FIELD LUMINANCE MAPPING OF THE SKY

PORTABLE, DURABLE INSTRUMENTS FOR SKY LUMINANCE DISTRIBUTION FIELD MEASUREMENTS

ANOTHAI THANACHAREONKIT, PH.D
Post-Doctoral Researcher
California Lighting Technology Center

LUÍS LOMELINO FERNANDES, PH.D
Research Engineer
California Lighting Technology Center

KONSTANTINOS PAPAMICHAEL, PH.D
Co-Director, Professor
California Lighting Technology Center

When sky luminance distributions are measured far from a laboratory facility, portable and inexpensive instruments are useful. High dynamic range (HDR) photography has become a practical method for sky luminance mapping. However, long exposure photography directed at the sun can cause severe damage to digital camera sensors. To avoid this problem, a system was designed that integrates an adjustable shading disk with an HDR camera. Simultaneous global horizontal illuminance measurements indirectly provide luminance data for the area of the sky that is occluded by the shading disk. In tests, the system presented here has achieved relative errors for the zenith luminance of approximately 10%. An integrated shading disk for an illuminance meter also is presented that allows diffuse horizontal illuminance measurements to be easily performed.

BACKGROUND

Sky luminance mapping using high dynamic range (HDR) digital photography has become a practical method for measuring the luminance distribution of the sky. However, the HDR technique requires a sequence of multiple exposure images, and when frequent long exposures of the sky are taken, the sun can damage the camera sensor. This poster presents an HDR-based system for measuring the sky luminance that protects the digital camera’s sensor from direct exposure to the sun. Besides a digital camera, it comprises an adjustable shading device that attaches to the cylindrical section of a fisheye lens and an auxiliary illuminance meter for measuring global horizontal illuminance. The luminance value at the region covered by the shading disk can later be computed using data from simultaneous global horizontal illuminance measurements. In addition to the sky luminance distribution and global horizontal illuminance, measuring diffuse horizontal illuminance often is required in a daylighting study. For this purpose, the system presented here also includes an adjustable shading disk attached to the illuminance meter.

INSTRUMENT SETUP

The instrument setup for field measurements includes a digital camera with a fisheye lens, together with an illuminance meter and a luminance meter, for reference.
SHADING DISKS

The holding bracket of the camera shading disk is provided by a milling machine universal indicator holder, to which a custom adjustable stem and shading disk is attached. This device attaches to the fisheye lens of the HDR camera and allows the disk to shield any region of the field of view of the fisheye lens. The holding bracket of the illuminance meter shading device is an aluminum holder, attached to the illuminance meter using the camera tripod screw. For each of these devices, the arms can be positioned to shade the sun in any direction. Three interchangeable shading disks, of three different sizes (2.2 cm, 3.2 cm, and 3.8 cm), can be mounted on the arms.

DIGITAL CAMERA & FISHEYE LENS

A Nikon Coolpix 5400 digital camera with a fisheye lens was used to capture the digital images of the sky. To obtain the HDR images and sky luminance distribution, a sequence of 16 exposures, from 1/4000 to 8 seconds, was taken, with the aperture set to f/7.9. Each set of images was merged using the Photosphere image builder program to create an HDR image. Before sky luminance measurements, the HDR imaging system was calibrated under controlled lighting conditions.

OTHER PHOTOMETRIC INSTRUMENTS

A Konica Minolta CL-200 Chroma Meter was used to measure horizontal illuminance, and a Konica Minolta LS 110 spot luminance meter was used to measure zenith luminance.

TESTING PROCEDURE

Instruments were tested under clear sky conditions. The angular height of surrounding obstructions was less than 10 degrees.

1. Instruments placed on tripods and leveled.
2. Global and diffuse horizontal illuminance measurement taken.
3. Sixteen digital camera exposures taken, each simultaneously with a zenith luminance measurement. Global and diffuse horizontal illuminance measurements repeated every four camera exposures.
RESULTS

In this example, the luminance values obtained with the luminance meter are relatively stable around an average of 2,560 cd/m². After processing the 16 digital images, the luminance mapping gives a zenith luminance of 2,383 cd/m². Average global horizontal illuminance was 7,020 footcandles, and average diffuse horizontal illuminance was 1,125 footcandles.

---

CALIFORNIA LIGHTING TECHNOLOGY CENTER

The California Lighting Technology Center’s (CLTC) mission is to stimulate, facilitate, and accelerate the development and commercialization of energy-efficient lighting and daylighting technologies. This is accomplished through technology development and demonstrations, as well as offering outreach and education activities in partnership with utilities, lighting manufacturers, and end users, builders, designers, researchers, and government agencies.

CLTC.UCDAVIS.EDU

THIS PROJECT WAS FUNDED IN PART BY THE CALIFORNIA ENERGY COMMISSION’S PUBLIC INTEREST ENERGY RESEARCH (PIER) PROGRAM