The opposition of Mars, 2016: Part II

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In Part I we described the interplay of airborne and settled dust with surface features. Here we review meteorological phenomena. Seasonal date limits for the Equatorial Cloud Band and orographic clouds were similar to past years. Despite an unfavourable value of tilt, north polar spiral clouds were witnessed during *Ls* = 126–153°. Frontal systems, in the form of bands of clouds inclined to the equator and moving off the N. polar region, were recorded. Observers watched to see if the near-opposition coincidence of the sub-Earth and subsolar latitudes on 2016 May 20–21 would result in 'flashes' from the *Schiaparelli* crater in *Edom*, as in 2001, but the +10° coincidence in the latitude fell too far north, and none were reported. The detachment of *Olympia* from the NPC occurred by *Ls* = 72°. The N. polar cap was progressively covered by the hood during *Ls* = 163–172°, later than in 2014, while the cap summer remnant was larger in 2016; the recession was less extensive than in 2014. *Novus Mons* separated from the shrinking S. polar cap by *Ls* = 243°.

Introduction

Part I dealt with surface features and dust storms.[39] Part II focuses upon white clouds and polar regions. The numbering of figures and references continues consecutively from Part I.

White clouds & blue-violet light phenomena

These meteorological indicators were previously described and explained:[1,2] see Figures 13–19.

Equatorial Cloud Band (ECB)

Seasonal commencement was unobservable, though the ECB was present and complete to Morita and Olivetti by 2015 Nov 14–15 (*Ls* = 68–69°), and remained prominent through 2016 March (Figure 14). It faded in April. Kumamori on Apr 11–15 showed it complete but weak, while on Apr 19 (*Ls* = 140°) it was pale and only partially visible. The best data showed that in its later stages it consisted of fibrous, partially complete east–west cloud streaks. For instance, Akutsu, Kumamori and Olivetti on Apr 29 – May 1 showed this aspect around CM = 230–300° (Figure 14). Possibly the last trace of partial ECB was caught by Olivetti on May 6 around CM = 210°, at *Ls* = 148°.

Peach (Figure 14) continued to record fragments of streaky clouds in his high-resolution June images, particularly in the N. polar region, although the ECB season had finished.

The *Syrtis* Blue Cloud

Seasonal commencement of this too was unobservable, but the feature was recorded for certain in the morning and/or evening from 2015 Nov 23 – 2016 Apr 28: nearly the same epoch as the ECB.

As usual, one or more discrete clouds were sometimes seen over central *Syrtis Major*, near the evening limb. Morales caught one on Feb 29. Many observers showed these clouds more prominently – and in considerable detail – from around Mar 16 till May 13 (*e.g.*, Akutsu's Apr 29 image in Figure 14). Justice and Valimberti found them hardly visible by May 24: our final sightings.

The *Hubble Space Telescope* (HST) obtained a superb image of such a cloud on May 12,[40] bearing a striking resemblance to its shape upon Foster's image of May 2 (Figure 17).

Orographic clouds

The evening *Tharsis Montes, Olympus Mons, Alba Patera & Elysium Mons*

The orographic clouds over the Martian volcanoes were beautifully seen in the months leading up to opposition (Figures 13–14 and Part I, Figures 2–4), although their seasonal commencement was unobservable. They were still visible up to the time when we could no longer access the evening terminator, so that the later date limits quoted do not represent a seasonal limit.

Elysium Mons

Bright in the evening over this range: 2015 Nov 28 (or earlier) – 2016 Jun 24.

Olympus Mons

Bright in the evening upon images during: 2015 Nov 14 (or earlier) – 2016 Jun 20 (very weak on this latter date). Visually, Gray saw the evening cloud here even earlier, on 2015 Sep 11. In March–April, the banner cloud streaking to the west of the caldera was especially well seen: see Part I, Figure 3.

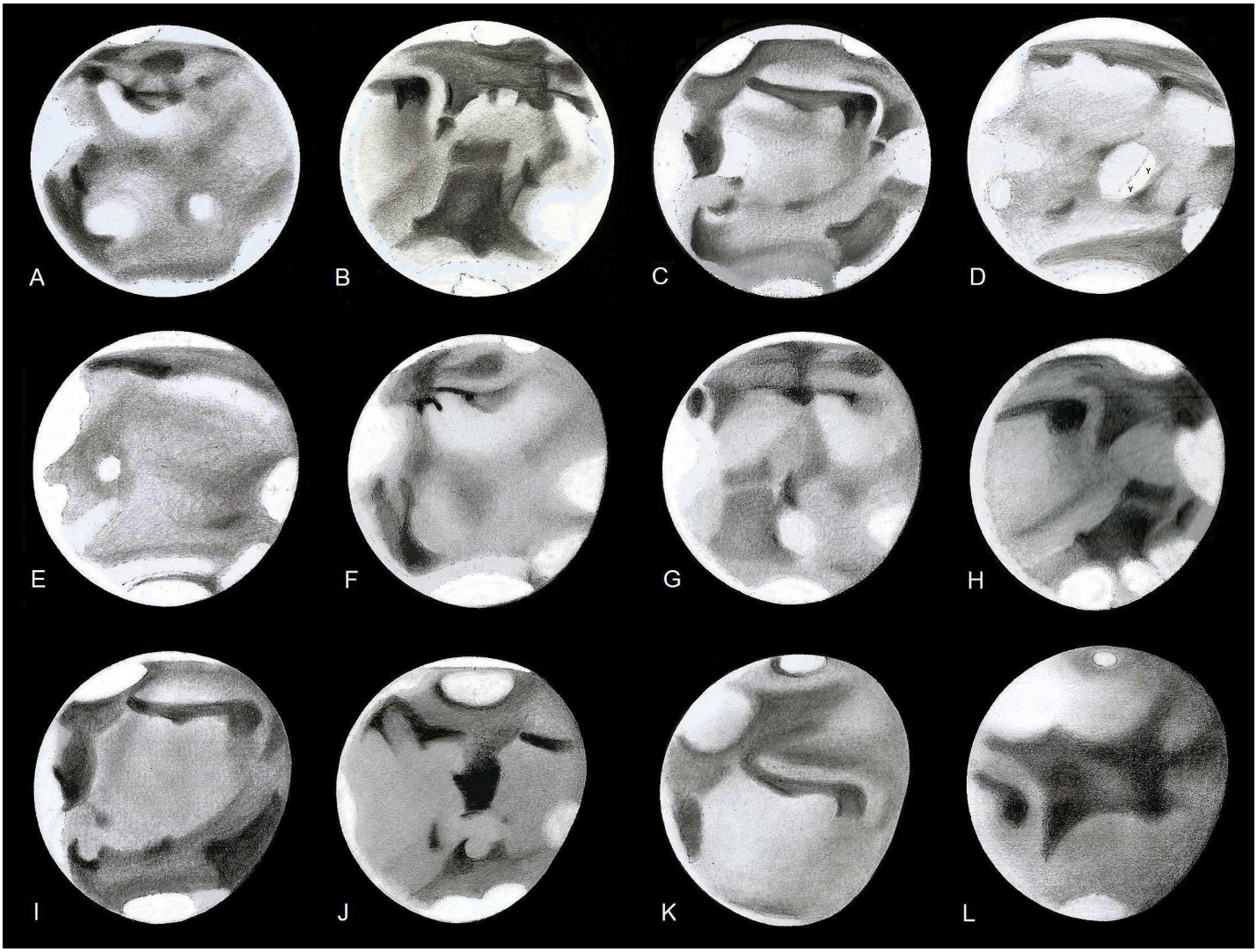

Figure 13. Drawings of Mars in 2016–'17 by R. J. McKim (410mm DK Cass., ×265, ×311, ×410; white light and W23A orange filter).

(A) 2016 May 27, 21:40 UT, CM = 091°; orographic clouds; *Argyre* bright in (A)–(C).
(B) 2016 Jun 4, 21:55 UT, CM = 024°; polar clouds seen around the NPC remnant.
(C) 2016 Jun 9, 21:40 UT, CM = 336°; *Pandorae Fretum* invisible (and in (I)).
(D) 2016 Jun 22, 20:50 UT, CM = 207°; bright dust fallout at W. *Elysium* (indicated 'YY'); SPC now visible.
(E) 2016 Jun 27, 21:20 UT, CM = 169°; 'front' south of NPH.
(F) 2016 Jul 5, 20:58 UT, CM = 090°; *Baetis*, and the *Tharsis Montes* faintly visible.
(G) 2016 Jul 8, 20:40 UT, CM = 058°.
(H) 2016 Jul 13, 21:50 UT, CM = 029°; complex N. polar clouds.
(I) 2016 Jul 17, 20:32 UT, CM = 333°; evening cloud at *Hellas*.
(J) 2016 Jul 22, 21:00 UT, CM = 293°; large NPH; *Nodus Alcyonius* well seen.
(K) 2016 Oct 31, 17:20 UT, CM = 347°; *Pandorae Fretum–Mare Serpentis* darkened.
(L) 2017 Jan 5, 17:25 UT, CM = 055° (*D* = 5.6″); SPC summer remnant.

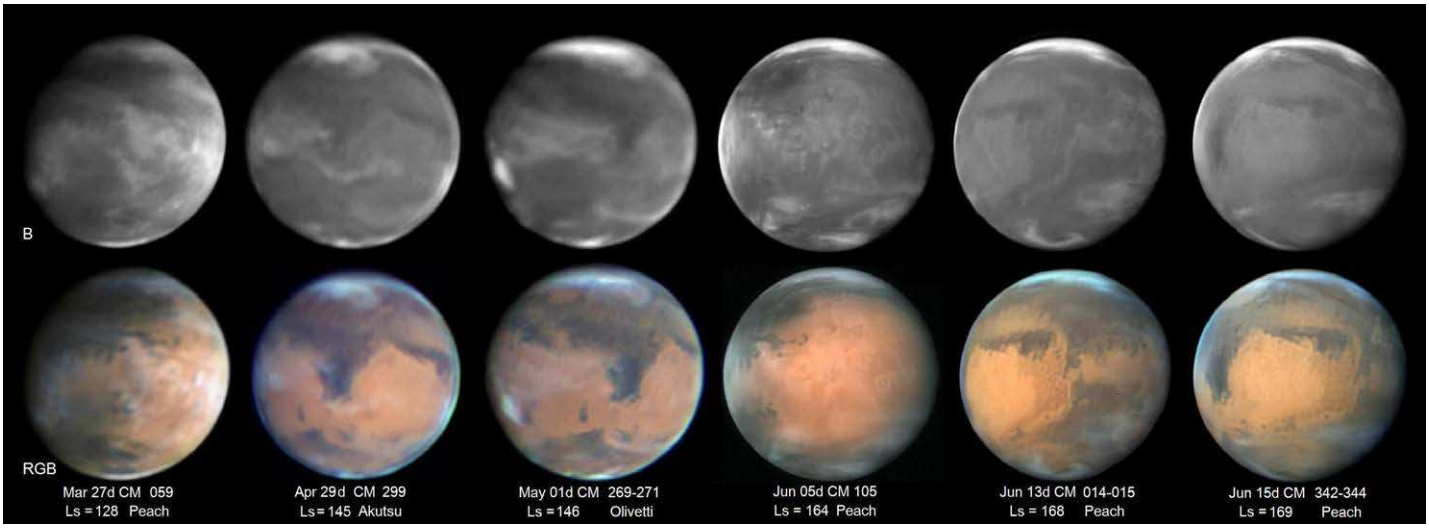

Figure 14. High-resolution blue-light images (with RGB comparisons) taken in 2016, showing the Equatorial Cloud Band in March–May, orographic clouds, and long strips of E–W cloud in the S. and N. polar regions. By Akutsu (ASI 290MM camera), Olivetti (Blackfly ICX692 and Astrodon B filter) and Peach (ASI 120MM-S and Astronomik B filter). The *Ls* values are indicated.

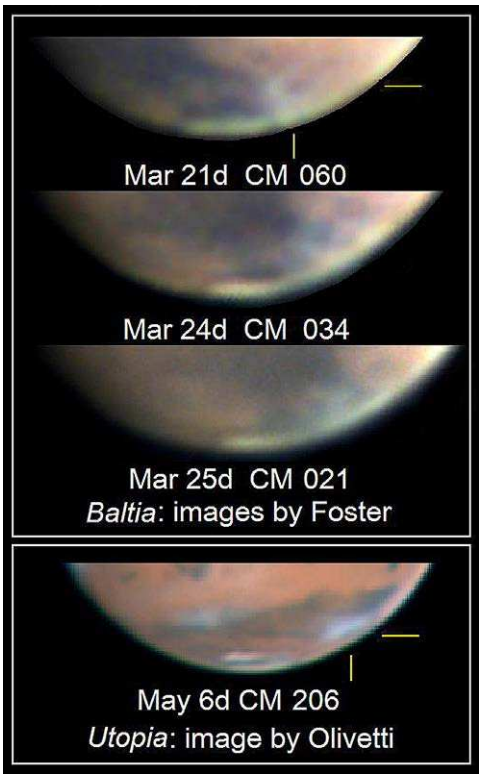

Figure 15. N. polar spiral clouds in 2016, according to RGB images by Foster (ASI 224MC camera) and Olivetti (Blackfly ICX692).

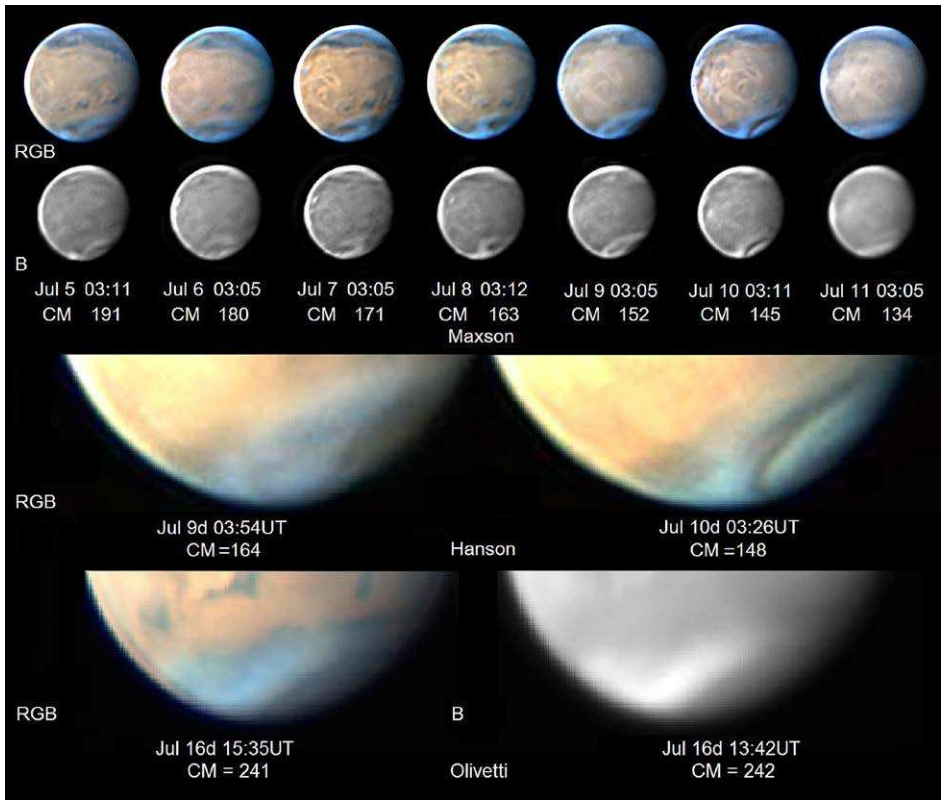

Figure 16. N. polar cloud fronts in 2016, according to RGB and B images by Hanson (ZWO 174MM camera), Maxson (ASI 290MM) and Olivetti (Blackfly ICX692).

The *Tharsis Montes*

Arsia Mons was observed in the evening from 2015 Nov 14 (or earlier), till 2016 Feb 2 (*Ls* = 103°). After this it was smaller and less conspicuous, but it became bright again during Apr 27 (*Ls* = 144°) – Jun 18.

The MRO cameras found seasonally later white cloud activity at *Arsia*, which was much reduced by the atmospheric warming caused by a large Regional dust storm in 2017 February–March.[39] This could no longer be checked using ground-based data.

Pavonis Mons appeared bright in the evening over the range 2015 Nov 14 (or earlier) – 2016 Jun 18.

Ascraeus Mons was bright in the evening over 2015 Nov 14 (or earlier) – 2016 Jun 18. (Maxson imaged a trace of it again on Jul 6 & 10, but otherwise it was not seen after Jun 18.)

Alba Patera

Bright in the evening over this range: 2015 Nov 14 (or earlier) – 2016 Jun 18 (very small and weak during Jun 14–18).

The morning *Montes*

With the ECB season already finished by opposition, the summits of the *Tharsis Montes* poking through this extensive cloud belt near the morning terminator could not be well observed. Some observations between mid-February and mid-May do show the phenomenon close to the limb. When, after opposition, there happened to be patchy white clouds near the terminator, it was also occasionally seen: for example, to Peach on Jun 8–10, Kumamori on Jun 26 and Morita on Jul 29.

N. polar spiral clouds

In 1999,[41] BAA data recorded N. polar clouds from *Ls* = 127° onwards. In 2012,[1] the clouds revealed a spiral character from *Ls* = 129°, while in 2014 this vorticity had been apparent slightly earlier,[2] from *Ls* = 124°. The value of D_e at the right season in 2016 was unfavourable, the seasonal period falling well before opposition, with the dawn terminator – where the polar clouds are always best formed – not yet observable. Nonetheless, positive sightings were recorded: see Figure 15.

Seasonally first to appear are the clouds at *Baltia–Mare Boreum*. Spacecraft data (*Mars Express*) first revealed an irregular a.m. cloud here from Mar 9 (*Ls* = 120°) and clear spirality during Mar 11–21. (On Mar 22 a patch of dust was also caught by MRO at the edge of the cap, but below telescopic resolution.) Our observers were quick to follow, and on Mar 21 & 24, Foster recorded a small, shapeless polar cloud following *Mare Acidalium*. On Mar 25 & 26 there was a faint but definite spiral cloud with a darker hollow centre on the morning side at *Baltia*, and the same type of feature appeared, less perfectly, on Mar 27–28.

Foster and Morales on May 5–9 caught a dusty white cloud here, showing once again that dust can be associated with these seasonal features. (See also Part I.) The HST on May 12 imaged a very irregular spiral. Kumamori saw a.m. cloud on May 21–30; on the last date (*Ls* = 161°) he imaged a dark patch at the terminator with cloud around it: a partial spiral. On Jun 2, Dijon saw

an irregular spiral at *Baltia*. Later observations mostly revealed only the normal clouds forming the north polar hood (NPH): for example, on Jun 4 the author saw irregular southward projections from the hood, while on Jun 11 a vertical white streak was recorded by Olivetti. However, a very small spiral can be traced upon Wesley's Jun 22 image.

Polar clouds over *Utopia* begin seasonally later. Maxson imaged morning cloud there from Apr 22 (Ls = 141°) and many observers up till May 7 saw them, while Olivetti's image of May 6 showed a curved streak above *Utopia*: a partial spiral. Many recorded weak a.m. cloud here up till Jun 3.

Evening remnants of the *Utopia* clouds were seen occasionally. Several observers on Jun 1 recorded a N–S elongated streak, not obviously cyclonic. In late May, evening cloud had been seen here in conjunction with a banner cloud off the subliming north polar cap (NPC) outlier, *Olympia*, suggesting a link between the two phenomena: see Part I, Figure 5 (especially May 20).

In summary, the clouds appeared during Ls = 126 till 161°, and sometimes showed vorticity from Ls = 127°. The corresponding values for 2014 were Ls = 117–153° and Ls = 124°.[2] Historical data show these phenomena, albeit at lower resolution.[42] Schmude has recently discussed NPH and annular cloud activity.[43]

'Violet holes'

Examples of these features – darkenings in blue light interpreted as a local lack of atmospheric water vapour – were again observed. We mention only striking examples.

In blue-light images of 2016 Jun 11–16, Peach recorded a pair of well-defined and parallel dark bands running diagonally S*p*. to N*f*., linking the N. edge of the SPH to *Mare Erythraeum*: see his Jun 15 image in Figure 14 (and for Jun 18, see Part I, Figure 3B). These anomalies are even obvious in colour images as dark reddish-brown bands. A small, bright white cloud was evident on the E. side of the streak, trailing N*f*. and distinctly separated from the bright white cloud in southern *Hellas*. Thus the streaks lay between high concentrations of water vapour. The phenomenon was already less evident on Jun 17–18. The W. part of the foregoing dark feature was also apparent upon blue images and RGB composites by Kumamori (Part I, Figure 3D), Morita and others in May. The *Hellas* basin had become frost-free by about Jun 7 (see later), and had ejected streaks of dust to the west several days prior to Jun 11. One of the reddish bands described closely marked part of the trajectory, so the coincidences with the violet holes were not accidental. An association between such streaks and dust activity was identified during the 2005 October Regional dust storm.

Tanais, which runs northwest from the NW corner of *Mare Acidalium*, was also apparently darkened in some images during May and June (see also Part I, Figure 3E). It lay adjacent to seasonal bright polar clouds, denoting high concentrations of water vapour. Morita imaged the same darkening on Mar 15. Recall the cessation of the ECB around Ls = 140°; the May observations fell shortly afterwards.

Martian 'flares'

No 'flares' or flashes were observed in 2016. In 2001 June, D_e and D_s (the latitudes of the sub-Earth and subsolar points) briefly coincided at +2.1°, within the boundaries of *Schiaparelli* crater (lat. +1 to –6°, long. 339.5 to 347°) inside *Edom*. Bright flashes were observed (from reflective mineral sheets upon the crater floor), reminiscent of the 1954 sightings.[44]

On 2016 May 20–21 (D = 18.3″) D_e and D_s again coincided near opposition, but this time at latitude +10°, to the north of *Edom*. (Longitude 343.2° marks the centre of *Schiaparelli* crater, which transited the meridian at 10:08 & 10:44 UT on those dates, limiting observations to the longitude of Australasia.) With the phase angle i close to 0°, two days prior to opposition, the correction of i/2 needed for any specular reflection, 'flare' or 'flash' event was negligible.[44] (On May 20, i/2 = 1.0°; on May 21, i/2 = 0.6°, involving a maximum correction of four minutes to predicted times.) Few images for May 20–21 showed *Edom* close to the CM. The nearest were Weldrake's. His May 20 images from 10:59–11:58 UT show no brightness enhancements. On May 21, Adachi saw nothing unusual visually at 12:10 UT, and on May 21 & 22 Morita and Konnai obtained negative results with *Edom* somewhat past the CM; the Australians likewise on May 24 and later.

Minami considered that an *Edom* 'flare' might possibly be caught during Aug 10–31, during which time the value of $(D_e + D_s)/2$ lay between +1° and –6°. But none was reported. Another coincidence in D_e and D_s was on 2016 Dec 24–25 (D = 5.9″), for latitude –24°. We know of no positive observations then.

Polar regions

North polar region

The NPH & NPH/NPC transition

The NPH & NPH/NPC transition was unobserved: observations in 2015 had begun at Ls = 34°, well after the NPH would have dispersed. The NPH reformed in 2016 June, as described later.

NPC recession

Many of the images of the early spring cap were neither large nor sharp enough to establish the early recession curve in MY 33. The summer NPC was easily observable, but even then, D_e was not very favourable: see Figure 17. To ensure reliable data, we only measured the latitude of the summer cap just prior to its coverage by polar clouds. We analysed 257 images by 27 observers for the latitude of the S. edge upon the CM during Ls = 136–165° (2016 Apr 11 – Jun 26). The mean latitude in 2016 was 78.2°, compared with 82.5° in 2014 (s.d. ±1.2°). For discussion, see later.

NPC fragmentation

The complete separation of *Olympia* was first imaged by Maxson, in superior seeing, on 2015 Nov 23 (D < 5″; Ls = 072°) & 28: seasonally normal. Foster confirmed it on Dec 17, and Justice saw it well on Jan 6. (Any seasonal dust activity at separation, seen in 2010, 2012 and 2014, would not have been resolvable.) It persisted, often elusive due to the unfavourable value of D_e, till the cap was hidden by polar clouds. Wesley on May 5–6 and Jolly on

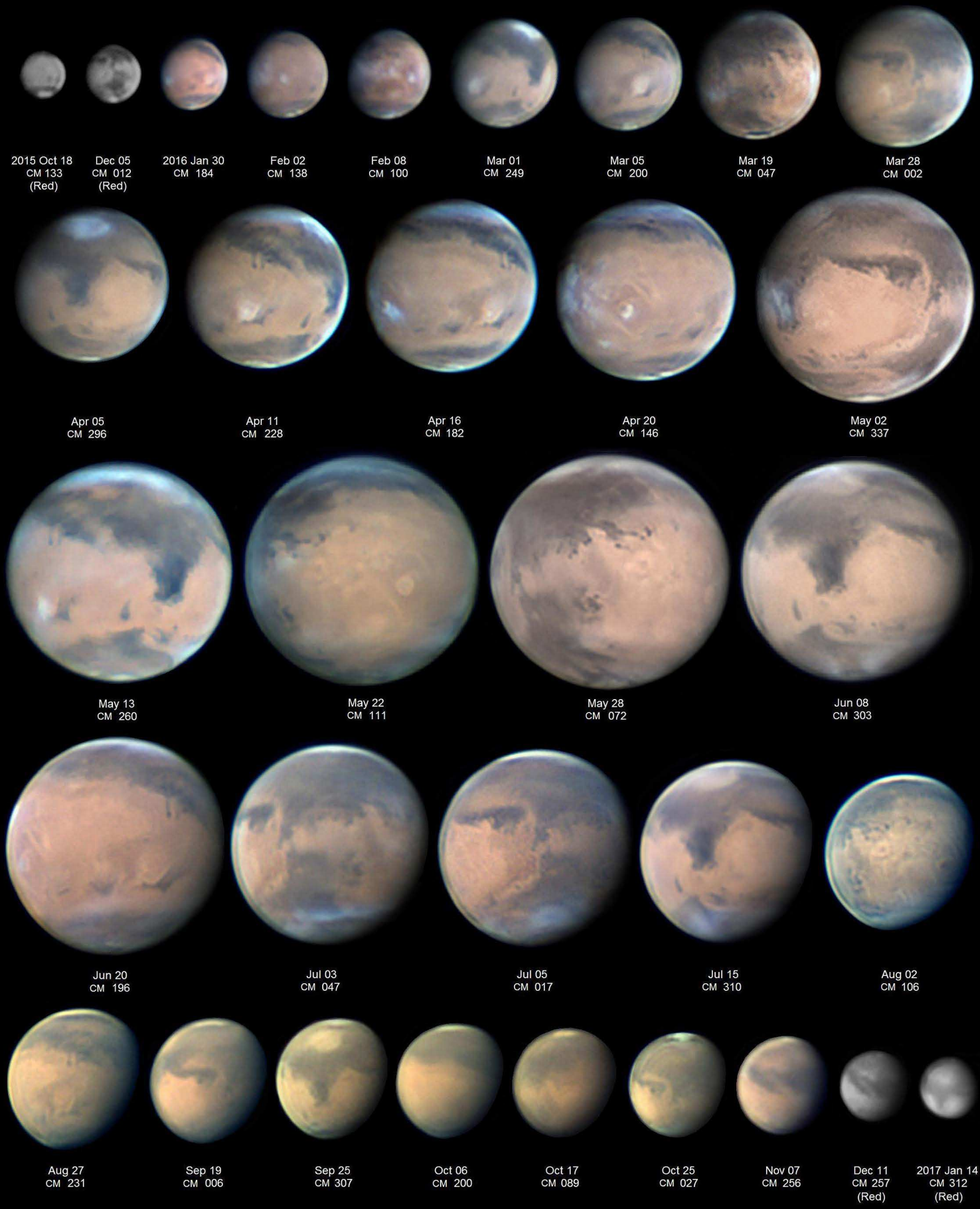

Figure 17. RGB collage obtained with a 355mm SCT and ASI 224MC camera, 2015 Oct 18 to 2017 Jan 14, showing the enormous variation in disc diameter. Date and CM longitude are indicated. *C. Foster*

May 29 showed *Olympia* irregular, the *f.* end fragmenting. The feature showed clear evidence of nebulosity in blue light – and/or a white banner cloud on the western side – on occasion: to Justice on Jan 6 and Morales on May 20–24 (Part I, Figure 5).

The *Ierne* outlier was again resolved near opposition: the best images between Apr 11 and May 28 showed it fragmented into a string of beads, as in 2014. *Chasma Boreale* was also seen.

The return of the NPH

As always, the gradual transition from cap to hood was dependent upon Martian longitude and therefore upon the terrestrial longitude of the observer.

From the Americas, the NPC began to be dimmed and obscured by adjacent polar clouds on Jun 2, remaining intermittently visible till Jun 19 (when Maxson still recorded a dull patch), after which the hood covered it. Peach shows it particularly well in several images from Barbados: during Jun 9–18 it was clearly visible together with its dark surrounding band, but always heavily obscured and in blue light with streaks of cloud swirling around it (Figure 14).

From Australia and Japan, the cap was clearly observable until Jun 5, after which polar clouds gradually interposed. The final cap sightings were by Iwamasa, Kumamori and Wesley on Jun 21. From Jun 22, polar clouds obscured the cap.

From the longitude of Europe and South Africa, McKim's first sighting of polar cloud was on Jun 4 when he saw a finger of cloud extending south from (and rotating with) the cap (CM = 005–024°), while other clouds were seen at the cap's *p.* and *f.* edges (Figure 13B). On Jun 18, he again saw polar clouds flanking the hood-covered cap. The hood greatly expanded southwards (CM ~ 030°) between Jul 10 & 13, and this month it would often appear to extend south along the morning terminator at *Mare Acidalium* (Figure 13H): typical behaviour. Foster from Jun 8 found the cap partly veiled, even in red light. He continued to record the cap with ever greater difficulty, mainly only in red and IR, until Jun 15 when it was visible but dull. Next day, only polar clouds were present.

In summary, the following were observed: only the NPC until Jun 2 (Ls = 162°); polar clouds and cap alternating at different longitudes, Jun 3–21 (Ls = 163–172°); and hood only from Jun 22 (Ls = 173°). The time of appearance of the hood was typical, though a small interannual variation is always likely. In 2014 the hood covered the cap earlier, the transition phase then being Ls = 153–162°.[2]

North polar fronts

North polar frontal systems were seen on occasion, in the form of narrow E–W strips of white cloud which moved south on successive days. The author saw one visually on Jun 27 (Figure 13), when a lighter E–W cloud band and the cap summer remnant were separated by a dark feature that was too wide to be merely the NPC band, and he recorded another without the dark belt on Jul 5 (see also below). Another front was seen on Jul 3 by Foster, which also involved an anomalous E–W dark band.

The most interesting example occurred on Jul 9–10 (CM = 145–164°), according to Hanson and Maxson (Figure 16), when an intensely dark curved band, obliquely aligned with the rotational axis, appeared between belts of white polar cloud. (The NPC by now had been masked by the hood.) These belts were weakly present from Jul 5, but the southern one was apparently reinforced on Jul 8 by a burst of cloud from the north. On Jul 9 a dark belt was seen near the morning terminator; it appeared more to the south and apparently more intense next day. The difference in D_e and D_s could not have produced a broad shadow, so the darkening (observed in white light, yet strongest in blue) must have been on the ground. Although polar clouds could have raised dust, thus darkening the terrain, it is simpler to envisage a gap in the white cloud canopy which allowed a view of the normally dark *Scandia* at that latitude. (And moreover, as for the 'violet hole' phenomenon, a low concentration of atmospheric water vapour adjacent to a white cloud belt would have resulted in greater transparency and a clearer view of the surface at shorter wavelengths.)

We have similar images by Flanagan, Maxson and Olivetti for Jul 14 & 16 (Figure 16), but the strikingly dark belt or gap was never seen again, surely because of the seasonal growth of the polar hood towards the south.

Less impressive or incomplete sightings are to be found in Flanagan's and Jolly's images of Jul 14 (CM = 111–128°), in Morita's of Jul 22 (CM = 166°, similar Jul 9–10), in Iwamasa's for Jul 24 (CM = 127°), in Iwamasa's and Morita's of Jul 29 (CM = 76–89°), and in Foster's of Jul 31 (CM = 128°), the latter of which show a dark border to the inner core of the NPH, south of which white clouds also existed. The latter dark boundary was in part faintly visible on Jul 30 (CM = 138°), but invisible on Aug 1. Outside this longitude range, Foster's images of Jul 24 (CM = 230°) also show an eccentric dark band within merged morning and polar-hood cloud.

Compared with 1999 and 2001, we now routinely reach much higher resolution. Earlier phenomena of this type could easily have been missed.

Interannual comparisons

Comparing the successive apparitions of 2012, 2014 and 2016 shows that the late NPC recession during 2016 was the slowest, with a larger summer cap remnant and later onset of the polar hood. Witness the various confirmatory indicators in Ls (°):

Opposition:	*2012*	*2014*	*2016*
First appearance of N. polar 'cyclonic' clouds	116	117	126*
NPC summer remnant mean latitude (°) during Ls = 136–165°	–	82.5	78.2
First appearance of N. polar hood	151	153	163

*120° according to *Mars Express*.

The NPH to NPC transition in 2017

Kidd's image of 2017 Apr 7 and Iwamasa's images of Apr 13 (Ls = 349°) still show a prominent NPH, which was less obvious to the latter in poorer seeing on Apr 28. The final images on May 4, in very poor seeing, do not show an obvious ground cap. However, MRO-MARCI imaging had already revealed the first signs of part of the new ground cap in the week of Mar 6–12.

Figure 18. The S. polar region, 2016 August – 2017 February (D = 11.8–5.0″), according to drawings by Gray (415mm DK Cass. stopped to 152mm, with W22 filter, or (Sep 17) 120mm OG) and images by Kidd (ASI 224MC camera), M. R. Lewis (ASI 224MC), Morales (Flea3), Milika & Nicholas (ASI 290MM) and Olivetti (Blackfly ICX692).

South polar region

South polar hood (SPH) to polar cap (SPC) transition

Figures 17–18 show the general behaviour of the S. polar region. The SPR was turned away from the Earth at the critical SPH/SPC transition, but to Foster a short arc of S. limb was especially bright at all wavelengths on Jun 8 (Ls =166°), lengthening on Jun 10 and later. By then it was obvious that the ground cap had been imaged. However it was not yet hood-free south of *Argyre*, for at that longitude on Jun 8 only the bright hood had been visible to Peach. Peach's images of Jun 15–18 show both hood and cap in much detail (Figure 14). Other observations prior to mid-June that showed the SPC in part were due to Kumamori on Jun 3, 10 & 14, and Flanagan on Jun 8–11.

On his high-resolution image of Jun 5, Peach captured the frosted *Lowell* crater at the SPC N. boundary (Figure 14).

During July–September, the cap's E–W arc shortened as it began to shrink asymmetrically. Only from Sep 24 was the cap's full E–W extent visible, as D_e became negative. By then, D had fallen to 9.1″, but as Ls already stood at 229° (past mid-spring), it was not worthwhile to construct a recession curve.

SPC recession & fragmentation

By Sep 19, Foster showed a brightening and northward bulge in the cap outline at the longitude of *Novus Mons*. A dark rift had separated *Novus Mons* from the cap, by Oct 16 (Ls = 243°) to Iwamasa and by Oct 23 to Olivetti. Under much better conditions of disc diameter in 2003,[45] this rift had first separated it in images by Ls = 238° (and by Ls = 243° visually). Spacecraft data show that *Novus Mons* had sublimed away by early December.

To Morales on Dec 8–15, in good seeing, the area where *Novus Mons* had existed was soft-edged and faded. This was also the case to Kardasis on Jan 13–23 and Iwamasa, Dec 30 – Feb 3: the same had been seen in 2003.[45] (After *Novus Mons* sublimes away, a light-hued trench remains.)

Foster on Sep 13–19 and Oct 17–25 showed a brightening and deflection in the SPC N. edge, at the location of *Argenteus Mons*. On Oct 22–23 there were two adjacent northward protrusions. Flanagan showed a very bright point at this longitude, Aug 24–25.

A rift that always divides the summer cap unequally was imaged as an indent near longitude 90° by Foster on Oct 17–21 and by Morales on Oct 29.

McKim followed the cap remnant visually till 2017 Feb 18, while Lewis imaged it as late as Mar 15 (Ls = 333°, D = 4.4″).

Southern-hemisphere cold traps

Hellas

See Figure 19. It was lightish to Maxson from 2015 Sep 7 onwards, as later confirmed by other observers. In early January of 2016 a number of images showed it bright at the CM in all wavelengths, indicating a surface deposit: Justice on Jan 6 (Ls = 92°), Milika & Nicholas on Jan 12, and Foster on Jan 15. A bright area at the W. edge is suggested in the earlier images of Maxson for 2015 Dec 28–30. In 2014 the basin had become frosted on Feb 18, again at Ls = 92°. In 2016 it was extremely prominent during January–April (Figures 17 & 19).

The basin was not evenly frosted, there being a higher concentration to the west. Up till Apr 15, *Hellas* was still completely frosted, but to Justice on Apr 25 the western bright part had sublimed, and during May 6–13 the only remaining sign of frost was in the southeast. From Jun 7 onwards the basin was frost-free, but patches of white cloud persisted from time to time. During Jun 7–15 and Jul 15–17, this cloud was streaking out of the basin to the west. White cloud sometimes remained strongly visible in the evening for some time, *e.g.*, to McKim on Jul 17 (Figure 13I), but later the basin was dull throughout the day.

It is clear that this white cloud activity was not unrelated to weak dust activity in the basin in May–June, already discussed in Part I. Later dust activity in *Hellas* (2016 late August) was also reviewed in Part I.

Argyre

Until just after opposition, *Argyre* generally appeared as a bright hazy patch. The first signs of slight brightness had been seen in 2015 late December, and it appeared quite bright (and frosted) in

February–May, though surrounded by light SPH. It became less bright after mid-June. High-resolution May–June images resolved the polar hood surrounding the basin into streaks and patches. *Argyre* looked only weakly bright to Wesley by Jun 22, and later images showed it dull at the CM.

It collected dust fallout from the late August dust storm that had commenced in *Hellas*, and appeared as a bright yellow patch, slowly fading.

On the east side of *Argyre* lies the small *Galle* crater: its frosted floor was beautifully caught in images by Valimberti and Wesley on Apr 17.

Martian satellites

Wesley imaged both satellites, and Maxson caught Deimos. Gray reported seeing Deimos visually on May 15, and both moons on May 23.

Conclusion

Our findings for this apparition significantly add to the statistics on seasonal phenomena and dust storm incidence. If one had to pick just one unusual phenomenon to highlight, it would be the initiation site of the local dust storm east of *Elysium* in SW *Arcadia* in 2016 September (Part I, Figure 10), never previously recorded telescopically. This event, with the continuing faintness of albedo features around *Elysium*, provides evidence of a slow net accumulation of dust fallout over the northern hemisphere.

Mars was not well placed for observers in Great Britain, but at least the planet was located against one of the densest parts of the Milky Way. Figure 20 captures the scene, to conclude this report.

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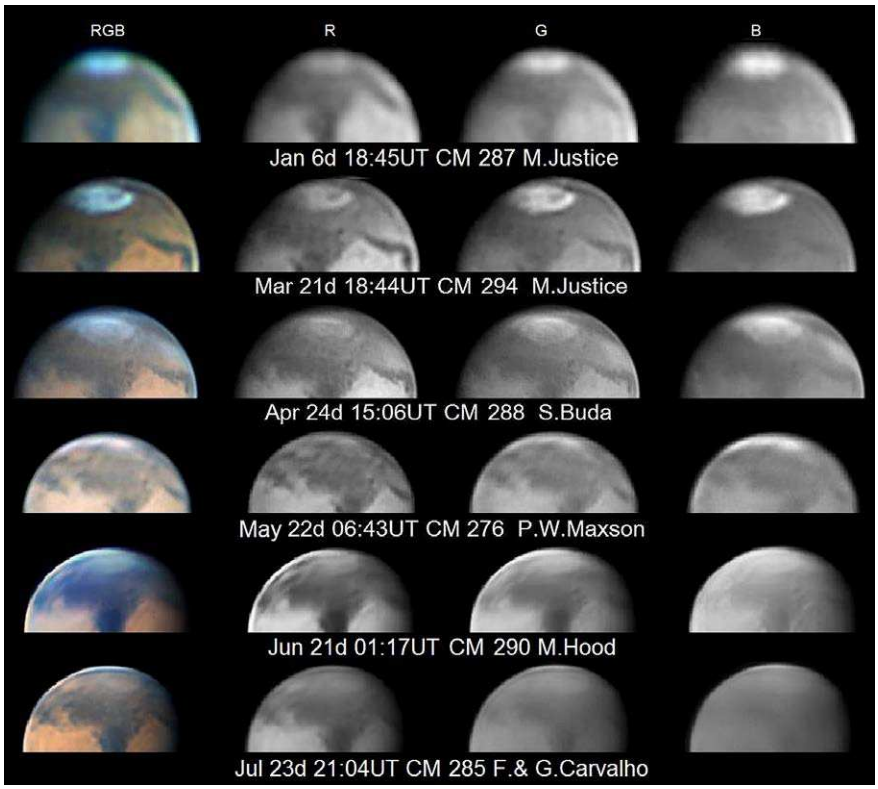

Figure 19. *Hellas* meteorology, 2016 March–May, showing the clearance of ground frost according to images by Hood (ASI 290MM camera), Justice (DMK 21AU618), S. Buda (ASI 120MM), F. & G. Carvalho (QHY5L-II) and Maxson (ASI 290MM).

Figure 20. Wide-angle field on 2016 Aug 25, imaged with a remote Takahashi FSQ 106 telescope at Siding Spring, Australia. The brilliant post-opposition Mars (top left) appears with Antares (lower centre), the Rho Ophiuchi dark nebula (top centre) and the Messier 4 globular cluster (lower right). North is uppermost. Mars was closest to Antares (separation 1.8°) on the previous day. *D. A. Peach*