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Losing the Dark: How light pollution impacts humans and the environment, and what we can do to win back the night

Marc Gagné

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The background features a dark blue gradient with faint, glowing circular patterns and a scale from 140 to 260. The scale is positioned on the left side, with numbers increasing from top to bottom. The circular patterns consist of concentric circles, some solid and some dashed, with arrows indicating a clockwise direction. The overall aesthetic is technical and scientific.

LOSING THE DARK: HOW LIGHT POLLUTION IMPACTS HUMANS AND THE ENVIRONMENT, AND WHAT WE CAN DO TO WIN BACK THE NIGHT

WEST CHESTER UNIVERSITY
SUSTAINABILITY RESEARCH AND PRACTICE SEMINAR

SEPTEMBER 21ST, 2022

MARC GAGNÉ

ACKNOWLEDGMENTS

1. West Chester Green Team
2. State Senator Carolyn Comitta
3. Dark Sky Committee
4. Diane Turnshek
5. International Dark Sky Association

[Losing the Dark: https://www.youtube.com/watch?v=dd82jztFlo](https://www.youtube.com/watch?v=dd82jztFlo)

LIBREVILLE	635
BIFOUN	469
NDJOLE	409
MITZIC	219
OYEM	101
BITAM	26











The Bortle scale is used to classify sky quality







Van Gogh painted “Starry Night” in Saint Rémy, France, in 1889. Now, the Milky Way can no longer be seen from Saint Rémy. If he were alive today, would he still be inspired to paint Starry Night?

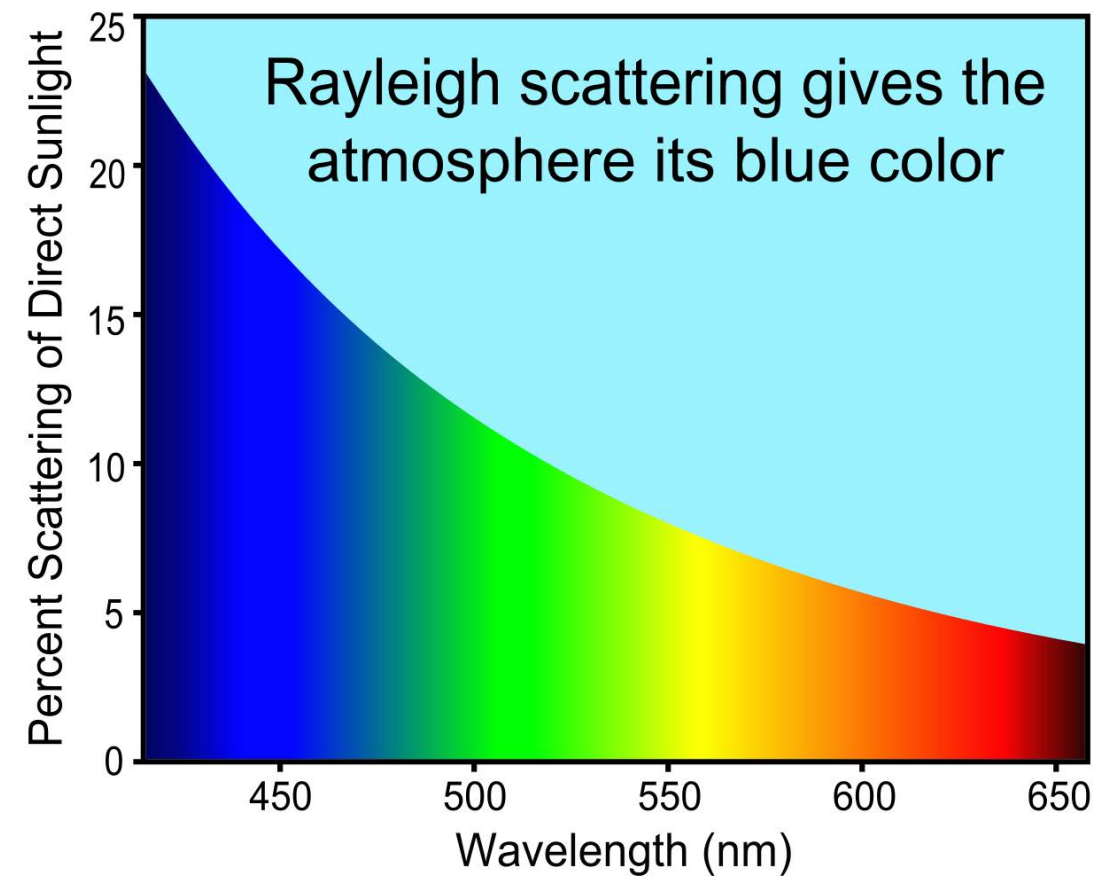
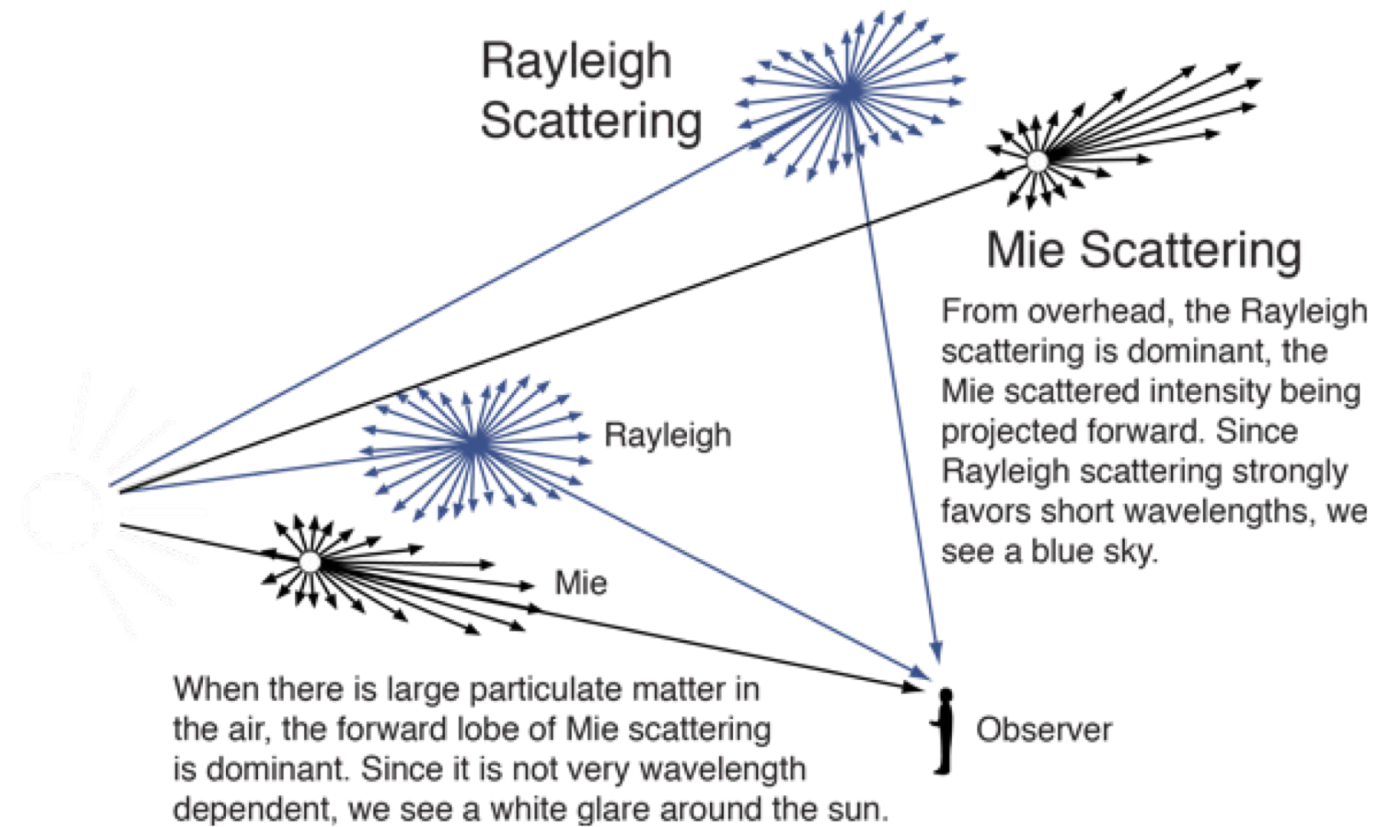
“For my part I know nothing with any certainty, but the sight of the stars makes me dream.”
— Vincent van Gogh



Metro New York City, Philadelphia and Wilmington at night, taken from the International Space Station



Sky Glow over Las Vegas, from hundreds of miles away



What is sky glow and why do we see light pollution from hundreds of miles away?

Scattering. O_2 , N_2 and H_2O redirect light via Rayleigh scattering. Particulate matter produces Mie scattering, which does not depend on the color of the emitted light.

Why is blue light especially bad for light pollution? The likelihood that a photon will be scattered via Rayleigh scattering increases from red to violet. the daytime sky is blue.

ENERGY WASTE

What is light pollution costing us?



13% of residential electricity use in the U.S. is for outdoor lighting



Average House

Bad outdoor lighting wastes **0.5 kilowatt-hours (kWh)** of energy per house, per night

0.5 kWh of electricity

= enough energy to power a 50-inch plasma TV for 1 hour



CO₂

About **15 million** tons of CO₂ are emitted each year in order to power residential outdoor lighting in the U.S.

About **35%** of light is wasted by unshielded and/or poorly-aimed outdoor lighting

SKYGLOW

is the artificial brightness of the night sky that's caused by light pollution.

About **3 million** passenger cars have the same CO₂ emission rate, which is 40,000 tons per day.



This is about **\$3 BILLION** per year worth of energy lost to skyglow



Which is about **\$10.00** spent for every man, woman, and child in the U.S. every year

About **600 million** trees would need to be planted to offset that amount of carbon emission



The drive to save money and “improve” lighting has motivated states and municipalities to replace conventional fixtures with LED fixtures.

The new fixtures are nearly always brighter and bluer than the ones they replace.

But why brighter and all night? Is it safety? Research has shown that switching off streetlights at night does not increase car crashes or crime.

Milan in 2012 (before LED installation)

LED conversions can make a city brighter.

Los Angeles before and after installing LED streetlights. High intensity results in high illuminance.

LIGHT POLLUTION IS NOT SOLVED WITH UNSHIELDED NOSTALGIC DECORATIVE FIXTURES THAT ARE TOO BRIGHT.

Milan in 2015 (after LED installation)



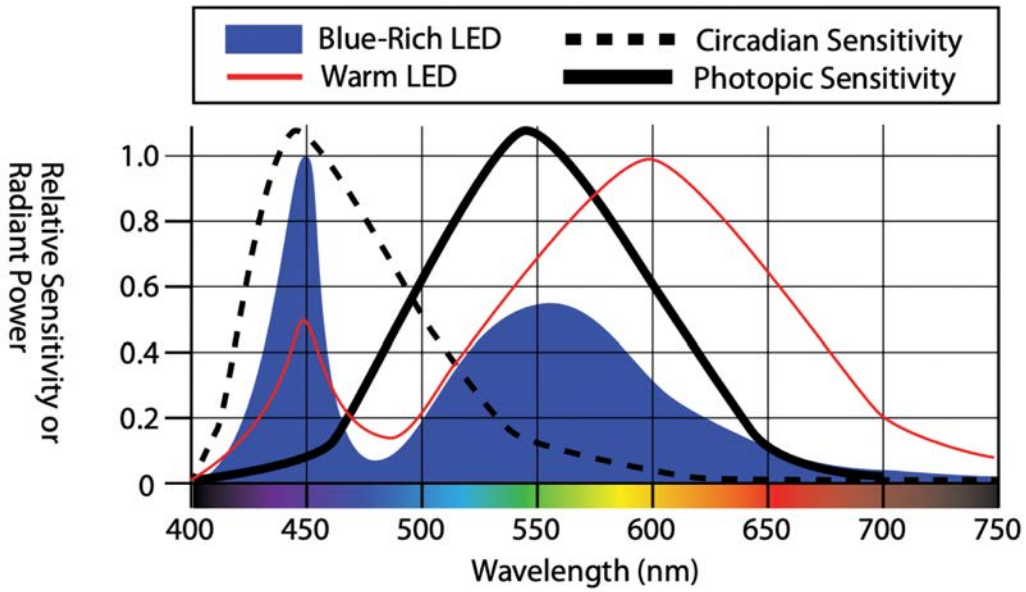
Most decorative luminaires, such as acorns and teardrops, throw light in all directions.



2010

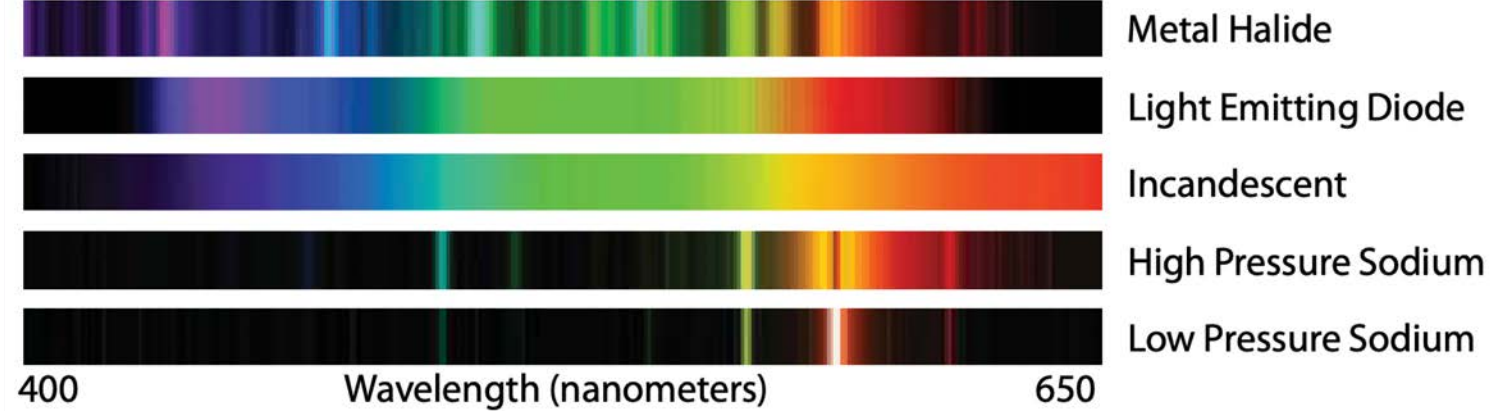
2012

What lights are the best lights for human health?



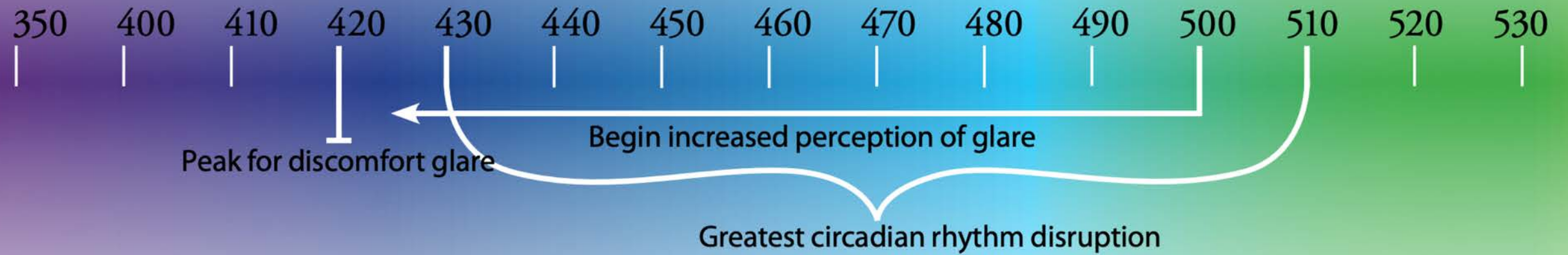
Human photopic and circadian sensitivity curves displayed against a typical blue-rich and warm white LED spectrum.

Spectra of five common lighting sources

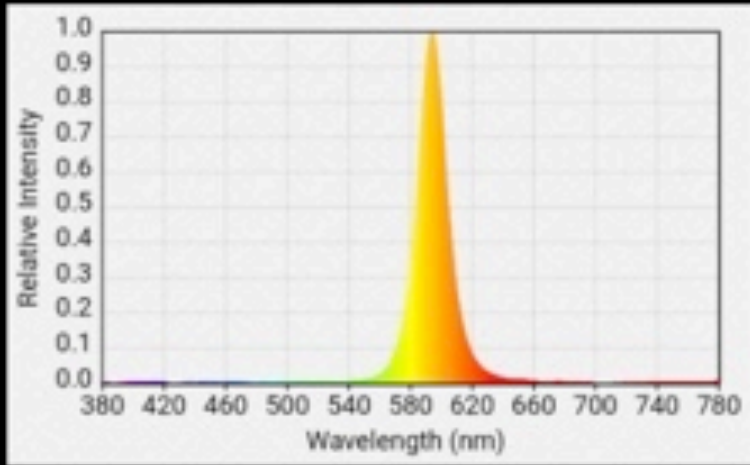


Blue-rich artificial light

Recommended wavelength range for minimizing adverse effects of blue light on sky quality

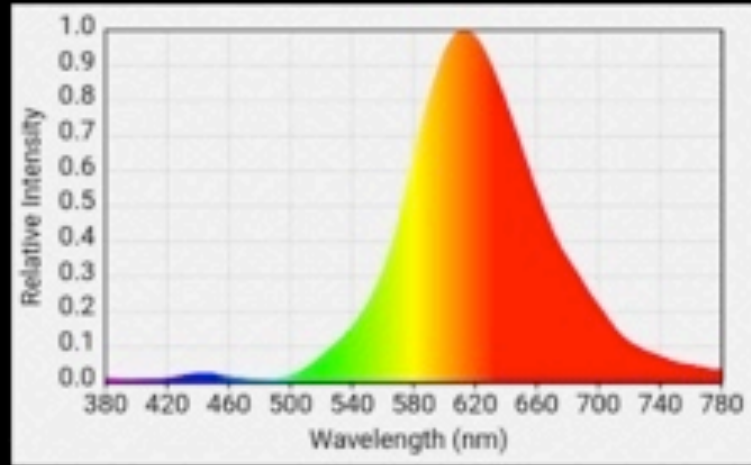


From "Seeing Blue", IDA review paper, 2010



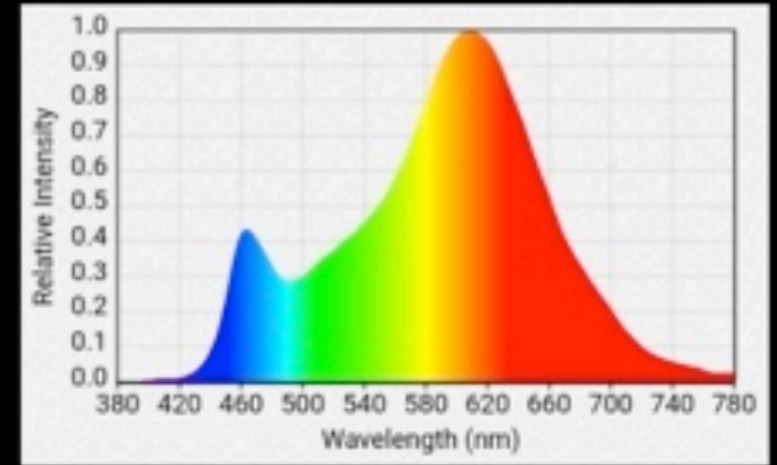
**Narrowband or Direct Emission
Amber LED
(NBA LED)**

Sky Glow Impact: 1.0 – 1.3



**Phosphor Converted Amber LED
(PCA LED)**

Sky Glow Impact: 1.8 – 4.1



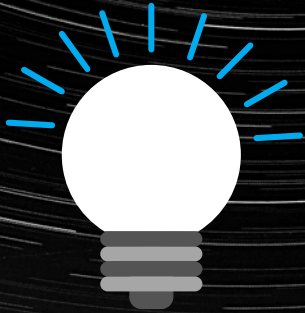
**White LED
(this example is 2700K CCT)**

Sky Glow Impact: 4.7 – >8

Flagstaff Dark Sky Coalition
Dark Sky Commercial Lighting Products

<http://www.flagstaffdarkskies.org/dark-sky-commercial-lighting-products/>

Outdoor lighting: 3 Steps to Improving our Designs



Intensity

Outdoor lighting often shines too intensely, leading to impacts like:

- Light trespass
- Visual glare
- Disruption to ecosystems

Light fixtures should be designed to eliminate harshness and include dimming features to minimise the light's impact when not in use.



Temperature

Color temperature is critical to efficient light design; the more blue light a source contains, the more it illuminates the night sky by scattering, and the more it damages ecosystems.

Instead, lights should have **warm** temperatures, and be no greater than 3000 Kelvin.



Shielding

When lights are not properly shielded, they illuminate far more than their intended target. Compounded with high-intensity lights, unshielded bulbs aggravate problems like light trespass and skyglow.

Properly-shielded lights should point directly downwards to minimise these impacts.

New LED fixtures.

Old high-pressure sodium fixtures.



What would
you do
differently?

So how bad is light pollution in the western suburbs of Philadelphia?

Google Earth Engine is a new service that allows users to easily select, download and filter Remote Sensing data. You can simply overlay those data onto a Google map or as a Google Earth layer.

VIIRS is the Visible Infrared Imaging Radiometer Suite. It is a sensor on board the polar-orbiting Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA-20 weather satellites.

The sensors have a calibrated light pollution channel. They have been collecting daytime and nighttime data continuously since 2011. The sensor's swath as it passes overhead at 829 km altitude is over 3,000 km.

The downside: like most weather satellites, the resolution of the detector system is poor. Each pixel is 750 meters, or about $\frac{1}{2}$ a mile.

VIIRS Nighttime Day/Night Band Comp...

by n l g p t v c 13 b r r y n l g

Apr 1, 2012 - May 1, 2012 [Jump to date](#)

Visualization

1 band (Grayscale) 3 bands (RGB)

avg_rad

Range

0 - 150 Custom

Opacity

Gamma Palette

1.00

1.00

Save Apply Cancel

Map Satellite

+

VIIRS Nighttime Day/Night Band Comp...

ny n i g p d w v c 13 b r r y n i g

Apr 1, 2012 - May 1, 2012

[Jump to date](#)

Visualization

1 band (Grayscale) 3 bands (RGB)

avg_rad

Range

0 - 150

Custom

Opacity

0.60

Gamma Palette

1.00

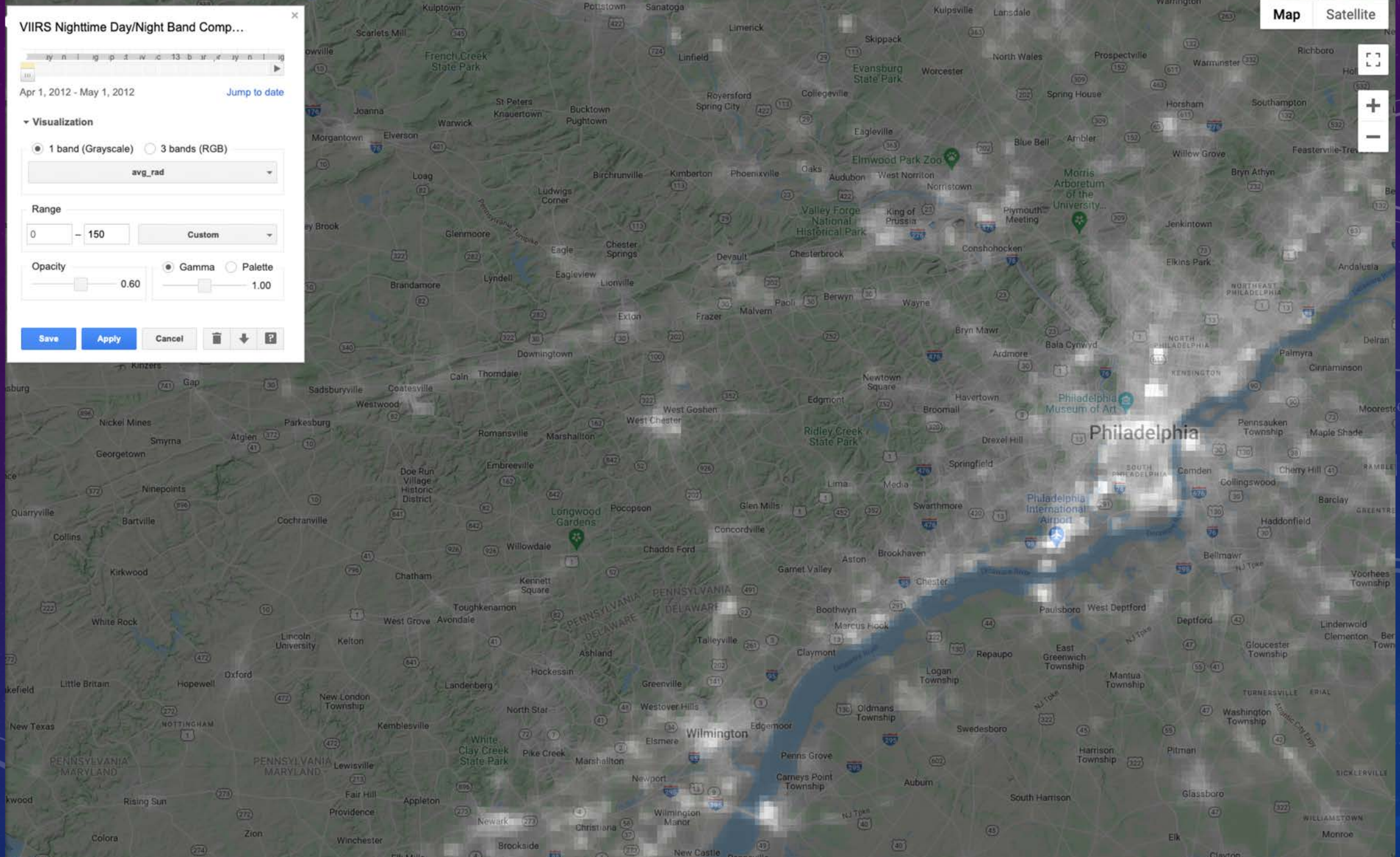
Save

Apply

Cancel



Map Satellite



VIIRS Nighttime Day/Night Band Comp...

Timeline navigation: Apr 1, 2021 - May 1, 2021

Jump to date

Visualization

1 band (Grayscale) 3 bands (RGB)
avg_rad

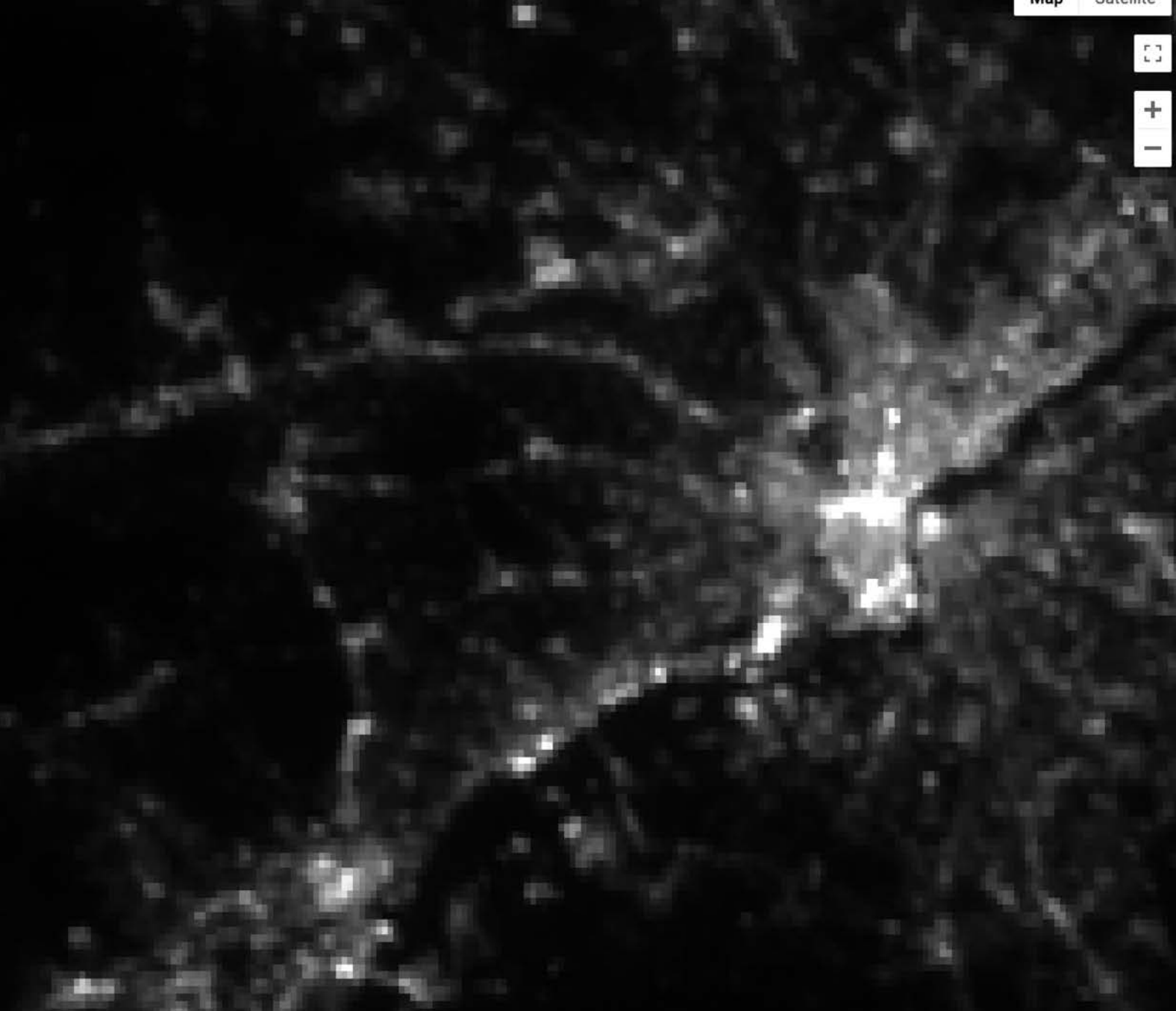
Range: 0 - 150 Custom

Opacity: Gamma Palette
1.00 1.00

Save Apply Cancel [trash] [down] [help]

Map Satellite

[full screen] [zoom in] [zoom out]



VIIRS Nighttime Day/Night Band Comp...

p t w c 21 b r r y n l i g p t w c 2

Jan 1, 2022 - Jan 31, 2022 [Jump to date](#)

Visualization

1 band (Grayscale) 3 bands (RGB)
avg_rad

Range
0 - 150 Custom

Opacity
 Gamma Palette
1.00 1.00

Save Apply Cancel

Map Satellite



VIIRS Nighttime Day/Night Band Comp...



Jan 1, 2022 - Jan 31, 2022 [Jump to date](#)

Visualization

1 band (Grayscale) 3 bands (RGB)

avg_rad

Range

0 - 150 Custom

Opacity

Gamma Palette

Save Apply Cancel [trash] [down arrow] [help]

Map Satellite



VIIRS Nighttime Day/Night Band Comp...

Jan 1, 2022 - Jan 31, 2022

[Jump to date](#)

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Opacity

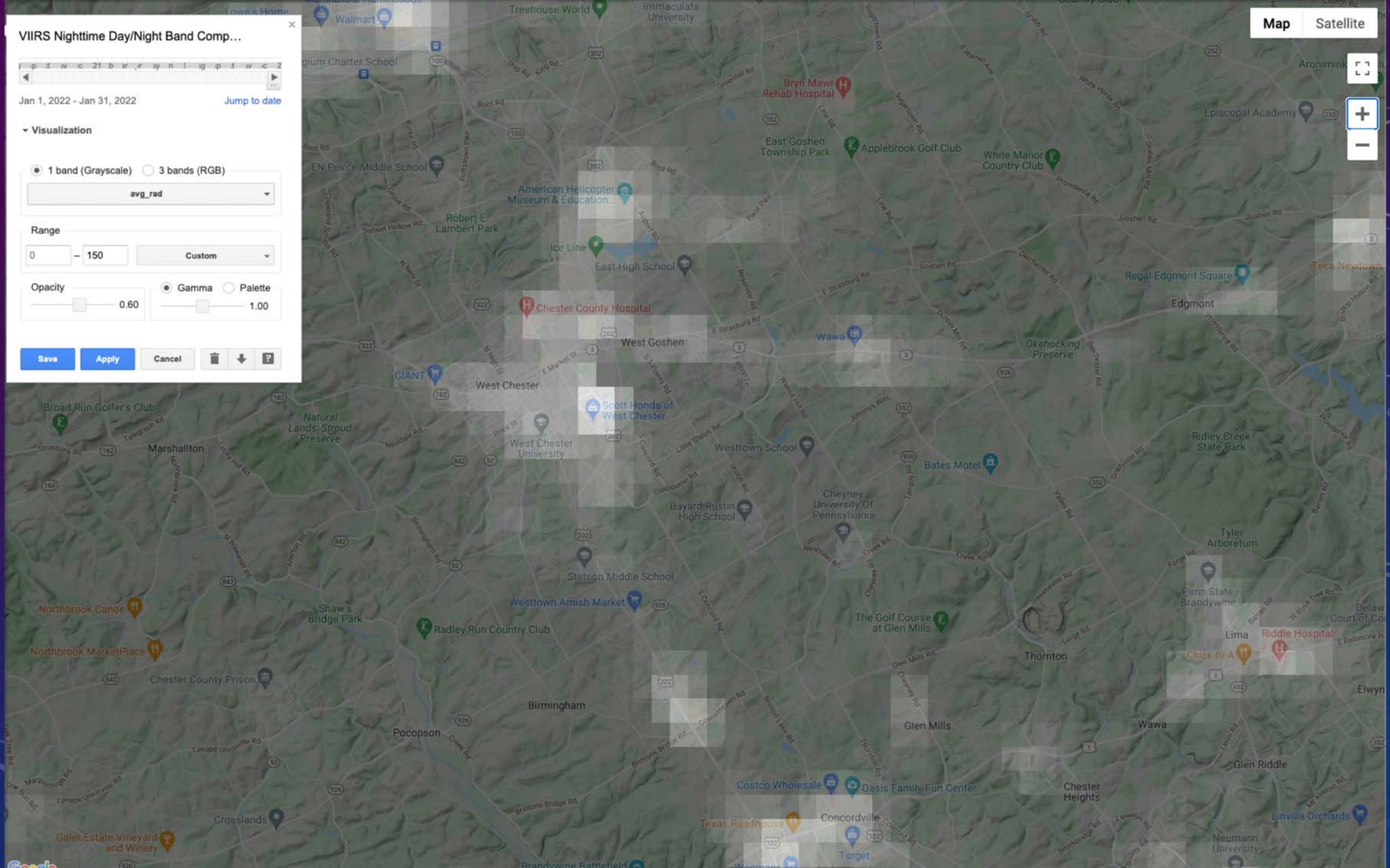
0.60

Gamma Palette

1.00

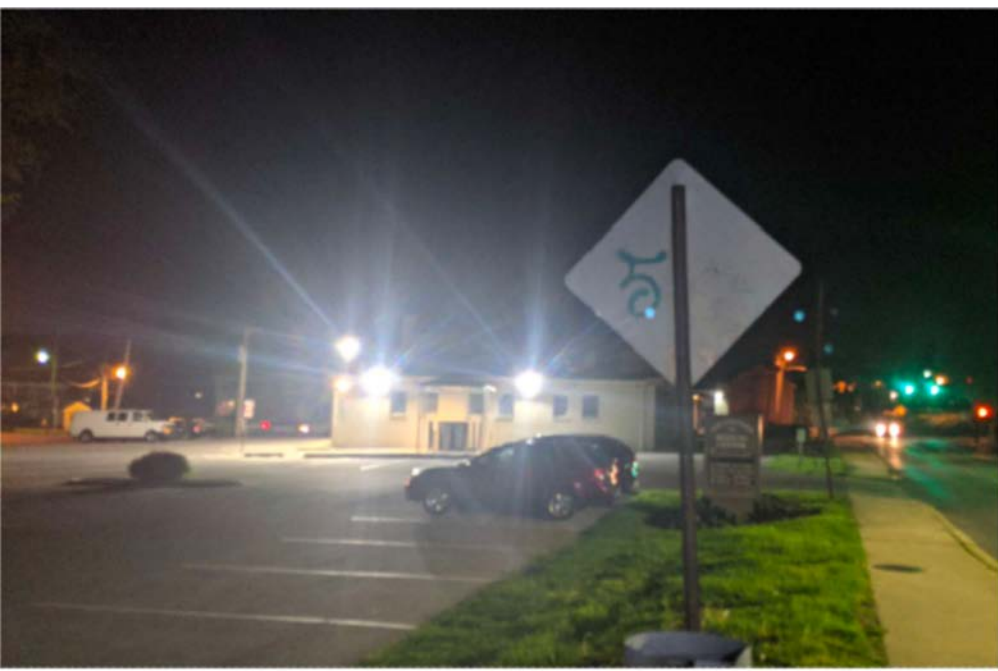
[Save](#) [Apply](#) [Cancel](#)   

Map Satellite





"Sky-glow" over Downingtown, looking East down Carpenter Alley, 8.00pm, January 2022



So, what are we* doing to reduce light pollution?

1. Public outreach: talks, planetarium shows, outdoor events like West Chester Porchfest...
2. Research:
 1. Quantify the extent of the light pollution problem.
 2. Create a database of satellite imagery, geo-referenced sky quality measurements, ground-level photography, and drone imagery.
 3. Identify good lighting solutions for the University, the Borough and surrounding townships.
3. Advocacy:
 1. work with township, borough, county and state officials on smart solutions and smart legislation.
 2. Work with residents and businesses to voluntarily improve and reduce outdoor lighting.

* We are the West Chester Green Team Dark Sky Committee

How To Conduct A Sky Quality Survey



Two hikers taking SQM measurements of the night sky on a trail in Saguaro National Park, Arizona. Photo by Jeremy White, National Park Service.

A thorough sky quality survey is essential to a successful application to the International Dark Sky Places Program.

There are a variety of ways to approach making a survey. These include:

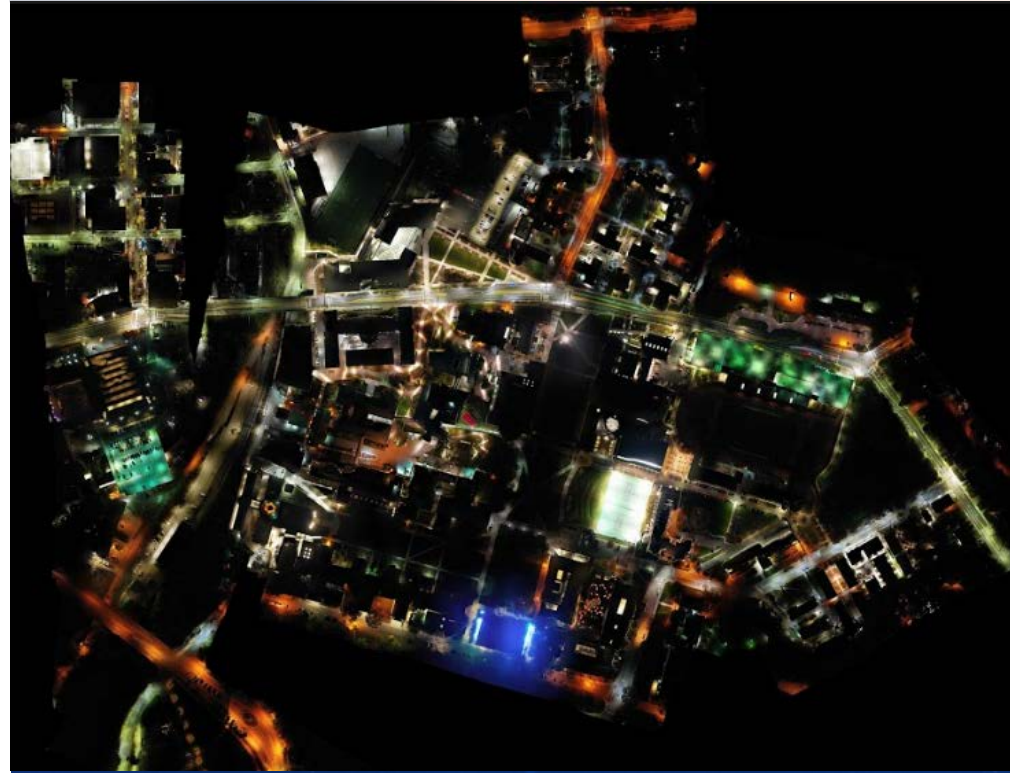
1. Sky Quality Meter Survey
2. Bortle Scale Interpretation
3. Photographic Evidence

SKY QUALITY METER SURVEY



The UniHedron Sky Quality Meter (SQM) is the most widely used device for taking scientific-quality measurements of sky brightness. This small, battery-powered device is [available directly from the manufacturer](#) for US\$119.99 plus shipping and handling.

The SQM is easy to use: simply hold the device above your head, pointing the photometer at zenith, and click the button. The screen will then



Drones will provide high-resolution 400-foot imagery at night.

Here is an image from Pittsburgh courtesy of Diane Turnshek.

Drones can do this in a timely fashion. The data are assembled into a nighttime map used to identify hot spots.

Final thoughts...

Light pollution is one of many human-made environmental problems, and certainly not the most pressing. So, why should you care? Why do I care? Because our nighttime environment is worth restoring and protecting.

Although a century of excessive artificial light at night has depleted our resources, and contributed to climate change, light pollution can be eliminated by just shutting off the lights. There's no long, costly clean up and the solution to light pollution helps solve other problems.

So why is the problem getting worse? Many people just don't care. And why should they? The vast majority of Americans cannot see the Milky Way from their homes. We generally don't walk outside at night, and when we do we seek the refuge of lighted streets and parking lots.

To protect nature, first we have to experience nature.
We are losing the dark. Let's win back the night.