

DiCaLum

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1 Introduction

This document provides a short introduction to the usage of DiCaLum, a free code to estimate night sky quality based on digital camera RAW images. The code can be used as a standalone executable on windows machines or as a Python package. The usage is simple: all the inputs are provided in a JSON file. For the testing period, it works for a Canon EOS 6D camera with a Sigma 8mm f/3.5 fisheye lens. More cameras will be available later. DiCaLum's output based on the "Dark Sky Unit" (*dsu*) defined in this paper: *Z. Kolláth, A. Cool, A. Jechow, K. Kolláth, D. Száz, K. P. Tong: Introducing the dark sky unit for multi-spectral measurement of the night sky quality with commercial digital cameras, Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 253, (2020) 107162, <https://doi.org/10.1016/j.jqsrt.2020.107162>.*

2 JSON input

The JSON input file has a standard format, and the category names cannot be changed. It can be edited by any standard ASCII editor, like Notepad in Windows or pico in the Linux operating system. The sample JSON input provided with this document contains this information:

```
{
  "MODE": "FR",
  "TIF FILE": "N",
  "RAW FILE": "IMG_1535.CR2",
  "MAXDSU": 100,
  "MAXPLOT": 41,
  "CAMERA": "EOS6D",
  "LENS": "Sigma8mm",
  "ISO": 0,
  "APERTURE": 0,
  "SHUTTER": 0,
  "TITLE": "Zselic",
  "OBSERVER": "Zoltán Kolláth",
```

```

"LOCATION": "Measuring point 1",
"LONGITUDE": 46.2904,
"LATITUDE": 17.6844,
"DATE": "N",
"TIME": "N"
}

```

MODE: For fisheye raw images, the mode should be "FR" (Fisheye Raw). There are different modes for reading partial images for mosaics, pre-processed TIF files or dark frames. It will be described in a later edition of this document.

RAW FILE: gives the name of the RAW camera file(s). It can be a comma-separated list of image files. If two image file names are given, DiCaLuM processes all the files from the same directory whose names are between the two in the alphabetically ordered list of file names.

MAXDSU: defines the maximum *dsu* value assumed in the measurement. 100 gives a reasonable value for places with low light pollution.

MAXPLOT: gives the maximum sky radiance in *dsu* for the plots (primarily the colourmaps of radiance). It should be selected according to the level of light pollution.

CAMERA and **LENS** can be selected from the list of calibrated devices. Please do not change it for the beta testing of DiCaLum.

APERTURE, **SHUTTER** and **ISO** are read from the RAW file's EXIF information; they should be 0 (zero). For some cameras, the value of the EXIF data is not provided, and then the values from the JSON file are used.

DATE and **TIME** are obtained from the EXIF data if the string "N" is given here. If necessary, the values in the JSON input override the values from the RAW file.

All the other inputs are for providing additional information on location and observer - those are added to the pdf output.

3 TIF output

DiCaLum dumps a standard TIF file with calibrated pixel values. The TIF file can be used in additional processing and statistical analyses. The file contains three 16-bit colour channels for the R, G and B *dsu* values. The conversion from the digital numbers (*DN*) to *dsu* values is provided by the following formula:

$$dsu = (DN/65536)^2 * MAXDSU$$

4 JSON output

The output JSON file stores additional information, like the data loaded from the RAW file's EXIF data. It also stores some preliminary statistics, like zenith, minimum and maximum values. Mean values of some specific regions are also provided. More details will be provided later.

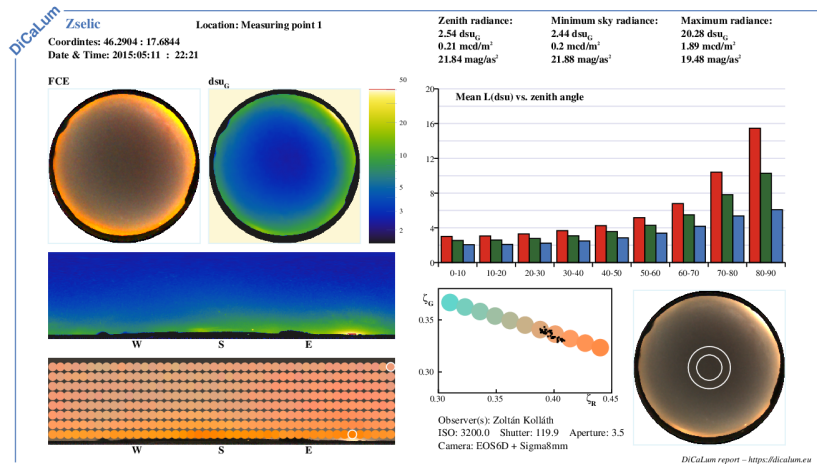


Figure 1: Sample pdf output of DiCaLum

5 PDF output

The major results of the processing are displayed in a pdf report. Besides the sky’s radiance, the DiCaLum report emphasizes the actual colour of the sky. Natural sky exhibits a significant variation of colour due to changes in airflow (see Kolláth & Yecko, JQSRT in preparation). Therefore it is crucial to detect the actual colour of the sky.

Figure 1 displays a sample output of DiCaLum. Most of the information in this report is self-explanatory. The circular images show the upper hemisphere in different representations, like a "heatmap" of the dsu_G radiance, the False Colour Enhancement (FCE) image [1]. The lower right circular image displays a version similar to the output TIF image.

Here we provide additional information on the colour-colour diagram. We define the dsu -based relative colours by:

$$\zeta_R = L_R / (L_R + L_G + L_B),$$

$$\zeta_G = L_G / (L_R + L_G + L_B),$$

where L_R , L_G and L_B are the radiances in dsu units. The lower middle colour diagram displays the $\zeta_R - \zeta_G$ values calculated from the ring bracketed by the white circles in the lower right circular image. For reference, the corresponding FCE colours are displayed for some coordinates representing the most probable natural sky colours.

Figure 2 displays the colour diagram with additional FCE information. These colours are used in the lower left panorama image providing information on the colour distribution of the sky. The correlated colour temperature (CCT) is frequently used to qualify the colour of the night sky. Therefore, we provide approximate iso-CCT lines in the figure as a reference. We emphasize

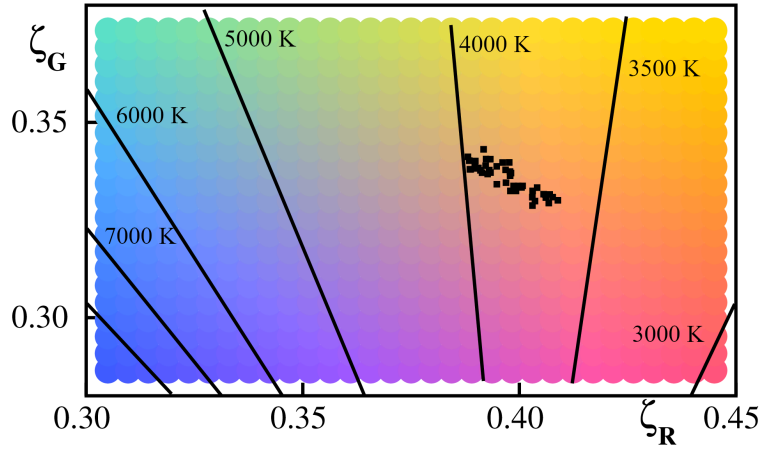


Figure 2: Colour diagram with the corresponding FCE colours

that the CCT is only approximate, as different spectra with the same colour can result in different CCT values. Please note that the colour of the night sky is a 2D quantity, while CCT provides only a single coordinate. Thus we recommend using the ζ_R and ζ_G coordinates instead of CCT.

6 References

- [1] Zoltán Kolláth, Dénes Száz, Kai Pong Tong, Kornél Kolláth: The Colour of the Night Sky. *Journal of Imaging*. 2020; 6(9):90. <https://doi.org/10.3390/jimaging6090090>