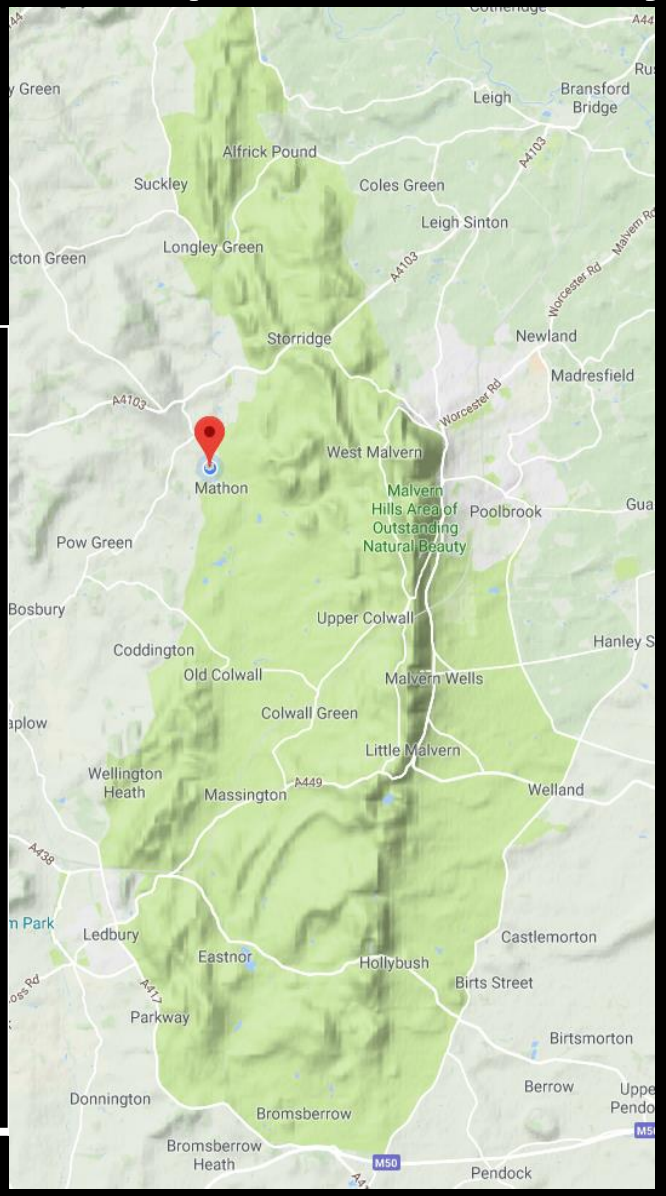
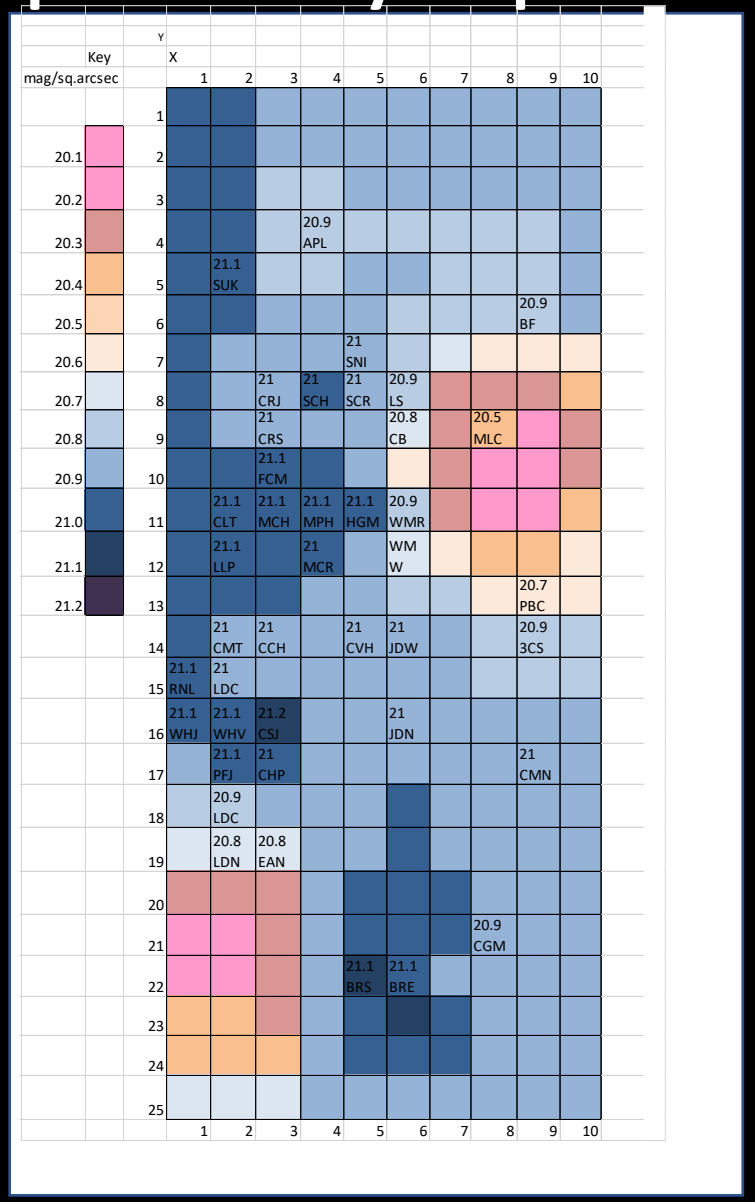
2012 MHAONB Geographic photometry Dark Sky Survey, Map and Summary photometry map

(a), Map of the Malvern Hills area and 2012 Dark Sky Survey site locations. Mathon the observatory site West of the Hills, Malvern town mostly. Light-Orange: East of the Hills , Castle Morton to the South East, Wellington Heath South, and Alfrick Pound. (Google Maps)





(b), Corresponding SQM MHAONB 2012 photometry results for clear skies on 1 Km grid.

(a), 2012-09-18 Mathon Observatory.

(b), 2012-09-18 Malvern Link Common.

(c), 2012-09-18 Poollbroook Common.

All locations outside Malvern show similar Zenith sky brightness within 0.2mag.arcsec^-2 after correcting for the Milky Way, despite being at different distances form Malvern and Ledbury the only local towns Malvern Commons 0.3 higher. This shows that not all is from local sources. While despite being many km apart, they all show a dominant sky dome on the NNE horizon (Top Left). So that source must be distant, the orientation corresponds to the Birmingham area, at 60 km.

(d), 2012-09-18 Castle Morton Common.

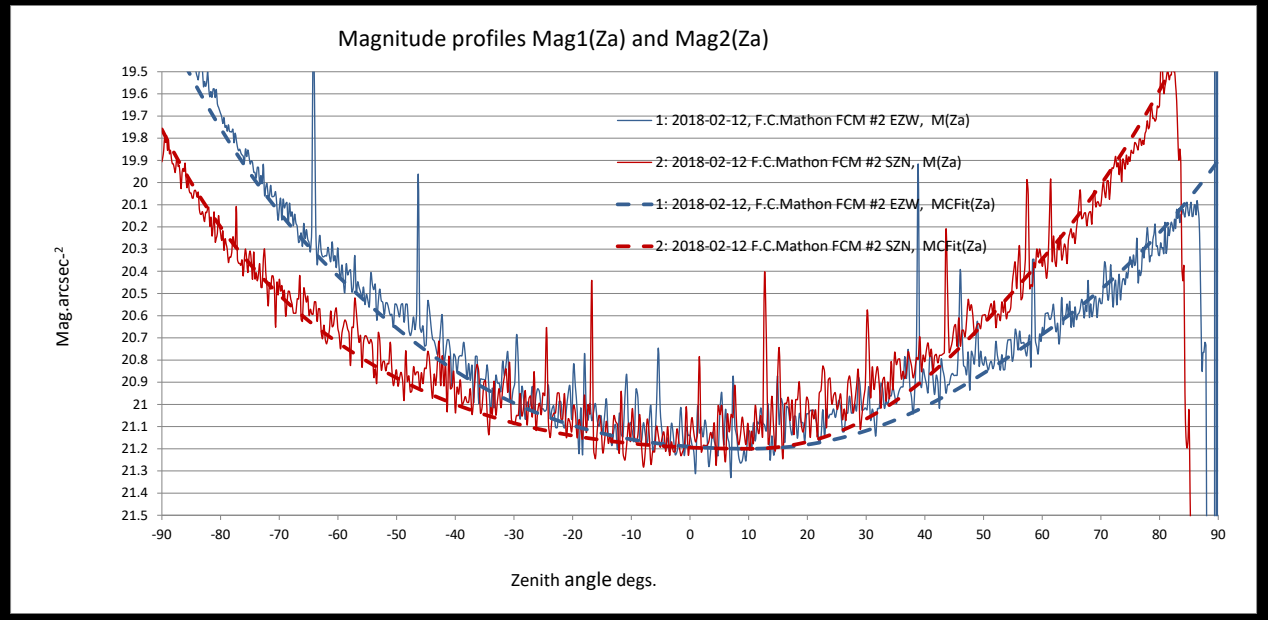
(f), 2012-09-18 Wellington Heath Vista.

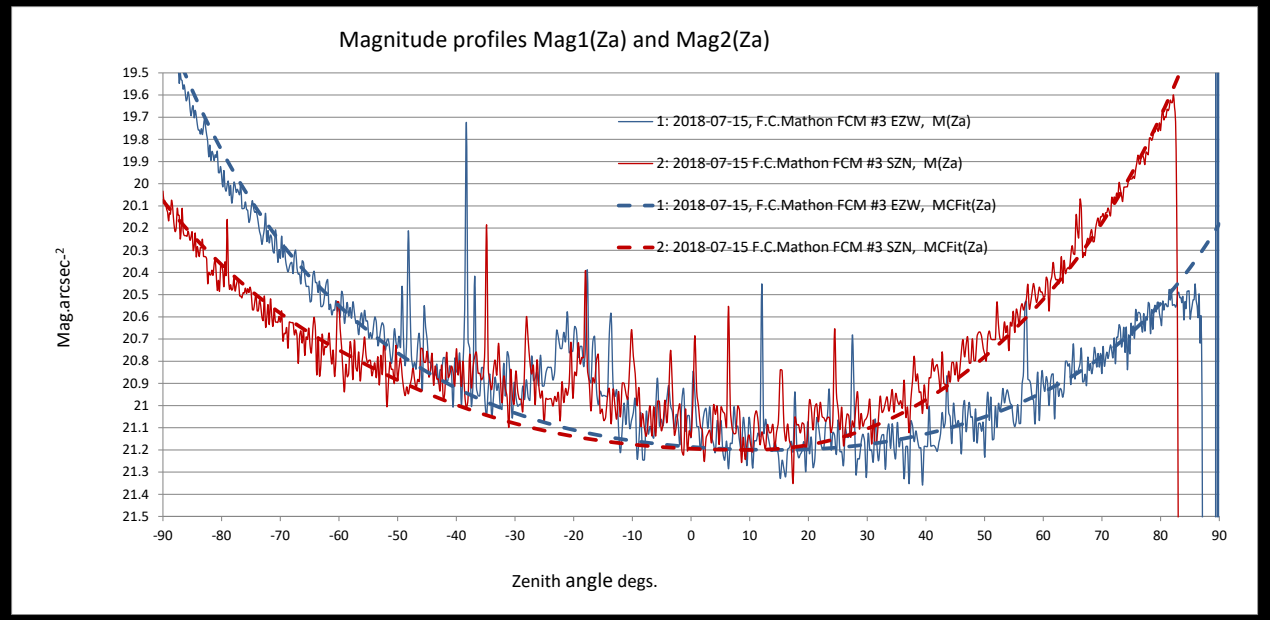
(e), 2012-09-18 Jubilee Drive Malvern.

(g), 2012-09-18 Alfrick Pound LG.

(h), 2012-09-18 Ham Green Mathon.

Curve fits and example of Milky Way uplift





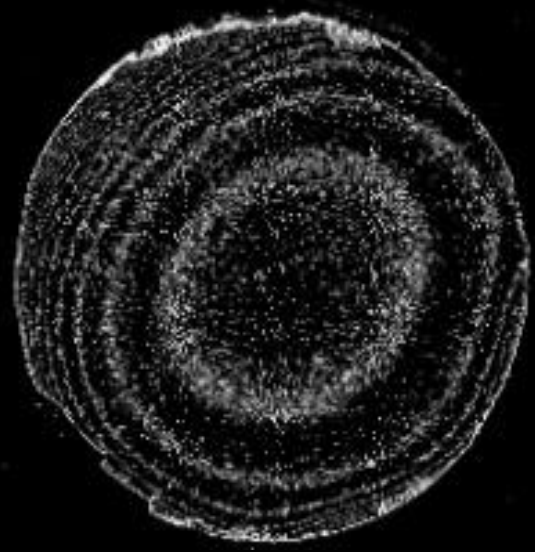
Example 2018-02-12 (no Milky Way) and 2018-07-15 (with Milky Way) F.C.Mathon, photometry profiles, Blue E. to W. via zenith; Red S. to N., spikes are mostly from stars (they differ in the two shown cases) and drops are fixed pattern noise.

It shows the pararmetric curve fits (dottted lines). Parameter sets: zenith value, values at specified Zenith angles 60..dgrees or more either side, and fitted power law gradient at those points. Here 2018-02-12 averaged tilt corrected Zenith value 21.25 mag.arcsec^-2 (0.32 mCdm^-2). The fitting is good to 0.05, mag.arcsec^-2, the meter accuracy, and found to be consistent on the best of nights. Note the precision of the curve fitting which is different in each case, clearly showing the 0.3 mag.arcsec^-2 uplift from the Milky Way.

Example 2018-02-12 F.C.Mathon. Image and isophote map. Good visibility.

Sky glow domes from many towns and cities over the horizon, the brightest are Birmingham NE. at 67km, Worcester NE. at 18km, Malvern E. at 5km, Cheltenham & Gloucester SE.. at 55km, Hereford at 27km, Monmouth SW at 45km & Cardiff 105km. The Milky Way is on the horizon.

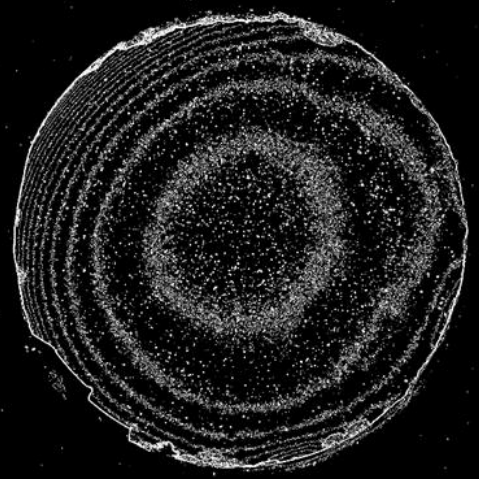
In poor visibity, local sources are enhanced, and distant ones suppressed, the sky can then be darker, or changing colour.

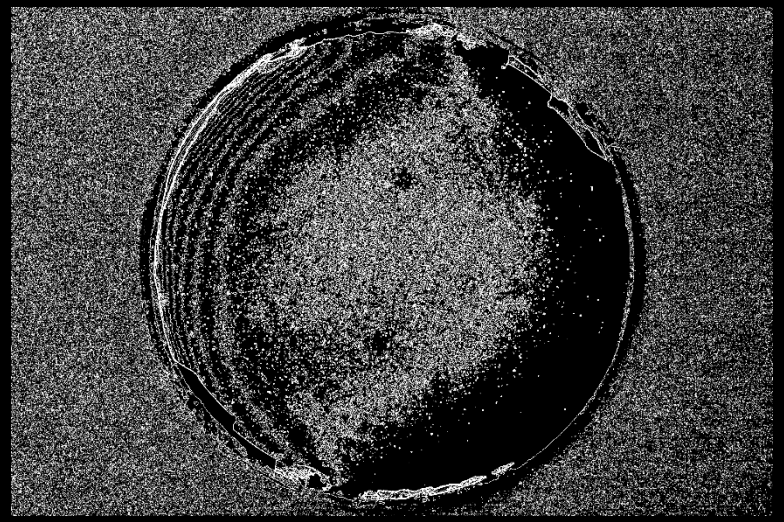


From samples of the all sky images, isophotes were plotted with identifiable city sky domes up to 120 km away.

Note the skewness the of the isophotes towards northwest (2 o’clock) where there are no towns in line of sight beyond the horizon. The departure from circular symmetry of the near-zenith isophotes indicates the directional contribution of local to over-horizon sources, also shown in the profiles.

Local to distant atmospheric condition dependence





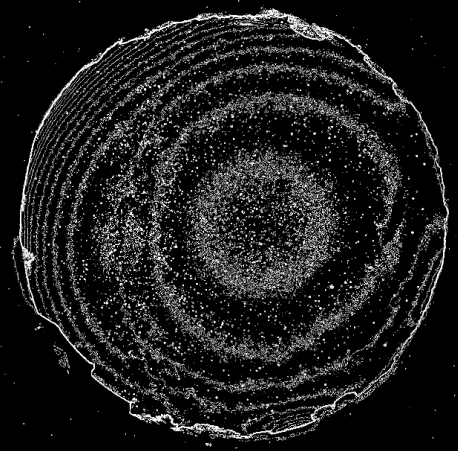
Isophote plots of the mirror image subtraction and shows the relative contribution of distant sources on the horizon to that of the zenith.

The example iabove shows the darkness towards the horizon west northwest (at 2 o clock) where there are no significant towns in the direction of Wales. In this case, the contribution of towns and cities beyond the horizon was about 10% of the zenith compared with local sources, but it is critical of the atmospheric conditions at the time.

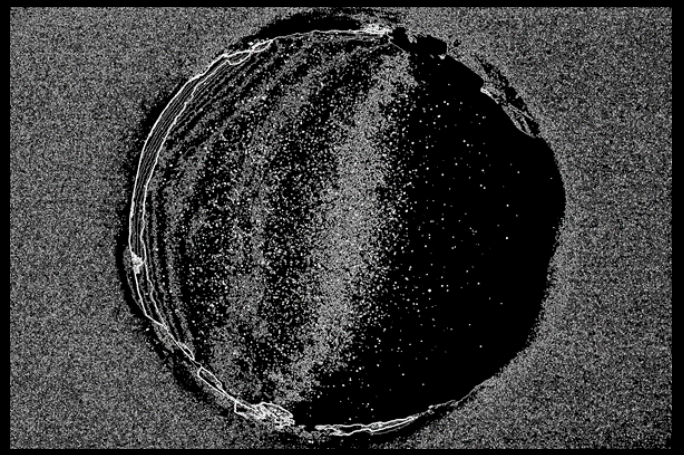
Colour variation and local to distant atmospheric condition dependence

The local fruit farm less than one kilometre away over a local ridge, is likely responsible for the orange colour at 3 o’clock. Compared with the white led lighting beyond the horizon.
This illustrates how local atmospheric conditions can suppress or enhance local lighting contributions with respect to distance, and change the colour of the sky temporarily.

Colour image



Isophote contours



Isophotes of asymmetry

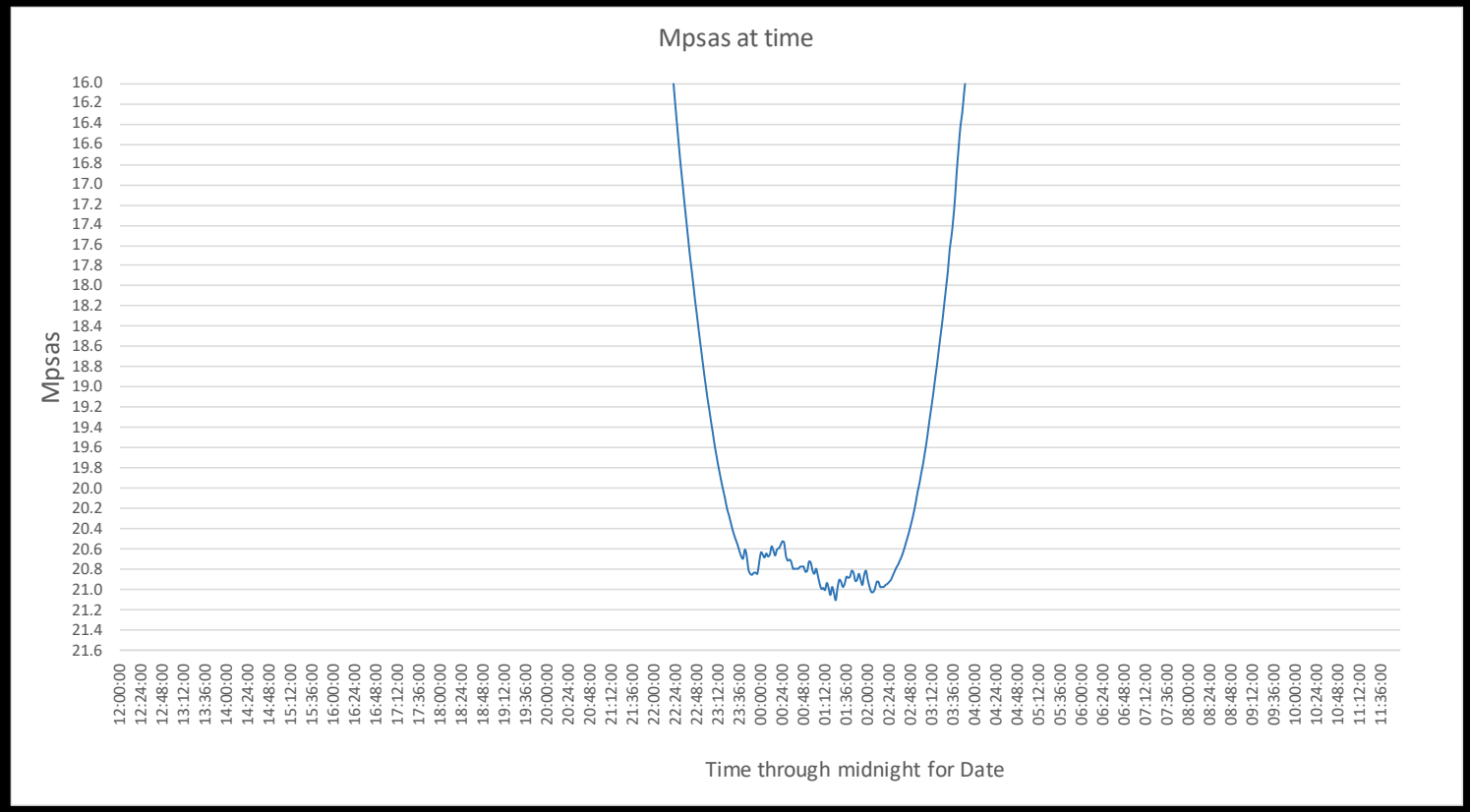
Colour change and brightness distribution over 6 years, 2017 to 2023

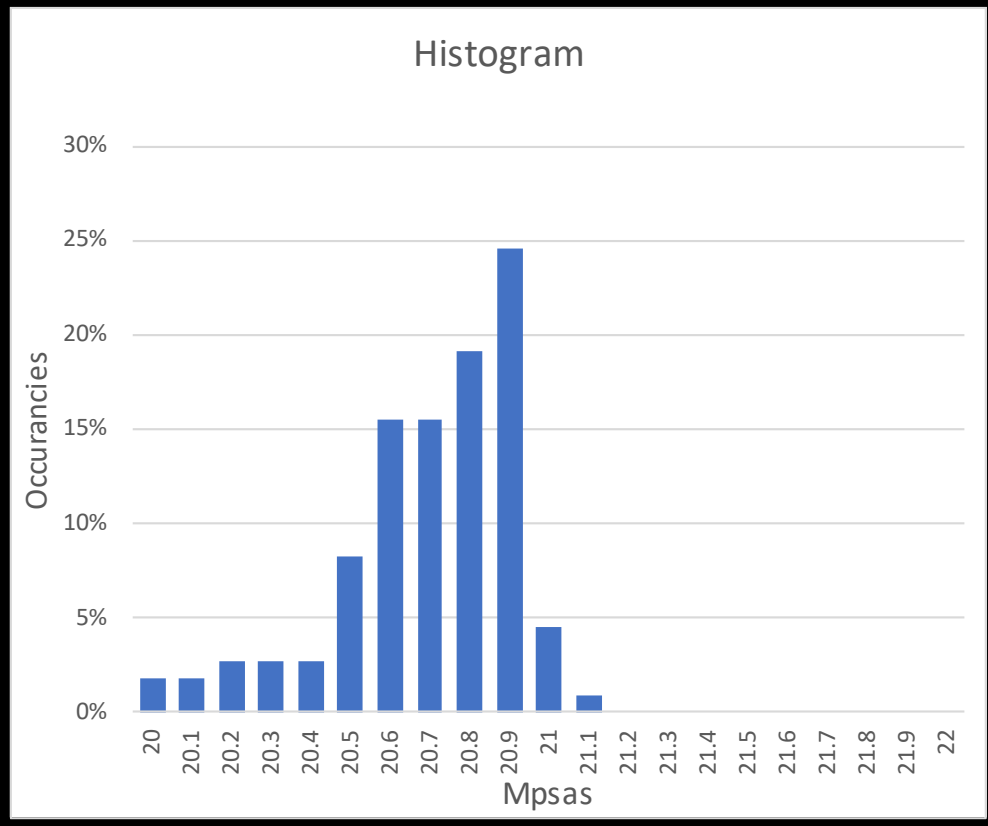
2017-05-24 Mathon

2023-05-24 Mathon. Same time and date of year.

There has been a very significant change in the overall colour, from orange pink to white from changes of HPS to blue-rich LEDs. Also an increase in sky brightness on the horizon concentrating more on towns and cities. Here showing the colour change from 2017 to 2023 at the same time of year. The horizon is typically 6 times brighter than the zenith.

2017-05-24 Time plot

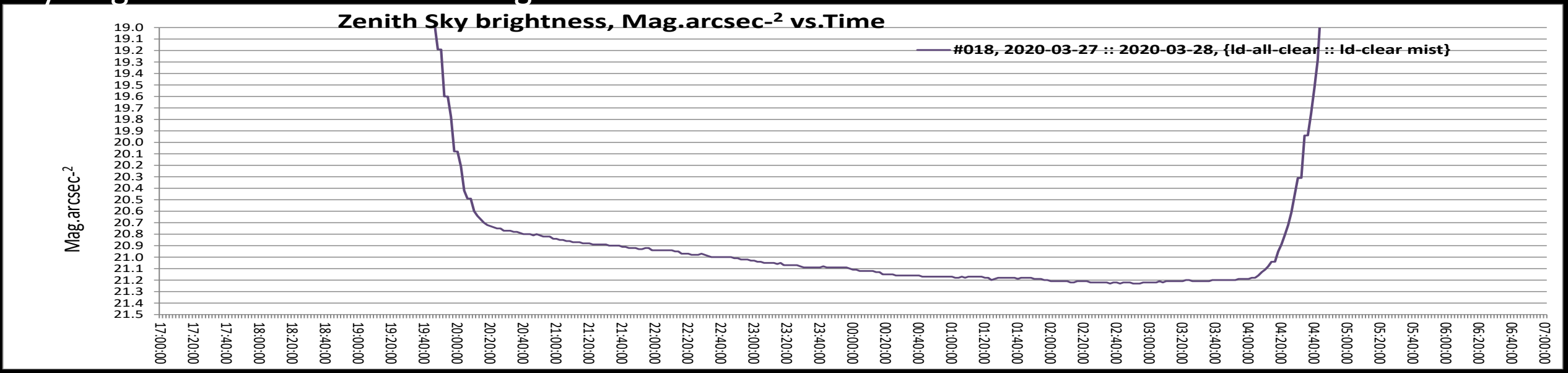




2017-05-24 to 25 Mathon, clear. Min Zenith brightness 21.1 mpsas

Darkest near-zenith brightness is still 21.1 mpsas.

Sky brightness decreases overnight to before dawn

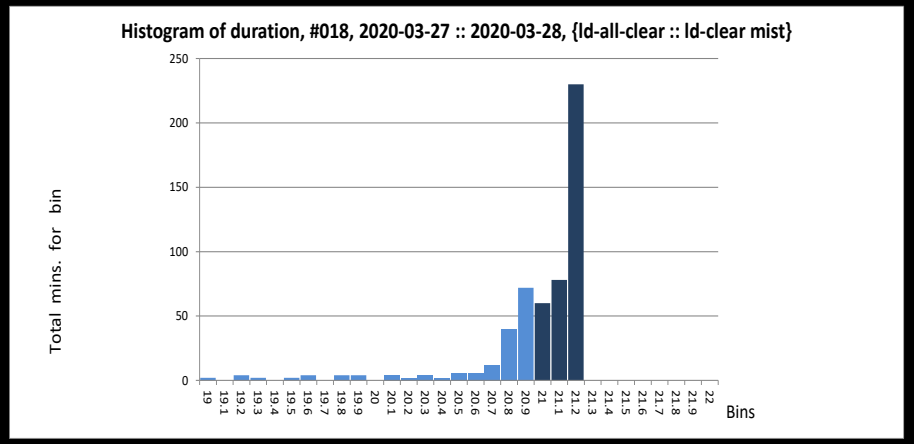


2020-03-28 Time plot dusk to dawn of clear night.

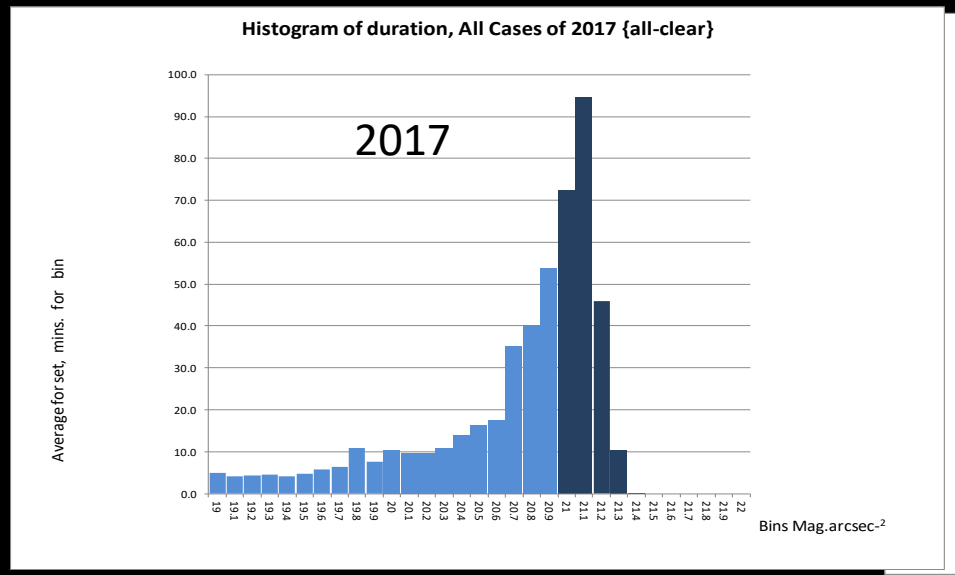
Sky brightness decreases by about 0.3 mag.arcsec^-2 , with time, to before dawn; the curve is always smooth and even in the reduction.

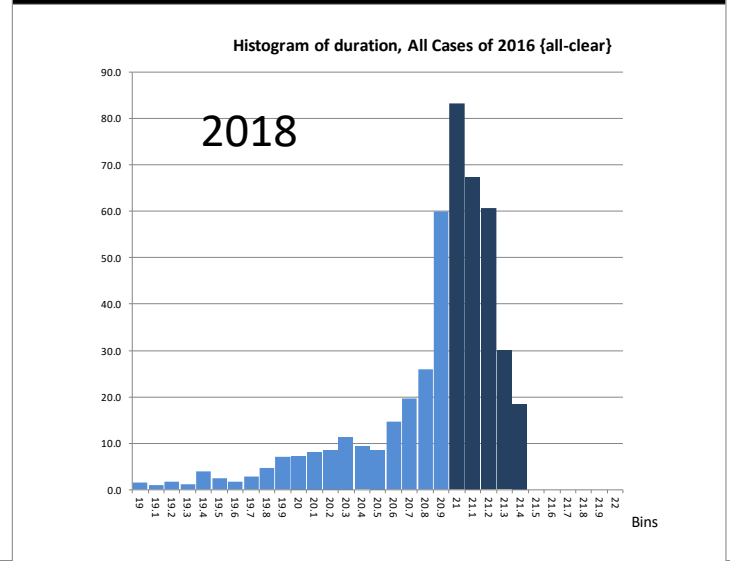
Most likely due to increasing humidity towards dew point from ground cooling to the sky, also some reduction in lighting at night during the early hours.

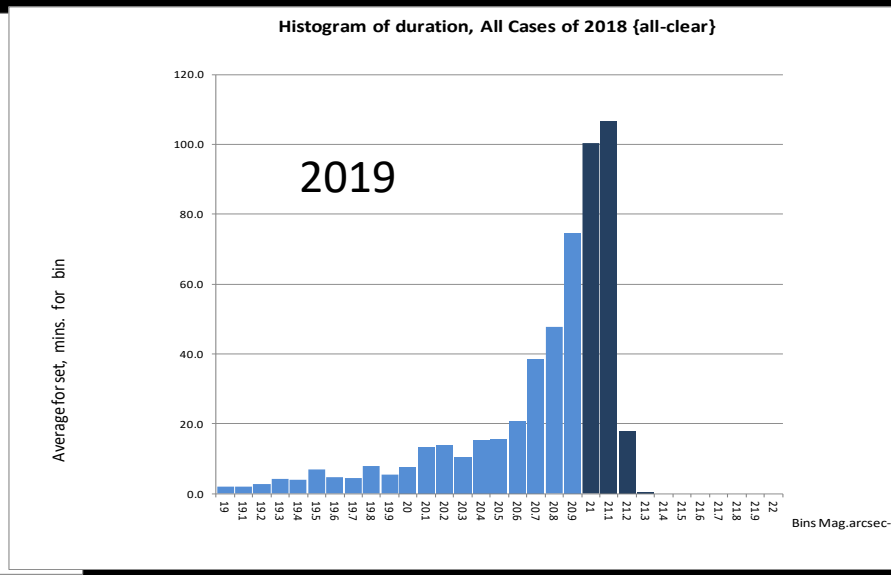
2020-03-28
Histogram of above.
0.1mag.arcsec^-2 bins, a significant number of brightess values below 21.1 mag.arcsec^2.



Darkest nights Histograms for Years 2016 to 2020, near Zenith.



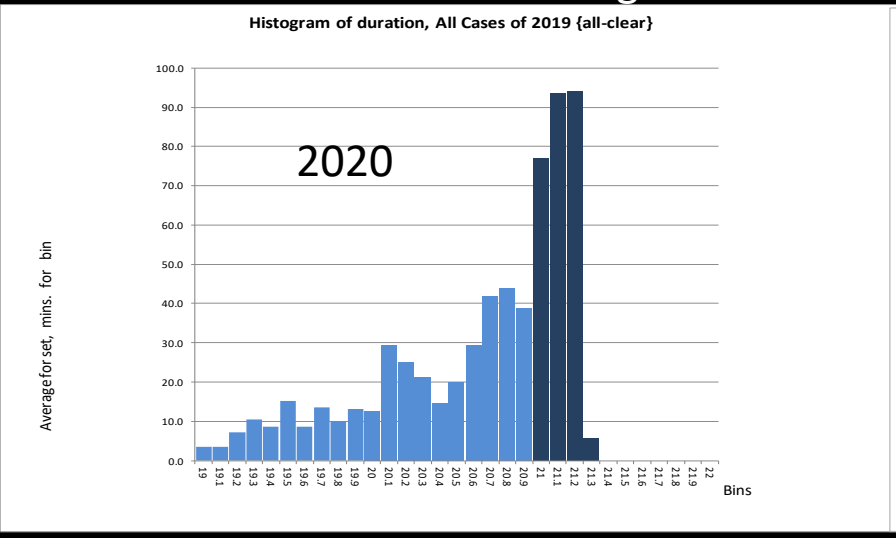


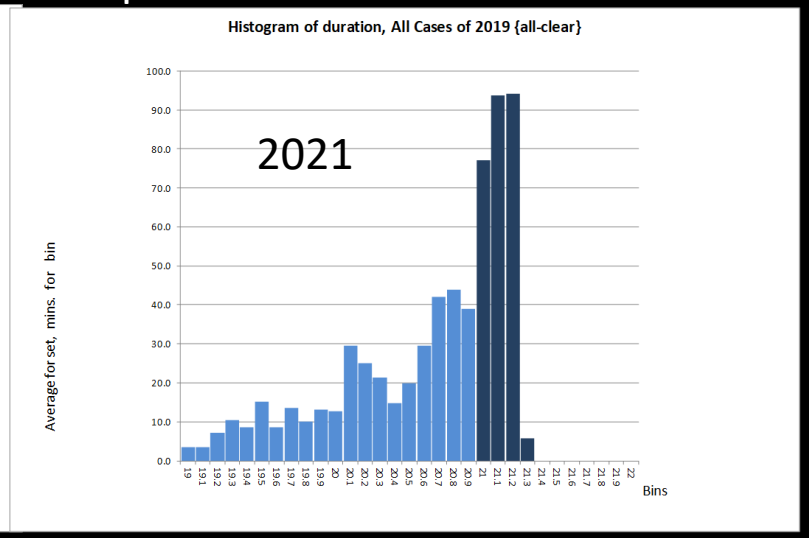


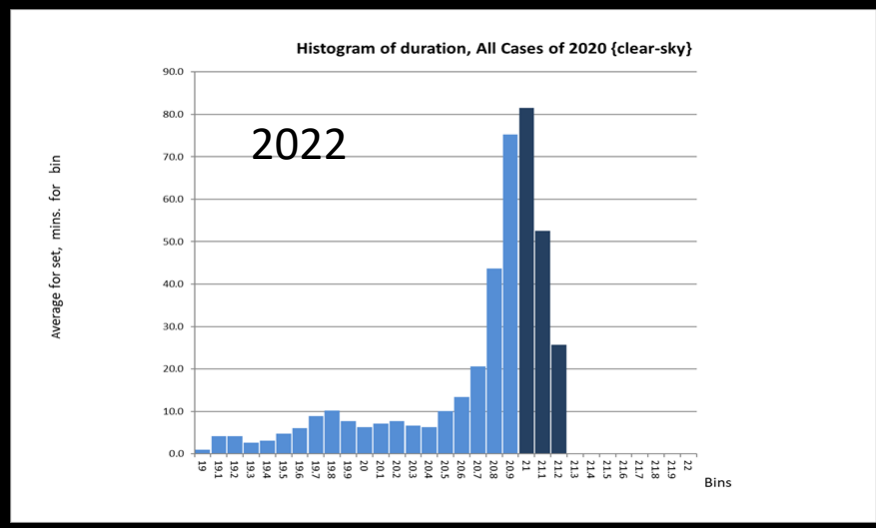
The number of minutes at any particular near zenith light level in bins of 0.1 magnitudes per square arc second. The dark bars meet the criteria of the International Dark Sky Association for dark sky status.

The horizon is typically six times brighter than near zenith. The horizon is changing with increasing light levels.

The near-zenith darkest readings remain at 21.1 mpsas.







Conclusions of MHAONB UK light pollution projects.(Typical UK rural area)

In dark rural areas, at zenith magnitude 21.1 / square arc second, individual skydomes can be seen from up to 150 kilometres away at about six times the zenith brightness

- A simple minimal parametric curve fit horizon to horizon photometric profile fits all the clear nights.
- The asymmetry due to horizon brightness can be seen from either the curve fits or isophote plots. By subtracting the mirror image of the original and then with the same processing, an estimation can be made of the horizon contributions in any direction. In all this is about 10% of the zenith sky glow from all sources.
- From the curve fit profiles, the Milky Way uplift is about 0.3 magnitudes per square arc second. The mast mounted SQM avoids it coming into the field of view by tilting it 20 degrees north of zenith.
- Over the last 10 years, the number of minutes at 0.1 magnitudes steps near zenith, has not changed significantly. There being about 24 clear nights per year without cloud and no Moon. The horizon brightness has increased and become more separated and much whiter, from older luminaires replaced with Colour temperatures CCT >4000 LEDs despite only pointing downwards. CCT< 2500K would reduce this significantly.

Conclusions continued

- The zenith background darkens continually during a clear night until an hour or so before dawn. By about 0.3 magnitudes per square arc second. Some of this will be due to increasing humidity with temperature drops to dew point, and some to dimming or turned off of light sources.
- The darkest readings are when the visibility is not good.
- The colour and brightness of the sky in hazy/misty conditions can change rapidly according to local mist as opposed to distant conditions as the contribution of local and distant sources changes through absorption and scattering.
- Local atmospheric backscatter ratio has been determined caused by purely ground reflection. Even a well designed lighting housing scheme with no direct lighting to the observer, will increase the local sky brightness significantly to the point of near invisibility of the milky way.

The earlier work is published, JQSRT.2018.05.011Corpus ID: 12583691 and JQSRT 267, June 2021, 107574

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The Educational message

- Sky-domes have become more obviously distinct and increasingly blue rich from replacement blue rich led lighting along the horizon; while the overhead darkness is the same as 10 years ago within variation of local weather conditions. It is local and distant weather that makes the biggest variation which can occur rapidly, including colour changes from local blocking due to a mist or fog or distant high clouds causing reflections.
- The Milky Way is only 20% contrast to background at zenith on the darkest nights, (MHAONB typically 21.10 mag.arcsec-2)
- Doubling the road light level across Europe would make the Milky Way invisible to all but it is our heritage, from whence our materials were made..
- The starry sky is the ultimate area of scientific interest, and yet has little protection in law.