An SPD databank

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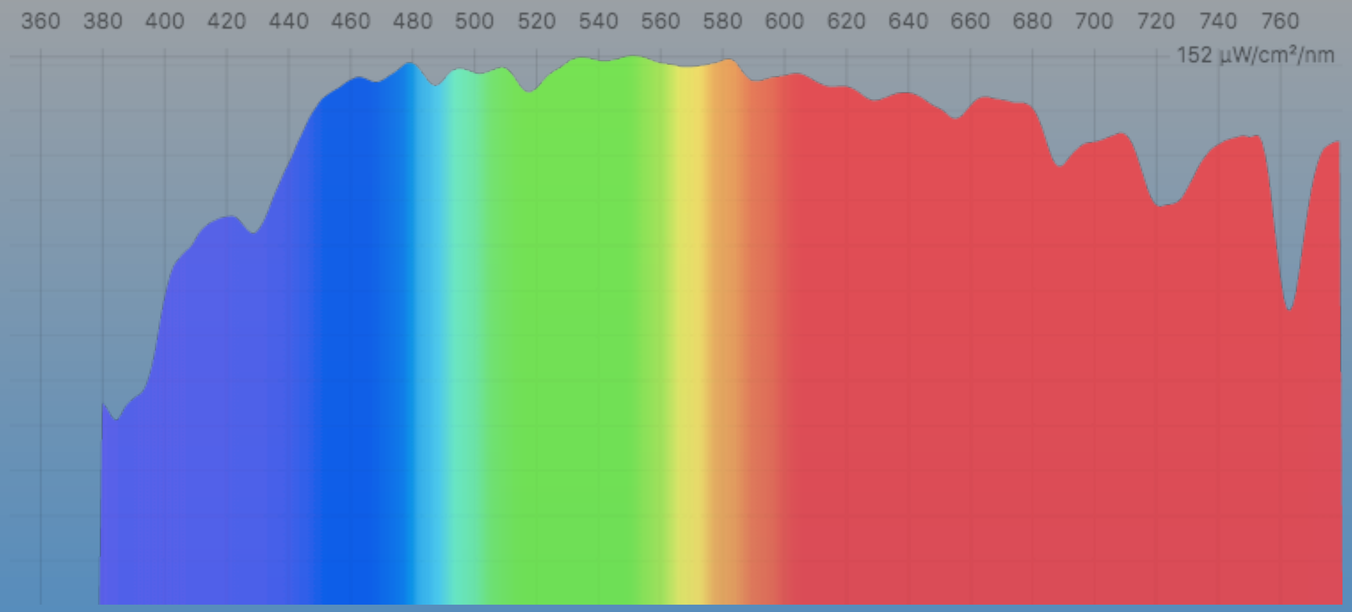
SPDs 101

- Radiant power per wavelength
- Measured with spectrometer or monochromator



Condition	Units
Total emitted (spherical)	W/nm
Spectral Irradiance (on a surface)	$W/m^2/nm$
Radiance (directional)	$W/sr/m^2/nm$
% Transmitted	Unitless (% at each wavelength)

What can you do with a single SPD?

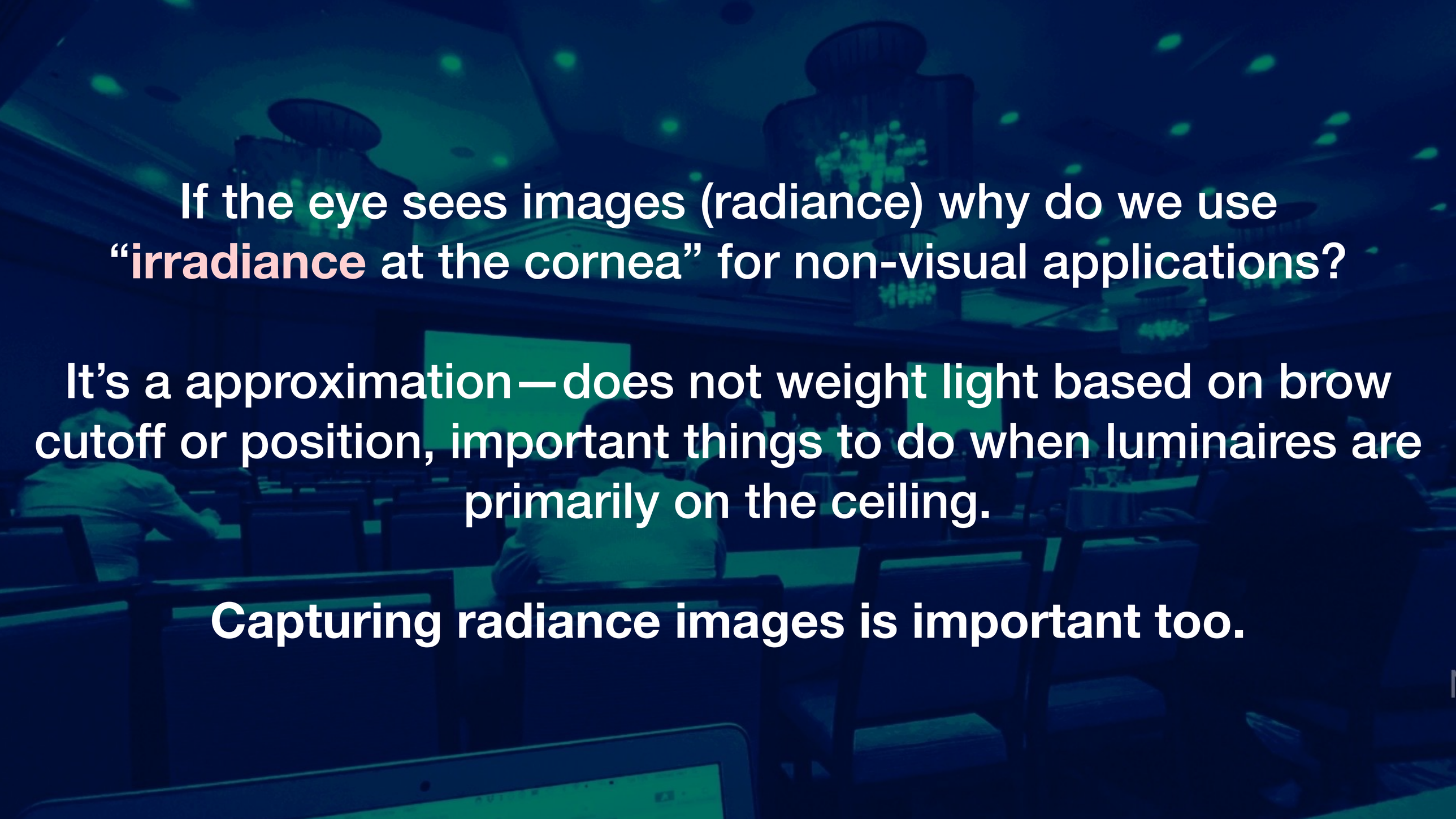
- With one spectral irradiance measurement, we can compute:
  - Color quality (TM-30, CRI, etc.)
  - α-opic photoreceptor responses (non-visual responses)
  - Physiologically-relevant luminance and chromaticity measurements
  - Plant responses
  - Animal responses
  - Individual variation (aging, cone differences)
  - Color shifts over time

Future-proof

- Remarkably, all of the models listed are <20 years old
- We could also model skyglow (based on distance from a light source), light-related hazard functions, tri-stable melanopsin, understand metameric sources, multiple species of plants, dose required for jaundice treatment, and dozens of other things with a simple SPD.
- In twenty more years, we will have new models, and SPDs will **still be able to compute those new metrics**, too

Not only sources

- Environments are spectral: TM30-15 uses a database of surfaces to evaluate color quality
- **Reflectance spectrum of surfaces (**like paint, floors, ceilings, textiles)
  - Consider a room with yellow walls vs. 98% reflective white paint—does a room act as an integrating sphere or does it absorb light?
- **Transmittance and reflection for window glazing and eyewear**
  - Transmittance explains if a window filters a particular part of the spectrum
  - Reflectance spectrum (from observer point of view) has a role in glare


If the eye sees images (radiance) why do we use
“irradiance at the cornea” for non-visual applications?
It’s a approximation—does not weight light based on brow cutoff or position, important things to do when luminaires are primarily on the ceiling.
Capturing radiance images is important too.

Research Repeatability

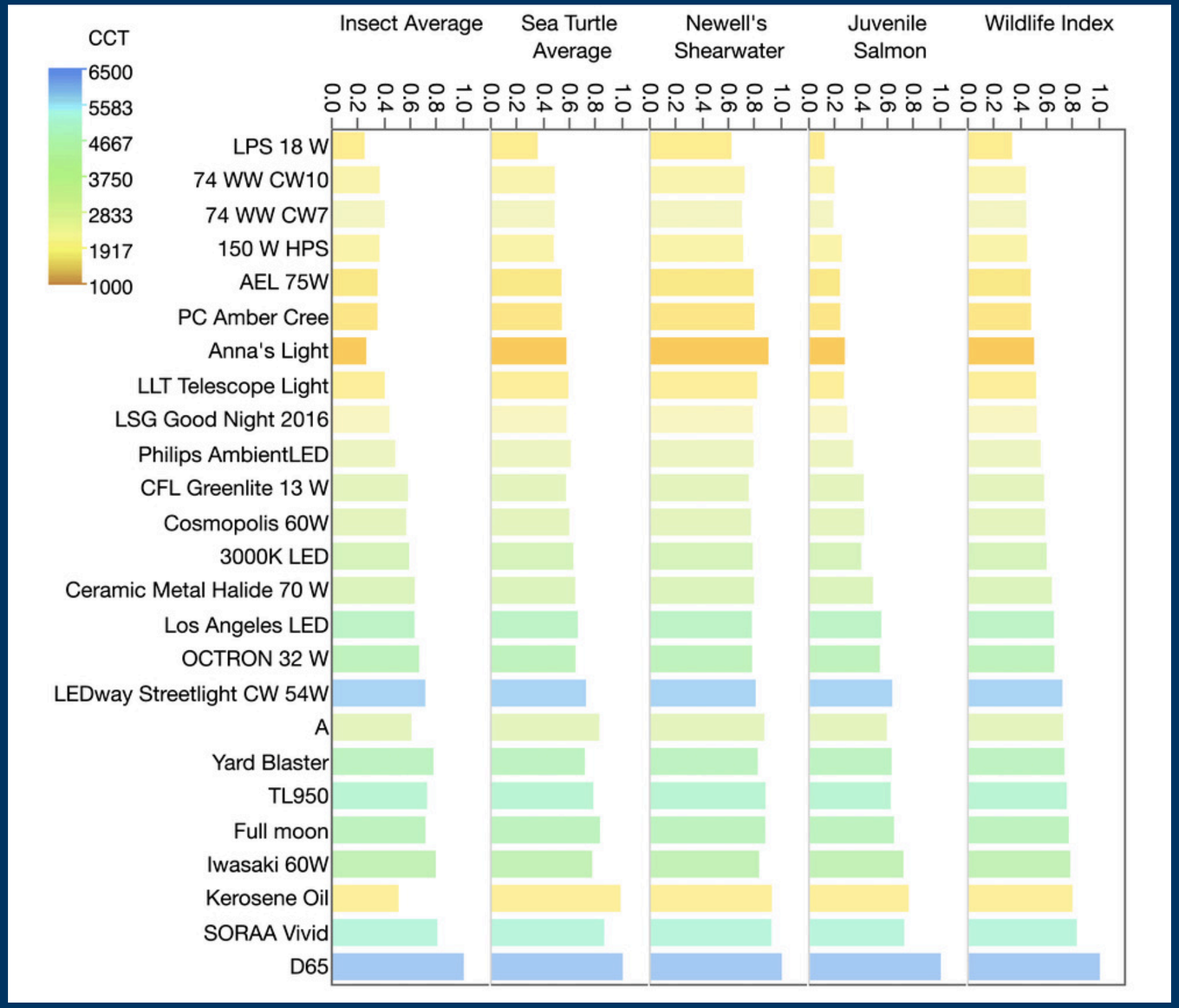
- A databank of similar studies would help too, as long as they're comparable
  - Background and stimulus SPD at the eye should be characterized
  - Available in plaintext or CSV on a relevant website (figshare, github, etc.)
  - α-opic photoreceptor responses should be computed as well
  - Duration and other details of protocol provided
  - Calibration details
  - For more guidelines, see *Spitschan, Manuel, et al. "How to report light exposure in human chronobiology and sleep research experiments." Clocks & sleep 1.3 (2019): 280-289.*

Translating research

- We must use rich descriptions of research conditions when comparing lab conditions to application: e.g., for non-visual effects, glare, flicker, etc.
  - Eyes dilated? Full field of view or a narrow one?
  - Contrast levels in the scene?
  - Light history and time of day (or circadian time)
  - Age, gender, time of year, etc.

Databank: Ranking and Learning

- Having a well-curated set of luminaires has value beyond replicating research
  - Identify light sources by type (match a measurement to database)
  - Quantifying effective luminaire age (by spectral shift)
- Rank effectiveness of filters (eyewear)
- Calibration limits of sensors (RGB cameras and light sensing)
- Understand prevalence of source types in daily life
- Weighting *multiple* factors



Weighting example: Ecological impacts
(with Travis Longcore)

With a database of SPDs, we can use wildlife action spectra to rank impacts of outdoor lighting

fluxometer.com/ecological

Longcore, T., Rodríguez, A., Witherington, B., Penniman, J. F., Herf, L., & Herf, M. (2018). Rapid assessment of lamp spectrum to quantify ecological effects of light at night. *Journal of Experimental Zoology Part A: Ecological and Integrative Physiology*, *329*(8-9), 511-521.

Time series and geography

- When we try to understand “what is twilight?” or “what is a cloudy day?” we have only a few datasets to use. Are we relying on measurements from a specific day?
    - More geographic diversity in our data is needed, with day-to-day *variance*.
- We don’t fully understand how simple variation in weather conditions affects our behavior and mood.
    - For instance, Tietjen-Kripke 1994 says that suicides go up 70% after 10 days of bad weather
    - We could collect more statistics about how spectrum changes over time?

Some initial efforts…

- TM-30 includes a database of >300 SPDs and many surfaces
- We publish data for many screens, lamps and filters (CC license) at fluxometer.com/rainbow/
- LSPDD.com includes 254 sources
- NGDC/NOAA data (captured for satellite images) at https://www.ngdc.noaa.gov/eog/spectra.html
- Several researchers publish SPDs as supplemental material
- Many proprietary databases

Unified Data & Quality

- A single place to unify all this information, from research to common application is needed
- Meters can go out of calibration, and they vary in capability (e.g., spectral resolution). These effects can be explained with proper documentation.
- Curation may be important (more is not *always* better)
  - Rare vs. common sources for daily use
  - Sources used in high-impact papers, with conditions explained

Thank you

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