Using Low-Cost Sensors to Detect UVA

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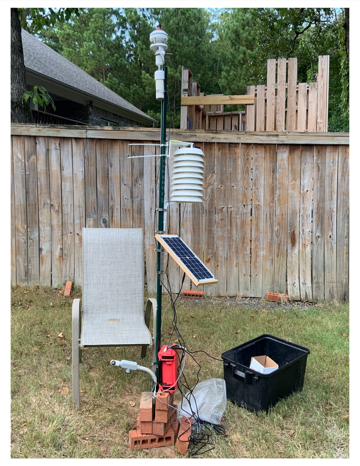
Overview

The LEMS (Low-Cost Energy-Budget Measurement Station) is an inexpensive solar-powered weather station that can measure soil/air temperature and humidity, solar irradiance, wind speed/direction, pressure, and surface temperature. The LEMS circuit board and code are customizable, Arduino-based, and open source. The LEMS has been used in a variety of environments including deserts, snowy mountains, and vineyards (Gunawardena et. al, 2018).



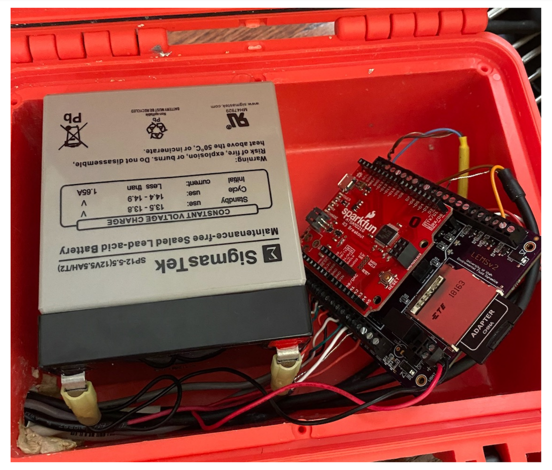


Figure #1: Pictures of the LEMS, LEMS Circuit Board, and the LEMS Soil Sensors

1 in 5 Americans will get skin cancer[7]

Literature Background

A study conducted in Spain found out it was possible to use linear regression to estimate UVB irradiation (280-315 nm) by knowing global solar irradiation (305-2800 nm) (Bilbao and de Miguel, 2010). The purpose of this project was to test if this method would work with the LEMS' pyranometer (a device that measures solar irradiance) and UVA irradiance.

Purpose/Hypothesis

The LEMS uses the Li200R pyranometer which measures in the range of 400nm to 1100nm (Gunawardena et. al, 2018). While this does not measure UV (~200nm to 400nm), I **hypothesized** that we could use linear regression to relate the output of the pyranometer to UVA exposure, and therefore to use the LEMS to estimate UVA exposure.

Results

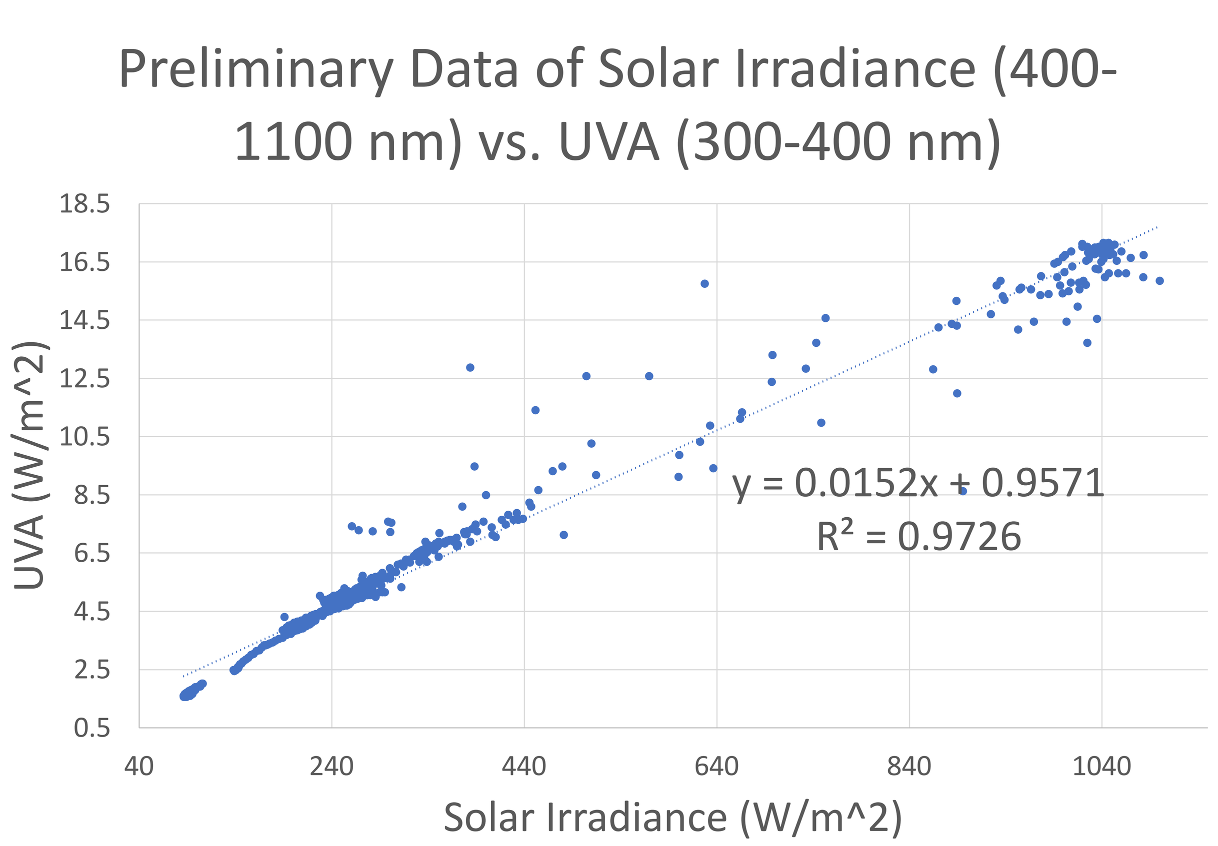


Figure #3: Aggregate Preliminary Data

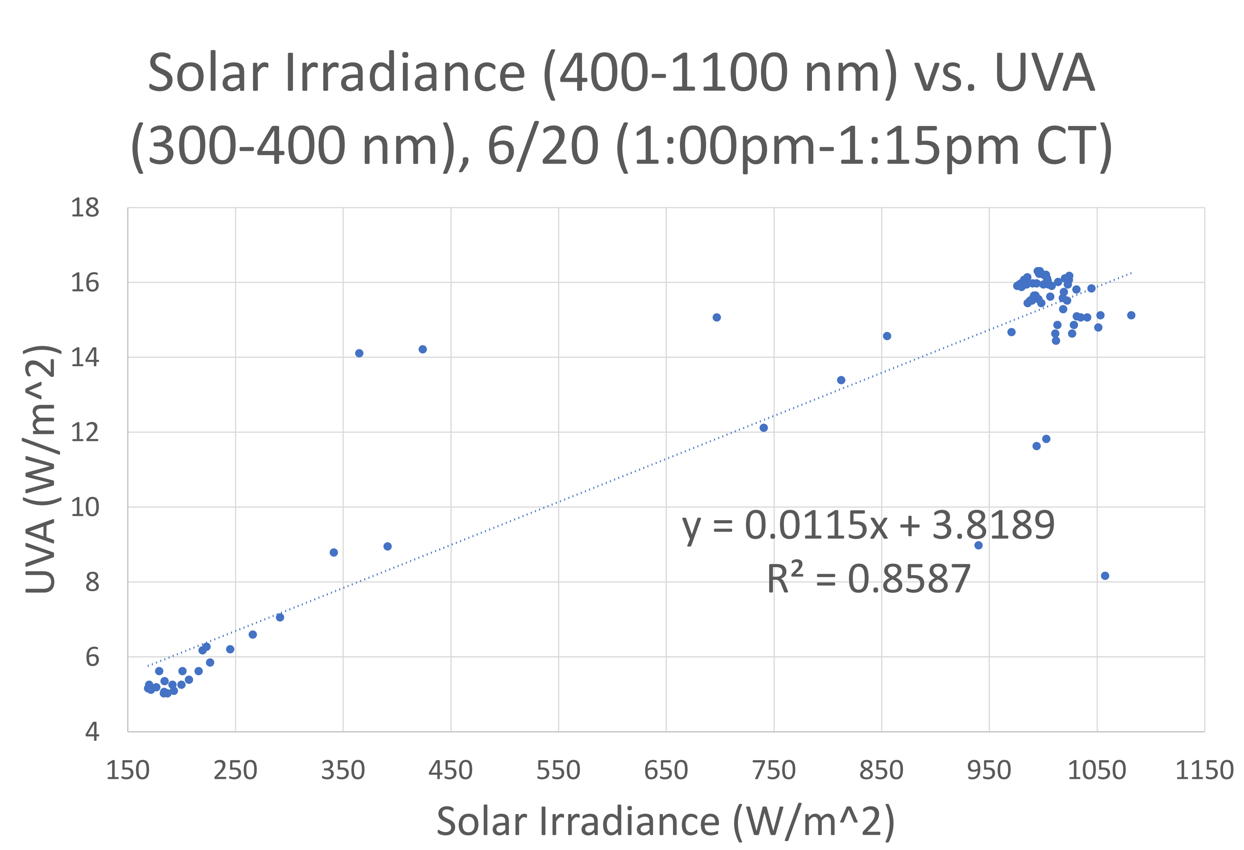


Figure #4: Graph for Random Sample

Introduction

Ultraviolet (UV) light emitted by the sun consists of three types: UVC, UVB, and UVA. UVC is filtered out by the ozone layer while UVB and UVA can pass through the ozone layer and hit our skin/eyes. UVB is responsible for sunburns and vitamin D synthesis. UVA can penetrate deeper into the skin and causes wrinkles and photoaging (Fioletov et. al, 2003/2010). Both UVB and UVA overwhelmingly cause skin cancer. There are various forms of skin cancer including basal and squamous cell cancers (American Cancer Society 2019). If we want to lower skin cancer rates, we need to educate people about UV and make UV readings easier to obtain.

Methodology

I collected data using the Apogee UVA Instrument (Model SU-220, spectral range 300-400 nm)[1] and data using the Li200R synchronously. During the first six 15 minute trials, I sampled data from various times and weather conditions to see if linear regression was reasonable. These six trials were preliminary and had minor errors with experimentation. Then, I selected a random time (via random number generator) to collect quality data every 10 seconds for 15 minutes. In this trial, both instruments were leveled (0.1°) and at the same height. Data collection occurred at exactly 1:00 pm – 1:15 pm Central Time in Little Rock, Arkansas. The weather condition was partly sunny/cloudy.

Figure #2: Experimental Set-Up

Results (cont…)/Discussion/Conclusion

Conf. Level	68%	95%	99%
T-Score	1.00017412	1.98760828	2.63352723
Upper Limit	0.01199213	0.01248558	0.01280836
Lower Limit	0.01099251	0.01049906	0.01017628

Table #1: Confidence Intervals for Random Sample

Solar Irradiance (W/m^2)	Irradiance of UVA (W/m^2)	Max. Exposure (minutes)
972	15	11.1
755	12.5	13.3
537	10	16.7
320	7.5	22.2
103	5	33.3

Table #2: Max. UVA Exposure Time[3]

The data shows a strong, linear, and positive relationship between solar irradiance (valid range ~100 to ~1100 nm) and UVA. There are limitations to this data since it technically can only be applied to my backyard (since that's where sampling occurred). To expand this research, I want to repeat this study in multiple locations throughout the world and make the data accessible to the public. We must make UV knowledge more accessible to the general public to combat the skin cancer epidemic.

References

1. *Apogee Instruments Owner's Manual USB Ultraviolet-A Sensor.* (2021, July 19). Apogee Instruments. Retrieved July 2, 2021, from https://www.apogeeinstruments.com/content/SU-220.pdf.
2. Bilbao, J., & de Miguel, A. (2010). Estimation of UV-B irradiation from total global *Expo*solar meteorological data in central Spain. *Journal of Geophysical Research: Atmospheres*, *115*(D1).
3. *Exposure Guidelines | Ultraviolet Radiation in the Workplace.* (August 1994). *Ontario Ministry of Labour, Training, and Skills Development.* Retrieved July 28, 2021, from https://www.labour.gov.on.ca/english/hs/pubs/uvradiation/gl_uvrad_3.php.
4. Fioletov, V., Kerr, J., & Fergusson, A. (2010). The UV Index: Definition, Distribution and Factors Affecting It. *Canadian Journal of Public Health / Revue Canadienne De Sante'e Publique, 101*(4), I5-I9.
5. Fioletov, V., Kerr, J., McArthur, L., Wardle, D., & Mathews, T. (2003). Estimating UV Index Climatology over Canada. *Journal of Applied Meteorology (1988-2005), 42*(3), 417-433.
6. Gunawardena, N., Pardyjak, E. R., Stoll, R., & Khadka, A. (2018). Development and evaluation of an open-source, low-cost distributed sensor network for environmental monitoring applications. *Measurement Science and Technology*, *29*(2), 024008.
7. *Skin Cancer Facts & Statistics*. (2021, Jan. 13). Skin Cancer Foundation. Retrieved June 21, 2021, from https://www.skincancer.org/skin-cancer-information/skin-cancer-facts/.
8. *What is UV radiation?* (2019, July 10). American Cancer Society. Retrieved June 22, 2021, from https://www.cancer.org/cancer/cancer-causes/radiation-exposure/uv-radiation.html.

Acknowledgements

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