

SPECTRAL SKIES

**The colour(s) of the sky - Bridging the theory and practice:
Implementation, Benefits and Application Areas**

Aicha Diakite, Technische Universität Berlin

DAYLIGHT



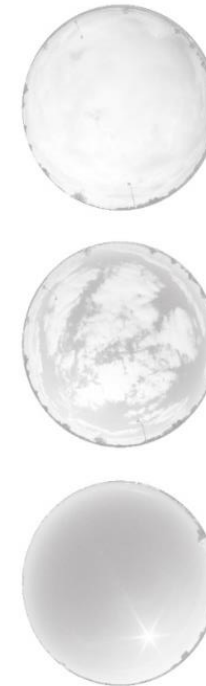
DAYLIGHT



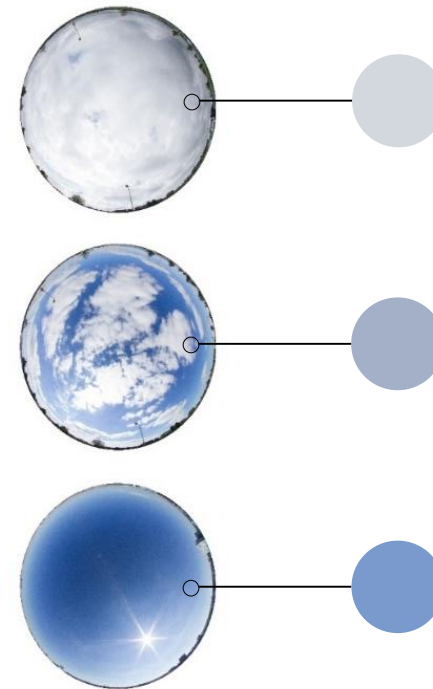
DAYLIGHT



Temporal Changes →



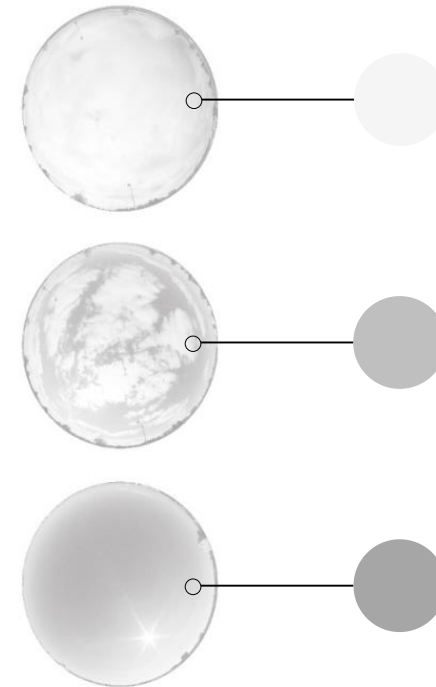
DAYLIGHT



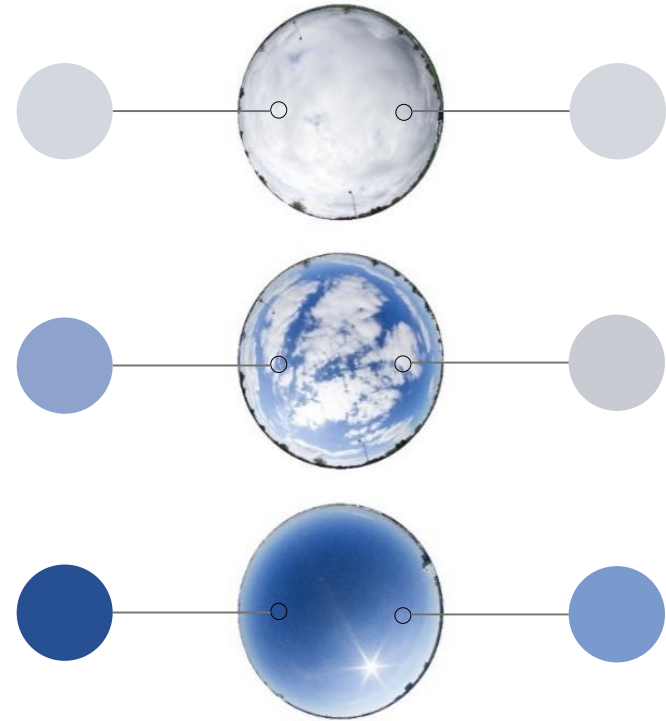
DAYLIGHT



Spectral Distribution →



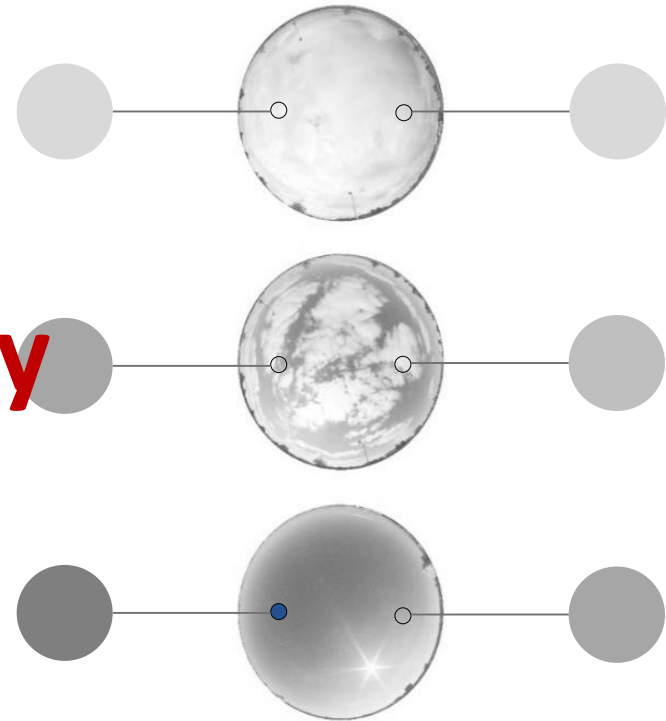
DAYLIGHT



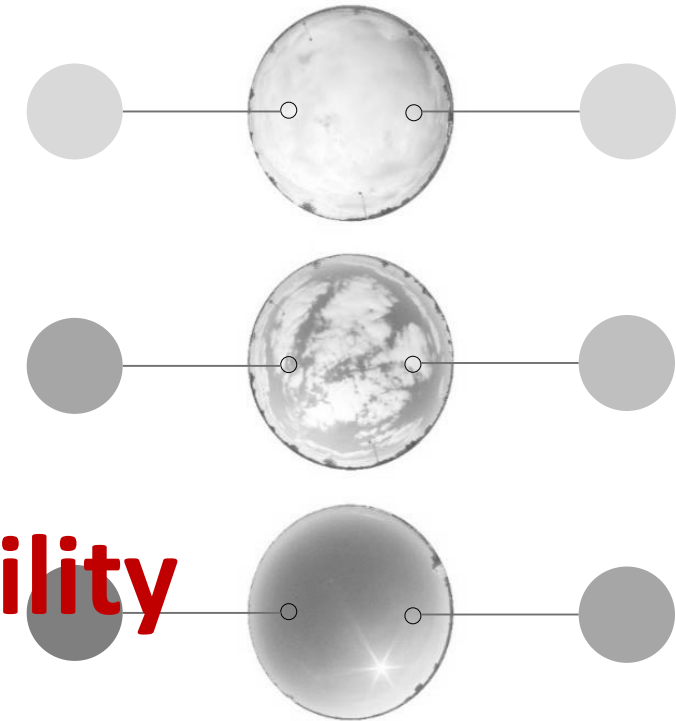
DAYLIGHT



Spatial Variability

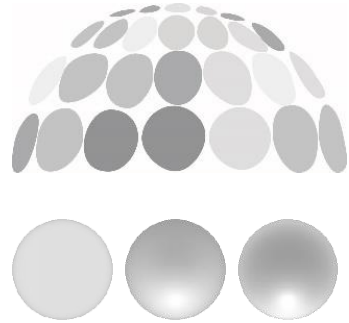


DAYLIGHT



SKY MODELS

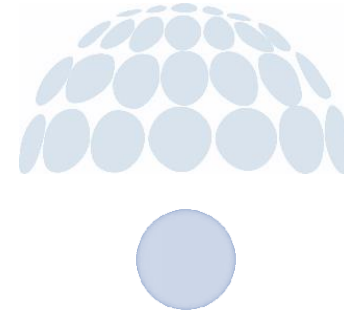
Luminance Distribution



CIE Standard General Sky
ISO 15469:2004(E)/CIE S 011/E:2003

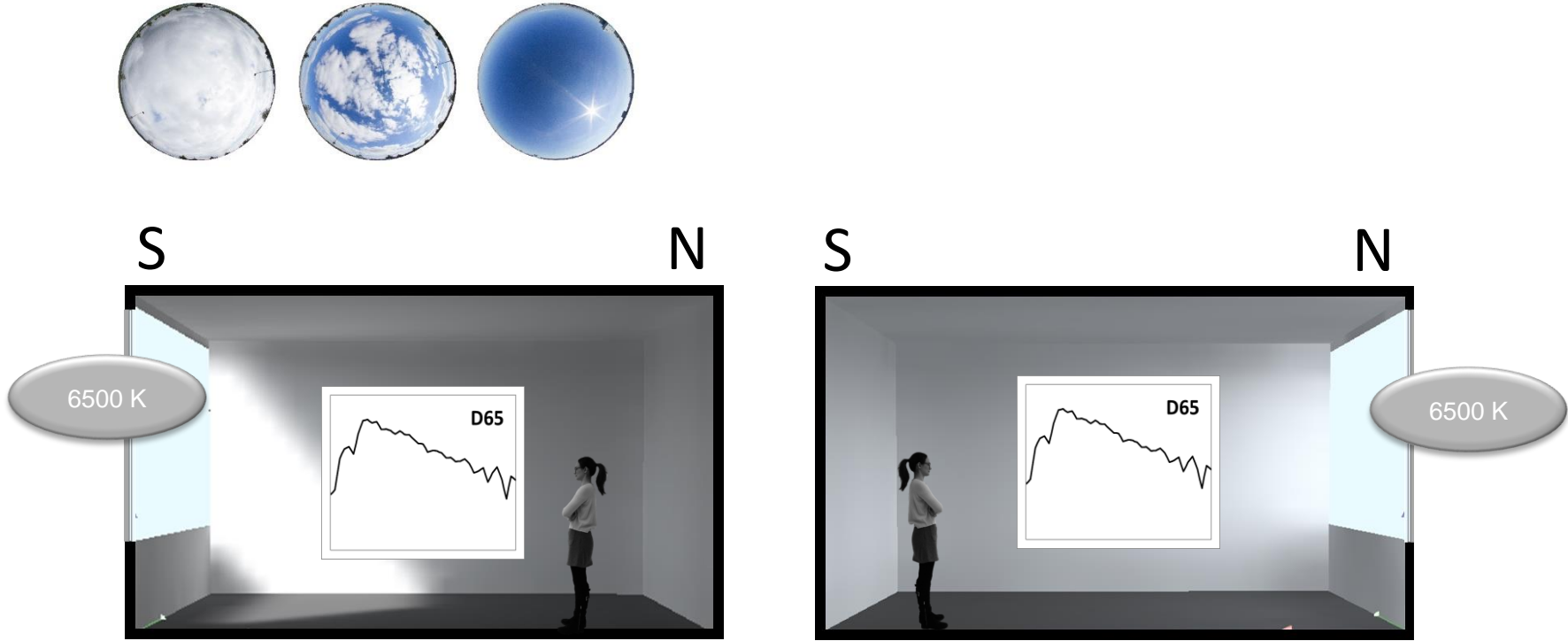
All-Weather Model
Perez et al. 1993

Spectral / CCT Distribution

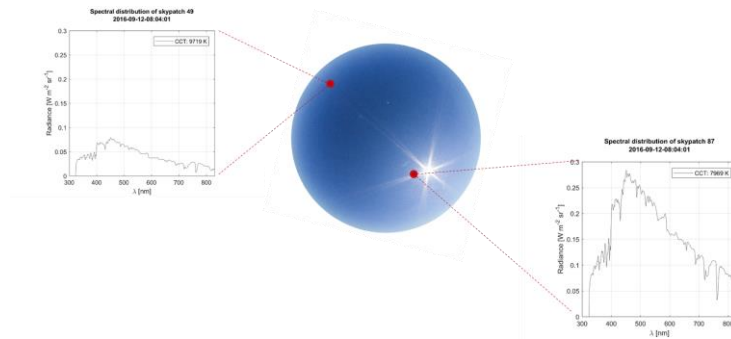


D65
CIE S 014-2/E:2006 ISO 11664-2:2007(E)

PRACTICAL APPLICATION



PRACTICAL APPLICATION

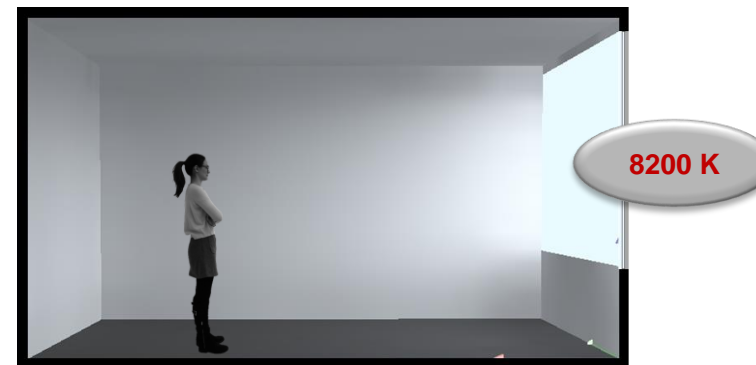
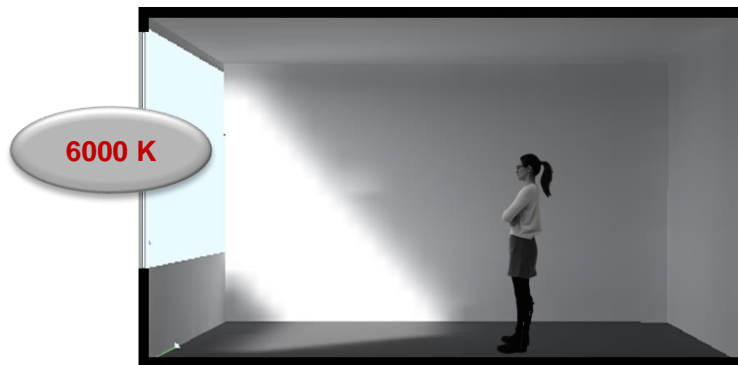


S

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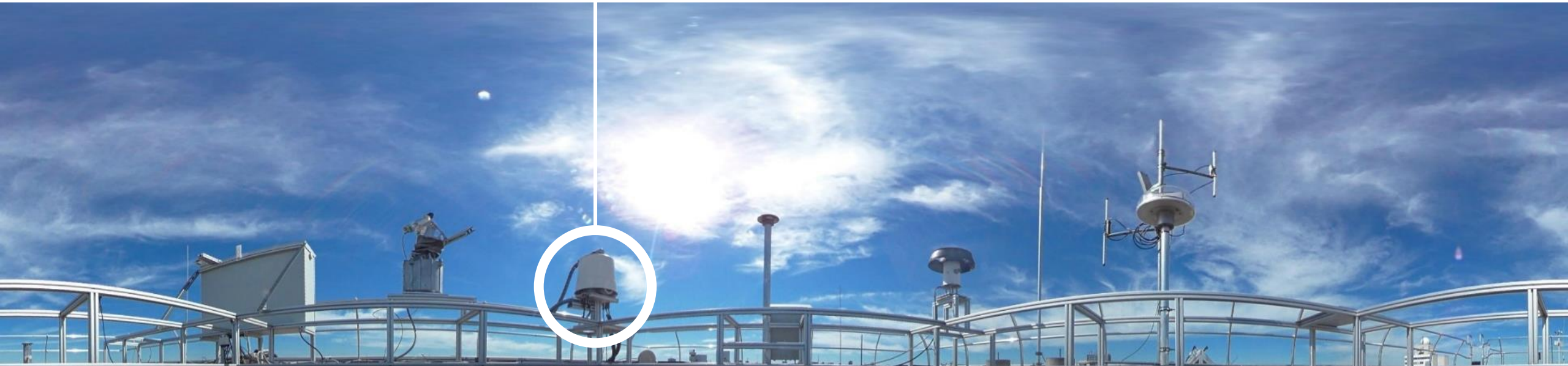
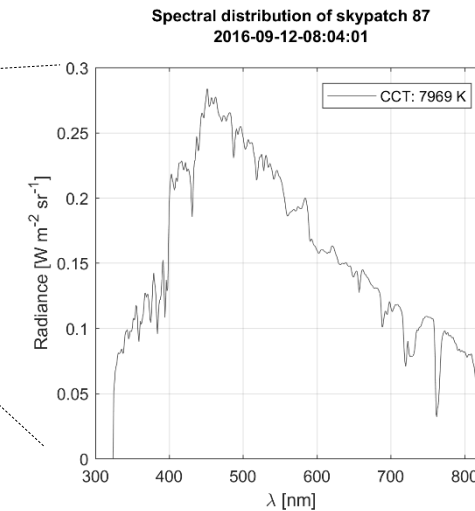
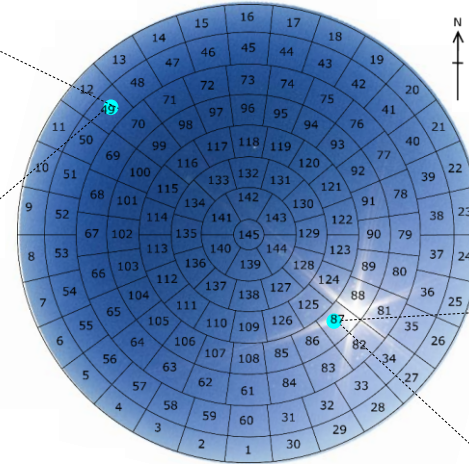
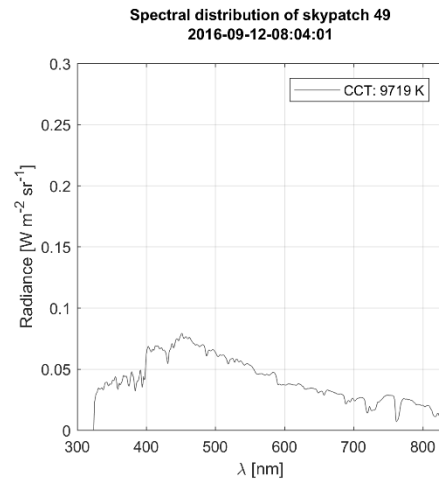


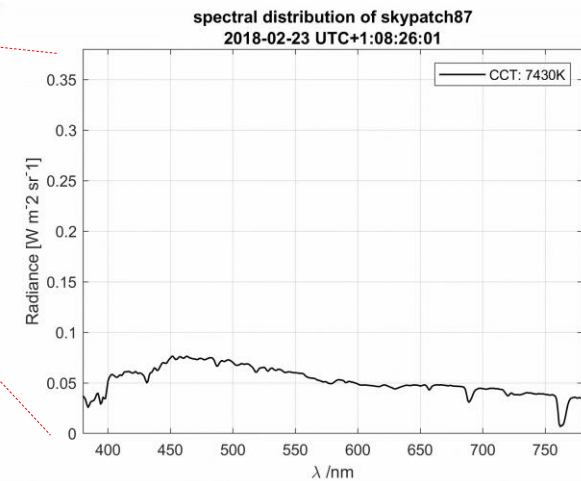
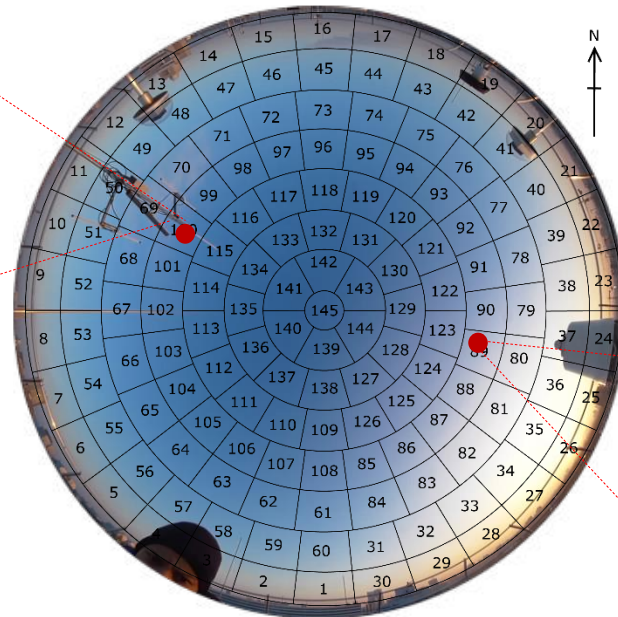
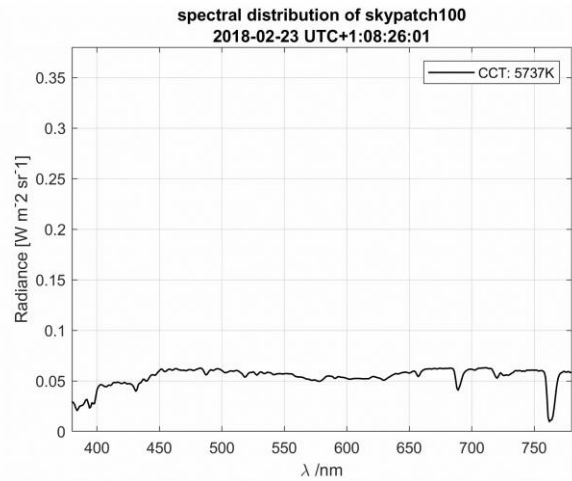
Photo: Nils Weber

SPATIALLY RESOLVED SPECTRAL DATA

September 12 2016. 08:04 UCT = 09:00 TST, Berlin



SPATIALLY RESOLVED SPECTRAL DATA

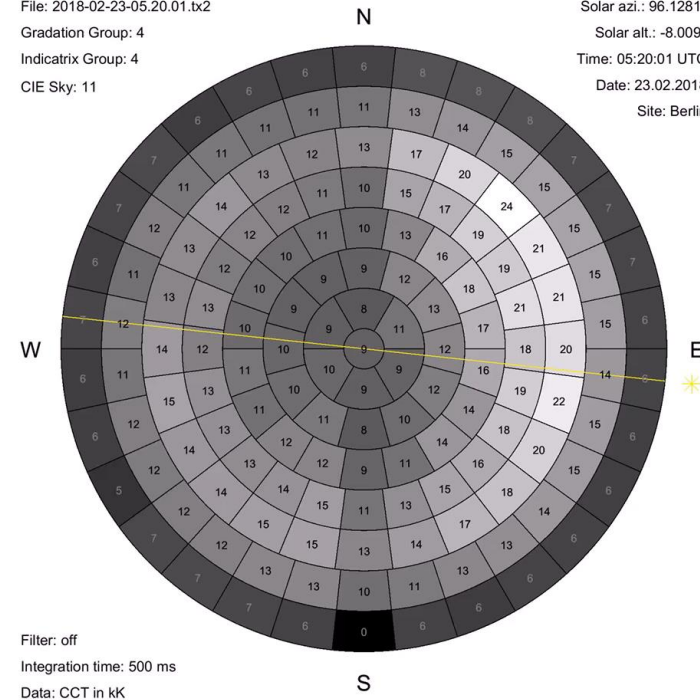


SPATIALLY RESOLVED COLORIMETRIC DATA



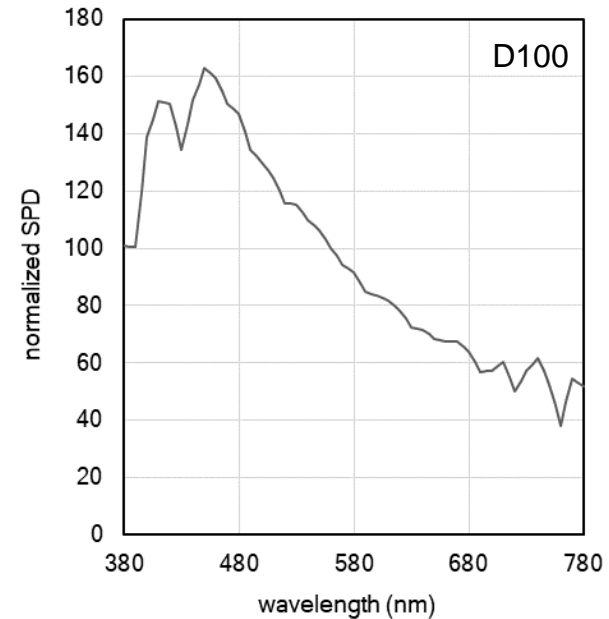
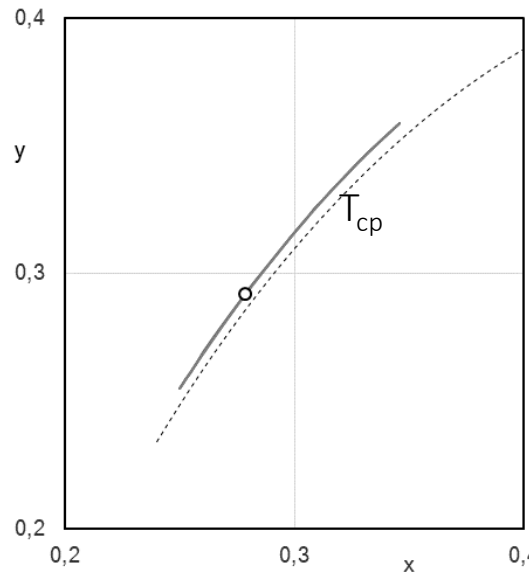
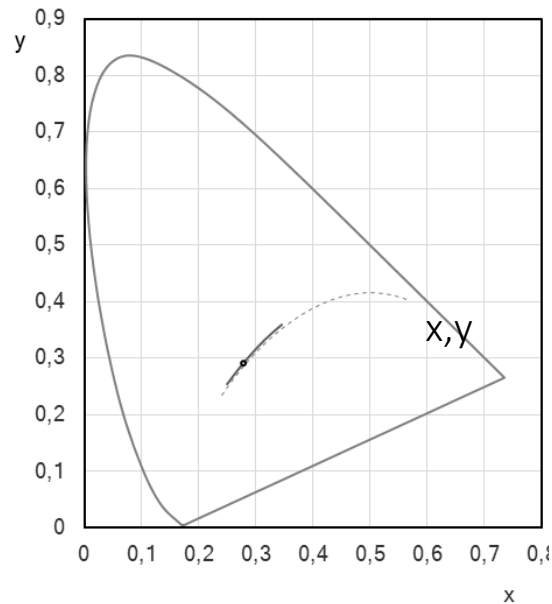
File: 2018-02-23-05.20.01.tx2
Gradation Group: 4
Indicatrix Group: 4
CIE Sky: 11

Solar azi.: 96.1281°
Solar alt.: -8.009°
Time: 05:20:01 UTC
Date: 23.02.2018
Site: Berlin

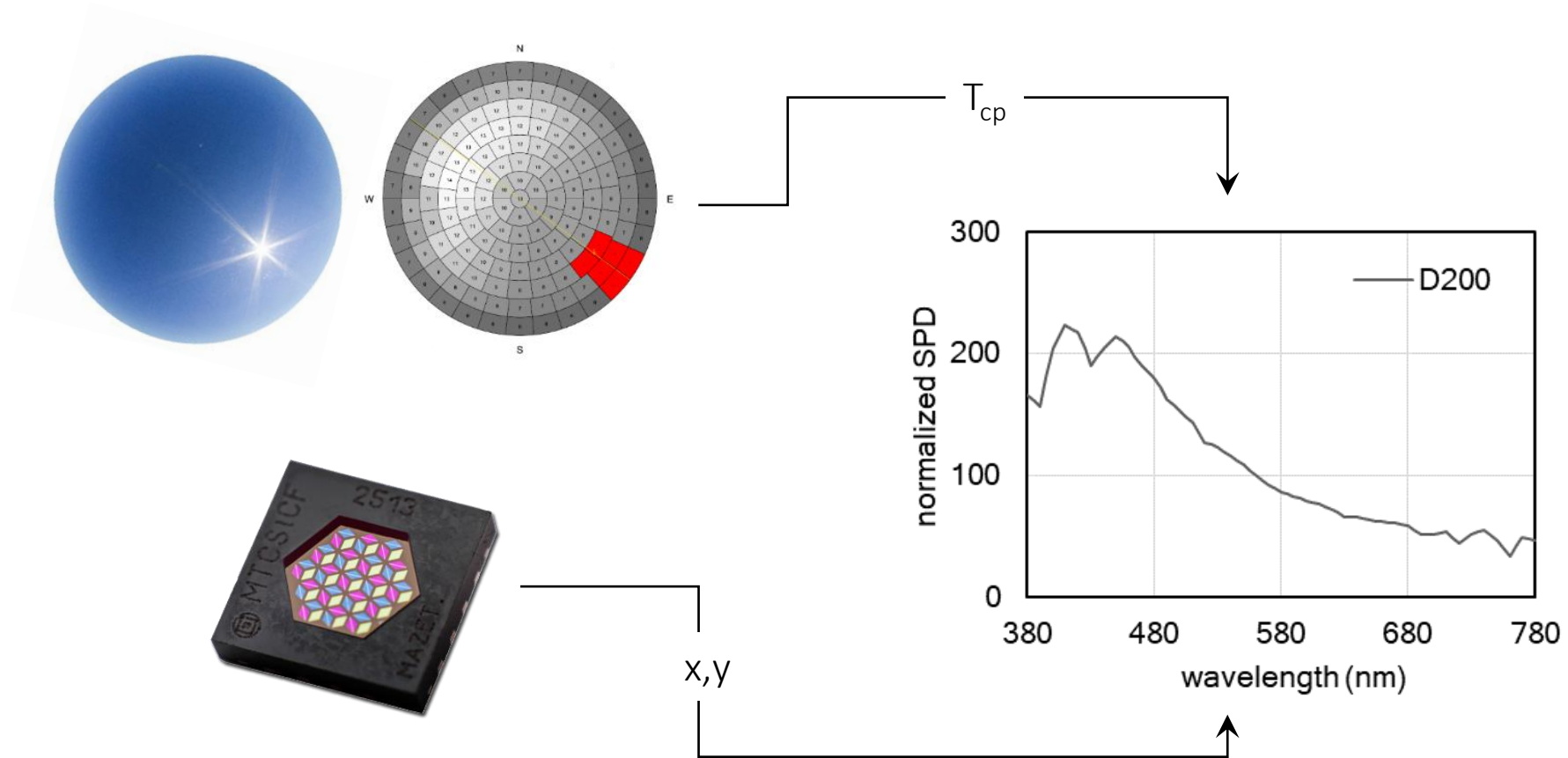


RECONSTRUCTION OF SPDs

- Judd et al. (1964) | CIE 15:2018
- Rochester (US), Enfield (UK) and Ottawa (CA)
- 622 SPDs for CCTs between 4000 K and 25000 K

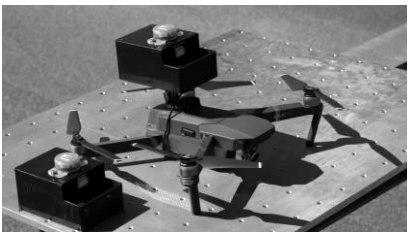
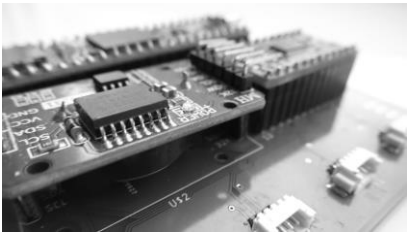
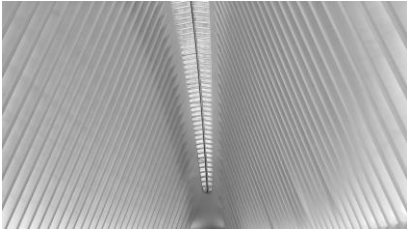


PRACTICAL APPLICATION



PRACTICAL APPLICATION

GOAL: To enhance user well-being and performance in interiors

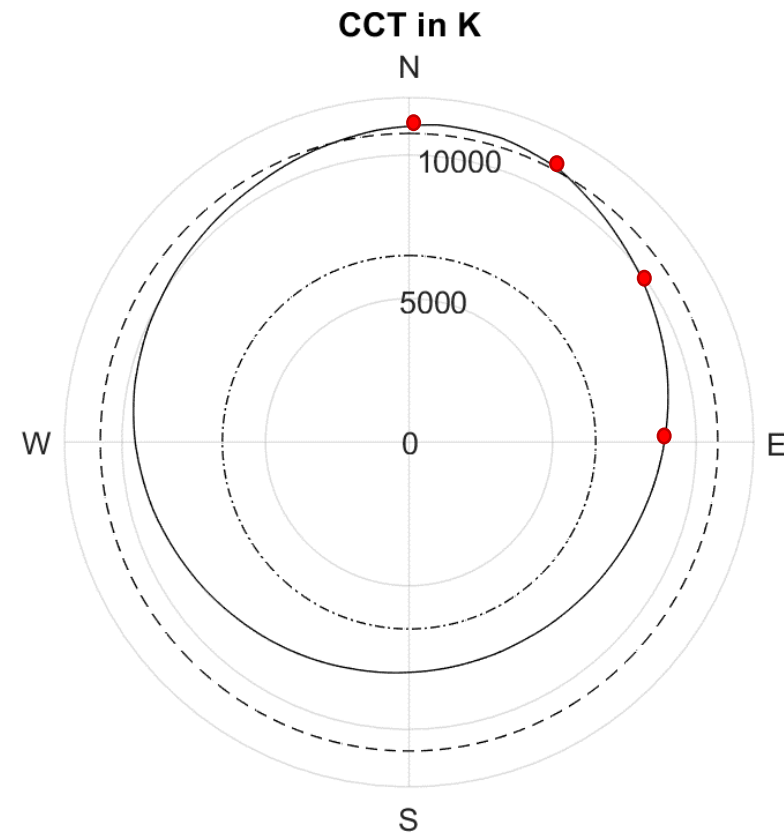
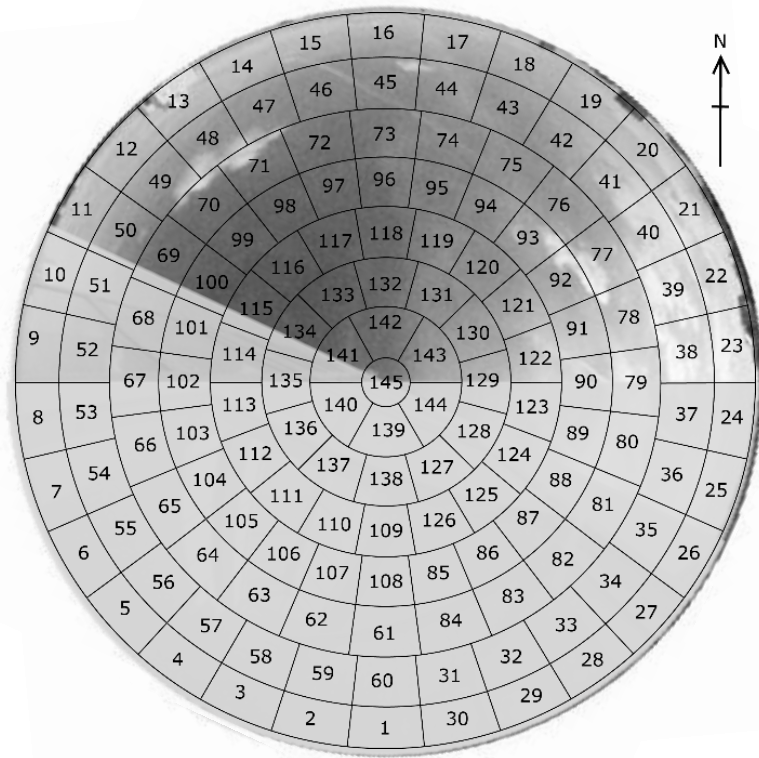


Measure – Describe – Evaluate – Use



DAYLIGHT PLANNING

Spectral Daylight Potential Diagrams (SDPDs)

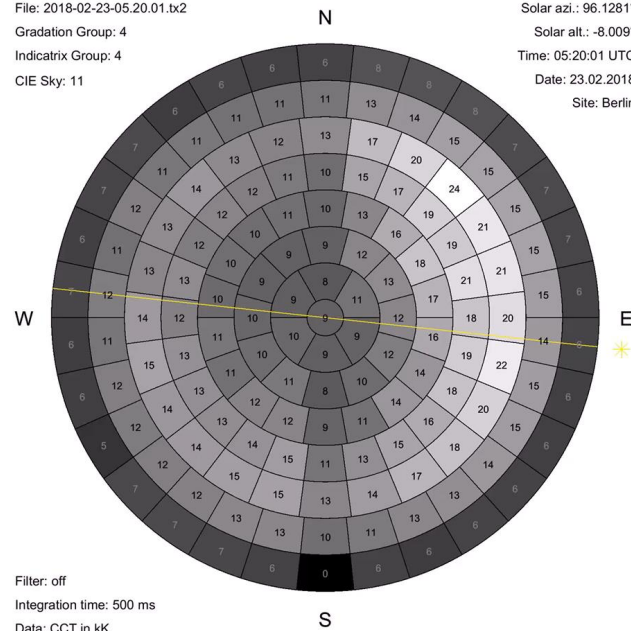


SDPDs

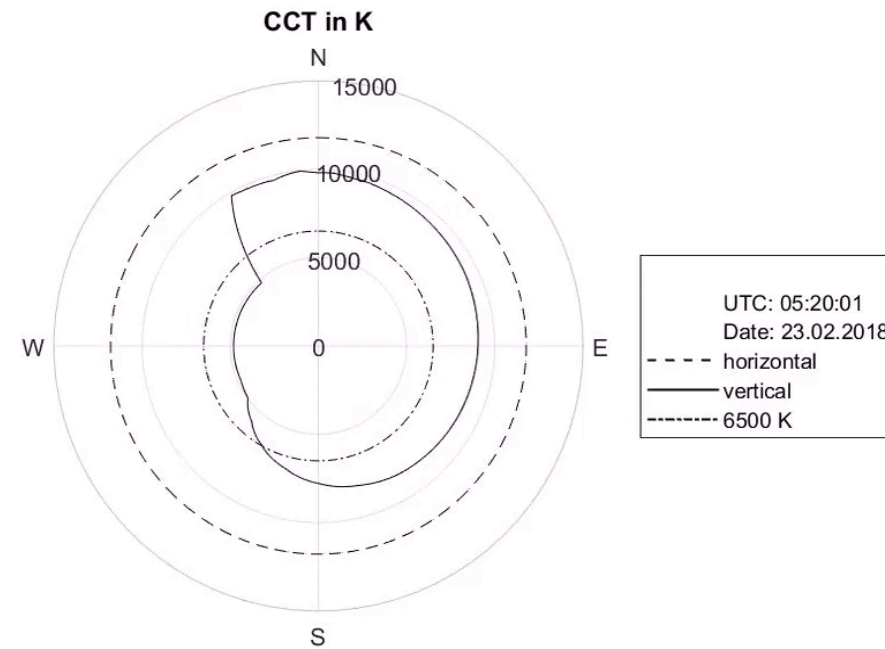


File: 2018-02-23-05.20.01.tx2
Gradation Group: 4
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Solar azi.: 96.1281°
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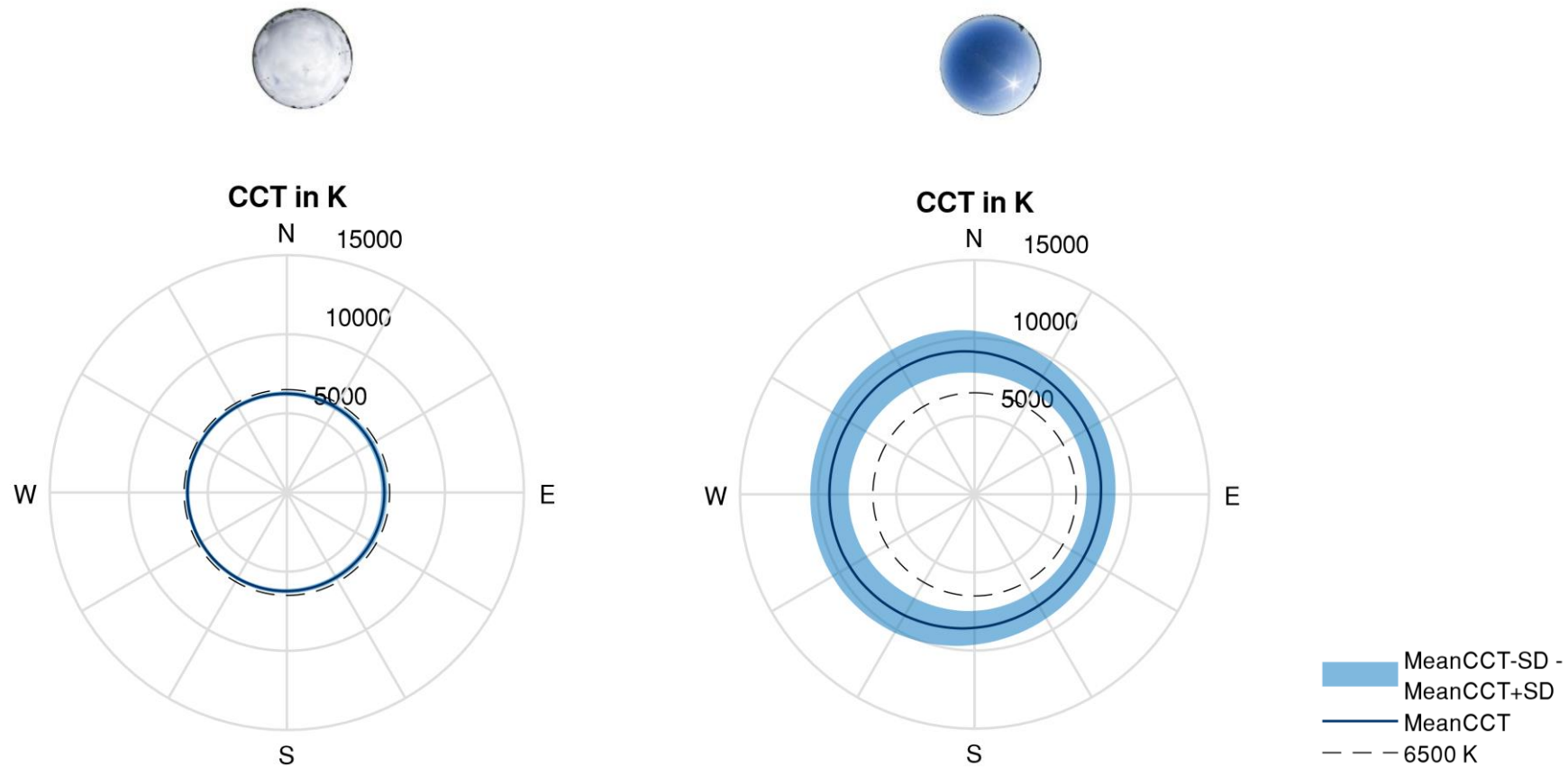


Filter: off
Integration time: 500 ms
Data: CCT in kK



UTC: 05:20:01
Date: 23.02.2018
--- horizontal
— vertical
- - - 6500 K

Exemplary SDPDs



CIE 3:12
Summer 2015
Orientation 1° steps
UTC 7:30 a.m. - 8:30 a.m.

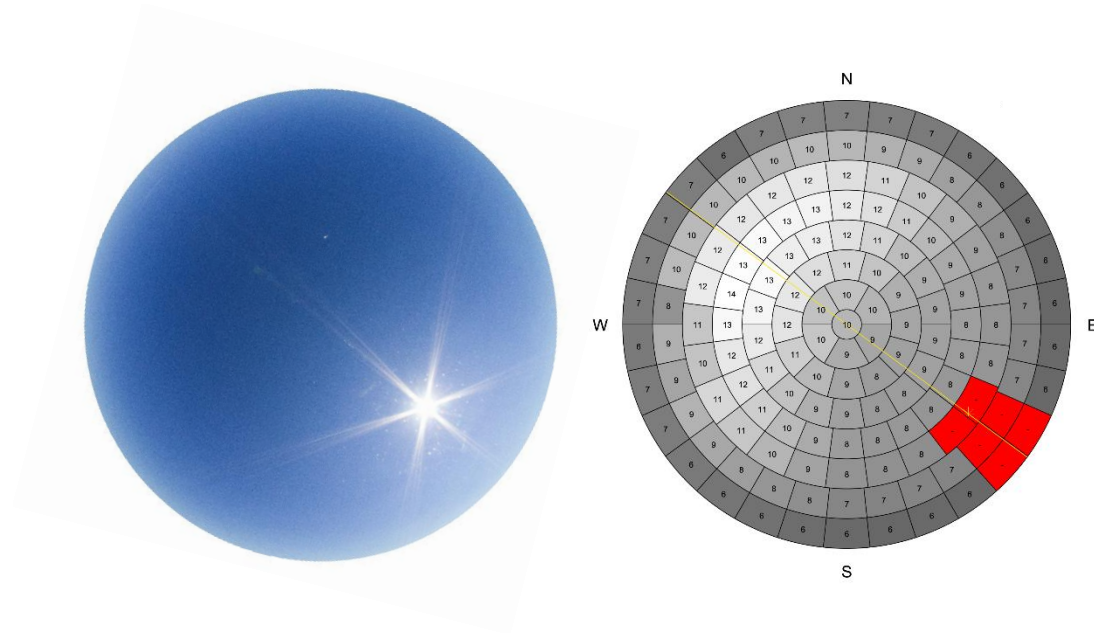
DISSEMINATION



Lighting Recommendations IEA SHC Task 61/ EBC Annex 33 on “Integrated Solutions for Daylighting and Electric Lighting”

The screenshot shows the website for SHC Task 61. At the top, there is a navigation bar with links for 'IEA SHC HOME', 'TASK HOME', 'MEMBER LOGIN', and a search bar. The main header features the SHC logo (Solar Heating & Cooling Programme, International Energy Agency) and a large image of a hand pointing at a glowing circuit board. Below the header, a red box highlights 'SHC Task 61 Solutions for Daylighting & Electric Lighting'. A left sidebar contains a menu with items: 'About Project', 'Participants', 'Meetings / Events', 'News', 'Publications', 'Related Sites', 'Member Area', and 'Contact'. The main content area has a title 'Integrated Solutions for Daylighting and Electric Lighting: From component to user centered system efficiency' and an 'Overview' section. The overview text states: 'Lighting accounts for approximately 19% of the global electric energy consumption. Research and development in the field of energy efficient lighting techniques encompassing daylighting, electric lighting and lighting controls potentially can contribute significantly to reduce this demand. Nonetheless, growing economies, higher user demands for quality lighting and rebound effects as a result of low priced and more versatile electric lighting – “more for less” – lead to an absolute increase of the worldwide lighting energy consumption. More light is used, less consciously. The lighting as well as the façade market have seen significant technological developments and strong growth in the past decade - where nevertheless both market sectors still act mainly completely independent'. To the right, a 'Task Information' box provides details: 'DURATION: January 2018 — June 2021', 'OPERATING AGENT: Dr. Jan de Boer, GERMANY, +49 711 / 970-3401 fax: +49 711 / 970-3399, jdb@ibp.fraunhofer.de', and 'COLLABORATION: This is collaborative work with IEA EBC and is referred to as EBC Annex 77'.

SPECTRAL SKY MODELS



SPECTRAL SKY MODELS

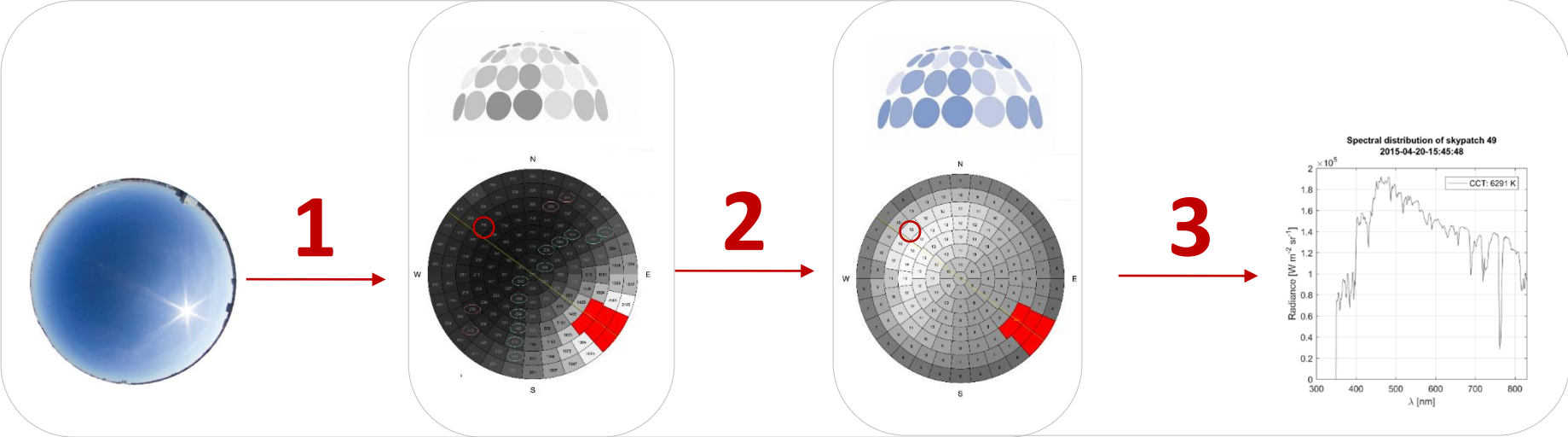


CIE Standard General Sky
ISO 15469:2004(E)/CIE S 011/E:2003

All Weather Model
Perez et al. 1993

$CCT = f(L, x_1, x_2, \dots)$
TU Berlin

$S(\lambda) = f(CCT)$
Judd et al. 1964
CIE 015:2018



DISSEMINATION

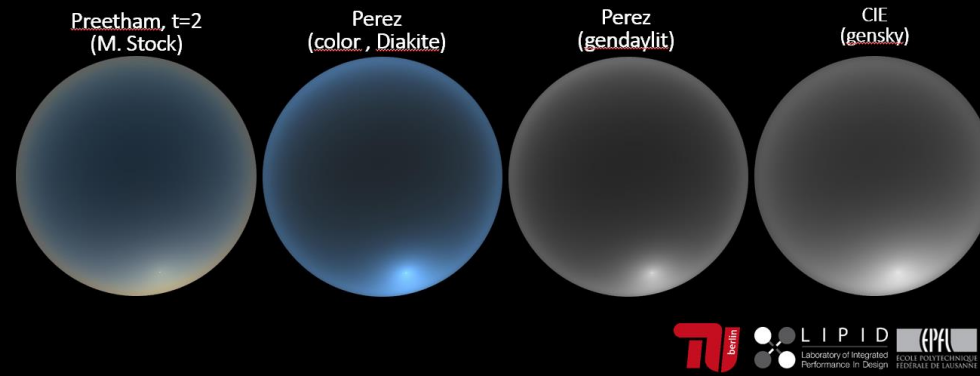


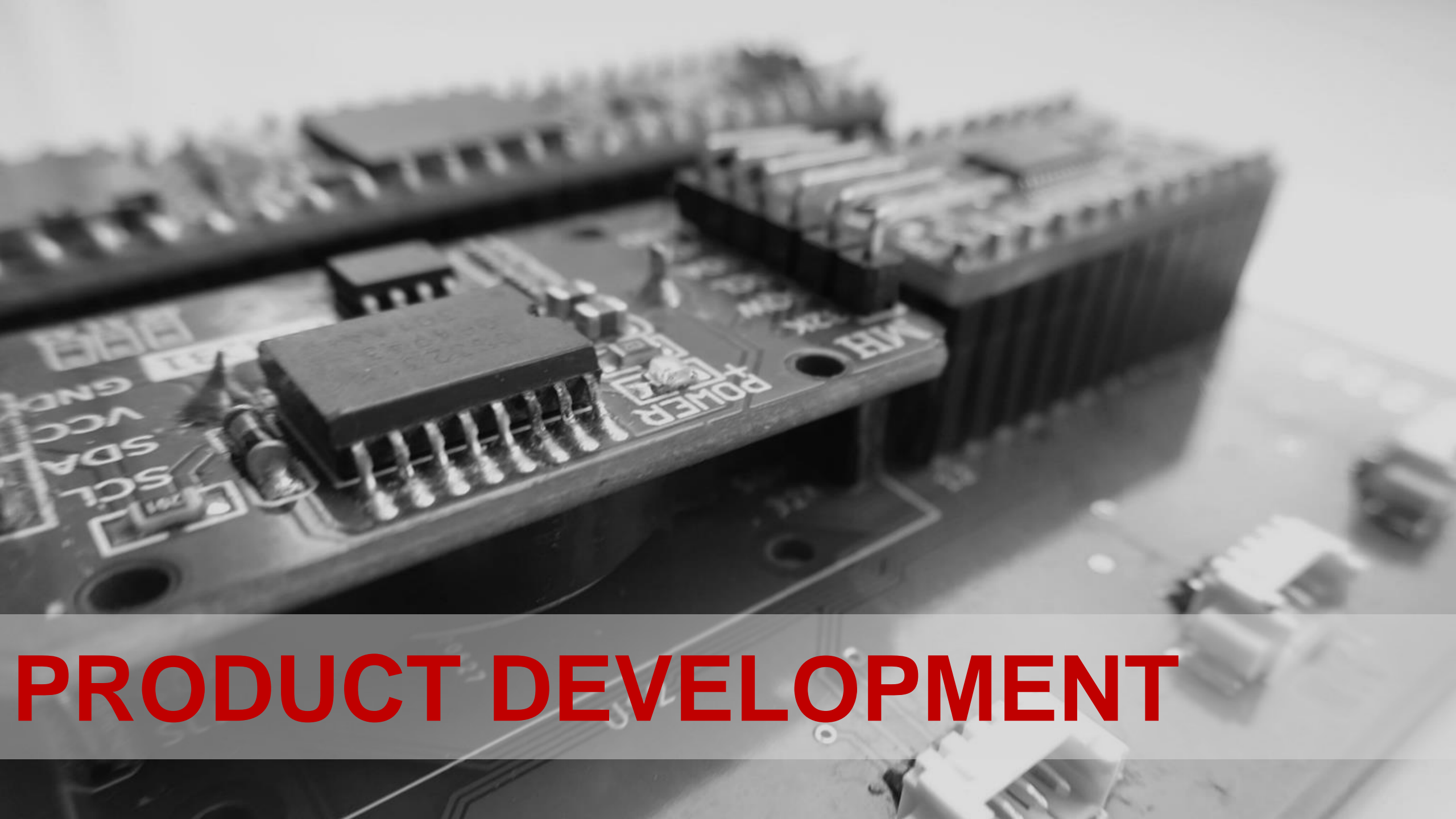
Simulation tools

**Implementation in Radiance in collaboration
with Jan Wienold - LIPID EPFL**

Implementation – examples and comparison

Winter sun: February 18, 13:14 Berlin. $I_{dir} = 755 \text{ W/m}^2$ $I_{diff} = 17 \text{ W/m}^2$
 $\gamma = 15.8^\circ$, $\varepsilon = 12$, very clear sky



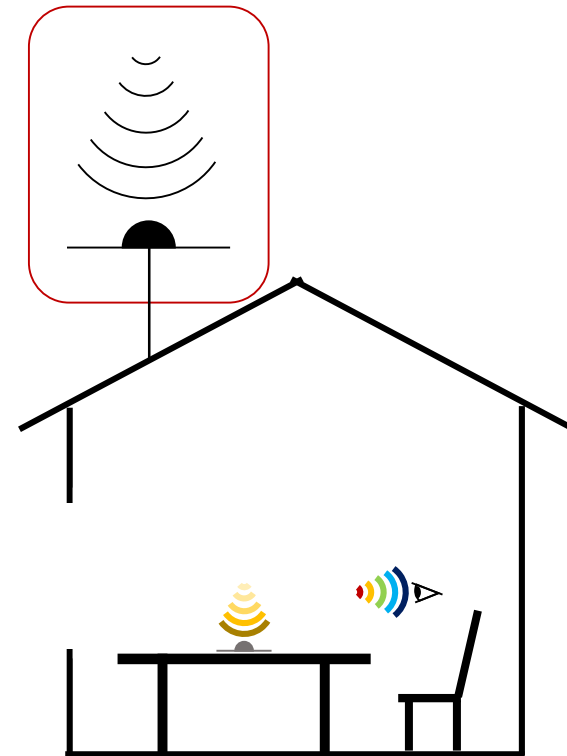


PRODUCT DEVELOPMENT

SPECTRAL SENSOR



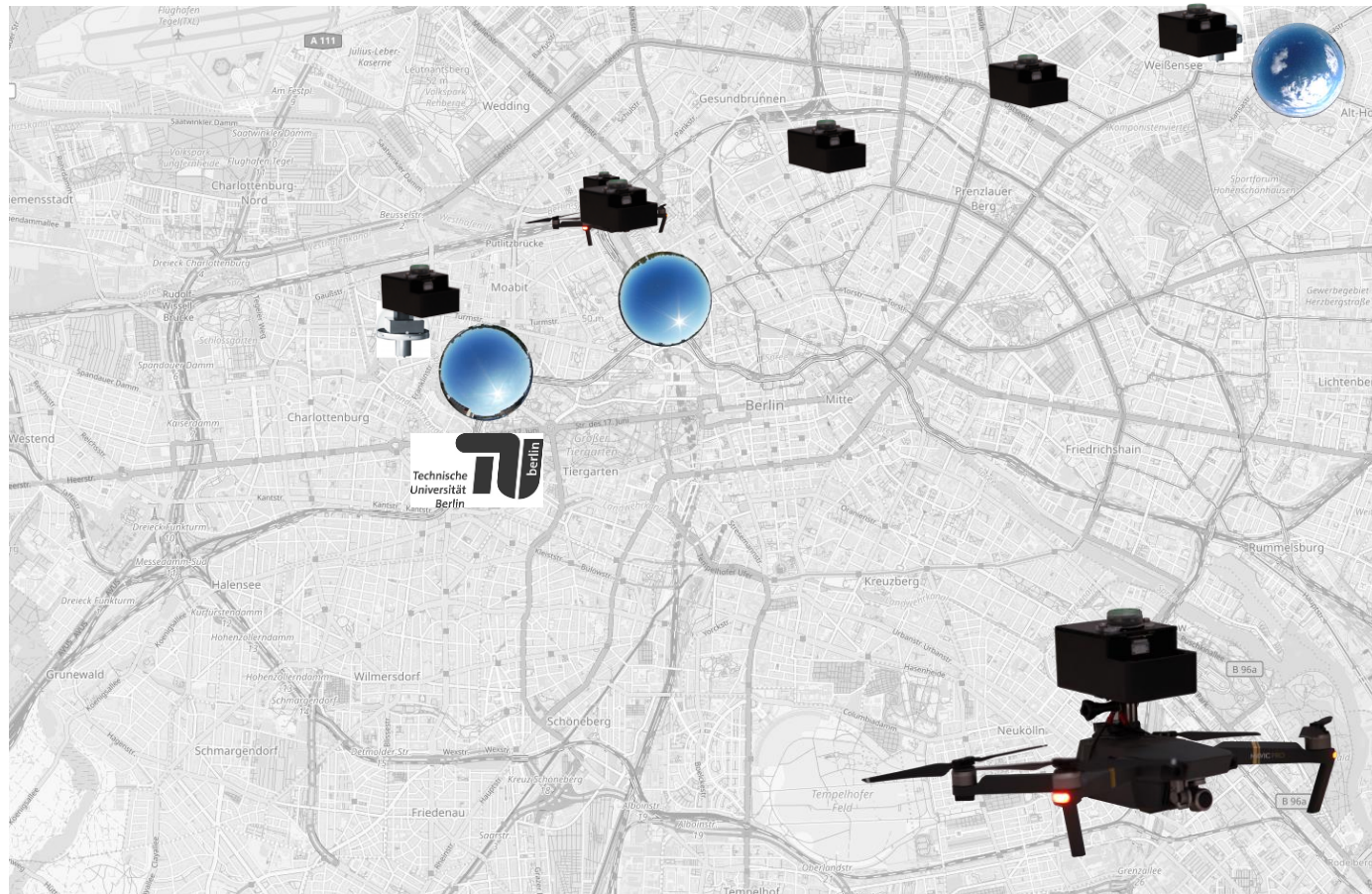
- Spatial and spectral data (rgb sensors)
- Determination of the incident daylight for integrative lighting solutions
- For areas (for more than one building)





RESEARCH

RANGE OF THE MEASUREMENTS



50 m



20 m



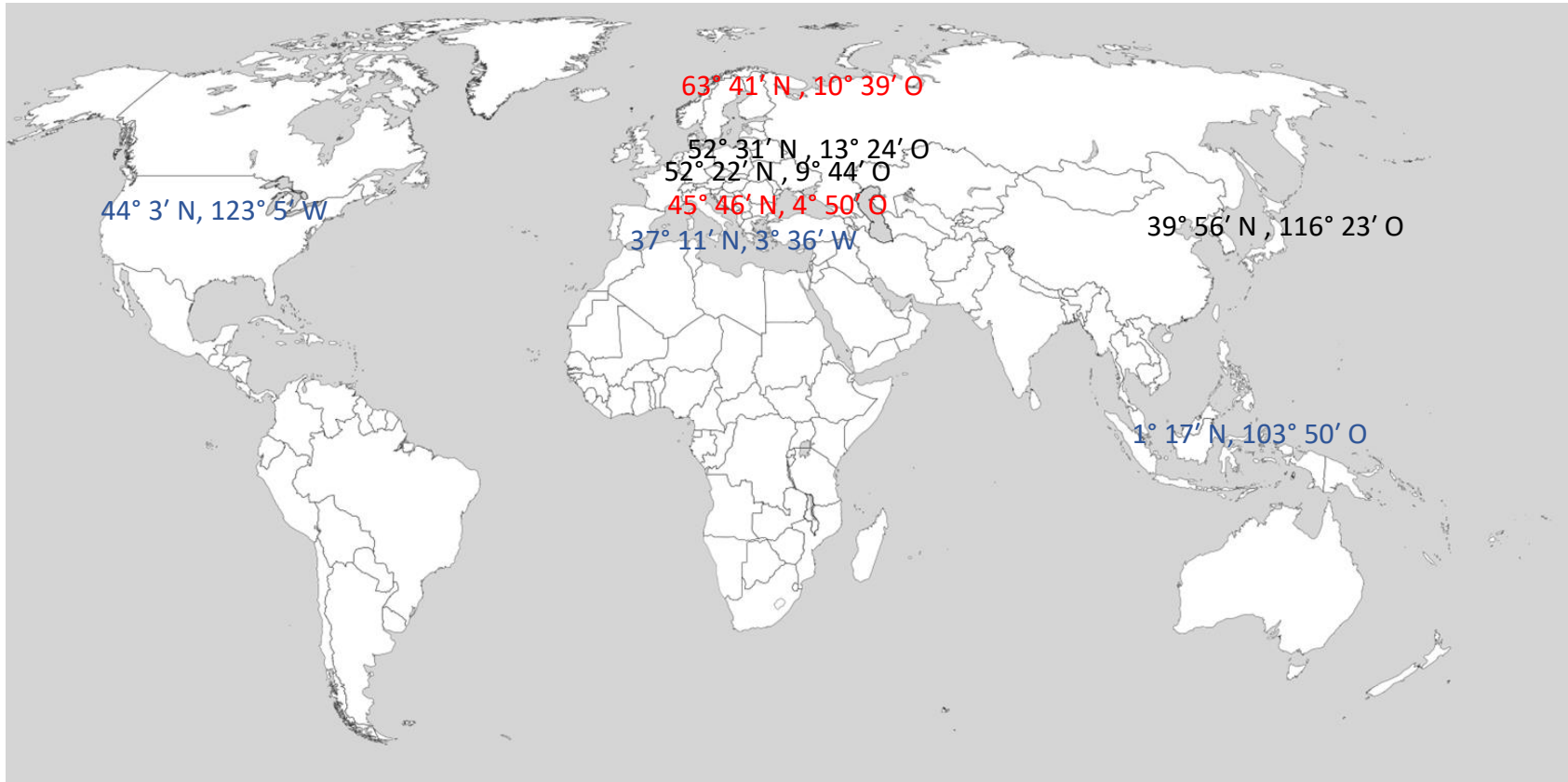
10 m



2 m

WORLD WIDE MEASUREMENT CAMPAIGN

WORLD WIDE MEASUREMENTS



Picture: Petr Dlouhý https://commons.wikimedia.org/wiki/File:A_large_blank_world_map_with_oceans_marked_in_blue.svg)

DAYLIGHTING AND INDOOR LIGHTING TEAM



**Daylighting and
Indoor Lighting
Group Leader**
Dr Martine Knoop



**Sensor
Development**
Nils Weber



**Directionality
of ILL-Effects**
Kai Broszio



**Spectral Models
& Daylight
Planning**
Aicha Diakite



**Virtual Reality
Light**
Silke Müller



**Spectral Data:
Simulations &
ILL-Effects**
Frederic Rudawski



**Virtual Reality
User Reaction**
Marina Leontopoulos

DAYLIGHTING AND INDOOR LIGHTING TEAM



Prof. Stephan Völker | Chair of the Lighting Technology
Ingbert Zimmermann | Laboratory supervisor
Jörg Oertwig | Technician

Dimitri Belostowski | Student Assistant
Lucas K. Liegener | Student Assistant
Sebastian Bremer | MA thesis
Eric Rockstädt | BA thesis

https://www.li.tu-berlin.de/menue/equipment/dms/indoor_daylight/parameter/en/



THANK YOU FOR YOUR ATTENTION!



www.aichadiakite.com

VELUX STIFTUNG

