Jupiter in 2018, Report no.2: Interim report and preview of PJ-12

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I. Interim report on atmospheric phenomena

The most important phenomena are still:
--Continuing development of the large-scale pattern in the NEB;
--Interaction of the S. Tropical Disturbance (STropD) with the GRS;
--Transformation of the STB Ghost as it approaches oval BA.
For more background, previews, and references about these, please refer to our previous report [2018 Report no.1: https://britastro.org/node/12201].

Introduction

The planet is now high enough that observers in tropical and southern latitudes are obtaining superb images, and the JUPOS team have produced detailed charts up to March 1. This report is produced thanks to the assiduous work of many observers (notably Andy Caseley, David Carlish, Hideo Einaga, Clyde Foster, Chris Go, Paul Maxson, Isao Miyazaki, Phil Miles, Damian Peach, Avani Soares, Anthony Wesley) and the JUPOS team (Gianluigi Adamoli, Michel Jacquesson, Marco Vedovato, Rob Bullen, Hans-Jörg Mettig). **Appendix 1** (ZIP file) contains large compilations of images in two longitude sectors, covering the GRS/STropD and STB Ghost/Oval BA regions respectively.

This report also refers to the maps produced from NASA's Juno orbiter where relevant. Perijove-9 (PJ9) (2017 Oct.24) was the last time that JunoCam obtained a map of the whole northern hemisphere, but maps of the southern hemisphere were obtained at PJ10 (Dec.11) and PJ11 (Feb.7); all are posted in our 'Results from Juno' pages. For these we are indebted to Dr. Candy Hansen, Gerald Eichstädt, and the rest of the JunoCam team.

This report follows our usual conventions: longitudes in System II (L2), drift rates in degrees longitude per 30 days (DL2: deg/mth), planetographic latitudes. P.= preceding (east), f.= following (west). North is up in all figures. **Appendix 2** (ZIP file) contains annotated JUPOS charts of some regions; because of the standard orientation of these charts, their aligned maps have south up.

Figure 1 is a map on Feb.5-8, spanning Juno's Perijove-11. Figure 2 is a map on Feb.26-28. Figure 3 is a set of methane-band images all round the planet around the same time.

Northern hemisphere

NNTZ: Anticyclonic ovals WS-4, WS-6, and LRS-1 are still prominent, plus one new one. All are now white. LRS-1 and WS-4 approached very close in October (PJ9) but have separated again; ditto WS-4 and the new one, which rebounded suddenly on Feb.6.

NNTB: The belt is not well-defined, but there are still many NNTBs jet spots, tracked with DL2 = -68 to -82 deg/mth. The latest map shows a very large FFR. It is not the same FFR that was seen in 2017 [splendidly shown in the JunoCam images at PJ6 (May 19) & PJ9 (Oct.24) & PJ11 (Feb.7)], which probably still exists alongside WS-6.

NTZ & NTB(N): A new N. Temperate Disturbance (NTD) – a dark patch centred on a very dark ring in the NTZ latitude – is seen in the map of Feb.27-28 (Figure 2). It developed in January, downstream of the rifted sector of NTB(N); this is typical at this stage of the 5-year NTB cycle. This rifted sector was shown in closeup JunoCam images at PJ9 (Oct.24) and PJ10 (Dec.11), and became resolvable again in ground-based maps in mid-Feb. P. the rifted sector, the NTB(N) has a dark bar and an outbreak of tiny prograding dark spots (N. Temperate Current B). Otherwise, the NTB(N) has largely faded now. It has failed to produce the waves and dark spots that were so impressive in the previous two NTB cycles.

NTB(S) is still conspicuous diffuse orange.
NTropZ is now very narrow but bright white.

North Tropical domain

Figure 4 is a set of maps showing the development of the NEB; also see the JUPOS chart in Appendix 2. The NEB continues to show impressive evolution on a grand scale, following on from the NEB expansion event in the first half of 2017, and the increasing prominence of a circumglobal wave pattern in the second half of 2017. The wave pattern is now fading at visible wavelengths (though still striking in the methane band: Figure 3), and is being succeeded by a classic array of cyclonic brown circulations (barges) and anticyclonic white ovals (AWOs), as the NEBn edge recedes northwards.

From L2 ~ 40-160 (f. White Spot Z), as seen in the maps (Figure 4), the waves are still present without obvious AWOs, although circulations could become evident as the dark belt recedes further. The mean wavelength has varied from ~17º (at PJ9) to 22º (in Feb.). The maps show that these waves were slow-moving: DL2 = +5 to +7 deg/mth (Jan.20-Feb.28). (This speed would also be typical for nascent barges.)

From L2 ~ 145-325, in contrast, within each dark wave a small dark barge has developed: 3 or 4 existed last August but now there are 9 of them, with mean spacing 31º. Many of the spaces between them are occupied by anticyclonic circulations: 3 AWOs from last year (WS-a, b, d) plus a new one, and an oval with a red core (p. the first barge).

White Spot Z (WSZ), which has been reddish, is now dull off-white, often with a tiny white spot in its northern part.

The north part of the expanded NEB is fading rapidly and unevenly. In some sectors the remaining dark belt has a sharp edge at 16-17ºN, which is typical, but in others it is at 13ºN, as in 2011. Is this a temporary phase, or will the whole belt narrow to this extent? If it does, it will set the scene for a spectacular NEB Revival as in 2012.

The NEBs edge is at 9ºN, unusually far north.

There are a few small rifts in the NEB. (They included one with a persistent tiny white core, from mid-Feb. to March 5, which passed north of the GRS on March 1, when the white core was weakly methane-bright [P. Miles]. A second white point arising in it on March 5 was also methane-bright [C. Go].)

NEBs: There is an array of prominent NEBs dark formations (‘hot spots’) all around the planet, with conspicuous bluish festoons, and in some cases bright plume cores. Some sectors are especially dramatic and complex. The JUPOS chart shows a complex range of speeds, both near-stationary and positive in L1.

South Tropical domain

This domain is generally quite, except for the S. Tropical Disturbance (STropD or STrD) and its interaction with the GRS. There is a narrow but dark S. Tropical Band all around the planet, connected to the p. and f. ends of the STropD; this is not the STB.

The GRS is still small, dark, and very red, with a bright white collar that the STropD cannot penetrate. The GRS was stationary at L2 = 286 from mid-Jan. to late Feb.

Is the GRS accelerating (less positive DL2) as a result of its interaction with the STropD? When the Great STropD passed it many times between 1902 and 1920, the GRS typically drifted faster by 1.5 deg/mth when it was inside the STropD than otherwise [Ref: 'The Giant Planet Jupiter' pp.200-202]. (One other such event occurred in 1970-71, and the GRS again accelerated by ~1 deg/mth, but the SEB and STropD were faint then.)

The JUPOS chart suggests that this may already have started [Figure 5]; however, the striking acceleration in 2018 Jan. and Feb. may be no more than the accelerating phase of the normal 90-day oscillation, which was then due; we need a few more weeks' observations to see if this is a sustained change.

The STropD (Figure 6; also see sets of images in Appendix 1) reached 33º in length in early Feb. The p. end, a conspicuous curved projection near the GRS, accelerated to merge with a dark bulge just f. the GRS, then halted on about Feb.4 at L2 = 289, blocked by the bright collar of the GRS (Red Spot Hollow). Much dark material from the STropD then started flowing around the S side of the GRS, along the distorted S.Trop.Band (which already had much small-scale disturbance on it emanating from the STropD). During Feb. and up to March 8, turbulent dark material has been accumulating on the S.Trop.Band and S.Temp. domain p. the GRS. A set of maps has been posted by S. Mizumoto on the ALPO-Japan web site, with an animation at: http://alpo-j.asahikawa-med.ac.jp/kk18/j180226u.htm.

Discussion: We are now watching a STropD interacting with the SEB and the GRS in a way that has never before been observed at such high resolution.* One revelation is how turbulent it all is: it is a 'disturbance' not just in the formal sense of a reconfiguration of the jets, but in the colloquial sense of intense turbulence and convection. This has been seen within the SEB, where the post-GRS convective rifts have revived alongside and f. the STropD; and within the dark p. end itself; and on the S.Trop.Band as it streams past the GRS. The hi-res amateur images will enable studies of the dynamics, via map projection and animation and wind tracing. Interesting questions include:
--Is there a pattern to the turbulence?
--Is there an organised zonal wind profile within the STropD?
--How does the p. end of the STropD pass the GRS? (I speculate that the anticyclonic vorticity of the hemi-circulation at the p. end has broken up into small vortices streaming past the GRS, which will re-group to re-form the p. end. But even if this does happen, which is not assured, it could be a stochastic process with unpredictable delay, rather than a coherent reassembly as inferred from historical visual records.)

*[Note: The creation of a new STropD was observed by Voyager 2, as described in my book, but it occurred in a different way from the present one, by interactions of large anticyclonic vortices retrograding on the SEBs jet. There are no such vortices at present, and there have never been hi-res images of a STropD passing the GRS.]

In the SEB itself [Figure 6] the other interesting feature is the long-lived barge, which developed in 2017 from a white spot present in 2016. It is now intensely dark red-brown, and

still has a small white patch on its N edge. The chart also shows many retrograding tracks of tiny white spots in southern SEB (~18ºS; visible in Figure 7), on the N flank of the SEBs jet.

South Temperate domain

The STB has been entirely absent, but the two long-lived cyclonic circulations are darkening as they interact with the STropD and Oval BA respectively.

The STB Spectre passed the GRS in January, very faint. In Feb. it became patchily shaded, being involved with the turbulence from the STropD, and its outline was indistinct; but it was still well defined in methane images, from Juno at PJ11 (Feb.7), and from amateurs subsequently (Figures 3 & 6, & Appendix 1). In early March it seems to be lighter again internally.

The STB Ghost, approaching oval BA, is undergoing a dramatic transition to a turbulent dark STB segment, as expected. This started on Feb.4 with a sudden convective outbreak in the form of a tiny brilliant spot – exceptional for this latitude**, but just what was observed on 2010 June 17 in the same circumstances [see 2018 Report no.1]. Its development is shown in Figure 7 (set of maps), Appendix 1 (large set of images), & Figure 8 (animation showing its turbulence).
A large set of maps has been posted by S. Mizumoto on the ALPO-Japan web site at:
http://alpo-j.asahikawa-med.ac.jp/kk18/j180226t.htm.

The initial white spot was first imaged on Feb.4 by 4 observers in S. America (Fernando Silva, Conrado Serodio, F.S. Correa, & D. Peach using ChileScope remotely), but was reported by A. Wesley on the next rotation when it was extremely bright in near-IR (continuum) and the methane band – though in RGB images it was only modestly bright for the next 2 days. It was rapidly stretched and twisted by the cyclonic circulation of the STB Ghost, as shown in the maps (Figure 7). Up to Feb.8, the white streak was still methane-bright while the rest of the Ghost remained methane-dark. Soon it filled the whole Ghost with turbulence, including some bright white and some very dark blue-grey spots, all changing very rapidly and evolving to smaller scales. It was still variegated in hi-res methane images (e.g. Feb.18) but gradually reverting to methane-dark. Now the turbulence has affected the adjacent dark spot f. BA, which appears disrupted or obscured as a brownish blur. Animations (Figure 8) show how intense the turbulence has been. These images (or the accompanying v-hi-res IR images) will enable studies of the dynamics, via map projection and animation and wind tracing.

Oval BA does not yet show any clear acceleration (present DL2 = -12) nor a very dark collar, but I expect these to develop soon.

**[Similar brilliant eruptions on a smaller scale are common in high-latitude cyclonic regions; Juno's PJ11 images showed them in the large NNTB FFR, in the SSTB (due S of the GRS; transiently visible in amateur images), and in the large S3 FFR, and at even higher latitudes. See our report on Juno at PJ11.]

High southern latitudes

S2 domain: The 8 long-lived AWOs are still present although the distances between them continue to vary.
But AWO A5a, which had been growing slowly during 2017 as it absorbed mini-AWOs that developed in the wake of a long FFR, has now shrunk again. This is best shown in the JunoCam maps (Figure 9). Will it disappear, as most other new AWOs in this domain do within 2 years? It has been passing a very long FFR in the S3 domain, and is approaching the long FFR in the S2 domain; are these now draining it of energy?

S4 domain: LRS-1 is unchanged, but now only one AWO is visible: AWO-3 has either disappeared or merged with AWO-2. (Both were shown on Dec.30 [P. Miles, IR], 30º apart. On Jan.3, AWO-2 was S of oval BA, and AWO-3 possibly still seen far away [C. Foster] or invisible [C. Go]. On Jan.6, only AWO-2 was present [P. Miles, A. Wesley, IR & RGB].)

II. Preview of Juno perijove-12 (2018 April 1).

Because of the evolving orientation of Juno's orbit, it is now impossible for the pointing instruments to view the nadir (the sub-spacecraft point) at perijove if the antenna and solar panels are pointing to Earth and Sun (for diagram see our report on PJ-10). To turn the spacecraft so that the MWR (as well as JunoCam) can view the nadir is costly in fuel and in solar energy input. But this will be done at PJ-12, for what could be the last time.

There is no longer any public voting for targets, and much of the data volume may be reserved for images of the poles (monitoring the polar polygons of cyclones) and of the Equatorial Zone (possibly the last closeups of it). But there will also be images of other latitudes, and Figure 10 shows what may be visible. Most importantly, the track runs ~11° p. the p. end of the GRS, and right over the region where the p. end of the STropD may be re-assembling at that time. Thus it may be possible to get unique closeups of this phenomenon, and complete views of the GRS as the spacecraft moves south. Other interesting regions include the NEB (where a small barge should be in view), and the NNTZ (where WS-4 could be in view, though this is uncertain).

Figures (miniature copies) *on following pages:*

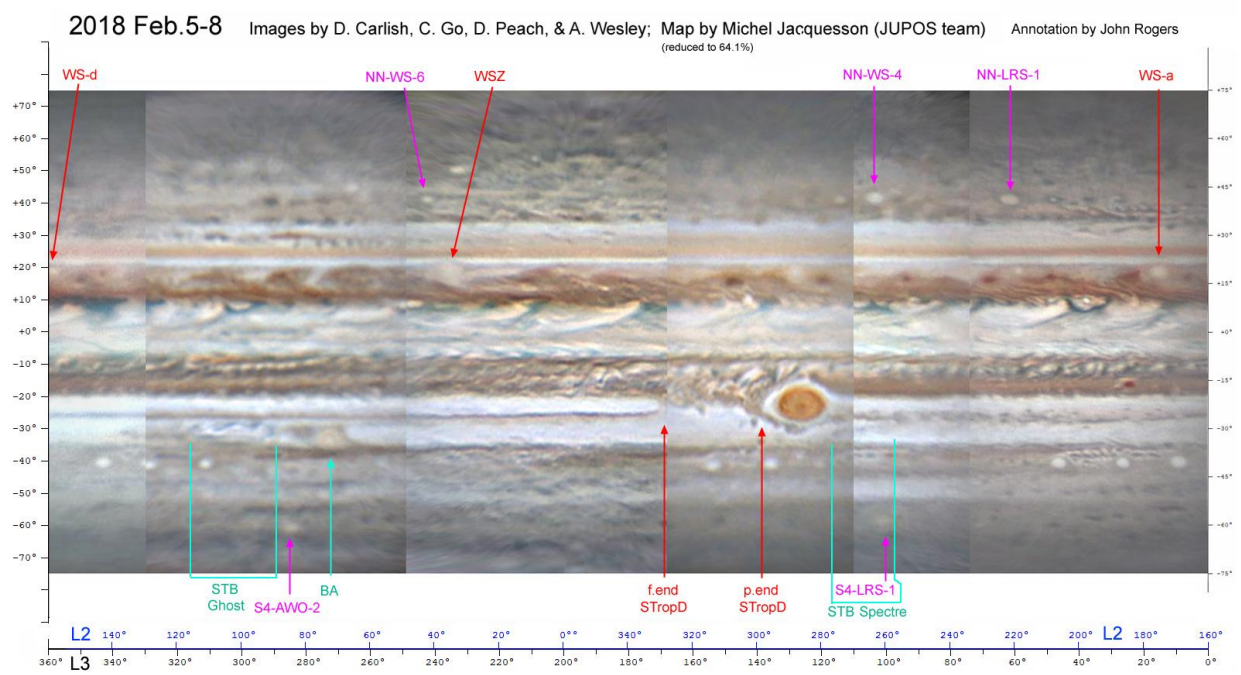

Figure 1. Map on 2018 Feb.5-8, spanning Juno's Perijove-11.

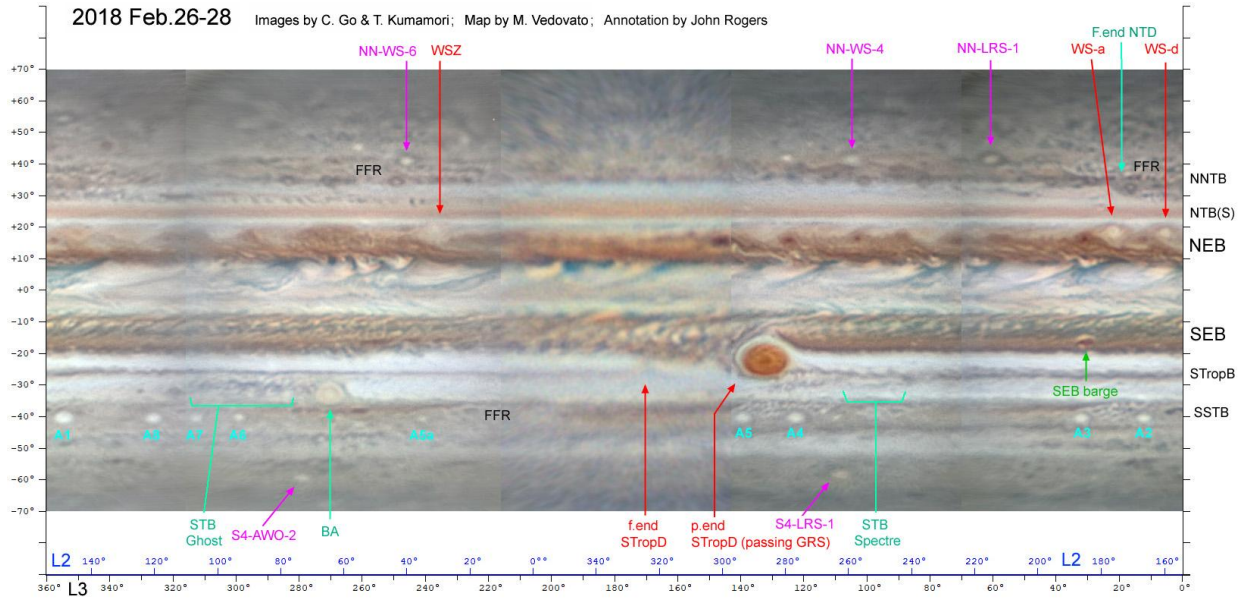

Figure 2. Map on 2018 Feb.26-28.

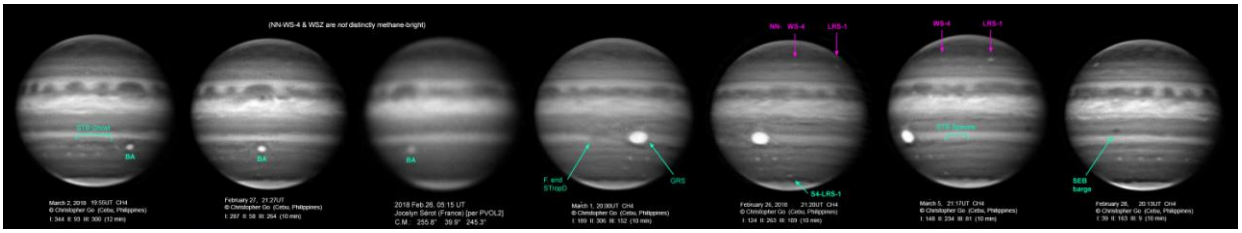

Figure 3. Set of methane-band images all round the planet, by Chris Go, plus one by J. Sérot.

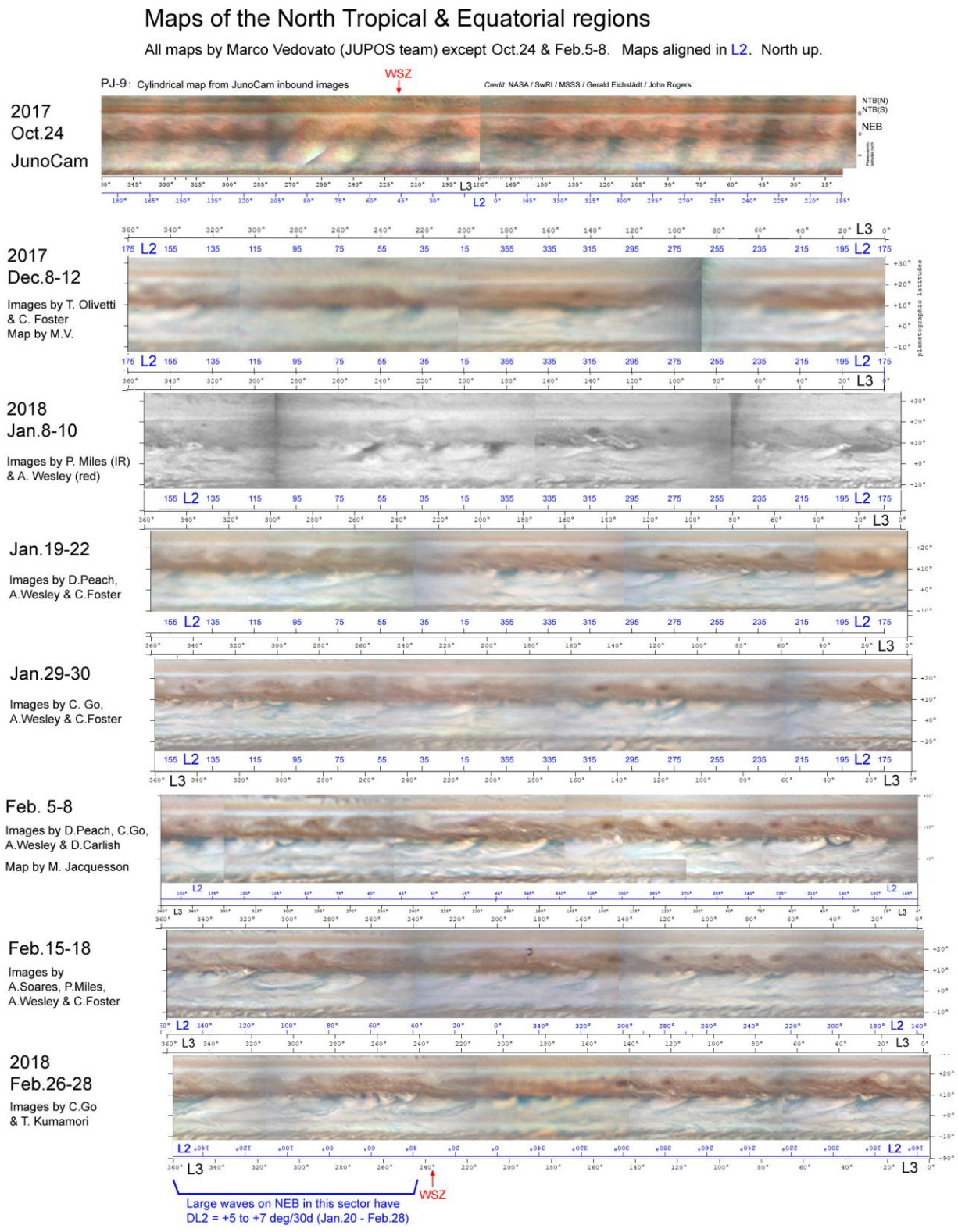

Figure 4. Set of maps showing the development of the NEB.

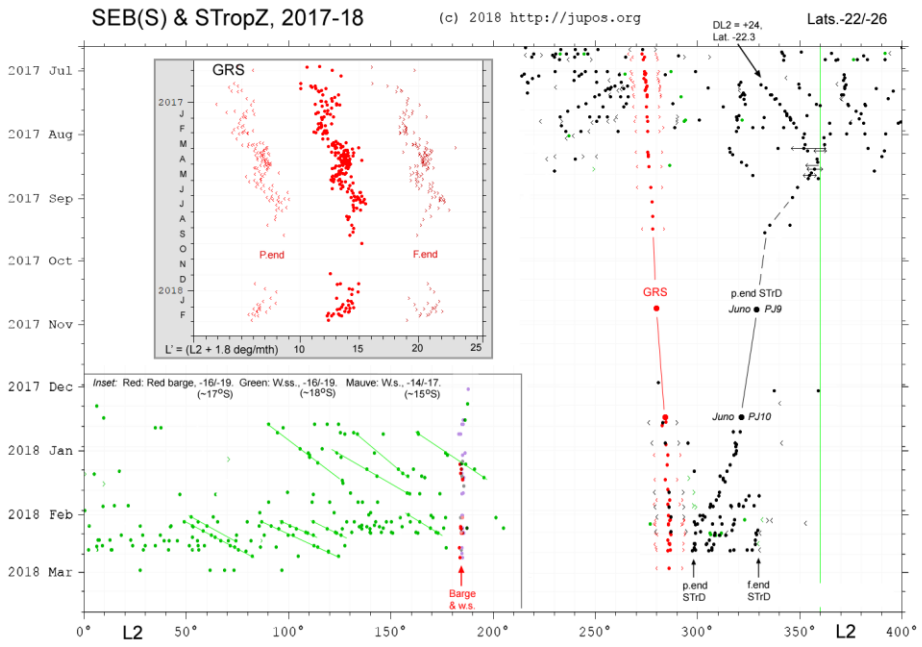

Figure 5. JUPOS charts of the STropZ (right) and southern SEB (lower left), on the same scale, and the GRS (upper left) on a different scale.

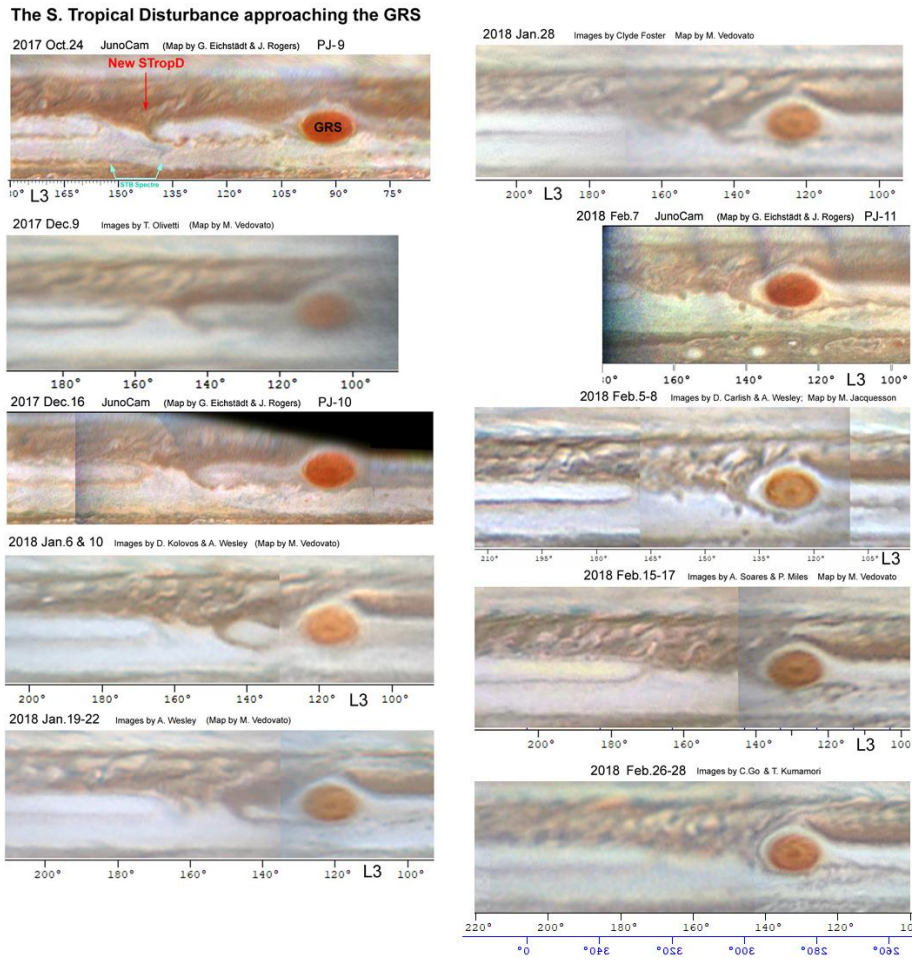

Figure 6. Maps showing the STropD and its interaction with the GRS.

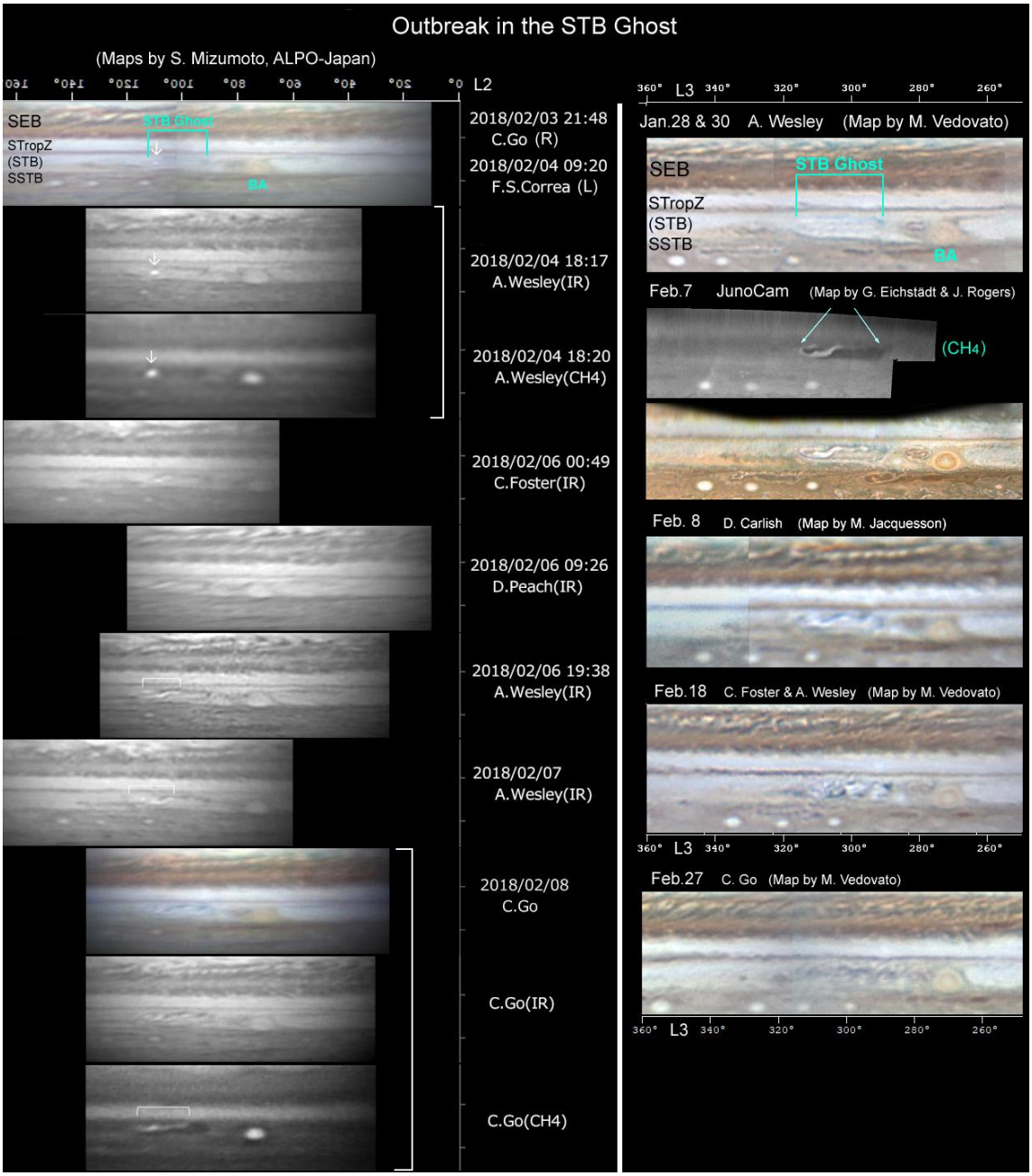

Figure 7. Maps showing the convective outbreak in the STB Ghost. The left side is adapted from a set prepared by S. Mizumoto, posted on the ALPO-Japan web site. He has now posted a much more extensive set: http://alpo-j.asahikawa-med.ac.jp/kk18/j180226t.htm.

Figure 8 [posted separately]. ***Animation*** of maps of the STB Ghost at the height of its outbreak, Feb.15-18, showing its intense turbulence within its circulation. (Maps made by Michel Jacquesson.)

Figure 9. Maps of the S2 domain from JunoCam images.

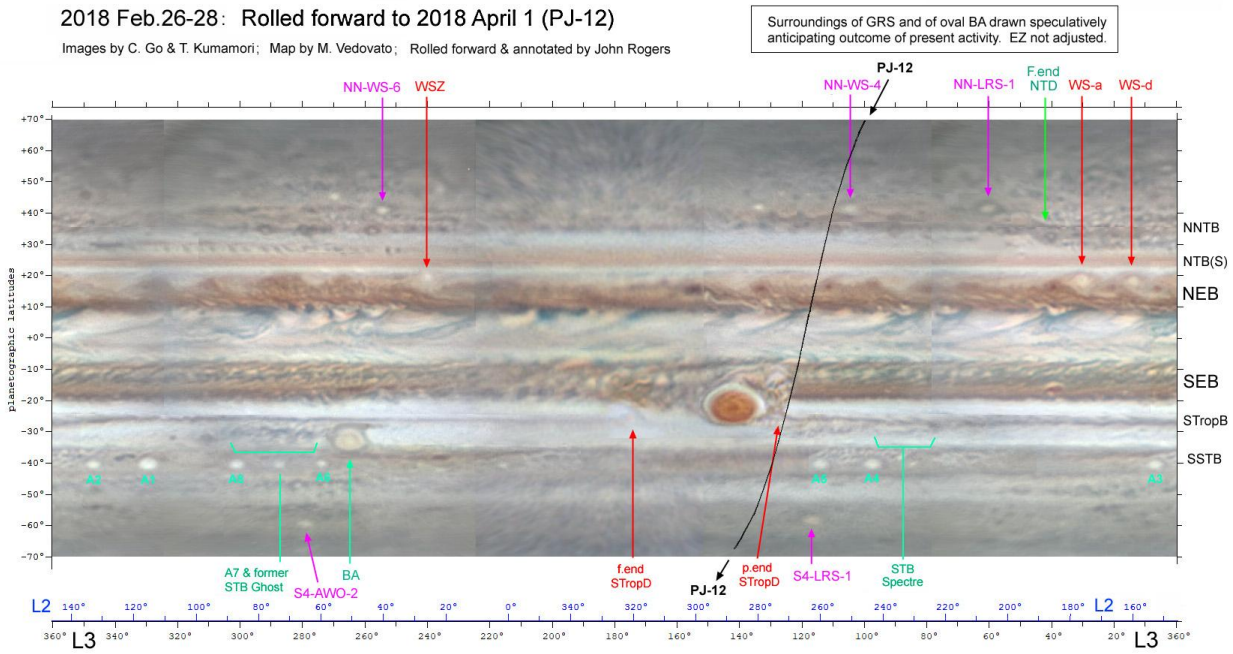

Figure 10. Predictive map for JunoCam imaging at PJ12 on April 1.