Jupiter in 2021/22, Report no.7: Equatorial Region Update

--John Rogers (BAA), 2022 Jan.24

Part I. Slow-moving methane-bright patches on EZ

In 2020, from amateur methane-band (889 um) images, we discovered an unprecedented pattern of waves on the EZ that were almost stationary in System 3 longitude (L3), and thus disconnected from the fast equatorial current [see our 2020 reports no.4 (Part III) & no.5, and Ref.1]. This wavetrain, with wavelength ~20° longitude, was present around L3 ~ 150-250 in 2020 May and July, although not distinctly during most of June. In 2021, similar features have again been observed, but instead of extended wave-trains, they are large isolated methane-bright patches that extend across the whole EZ. As in 2020, they move only slowly in L3, and are principally visible in methane-band images, although they are associated with the orange, UV-dark Equatorial Band (EB). In fact, this year we also detect them in UV images, as the methane-bright patches are centred on UV-dark bulges in the EB. They are usually not evident in RGB images because of interference from streaks of other colours. In methane images they tend to be most obvious when near the limb.

The recorded instances are summarised below, and illustrated in compilations of methane-band images (Figures 1-7), either as cylindrical maps produced by Shinji Mizumoto (ALPO-Japan), or as images. A few UV images are also included. Figures 1-8 are all large compilations of maps or images, provided in a ZIP file.

1. May-June: This methane-bright patch was reported briefly in our 2021 report no.2 & in an EPSC talk (Ref.1)]. It was present at least from May 11 to mid-June (Figs.1&2). It was reported by Chris Go on May 22 and attracted much attention from observers, including professionals, while Shinji Mizumoto made a very useful series of strip-maps by which to track it. It was initially at L3 ~ 245 (overlapping the longitude range of last year's wavetrains). Its south edge was initially a trough in a short wave-train like those in 2020, extending as far as 6-7°S (SEBn), but soon the flanking waves disappeared. Its north edge was an arc projecting to 8-9°N (NEBs); the f. end of this arc remained near L3 ~ 248 since May 22, whereas the p. end accelerated to lower longitudes, suggesting that this methane-bright streak was increasingly affected by the rapid equatorial current (see chart in Fig.2). Many of the subsequent methane-bright patches showed a similar semi-detached northerly streak.

[Figure 1 (maps by Shinji Mizumoto) includes RGB maps which do not show the methane-bright patch, but do show two small, apparently unrelated, white outbreaks in the NEB, both indicated by green arrows:
(i) A rift in the NEB(S) that had begun as a bright point on May 8, and progrades and expands and breaks thru into the EZ(N).
(ii) A small bright white point that appeared following White Spot Z in the northern NEB (at top left): we can see that it only lasted a few days.
(Note that these rifts are not expanding across the width of the NEB, which is extremely quiet, as in 2011.)]

2. In mid-August a similar feature developed near L3 ~ 70, and by Aug.31 there were two similar features at L3 ~ 40 (subsequently nearer 30; this was the least distinct of the three) and L3 ~ 0 (Fig.3). The three of them persisted until Sep.23 (Figs.4&5). By early Oct., they were dissipating, but the initial one still existed at L3 ~ 73 with a very bright northern streak, and a new one was developing at L3 ~ 312 (Fig.6).

The Hubble OPAL maps on Sep.4 (not shown here) include this trio of methane-bright patches, and a blink animation of the methane-band maps shows the complexity of rapidly moving and varying streaks relative to the three larger, quasi-stationary bright areas. They are also clearly visible in UV maps.

3. From Oct.20 to Nov.11, there was an isolated methane bright patch near L3 ~ 310 (probably the same one observed from Oct.6-8 as there were few methane images here in the interim). It was also especially distinct in UV as a dark swelling of the EB. By Nov.20, methane images showed it only as a bay in EZs, and it was not detected thereafter.

4. From Dec.21 to 2022 Jan.5 there was a methane-bright patch at L3 ~ 240-250 (just Nf. the GRS) – mainly shown in images by Joaquin Camarena, Manos Kardasis & Isao Miyazaki (Fig.7). It was only slowly prograding in L3. Like similar patches earlier in 2021, it spanned the EZ with northern and southern arcs; and was quite distinct when near the limb. The last images showing a trace of it were on Jan.12-14.

These were the most prominent and persistent such features during 2021. They appeared at various well-separated longitudes (but not near any of Juno's equator-crossing longitudes). Although this survey may have missed some lesser ones, and there were some gaps in methane-band coverage, such features were definitely absent over large sectors, for instance near the GRS longitudes in Aug. & Sep. The EZ often appeared complex in methane images, and there may well have been a confusing mixture of streaks drifting and evolving at very different speeds, which would require more intensive observation and analysis to dissect (e.g. with the Hubble OPAL maps on Sep.4).

The leading hypothesis for these slow-moving features is that they are at very high altitude. The fast equatorial jets are expected to weaken with increasing altitude until they reach almost zero speed. High-level wind speeds on the equator cannot be readily calculated from available data, and may be variable, but the zero-speed level could perhaps be around 100-200 mbar (interpolating across the equator in Fig.D3 of Ref.2), or around 10-20 mbar (Ref.3). It is plausible that the methane-bright orange haze over the EZ could extend that high. It may be possible to test this hypothesis using IR images in the 2-3 micron range, which Dr Glenn Orton and colleagues have obtained with the NASA IRTF on several dates.

References:

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Part II. Bright plume outbreaks in the narrow NEB(S)

In our 2021 Report no.6 (https://britastro.org/node/26451), we described these outbreaks up to 2021 Dec.4, including one directly observed by JunoCam at PJ38 on Nov.29. Since then, the same active sector has intensified with two more outbreaks starting on Dec.18 and Jan.9. Figures 8 & 9, from Shinji Mizumoto, continue the series in Report no.6.

Outbreak no.7 behaved just like its predecessors. It began as a tiny white spot on Dec.18, brighter on Dec.21, initially with positive DL1, and after about a week, a very dark bluish, very methane-dark spot formed adjacent to it. The growing bright spot then moved south to break thru into the EZ (forming a miniature plume head, like that of no.6 that was imaged at PJ38) and changed to negative DL1: ~-1.7 deg/day, i.e. in the same super-fast range exhibited by other features on NEBs at this time. Meanwhile the (extremely) methane-dark spot, at 9°N, retained its positive DL1: ~+1.7 deg/day, which would be normal for a latitude of 10°N.

Outbreak no.8 appeared close to plume no.7 on Jan.9. It again had a northerly latitude and positive DL1, which it has retained, as it passed along the increasingly disturbed sector between plume no.7 and its methane-dark spot. We await Juno's PJ39 images within this sector. Any further developments will be of great interest given the very abnormal state of the NEB at present, but may be lost to us due to the imminent solar conjunction.

Figure 9: