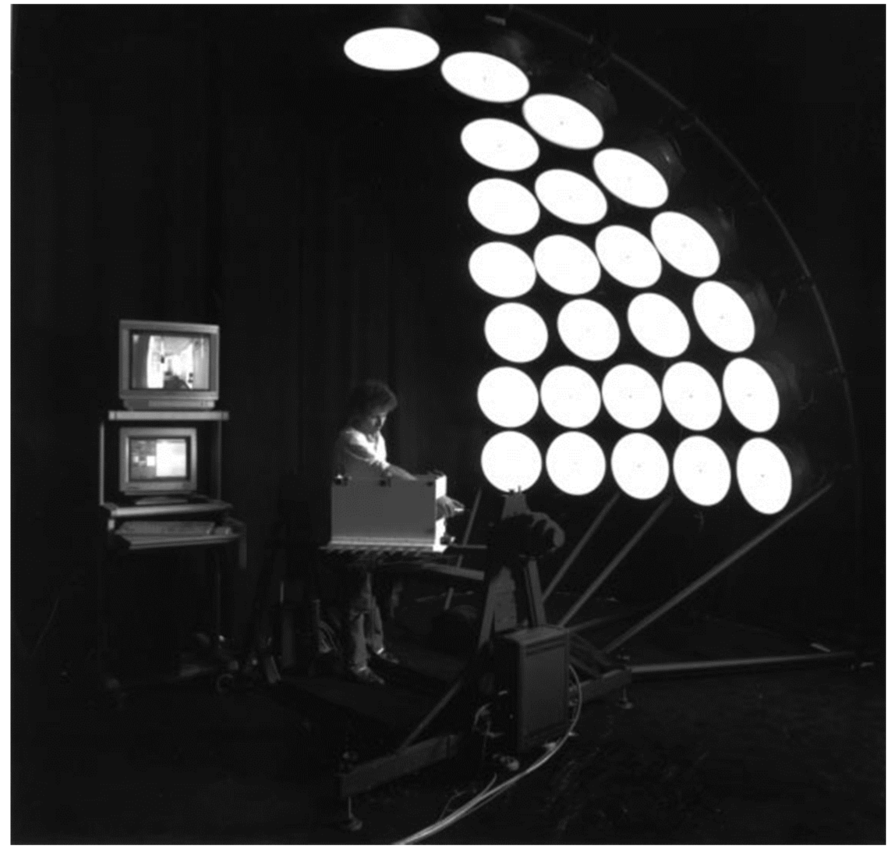
Validating lighting simulations



Why does your simulation need validation?

- **Validating a new simulation tool/technique**

→ **establish a universal set of 'test cases' and compare results**

  - **CIE 171:2006** Test cases to assess the accuracy of lighting computer programs | CIE
  - **CIBSE TM28/00** Benchmarking Lighting Design Software
  - **Mardaljevic, J.**, 2001. The BRE-IDMP dataset: a new benchmark for the validation of illuminance prediction techniques. Lighting Research & Technology, 33(2), pp.117-134.

→ **real spaces comparisons**

  - **Mardaljevic, J.**, 1995. Validation of a lighting simulation program under real sky conditions. Lighting Research and Technology, 27(4), pp. 181-188.
  - **Reinhart, C. & Breton, P.-F.**, 2009. Experimental validation of Autodesk® 3ds Max® Design 2009 and Daysim 3.0. LEUKOS: The Journal of the Illuminating Engineering Society of North America, 6(1), pp. 7-35.
  - **Jones, N.L. and Reinhart, C.F.**, 2015. Validation of GPU lighting simulation in naturally and artificially lit spaces. In Proceedings of the IBPSA Building Simulation Conference.

- ***Confirm accuracy of simulated scenario***

  → *how close are simulated outputs to measured values?*

Examples of Simulation Outputs

- Illuminances (point, average, uniformity)
- Luminances
- Glare indices
- Daylight autonomies
- Electric lighting usage/savings
- Energy efficiency metrics
- BRDF/BTDF

Sources of uncertainty and error in validation simulation process

- Simulation inputs
  - Light source modelling
  - Material surface characterisation
  - Geometry of interiors
- Simulation method
  - radiosity/raytracing parameters
- Measurement in real spaces
  - Instrumental uncertainty
  - Disparity between intended and actual use of space

Simulation Inputs

- Electric Lighting – photometric data (.ies files etc)
- Daylight – weather files, sky models

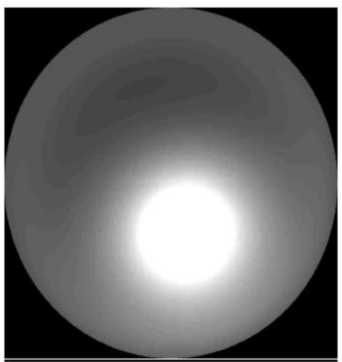
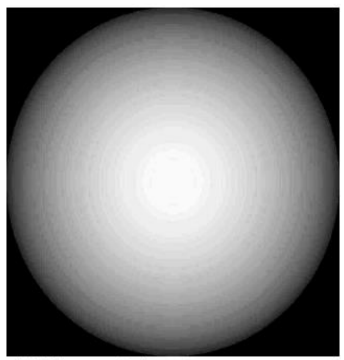
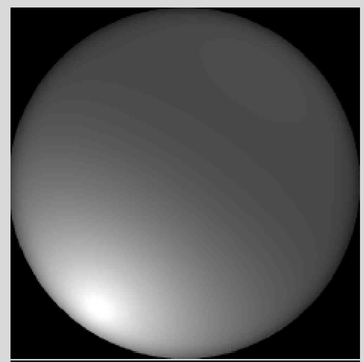


Figure 2-4: (a) CIE clear sky



(b) CIE overcast sky



Perez

- Material descriptions – surfaces, glazing
- Interior geometry – e.g. furniture

Simulation methods

Uncertainty in measurement…

	Effect on average illuminance %	Effect on direct point illuminance %
Measurement Errors		
Sensors		
Cosine correction	0.5	2
Colour correction	1	1
Calibration	2	3
Repeatability of position	0	3
Levelling	0	2
Photometry factors affecting measurement		
Lumen output - temp	2	2
Lumen output - power	1	1
Room factors		
Dimensions and irregular features	0.5	0.5
Luminaire positions	0	2
Measurement positions	0	2
Surface reflectances	2	2
Total measurement error	3.8	6.7

Figure 2: Measurement Error Estimates

From **CIBSE TM28/00** Benchmarking Lighting Design Software

Issues in measurement of daylit spaces

- Achieving consistent & reproducible sky conditions, simultaneous exterior measurements are required
  - Horizontal global illuminance
  - Vertical sky illuminance (at window if relevant)
- Dynamic conditions may require multiple instruments or a fast hand (e.g. measuring over a grid requires a stable daylight condition)
  - Check your first measure immediately after your last as a check
- Key measures are user dependant
  - Electric lighting use
  - Blinds/shading use
  - Visual comfort, perceived glare

Challenges measuring in real & occupied spaces

- Lighting calculation is typically conducted on a prescribed grid – that can’t be reproduced exactly in real furnished spaces
- In occupied spaces, measurement should not interfere with users’ tasks or movement through space
- If continuously logging data, loggers must be interference proof!
- Note: most low-cost loggers will have higher measurement uncertainty than high-quality meters

Additional material discussed during the workshop

- Perfect Lite + TULIP - Home Page
- Słomiński, S., 2019. Advanced modelling and luminance analysis of LED optical systems. Bulletin of the Polish Academy of Sciences. Technical Sciences, 67(6).
- Brembilla, E. and Mardaljevic, J., 2019. Climate-Based Daylight Modelling for compliance verification: Benchmarking multiple state-of-the-art methods. Building and Environment, 158, pp.151-164.
- LITG (iea-shc.org)
- Rizki A. Mangkuto (2016) Validation of DIALux 4.12 and DIALux evo 4.1 against the Analytical Test Cases of CIE 171:2006, LEUKOS, 12:3, 139-150
- Ignacio Acosta, Carmen Muñoz, Paula Esquivias, David Moreno, Jaime Navarro (2015) Analysis of the accuracy of the sky component calculation in daylighting simulation programs, Solar Energy, Volume 119, 2015, Pages 54-67,