Jupiter in 2021: Report no.6

Bright plume outbreaks in the narrow NEB(S)

John Rogers (BAA) (2021 Dec.18)

Summary: This interim report deals with the small brilliant white spots in the narrow dark NEB(S) that captured observers' attention in November, in the absence of other activity in the NEB. One of them was imaged by JunoCam. There have actually been six such outbreaks this year, with only local, transient effects, though such an outbreak could eventually initiate the expected NEB Revival. Meanwhile, the NEBs jet has accelerated to 'super-fast' speeds as the usual NEBs dark formations have disappeared. This report is partly compiled from comments by observers including Clyde Foster, Andy Casely & Chris Go, and especially from analysis by Shinji Mizumoto, whose maps and charts are reproduced here by permission.

Introduction: The NEB has been in a very exceptional state in 2021: it has faded across almost its whole width, leaving only a very narrow, dark reddish-brown NEB(S) component. There is also a series of very dark brown barges that stand out strongly in the whitened northern NEB, and a series of anticyclonic ovals in the NTropZ that now have rather little contrast. The belt is also very quiet, with none of the usual 'rift' activity within it. All this is similar to the state in 2011-12, which was terminated in 2012 by the first full NEB Revival for nearly a century [references 1-3], and it is likely that a similar NEB Revival will occur soon. According to the usual 3-year schedule for such events, it will probably start in 2023, but an earlier date cannot be ruled out.

The November outbreaks: One small brilliant white spot at ~10°N was noticed in the NEB(S) by Clyde Foster on Nov.1. It was a bright spot in his methane-band image then, but faded in methane for the next five days in Japanese observers' images. After about a week it extended tenuous white streaks to Sp. and Nf., like a miniature NEB rift, and extremely methane-dark spots appeared adjacent to it. Also after about a week, the dark brown NEB(S) became broadened Nf. the plume, giving the impression of a wake that was disrupting the whitish cloud cover of the mid-NEB. Maps of this outbreak, by Shinji Mizumoto, are in Figure 1. All this suggests that this was a convective plume outbreak, and vigorous updraft in the plume has probably led to adjacent downdrafts and a disturbed wake. However, all this was localised and did not progress to a general revival of the belt.

A second bright white, methane-bright spot appeared on Nov.21, 18 deg f. the first one. Mizumoto's longitude chart for these white spots is in Figure 2 (spots 5 & 6). He noted that the first one moved south and accelerated (from DL1 = +2.8 deg/d to DL1 = -0.7 deg/d), and the second one appeared on the extrapolated original track of the first, so the two outbreaks may have come from a common source. A prominent dark blue, very methane-dark formation developed on NEBs between the two outbreaks (Fig.3) though it was short-lived.

Juno's images: By good fortune, Juno passed directly over this outbreak at PJ38 on Nov.29. Although the outbreak was declining rapidly at the time (see images in Fig.3), JunoCam showed it as a raft of bright white cloud with thinner haloes and veils in various colours (Fig.4).

Previous outbreaks: This was not the first time that such spots had appeared in the NEB(S). A survey of Mizumoto's maps showed that there were four similar outbreaks previously this year, beginning on approx. May 4 (renewed on May 23), May 31, Aug.18, and Sep.13, before the latest ones that began on Nov.1 and 21 (see his chart in Fig.2). All of these small

outbreaks at ~10°N were similar. Most of them elaborated to produce bright white spots p. on NEBs and dark brown streaks f. into the NEB, like the present one, and the bright plume usually moved south to NEBs. They all died out within a few weeks.

Mizumoto's chart (Fig.2) shows that all these outbreaks occurred close to a single track, with DL1 ~ +1.3 deg/d suggesting that they all erupted from a single, otherwise unseen, disturbance. This would correspond to a latitude of ~10°N, as observed. (If the first two outbreaks are omitted, the later ones fit better to DL1 ~ +0.4 deg/d.)

They are similar to tiny brilliant spots that have been noticed in NEB(S) in other years; they were quite common in 2019 (e.g., see our report on Juno at PJ20) and generally do not develop into larger rifts or disturbances. However, the NEB Revival in 2012 did begin with bright spots in this latitude [ref.3]. So spots like these could eventually initiate the next NEB Revival.

Acceleration of the NEBs jet: Another remarkable aspect of the NEBs is revealed by the latest charts from the JUPOS team (Fig.5): the NEBs jet has accelerated to 'super-fast' speed, just as it did in 2011 [refs.1&2]. Speeds in this range (DL1 ~ -40 to -80 deg/30d, *u* ~ 125-144 m/s) were never recorded by ground-based observers until the late 2000s, and developed all around the NEBs in 2011. In 2021, just as in 2011, the usual large NEBs dark formations (NEDFs) subsided and gradually disappeared; the JUPOS chart allows the last surviving ones to be identified by the near-zero DL1 of their p. ends (near-vertical shaded bands). These disappeared in August, and around that time, much faster tracks appeared on the chart, representing smaller features on the NEBs.

From Aug.to Oct., there were at least 5 features with DL1 = -33 to -43 deg/30d (one persisting into Nov.); in Oct. these were at L1 ~ 20-70, p. the extrapolated track of the last NEDF. But there were also at least 5 features with DL1 = -61 to -77 deg/30d, at L1 ~ 130-180, f. the track of the last NEDF. These drifts, albeit quite sparse, are consistent with the gradient of speed with longitude relative to dying NEDFs that was recorded in 2011 [ref.2]. In Nov-Dec., fast speeds are seen all around the NEBs, DL1 ranging from -51 to -79 deg/30d.

References:

These are our 3 papers on the NEB and its cyclic upheavals, published in the Journal of the BAA and available at: https://britastro.org/node/15627 (preprints & abstracts) & https://britastro.org/node/7229 (published PDFs).

Rogers JH (2019 Feb.) JBAA 129 (no.1), 13-26. 'Jupiter's North Equatorial Belt and Jet: I. Cyclic expansions and planetary waves.' Also at: http://arxiv.org/abs/1707.03343.

Rogers JH (2019 April) JBAA 129 (no.2), 94-102. 'Jupiter's North Equatorial Belt and Jet: II. Acceleration of the jet and the NEB Fade in 2011-12.' Also at: http://arxiv.org/abs/1809.09719.

Rogers JH & Adamoli G (2019 June) JBAA 129 (no.3), 158-169. 'Jupiter's North Equatorial Belt and Jet: III. The 'great northern upheaval' in 2012.' Also at: http://arxiv.org/abs/1809.09736.

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Figures:

(North is up in all figures)

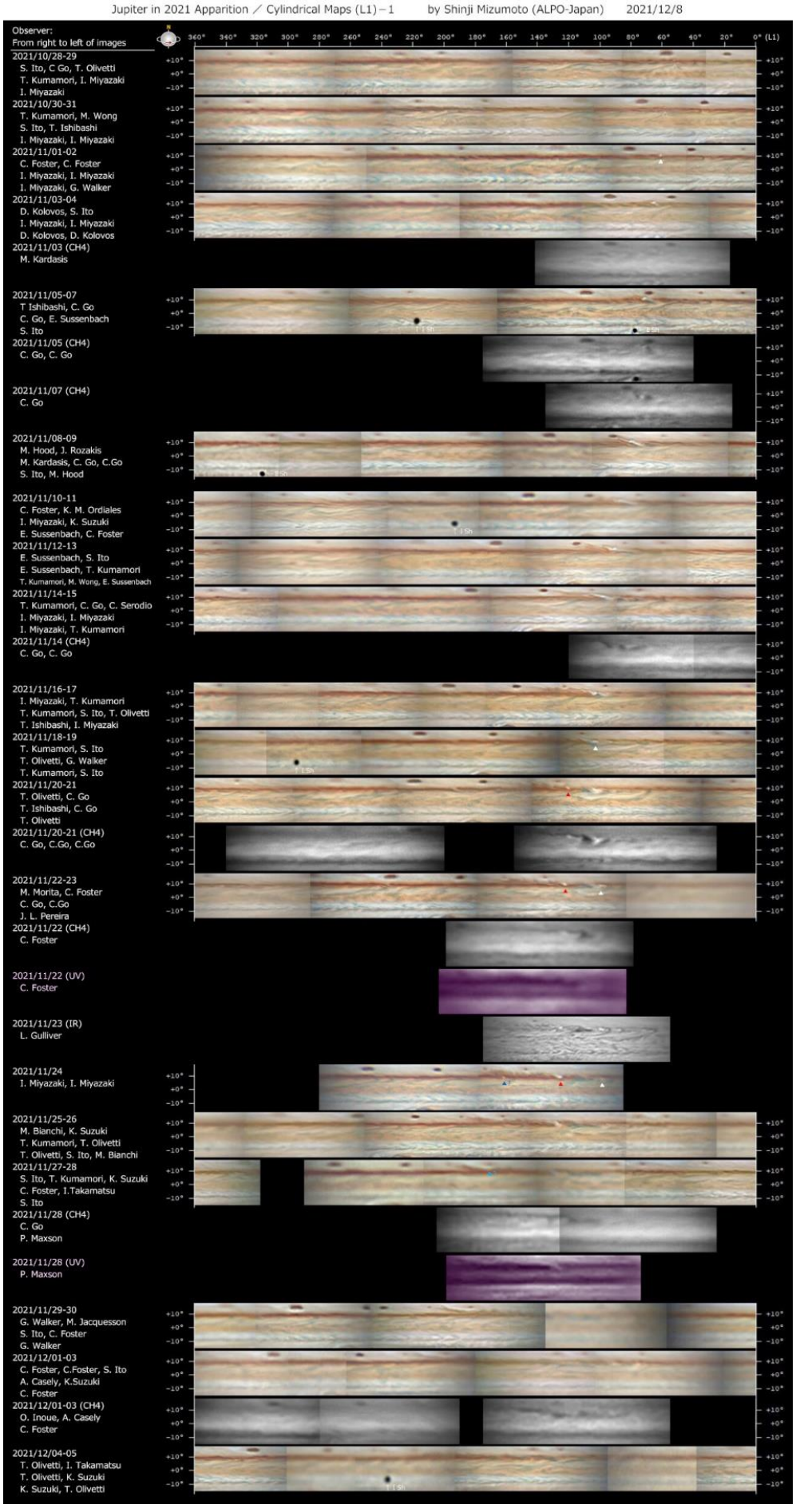
Jupiter in 2021 Apparition / Cylindrical Maps (L1) – 1 by Shinji Mizumoto (ALPO-Japan) 2021/12/8
Observer:
From right to left of images
2021/10/28-29
S. Ito, C Go, T. Olivetti
T. Kumamori, I. Miyazaki
I. Miyazaki
2021/10/30-31
T. Kumamori, M. Wong
S. Ito, T. Ishibashi
I. Miyazaki, I. Miyazaki
2021/11/01-02
C. Foster, C. Foster
I. Miyazaki, I. Miyazaki
I. Miyazaki, G. Walker
2021/11/03-04
D. Kolovos, S. Ito
I. Miyazaki, I. Miyazaki
D. Kolovos, D. Kolovos
2021/11/03 (CH4)
M. Kardasis
2021/11/05-07
T Ishibashi, C. Go
C. Go, E. Sussenbach
S. Ito
2021/11/05 (CH4)
C. Go, C. Go
2021/11/07 (CH4)
C. Go
2021/11/08-09
M. Hood, J. Rozakis
M. Kardasis, C. Go, C.Go
S. Ito, M. Hood
2021/11/10-11
C. Foster, K. M. Ordiales
I. Miyazaki, K. Suzuki
E. Sussenbach, C. Foster
2021/11/12-13
E. Sussenbach, S. Ito
E. Sussenbach, T. Kumamori
T. Kumamori, M. Wong, E. Sussenbach
2021/11/14-15
T. Kumamori, C. Go, C. Serodio
I. Miyazaki, I. Miyazaki
I. Miyazaki, T. Kumamori
2021/11/14 (CH4)
C. Go, C. Go
2021/11/16-17
I. Miyazaki, T. Kumamori
T. Kumamori, S. Ito, T. Olivetti
T. Ishibashi, I. Miyazaki
2021/11/18-19
T. Kumamori, S. Ito
T. Olivetti, G. Walker
T. Kumamori, S. Ito
2021/11/20-21
T. Olivetti, C. Go
T. Ishibashi, C. Go
T. Olivetti
2021/11/20-21 (CH4)
C. Go, C.Go, C.Go
2021/11/22-23
M. Morita, C. Foster
C. Go, C.Go
J. L. Pereira
2021/11/22 (CH4)
C. Foster
2021/11/22 (UV)
C. Foster
2021/11/23 (IR)
L. Gulliver
2021/11/24
I. Miyazaki, I. Miyazaki
2021/11/25-26
M. Bianchi, K. Suzuki
T. Kumamori, T. Olivetti
T. Olivetti, S. Ito, M. Bianchi
2021/11/27-28
S. Ito, T. Kumamori, K. Suzuki
C. Foster, I.Takamatsu
S. Ito
2021/11/28 (CH4)
C. Go
P. Maxson
2021/11/28 (UV)
P. Maxson
2021/11/29-30
G. Walker, M. Jacquesson
S. Ito, C. Foster
G. Walker
2021/12/01-03
C. Foster, C.Foster, S. Ito
A. Casely, K.Suzuki
C. Foster
2021/12/01-03 (CH4)
O. Inoue, A. Casely
C. Foster
2021/12/04-05
T. Olivetti, I. Takamatsu
T. Olivetti, K. Suzuki
K. Suzuki, T. Olivetti

Figure 1

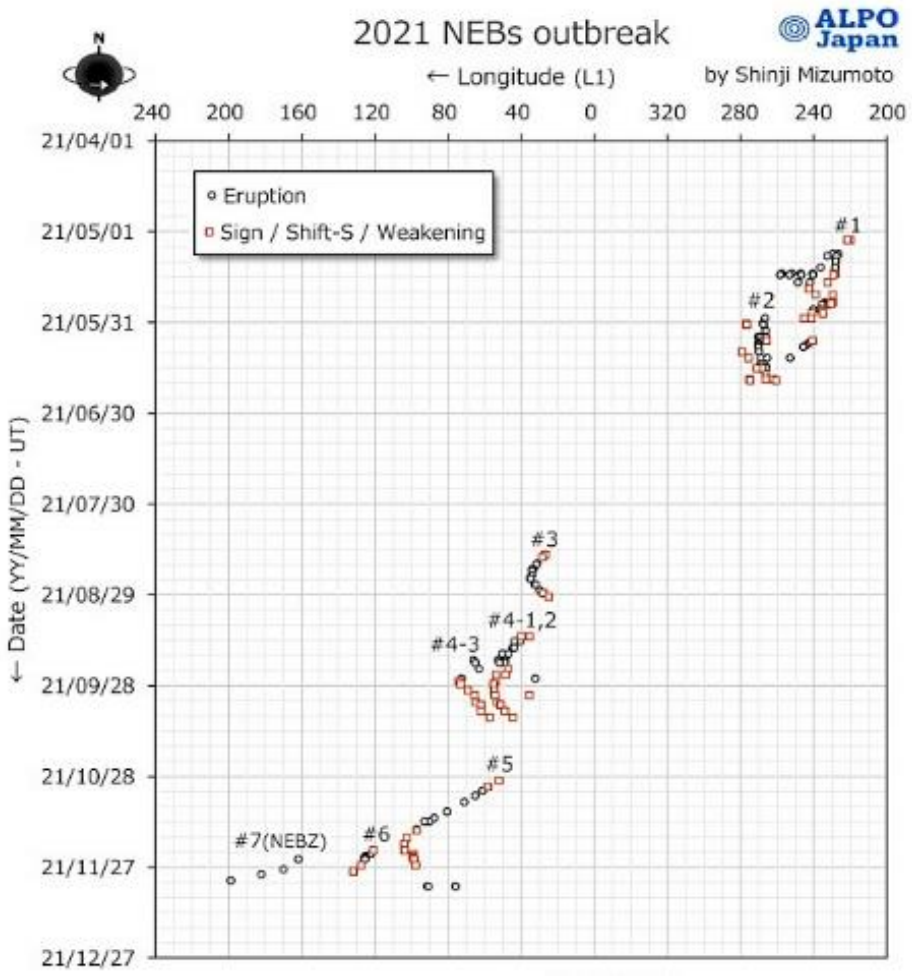
2021 NEBs outbreak
ALPO Japan
by Shinji Mizumoto
← Longitude (L1)
240 200 160 120 80 40 0 320 280 240 200
21/04/01
21/05/01
21/05/31
21/06/30
21/07/30
21/08/29
21/09/28
21/10/28
21/11/27
21/12/27
← Date (YY/MM/DD - UT)
Eruption
Sign / Shift-S / Weakening
#1
#2
#3
#4-1,2
#4-3
#5
#6
#7(NEBZ)

Figure 2

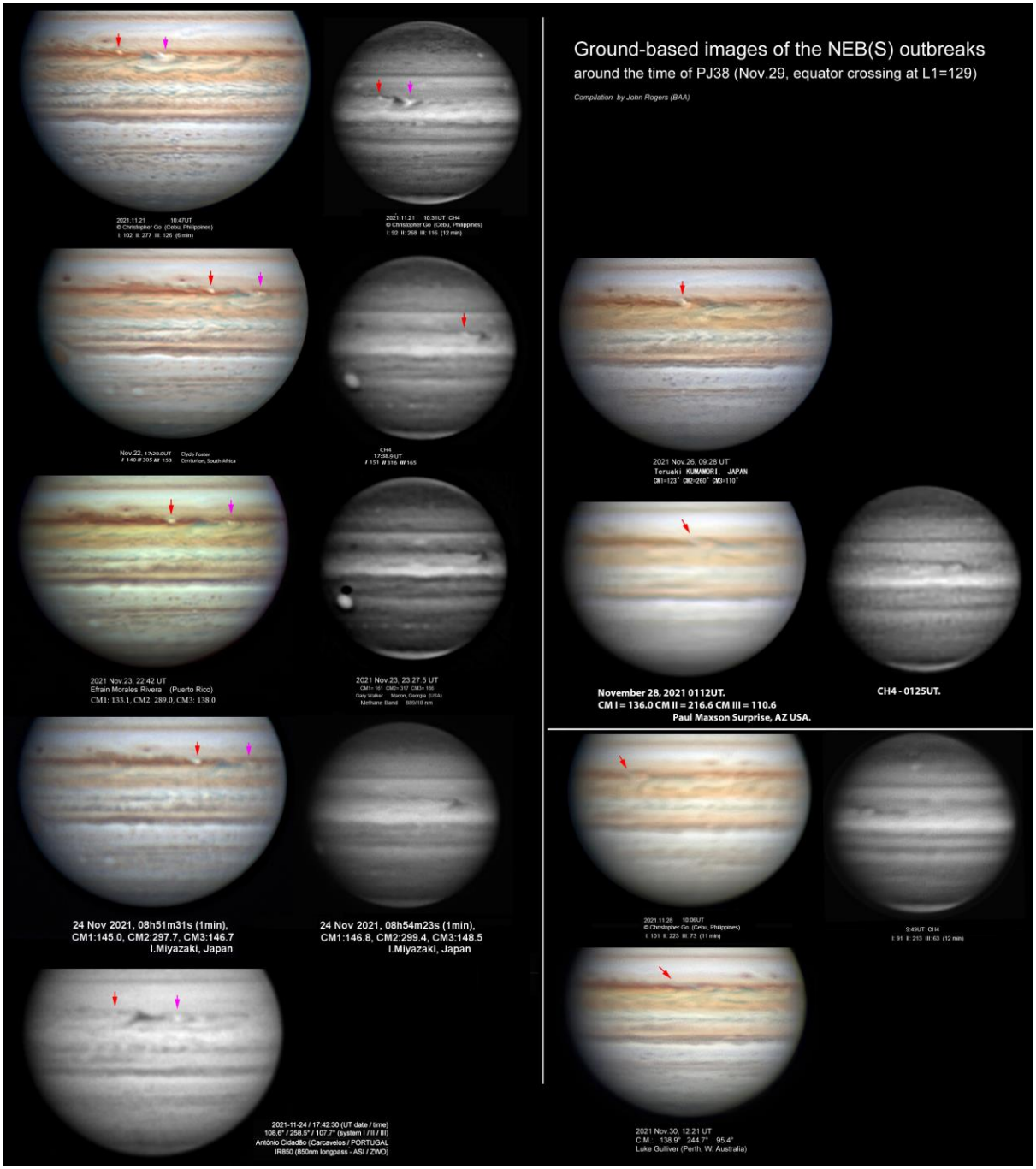
Ground-based images of the NEB(S) outbreaks
around the time of PJ38 (Nov.29, equator crossing at L1=129)
Compilation by John Rogers (BAA)
2021 Nov 26, 09:28 UT
Teruaki KUMAMORI, JAPAN
November 28, 2021 0112UT.
CM I = 136.0 CM II = 216.6 CM III = 110.6
Paul Maxson Surprise, AZ USA.
CH4 - 0125UT.
24 Nov 2021, 08h51m31s (1min),
CM1:145.0, CM2:297.7, CM3:146.7
I.Miyazaki, Japan
24 Nov 2021, 08h54m23s (1min),
CM1:146.8, CM2:299.4, CM3:148.5
I.Miyazaki, Japan
2021 Nov 30, 12:21 UT
Luke Gulliver (Perth, W. Australia)

Figure 3

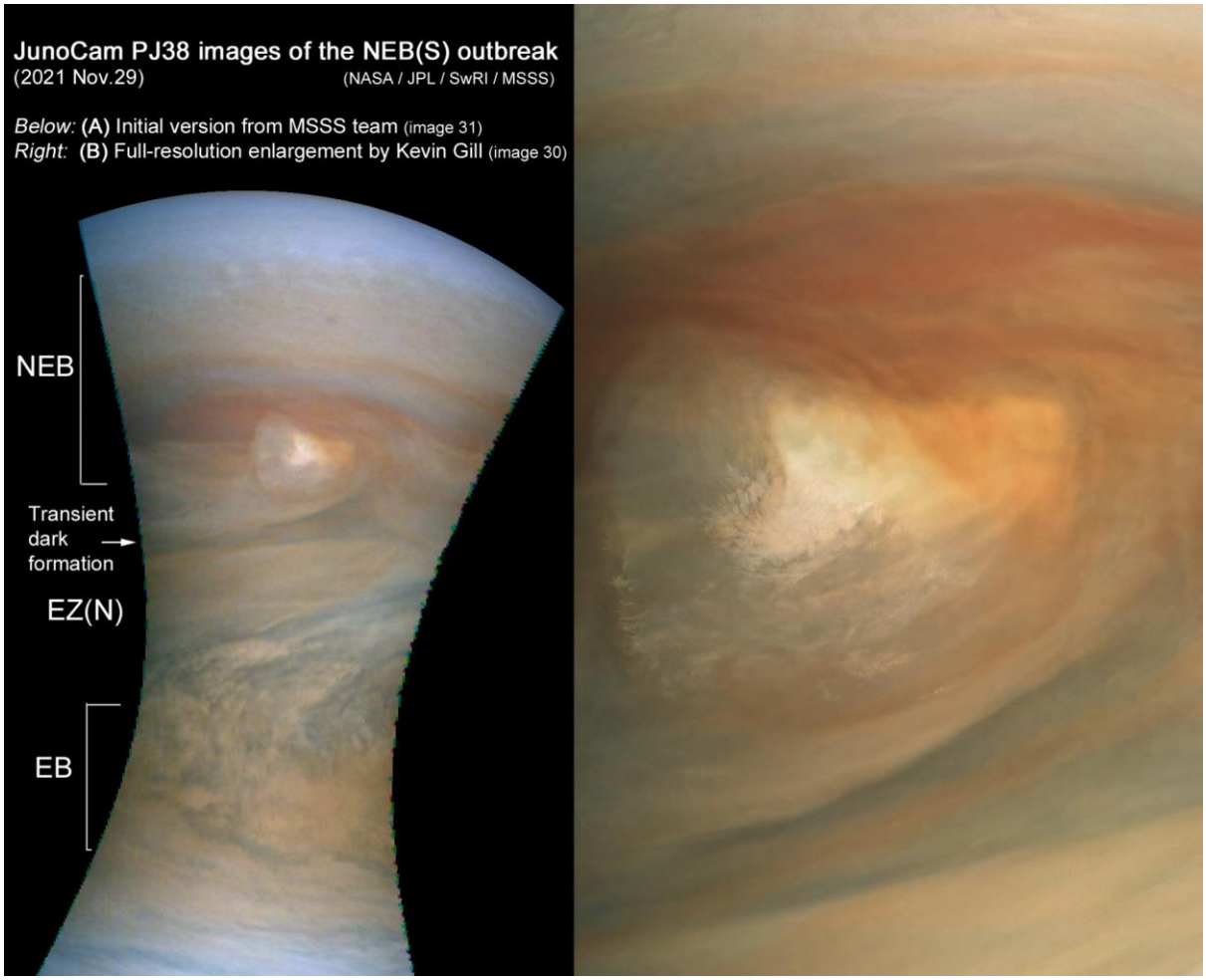
JunoCam PJ38 images of the NEB(S) outbreak
(2021 Nov.29)
(NASA / JPL / SwRI / MSSS)
Below: (A) Initial version from MSSS team (image 31)
Right: (B) Full-resolution enlargement by Kevin Gill (image 30)
NEB
Transient dark formation
EZ(N)
EB

Figure 4

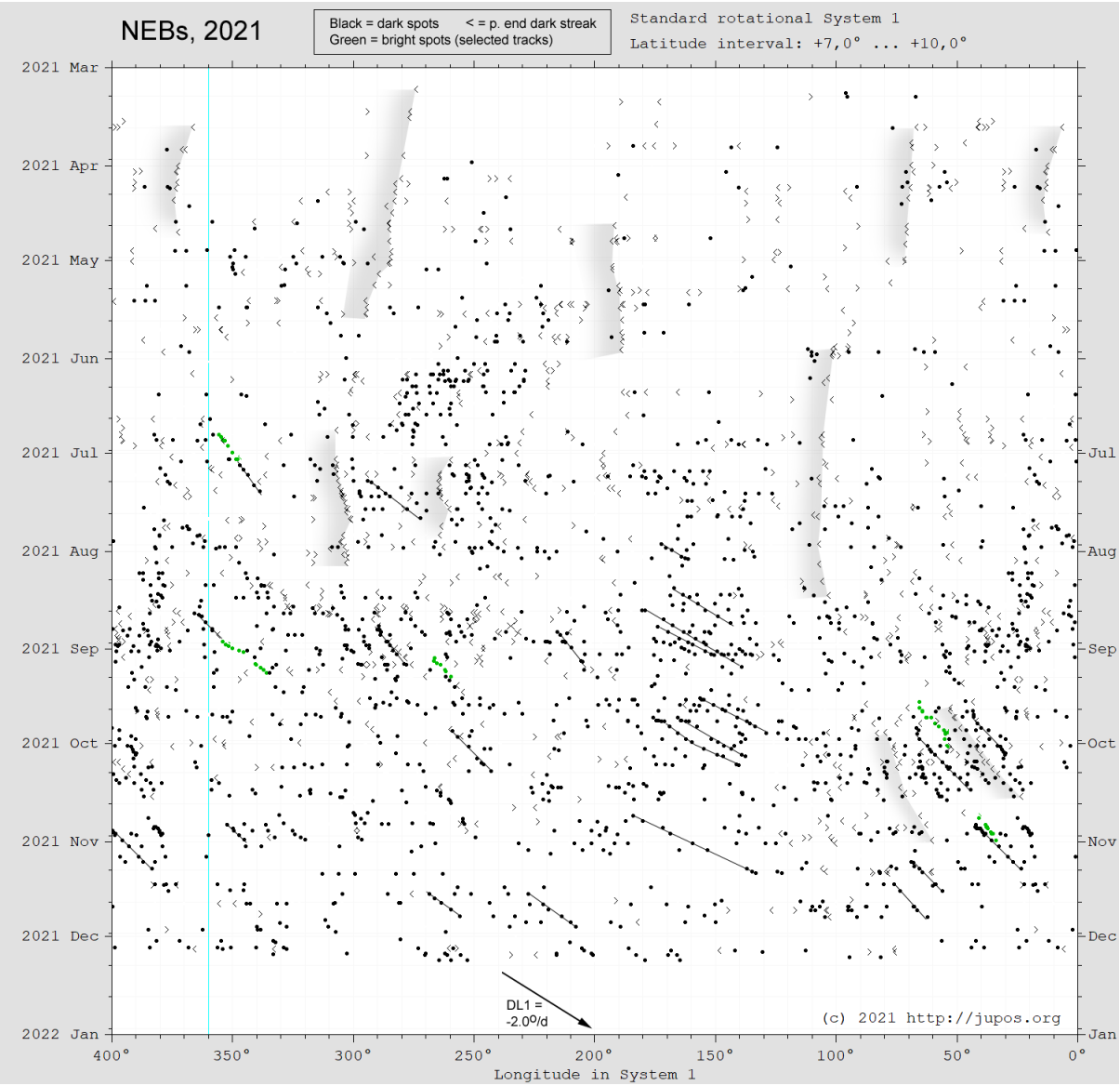
NEBs, 2021
Black = dark spots < = p. end dark streak
Green = bright spots (selected tracks)
Standard rotational System 1
Latitude interval: +7,0° ... +10,0°
2021 Mar
2021 Apr
2021 May
2021 Jun
2021 Jul
2021 Aug
2021 Sep
2021 Oct
2021 Nov
2021 Dec
2022 Jan
Jul
Aug
Sep
Oct
Nov
Dec
Jan
DL1 =
-2.0°/d
(c) 2021 http://jupos.org
400°
350°
300°
250°
200°
150°
100°
50°
0°
Longitude in System 1

Figure 5