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

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 use the LEMS to estimate UVA exposure.

Results

Preliminary Data of Solar Irradiance (400-1100 nm) vs. UVA (300-400 nm)

Solar Irradiance (400-1100 nm) vs. UVA (300-400 nm), 6/20 (1:00pm-1:15pm CT)

Figure #3: Aggregate Preliminary Data

Figure #4: Graph for Random Sample

Table #1: Confidence Intervals for Random Sample

<table>
<thead>
<tr>
<th>Solar irradiance (W/m²)</th>
<th>Irradiance of UVA (W/m²)</th>
<th>Max. Exposure (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>972</td>
<td>15</td>
<td>11.1</td>
</tr>
<tr>
<td>755</td>
<td>12.5</td>
<td>13.3</td>
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<td>537</td>
<td>10</td>
<td>16.7</td>
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<tr>
<td>320</td>
<td>7.5</td>
<td>22.2</td>
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<tr>
<td>103</td>
<td>5</td>
<td>33.3</td>
</tr>
</tbody>
</table>

Table #2: Max. UVA Exposure Time

The data shows a strong, linear, and positive relationship between solar irradiation (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.

Methodology

I collected data using the Apogee UVA Instrument (Model SU-220, spectral range 300-400 nm) 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.

Results (cont…)/Discussion/Conclusion

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.

Acknowledgements

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