Characterizing and Quantifying Night Sky Brightness in Utah and Arizona

Rachel Nydegger[1], **Shane L. Larson**[2], **Constance E. Walker**[3]

[1]Utah State University, [2]Northwestern University, [3]National Optical Astronomy Observatory

Abstract

As part of a Research Experience for Undergraduates (REU) program with the National Optical Astronomy Observatory (NOAO), I (with mentor Dr. Constance Walker of NOAO) characterized light pollution in and near Tucson, Arizona using eight Sky Quality Meters (SQMs). In order to analyze the data in a consistent way for comparison, we created a standard procedure for reduction and analysis using python and MATLAB. The series of python scripts and MATLAB codes to remove faulty data and examine specifically anthropogenic light pollution and illustrate how the light pollution changes in relation to time, distance from the city, and airglow. Data are then analyzed by a recently developed sky brightness model created by Dan Duriscoe of the U.S. National Park Service. To quantify the measurements taken by SQMs, we tested the wavelength sensitivity of the devices used for the data collection. The findings from the laboratory testing have prompted innovations for the SQMs as well as given a sense of how data gathered by these devices should be treated. Dr. Shane Larson and I are implementing findings and procedures at Utah State University (USU), along with equipment acquired through the Undergraduate Research and Creative Opportunities (URCO) grant to create a light-map of the university campus and surrounding city. Additionally, the luminosity output of outdoor light fixtures will be analyzed via a Pocket Lux Light Meter. As USU has a sustainability program, Blue Goes Green, that has already implemented lighting codes, the goal of this project is the work with the collegiate administration to renovate old lighting fixtures.

Background

Over the summer of 2013, I worked at the National Optical Astronomy Observatory (NOAO) in Arizona to create analytic procedures for the housed data-logging SQMs (SQM-DLs). These devices have a FWHM FOV of 20^o and gather light in roughly the V band. They gather data remotely based on time and darkness, and can be left on-site for up to two months. After sufficient data is gathered, amateur astronomers try to make sense of the results. Unfortunately, there is no widespread standard method of analyzing this data, which makes data comparison difficult in a scientific community. The aim of this research is to address said issue by creating a standard method of analyzing SQM data, which will create more concrete evidence of the harmful nature of light pollution for public outreach.

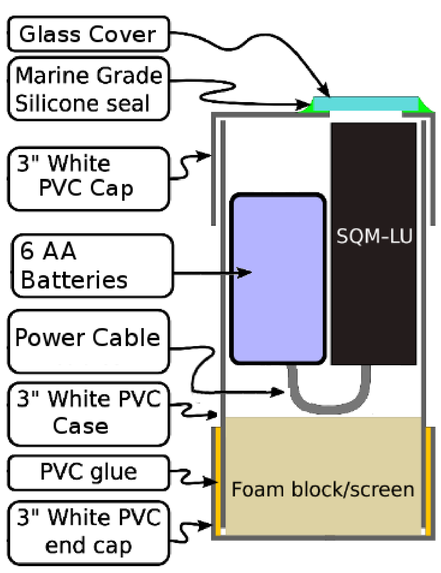

Figure 1: Diagram of an DQM-DL+H.

Laboratory Testing

According to manufacturer, the silicon detector should be only sensitive to wavelengths between 300nm and 700nm due to a near-IR filter. However, results from a wavelength sensitivity test show that light is not being filtered as expected. The filter inside is contained in a plastic casing, which we found to have an index of refraction such that light is effectively light-piped (i.e. leaking) around the filter.

Automation

To assist citizen science studies in anthropogenic skyglow, we have created a series of python scripts that remove readings taken when the moon, sun, or Milky Way is overhead, in order to isolate the anthropogenic factors. These scripts also remove erroneous readings, such as mislogged dates or times. Then the data are analyzed and plotted by a set of octave codes to aid in the search for various spatial and temporal trends. All of these codes will be implemented into a Globe at Night GUI.

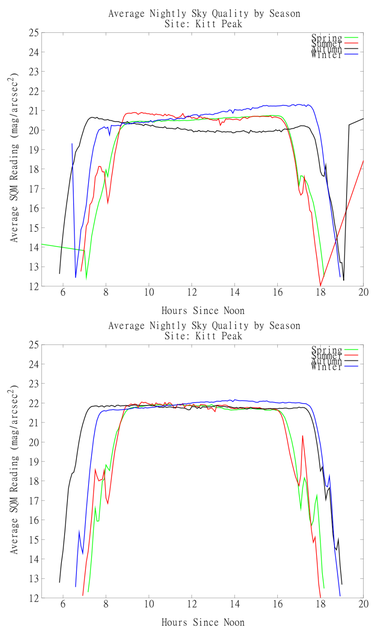

Figure 2: 2.a is raw data for the average night for each season at KPNO. 2.b is the average seasonal nights at KPNO with the reduced data.

Comparing Temporal Trends

Light pollution levels at Utah State University (USU) in Logan, UT have been monitored since August of 2012 with one long-term goal being the production of a database on the scale of the one generated in Tuscon at NOAO (which continues to grow). This would enable comparison of long-term trends in light pollution intensity at two different geographic locations. Two SQM-DLs have been placed on USU campus. Data collected from these meters will be analyzed using the techniques and procedures developed at NOAO.

One benefit of making these measurements in Logan, UT is that USU's atmospheric science group routinely conducts measurements of quantities possibly correlated with light pollution such as airglow and atmospheric density. Additionally, Logan's high snowfall may help quantify the effect of ground reflectivity on skyglow.

Mapping USU Campus

Figure 3: Light map of USU campus.

At USU, sky quality measurements have been taken across campus in an effort to identify major sources of light pollution and to investigate how sky quality varies from place to place. These data are contoured in gnuplot and overlayed onto Google Earth to create a light map, shown below. We also purchased a Pocket Lux light meter, which allows measurement of the luminous output of different types of streetlights on campus.

Outreach

Aside from scientific goals, a major focus of the project to map light pollution on USU campus is to increase awareness. USU is considered a sustainable university, and has been only using International Dark-Sky Association approved streetlights in new construction projects. However, many of the older streetlights could be retrofitted to decrease light pollution (as seen in Figure 3). When a more comprehensive light map is finished, it will be presented to the council for sustainability on campus, Blue Goes Green. Ideally, funding will be provided to fix these inefficient light fixtures. In the meantime, however, we are trying to raise public awareness and encourage people to make more sky-friendly choices when deciding on residential lighting.

Figure 4: Image of light pollution used for public outreach.

The research conducted at USU and NOAO has attracted the attention of local news media, such as FOX 13 and Utah Stories, which has enabled us to bring the issue of light pollution to the attention of the public. Community members have expressed interest in improving their night skies by requesting more information about responsible lighting and city light codes.

Future Work

Data collected by the Visible Infrared Imager Radiometer Suite (VIIRS) on the Suomi satellite are an excellent comparison for light pollution meaurement validation. Along with monitoring global weather, this suite collects images of the nighttime sky in the visible and infrared ranges. We plan to take advantage of this resource in future work.

Because data collected from Kitt Peak showed a strong correlation to OI 557.7nm airglow, we intend to make use of airglow measurements taken at USU to further investigate this connection.

Logan, Utah, is known for poor air quality, and so will provide an excellent venue for investigating and quantifying the relationship between air pollution and light pollution.

Figure 5: The Suomi Satellite. The VIIRS instrument aboard this satellite will provide alternate light pollution measurements.

Acknowledgements

This project has been supported by funding from the National Science Foundation and the Undergraduate Research and Creative Opportunities grant.
Travel funding was given by the USU Physics and Honors departments and the USU Academic Senate.