CALIFORNIA STATE SCIENCE FAIR
2006 PROJECT SUMMARY

Name(s)
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Project Number
S1514

Project Title
Quantifying the Effect of Skyglow on the Visibility of Stars

Abstract

Objectives/Goals
Skyglow caused by excess light from urban centers obscures the visibility of stars and is an increasing problem for astronomical observations. This experiment determines whether the amount of skyglow can be predicted based upon the angle of observation and a site's distance from an urban center.

Methods/Materials
I used a digital (CCD) camera to take over 300 60-second time exposures in similar weather and moonlight conditions between September 2003 and March 2004 from sites around San Diego County at distances of 30, 45, 60, 75, 100, and 124 kilometers from the urban center and over 400 exposures between September 2005 and February 2006 at three sites 75 kilometers from the center at angles of 45, 60, 75, 90 (zenith), 105, 120, and 135 degrees. The images were downloaded and converted into bmp files. I developed a custom computer program to isolate skyglow pixel values by removing CCD noise and star pixels from the images and to compute the average intensity of the skyglow pixels for each image. Resulting intensities for each site were averaged, graphed, and compared to known functions to determine a best-fit mathematical correlation to the intensity (skyglow) as a function of a site's distance from the urban center and the angle of observation.

Results
The average intensity of the zenith images varied greatly at the eight sites, from 32.4 at 30 km from the urban center to 13.6 at 45 km, 7.1 at 60 km, 5.8 at 75 km, 3.9 at 100 km, and 3.1 at 124 km. Based upon the data, I derived an approximate formula for zenith skyglow value, "S", as a function of distance, "d": S = 2.4 X 10^2 X d^-1.9. The amount of skyglow at 60 to 75-degree angles of observation averaged up to 34% more than zenith skyglow values for the same distance and up to 15% average increase at 105 to 120 degrees.

Conclusions/Discussion
The amount of skyglow (S) decreased inversely with the distance (d) from the urban center, as approximated by the equation: S = 2.4 X 10^2 X d^-1.9 per one degree of sky, with significantly greater amounts of skyglow for non-zenith angles of observation both towards and away from the urban center. The formula reveals that observable visible light from stars remains below 50% until over 50 km from a city the size of San Diego and does not improve to 90% visibility until over 115 km from the urban center, indicating an increasing threat to astronomical observations at the nearby Mt. Laguna and Palomar Observatories.

Summary Statement
This project examines the effect of urban skyglow on the visibility of stars using computer analysis of CCD pixel data and derives a formula for skyglow as a function of a site's distance from an urban center and the angle of observation.

Help Received
Thanks to my dad for driving me out to the desert so many times in the middle of the night and for teaching me to program in C++. Thanks also to John Hoot, astronomer and computer scientist, for loaning me the Meade LPI and LX90 telescopes and teaching me about CCD astrophotography.