

## **Jupiter in 2018:** **First Interim Report, Preview of Juno's Perijove-11, and Prospects for 2018**

--John Rogers (2018 Jan.19)

There have been important changes in several belts on Jupiter during solar conjunction, which presage exciting events to view in 2018. The main changes are the evolution of the wave pattern in the NEB into a chain of new circulations; the appearance of a new S. Tropical Disturbance; very recent resumption in rifting in the SEB; and the approach of the STB Ghost to oval BA.

There was no long gap in observations during solar conjunction in 2017 October, because JunoCam obtained a complete global map from orbit at Perijove-9 on 2017 Oct.24, just two days before conjunction. JunoCam then obtained a good map of the southern hemisphere at PJ-10 on Dec.16. [See our reports at: 'Results from Juno', <https://www.britastro.org/node/7982>] Several amateurs were also producing useful images in Dec; indeed, lo-res images were produced from Nov.17 onwards by Isao Miyazaki, and by Paul Maxson, Clyde Foster and Tomio Akutsu from Nov.25 onwards (after sunrise). In Dec. and Jan. these observers have been joined by Anthony Wesley, Phil Miles, Tiziano Olivetti, Chris Go, Eric Sussenbach, and a few others, who are now obtaining some good hi-res images. The first batch of measurements from the JUPOS team was released in early Jan., and has provided drift rates for this report.

As usual, we give longitudes in System II (L2), and drift rates in degrees longitude per 30 days (DL2: deg/mth). P.= preceding (east), f.= following (west). North is up in all images.

### **I. The present state of Jupiter's atmosphere**

Figure 1 is a global map covering 2018 Jan.6-11; Figure 2 is a set of colour and I-band images in Dec.; Figure 3 is a set of methane-band images in Dec.; and Figure 4 is a set of recent hi-res colour images.

#### *N.Temperate domain:*

The NTB(N), formerly dark grey, has faded considerably. But it contains one very dark bar (L2 ~ 60-80), followed by a turbulent region (FFR), which may yet generate more conspicuous disturbance. The orange NTB(S) is still prominent.

#### *N.Tropical domain:*

Here, the NEB broadening event which occurred in 2017 has been followed by rapid large-scale changes. A series of large-scale waves in the NEB, initially evident in methane images, were also visible in RGB images by 2017 August, and strikingly so in the JunoCam map on Oct.24 (wavelength 17°-21°). They are also obvious in the recent methane images (Fig.3) and colour images (Fig.4) (wavelength 21° in the map: Fig.1), and appear to be resolving into an impressive array of dark brown 'barges', some of which are separated by anticyclonic white ovals (AWOs). Development of such arrays is a typical sequel of a NEB expansion event, but we have never previously seen it to occur through such a prominent wave phenomenon. The northern half of the NEB is rapidly fading, making the barges more conspicuous.

The only AWO which existed before the expansion event, White Spot Z (WSZ), is actually dull pale orange now, as it has been since summer 2017 (and especially in the JunoCam closeup images on Oct.24). Its recent drift rate is  $DL2 = -4.5$  deg/mth.

On the NEBs edge, the usual dark formations are present and some are very large and dark. At least some of them maintain a drift close to  $DL1 \sim +8$  deg/month.

#### *S.Tropical domain:*

The GRS was at  $L2 = 285$  on Jan.1, and will probably remain at  $L2 = 286$  until early Feb., given the phasing of its 90-day oscillation. It is still small and dark red, and separated from the SEB.

A notable new feature was discovered in the JunoCam PJ-9 images made on Oct.24: a new South Tropical Disturbance (STropD). It was described and discussed in our Juno PJ9 report, as reproduced in the Appendix below. [Figure 2](#) shows some early views of it in 2017 Dec. It has distinct p. and f. ends, 20 deg apart. The p. end ( $DL2 = -4.5$  deg/mth) is most conspicuous and is approaching the GRS ( $DL2 = +2$  deg/mth); if maintained these drifts would bring them into contact in mid-March, but they may well interact before then.

The SEB was largely quiet through solar conjunction, but rifting activity has recently resumed. The perennial rifting f. the GRS and in the mid-SEB outbreak dwindled to a low level in autumn 2017, as both sectors quietened down; in Juno's PJ-9 images there were only a few small white spots f. the GRS (associated with the STropD) and in the remnants of the mid-SEB outbreak. Accordingly, there are no distinct spots on the SEBs jet, and most of the belt appears internally quiet, and the red-brown barge is prominent (at  $L2 = 186$ , with a long-lived white cloud on its N edge).

However, recent images ([Figure 4](#)) show new white spots in the southern SEB developing into rifts f. the STropD, and this may well be a resumption of the usual rifting activity f. the GRS.

The rifting in Dec. was not easy to assess, because most images were taken in near-IR, where bright white spots cannot be easily distinguished from pale brownish patches. However, enough colour images were available to show what happened ([Fig.2](#)). White rifting was occurring alongside the STropD throughout 2017 Dec., and were very turbulent [many intricate changes can be seen from Dec.28.1 (Foster) to Dec.29.8 (Wesley)]. Further f., the JunoCam maps showed no activity except for subdued turbulent streaks remaining from the mid-SEB outbreak, containing a few tiny white points; by PJ-10 (Dec.16) this remnant disturbance had prograded close to the STropD. Ground-based images showed it as a chain of light patches, not visible on Dec.2 and 9 (Olivetti) but visible from Dec.12 onwards and getting brighter, esp. on Dec.31 (Miyazaki) ([Fig.2](#)). On Jan.10 [Wesley's image, mapped in [Fig.1](#)] showed two tiny bright white points (at  $L2 = 3$  and 19) on the south edge of the chain of light patches, and these expanded rapidly into bright rifts over the next few days ([Fig.4](#)), rapidly prograding at  $DL2 \sim -51$  deg/mth. We wait to see whether further white spots will appear.

#### *S.Temperate domain:*

This domain still has three structured sectors but no dark STB; but changes are imminent, and could be dramatic as discussed in Part III below.

One structured sector consists of the orange anticyclonic *oval BA* and a small dark spot f. it (plus a small AWO); BA is still drifting with mean  $DL2 = -12$  deg/mth. Another is the *STB Ghost*, a large cyclonic circulation, which was splendidly imaged by Juno at PJ-10 on Dec.16 [see our reports]. With steady  $DL2 = -16$  deg/mth, it will soon collide with the dark spot f. BA.

The third structured sector is the *STB Spectre*, which is a younger, smaller duplicate of the STB Ghost. It has moved ahead of the STropD, and is now passing the GRS and very inconspicuous, but it could become more visible after the passage.

*S.S.Temperate (S2) domain:*

In the absence of a STB, the SSTB is a continuous belt, with no white sectors at present, although it includes pale turbulent FFRs. The 8 long-lived AWOs that were present in 2017 Jan. are still present. A ninth, called A5a, has grown substantially by merging with multiple tiny AWOs that are generated as eddies f. the large FFR, although it is still not as large as the others. (The growth of A5a is most systematically assessed by comparing the global maps we have made from JunoCam images.) The AWOs had rapid drift during 2017, most of them averaging  $DL2 = -30$  to  $-32$  deg/mth, but with oscillations, maintaining ovals A6-A7-A8-A1-A2-A3 in a close array. This is still their behaviour now.

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## II. Preview of Juno's Perijove-11 (2018 Feb.7)

Figure 5 is a predictive map for PJ-11 on Feb.7, produced by 'rolling forward' the mid-latitude domains from Figure 1 using drift rates from recent JUPOS charts. The track (marked) will be quite similar to PJ-9, but as at PJ-10, the views will look obliquely west of the track rather than straight down. Although there is no public voting now, it is still of interest to note promising imaging targets for imaging.

The NTropZ/NEBn is very worth targetting, because a prominent dark brown spot (barge?) should be close to the track, and the long-lived AWO, White Spot Z, will probably be visible towards the western horizon. It was imaged close up at PJ-9, but may be imaged more completely this time.

The southern SEB is of interest because convective white spots have started appearing again, close to the PJ-11 track.

Images taken over the SSTB will be worthwhile, to give an overview of the STB latitudes, and to view the big FFR in the SSTB. The sector again covers the STB latitudes east of oval BA, which I would like to monitor for any developing circulations, though there has been no disturbance there recently. Oval BA might be visible near the horizon. The track will go over the big FFR in the SSTB, which should look impressive, and the images would also cover the sector to the west where I think eddies from it develop into new little AWOs.

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## III. Prospects for 2018

In 2015 March, I posted a 3-year forecast:

Rogers J (2015) 'A 3-year weather forecast for Jupiter: Prospects for Jupiter in 2015-2017.'  
[http://www.britastro.org/jupiter/2014\\_15reports.htm](http://www.britastro.org/jupiter/2014_15reports.htm) [go to Report no.5].

All the large-scale events predicted in it have occurred or (in the STB) are about to occur, although the predicted timings were not accurate, some being out by more than a year. I don't think that a definite new forecast is possible at present, because in each of the major domains there are no clear indications as to whether a new cycle will start soon or not. So here I outline the possible scenarios for this year.

*N.Temperate domain:*

The NTB will continue to settle down after the 2016-17 Revival. It could generate impressive waves and dark spots on its N edge, though perhaps not, as the NTB(N) is currently

fading. If the rifted region persists, it could generate a dark sector of NTZ (N. Temperate Disturbance) f. it.

*N.Tropical domain:*

The northern NEB is currently fading and receding after the NEB expansion event of 2017, creating an impressive array of many barges and some AWOs on its N edge. This may produce an NEB of normal width for the next 2 years or more.

However, in Wesley's image on Jan.16, the N edge of the dark brown NEB has receded so far southwards that I begin to wonder whether it will become as narrow as in 2011-12, leaving the barges very dark and detached; this could set the stage for a vigorous Revival in 2019-20.

*S.Tropical domain:*

The STropD will interact with the GRS in the next few months; the dark p-STropD structure could flow around the S edge of the GRS and re-form p. the GRS.

The big question is whether the SEB will become completely quiet and then proceed to fade, or whether it is now returning to normal activity with the perennial rifting f. the GRS. The quiescence of the SEB in the autumn, along with the appearance of the STropD [see Appendix below], suggested that the SEB might be due to fade in 2018; this would set the stage for a Revival, which would not begin before late 2018. But the recent upsurge in rifting activity suggests otherwise: if it persists, maintaining the usual rifted region f. the GRS, the SEB will not fade.

*S.Temperate domain:*

The STB Ghost will soon collide with the dark spot f. BA; on present courses this would happen in late April, but interaction could begin at any time in the next six months. Spectacular effects could occur suddenly, as happened on 2010 June 17 when an identical feature, the STB Remnant, underwent an identical collision. Whatever the short-term events, I expect the overall effect to be as in previous such events, esp. in 2010 [see references in Appendix]: the STB Ghost will convert into a dark turbulent STB sector f. oval BA, oval BA will accelerate, and dark spots will be emitted p. on the STBn jet and f. in the STZ.

It is likely that a new structured sector will appear in the next year or two, probably starting off as a small dark cyclonic spot tens of degrees p. oval BA [see refs in Appendix].

The S. Temperate domain may be due for even more dramatic change, viz., a revival of the now-absent STB, as last happened in 1993 [see Appendix].

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***Appendix [reproduced from our Juno PJ9 report part I]:***

***Discussion of the South Tropical Disturbance and South Temperate Domain at PJ-9***

The map shows major changes in the southern hemisphere: most importantly and unexpectedly, a new South Tropical Disturbance (STropD), i.e. a recirculation across the S. Tropical Zone. Although it was not recognised till now, amateur images and JUPOS analysis show that it was initiated in early August when dark streaks, modestly retrograding in the northern STropZ, merged and recirculated into the mid-STropZ alongside the p. end of the STB Spectre. [We will show the data in a forthcoming report.] Early stages are visible in Fig.1. The STropD is prograding towards the GRS.

I think this enhances the likelihood of a SEB Fade developing within the coming year. In recent decades, S.Tropical Disturbances have tended to appear in association with SEB Fades (notably in 1993 and 2007\*). The SEB will probably not fade immediately because the map also shows some small-scale

rifting (white convective streaks) in the SEB alongside the STropD, and also at remote longitudes in the remains of the mid-SEB outbreak (also see close-ups in Part II). We will have to see how this plays out over the coming months, but I suspect that the rifts will soon die out and a SEB Fade may then develop in the first half of 2018.

There are also signs of possible disturbance in the S. Temperate domain. This domain has been in an anomalous state with no dark belt for a few years, and may be ripe for a revival of the now-absent STB, as last happened in 1993\*. In the PJ9 map we can see:

- disturbance apparently prograding on the STBn jet from the new STropD towards the GRS;
  - various small dark spots in the domain p. the GRS (in the 2016/17 apparition, this sector showed various shadings or blue colour as oval BA then the STB Ghost prograded along it);
  - the STB Ghost is still pale, but there is the (short) orange recirculation loop Sf. it; and it is approaching the dark spot f. oval BA, so I expect a vigorous interaction when they collide in 2018 [now expected for 2018 April, +/- several months], and the STB Ghost will become dark;
  - the orange recirculation loop Sf. the STB Spectre now appears to be ~50 deg long.
- So in 2018 we could see a repeat of the events of 1993 with revivals of the STB and SEB.\*

\* Reports on the 1993 and 2007 events:

Our full report on 1993, unfortunately, has never yet been finalised for publication, but a summary was given in: Rogers J (1993) 'Exciting events on Jupiter.' JBAA 103, 157-159. <https://britastro.org/node/8241>

The S. Temperate events are described in:

Rogers JH (2016) 'Jupiter's South Temperate domain: Evolution 1991-1999 and dynamics of cyclonic structured sectors as seen in Hubble maps.' <https://www.britastro.org/node/7230>

The S. Tropical events (STropDs and SEB Fade/Revival) have been described by:

Sanchez-Lavega A, Gomez JM, Lecacheux J, Colas F, Miyazaki I, Parker D & Guarro J (1996) 'The South Equatorial Belt of Jupiter, II: The onset and development of the 1993 disturbance.' Icarus 121, 18-29.

Our full report on 2007 is: Rogers J & Mettig H-J (2008), 'Jupiter in 2007: Final Numerical Report.' <http://www.britastro.org/jupiter/2007report20.htm>

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& References on collisions between structured sectors of the STB:

For details of the collision of the STB Remnant with oval BA, see:

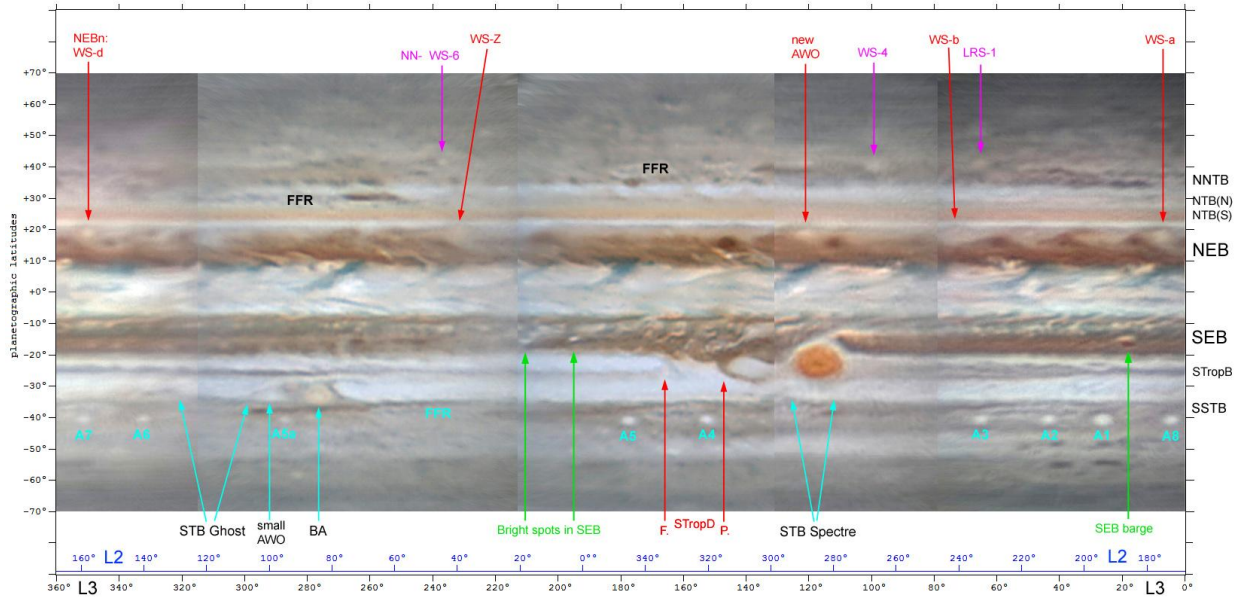
Reports 2010/11 no.4 & no.8. <http://www.britastro.org/jupiter/2010reports.htm>

Long-term reports on the STB describing the effects of collisions with oval BA:

Rogers J, Adamoli G, Hahn G, Jacquesson M, Vedovato M, & Mettig H-J (2013). 'Jupiter's South Temperate domain: Behaviour of long-lived features and jets, 2001-2012.' <http://www.britastro.org/jupiter/stemp2013.htm>

Rogers JH (2015) 'Jupiter's South Temperate Domain, 2012-2015'. [http://www.britastro.org/jupiter/2014\\_15report08.htm](http://www.britastro.org/jupiter/2014_15report08.htm)

*Figure legends and miniatures are on the following pages.*

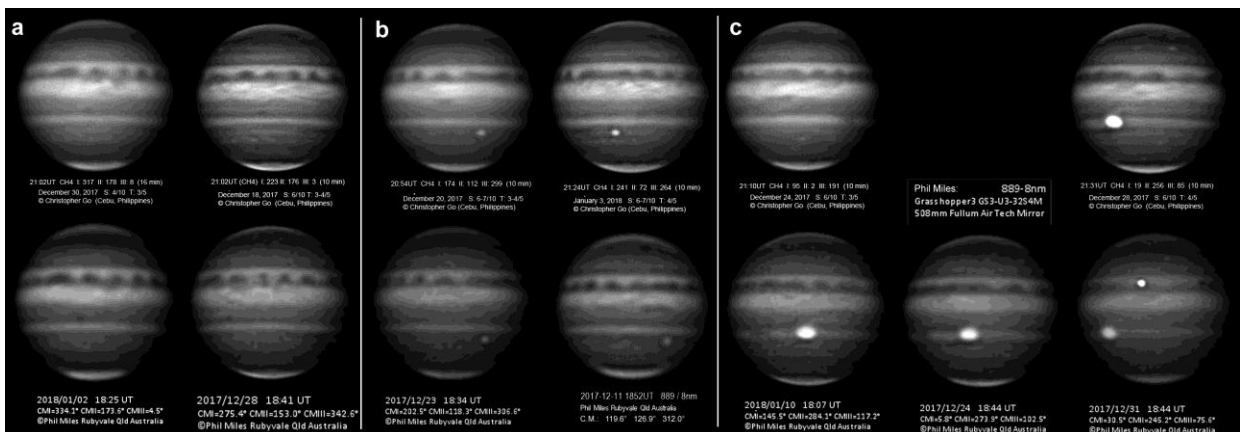


**Figure 1.** Map of Jupiter on 2018 Jan.6-11.

**Figure 2** [not shown in miniature].

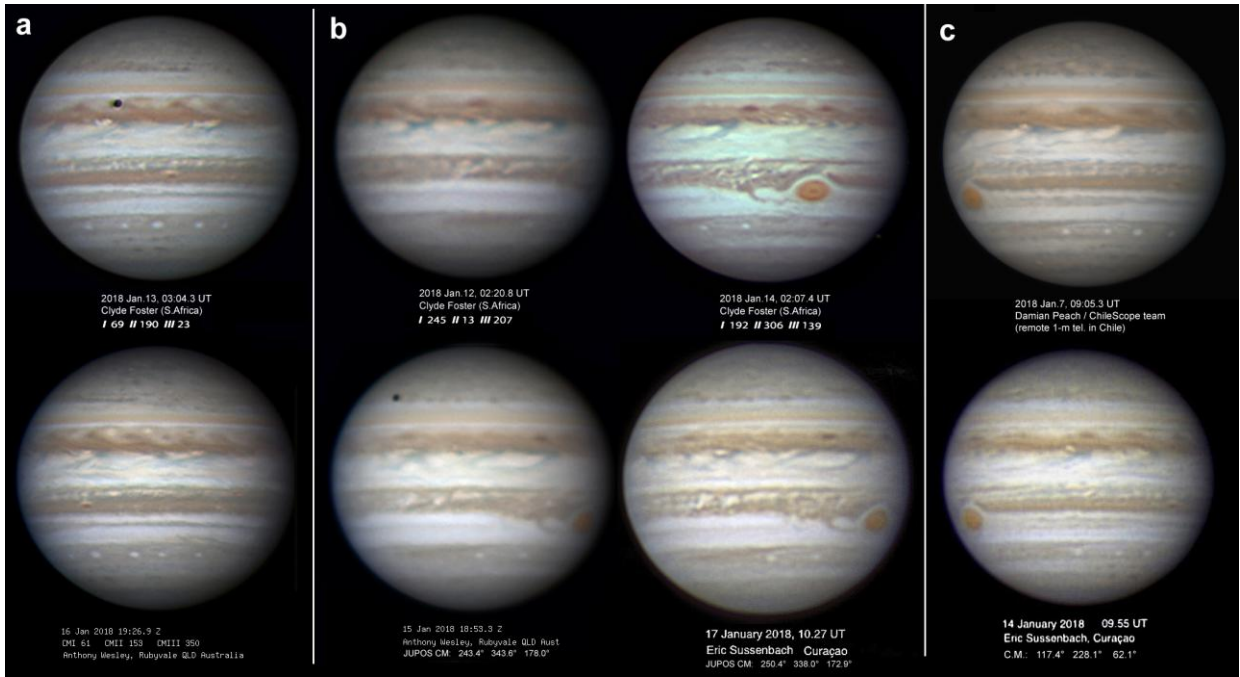
Images in 2017 Dec. A large number are included, esp. colour and some of the best near-IR images, in order to thoroughly cover this important early stage of the apparition.

- (a) CM2 = 97-162, including oval BA and the STB Ghost f. it.
- (b) CM2 = 251-288, including the GRS.
- (c) CM2 = 300-331, including the STropD and GRS, with SEB rifts alongside the STropD.
- (d) CM2 = 7-45, between oval BA and the STropD, showing the residual rifted sector of SEB, which appears to be gradually brightening. In (d) and (e), even images of modest resolution were important for recording this sector.
- (e) The same sector as in (c) and (d) in early Jan. In the last image, Phil Miles captured all 4 moons adjacent to the planet (Io emerging from occultation, Europa in transit, Ganymede and Callisto beyond the planet at lower right).

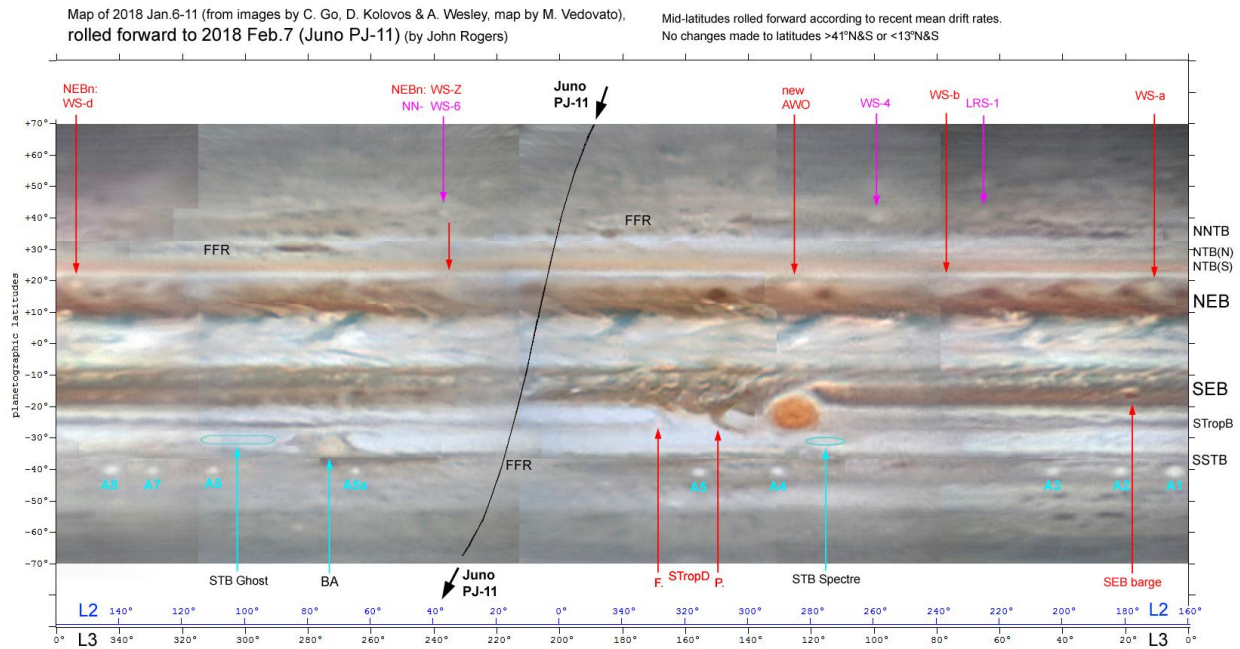


**Figure 3.** Methane-band images in 2017 Dec., at 889 nm, by Chris Go (top) and Phil Miles (bottom).

- (a) Sector with the SEB barge (visible as a small methane-dark spot).
- (b) Sector with oval BA (methane-bright oval).
- (c) Sector with GRS (methane-bright oval) and STropD (methane-dark, f. GRS) and NN-LRS-1 (methane-bright spot at upper right of images). NEB waves are very prominent in all sectors.



**Figure 4.** Some of the best colour images from 2018 Jan.12-17 (and one from Jan.7).  
 (a) Sector with the SEB barge. (b) Sector with SEB rifts and the STropD; GRS near p. limb.  
 (c) Sector from the GRS (near f. limb) to the SEB barge (near p. limb).



**Figure 5.** Predictive map for 2018 Feb.7 (Juno Perijove-11), with Juno's track marked.