Towards a skylight spectral remote sensing camera

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Introduction

To date the research in the Meteorological Optics meetings has been devoted to *romantic* topics as rainbows, ice crystal halos, glories, coronas and iridescence, sky colors, mirages and refraction effects, contrast phenomena, optics of lightning phenomena, auroras and generally light scattering phenomena in the atmosphere. But most of these topics need *prosaic* instruments to measure those phenomena.

Being prosaically and pragmatic (in other words very daringly for the standard audience of these meetings, so we beg pardon for this audacity), we tackle here the design of a camera that will allow to perform spectral remote sensing of skylight (one of the classic *romantic* topics).

Spectral characteristics of skylight

Skylight spectra have been measured in past decades in different countries involving different detector orientations, fields of view, and sky states[1]. But despite this variety of conditions these studies reached an important conclusion: different skylight power spectra are highly correlated with one another[2], and this underlying similarity has many practical applications as, for example, in the use of low dimensional linear models to recover skylight spectra from the response of few sensors.

The skylight spectra recovery accuracy from the response of few sensors depends on 1) the recovery algorithm, and 2) the characteristics and number of these sensors. Here we opt for an algorithm based on inversion linear models[3] and for a number of Gaussian sensors (very similar to those of commercial CCD cameras) between three and five.

Optimal design

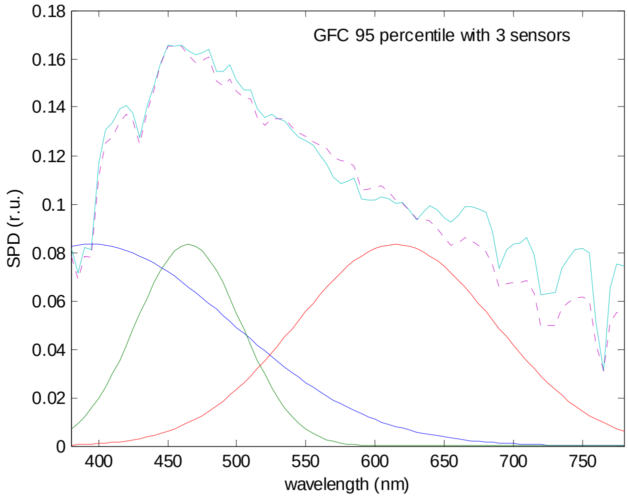
Among different methods[3] for selecting the optimal sensors we have made an exhaustive search to find the best set of Gaussian sensors for providing the maximum recovery accuracy. After testing different spectral position in the visible range (380-780 nm) and bandwidths (FWHM) of these sensors we choose those that provide simultaneously the best spectral similarity (evaluated by the GFC[2], the colorimetric

CIELAB difference, the integrated spectral irradiance error as well as the RSME error over a set of 1567 skylight measured[2] in Granada, Spain).

We have incorporated in our study the noise[3-4-5], both thermal noise (random additive noise normally distributed with variable standard deviation of 1, 3 and 5%) and quantisation noise (to simulate their analog-to-digital conversion into discrete 8-, 10- and 12-bit representations).

We have also checked the accuracy of such a realistic simulation over a set of 242 skylight spectra not measured in Granada and not included in the PCA we performed to obtain the eigenvectors needed in the linear model algorithm. This abroad skylight spectra set was measured in the USA.

The results obtained with both skylight sets show that although skylight have highly variable complex spectral profiles with different absorption bands our realistic computational simulation (including noise) reveals that a linear recovery algorithm with a set of a few optimum Gaussian sensors returns very-high-quality reconstructions of skylight, as shown in Figure 1 where the 95% percentile GFC recovery is shown as well as the spectral characteristics of the optimal sensors.



Example of skylight spectral recovery using the 3 optimal Gaussian sensors shown in the figure.

References

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