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 gathering SQMs (SQM-DLs). These devices have a 20° FWHM FOV of 20°. 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.

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 Globo at Night GUI.

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 Tucson 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

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.

The research conducted at USU and NOAO has attracted the attention of local news media, such as FOX 15 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 motivation about responsible lighting and light pollution.

Future Work

Data collected by the Visible Infrared Imager Radiometer Suite (VIIRS) on the Suomi satellite are an excellent comparison for light pollution measurements. 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.

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