# Supplementary Information

# Reproducing solar spectral irradiance by LEDs

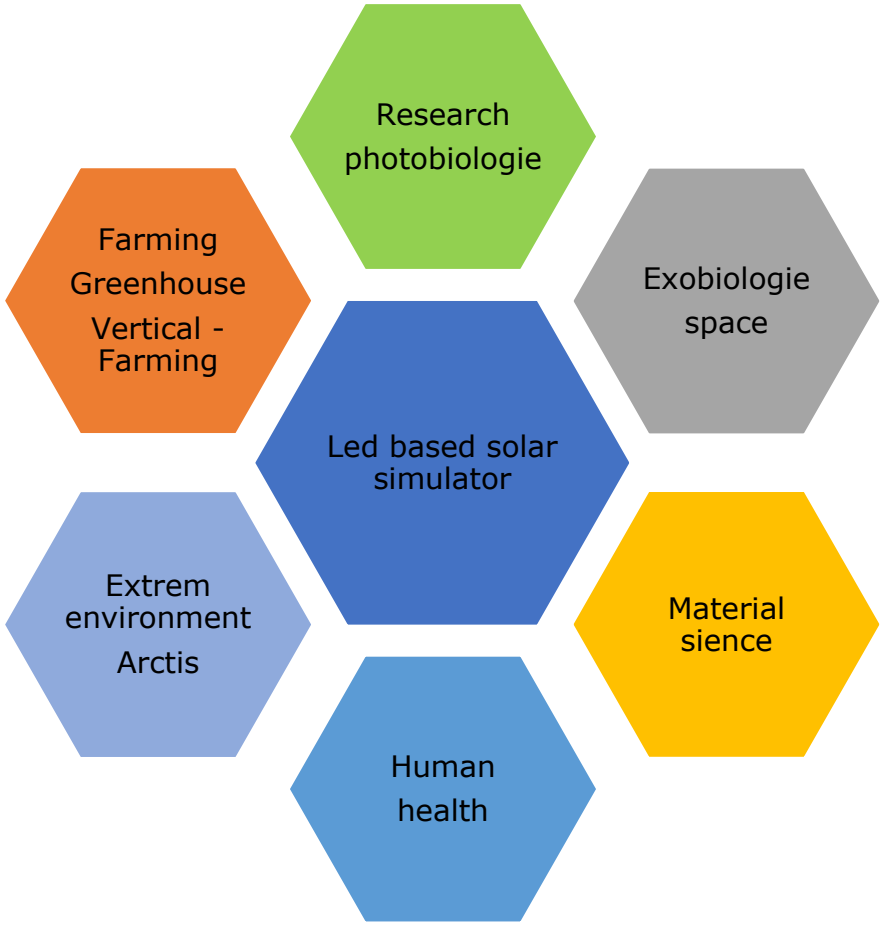
Anton Kopatsch[a], Peter Kary[a], Mustafa Özden[a], Andreas Albert[a], Andrea Ghirardo[a], J. Barbro Winkler[a], Gunther Seckmeyer[b*], Jörg-Peter Schnitzler[a*]

[a] Helmholtz Zentrum München, Institute of Biochemical Plant Pathology, Research Unit Environmental Simulation (EUS), Neuherberg, Germany

[b] Leibniz Universität Hannover, Institute for Meteorology and Climatology, Hannover, Germany

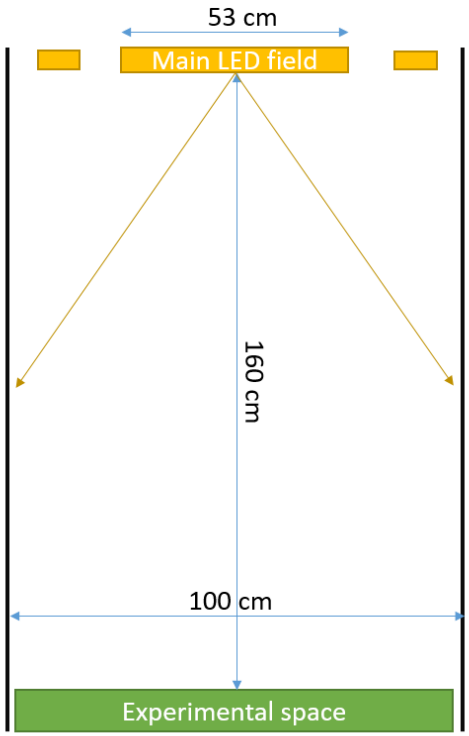
**Supplemental Figures**

**Figure S1**



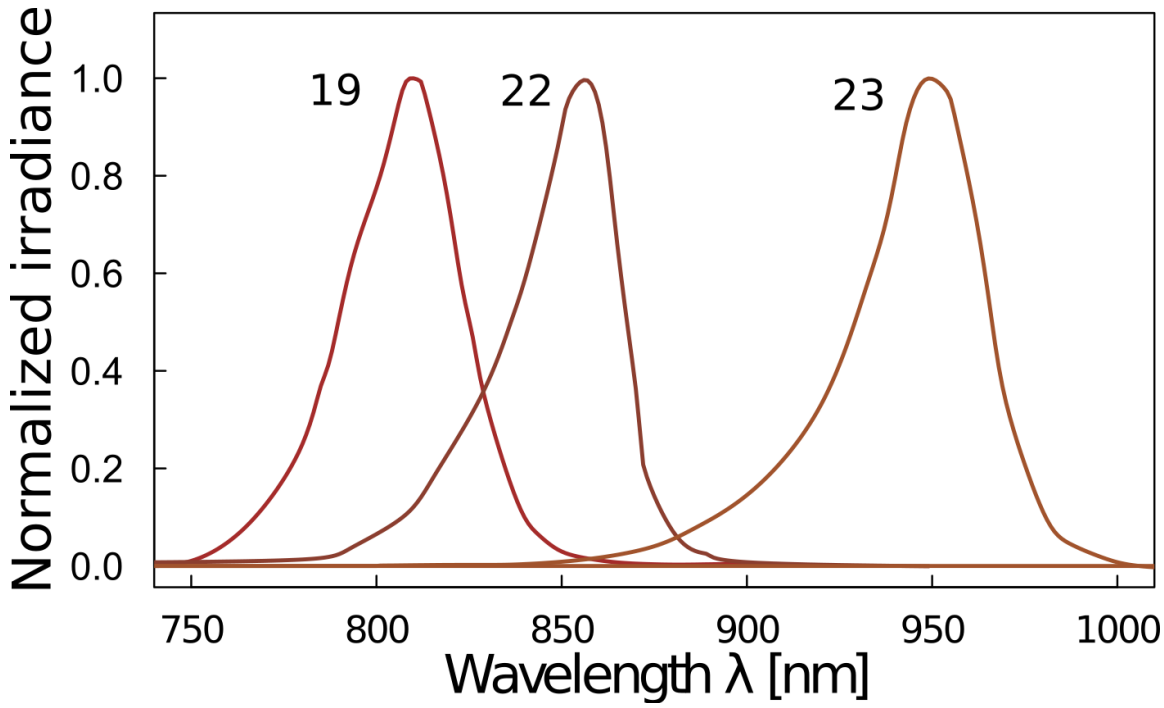

**Supplemental Figure S1** Different applications for a LED-based solar simulator.

**Figure S2**



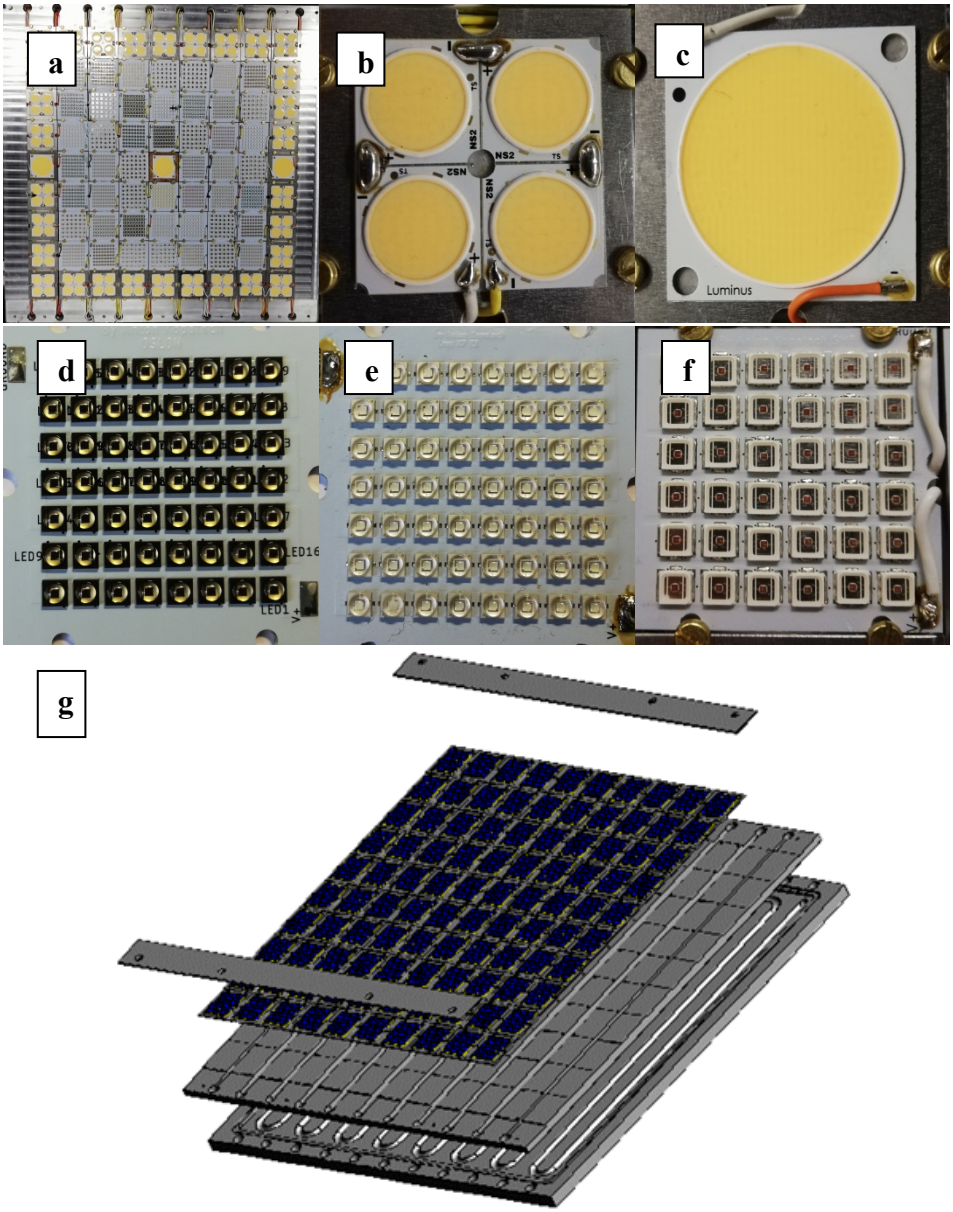

**Supplemental Figure S2** Setup of the experimental chamber and the prototype of the LED lighting field. Chamber with a ground area of one $m^2$ and a distance to the LED lighting field of 1.6 meter. For the side walls of the chamber a high reflective aluminium where used.

**Figure S3**



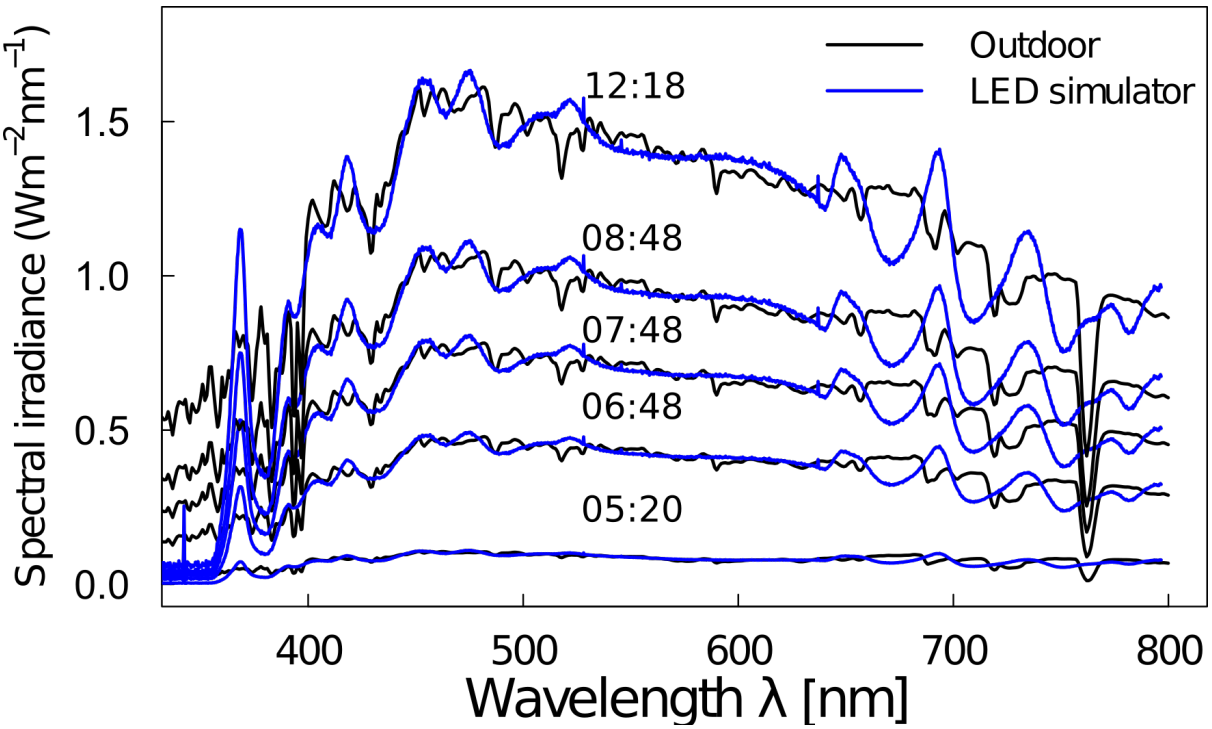

**Supplemental Figure S3** Normalized spectra of the 810 nm LED (19), 850 nm LED (22) and the 940 nm LED (23). The data were taken from the manufacture datasheets. The typical radiant flux of a single 810 nm LED is 0.52 W@800 mA, 25 °C. In the system are 108 LEDs (810 nm) integrated, which results to a radiant flux of 56 W. For the single 850 nm and 940 nm LED, the typical radiant flux is also about 0.52 W. In the system are 112 LEDs (850 nm) and 56 LEDs (940 nm) integrated. These results of an overall radiant flux of 58 W for the 850 nm LEDs and 29 W for the 940 nm LEDs. The sum of the overall radiant flux of the 810 nm, 850 nm and the 940 nm LEDs is 143 Watt.

**Figure S4**




**Supplemental Figure S4** Set up of the inner LED lighting field. (a) Picture of the inner LED lighting field, where 81 circuit boards are mounted. (b) Circuit board for the main 'white' LED (Seoul Semiconductor SAWS1566A), four COB (Chip On Board) LED connected in series (c) Circuit board for the 2nd 'white' LED. (d) Circuit board for 56 SMD (Surface Mounted Device) LEDs with a foot print of 2.7x2.7 mm. (e) Circuit board for 56 SMD LEDs with the foot print of 3x3.3 mm. (f) Light engine for 36 SMD LEDs with the foot print of 6x5 mm. (g) Exploded assembly drawing of the inner LED lighting field.

**Figure S5**




**Supplemental Figure S5** Measured natural diurnal solar spectra (19 May 2007; 48°13'13.1"N 11°35'51.4"E from 05:20 to 12:18 CET, Bentham Double-Monochromators) versus the corresponding synthesized LED spectra.

**Table S1** Six different LED drivers.

| *Model* | *Rated Power* | *Constant Current Region* | *Rated Current* | *Dimmimg* | *Number used in the System* |
|---|---|---|---|---|---|
| 1 | 150 W | 107-214 V | 700 mA | DALI | 29 |
| 2 | 150 W | 72–143 V | 1050 mA | DALI | 2 |
| 3 | 150 W | 150-300 V | 500 mA | DALI | 12 |
| 4 | 320 W | 46–91 V | 3500 mA | 0-10 V | 10 |
| 5 | 320 W | 114–229 V | 1400 mA | 0-10 V | 12 |
| 6 | 480 W | 171– 343 V | 1400 mA | 0-10 V | 15 |

**Table S2** Table of the used LEDs

| *LED Number* | *Peak / dominant wavelength* | *Typ.mW / Luminus Flux* | *Rth[K/W]* | *Footprint* |
|---|---|---|---|---|
| 1 | 365 nm | 492@25°C, 500 mA | 5.1 | 3.3x3.3 mm |
| 2 | 385 nm | 600@25°C, 500 mA | 8 | 3.3x3.3 mm |
| 3 | 395 nm | 700@25°C, 500mA | 8 | 3.3x3.3 mm |
| 4 | 405 nm | 700@25°C, 500mA | 8 | 3.3x3.3mm |
| 5 | 415 nm | 792@25°C, 500mA | 8 | 3.3x3.3 mm |
| 6 | 450 nm | 450@25°C, 350mA | 9 | 3.3x3.3 mm |
| 7 | 475 nm | 31 lm@25°C, 350mA | 9 | 3.3x3.3 mm |
| 8 | 505 nm | 71 lm@25°C, 350mA | 9.6 | 3x3 mm |
| 9 | 520 nm | 87.4 lm@25°C, 350mA | 15 | 3.3x3.3 mm |
| 10 | 590 nm | 87.4 lm@25°C, 350mA | 9 | 3.3x3.3 mm |
| 11 | 595 nm | 62 lm@25°C, 350mA | 7 | 3.3x3.3 mm |
| 12 | 615 nm | 67.2 lm@25°C, 350mA | 5 | 3.3x3.3 mm |
| 13 | 630 nm | 56.8 lm@25°C, 350mA | 5 | 3.3x3.3 mm |
| 14 | 655 nm | 350@25°C, 350mA | 8 | 3.3x3.3 mm |
| 15 | 690 nm | 520@25°C, 600mA | 10 | 4.4x5.2 mm |
| 16 | 730 nm | 383@25°C, 350mA | 3.5 | 3x3 mm |
| 17 | 760 nm | 400@25°C, 800mA | 10 | 4.4x5.2 mm |
| 18 | 780 nm | 500@25°C, 800mA | 10 | 4.4x5.2 mm |
| 19 | 810 nm | 520@25°C, 800mA | 10 | 4.4x5.2 mm |
| 20 | White 5600 K | 24800lm@85°C, 5000mA, | 0.1@ Junction-to-case | 38x38 mm |
| 21 | White 5000 K | 2655lm@85°C, 720mA, | 0.3@ Junction-to-solder | 19x19 mm |
| 22 | 850 nm | 745@25°C, 1000mA | 16 | 3x3 mm |
| 23 | 940 nm | 1340@25°C, 1000mA | 9 | 3x3 mm |