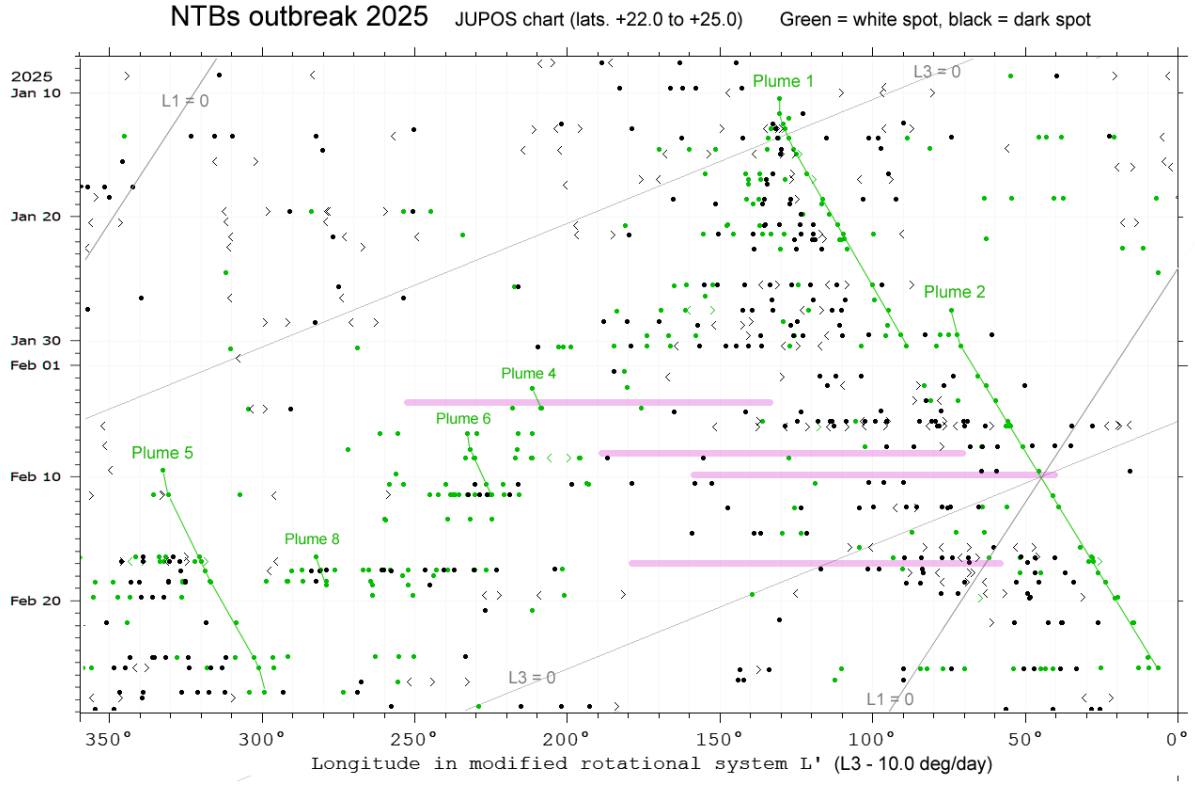

Figure 7. Drift chart of white and spots in the outbreak, by the JUPOS team, in a longitude system moving with L3 – 10.0 deg/day. Mauve bars indicate longitudes covered by the ZWPs in Section 3.

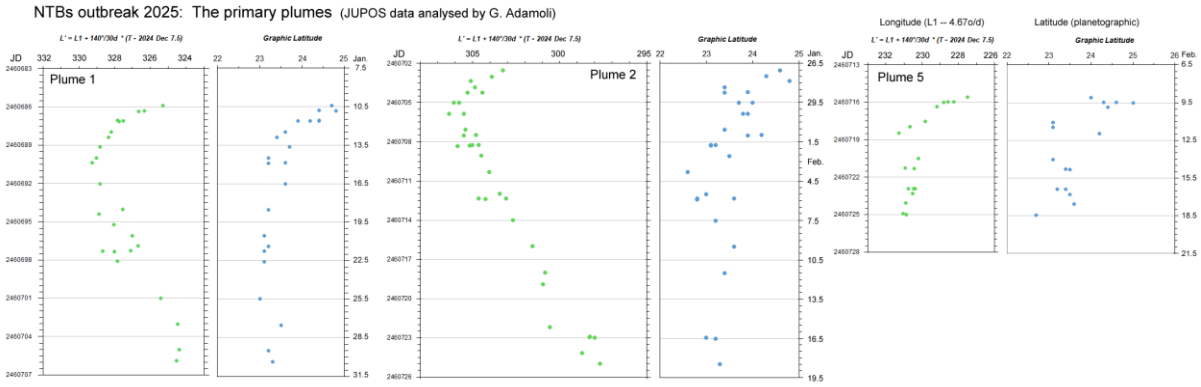

Figure 8. Charts of longitudes and latitudes for the early stages of the three primary plumes, plotted by G.A. from JUPOS measurements (mostly by G.A. himself). Longitudes are plotted in a system moving with L1 – 4.667 deg/d.

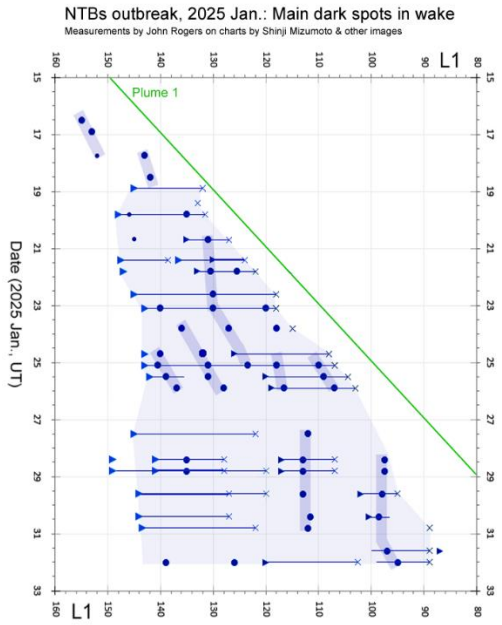

Figure 9. Drift chart of the larger dark patches in the wake, measured by J.R. from S.M.'s maps and a few other images.

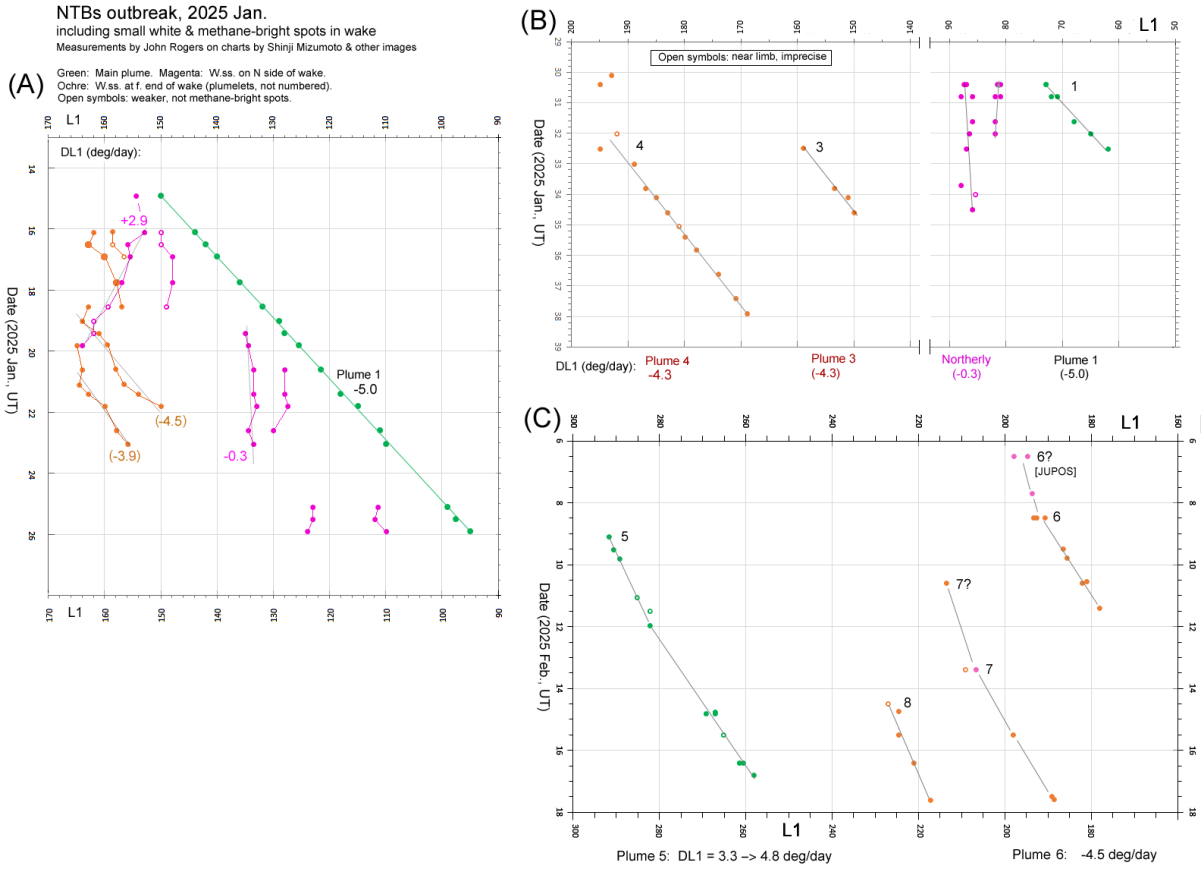

Figure 10. Charts of selected features that were tracked in S.M.'s maps (some indicated in Suppl.Figs.), measured from those maps and from other images.

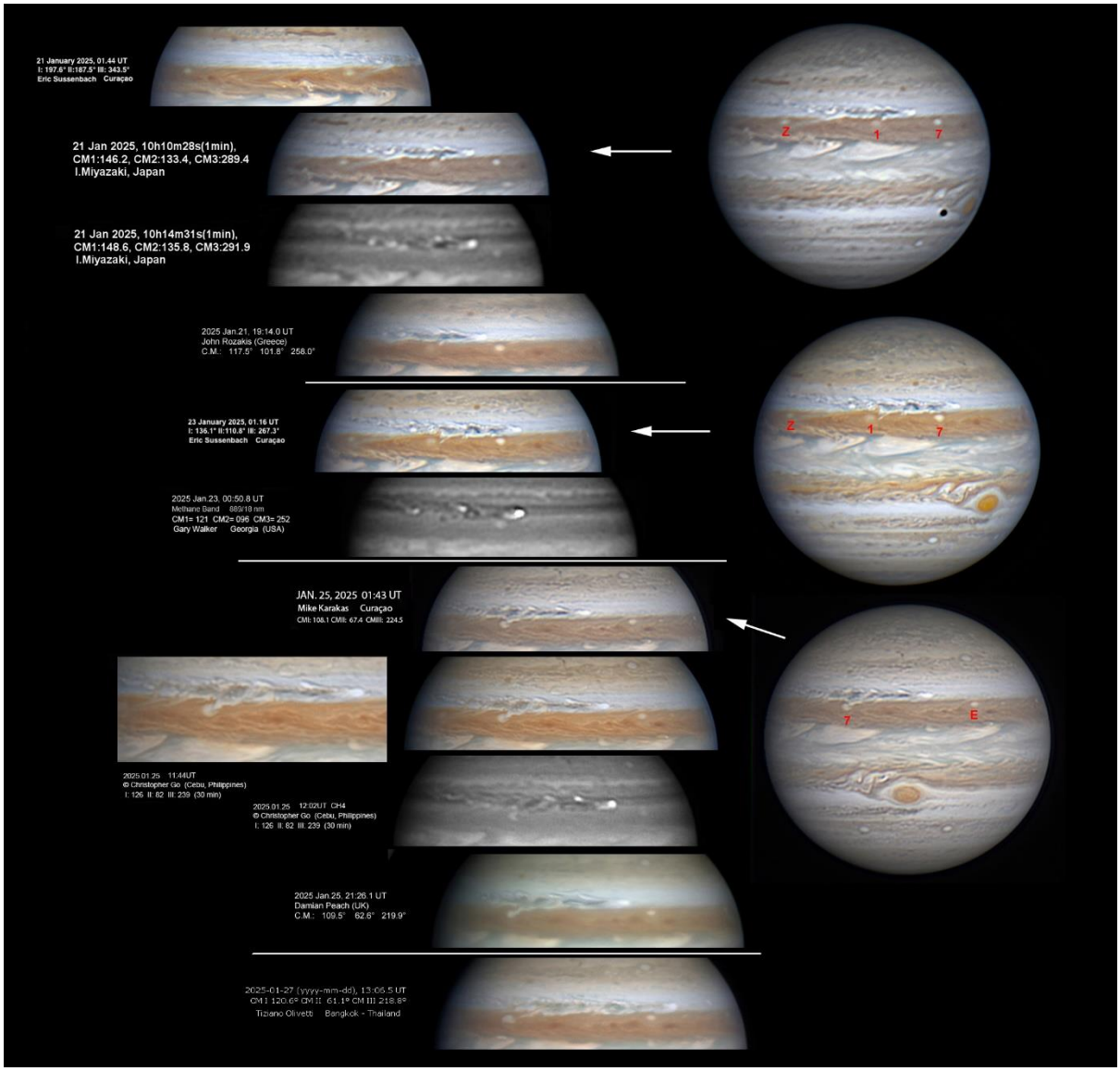

Figure 11. Images of the wake interacting with three AWOs in turn WS-Z, Jan.18-21; WS-1, Jan.21-25; WS-7, Jan.25-27. The AWOs are labelled on the whole-planet images at right.

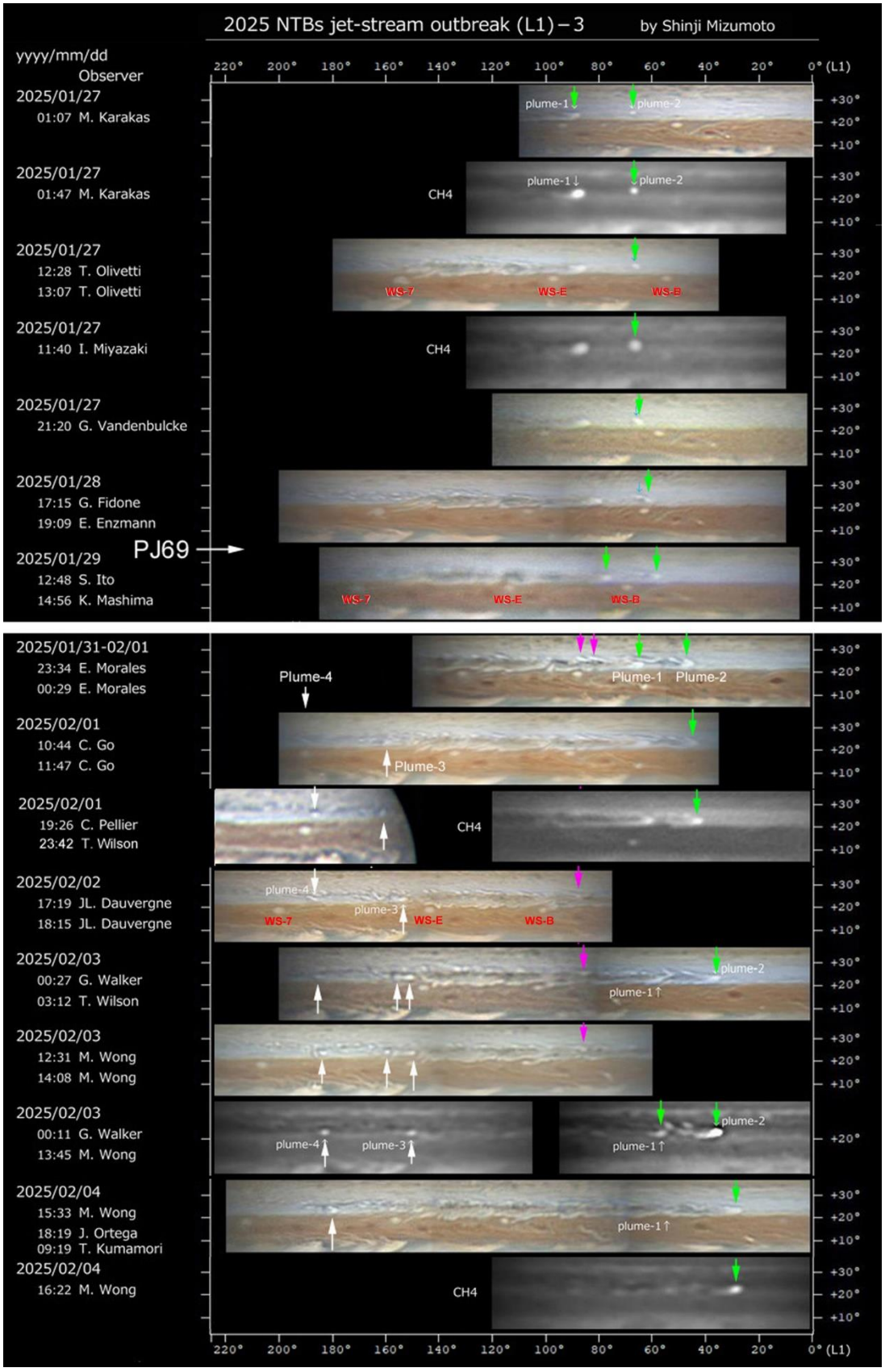

Figure 12. Strip-maps from Jan.27-29 and Feb.1-4, excerpts from S.M.'s Suppl. Figs. They show: The first appearance of plume 2 (Jan.27), then of its wake, and subsequent decline of plume 1 (green arrows); plumes 3 & 4 (white arrows); a northerly white spot (magenta arrow); and interactions of the wake with NEBn WS-E & WS-B from Feb.2 onwards.

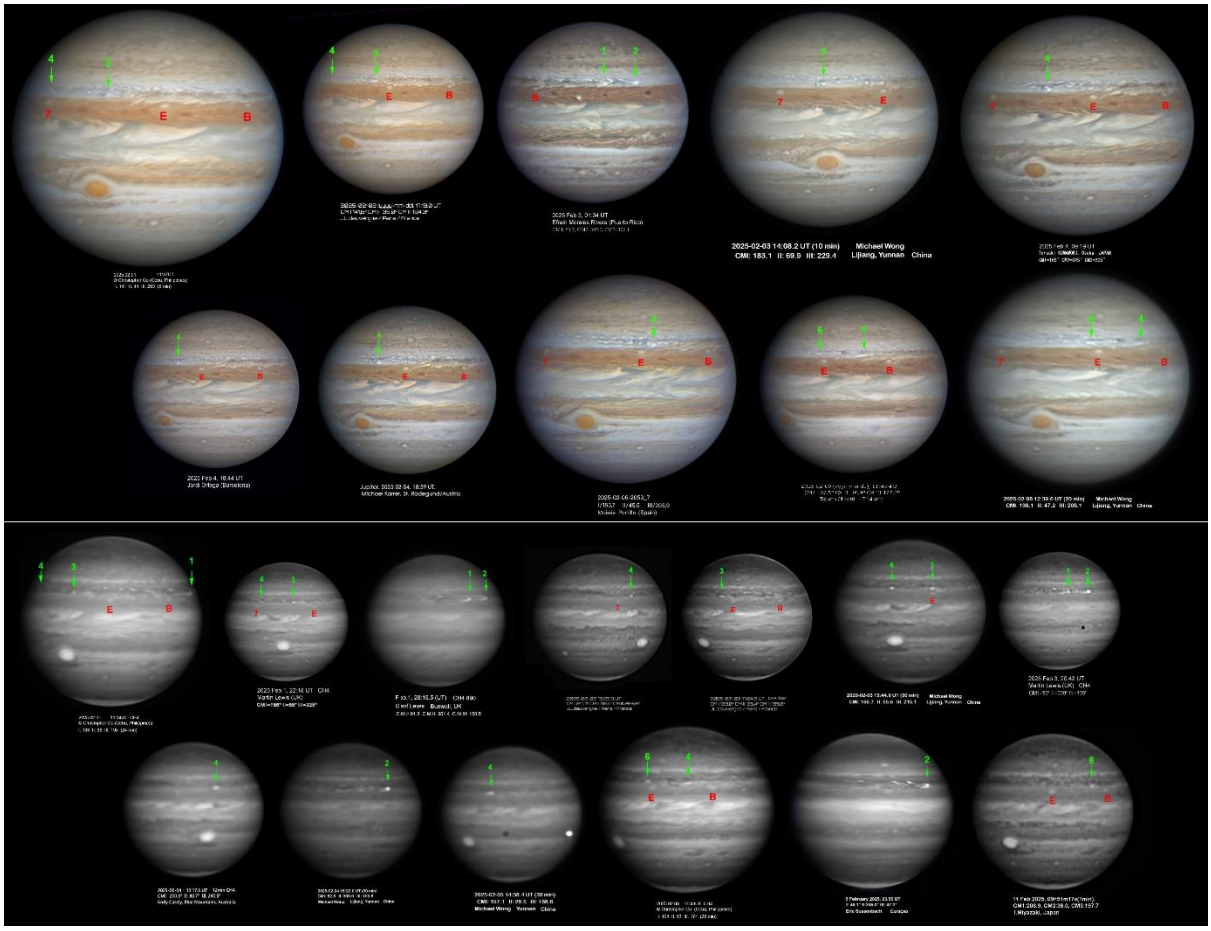

Figure 13. Hi-res images in early Feb., showing the same phenomena as Fig.12, especially the origins of plumes 3 & 4 (wake-induced plumelets), and the long wake running past NEBn WS-E & WS-B, with perturbations of NEBn.

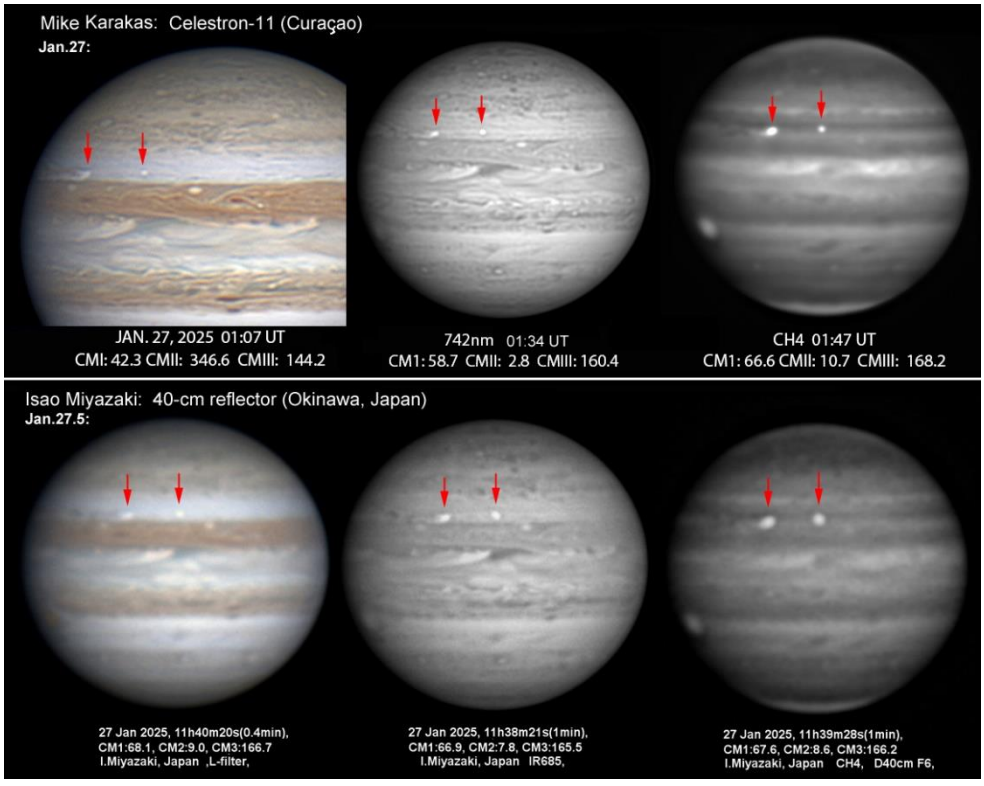

Figure 14: the first appearance of plume 2 on Jan.27, just to the right of plume 1.

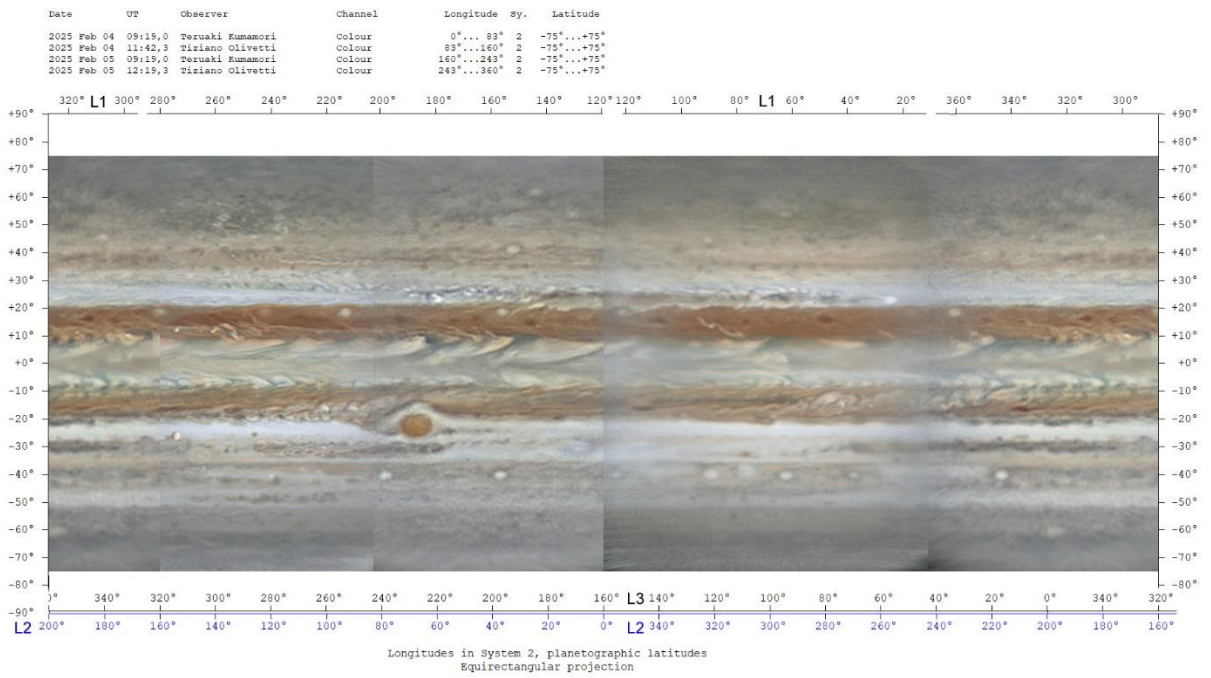

Figure 15. Global map by M.V., 2025 Feb.4-5.

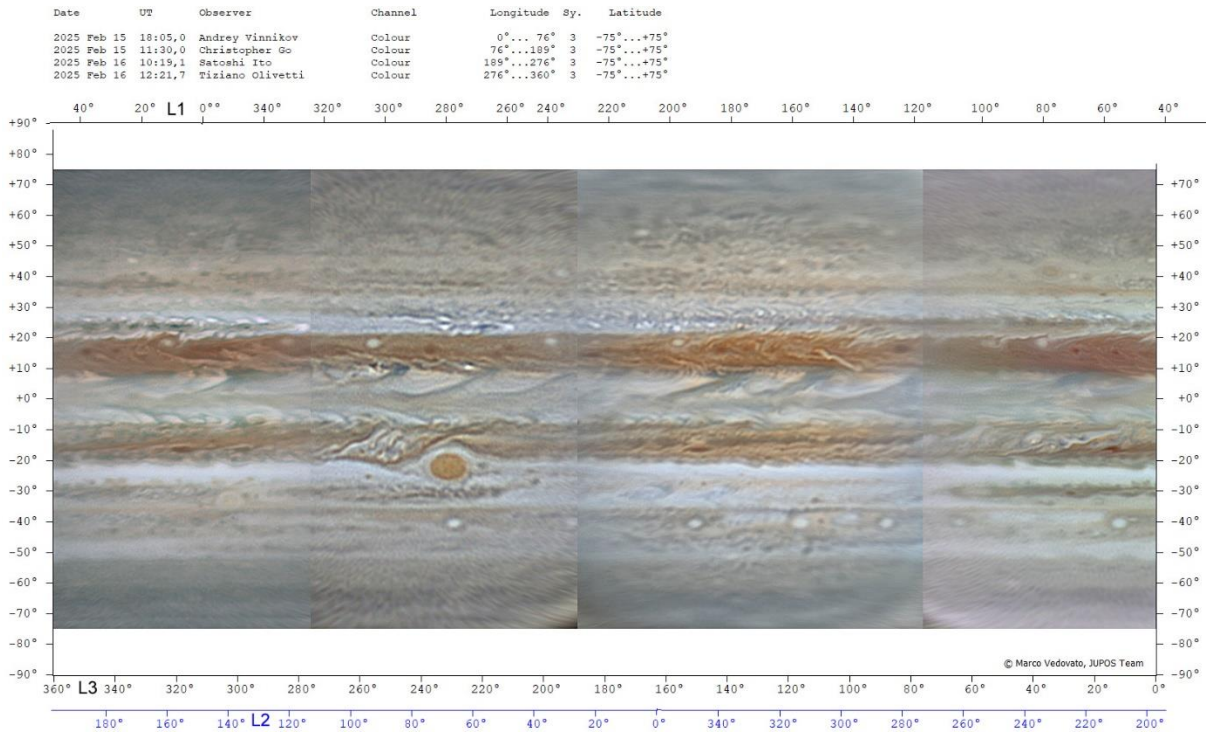

Figure 16. Global map by M.V., 2025 Feb.15-16.

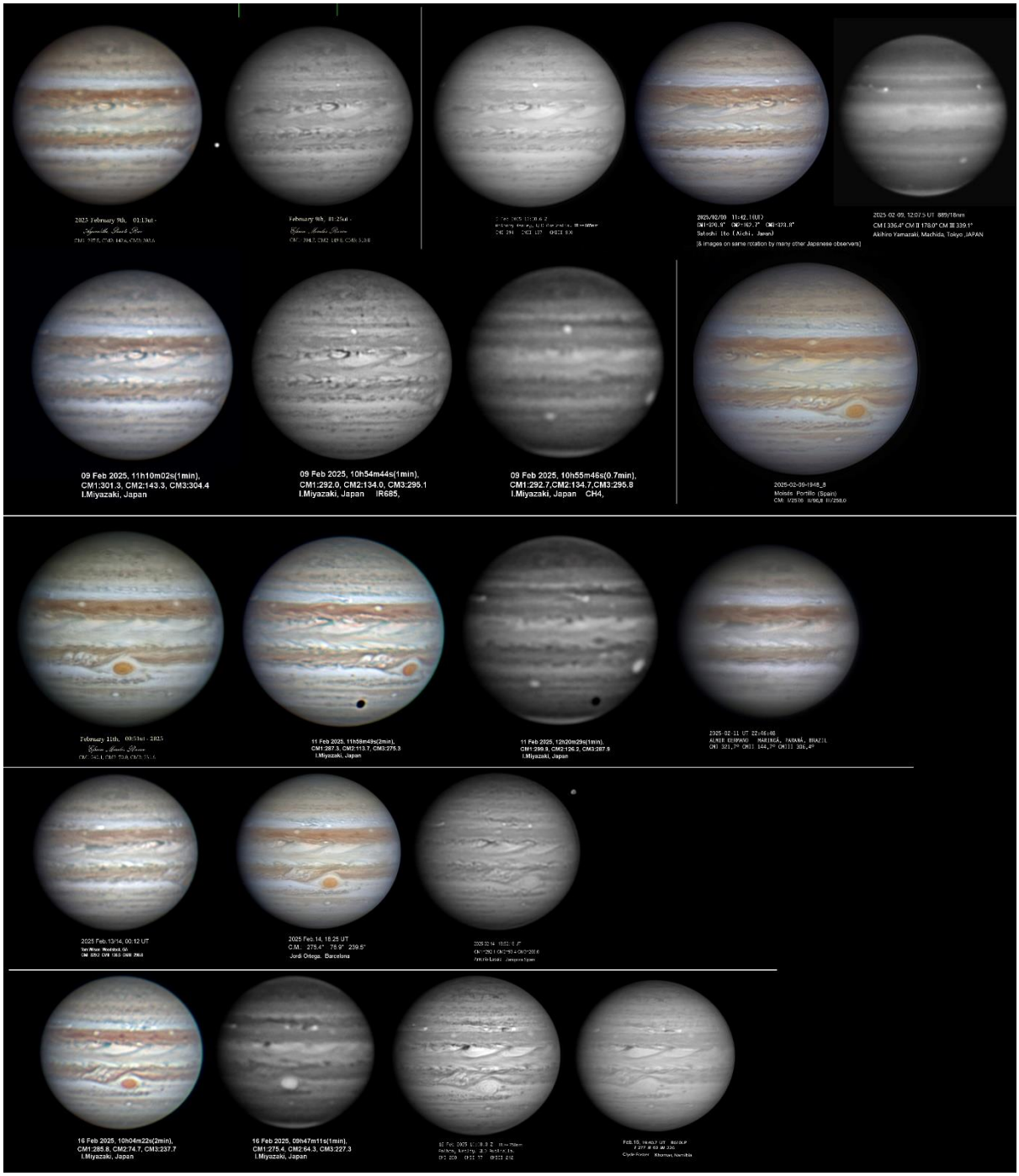

Figure 17. Set of images showing the origin of plume 5 on Feb.9.

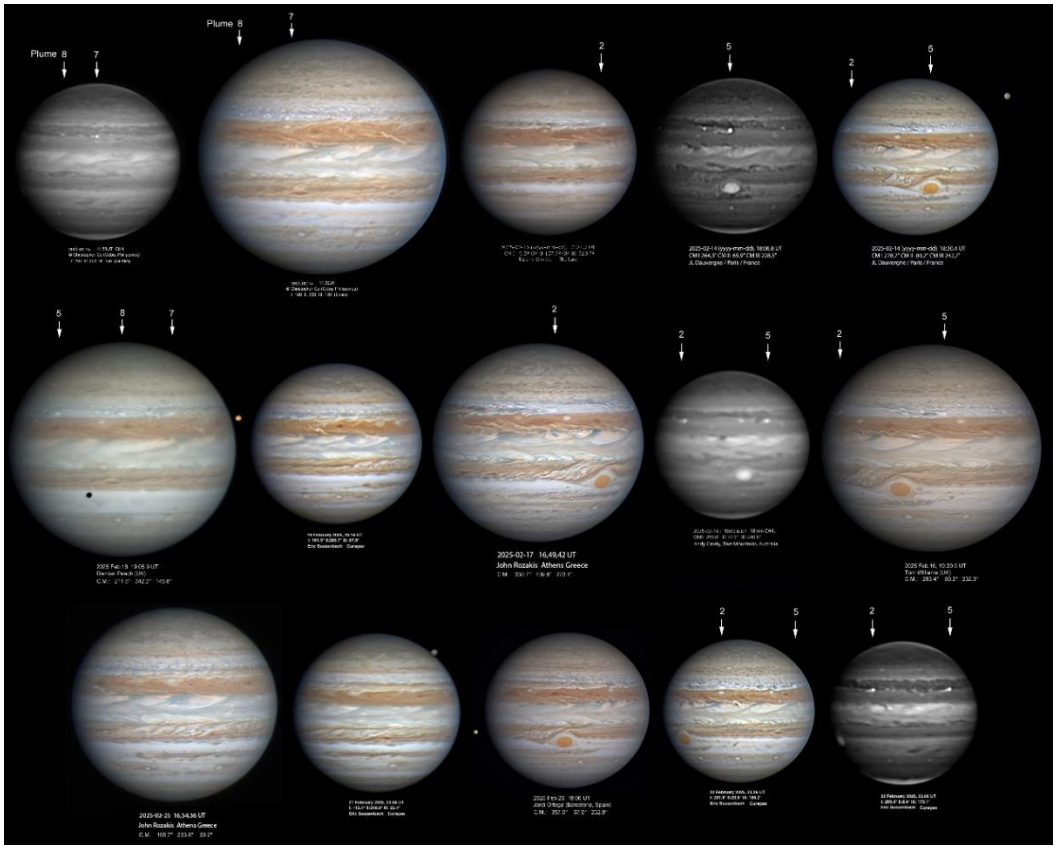

Figure 18. Some of the best images from Feb.14-26, showing the greatly extended wake, and main plumes 2 & 5, and wake-induced plumelets 7 & 8.

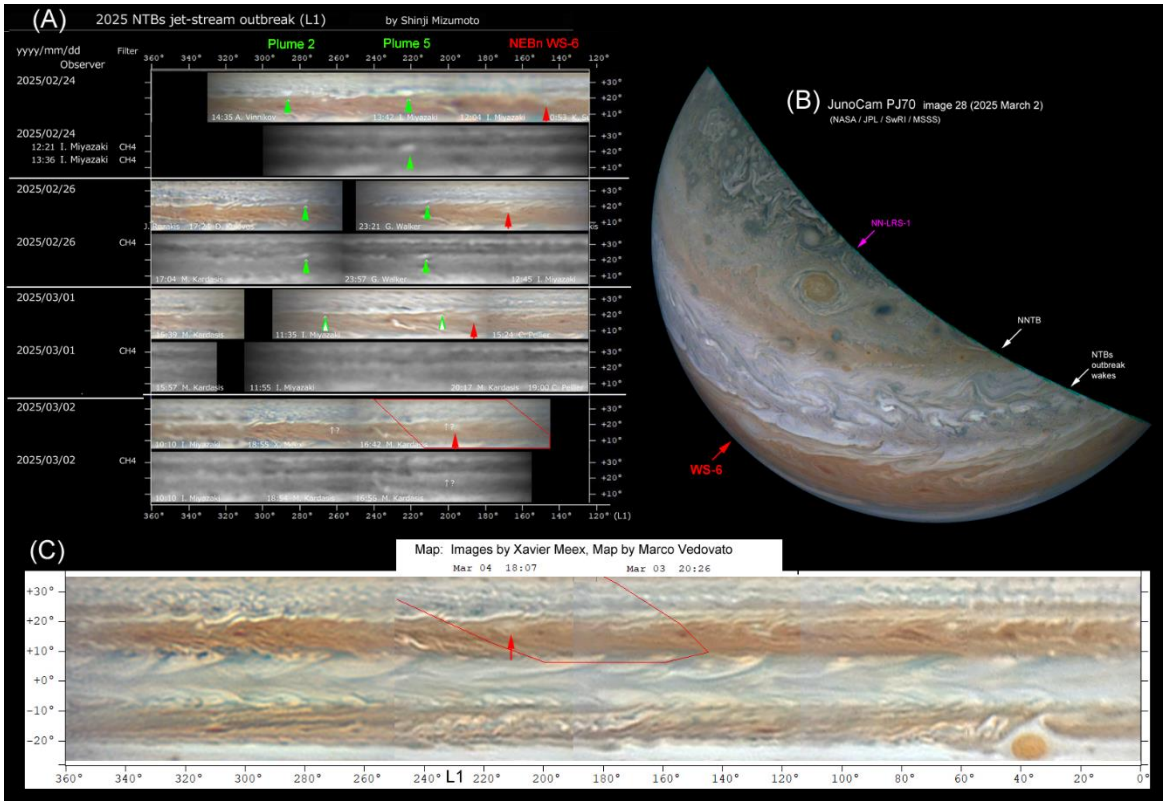

Figure 19. The NTB around the time of Juno's PJ70. (A) Ground-based maps up to March 2, showing how plumes 2 & 5 both disappeared in the previous few days; (B) JunoCam's PJ70 image 27 showing the region where the remains of plume 5 would have been, adjacent to the NEBs AWO called WS-6; (C) Ground-based map on March 3-4, with the area of image 27 (B) outlined in red.

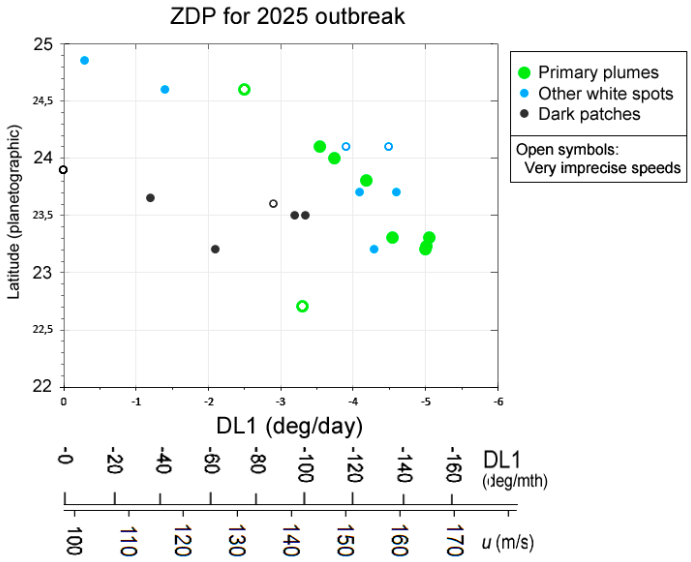

Figure 20. Zonal drift profile for the 2025 outbreak from our data in **Table 2** and Figure 10.

Figures 21 & 22: *See following pages.*

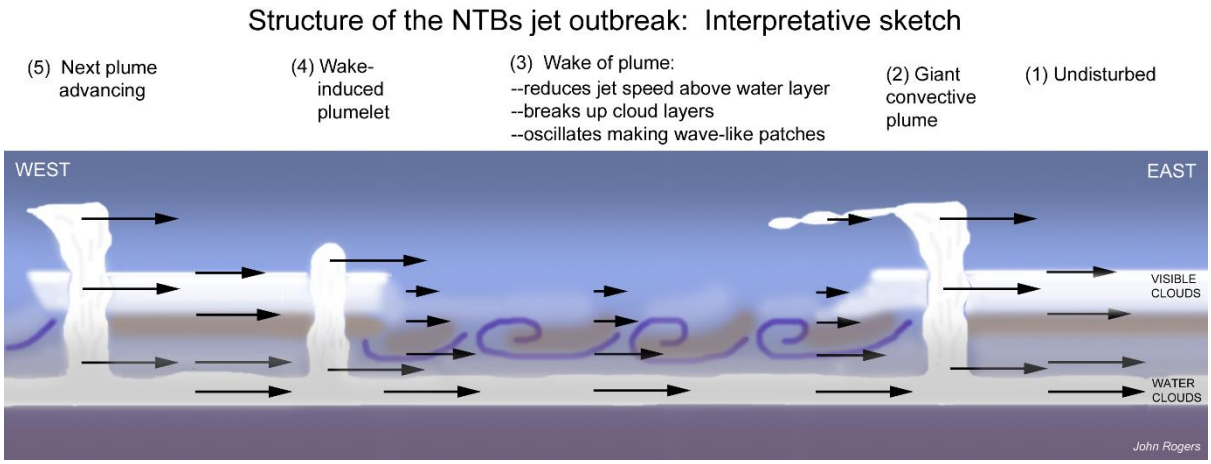

Figure 23. Diagram of the proposed structure of the outbreak, shown as a vertical profile (vertically much exaggerated) along the latitude of the NTBs jet. Arrows indicate the eastward wind strength. This is only a qualitative sketch, and is not intended to suggest any specific dynamical processes in the wake. Read from right (east) to left (west).

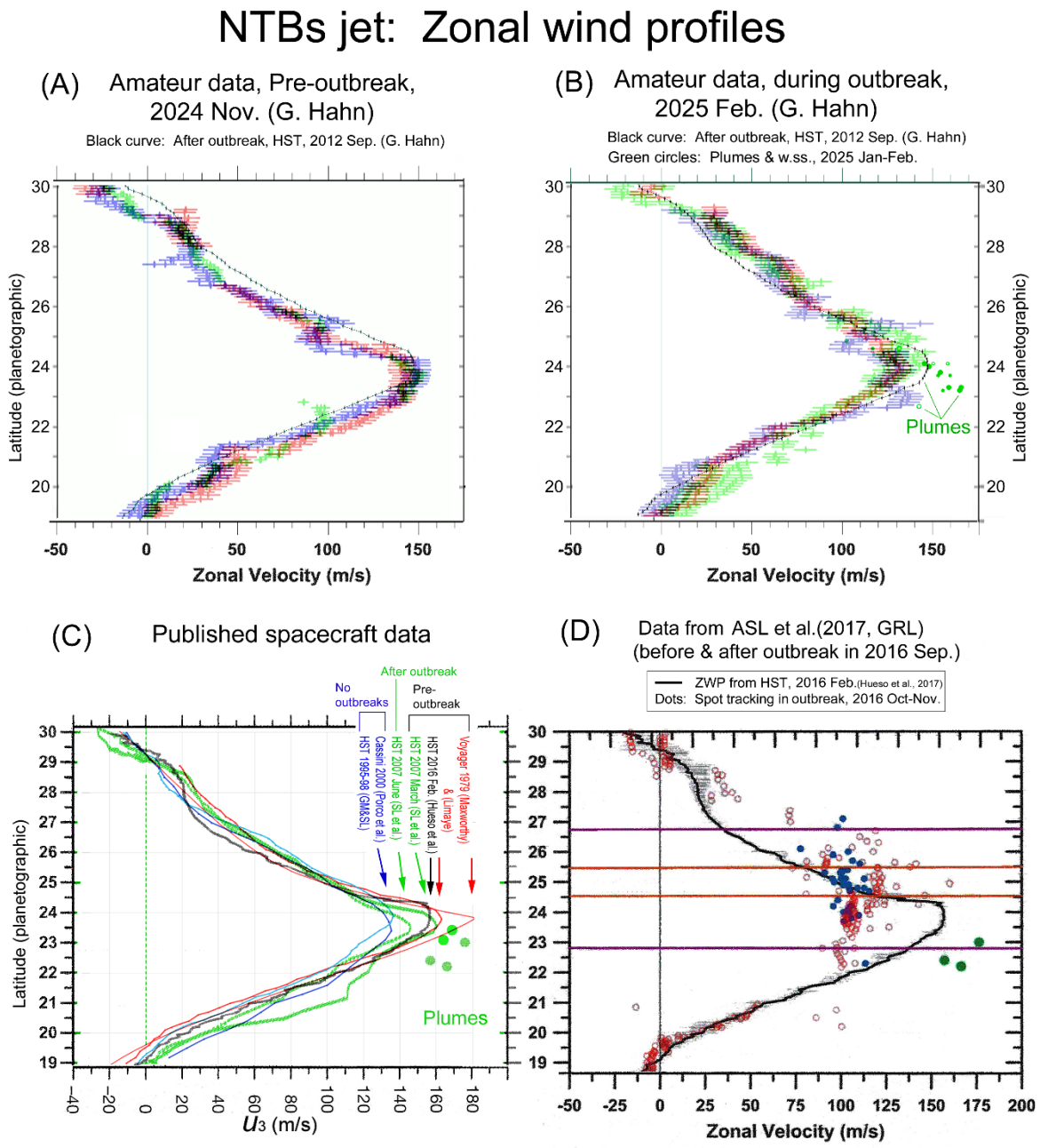

Figure 21. Zonal wind profiles of the NTBs jet, all adjusted to the same scale.

(A, B) Amateur data from 2024 Nov. and 2025 Feb.; ZWPs by G.Hahn. Each panel is a composite of three dates, shown in different colours, each of which is the sum of all channels. The black line is a ZWP from HST on 2012 Sep.20, by G.H. [ref.18]. (The same HST data were also used for ZDPs by M.Vedovato [in our ref.4], and by ref.25 (see Figure 22(C)), with very similar results. Both G.H. and M.V. have also produced ZWPs in other previous years, posted with our on-line reports, which are not included here.)

(C) Published spacecraft ZWPs from the following sources:

Voyager in 1979 (red line): Limaye (ref.19) & Maxworthy (ref.20).
HST in 2016 Feb. (black line) (ref.27).
HST on 2007 March & 2007 June (green lines) (ref.3).
Cassini in 2000 (ref.23).
HST in 1995-98 (ref.22).

Green circles represent the main plumes in 2007 (ref.3) and 2016 (ref.7: panel D)

(D) Published data for the 2016 outbreak, showing the pre-outbreak ZWP from HST in 2016 Feb. (ref.27), and spot tracking 1-2 months after the outbreak began (ref.7).

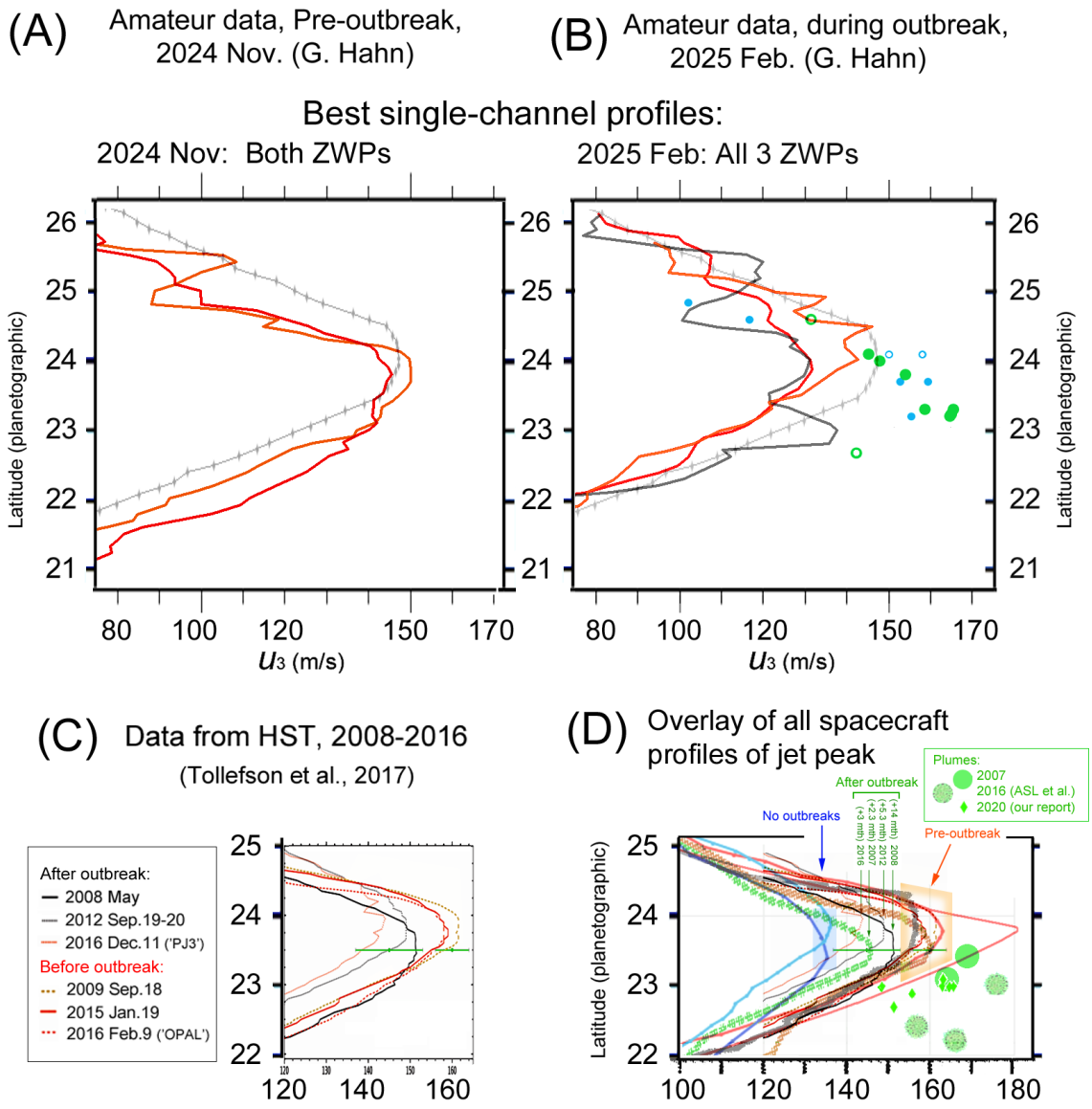

Figure 22. Zonal wind profiles, showing only the jet peak, all adjusted to the same scale and aligned.

(A, B) Amateur data from 2024 Nov. and 2025 Feb.; ZWPs by G.H. Each panel shows two of the most complete and reliable profiles in red light. (B) also shows one profile in white light, and our ZDP from spot tracking in Fig.20. The grey line is G.H.'s ZWP from HST on 2012 Sep.20.
(C) Published ZWPs from HST images, 2009-2016, from Tollefson et al.(ref.25), plus the 2008 profile from ref.24.
(D) Overlay of all the published ZWPs from Figures 21(C) & 22(C), relabelled to relate them to the phase of the outbreak cycle. The blue profiles, peaks enclosed by a pale blue box, were from 1995-2000 when no cycles of super-fast outbreaks were occurring, and have low speeds. The profiles in shades of red and grey, peaks enclosed by a pale orange box, were between or before super-fast outbreaks, and have consistent super-fast speeds. In between are four profiles labelled by year with green arrows, which have intermediate speeds increasing with time since the outbreak as indicated in brackets. Green circles and diamonds represent the individual plumes in 2007 and 2016 (as in Figure 21(C,D)) and 2020 (our data: ref.8).

Figure 23: *[See previous page]*

Table 1: Drifts & latitudes of NTBs features

(1) Before the outbreak							
JUPOS DATA:	*time interval*	*ΔL1(°/30d)*	*(deg/day)*	*U3(m/s)*	*lat.*	*SD*	*N*
Dark streaks (f. ends)							
Long-lived	2024 Jul-2025 Jan	-95.9	-3.20	141.1	23.5		7
Short-lived	2024 Jul-Sep	-100.4	-3.35	143.3	23.5	0.3	6
(2) White spots in outbreak		[see below for list of plumes]					
SUMMARY FROM G.A. DATA:							
	time interval	*ΔL1(°/30d)*	*(deg/day)*	*U3(m/s)*	*lat.*	*SD*	*n*
Plume 1	Jan 10 – 11	(~-60 to -90?)	(-2 to -3)	(124-137?)	**24.6**	0.21	3
	Jan 11 – 14	-125.8	-4.19	154.2	**23.8**	0.47	7
	Jan 16 – 30	-150.7	-5.02	166.1	**23.2**	0.19	10
Plume 2	Jan 27– 29	-112.2	-3.74	148.1	**24.0**	0.52	8
	Jan.31-Feb.18	-151.9	-5.06	166.6	**23.3**	0.39	16
Plume 5	Feb 9 – 11	-106.3	-3.54	145.4	**24.1**	0.68	8
	Feb 14 – 18	-136.4	-4.55	159.7	**23.3**	0.29	8
MEAS'TS BY J.H.R. FROM S.M.'s MAPS ETC:							
Plume 1	Jan 16-25	-150	-5.0	165.6	23.2	0.3	16
Plume 5	Feb.12-16	-144	-4.8	162.8			
	Feb.25-27	-99	-3.3	143.3	22.7		
W.ss. on N edge of wake	Jan 16-Feb.3	-9	-0.3	101.5	24.85	0.13	5
	Feb.7-11	-42	-1.4	116.3	24.6	0.3	5
Wake plumelets:							
Unnumbered	Jan.16-23	(~117,-135)	(~-3.9,-4.5)	(150,158)	24.1	0.4	9
3 & 4	Feb.1-6	-129	-4.3	156.2	23.2	0.3	3
6	Feb.6-11	-135	-4.5	158.9	var.		
7 & 8	Feb.12-22	-123,-138	-4.6, -4.1	153, 160	23.7	0.3	6
(3) Dark patches in outbreak							
Up to 4 dark patches	Jan.20-31		~0 to -2.9		~23.5 to 24		
	Jan.22	~0	~0		23.6 to 24.2		
	Jan.25	-87	-2.9		23.3 to 23.9		
JUPOS DATA:							n
Dark streak	Jan.19-22		-2.1		**23.2**	0.54	6
Dark spot	Jan.14-18		-1.2		**23.7**	0.80	6

Table 2: Dates of plumes & plumelets

	Appeared		*Fading*	*Last seen*
Number	*JHR*	*SM*		
1	**Jan.10**	**Jan.10**	**Feb.2**	**Feb.4**
2	**Jan.27**	**Jan.27**	**Feb.25**	**Mar.2**
3	Feb.1	Feb.2		Feb.3/4
4	Jan.31	Feb.2		Feb.8
5	**Feb.9**	**Feb.9**	**Feb.25**	**Mar.1**
6	Feb.6	Feb.9	Feb.13	Feb.16
7	Feb.10	Feb.12	Feb.19	Feb.22
8	Feb.14	Feb.14		Feb.22

Primary plumes are in **bold green.**