Making simulations more colorful: Extension of gendaylit to create a colored sky

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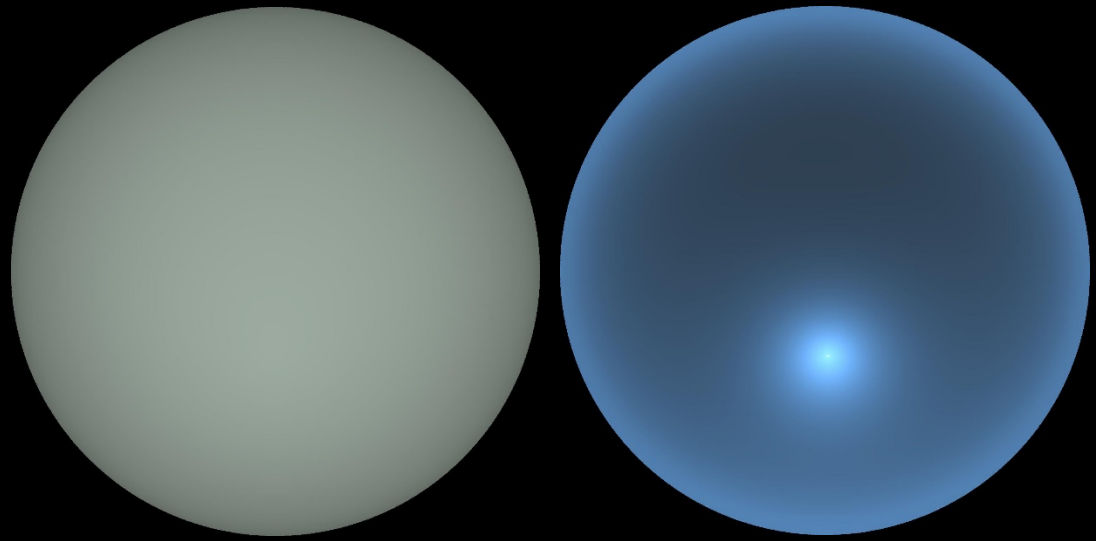

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Credits

All scientific results have been generated by Aicha Diakite and Martine Knoop at TU-Berlin

J. Wienold's role was the implementation into gendaylit.

Outline

Why: *Why do we need color for the sky?*

Basis: *Spatial measurements of the sky spectrum*

Model: *Derive of a (preliminary) color model for CIE-sky types*

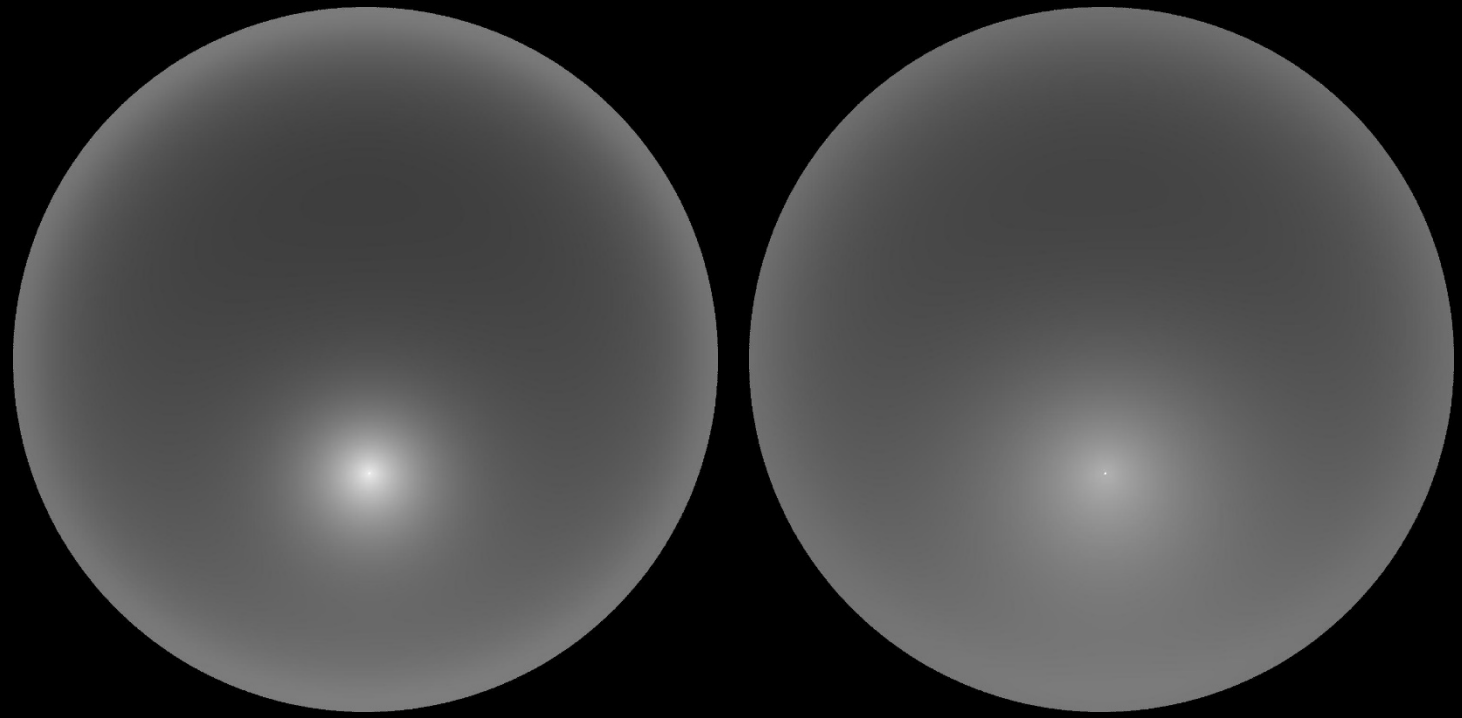
Implementation: *Application of the color model onto Perez-sky distribution (gendaylit)*

Comparison: *Comparison of new model and Preetham*

Why do we need a colored sky?

Status quo for daylight simulations:

CIE and Perez Sky models are used:



No color information!

Why do we need a colored sky?

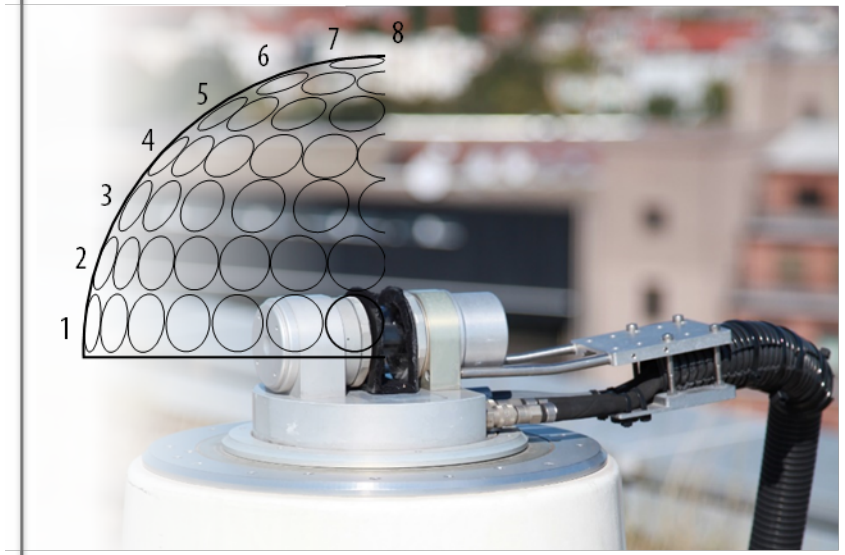
Non-visual effects – Spectral influence - peaking in the “blue”

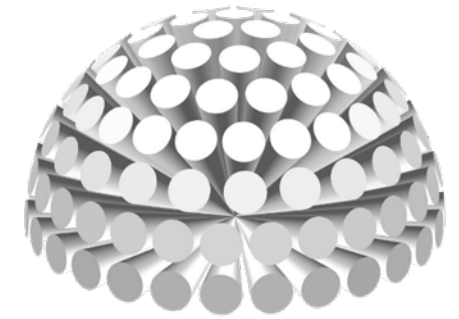
Visual comfort studies: To evaluate color and color rendering

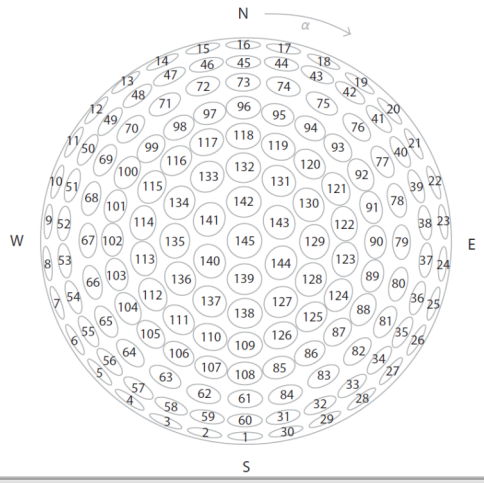
Higher realism

Measurements: Daylight Station TUB

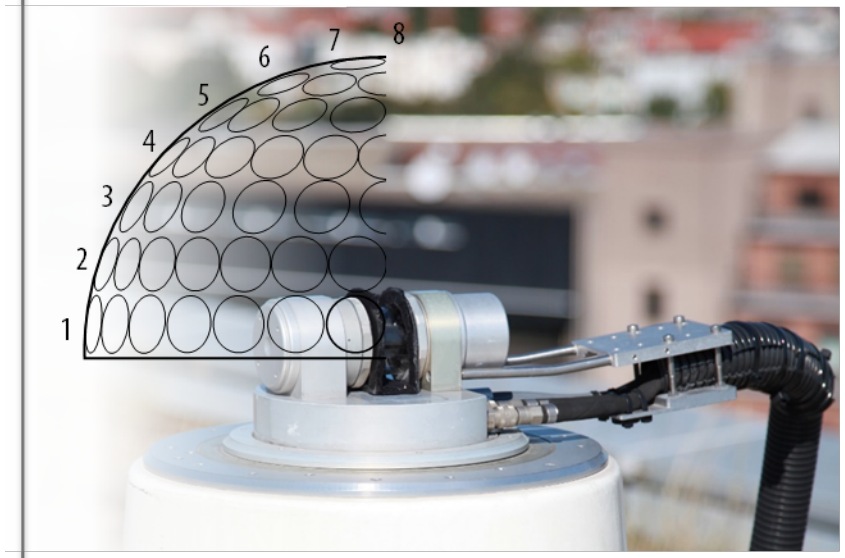
Spatially resolved spectral measurements







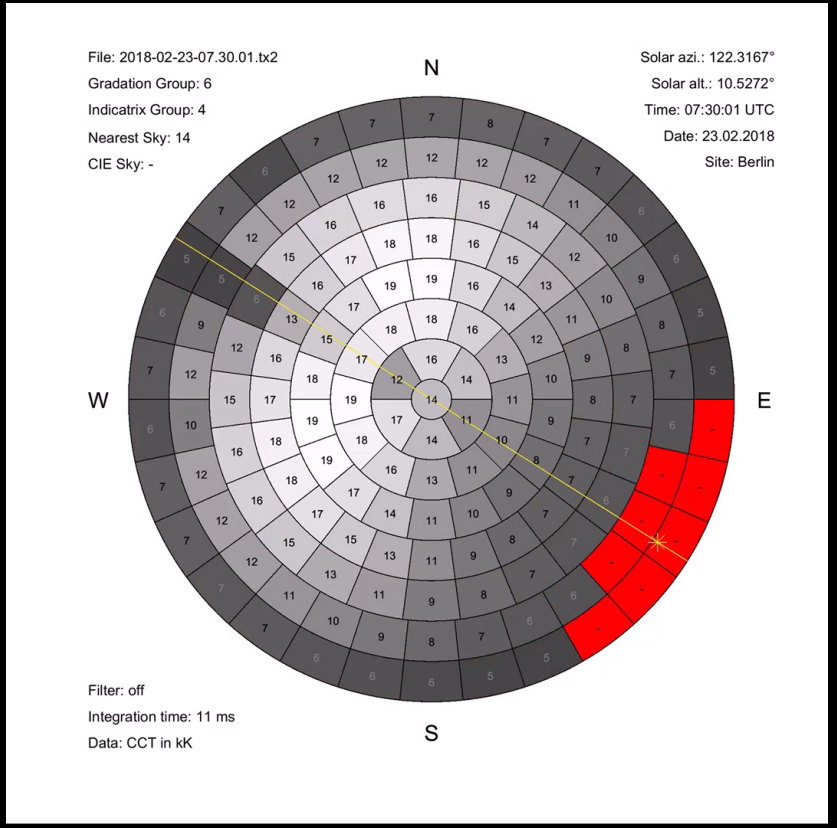
Spatially resolved spectral measurements

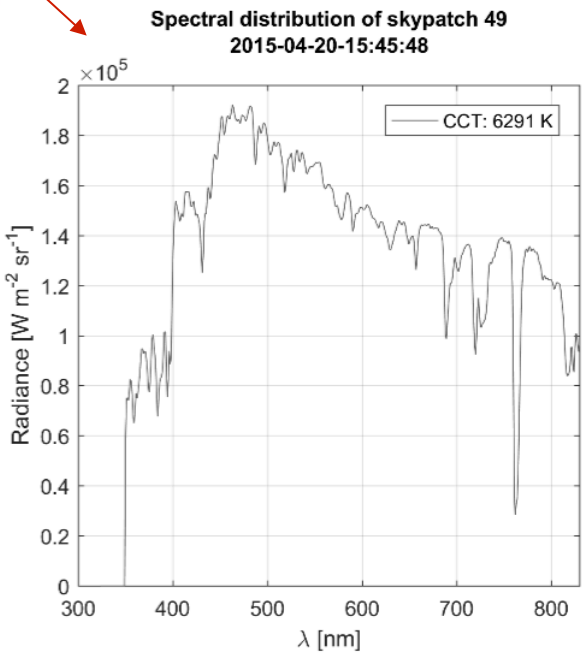


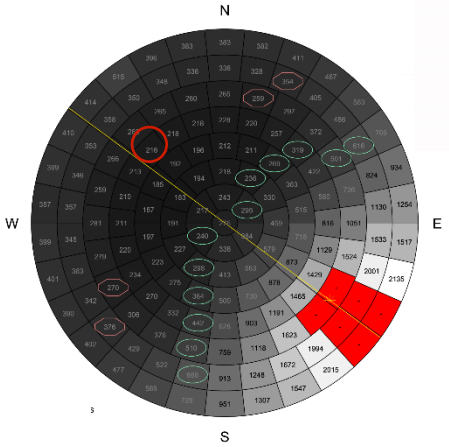
- since 2014
- 145 sky patches (Tregenza)
- SPD
- 280 nm - 980 nm
- Scan every 2nd minute
- Scan duration 1 minute

Sky scanner for spectrally and spatially resolved measurements

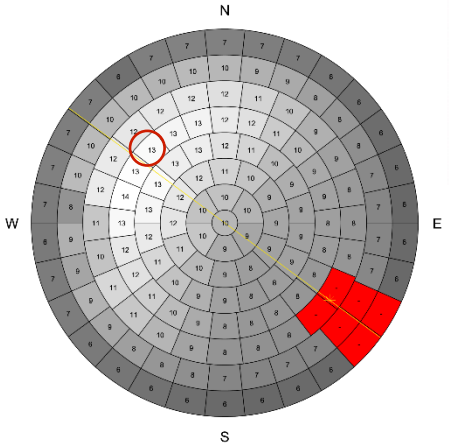
Spatially resolved spectral measurements





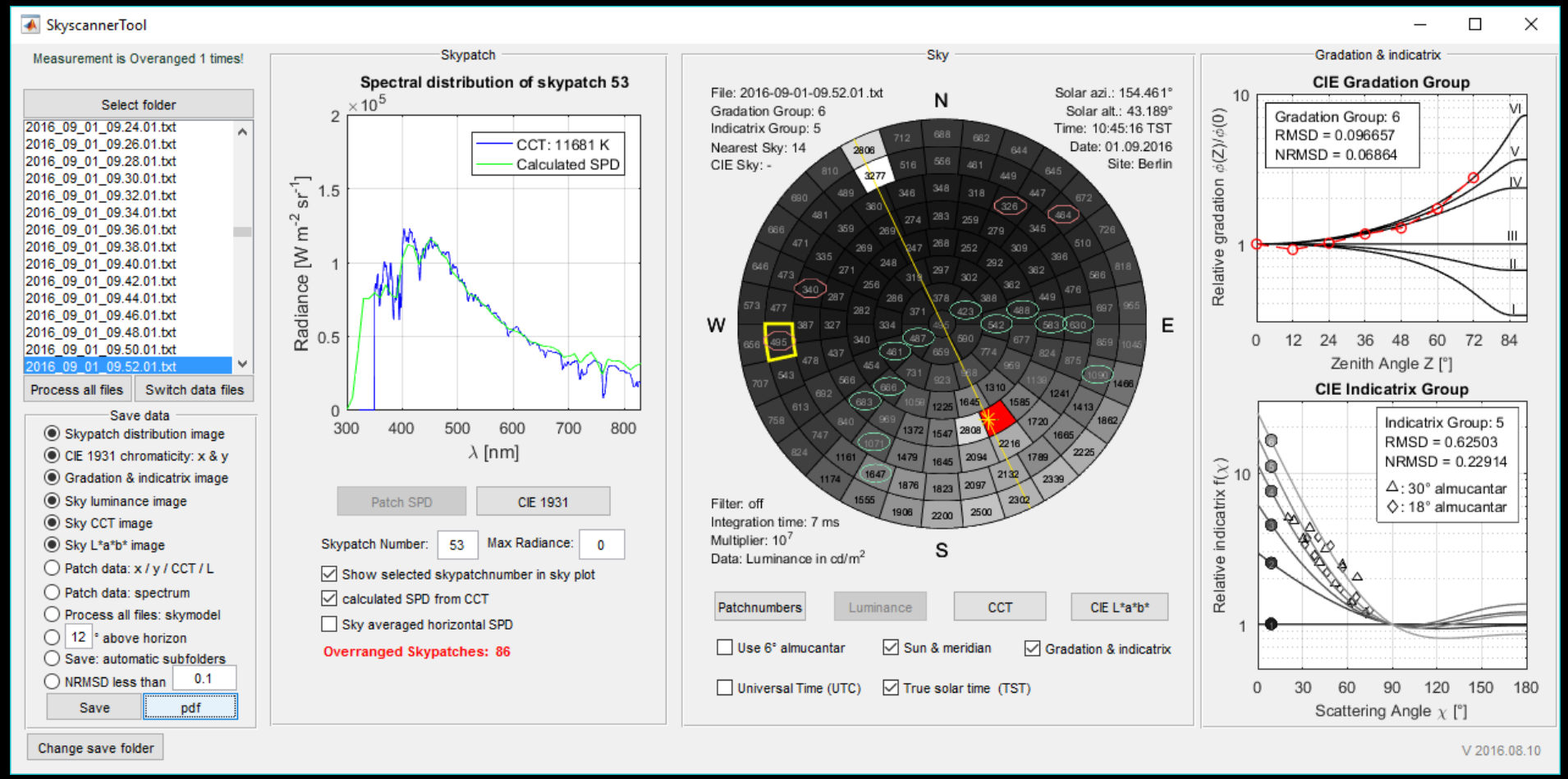


Luminance

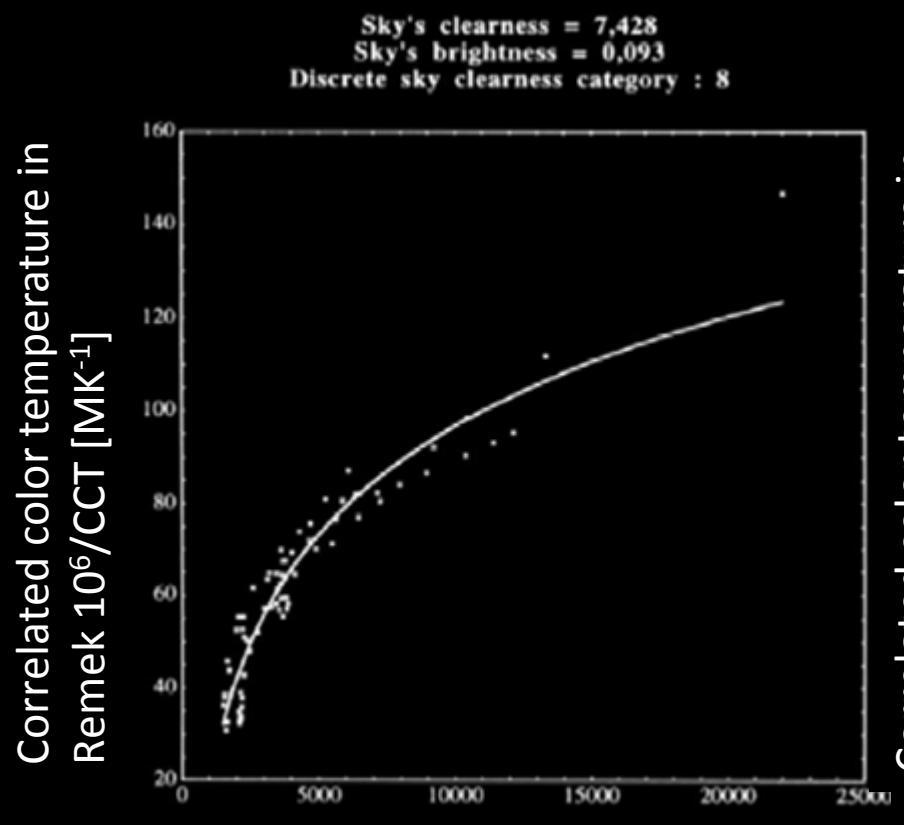


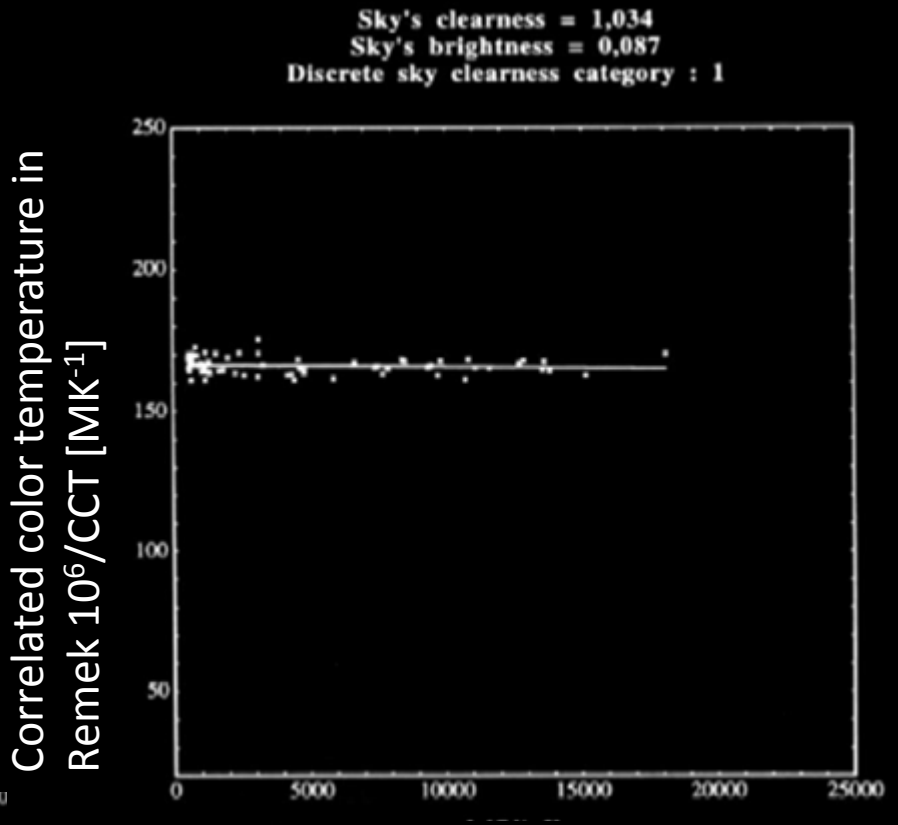
CCT

Data Processing: Tools



Model





Models and Figures from:
C. CHAIN; D. DUMORTIER, M. FONTOYNONT, A COMPREHENSIVE MODEL OF LUMINANCE, CORRELATED COLOUR TEMPERATURE AND SPECTRAL DISTRIBUTION OF SKYLIGHT: COMPARISON WITH EXPERIMENTAL DATA. Solar Energy, Volume 65, Issue 5, 1 April 1999, Pages 285-295

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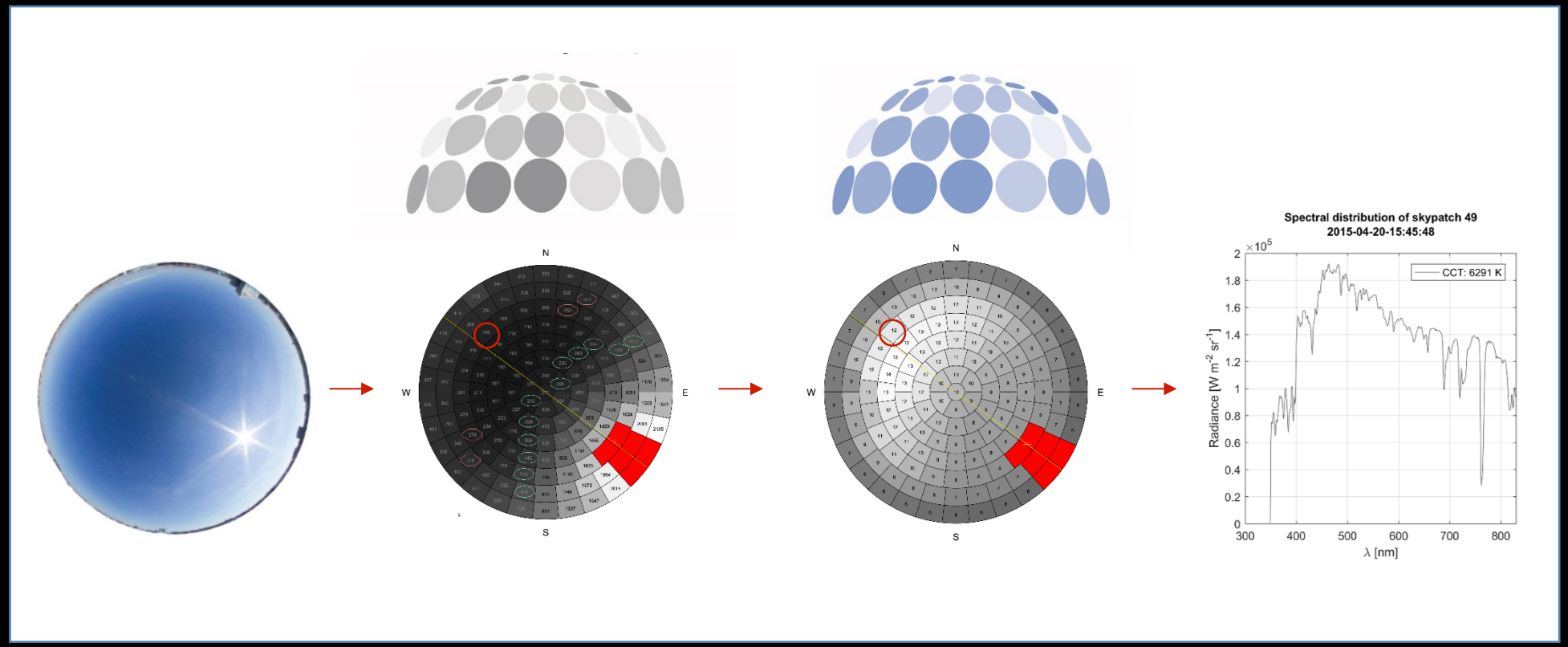
Model



Implementation

Model is based on the relation

CCT ~ L

Idea:

Use existing and validated luminance sky models (CIE, Perez)

“just” change the color information

Implementation

Luminance Model → **L to CCT** → **CCT to x_D, y_D** → **x,y,Y to to XYZ to Radiance RGB**

Perez-All-Weather Model

X=Y*x/y
Y=L
Z=Y*(1-x-y)/y

R= 2.569*X -1.167*Y -0.398*Z;
G= -1.022*X +1.978*Y +0.044*Z;
B= 0.075*X -0.252*Y +1.177*Z;

Implementation

Gendaylit generates modified output, colorfunc instead of brightfunc

New option(s) for gendaylit:

-C generate colored sky description (Default daylight locus: Berlin)

-CIE apply CIE daylight locus

Advanced option:

-l $l_1\ l_2\ l_3\ l_4\ l_5\ l_6\ l_7$ user defined daylight locus, according to :

+

Implementation - example

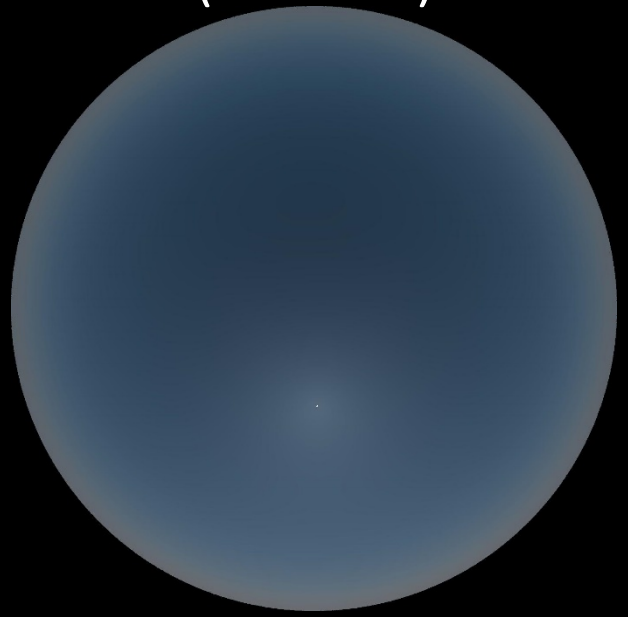
```
# gendaylit 6 20 12.2 -a 52.514861 -o -13.326908 -m -15 -C -W 829.5 55.15
# Local solar time: 12.07
# Solar altitude and azimuth: 60.9 1.9
void light solar
0
0
3 7.078e+06 7.078e+06 7.078e+06

solar source sun
0
0
4 -0.016475 -0.485873 0.873874 0.533000

void colorfunc skyfunc
4 skybright_r skybright_g skybright_b perezlum_c.cal
0
22 1.927e+01 2.896e+01 -1.006332 -0.229160 22.842973 -6.374109 1.275898 -0.016475 -0.485873 0.873874 12.009000 -4842999808.000000 2556800.000000
242.820007 0.232580 -4842999808.000000 2556800.000000 242.820007 0.232580 -1.284800 1.751900 -0.093786
```

Implementation – examples and comparison

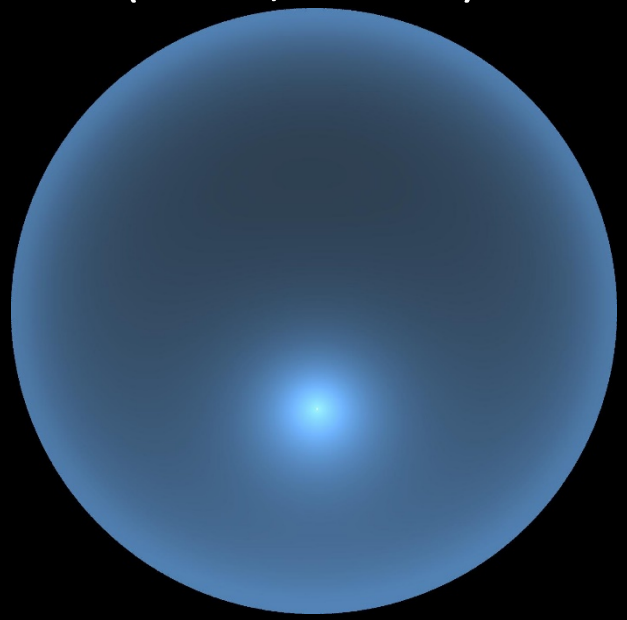
Summer sun: June 20, 12:12 Berlin. I_{dir}= 829.5 W/m^2 I_{diff}= 55 W/m^2

$\gamma = 60.9°$, $\varepsilon = 12$, very clear sky

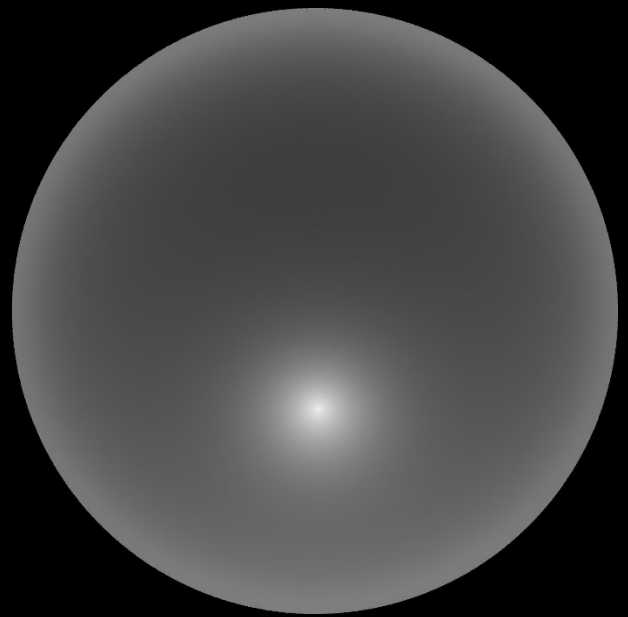
Preetham, t=2
(M. Stock)



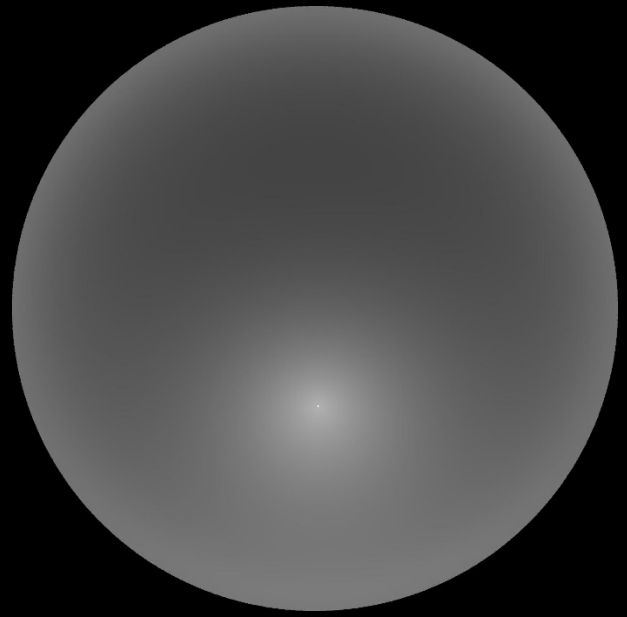
Perez
(color , Diakite)



Perez
(gendaylit)



CIE
(gensky)

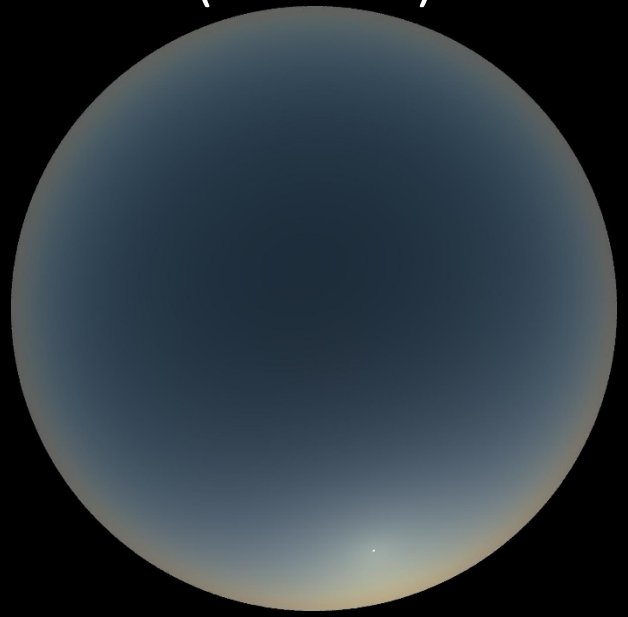


Implementation – examples and comparison

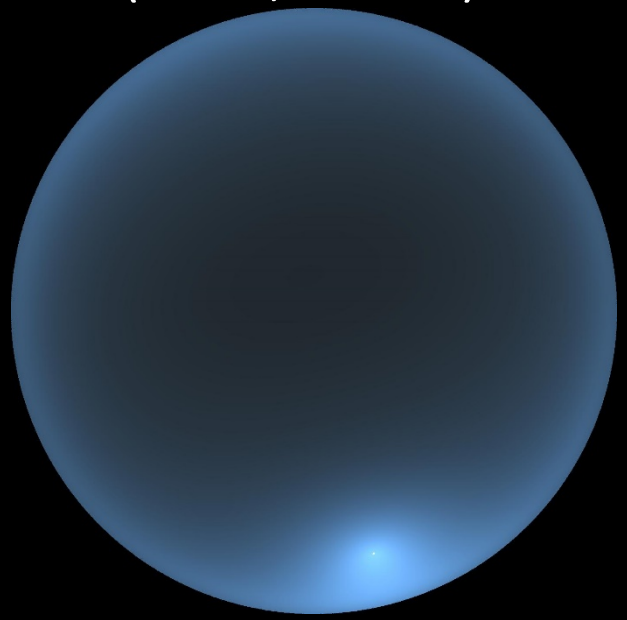
Winter sun: February 18, 13:14 Berlin. I_{dir}= 755 W/m^2 I_{diff}= 17 W/m^2

γ = 15.8°, ε = 12, very clear sky

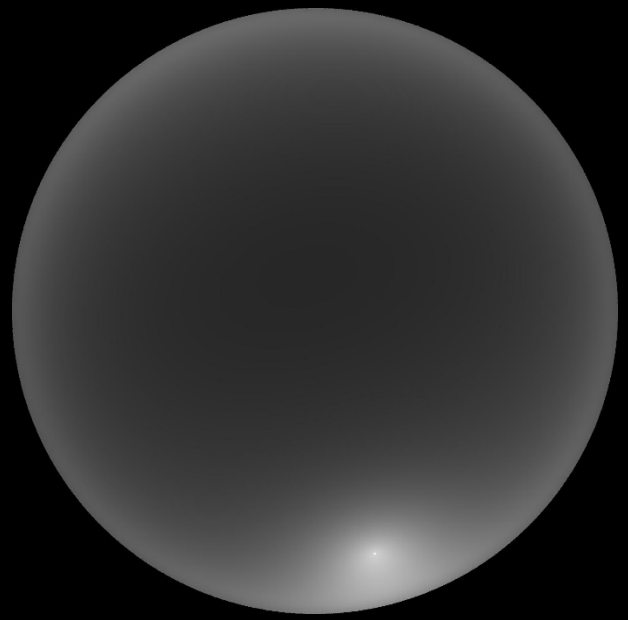
Preetham, t=2
(M. Stock)



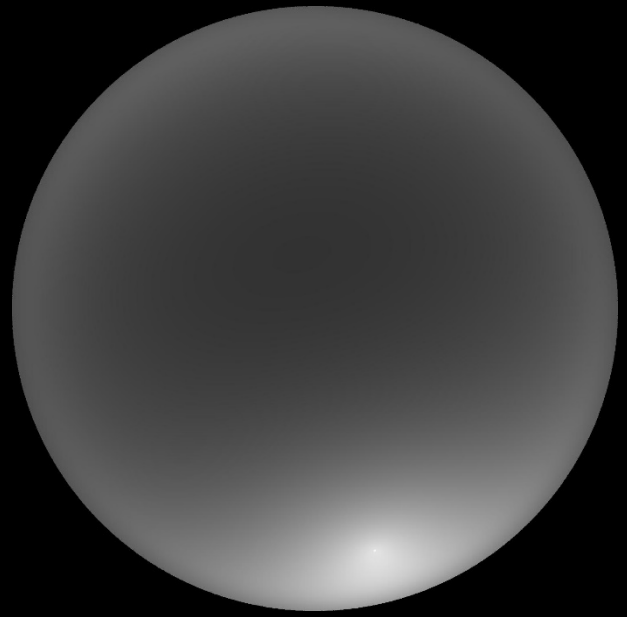
Perez
(color , Diakite)



Perez
(gendaylit)



CIE
(gensky)



Implementation – examples and comparison

Overcast sky: June 17, 12:04 Berlin. I_{dir}= 0 W/m^2 I_{diff}= 193 W/m^2

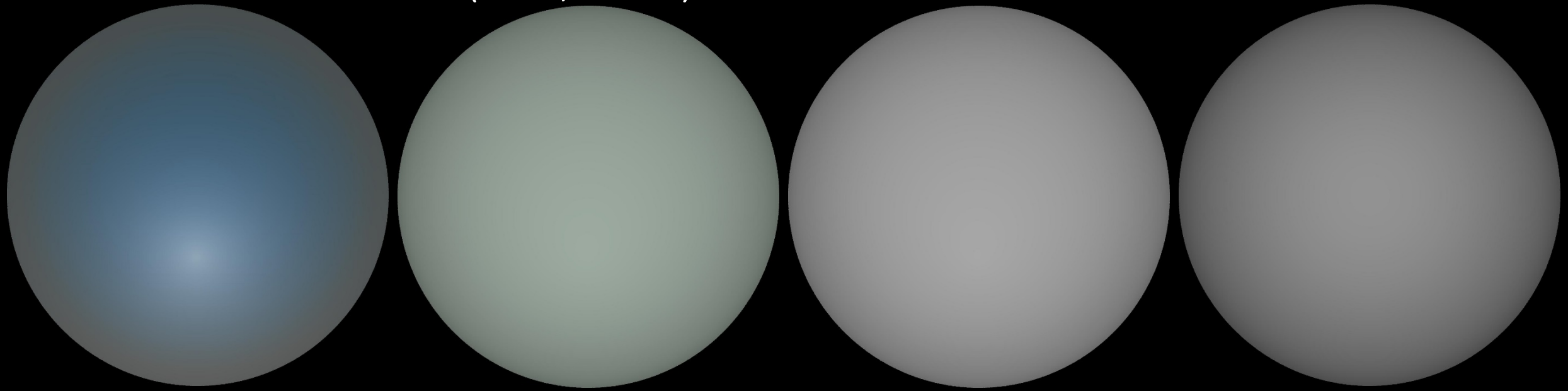
ε = 1.00, overcast

Preetham, t=30
(M. Stock)

Perez
(color , Diakite)

Perez
(gendaylit)

CIE
(gensky)



Implementation – status

Preliminary model

New version “checked-in” in head release and in Radiance installers on NREL server

gendaylit is fully “downwards compatible”

At the moment: Only for clear skies $\varepsilon > 4.5$ or overcast skies $\varepsilon < 1.065$

Intermediate skies: Automatic fall-back to “grey” model

Outlook

Intermediate skies

Full validation of the model (Development data: 1st year, validation data 2nd year)

Validation/adaptation to other locations: Large measurement campaign planned

Publication

Acknowledgement

This research is supported by the Velux foundation

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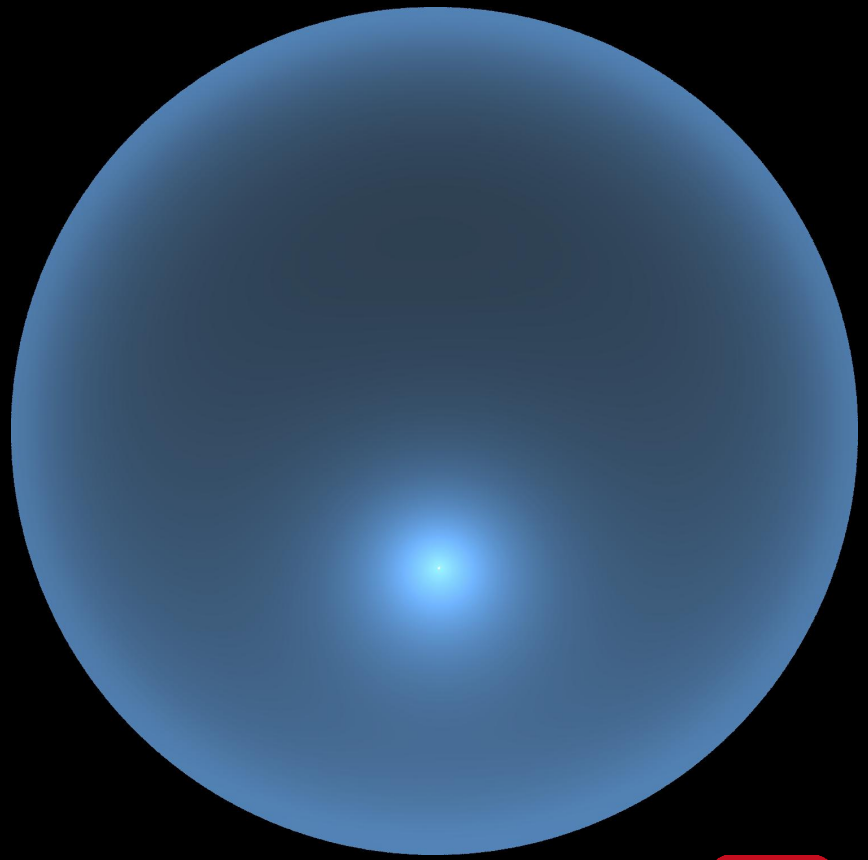
Thank you for your attention!

And have a colorful coffee break!



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