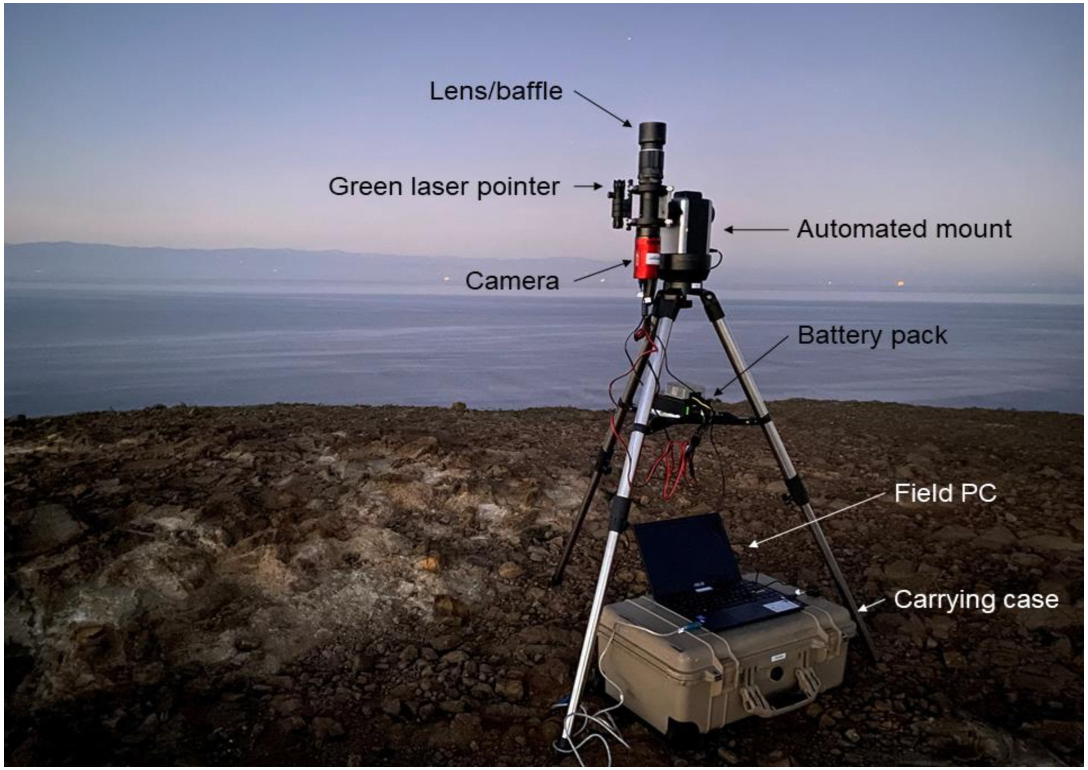
Ground-based measurements of spectrally-resolved sky radiance at U.S. National Parks

11/18/2025

SSLS, Inc.

Morgan Pattison, PhD, FIES, LC
Lisa Pattison, Ph.D.
Jeremy White

Quantifying Skyglow



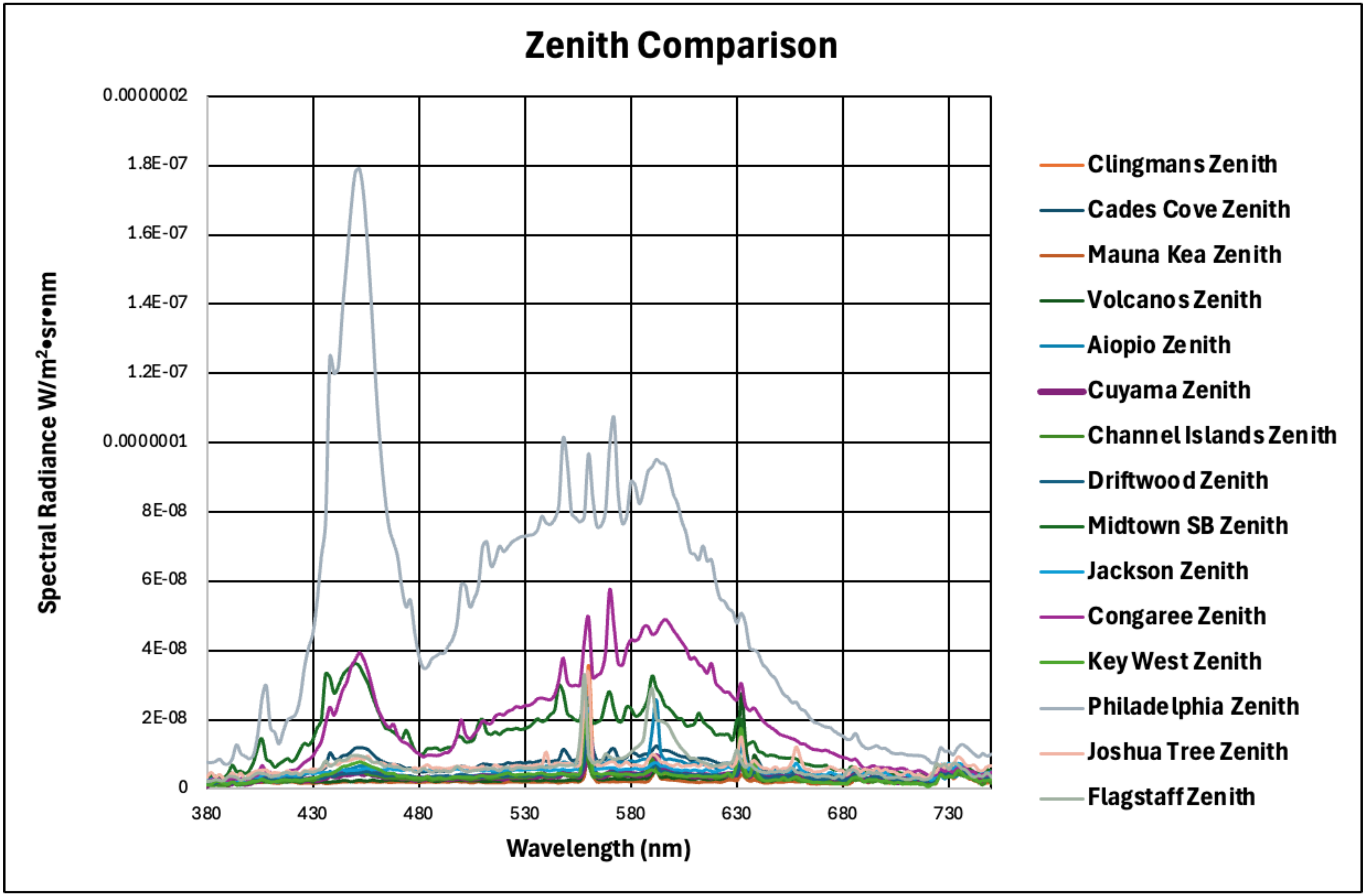
Night Sky Metrics Spectrometer
https://nightskymetrics.com

- Spectrally resolved
- Angularly resolved, azimuth and elevation
- Geographically resolved – GPS location
- Celestial alignment
- Highly sensitive
- Portable
- Measures absolute spectral radiance
- Measurement of light relevant to terrestrial perception

Measurement Sites

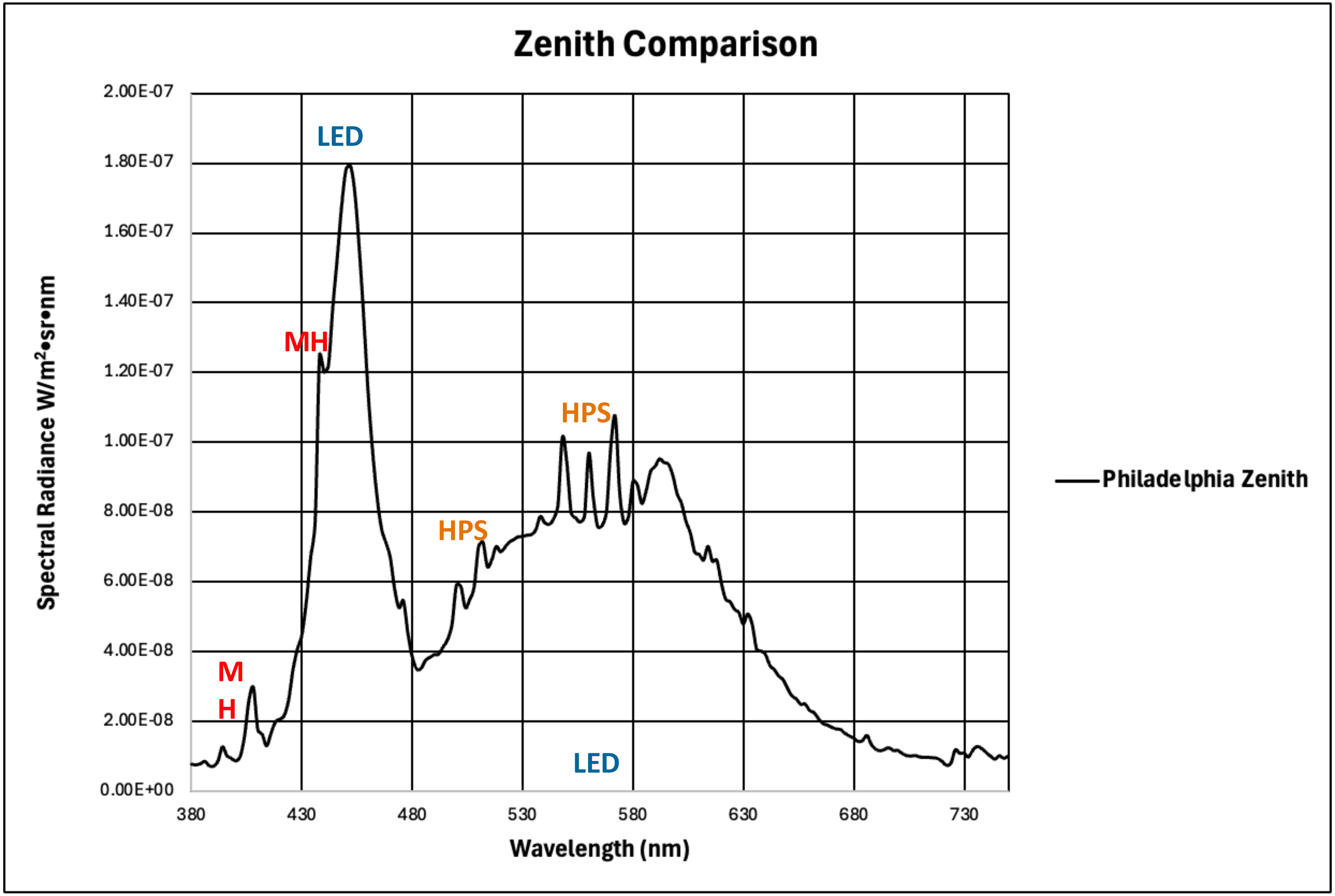
- Driftwood Beach State Park, OR – PacWave Marine Energy Testbed
- Hawaii, Ai’opio Beach, Kaloko-Honokohau National Historical Park
    - Turtle Habitat near Kona
- Hawaii, Volcanos National Park
- Hawaii, Mauna Kea Observatory
- Channel Islands National Park
- Carrizo Plains National Monument(Cuyama, CA) – Santa Barbara County
- Santa Barbara, CA
- Lookout Mountain, GA
- Grand Tetons National Park
- Great Smoky Mountains National Park
- Congaree National Park
- Key West
- Philadelphia, PA
- Joshua Tree National Park

Zenith Comparison



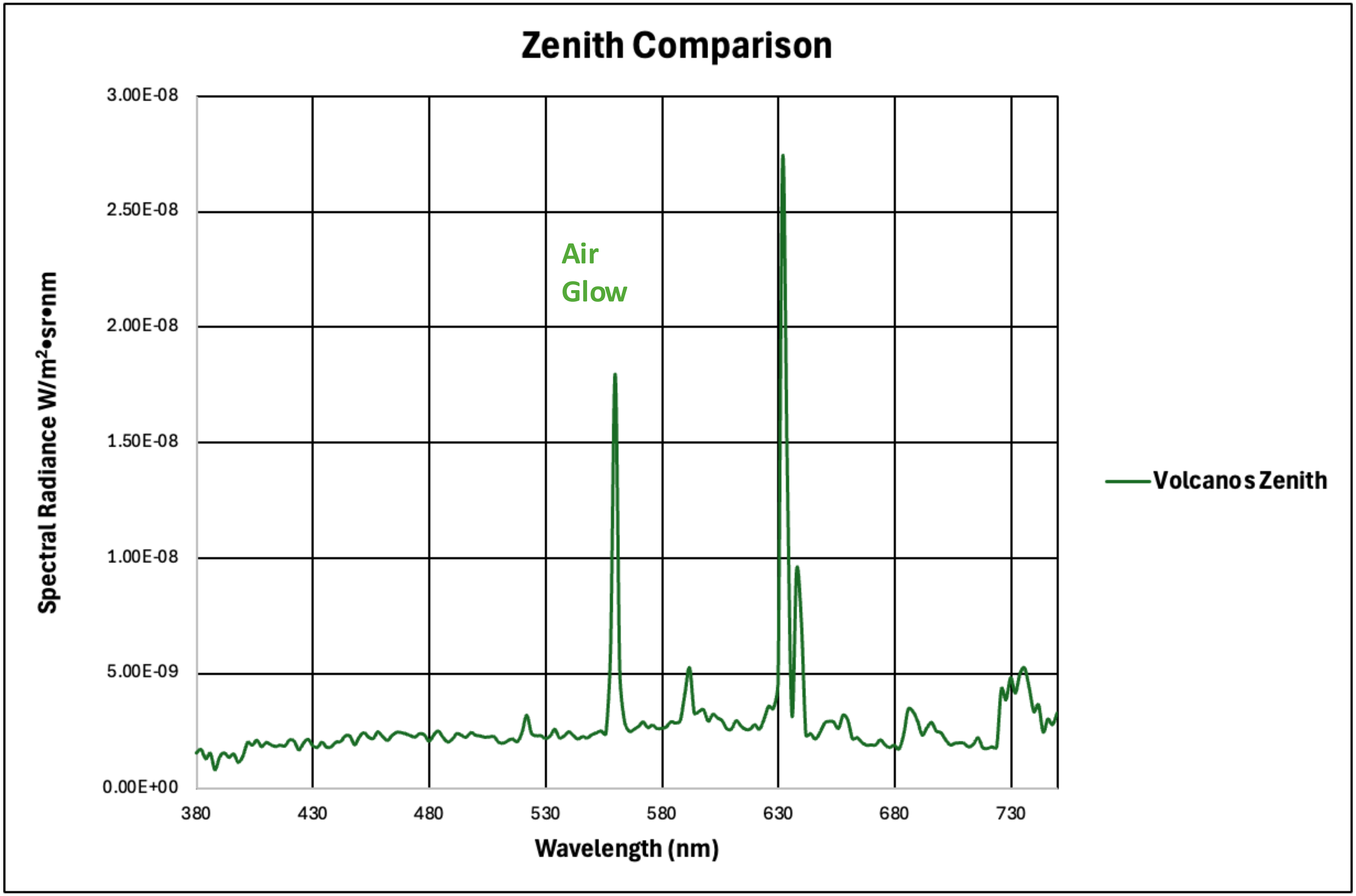
SSLS, INC

Brightest Zenith - Philadelphia



SSLS, INC

Dimmest Zenith – Hawaii Volcanos NP



SSLS, INC

Zenith –

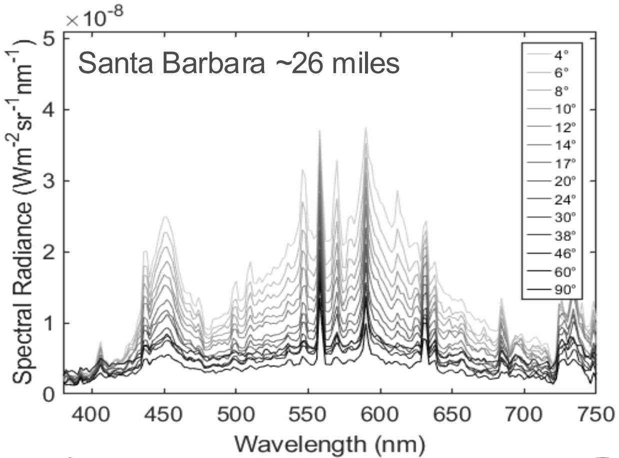
Measurement Site	S/P	Integrated Radiance (W/m^2sr) 380-750nm	Spectrometer Measured Sky Quality ($mag/arcsec^2$)	SQM Whole Sky Quality ($mag/arcsec^2$)
Clingmans Dome - Z	1.92	1.27×10^{-6}	21.26	21.26
Cades Cove-Zenith	1.88	2.32×10^{-6}	20.54	X
Cades Cove Measurement (2008)			20.93	20.22 all sky
Clingmans Dome (2008)			20.98	19.72 all sky
Aiopio - Zenith	1.57	1.86×10^{-6}	20.74	18.75
Volcanoes NP – Zenith	1.71	1.05×10^{-6}	21.66	21.4
Mauna Kea-Zenith	1.92	7.84×10^{-7}	21.96	21.51
Driftwood SP Oregon	1.93	1.46×10^{-6}	21.19	21.19
Channel Islands NP	1.92	1.21×10^{-6}	21.35	21.20
Cuyama, CA	1.87	1.29×10^{-6}	21.34	21.25
Midtown SB, CA	2.05	5.31×10^{-6}	19.64	
Grand Tetons, WY	2.04	1.96×10^{-6}	20.89	
Congaree, SC	1.52	7.05×10^{-6}	19.18	
Key West, FL	2.04	1.39×10^{-6}	21.20	
Philadelphia, PA	2.16	1.99×10^{-5}	18.20	
Joshua Tree, CA	1.99	2.42×10^{-6}	20.66	
Flagstaff, AZ	1.61	2.42×10^{-6}	20.51	

Southern California

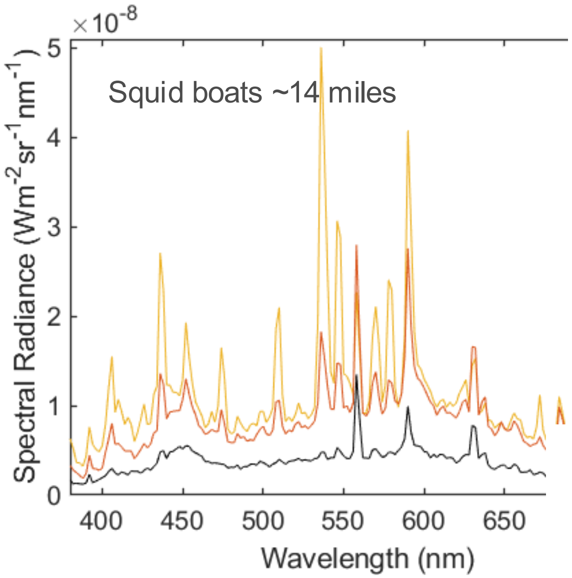
SSLS, INC

Channel Islands Skyglow Measurements

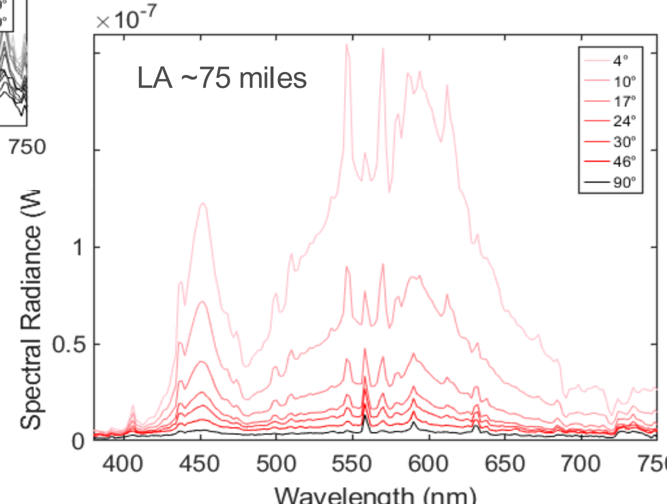
4º 5.62 X 10^{-6} W/m^{2}sr

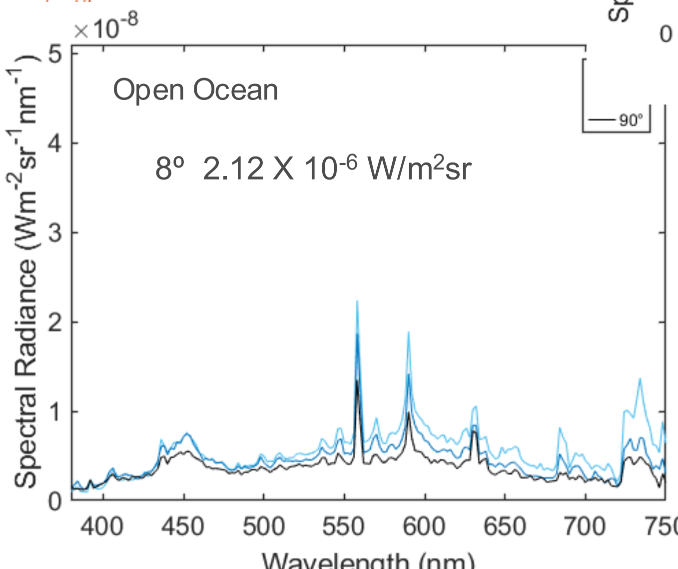


2º 4.09 X 10^{-6} W/m^{2}sr



4º 2.87 X 10^{-5} W/m^{2}sr



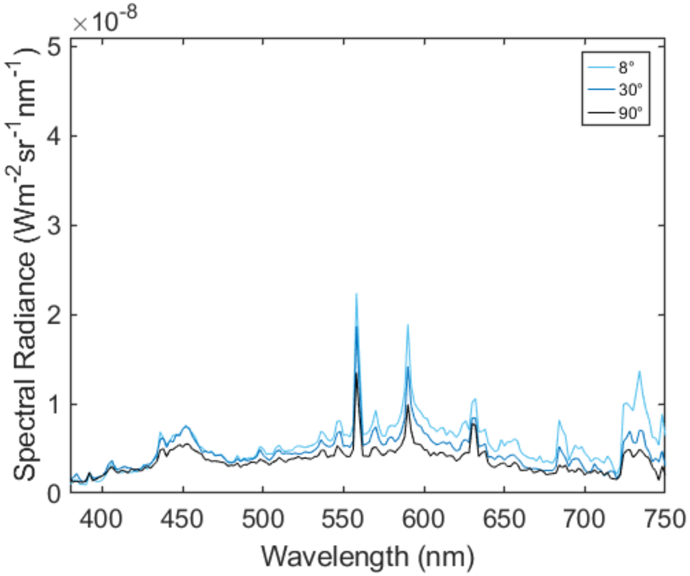


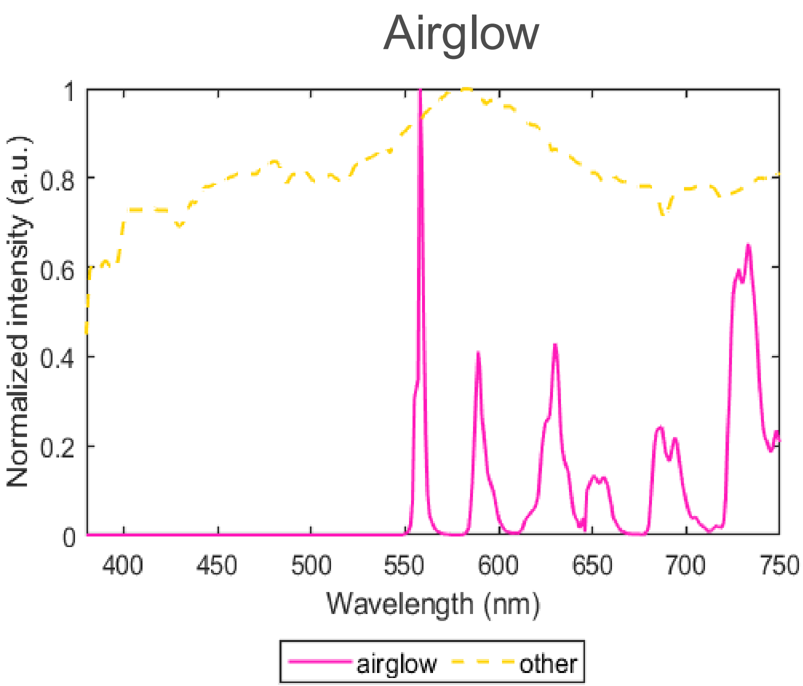
8º 2.12 X 10^{-6} W/m^{2}sr

Supported by NPS, unpublished

SSLS, INC

Open Ocean





Zoltán Kolláth, Andrew Cool, Andreas Jechow, Kornél Kolláth, Dénes Száz, Kai Pong Tong, "Sp," Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 253, 2020, 107162, https://doi.org/10.1016/j.jqsrt.2020.107162

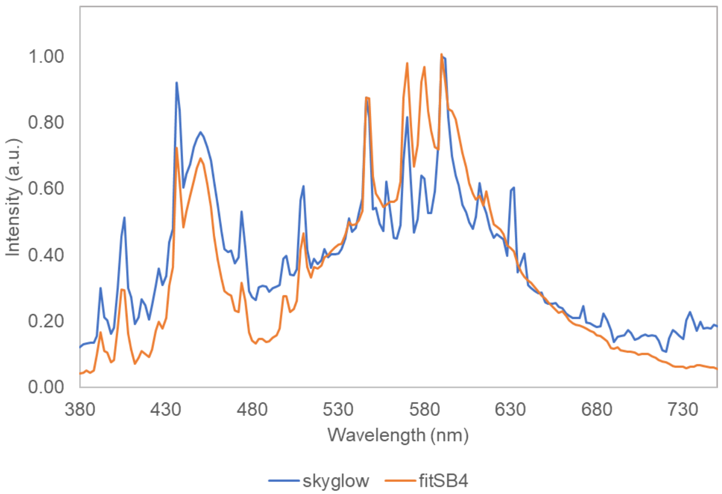
Spectral Decomposition

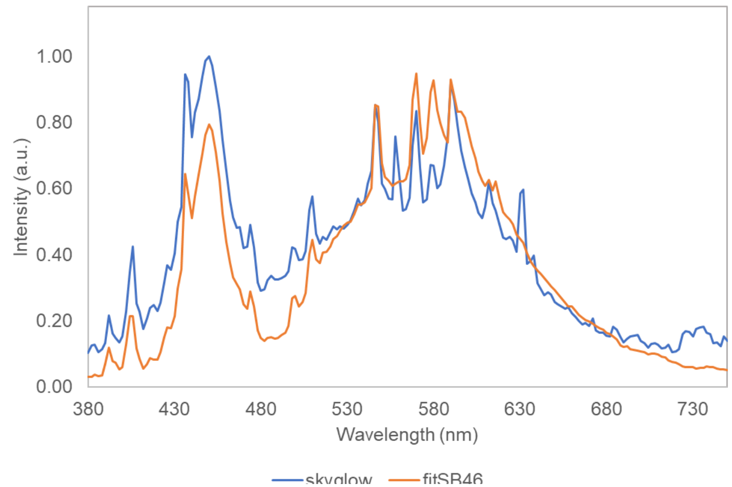
Using only 4577K LED for both SB 4° and SB 46° (data taken in SB)

SB_4 R-squared = 0.839950268

SB_46 R-squared = 0.821637563

	LED	HPS	MH	FL	data	fit
SB 4°	64.3%	17.4%	16.8%	1.4%	112.6%	100%
SB 46°	73.5%	13.6%	11.3%	1.5%	114.4%	100%





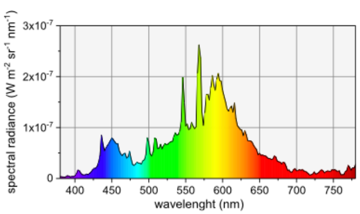
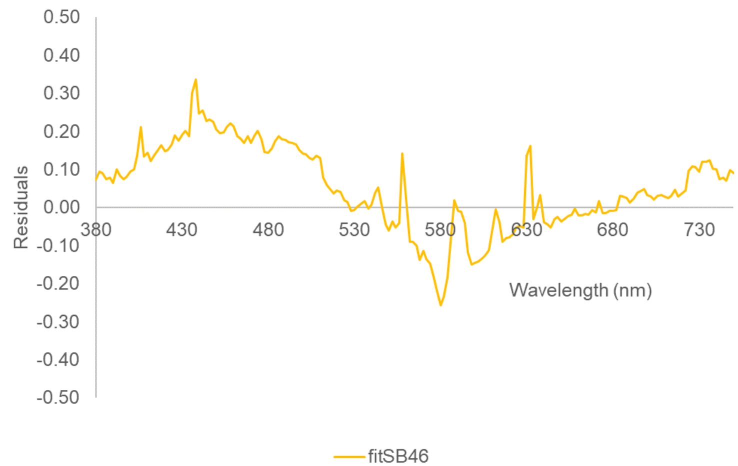


Figure 12. NSB spectrum 10° above Chicago taken by the spectrometer at Weko Beach, Michigan (Looking across Lake Michigan to Chicago).

Table 3. The same as in Table 2 but for Weko site.

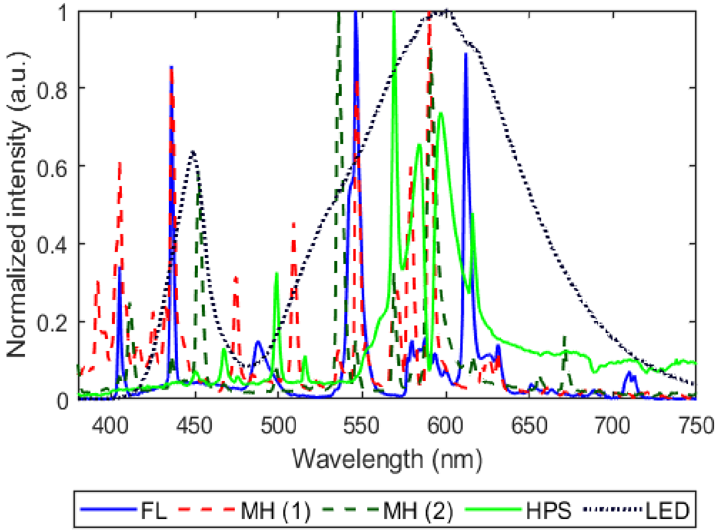
	Percent content		
	Min	Mean	Max
FL ~ 4000 K	2.9	3.8	4.7
HPS ~ 2000 K	13.0	14.0	14.9
LED ~ 3000 K	66.9	68.9	70.9
MH ~ 4000 K	11.5	12.8	14.0

Kocifaj Paper

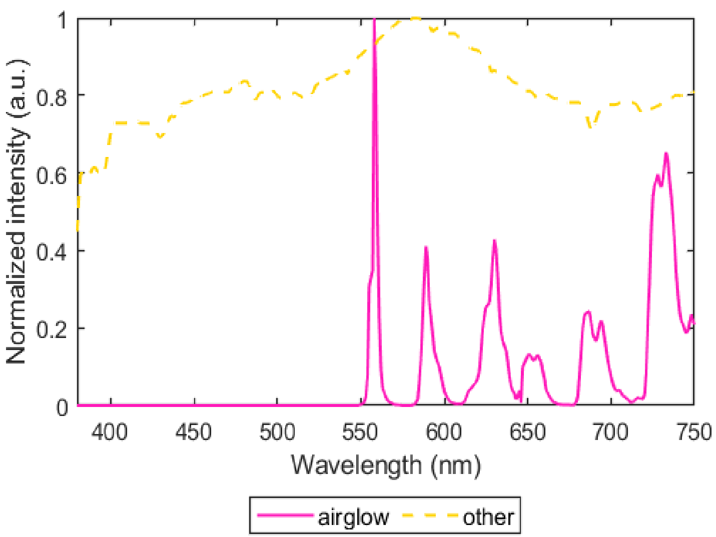


SSLS, INC

Skyglow Contributors – Spectral Signatures



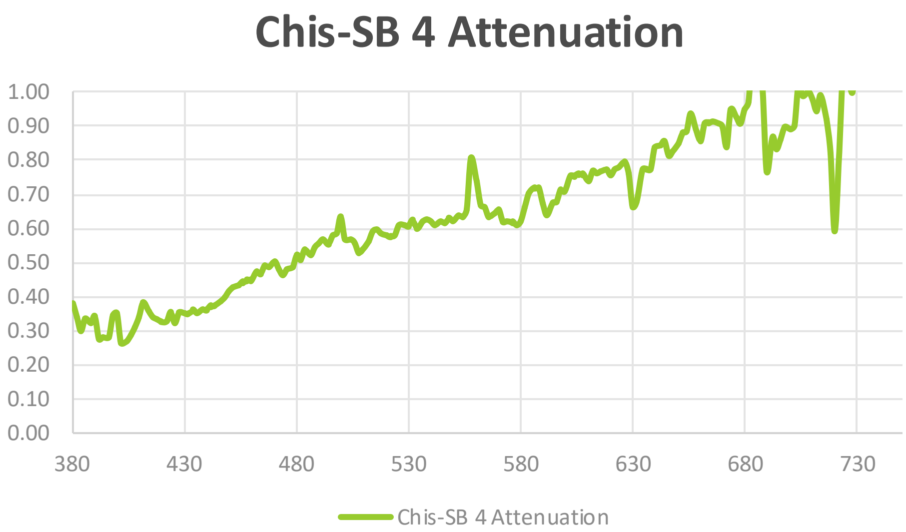
Lighting Technologies



Airglow

Kolláth, Z., Cool, A., Jechow, A., Kolláth, K., Száz, D., & Tong, K. P. (2020). Introducing the dark sky unit for multi-spectral measurement of the night sky quality with commercial digital cameras. Journal of Quantitative Spectroscopy and Radiative Transfer, 253, 107162.

Atmospheric Effects



40 kilometers

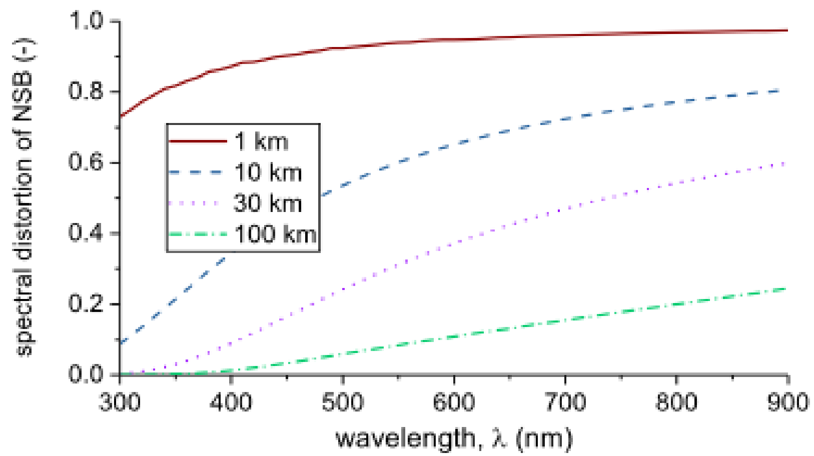
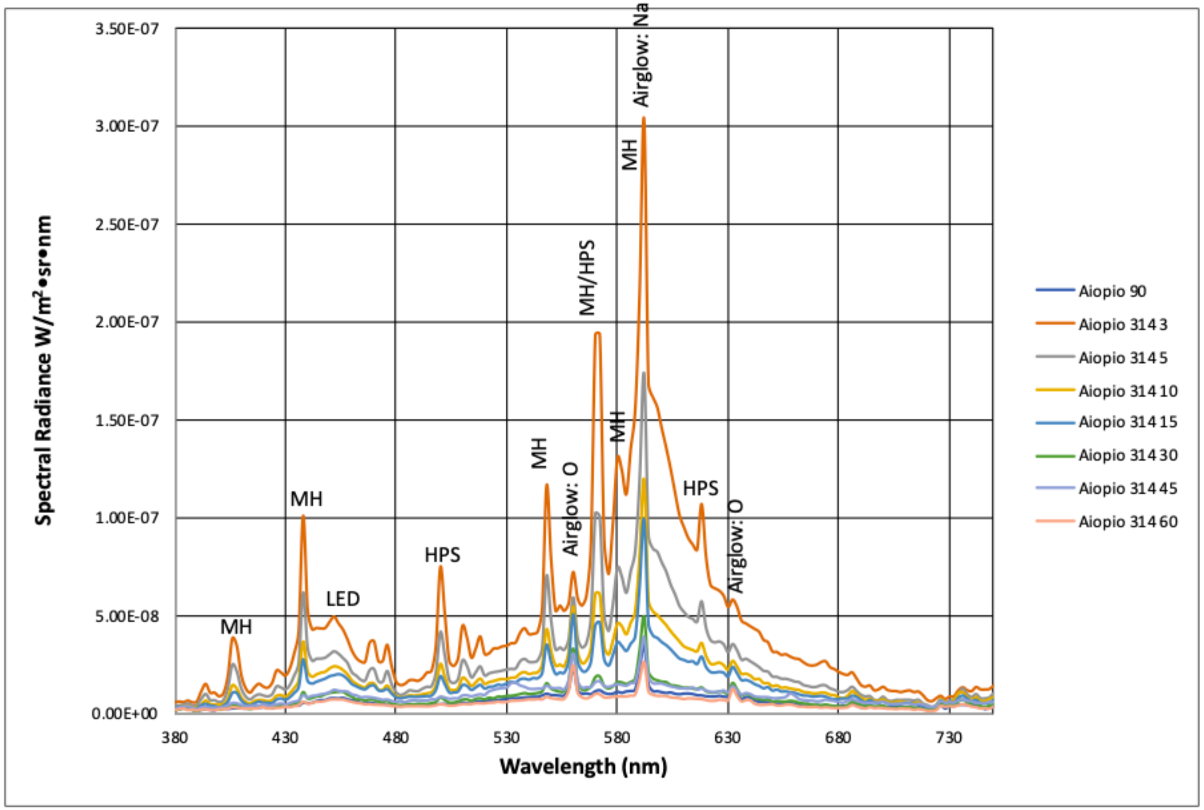


Figure 2. T-function-induced spectral distortion of night sky brightness 10° above the source of light. The distortion rate displayed on the y-axis is defined as the ratio of $\Psi_\lambda(T)$ and $\Psi_\lambda(T \equiv 1)$ (see equation 1). The results are shown for four discrete distances $D = 1$, 10, 30, and 100 km.

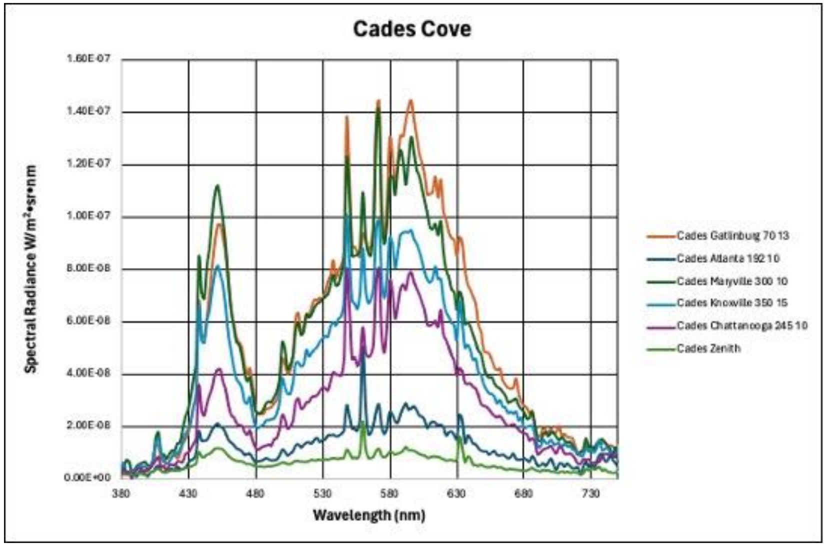
Kocifaj, M., Kundracik, F., Duriscoe, D. M., Balm, S. P., & Wallner, S. (2021). Using ground-based measurements to recover the spectra of radiation escaping from distant light-pollution sources. *Monthly Notices of the Royal Astronomical Society*, *506*(2), 2739-2745.

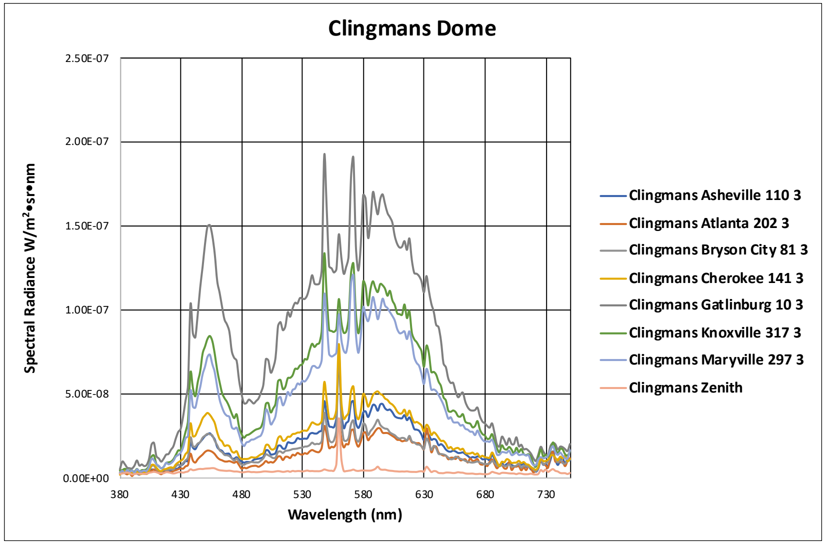
Aiopio Hawaii

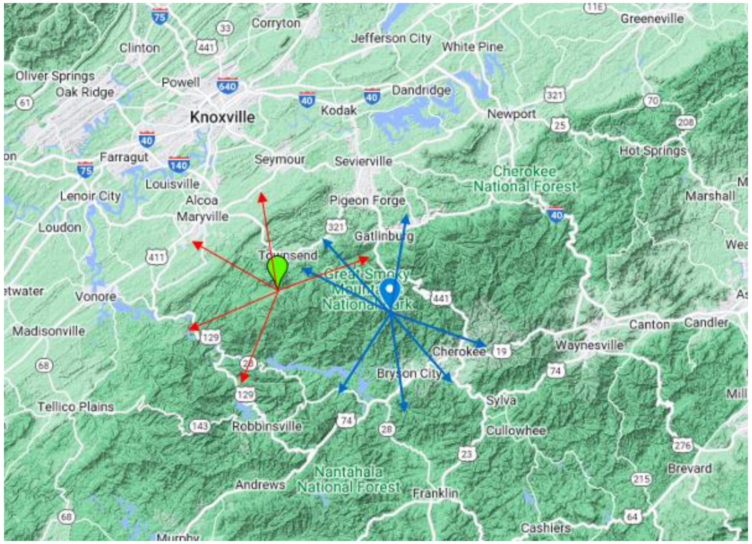


SSLS, INC

Great Smoky Mountains National Park







SSLS, INC

Conclusions/Takeaways/Future Work

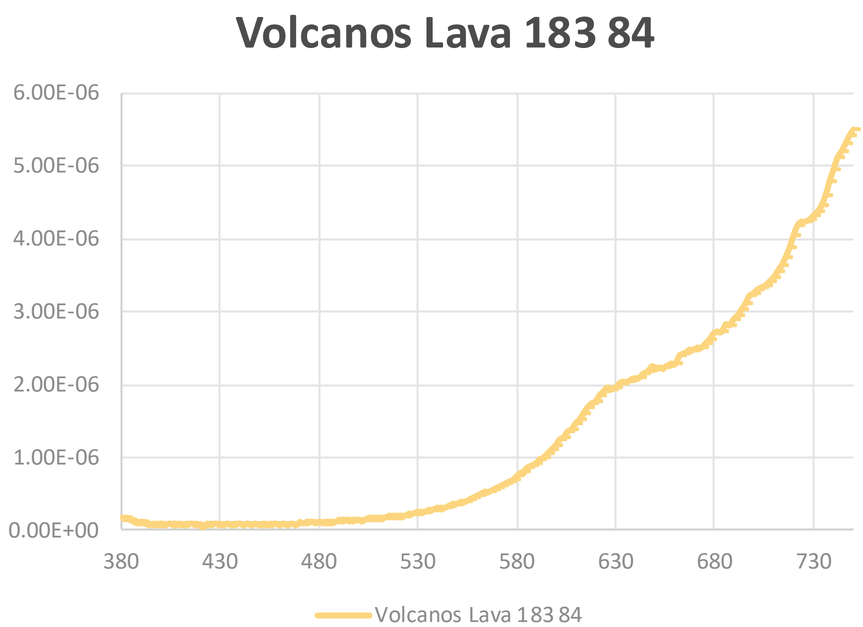
Findings

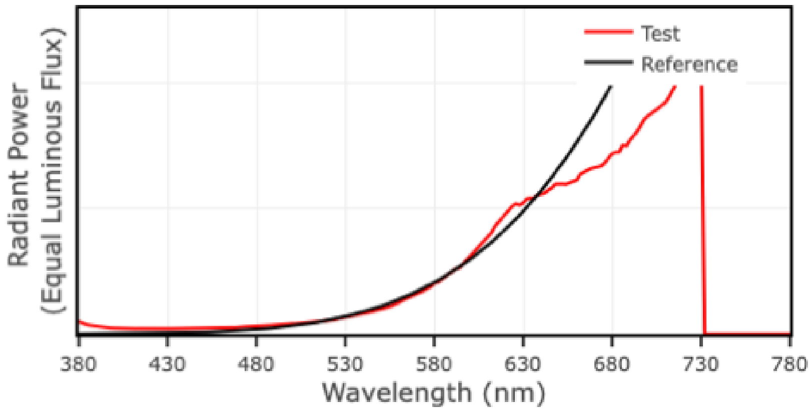
- Baseline measurements of spectral radiance taken at naturally dark and urban sites. Measurements show expected air glow emissions and combinations of lighting technology.
- Atmospheric scattering shows that shorter wavelengths scatter more and attenuate more rapidly.
- Lighting technology mix in Santa Barbara, CA is estimated at 65% LED, 17% MH, 17% HPS

Future Work

- Using measurements to evaluate atmospheric conditions – what can atmospheric scattering tell us?
- What can elevation data tell us about upward emissions?
- Modeling city emissions as a point source to determine total light output per capita
- Evaluating time of night effects
- Measurements of various natural conditions – moonlight, starlight, airglow, cloudy skies, clear skies
- Before/after measurements with new developments or deployed mitigations

Volcanos National Park

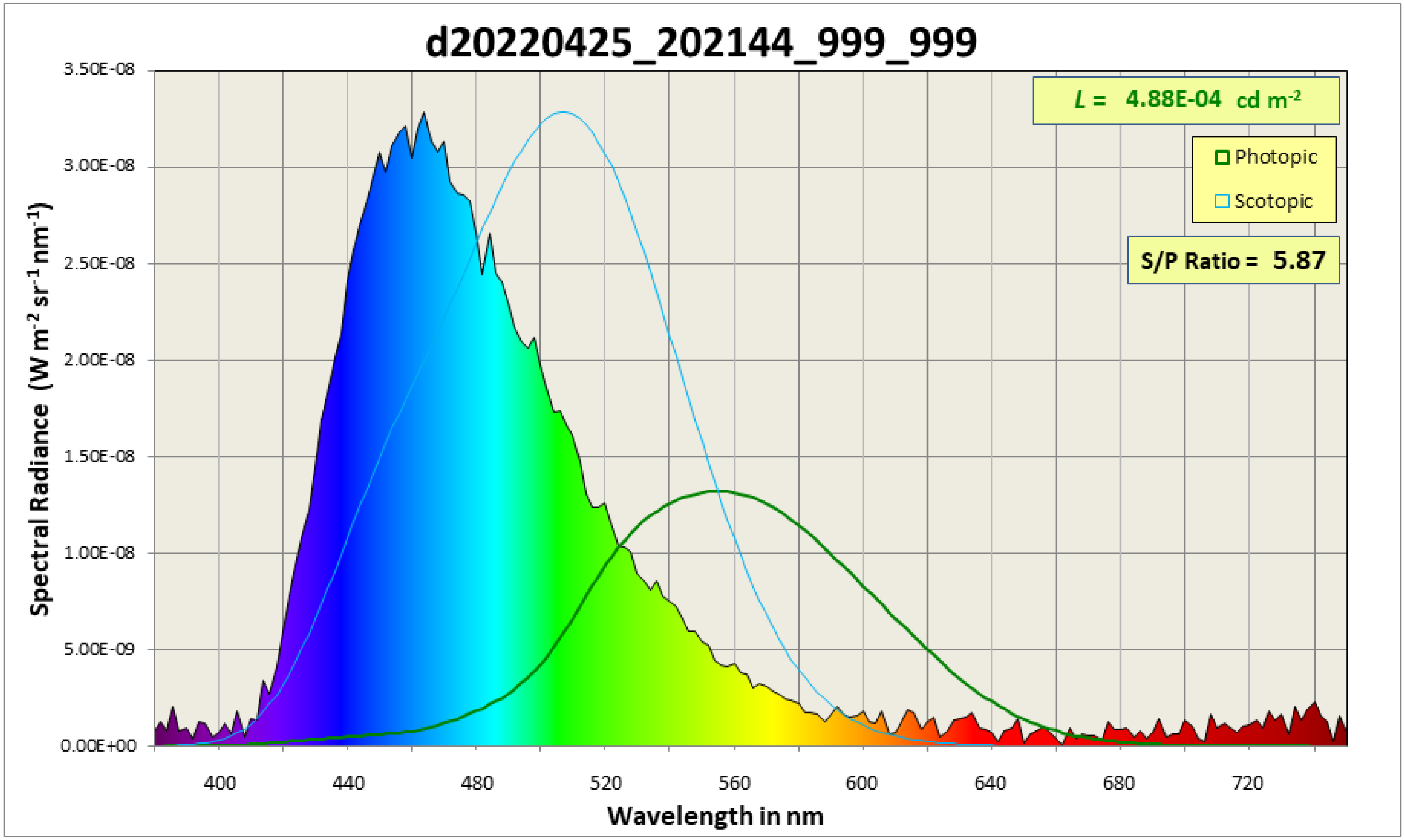




CCT = 1536K

SSLS, INC

Bioluminescence



SSLS, INC

Thank You!

Morgan Pattison
morgan@sslsinc.com
1-805-217-3878

SSLS, INC