



Dark and Quiet Skies for Science and Society II

Implementing the recommendations

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Recommendations for the protection of the night sky in dark sky oases

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What is light pollution?

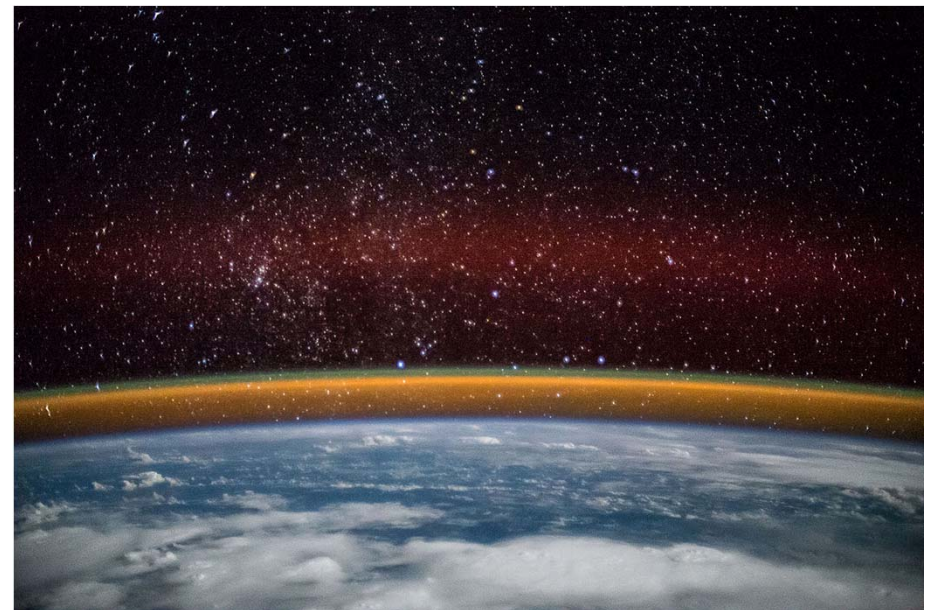
Light pollution is the sum of adverse effects of obtrusive artificial light at night (ALAN). It comprises:

- Glare
- Light trespass (spill light)
- Skyglow – resulting in a brighter night sky which impedes our ability to see the stars.

Skyglow is caused by scattering of light by air molecules and aerosols in the Earth's atmosphere.

Airglow seen from space

- Natural airglow photographed from the ISS by Italian astronaut Samantha Cristoforetti in 2014.
- Airglow is emission by air molecules high up in the atmosphere.
- Skyglow adds to the low brightness natural airglow.





Photometric SI units for sky brightness

The surface brightness or luminance of the night sky is measured in SI (Système International) photometric units of milli-candela per m².

The natural airglow is about 0.25 mcd/m² (unpolluted night sky) though the figure is somewhat variable in direction, time and observer's location.

Significantly polluted skies have luminance > 1 mcd/m².

The candela is defined in terms of the visual photopic passband, as defined by CIE and peaking at 555 nm. This bandpass is not very sensitive to blue light ($\lambda < 500$ nm).



What is a dark sky oasis?

A **dark sky oasis** (also often referred to as a ‘**dark sky place**’) is a location where the night sky is protected by an outdoor lighting policy, or in legal terms, by a *lighting ordinance*.

This limits the amount and the wavelengths of light that shine upwards into the sky. Blue light ($\lambda < 500$ nm) is especially harmful, as it scatters the most.

Most dark sky oases will have controls on

- street lighting,
- the lighting of sports facilities at night,
- outdoor lighting of commercial facilities (ports, factory yards),
- flood lighting of buildings.



The IUCN classification scheme for dark sky places

Class	Type of dark sky place	Number world-wide	
		May 2020	Aug 2021
1	Dark sky astronomy site	15	18
2	Dark sky park (protected natural area)	114	147
3	Dark sky heritage site	9	15
4	Dark sky outreach site (e.g. public observatory)	25	29
5	Dark sky reserve	21	24
	(mix of cooperating community, rural and natural area jurisdictions)		
6	Dark sky community (rural area, village or town)	39	46
Total (in 30 countries)		223	279

16% growth p.a.

IUCN = International Union for the Conservation of Nature. The classification is from the IUCN Dark Skies Advisory Group

The New World Atlas of Artificial Night Sky Brightness

Falchi, F.; Cinzano, P.; Duriscoe, D.; et al. (2016). The new world atlas of artificial night sky brightness. *Science Advances*, 2, 1-25.

The atlas is based on satellite data of light going from Earth into space recorded in the years 2013-2014, in wavelength interval 500-900 nm.

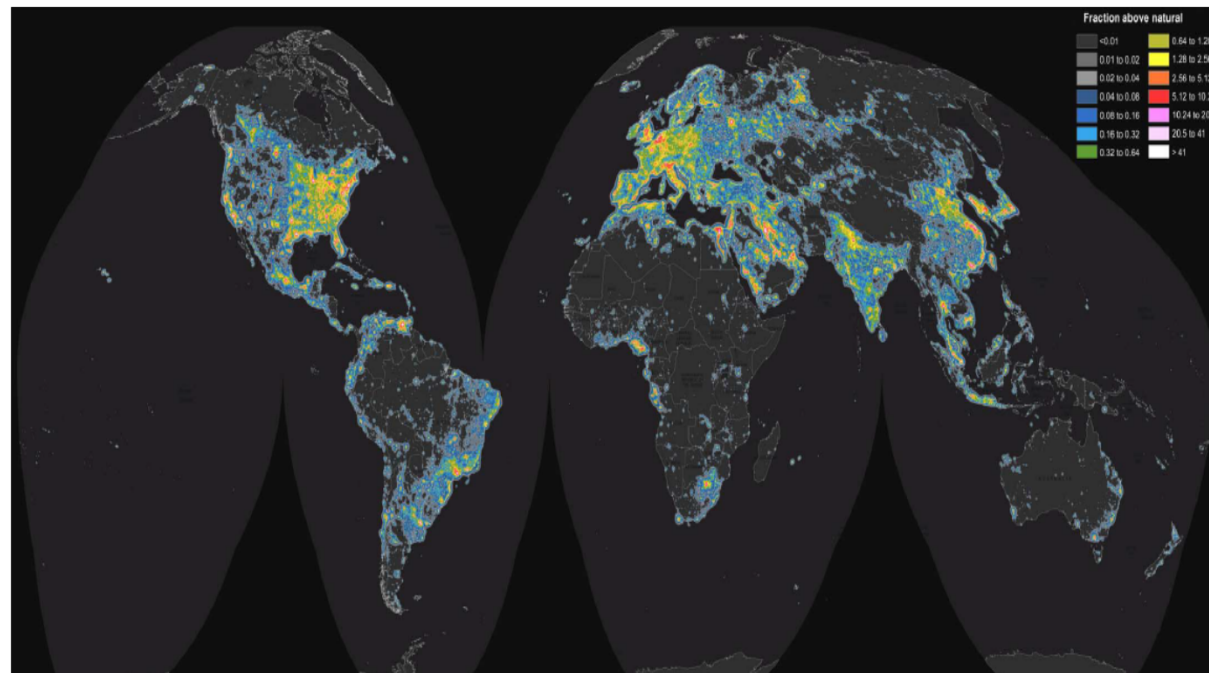
Computer modelling then predicts the night sky brightness in $\mu\text{cd}/\text{m}^2$ that would be observed from the ground.

The New World Atlas of Artificial Night Sky Brightness

Predictions of the New World Atlas:

- 80 per cent of the world and more than 99 per cent of the US and European populations live under light-polluted skies.
- The Milky Way is hidden from more than one third of humanity, including 60 per cent of Europeans and nearly 80 per cent of North Americans.
- 23 per cent of Earth's land surface area between 75°N and 60°S, experience light-polluted nights.
- 88 per cent of Europe and nearly half the area of the US experience light-polluted nights.

The New World Atlas of Artificial Night Sky Brightness



The red areas are highly light-polluted and have typically 5 to 10 times the natural night sky brightness, generally in excess of 1.25 mcd/m² and up to 2.5 mcd/m².

Recommendations to COPUOS

Aspirational night sky brightness limits recommended for dark sky oases

IUCN class	DSO type	Maximum sky brightness recommended			
		in terms of natural airglow		$\mu\text{cd}/\text{m}^2$	mag/sq arc sec
1	Astron. observatory	1.10x		<260	>21.7
2	Dark sky park	1.50x		<360	>21.4
3	Dark sky heritage site	2.75x		<660	>20.7
4	Dark sky outreach site	2.0x		<480	>21.0
5	Dark sky reserves	2.0x		<480	>21.0
6	Dark sky community	3.0x to 4.0x		<750 to <1000	>20.6 to >20.3
		rural	semi-urban	rural	semi-urban

Recommendations to COPUOS

- In all protected dark sky oases the default condition should be no artificial light.
- In ecological reserves and similarly sensitive sites with little or no human presence at night, artificial light should not be used. If it is used, it should be a narrowband amber LED or equivalent emitting no light at $\lambda < 500$ nm. Lighting should be strictly controlled and switched on only when it is needed.
- If phosphor-converted amber LED lights are used, the amount of blue light ($\lambda < 500$ nm) should be below 5 % of the total spectral power. Generally this requires using LEDs with a correlated colour temperature of 2200 K or less.
- All exterior lights should only distribute light below the horizontal, and the upward light output ratio (ULOR) should be no more than 0.5 %. This requires luminaires to be mounted horizontally and have flat screen glass below the light source.

Recommendations to COPUOS

- No development in or near highly ecologically sensitive sites should be permitted.
- Monitoring of night-time conditions in/near dark sky oases is encouraged through a combination of ground-based and remote sensing methods.
- Active management of natural night-time darkness as a natural resource is encouraged through recognised conservation best practices.
- Restoration plans should be implemented when sky brightness thresholds are routinely exceeded.



The need for national legislation

- Traditionally, exterior lighting has been the domain of local government (cities, counties, districts)
- Local government agencies are not well equipped to tackle a global environmental crisis.
- National governments need to impose national legislation on local bodies.
- The UN should provide guidelines for UN states parties (member states) so that national legislation follows globally accepted protocols.



The UN should should adopt a lighting convention for all states parties

- The UN should adopt a convention on lighting.
- The lighting convention should be drafted in consultation with CIE, IDA, IUCN.
- The lighting convention should be applicable for dark sky oases and also for urban environments, given the serious human health and environmental impacts of artificial light at night.
- The proposed UN lighting convention should be ratified by as many state parties as possible, especially by all those with dark sky oases within their borders.

UN Sustainable development goals (SDGs)

- In June 2021 the Fundación Starlight and the Federation of Business Women (Spain) signed an MoU to establish a new UN Sustainable Development Goal.
- SDG 18 would be for '*The quality of the night sky and access to starlight*'.
- The new SDG would promote the 2007 Starlight Declaration: *An unpolluted night sky that allows the enjoyment and contemplation of the firmament should be considered an inalienable right of humankind equivalent to all other environmental, social, and cultural rights, due to its impact on the development of all peoples and on the conservation of biodiversity.*
- I thank Antonia Varela (Director of the Starlight Foundation) for information on this initiative.



**DARK
& QUIET
SKIES**

The End