CALIFORNIA STATE SCIENCE FAIR
2003 PROJECT SUMMARY

Name(s)

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Project Number

J1532

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 impact of skyglow can be predicted based on a site's distance from an urban center.

Methods/Materials

A total of 120 photographs of the zenith (and controls) were taken with a 35mm camera using 100ASA color film for 30-second time exposures in similar weather and moonlight conditions between August 2002 and January 2003 from sites around San Diego County at 30, 60, 75, and 124 kilometers from the urban center. The pictures were developed and scanned into over 500 computerized bitmap files. I developed a custom computer program to convert the bitmap files into 600x600 pixel arrays with pixel intensity values from 0 to 767 and to calculate the number of pixels at each intensity level for each image. Resulting intensity intervals for each site were averaged, graphed, and compared to known functions to determine a best-fit mathematical correlation to the change in intensity (brightness) as a function of a site's distance from the urban center.

Results

The average number of "bright value" pixels in the photographs varied greatly at the four sites, from 68.4% of all pixels at 30 km from the urban center to 18.9% at 60 km, 8.4% at 75 km, and only 1.6% of all pixels at 124 km. A formula for the brightness value, "B", as an indication of skyglow varying with distance, "d", was derived: $B = 4.4 \times 10^8 \times d^{-2.2}$.

Conclusions/Discussion

The effect of skyglow, as measured by the brightness of the photographs at the sites (B), decreased inversely with the distance (d) from the urban center. The rate of change in brightness also diminished for increasing distances, as approximated by the equation I developed: $B = 4.4 \times 10^8 \times d^{-2.2}$. Applying the formula reveals that observable visible light from stars remains below 50% until nearly 35 km from a city the size of San Diego and does not improve to 90% visibility until over 70 km from the urban center, indicating an increasing threat to astronomical observations at the nearby Mt. Laguna and Mt. Palomar Observatories.

Summary Statement

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

Help Received

Thanks to my dad for driving me to the sites in the middle of the night and helping me write the custom "Countpixels" computer program, to Dr. Tony Ratcliffe for the Canon scanner, and especially to John Hoot, astronomer and computer scientist, for the photography equipment and recommendations.