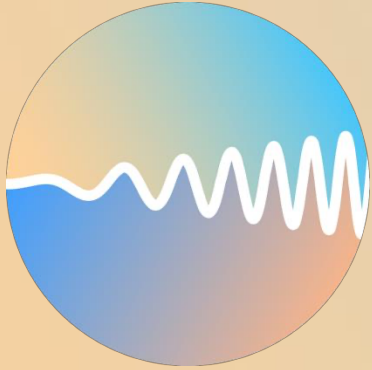




CHRONOBIOLOGY & HEALTH
TRANSLATIONAL SENSORY &
CIRCADIAN NEUROSCIENCE



Open and reproducible analysis of light exposure and visual experience data

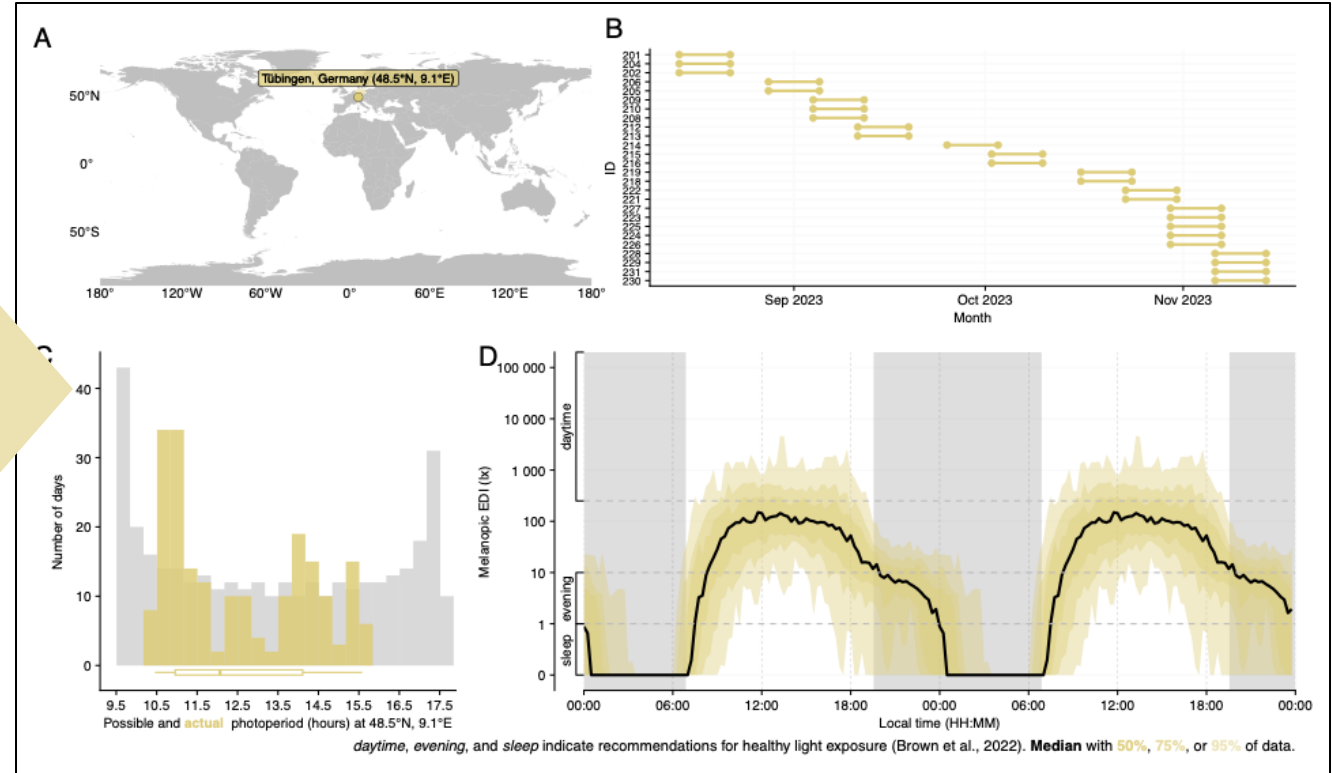
Dr. Johannes Zauner

Or: How to get from...

...this...

...to this

1	Patetime, Temperature, Activity Index, Photopic lux, Melanopic EDI, L-Cone EDI, M-Cone EDI, S-Cone EDI, Rhodopic EDI, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 4
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6	13:49:39 22/11/23, Disabled, Disabled, 116.2107162475586, 107.62003326416016, 115.21658325195312, 114.6249008178711, 114.45120239257812, 108.79608154296875, 0, 0.0000384295
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Funding Statement



Co-funded by the
European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EURAMET. Neither the European Union nor the granting authority can be held responsible for them.

**METROLOGY
PARTNERSHIP**



The project (22NRM05 MeLiDos) has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.



LightLogR's development is supported by the Wellcome Trust (www.wellcome.org), 226787/2/22/Z.

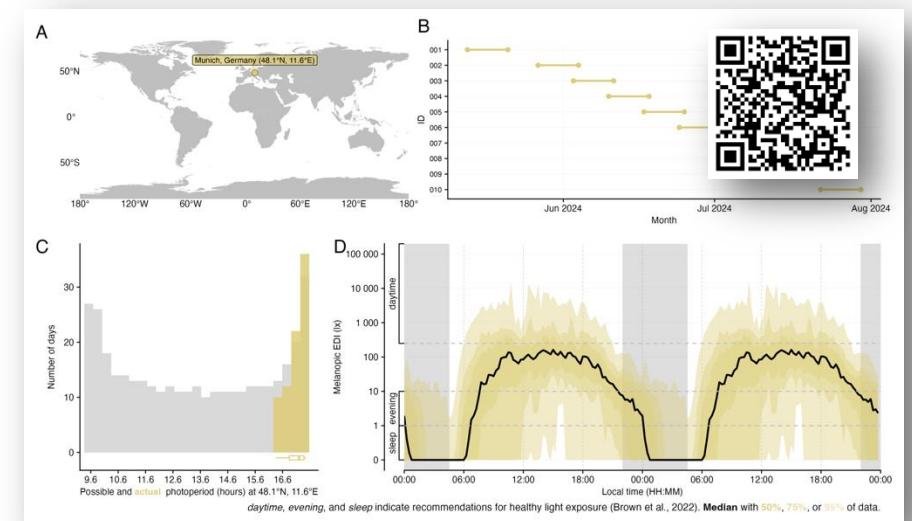
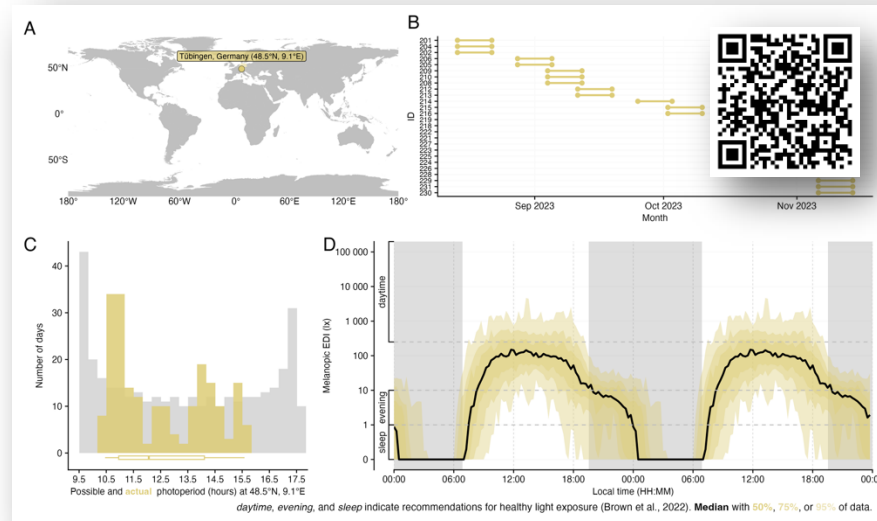
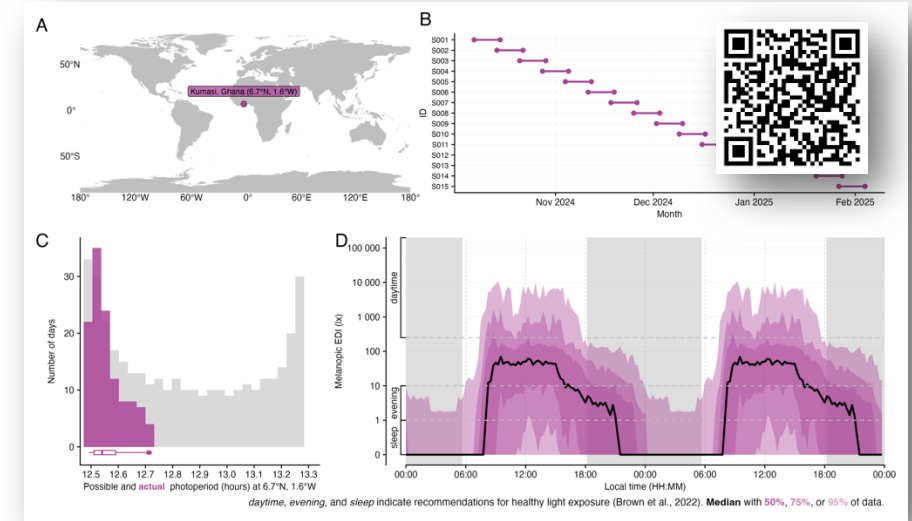
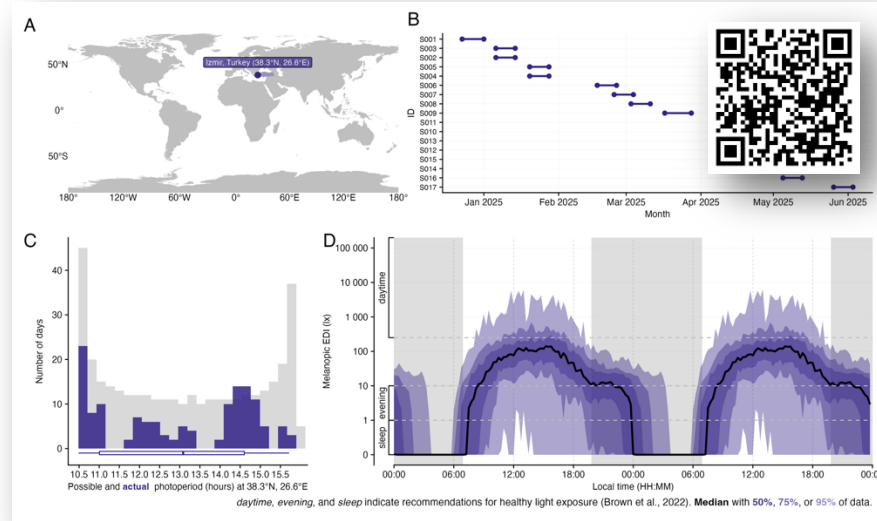


LightLogR's development is supported by the GLEE project (Global Light Exposure Engine, www.visualdiet.org) funded by Reality Labs Research.

Many research questions can only be tackled if data is openly available: Share anonymous research data to create the maximum impact!

„Among articles stating that data was available upon request, only 17% shared data upon request.“

Hussey, Ian (2025)
Data is not available upon request
Meta-Psychology DOI:
10.15626/mp.2023.4008



Laboratory experiments with fixed light settings are great for mechanistic insights, but real-world light exposure patterns are essential going forward

Stationary measurements:



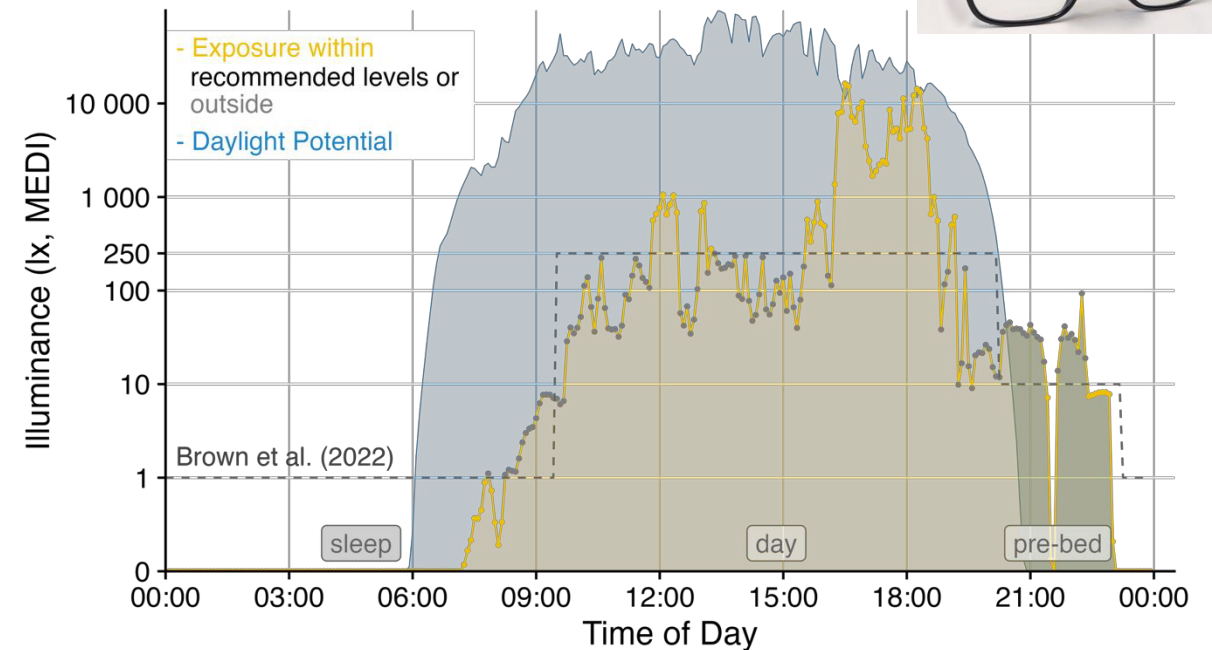
α -opic equivalent daylight (D65) illuminance³

Scene 1

Melanopsin (MEDI; lux)

241

Wearable data:

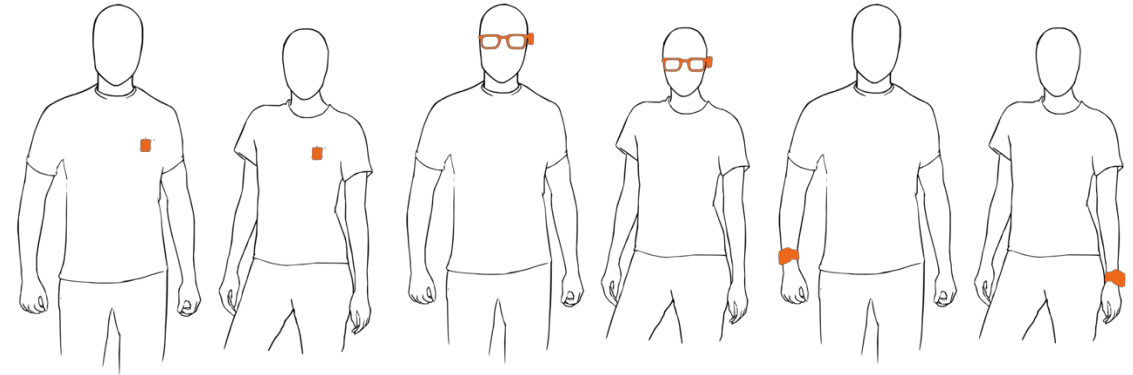


Spot Measurements
(few datapoints, per setting)

Time Series
(MB/GB of data, per participant)

Wearable light logging as a methodology lacks standard approaches, thus compromising the comparability of research from different laboratories

- 50+ wearable devices on the market / in scientific use
- No common set of output quantities / units
- No or very limited metadata
- No standard output format (file format)
- Time stamp / Time zone mess
- Dealing with gaps in the data
- A metaverse of metrics for light exposure

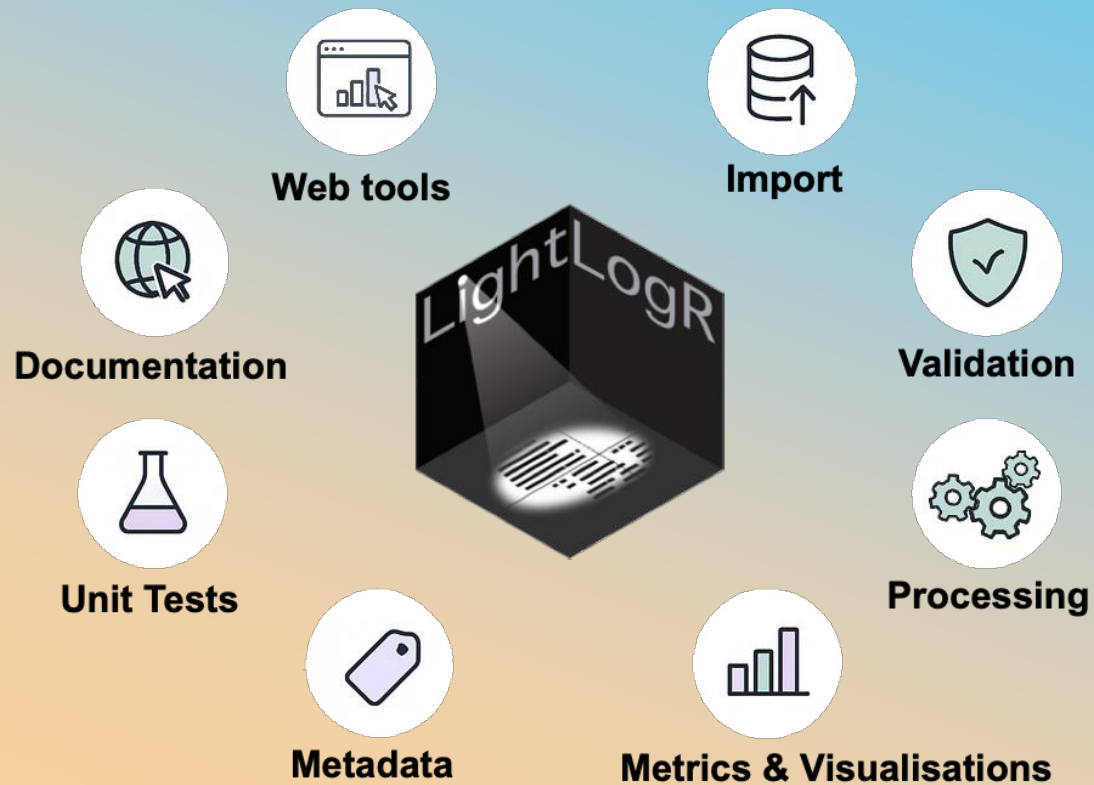


Illustrations: Max Dobberkau (MPI for Biological Cybernetics)

>> Solving these topics on a by-lab level is wasted research time!

LightLogR is a one-stop-shop for dealing with data from wearable devices

LightLogR: end-to-end framework for data from wearable light loggers and optical radiation dosimeters



```
install.packages(„LightLogR“) # R >= v 4.3  
library(LightLogR)
```

What to keep in mind

LightLogR is...

- a feature-rich analysis package for R statistical software, developed for time-series data from wearables
- a framework to prepare and transform data for formal analysis
- deterministic
- purposefully diverse about inputs and outputs (e.g., metrics)
- opinionated
- complaining whenever it can

... and is not

- feature complete
- a statistical method for inference
- probabilistic
- a substitute to good study design and data collection (garbage in – garbage out)
- a replacement for a theoretical basis on the topics, or critical thinking
- without danger to calculate absolute nonsense
- an imputation tool to guess missing data

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



LightLogR 0.3.4 Reference Articles Changelog

LightLogR

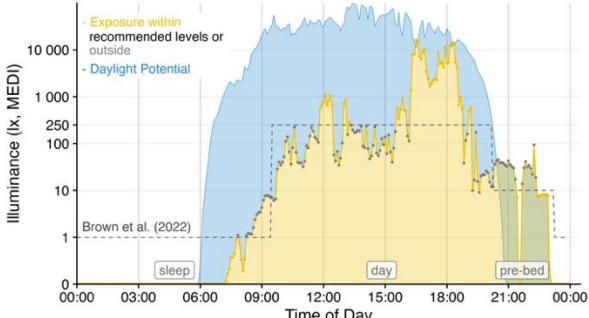
Personalized luminous exposure data is progressively gaining importance in various sectors, including research, occupational affairs, and fitness tracking. Data are collected through a proliferating selection of wearable loggers and dosimeters, varying in size, shape, functionality, and output format. Despite or maybe because of numerous use cases, the field lacks a unified framework for collecting, validating, and analyzing the accumulated data. This issue increases the time and expertise necessary to handle such data and also compromises the FAIRness (Findability, Accessibility, Interoperability, Reusability) of the results, especially in meta-analyses.



Links
[Browse source code](#)
[Report a bug](#)

License
[Full license](#)
GPL (>= 3)

Citation
[Citing LightLogR](#)



Light logger data can powerfully convey insights into personal light exposure

LightLogR is a package under development as part of the [MeLIDos](#) project to address these issues. The package aims to provide tools for:

- Generation of data and metadata files
- Conversion of popular file formats

LightLogR 0.3.4 Reference Articles Changelog

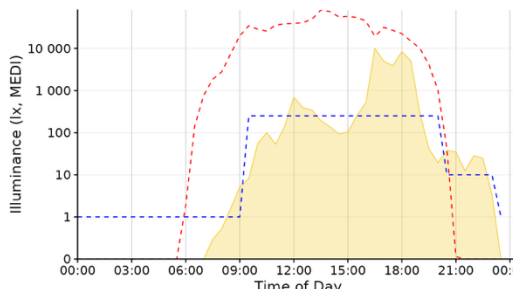
```
aggregate_Datetime2 <- function(...) {  
  aggregate_Datetime(...) %>% #aggregate the data  
  select(-Reference.Brown) %>% #remove the rounded  
  Brown2reference(Brown.rec.colname = Reference.Brown) #recalculate the brown ti  
}
```

Data aggregation

With the new aggregate function, let us taste some variants:

None 1 Minute 5 Minutes **30 Minutes** 1 Hour

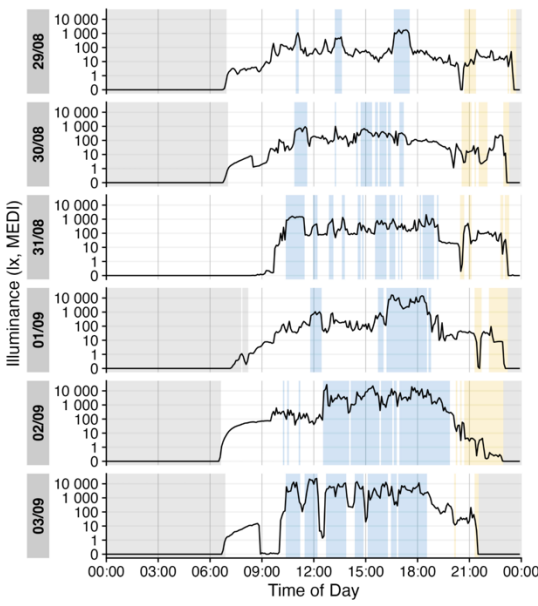
```
dataset.LL.partial %>% aggregate_Datetime2(unit = "30 mins") %>%  
gg_day(facetting = FALSE, geom = "ribbon", alpha = 0.25, size = 0.25,  
fill = "#EFC000", color = "#EFC000") + #base plot  
solar.reference + brown.reference + scale.correction
```



LightLogR 0.9.2 Reference Articles Changelog

Durations, States and Clusters

Source: [vignettes/articles/states.Rmd](#)



Following recommendations during the

- day
- evening
- night

Creating, adding, extracting, and visualizing states in the time series collected through wearable devices is essential to give context to light exposure data and related measurements. **States**, in this case, are defined as logical, categorical, binned, or ordered variables, that exist somewhere

LightLogR is developed as a community-driven open-source project with a permissive license, continuous integration, and continuous deployment



- Hosted on GitHub
- Open Source
- MIT Licence
- Inclusive development
- Issue tracking
- Continuous Integration
- **888 Unit tests** (07/2025) secure stable functionality

tscnlab / LightLogR

Code Issues 1 Pull requests Discussions Actions Projects Security 2 Insights Settings

LightLogR (Public) Edit Pins Watch 0 Fork 2 Starred 13

main 6 Branches 12 Tags Go to file Add file Code

JZauner Merge pull request #62 from tscnlab/desc-cosmetics ab29a64 · last month 478 Commits

.github	changing github links to documentation links	6 months ago
R	small fixes for CRAN release	last month
data-raw	new dataset	2 months ago
data	removed LYS datafile, added sample.data.irregular dataset	last month
inst	Update CITATION	last month
man	small fixes for CRAN release	last month
paper	updated citations	5 months ago
pkgdown/favicon	website updates	2 months ago
tests	new add_Date_col function	last month
vignettes	added the Datetime2Time function and adjusted articles f...	last month
.Rbuildignore	added and populated a CODE_OF_CONDUCT.md file	6 months ago
.gitignore	Updated gitignore	last year
CODE_OF_CONDUCT.md	added and populated a CODE_OF_CONDUCT.md file	6 months ago
CRAN-SUBMISSION	update general	last month
DESCRIPTION	Update DESCRIPTION	last month

About

R package for processing and analysing light logger and optical radiation dosimeter data

tscnlab.github.io/LightLogR/

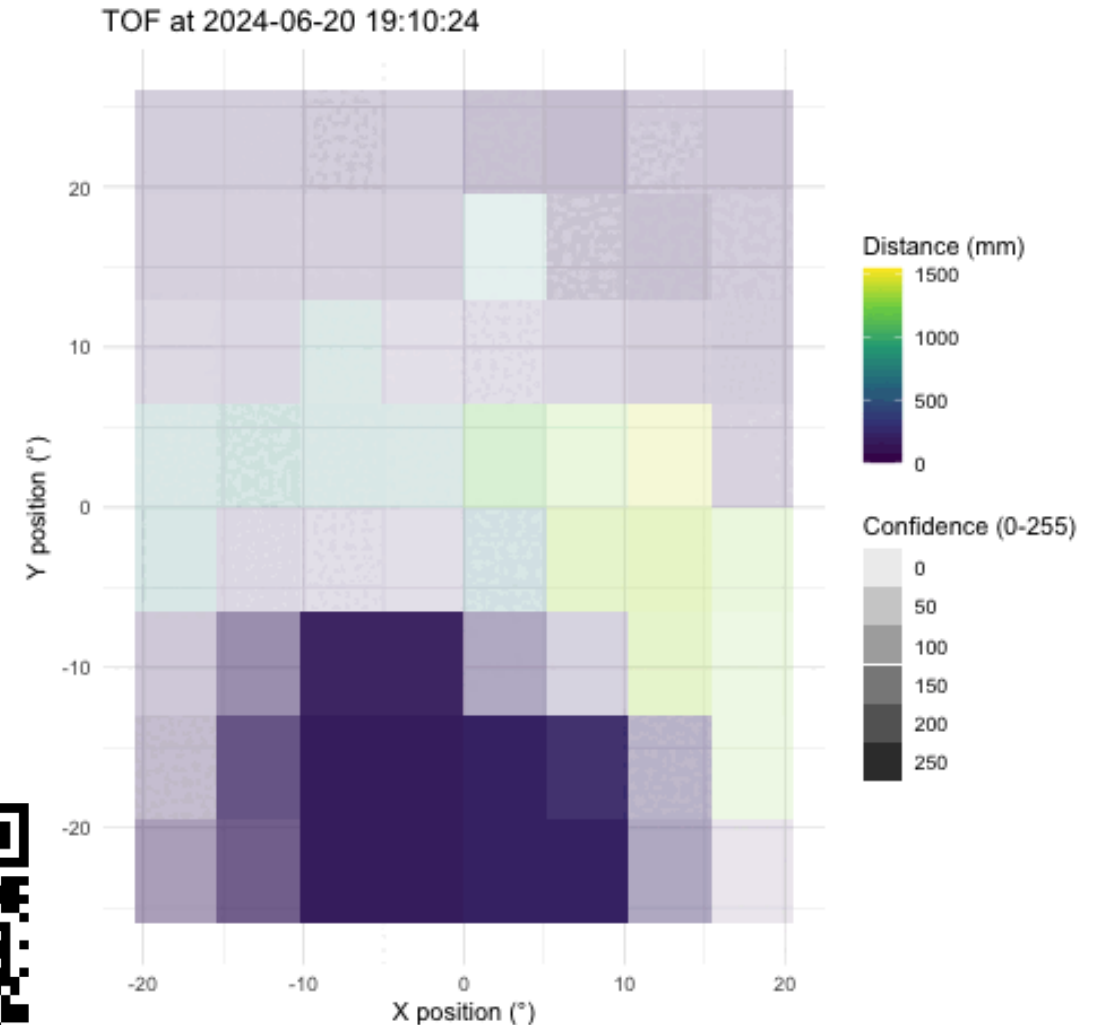
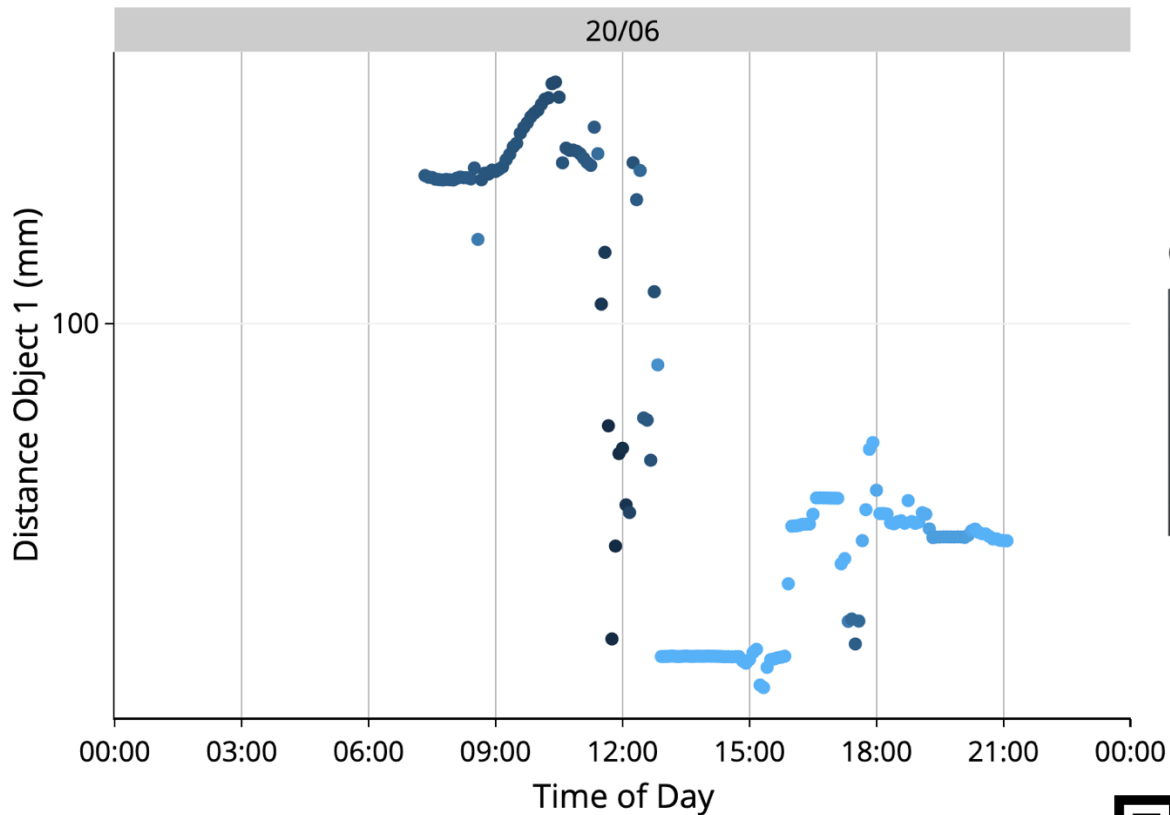
light wearable-devices time-series-analysis dosimetry rstats-package wearable-sensors

Readme Unknown, MIT licenses found Code of conduct Cite this repository Activity Custom properties 13 stars 0 watching 2 forks Report repository

Releases 12

v0.9.2 Sunrise Latest last month + 11 releases

LightLogR also works with other modalities of visual experience, such as distance and spectrum



Tutorial on distance, light, and spectrum:

https://tscnlab.github.io/ZaunerEtAl_JVis_2025/





Johannes Zauner



Steffen Hartmeyer



Manuel Spitschan



johannes.zauner@tum.de



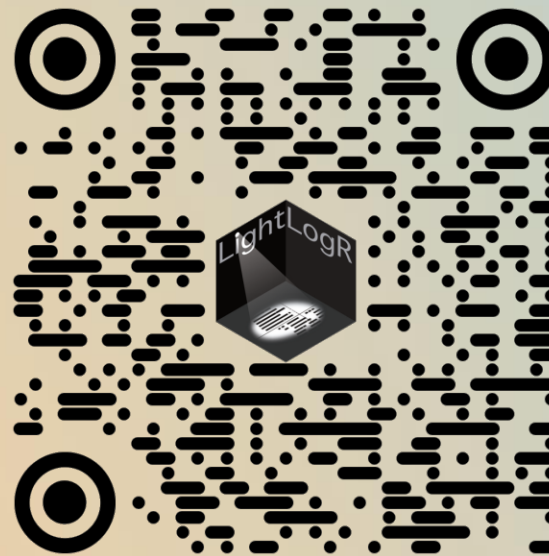
JZauner

LightLogR: Software for accessible and reproducible import, processing, visualization, and metrics of personal light exposure data

Join our LightLogR mailing list!

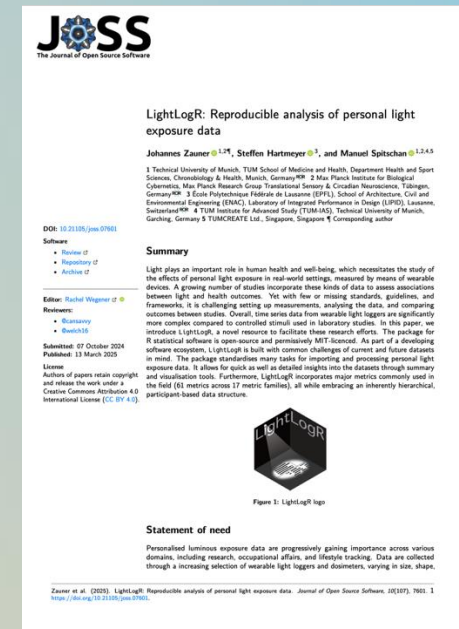
<https://lists.lrz.de/mailman/listinfo/lightlogr-users>

Software & Documentation



tscnlab.github.io/LightLogR/

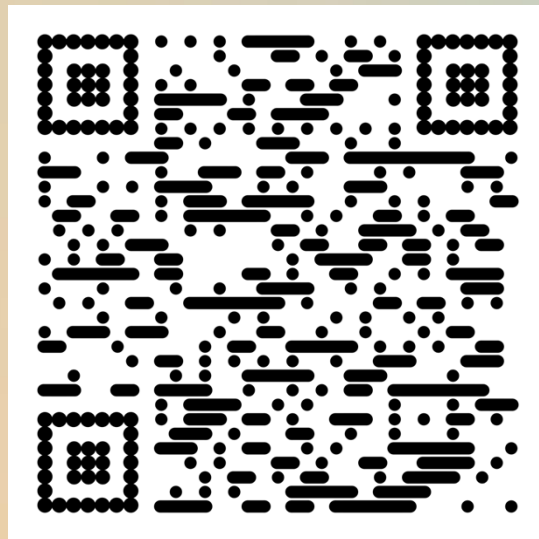
Paper



DOI: [10.21105/joss.07601](https://doi.org/10.21105/joss.07601)

You can live-test **LightLogR** on this page

https://tscnlab.github.io/LightLogR_webinar/



Some function showcases

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



At present, these are the devices we support in LightLogR:

- Actiwatch Spectrum
- ActLumus
- ActTrust
- Circadian Eye
- Clouclip
- DeLux
- GENEActiv with GGIR
- Kronowise
- LiDo
- LightWatcher
- LIMO
- LYS
- MotionWatch8
- nanoLambda
- OcuWEAR
- Speccky
- SpectraWear
- VEET

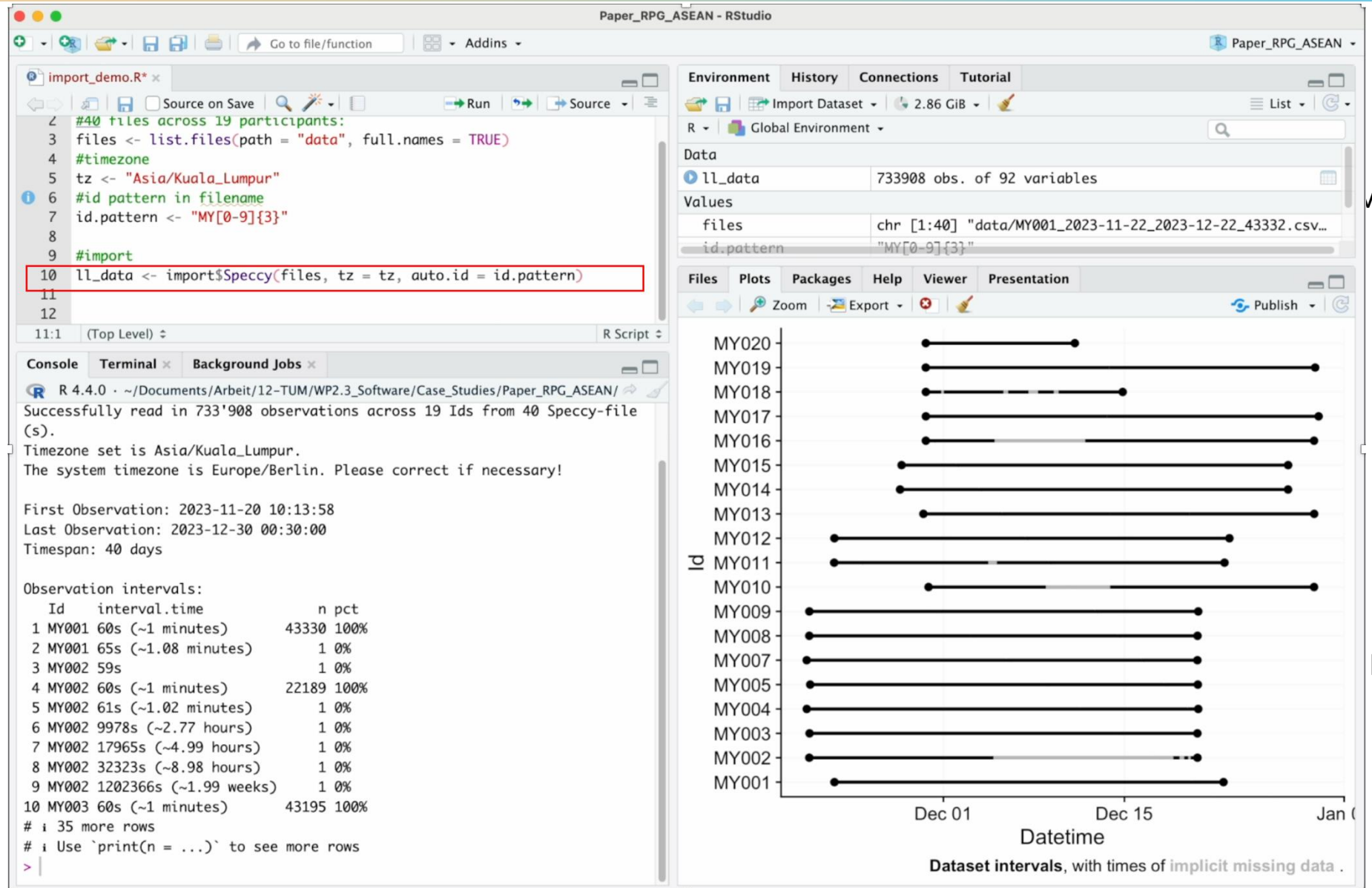
MY001_2023-11-22_2023-12-22_43332.csv
MY002_2023-11-20_2023-12-04_20512.csv
MY002_2023-12-18_2023-12-19_676.csv
MY002_2023-12-19_2023-12-19_432.csv
MY002_2023-12-20_2023-12-20_176.csv
MY002_2023-12-20_2023-12-20_400.csv
MY003_2023-11-20_2023-12-20_43196.csv
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MY005_2023-11-20_2023-12-20_43176.csv
MY007_2023-11-20_2023-12-20_43516.csv
MY008_2023-11-20_2023-12-20_43244.csv
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MY010_2023-12-13_2023-12-13_65.csv
MY010_2023-12-13_2023-12-29_22641.csv
MY011_2023-11-22_2023-12-04_17156.csv
MY011_2023-12-05_2023-12-22_25356.csv
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MY013_2023-11-29_2023-11-29_720.csv
MY013_2023-11-29_2023-11-30_1500.csv
MY013_2023-12-01_2023-12-04_5524.csv
MY013_2023-12-04_2023-12-10_8792.csv
MY013_2023-12-10_2023-12-13_4284.csv
MY013_2023-12-13_2023-12-13_36.csv
MY013_2023-12-13_2023-12-20_8740.csv
MY013_2023-12-20_2023-12-29_13904.csv
MY014_2023-11-27_2023-12-27_43212.csv
MY015_2023-11-27_2023-12-27_43056.csv
MY016_2023-11-29_2023-12-04_7656.csv
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MY017_2023-11-29_2023-12-13_20168.csv
MY017_2023-12-13_2023-12-30_23560.csv
MY018_2023-11-29_2023-11-30_1704.csv
MY018_2023-12-01_2023-12-05_6628.csv
MY018_2023-12-06_2023-12-07_2248.csv
MY018_2023-12-08_2023-12-09_1740.csv
MY018_2023-12-09_2023-12-14_7140.csv
MY019_2023-11-23_2023-12-13_202412.csv
MY019_2023-12-13_2023-12-29_22940.csv
MY020_2023-11-29_2023-12-11_16604.csv

```
1 patetime, Temperature, Activity Index, Photopic lux, Melanopic EDI, L-Cone EDI, M-Cone EDI, S-Cone EDI, Rhodopic EDI, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 445
2 13:45:39 22/11/23, Disabled, Disabled, 119.74858093261719, 109.33116912841797, 118.65250396728516, 117.75151824951172, 115.5701675415039, 118.88121032714844, 0, 0, 0.00003842953
3 13:46:39 22/11/23, Disabled, Disabled, 123.75494384765625, 113.59609985351562, 122.65340423583984, 121.81971740722656, 120.63529968261719, 115.0501937866211, 0, 0, 0.00004192313
4 13:47:39 22/11/23, Disabled, Disabled, 118.66667938232422, 109.10956573486328, 117.60900115966797, 116.87083435058594, 115.8132553100586, 110.47523498535156, 0, 0, 0.00003842953
5 13:48:39 22/11/23, Disabled, Disabled, 113.96721649169922, 102.23538970947266, 112.79206085205078, 111.78190612792969, 106.2637939453125, 104.31057739257812, 0, 0, 0.00003842953
6 13:49:39 22/11/23, Disabled, Disabled, 116.2107162475586, 107.62003326416016, 115.21658325195312, 114.6249008178711, 114.45120239257812, 108.79608154296875, 0, 0, 0.00003842953
7 13:50:39 22/11/23, Disabled, Disabled, 119.53792572021484, 109.59156036376953, 118.4554214477539, 117.6686539550781, 115.93230438232422, 111.047375824003906, 0, 0, 0.00003842953
8 13:51:39 22/11/23, Disabled, Disabled, 121.56615447998047, 108.7949447631836, 120.32823944091797, 119.12567138671875, 113.05644226074219, 111.02340698242188, 0, 0, 0.00003842953
9 13:52:39 22/11/23, Disabled, Disabled, 118.95539855957031, 106.43097686767578, 117.75745391845703, 116.54768371582031, 110.61883544921875, 108.61552429199219, 0, 0, 0.00003842953
10 13:53:39 22/11/23, Disabled, Disabled, 123.0753402709961, 113.14623260498047, 121.97101593017578, 121.2214126586914, 120.26903533935547, 114.5591812133789, 0, 0, 0.0000419231554
11 13:54:39 22/11/23, Disabled, Disabled, 64.04437255859375, 74.3553237915039, 64.18777465820312, 66.57548522949219, 83.06731414794922, 71.94395446777344, 0, 0, 0.00002096157792643
12 13:55:39 22/11/23, Disabled, Disabled, 162.0911407470703, 143.44773864746094, 160.82606506347656, 157.5943145751953, 150.6525421142578, 146.15122985839844, 0, 0, 0.0000524039393
13 13:56:39 22/11/23, Disabled, Disabled, 153.373046875, 130.5836639404297, 152.2213592529297, 147.51895141601562, 134.0523223876953, 134.21444702148438, 0, 0, 0.000048910345261295
14 13:57:39 22/11/23, Disabled, Disabled, 41.13190460205078, 33.95612335205078, 40.58906173706055, 39.611846923828125, 35.27802658081055, 35.25079345703125, 0, 0, 0.000013974383661
15 13:58:39 22/11/23, Disabled, Disabled, 96.41993713378906, 85.8476333618164, 95.60198211669922, 94.06383514404297, 88.98590087890625, 87.5854263305664, 0, 0, 0.00003144236446435
16 13:59:39 22/11/23, Disabled, Disabled, 97.81144714355469, 84.08356475830078, 96.89295959472656, 94.61765374758594, 86.39161682128006, 86.39161682128006, 0, 0, 0.00003144236446435
17 14:00:39 22/11/23, Disabled, Disabled, 71.06234741210938, 54.18647003173828, 70.98433685302734, 65.62789154052734, 52.26713562011719, 56.65913391113281, 0, 0, 0.00001746797958427
18 14:01:39 22/11/23, Disabled, Disabled, 405.96649169921875, 366.79010009756525, 406.09228515625, 392.6787414550781, 355.79364013671875, 373.08721923828125, 0, 0, 0.000502529204823
19 14:02:39 22/11/23, Disabled, Disabled, 34.46178436279297, 12.95722770609018, 33.77174758911133, 28.7644192626953, 17.725271224975586, 17.036073684692383, 0, 0, 0.000013974383661
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22 14:05:39 22/11/23, Disabled, Disabled, 22.03035545349121, 11.440658569335938, 21.71712303161621, 19.20822715792773, 13.50029087066504, 0, 0, 0.000020345311593
23 14:06:39 22/11/23, Disabled, Disabled, 47.92626190185547, 34.423458099365234, 47.88016128540039, 43.637882232666016, 28.450345993041992, 36.968536376953125, 0, 0, 0.0000264489061
24 14:07:39 22/11/23, Disabled, Disabled, 68.7338638305664, 36.28947448730469, 68.17916107177734, 59.335330963134766, 29.066492080688477, 42.13645535888677, 0, 0, 0.0000209615779264
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29 14:12:39 22/11/23, Disabled, Disabled, 27.49786376953125, 16.251840591430664, 27.473464965820312, 24.011146545041056, 11.755412101745605, 18.19711685180664, 0, 0, 0.00000698719
30 14:13:39 22/11/23, Disabled, Disabled, 25.129289627075195, 14.77726936340332, 25.10848617553711, 21.92048454284668, 10.552009582519531, 16.5624942779541, 0, 0, 0.0000069871918337
31 14:14:39 22/11/23, Disabled, Disabled, 25.922321319580078, 15.383077621459961, 25.88671875, 22.683242797851562, 10.934934616088867, 17.225414276123047, 0, 0, 0.0000069871918337
32 14:15:39 22/11/23, Disabled, Disabled, 25.962793350219727, 15.49109935760498, 25.915668487548828, 22.75974464416504, 12.86943435668945, 17.328824996948242, 0, 0, 0.00000698719
33 14:16:39 22/11/23, Disabled, Disabled, 28.135581970214844, 17.241683959960938, 28.09192657470703, 24.79483229614258, 12.585821151733398, 19.141693115234375, 0, 0, 0.00000698719
34 14:17:39 22/11/23, Disabled, Disabled, 15.178426742553711, 7.29591703414917, 15.330049514770508, 12.47077465057373, 4.343226989746094, 8.554973602294922, 0, 0, 0.00003493595916
35 14:18:39 22/11/23, Disabled, Disabled, 47.99697494506836, 27.52018928527832, 47.879669189453125, 41.756839752197266, 20.487483978271484, 30.980140686035156, 0, 0, 0.000013974383661
36 14:19:39 22/11/23, Disabled, Disabled, 66.08261108398438, 40.39484786987305, 65.77837371826172, 58.41614532470703, 32.33525085449219, 44.939918518066406, 0, 0, 0.000017467979584
37 14:20:39 22/11/23, Disabled, Disabled, 165.77066201171875, 108.27789306640625, 165.4759063720703, 147.80072012484375, 94.9402084350586, 117.58052062988281, 0, 0, 0.000045416745
38 14:21:39 22/11/23, Disabled, Disabled, 182.89869689941406, 105.8343276977539, 183.72976684570312, 156.29751586914062, 93.871623123291016, 0, 0, 0.0001187822684
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40 14:23:39 22/11/23, Disabled, Disabled, 184.84205627441406, 114.14643859863281, 184.0080108642578, 163.635389404297, 96.27821350097656, 126.9263916015625, 0, 0, 0.0000980334914
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42 14:25:39 22/11/23, Disabled, Disabled, 138.3342590320312, 88.79441833496094, 137.2710723876953, 124.23651123046875, 74.7827247314453, 98.25801086425781, 0, 0, 0.0000733655178
43 14:26:39 22/11/23, Disabled, Disabled, 84.3867416381836, 52.96669387817383, 83.65225982666016, 75.548828125, 43.644168853759766, 59.11064529418945, 0, 0, 0.00004541674570646137
44 14:27:39 22/11/23, Disabled, Disabled, 111.14132690429688, 75.573890668603516, 111.4519921575, 100.70221740205078, 65.59696064049219, 82.3307472798516, 0, 0, 0.0000768591077455
45 14:28:39 22/11/23, Disabled, Disabled, 37.03114318847656, 25.59709930419922, 36.63521957397461, 34.05867004394531, 21.544702529907227, 27.912580490112305, 0, 0, 0.000013974383661
46 14:29:39 22/11/23, Disabled, Disabled, 118.23494720458984, 64.11214440721484, 118.10794067382812, 100.84652709960938, 57.03404998779297, 73.72682189941406, 0, 0, 0.0000733655178
47 14:30:39 22/11/23, Disabled, Disabled, 632.1912231445312, 576.5641479492188, 630.2486572265625, 616.8340454101562, 556.5455322265625, 587.78265380085938, 0, 0, 0.000017881586651
48 14:31:39 22/11/23, Disabled, Disabled, 658.9392700195312, 583.1758422851562, 658.611328125, 634.5701293945312, 561.5537109375, 596.2244873046875, 0, 0, 0.0000524039393
49 14:32:39 22/11/23, Disabled, Disabled, 201.86306762695312, 191.9501190185547, 203.51126098632812, 195.19146728515625, 182.50148010253906, 193.03256225585938, 0, 0, 0.000020345311593
50 14:33:39 22/11/23, Disabled, Disabled, 812.8496704101562, 783.14697265625, 806.767626525, 813.1549682617188, 758.4000244140625, 793.430871679688, 0, 0, 0.00117392442189157
51 14:34:39 22/11/23, Disabled, Disabled, 1109.9521484375, 1079.1903076171875, 1106.679931460625, 1105.1982421875, 1096.1585693359375, 1084.4124755859375, 0, 0, 0.00187583795438212
52 14:35:39 22/11/23, Disabled, Disabled, 338.70220947265625, 317.2843017578125, 335.6307067871094, 337.01092529296875, 295.4957580566406, 323.98944091796875, 0, 0, 0.000435389694
```

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



script



variables

plots

console

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```
data |> has_gaps()
```

shows whether the dataset has gaps

```
has_gaps(data) # equal to above
```

country	year	cases	population
Afghanistan	1999	745	19987071
Afghanistan	2000	2666	20095360
Brazil	1999	31737	172006362
Brazil	2000	80488	174004898
China	1999	212258	1272015272
China	2000	216766	1280420583

variables

country	year	cases	population
Afghanistan	1999	745	19987071
Afghanistan	2000	2666	20095360
Brazil	1999	31737	172006362
Brazil	2000	80488	174004898
China	1999	212258	1272015272
China	2000	216766	1280420583

observations

country	year	cases	population
Afghanistan	99	75	19987071
Afghanistan	00	2666	20095360
Brazil	99	31737	172006362
Brazil	00	80488	174004898
China	99	212258	1272015272
China	00	216766	1280420583

values

Source: <https://r4ds.hadley.nz/data-tidy.html>

```
fun3(fun2(fun1(data))) # equal to below
```

```
data |> fun1() |> fun2() |> fun3() # %>% is another type of pipe
```

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```
data |> has_gaps()           # shows whether the dataset has gaps
```

```
data |> has_irregulars()    # shows whether the dataset has irregular intervals
```

```
data |> gap_finder()        # finds and extracts gaps
```

```
data |> gap_table(MEDI)     # summarizes the dataset per group and overall
```

Summary of available and missing data													
Variable: melanopic EDI													
	Data					Missing							
	Regular		Irregular	Range	Interval	Gaps				Implicit		Explicit	
	Time	%	n ^{1,2}	Time	Time	N	ø	Time	%	Time	%	Time	%
Overall	13w 4d 23h 6m 50s	94.0% ³	0	14w 4d 2h	10	5,900	25m 23s	6d 2h 53m 10s	6.0% ³	6d 2h 53m 10s	6.0% ³	0s	0.0% ³
201	5d 2h 50m 30s	85.3%	0	6d	10s	605	2m 6s	21h 9m 30s	14.7%	21h 9m 30s	14.7%	0s	0.0%
202	5d 21h 19m 40s	98.1%	0	6d	10s	97	1m 39s	2h 40m 20s	1.9%	2h 40m 20s	1.9%	0s	0.0%
204	5d 4h 20m 40s	86.4%	0	6d	10s	605	1m 57s	19h 39m 20s	13.6%	19h 39m 20s	13.6%	0s	0.0%
205	5d 8h 8m	89.0%	0	6d	10s	495	1m 55s	15h 53m	11.0%	15h 53m	11.0%	0s	0.0%

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```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime() # condense observation intervals into new bins
```

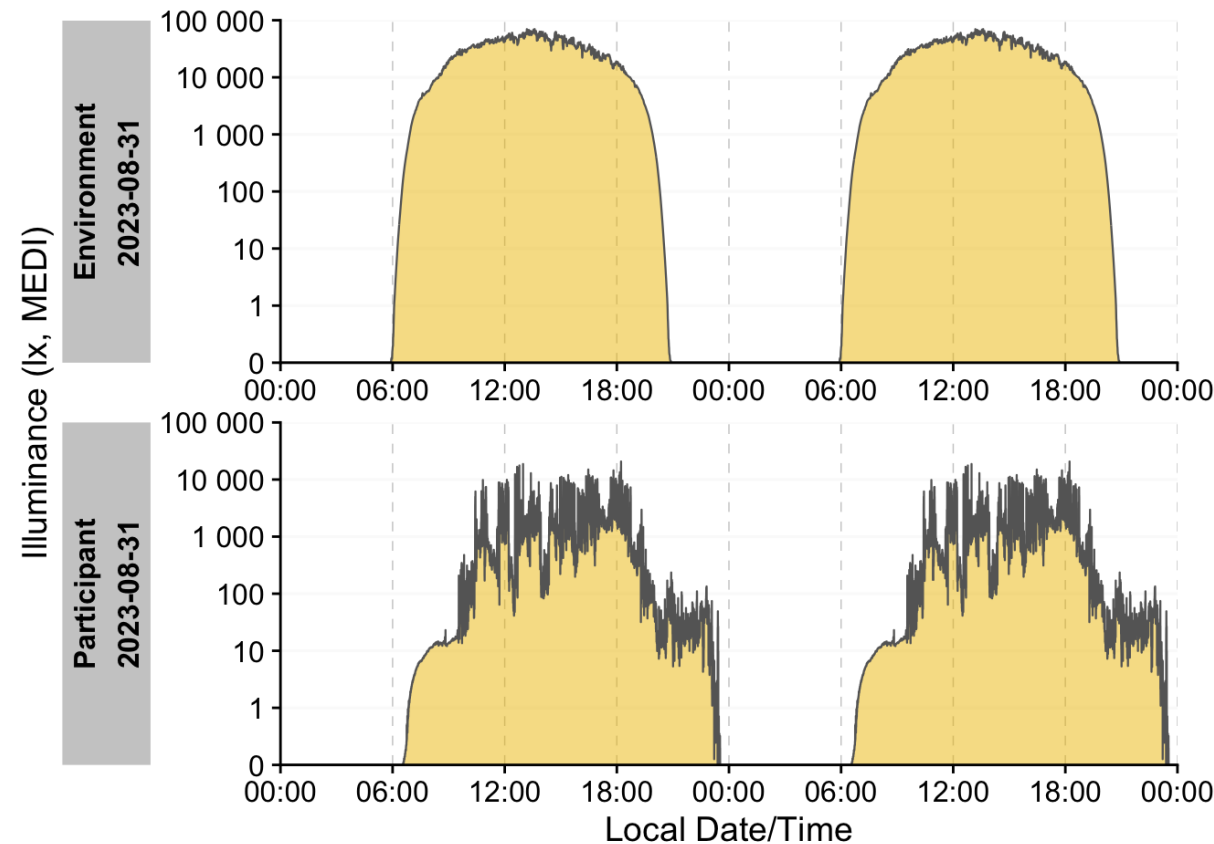
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler()
```

```
# makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“10 sec”) |>... # condense observation intervals into new bins
```



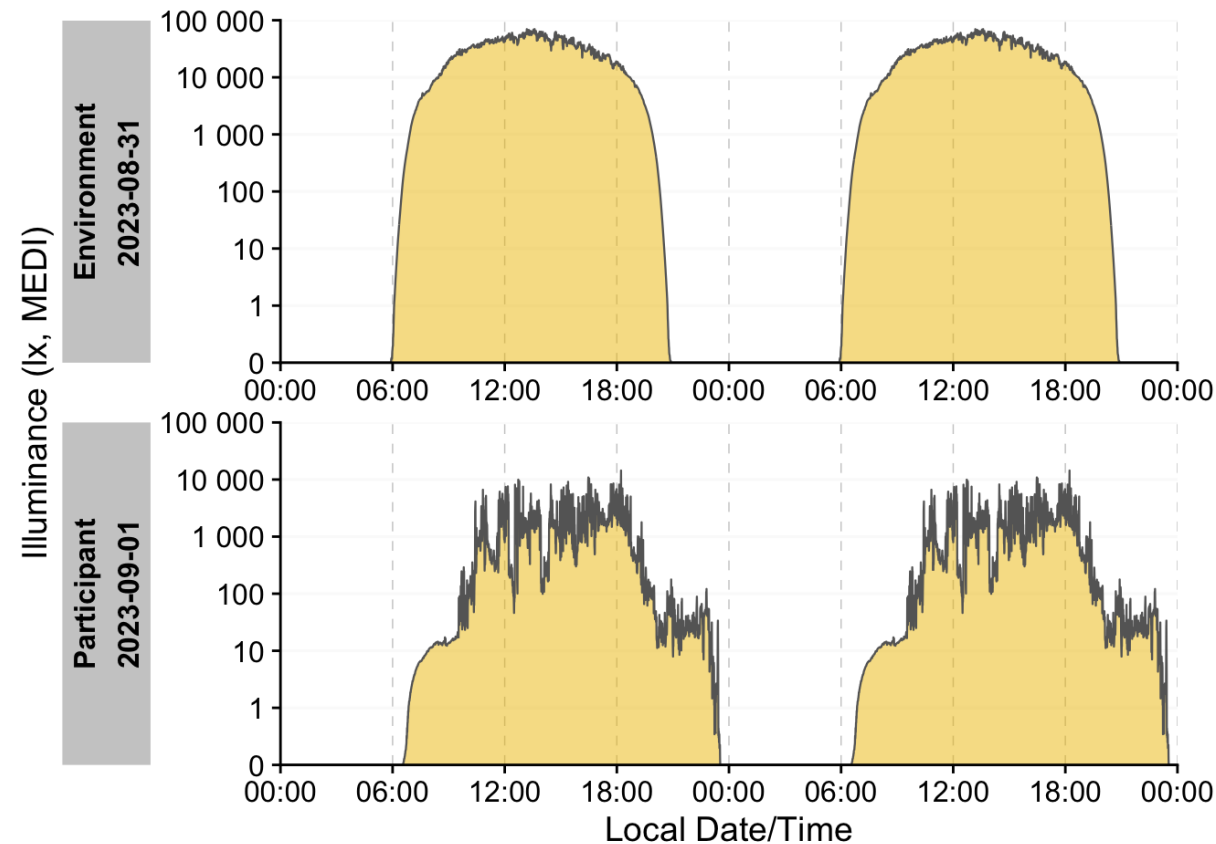
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler()
```

```
# makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“30 sec”) |>... # condense observation intervals into new bins
```

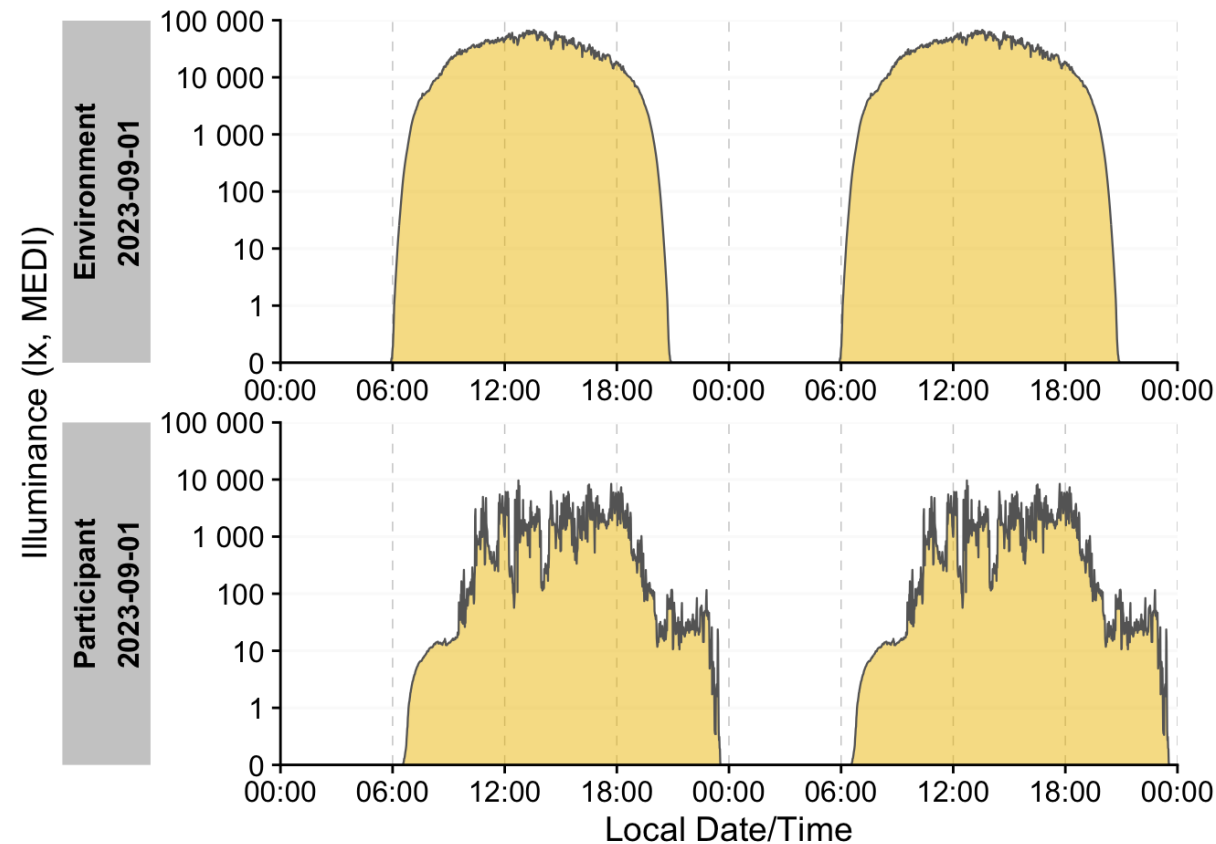


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```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“1 min”) |>... # condense observation intervals into new bins
```

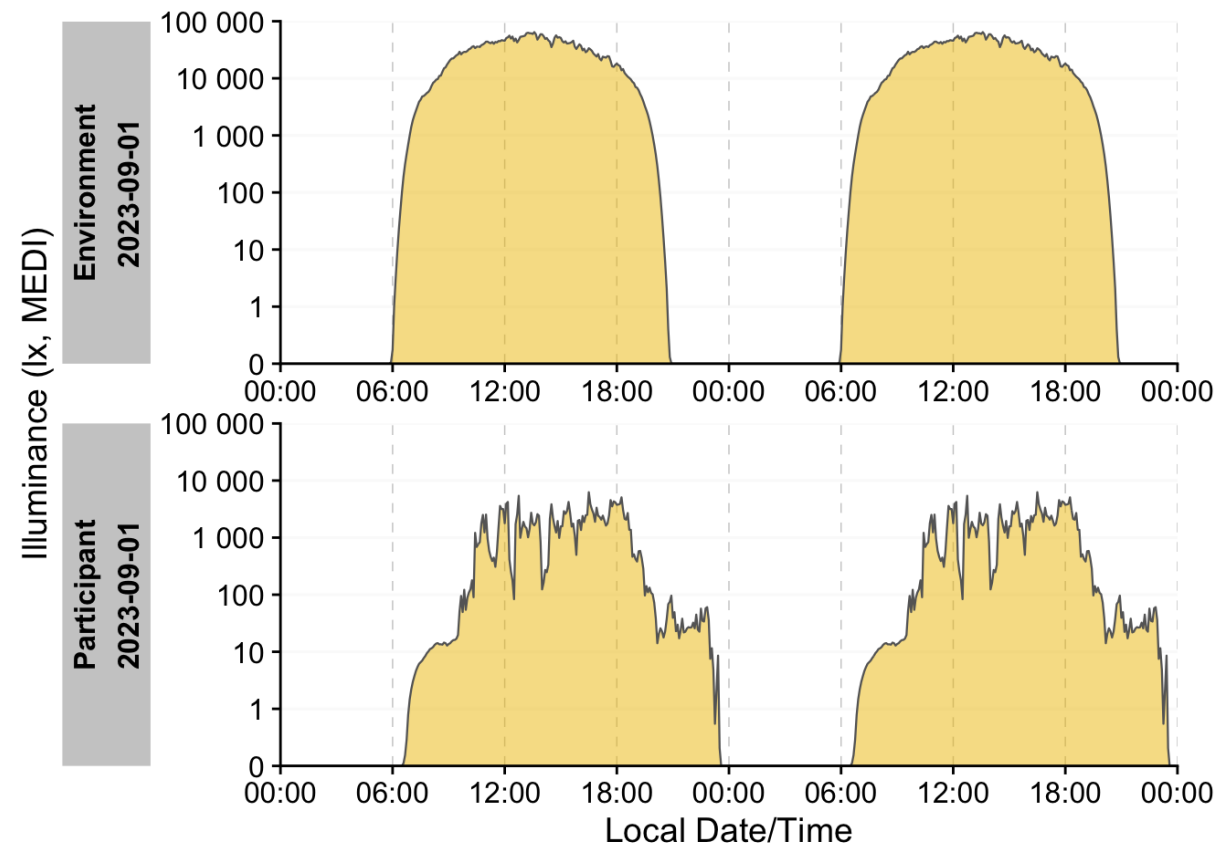


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```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“5 mins”) |>... # condense observation intervals into new bins
```

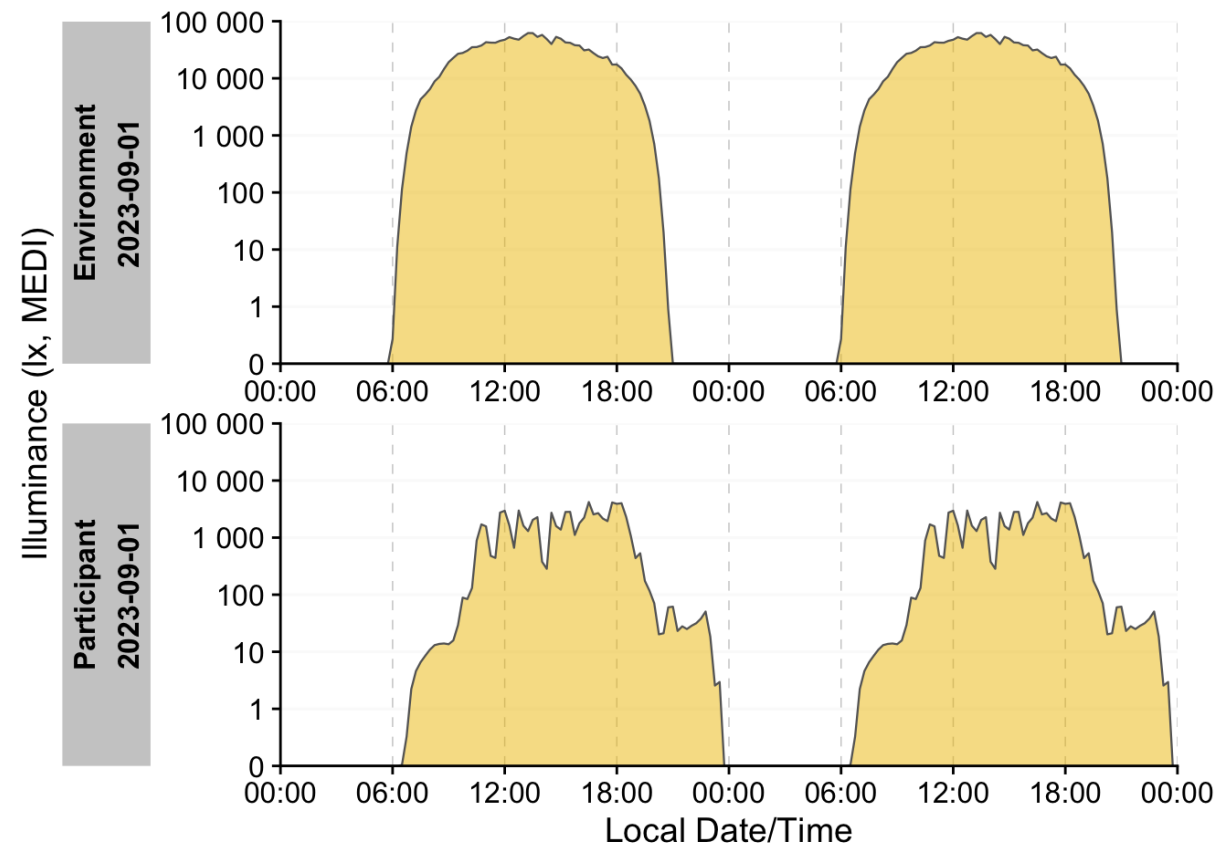


LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“15 mins”) |>...# condense observation intervals into new bins
```

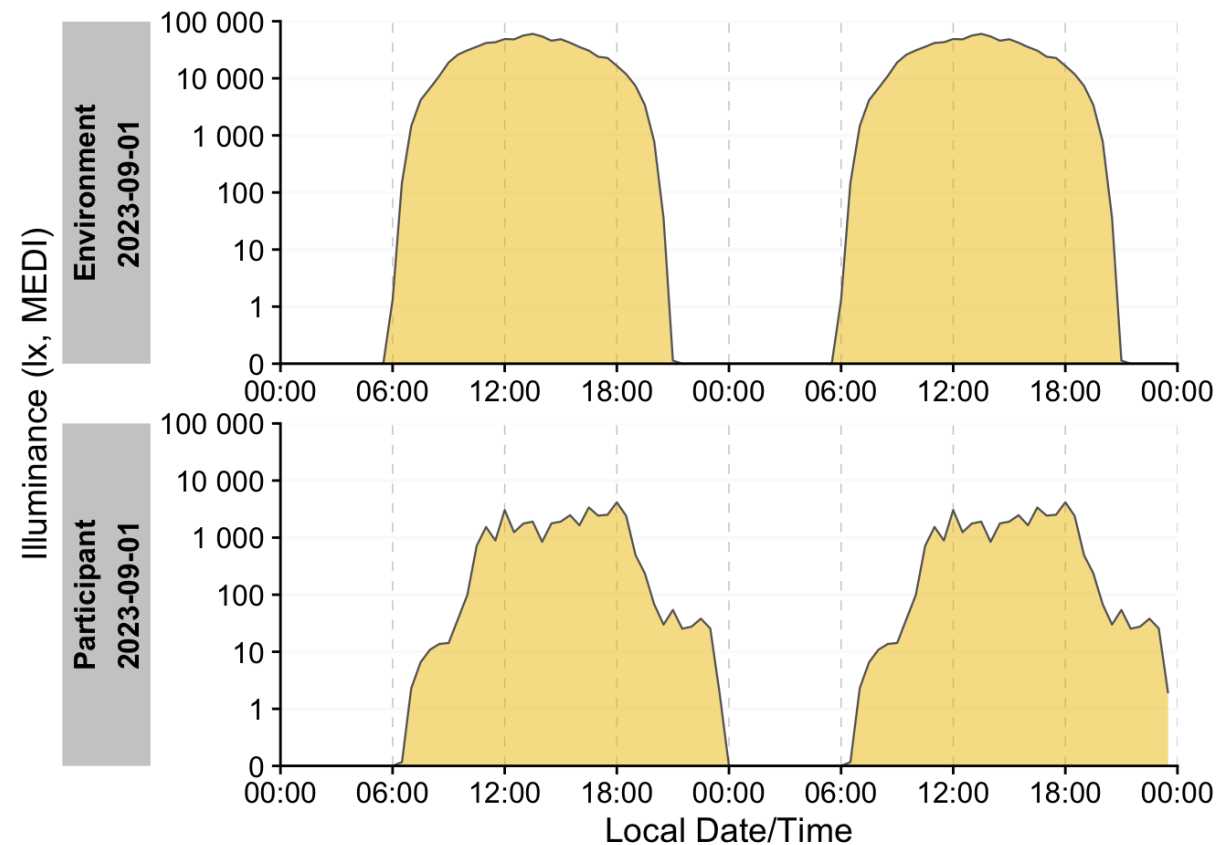


LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“30 mins”) |>...# condense observation intervals into new bins
```

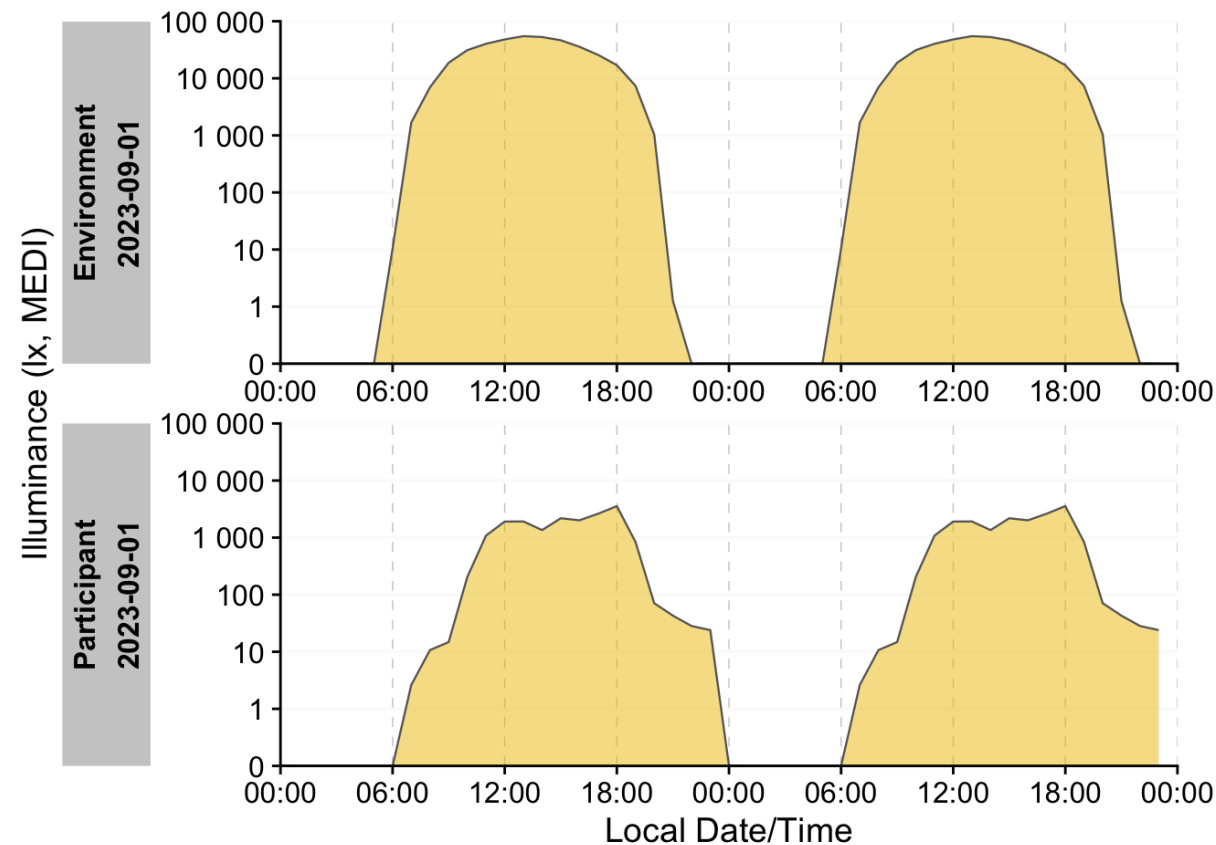


LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“1 hour”) |>... # condense observation intervals into new bins
```



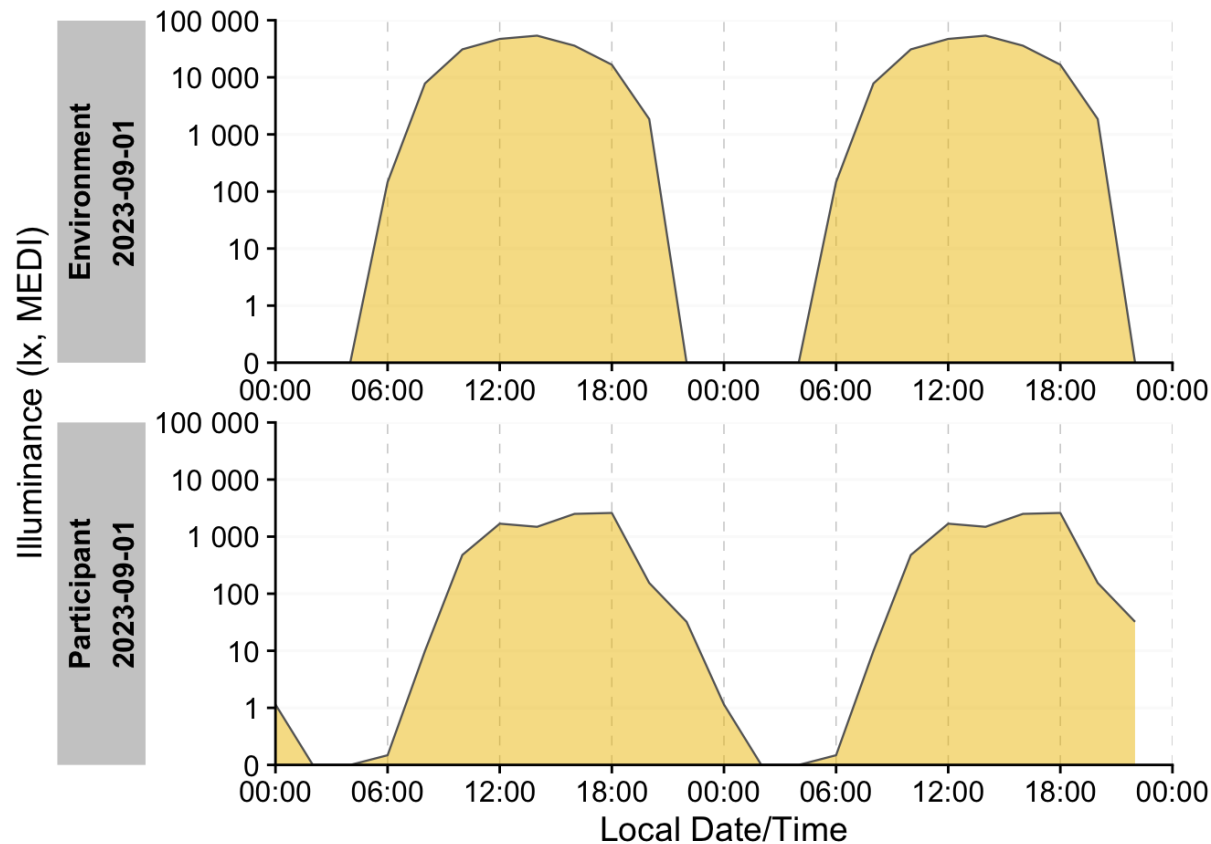
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler()
```

```
# makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime(“2 hours”) |>...# condense observation intervals into new bins
```



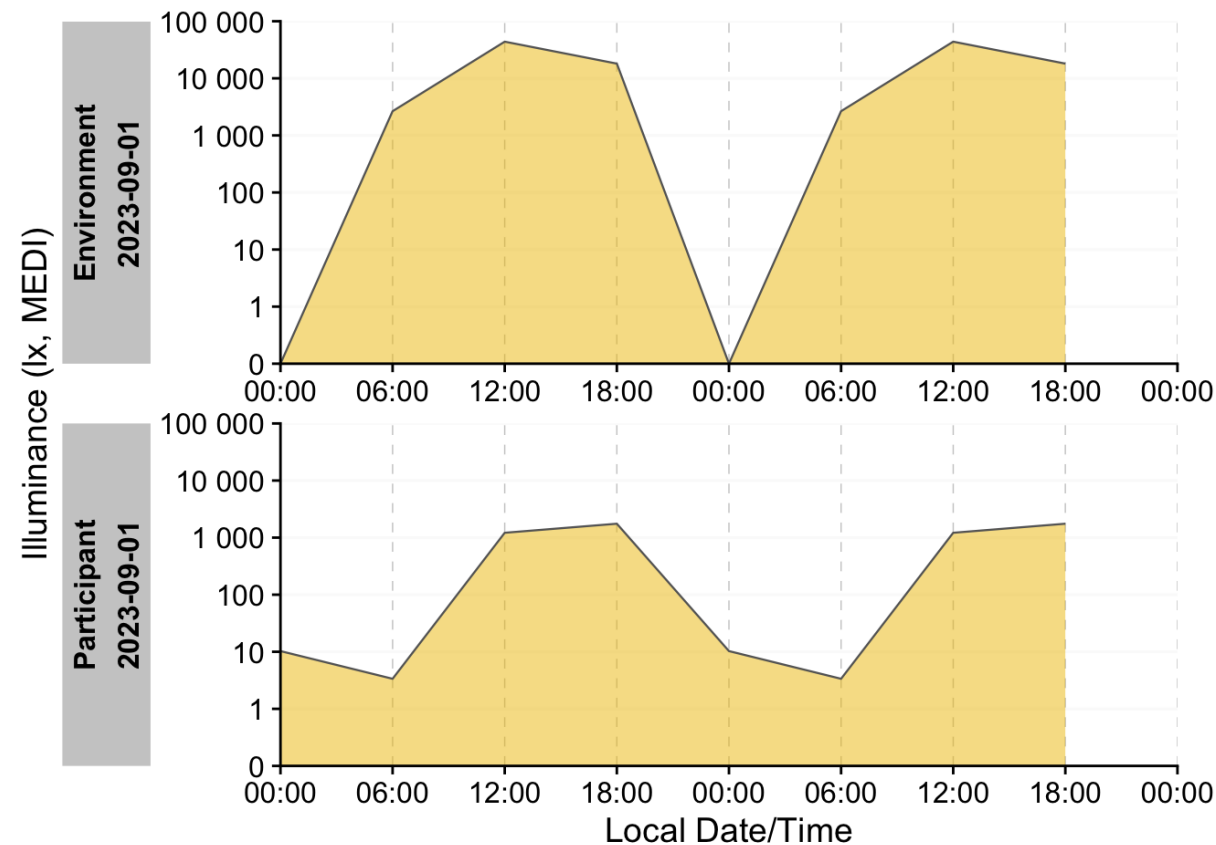
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler()
```

makes gaps explicit (i.e., into “empty” observations)

```
data |> aggregate_Datetime(“6 hours”) |>...# condense observation intervals into new bins
```



LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

```
data |> aggregate_Datetime() # condense observation intervals into new bins
```

```
data |> add_clusters() / extract_clusters() # find conditions that occur for a set duration
```

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gap_handler() # makes gaps explicit (i.e., into “empty” observations)
```

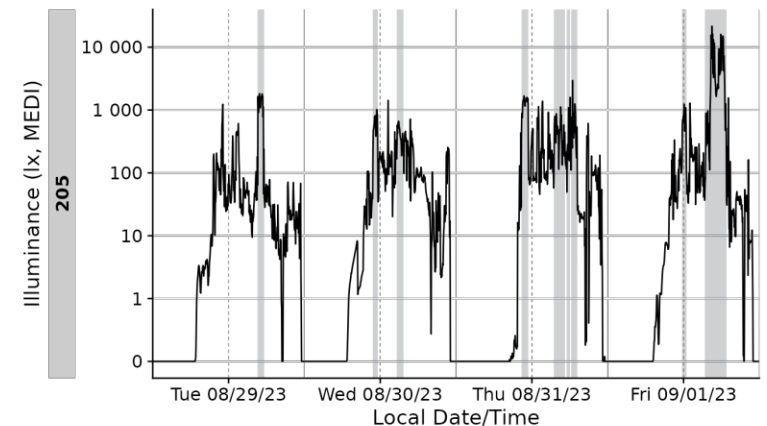
```
data |> aggregate_Datetime() # condense observation intervals into new bins
```

```
data |> # find conditions that occur for a set duration
  add_clusters(
    MEDI > 250,
    cluster.duration = „30 mins“, duration.type = „min“,
    interruption.duration = „3 mins“, interruption.type = „max“) |> ...
```

Clusters of 30 minutes or more above 250 lx
with interruptions of up to 3 minutes

Id	mean_start	mean_end	mean_epoch	mean_duration	total_duration	episodes
205	14:01:48	15:26:23	10s	5074s (~1.41 hours)	96410s (~1.12 days)	19

Clusters above 250 lx



LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> aggregate_Date()           # condense groups into one day (e.g., average)
```

```
data |> remove_partial_data()      # remove groups with too little data
```

```
data |> filter_Datetime() / _Date() / _Time() # trim data based on times or durations
```

```
data |> dst_change_handler()       # deal with daylight savings, if the device doesn't
```

```
data |> add_Date_col() / _Time_col() # convenience functions for grouping
```

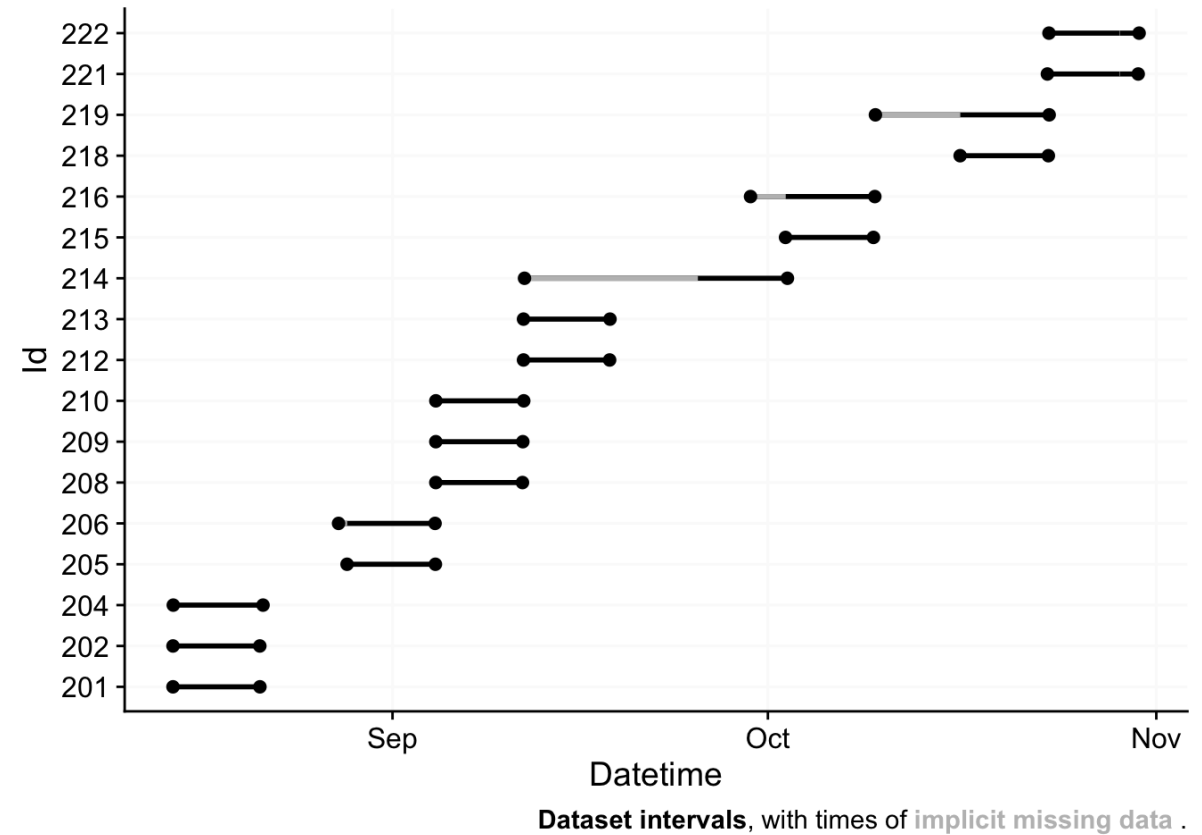
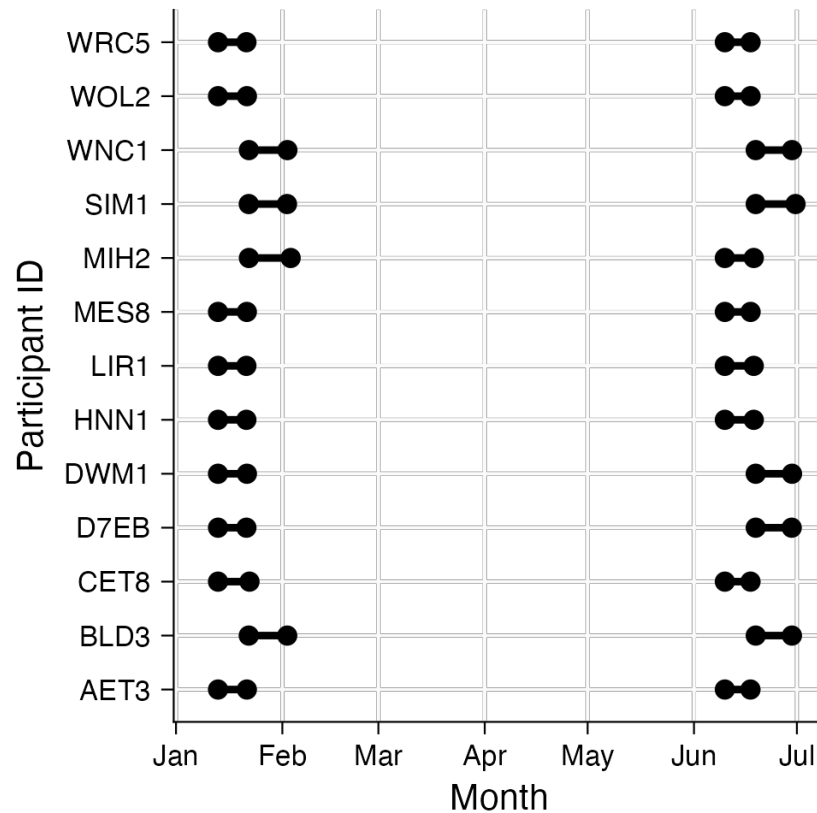
```
data |> add_photoperiod(coordinates = c(lat, long)) # add photoperiod information
```

```
data |> Brown_rec() / _check() / _cut() # work with Brown et al. 2022 recommendations
```

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gg_overview()
```

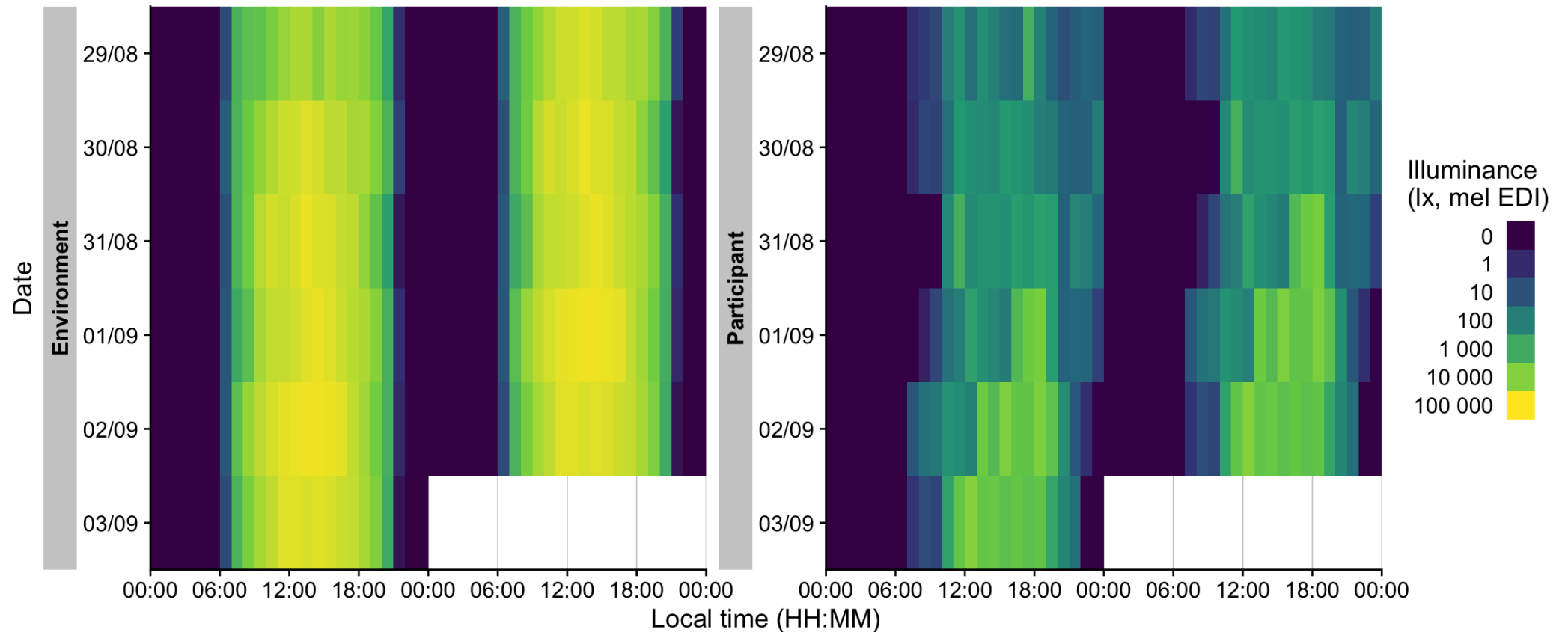


LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gg_heatmap(doubleplot = „next“)
```

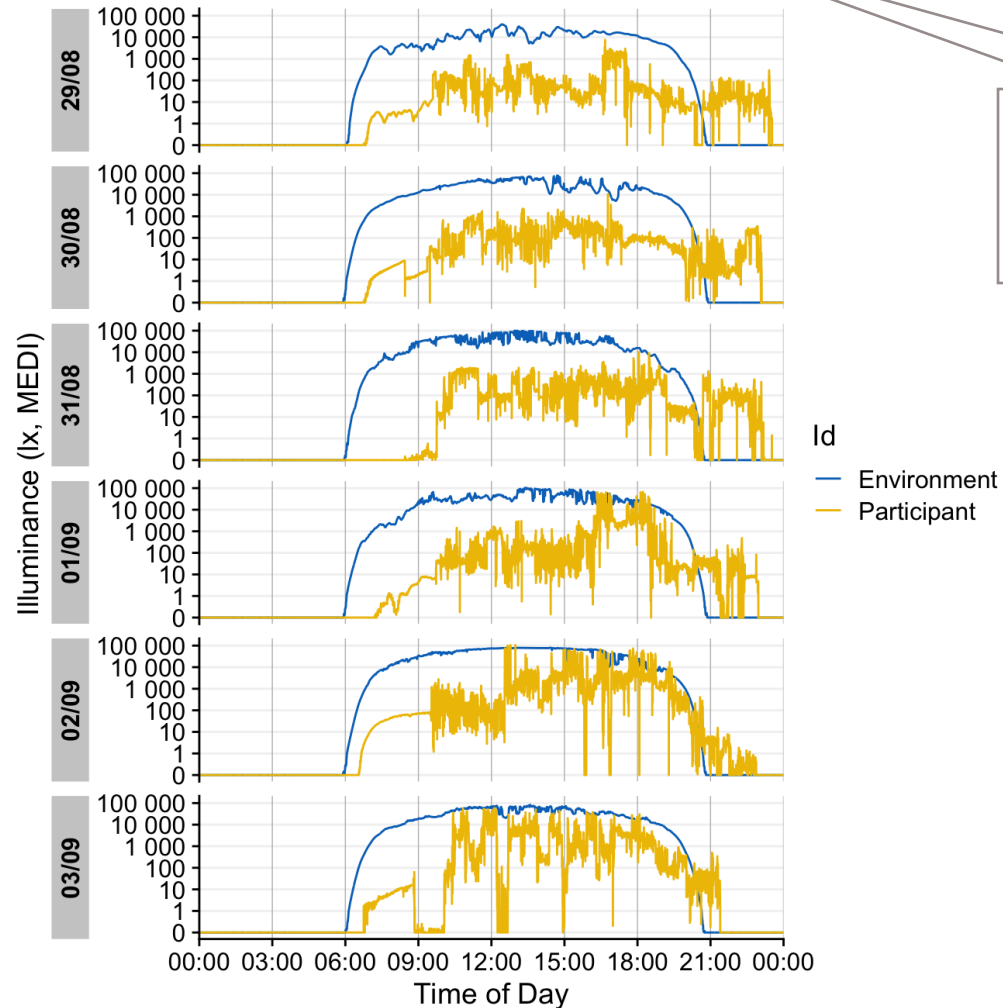
Shows the next day
to visualize patterns
across midnight



LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gg_day(aes_col = Id)
```

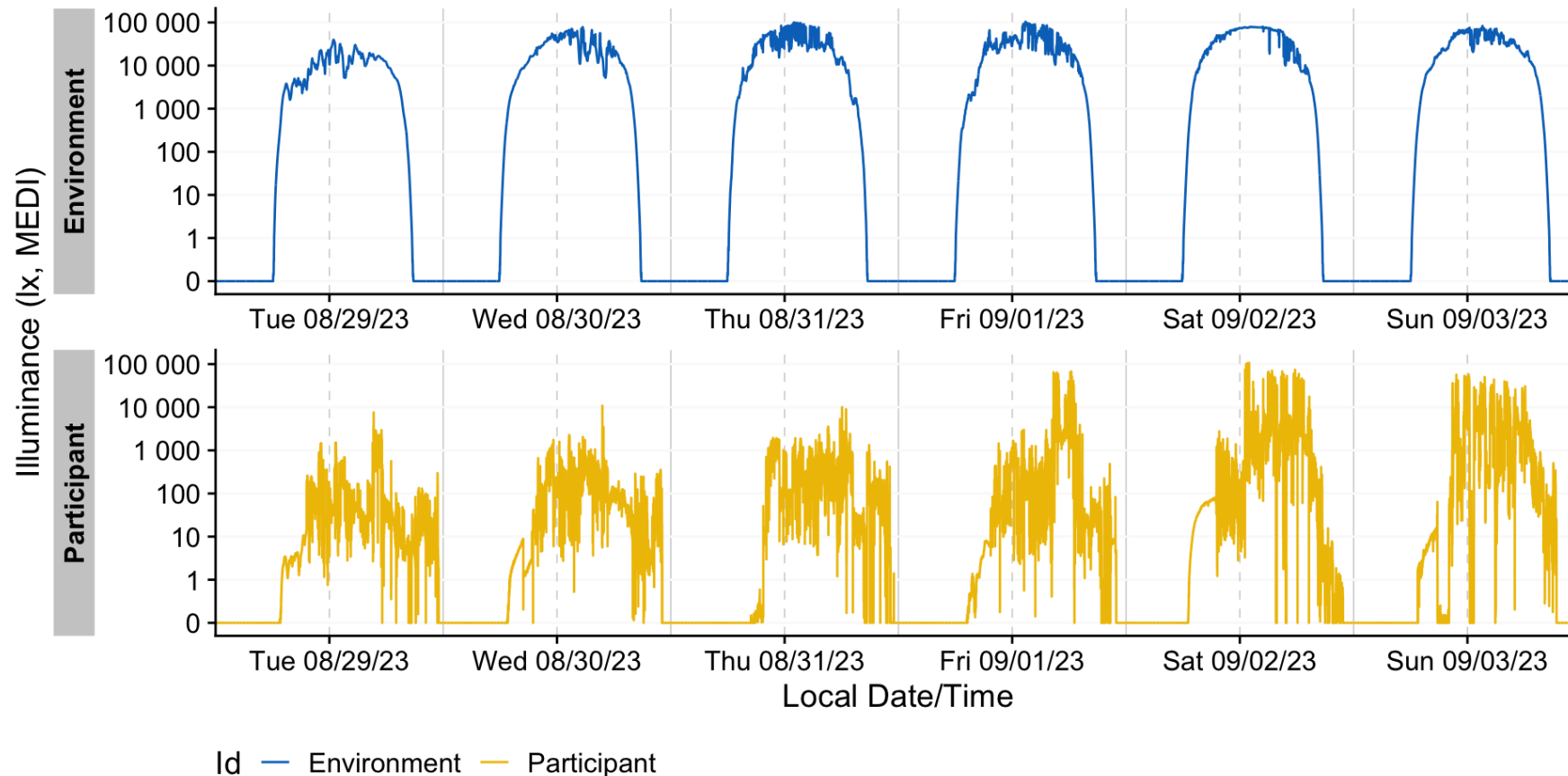


Sets individual colors
for every Id

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



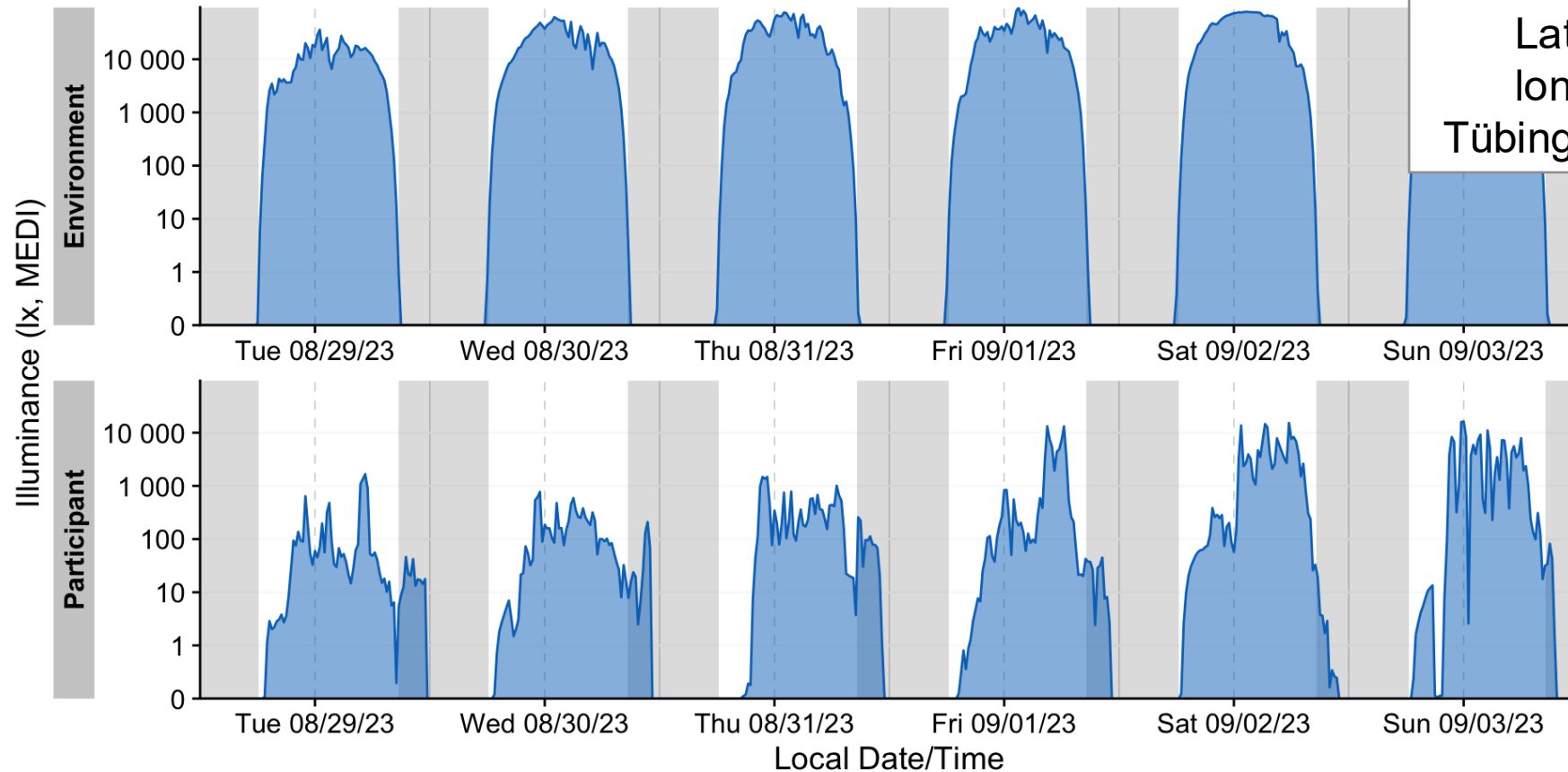
```
data |> gg_days(aes_col = Id)
```



LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> gg_days(...) |> gg_photoperiod(coordinates = c(47.5, 9.5))
```



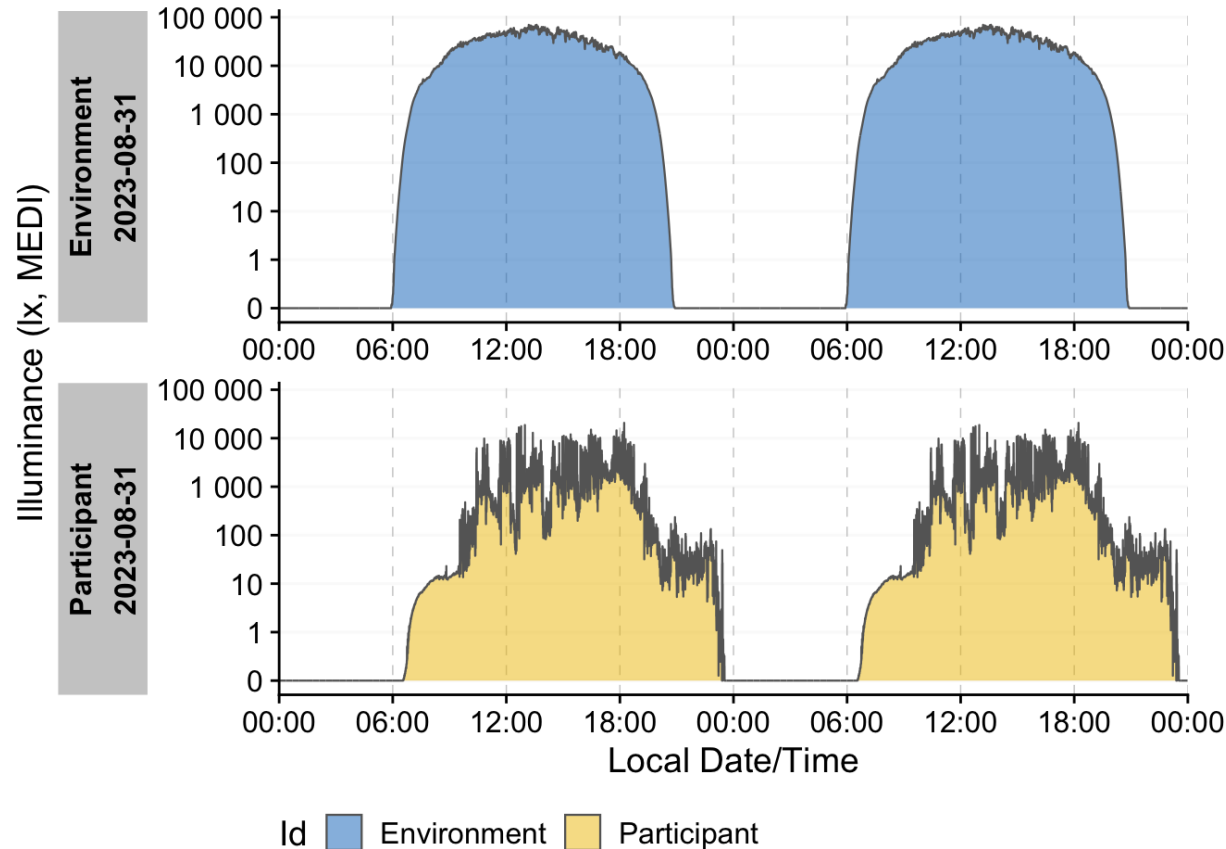
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> aggregate_Date() |> gg_doubleplot(aes_fill = Id)
```



Condenses data into
a single day per
group



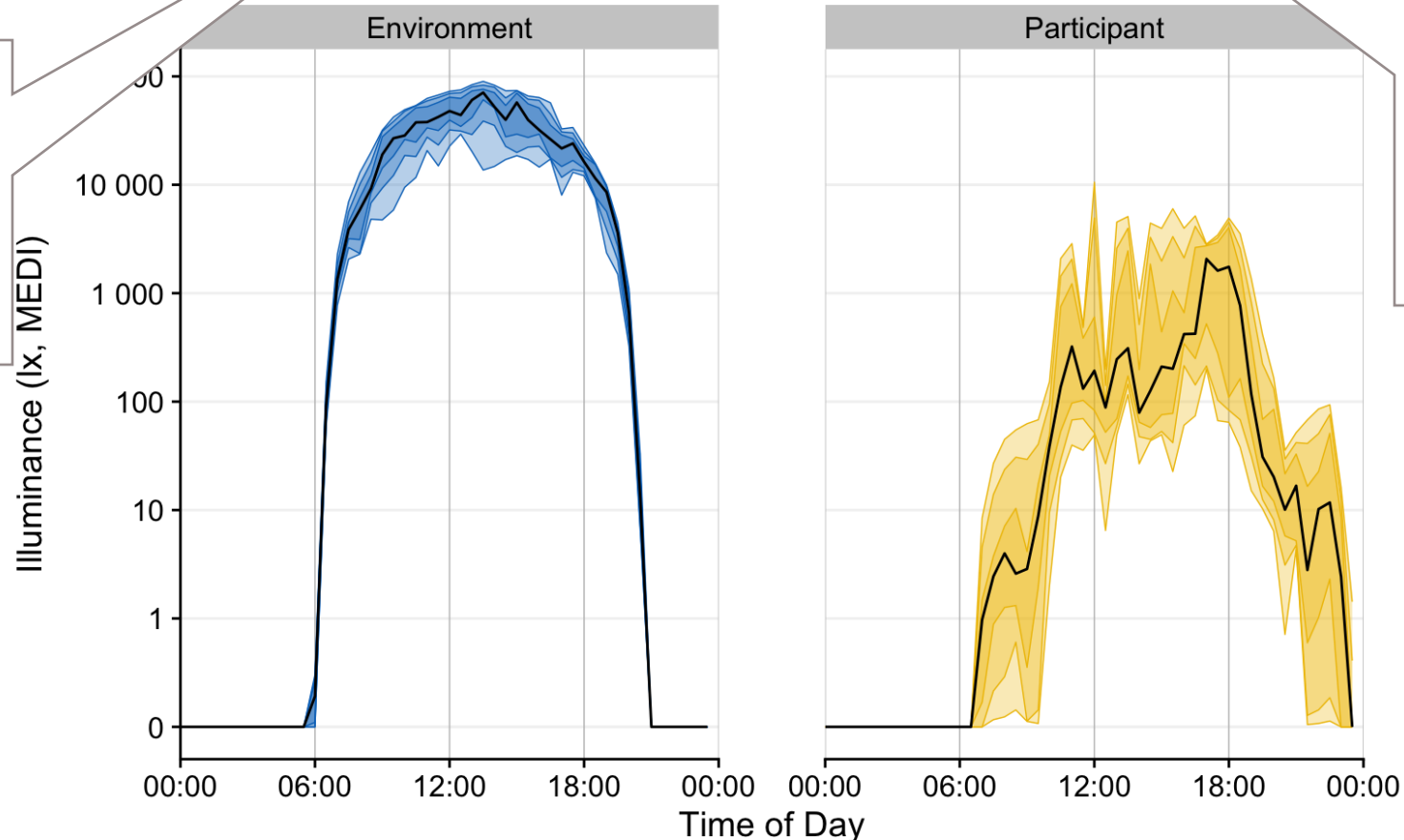
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> aggregate_Date(...) |> gg_day(...) + geom_ribbon(...)
```



Can calculate any metric for the day.
Here: upper + lower bands for 95%, 75%, and 50% of data



Not a LightLogR
function =
not a problem
-> Interfaces nicely
with standard plot
library

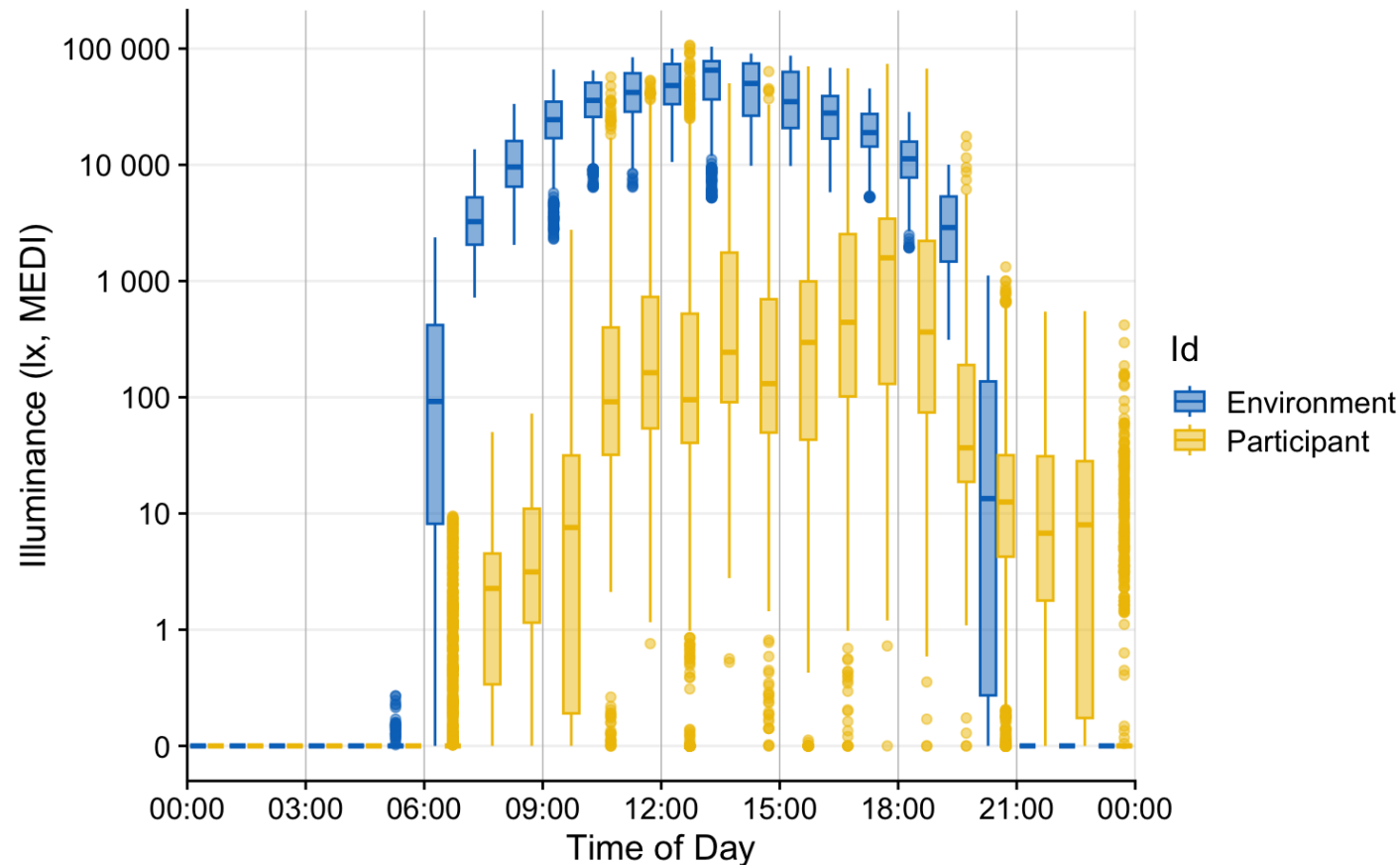
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> cut_Datetime(unit = „1 hour“) |> gg_day(geom = „boxplot“, ...)
```



Adds a new column
with 1hour sections



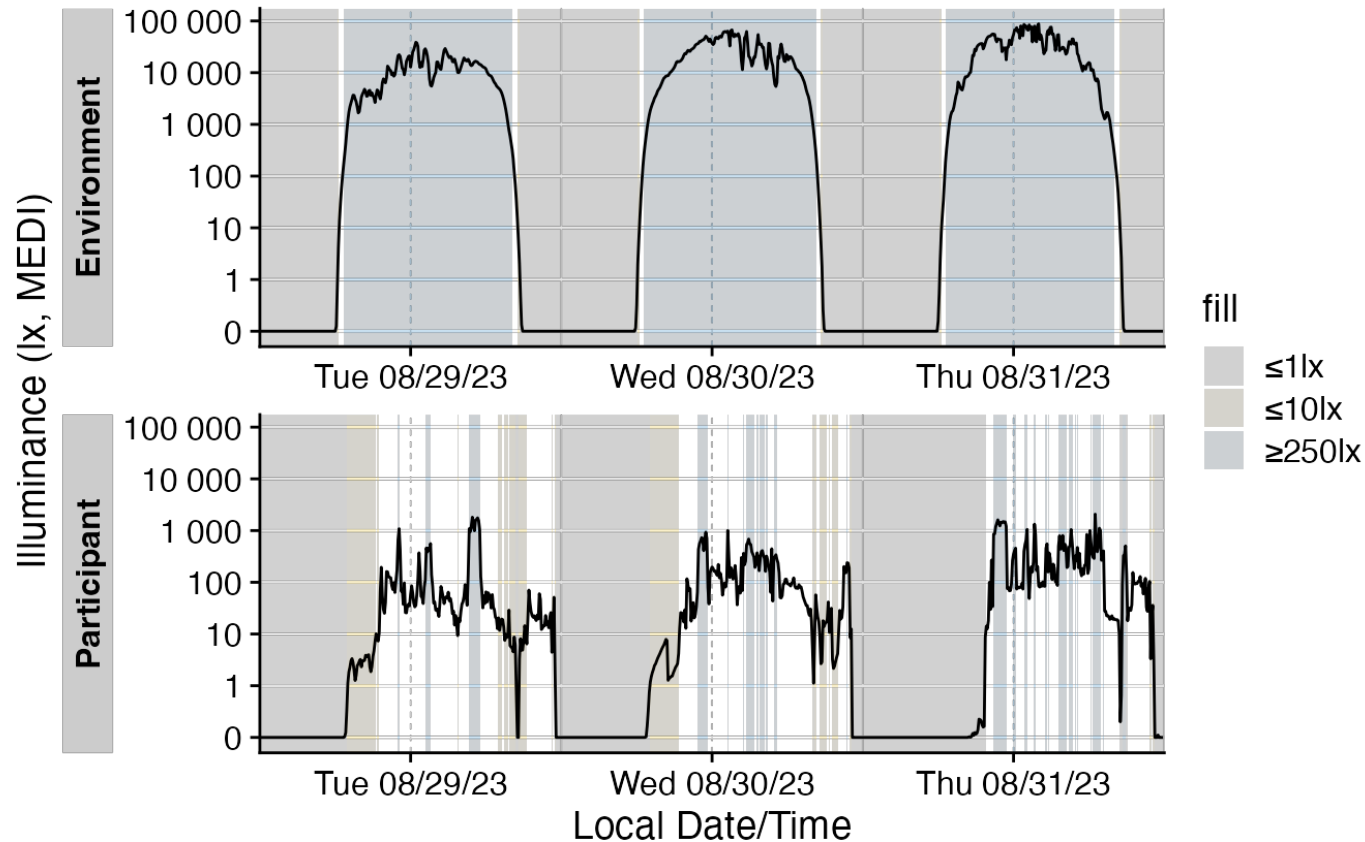
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> cut_Brown() |> gg_days() |> gg_state(state, aes_fill = state)
```



adds a new column
'state'



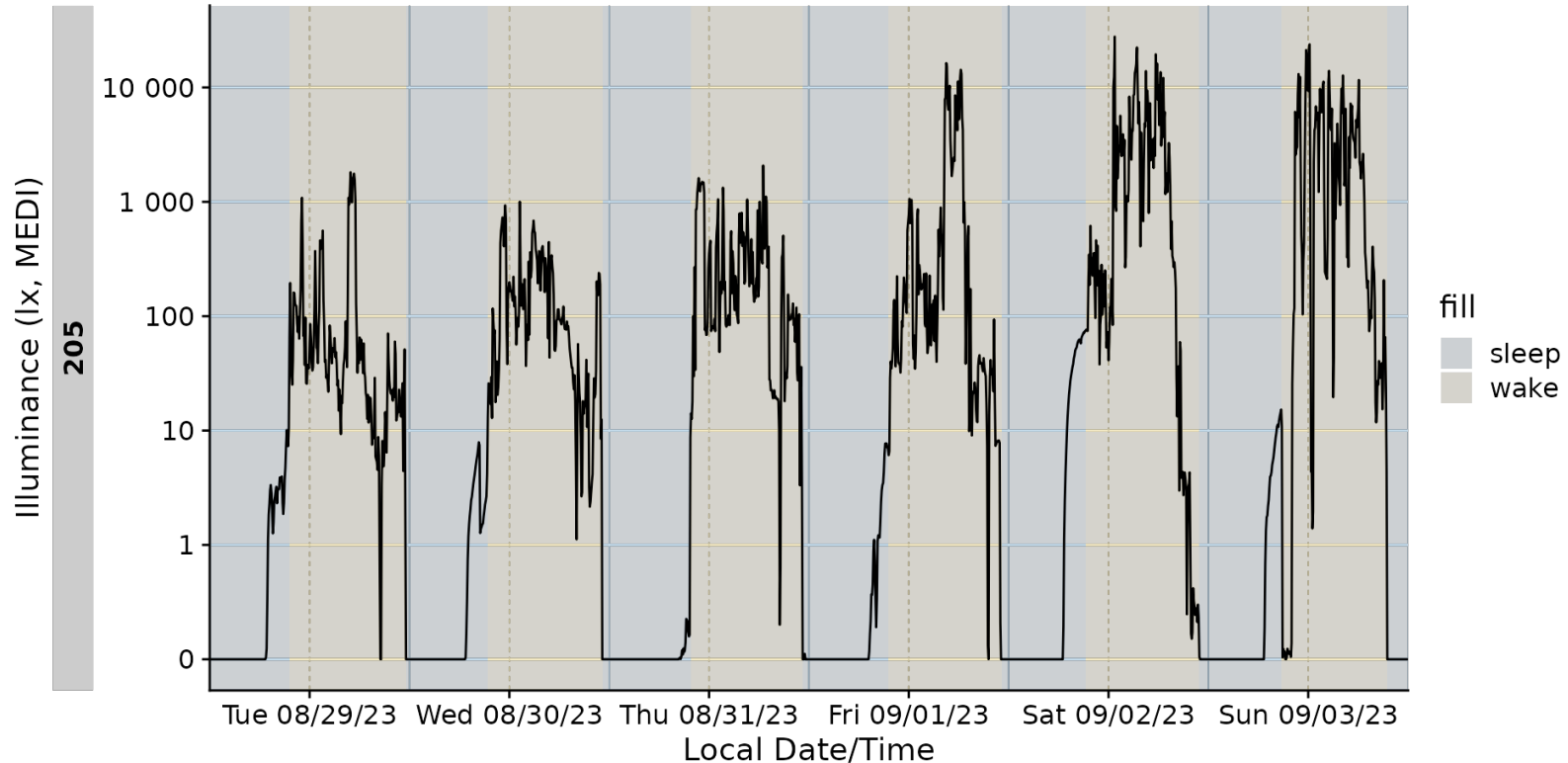
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |> add_State(sleep,...) |> gg_days() |> gg_state(state, aes_fill = state)
```



adds a new column
indicating sleep-wake
times from diary



LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



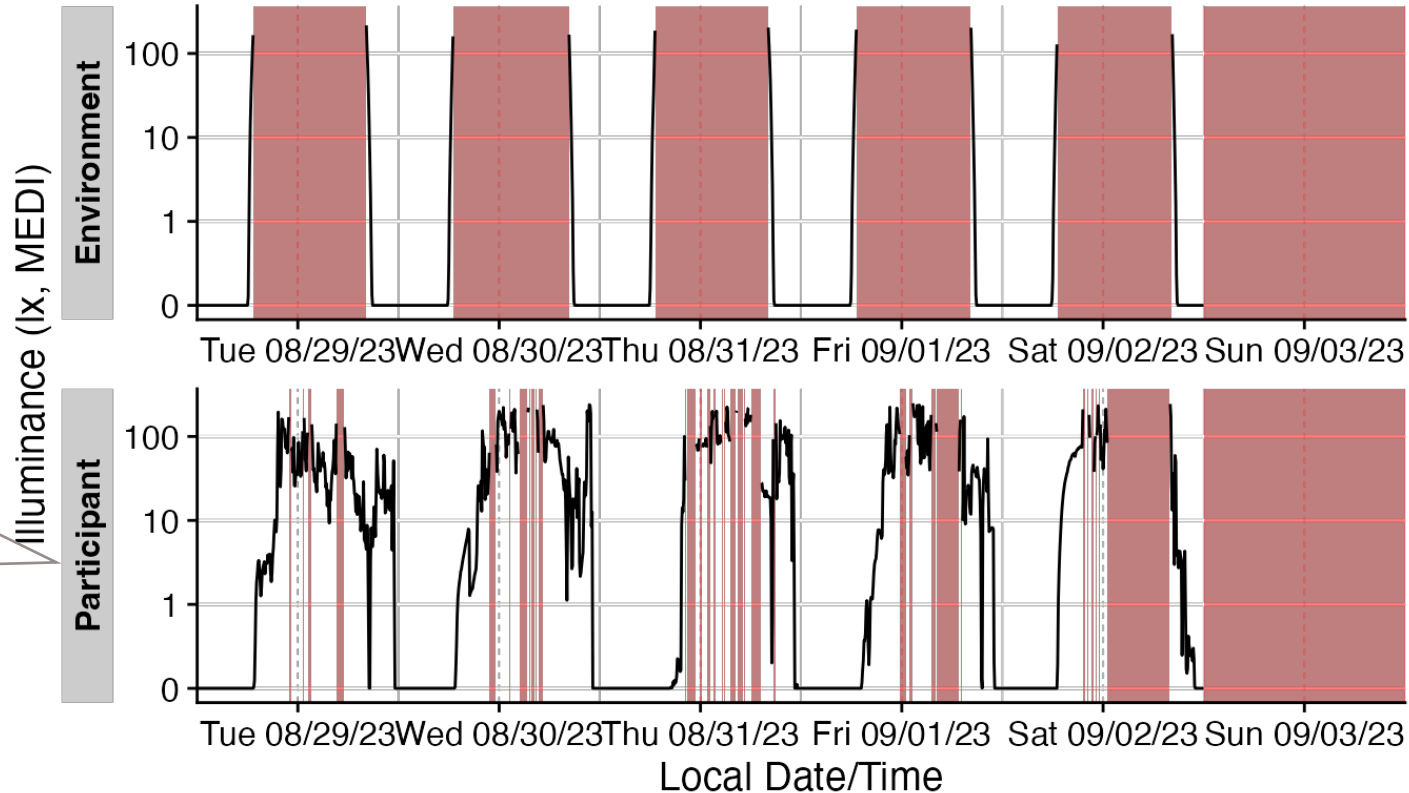
```
data |> ... |> gg_gaps(MEDI)
```



Throw data above a given threshold away

Will only show groups that have gaps

Gaps in the data (red)

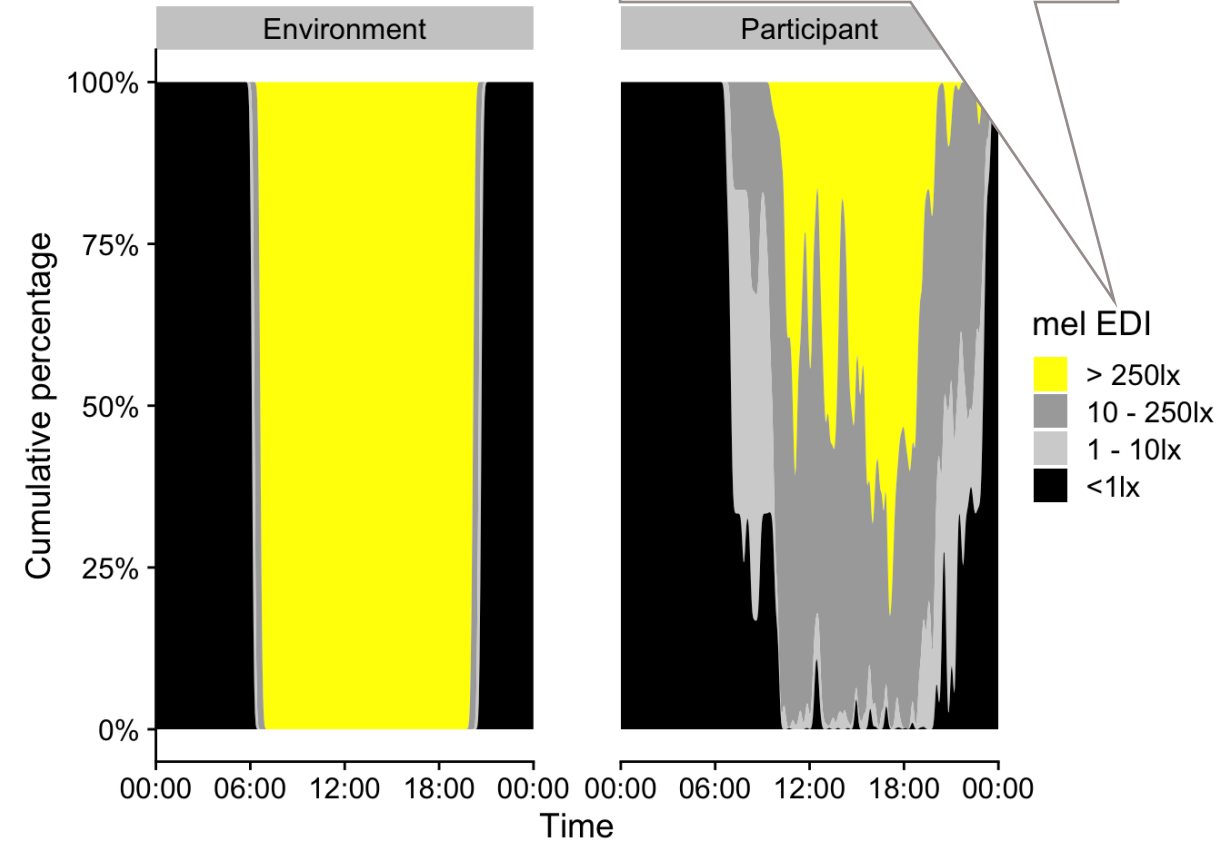
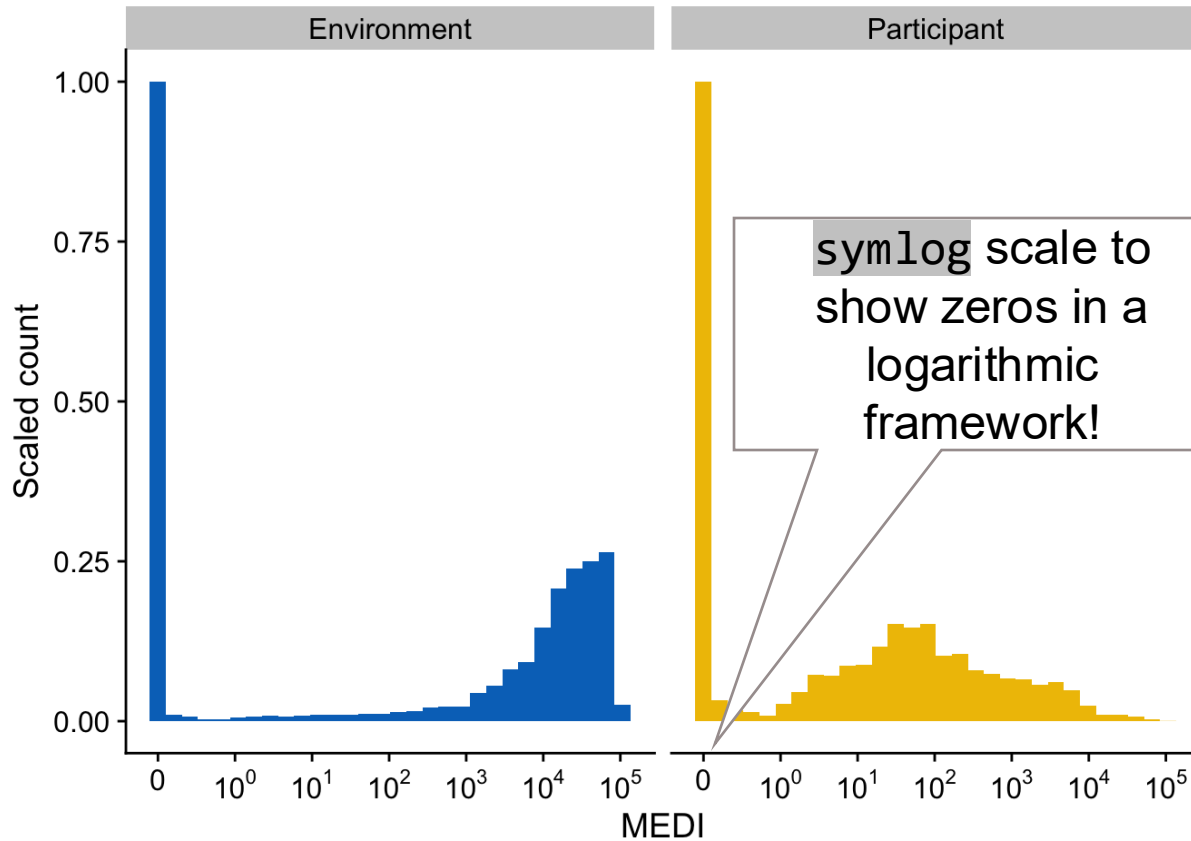


LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



These are standard visualizations that use LightLogRs functionality in parts

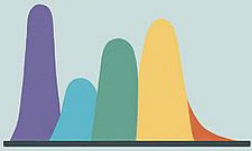
`cut_Brown()` facilitates these and other dividers



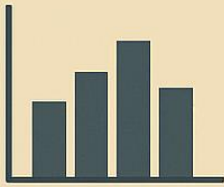
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



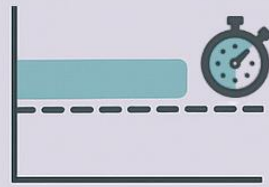
Spectral Composition



Level



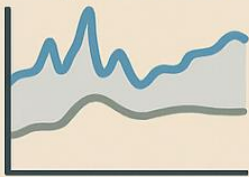
Duration:



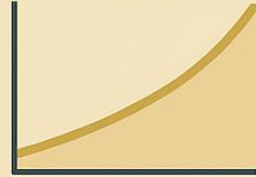
Timing



Temporal Dynamics



Exposure History



Metric Family	Metrics	Note
Barroso	7	
Bright-dark period	4 x 2	bright / dark
Centroid of light exposure	1	
Disparity Index	1	
Dose	1	
Duration above threshold	3	above, below, within
Exponential moving average (EMA)	1	
Frequency crossing threshold	1	
Intradaily Variance (IV)	1	
Interdaily Stability (IS)	1	
Midpoint CE (Cumulative Exposure)	1	
nvRC (Non-visual circadian response)	4	
nvRD (Non-visual direct response)	2	
Period above threshold	3	above, below, within
Pulses above threshold	7 x 3	above, below, within
Threshold for duration	2	above, below
Timing above threshold	3	above, below, within
18 Families	62 metrics	

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |>
  add_Date_col(group.by = TRUE, as.wday = TRUE) |>
  summarize(
    duration_above_threshold(MEDI, Datetime, „above“, 250, as.df = TRUE)
  )
```

Add weekday information and get outputs for each participant and day

Condense into one row per group

wDay	duration_above_250
------	--------------------

201	
-----	--

Tue	34500s (~9.58 hours)
-----	----------------------

Wed	32780s (~9.11 hours)
-----	----------------------

Thu	21820s (~6.06 hours)
-----	----------------------

Fri	31670s (~8.8 hours)
-----	---------------------

Sat	15010s (~4.17 hours)
-----	----------------------

Sun	24400s (~6.78 hours)
-----	----------------------

202	
-----	--

Tue	18760s (~5.21 hours)
-----	----------------------

Provide the measurement variable it has to be calculated for

Set the threshold. Default is „above“, but „below“ or „within two thresholds“ is also possible

Automated naming for output column

LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
data |>
  add_Date_col(group.by = TRUE) |>
  summarize(
    duration_above_threshold(MEDI, Datetime, "above", 250, as.df = TRUE),
    bright_dark_period(MEDI, Datetime, „brightest“, „10 hours“, loop = TRUE),
    ...
  )
```

Add as many
metrics as
needed

	Malaysia			Switzerland			Difference M-S	Boxplot
	Mean	SD	n	Mean	SD	n		
FLiT1000	38,664	8,857	413	35,909	8,818	489	2,755	
FLiT250	37,192	9,723	439	33,204	9,880	509	3,988	
FcT250	36	31	490	67	44	533	-31	
IS	0.162	0.0581	19	0.164	0.0664	20	-0.00129	

In the near future, LightLogR will be extended to work with rich metadata to support analysis and FAIR data



SOFTWARE

Open Access

Metadata recommendations for light logging and dosimetry datasets

Manuel Spitschan^{1,2,3*}, Grégory Hammad^{4,5,6}, Christine Blume^{7,8,9}, Christina Schmidt^{5,10}, Debra J. Skene⁴, Katharina Wulff^{11,12}, Nayanara Santhi¹³, Johannes Zauner^{1,2} and Mirjam Münch^{7,8,9}

BMC Digit Health 2, 73 (2024). <https://doi.org/10.1186/s44247-024-00113-9>

Study-level information	
Name	
Study ID	
Sample	
Clinical trial	
Ethics information	
...	
Group	Group name
	Description
	Inclusion criteria
Contributor	...
	Name
	ORCID
	Role
	...

Participant-level information	
Participant ID	
Age	
Sex	
Gender	
Characteristic	Name
	Value
	Unit
	Description

Dataset-level information	
Dataset Id	
Internal Crossref	Device ID
	Participant ID
	Study ID
Instructions	
Wearing position	
Sampling interval	
Keys: Datetime/mel EDI/...	
Geographical location	
Time zone	
Files and Formatting	File name
	Formatting
	Variable
	...

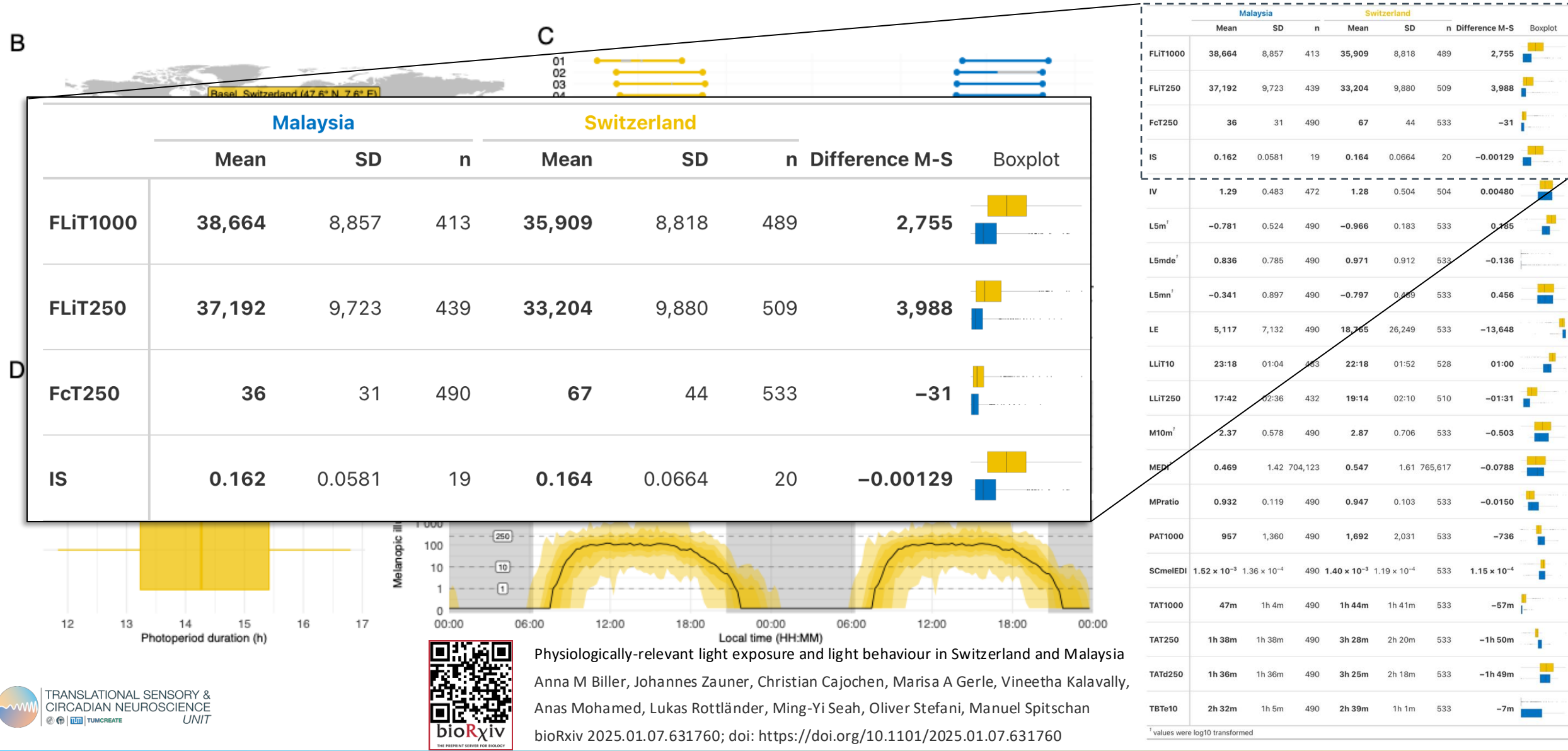
Device-level information	
Device ID	
Manufacturer	
Model number	
Serial number	
Calibration	
Sensor	Name
	Type
	Datasheet
Datasheet	Spectral sensitivity
	Linearity
	Directional response
	Response range
	Channels
	...

Iterable objects

Developing toolsets to access LightLogRs core functionality without programming are on the way. Data glance as proof-of-concept.



Example analysis from Biller et al. (2025): LightLogR provides an end-to-end framework for analysis



Summary

- **Personal light exposure is deeply related to human health**, both on a principled physiological and an epidemiological level
- The research **field is developing rapidly yet is fragmented**
- **Need for common metadata, file formats analysis pipelines, and secondary data!**
- **MeLiDos** and **CIE JTC20** work on **common standards**.
- **LightLogR**, as a common pipeline for analysis – available today and under continuous development!