

CHRONOBIOLOGY & HEALTH
TRANSLATIONAL SENSORY &
CIRCADIAN NEUROSCIENCE



Metrology for wearable light loggers
and optical radiation dosimeters

EUROPEAN PARTNERSHIP



METROLOGY
PARTNERSHIP



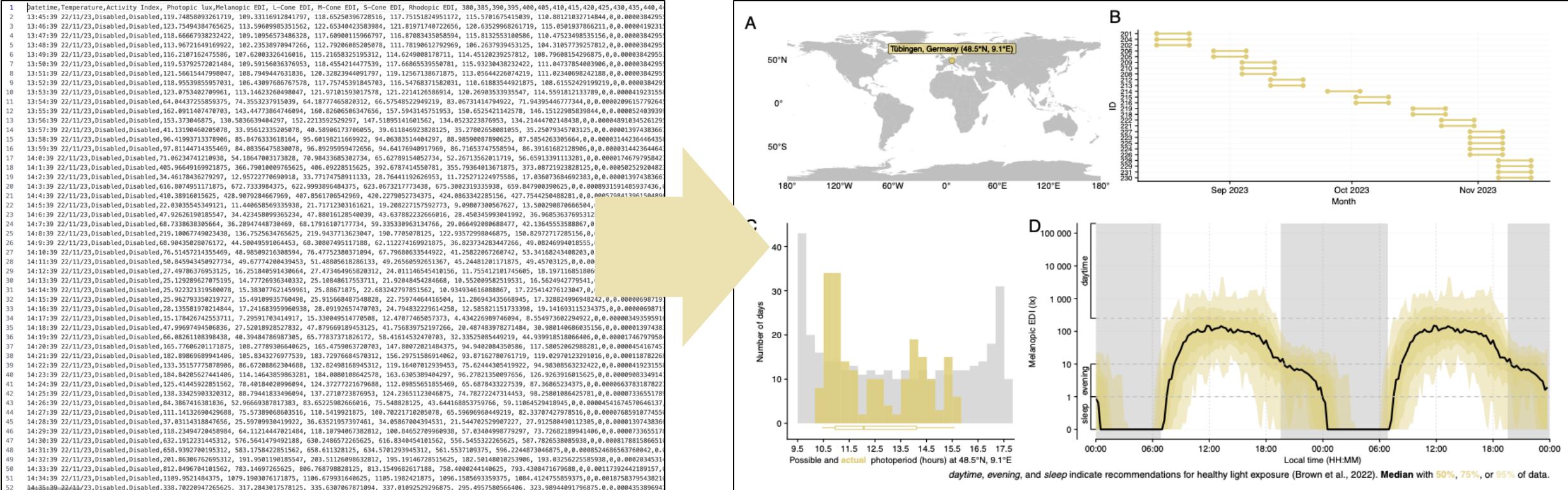
Open and reproducible analysis of light exposure and visual experience data

Dr. Johannes Zauner

Or: How to get from...

...this...

...to this



Funding Statement



Co-funded by the
European Union

METROLOGY
PARTNERSHIP



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.

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.

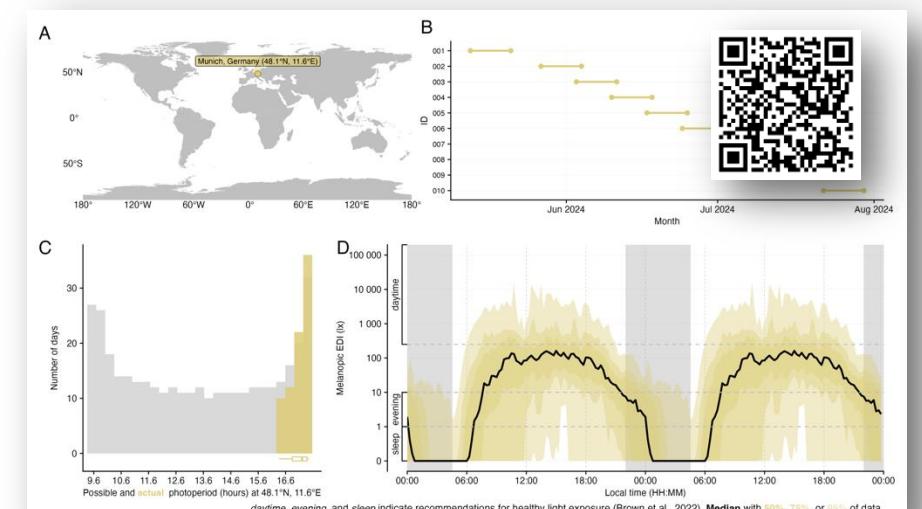
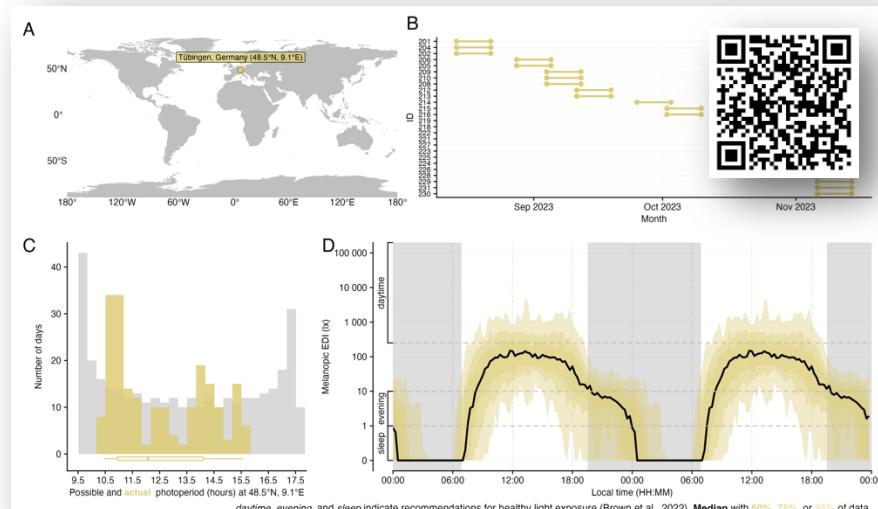
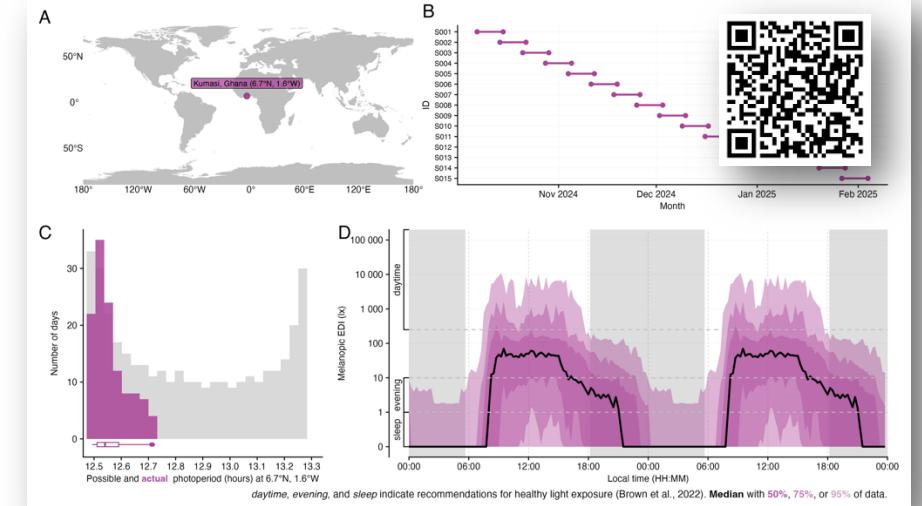
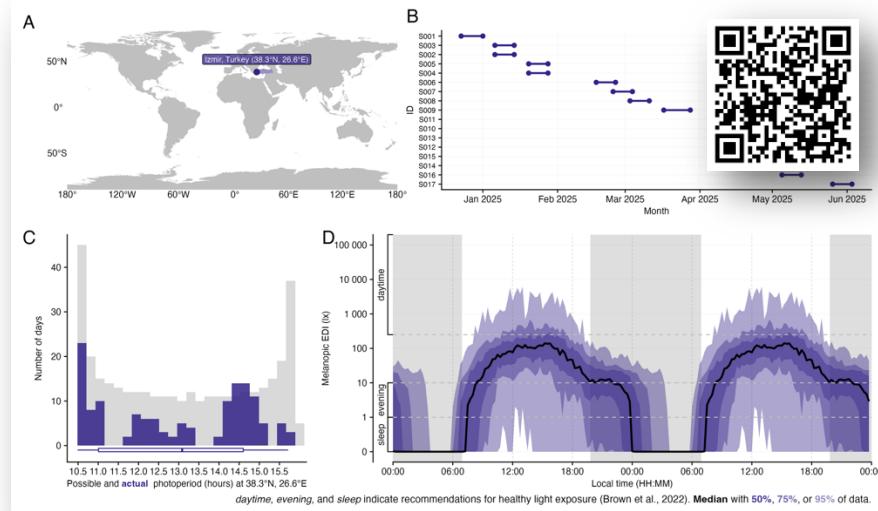
LightLogR's development is supported by the GLEE project (Global Light Exposure Engine, www.visualdiet.org) funded by Reality Labs Research.



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](https://doi.org/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

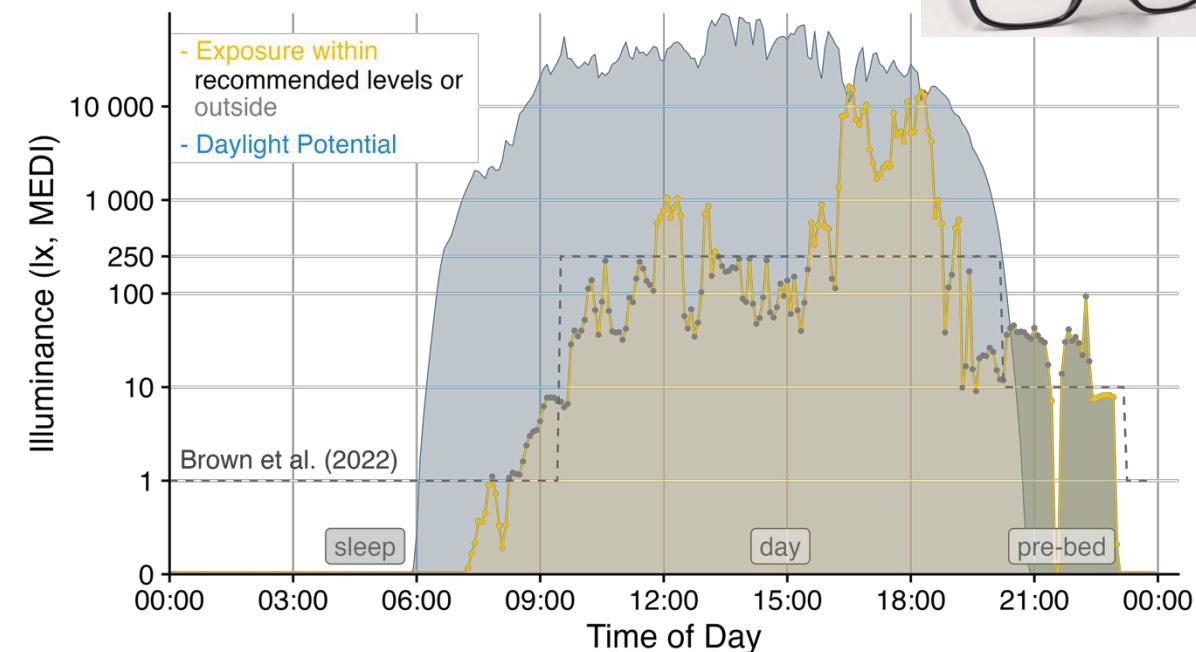
Stationary measurements:



α -opic equivalent daylight (D65) illuminance³

	Scene 1
Melanopsin (MEDI; lux)	241

Wearable data:

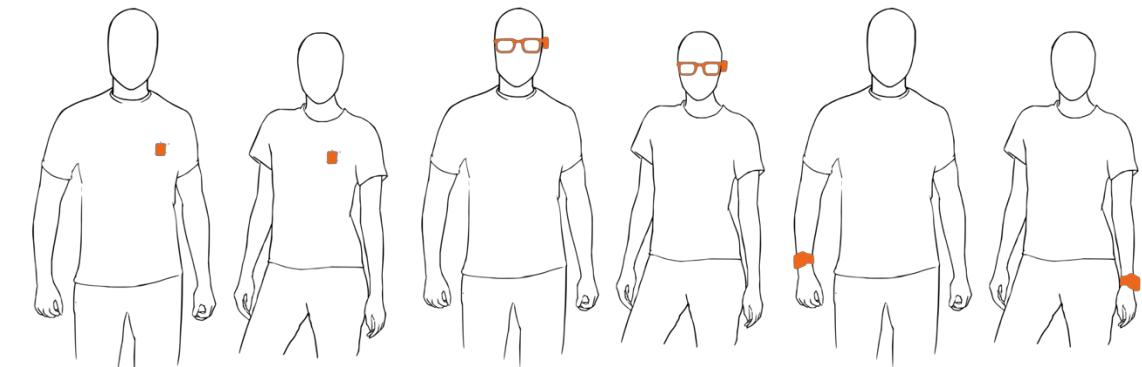


Spot Measurements
(few datapoints, per setting)

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

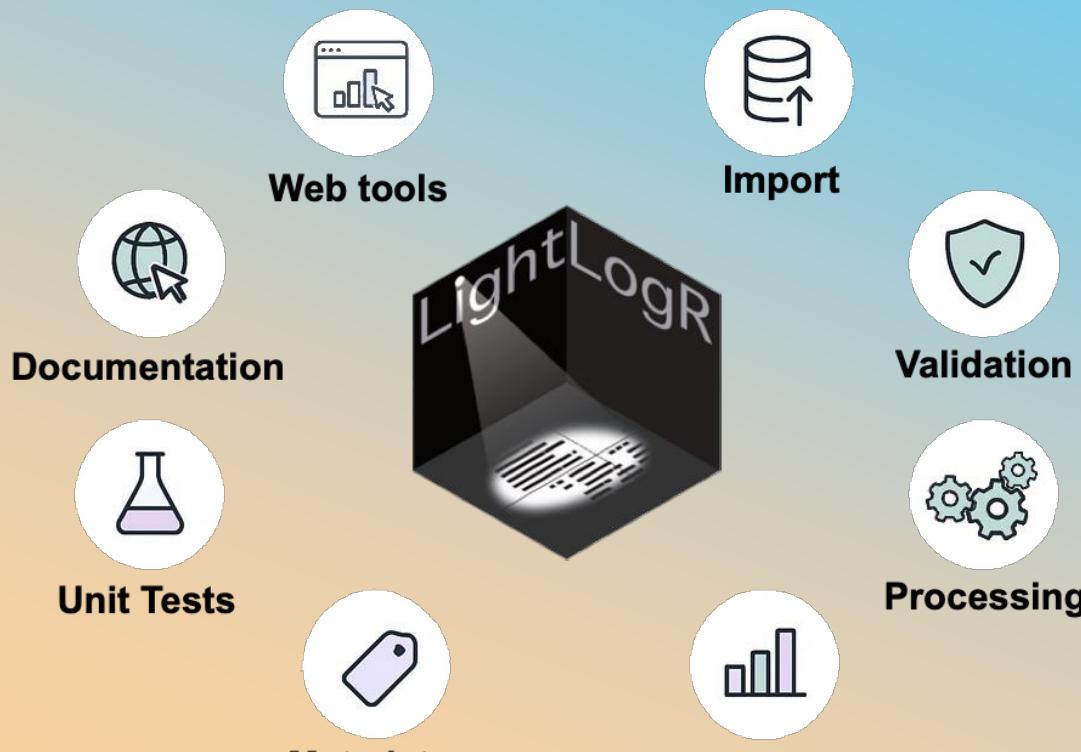


Illustrations: Max Dobberkau (MPI for Biological Cybernetics)

>> 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

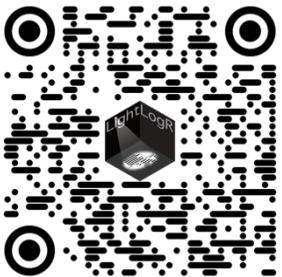
LightLogR is...

- 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.

Illuminance (lx, MED)

Time of Day

Exposure within recommended levels or outside

Daylight Potential

Brown et al. (2022)

sleep

day

pre-bed

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

Links

[Browse source code](#)

[Report a bug](#)

License

[Full license](#)

GPL (>= 3)

Citation

[Citing LightLogR](#)

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 time  
}
```

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
```

Illuminance (lx, MED)

Time of Day

30 Minutes

Reference

LightLogR 0.9.2 Reference Articles ▾ Changelog

Durations, States and Clusters

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

Illuminance (lx, MED)

Time of Day

29/08

30/08

31/08

01/09

02/09

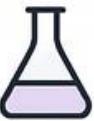
03/09

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



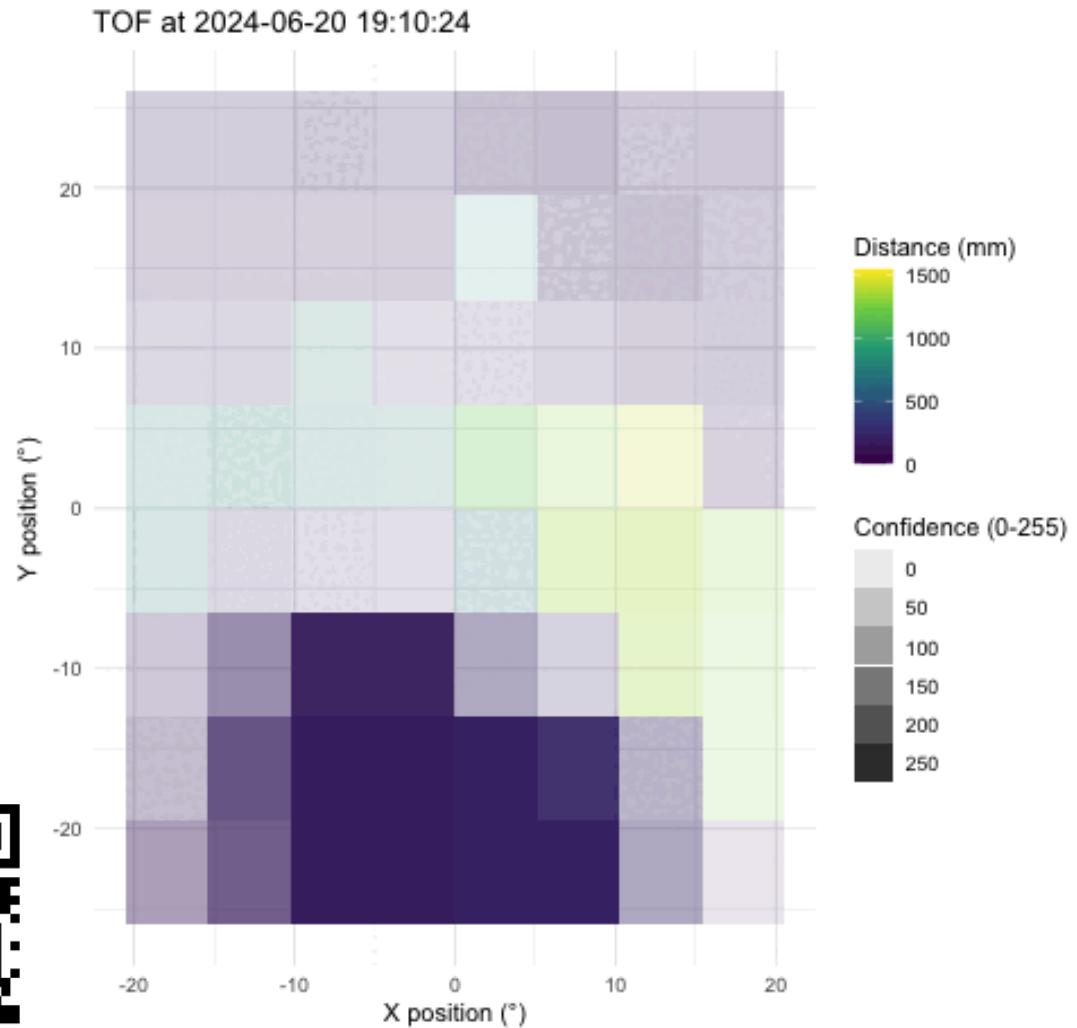
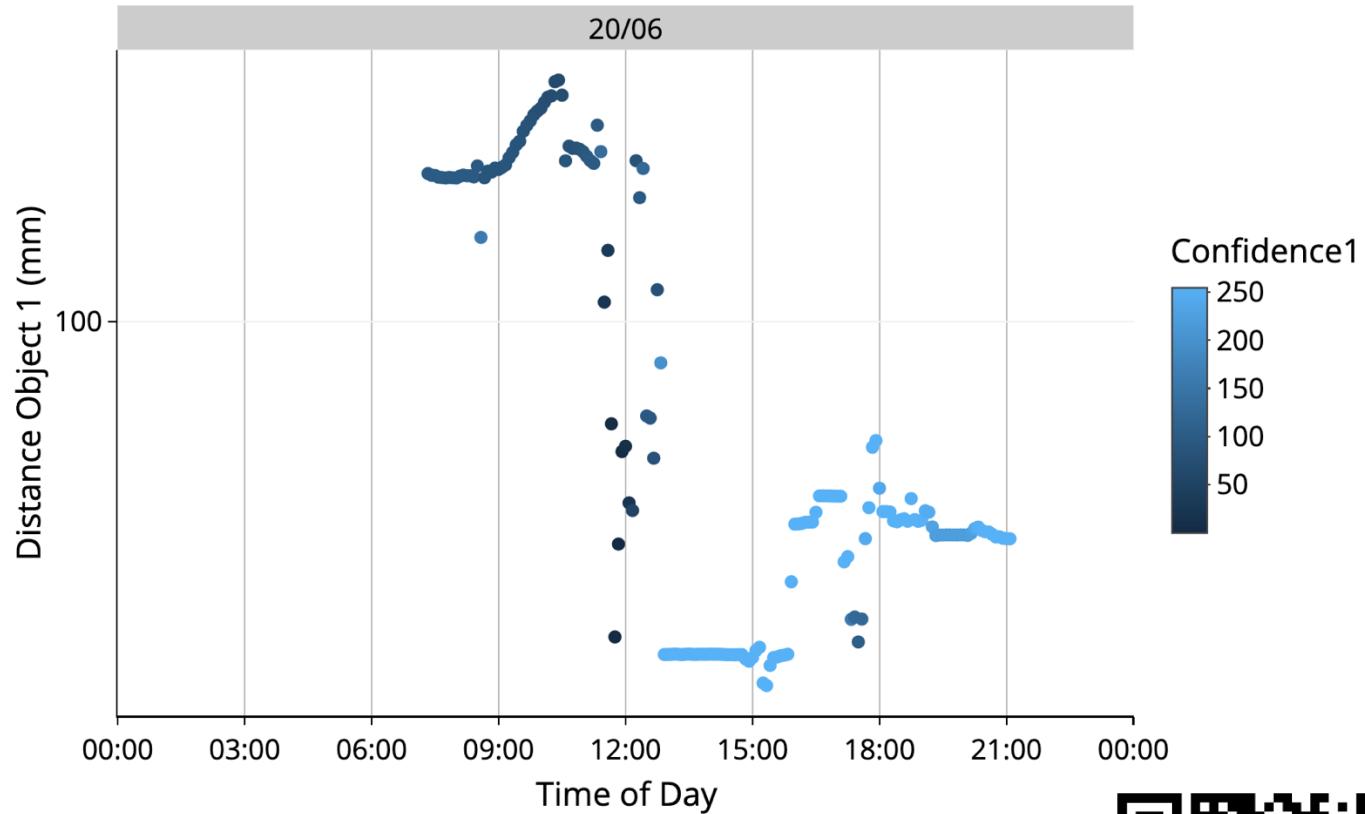
- Hosted on GitHub
- Open Source
- MIT Licence
- Inclusive development
- Issue tracking
- Continuous Integration
- **888 Unit tests**
(07/2025) secure stable functionality

The screenshot shows the GitHub repository page for 'LightLogR' under the 'tsclab' organization. The repository is public and has 478 commits. The code tab is selected, showing a list of recent commits from J.Zauner. The repository has 6 branches and 12 tags. The 'About' section provides a brief description of the package as an R package for processing and analysing light logger and optical radiation dosimeter data. It includes links to the package website and various tags like 'light', 'wearable-devices', etc. The 'Releases' section shows the latest release is v0.9.2 Sunrise, which was released last month. The 'Issues' tab shows 1 open issue.

Commit	Message	Date
J.Zauner Merge pull request #62 from tsclab/desc-cosmetics	changing github links to documentation links	6 months ago
.github	small fixes for CRAN release	last month
R	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

<https://github.com/tsclab/LightLogR>

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



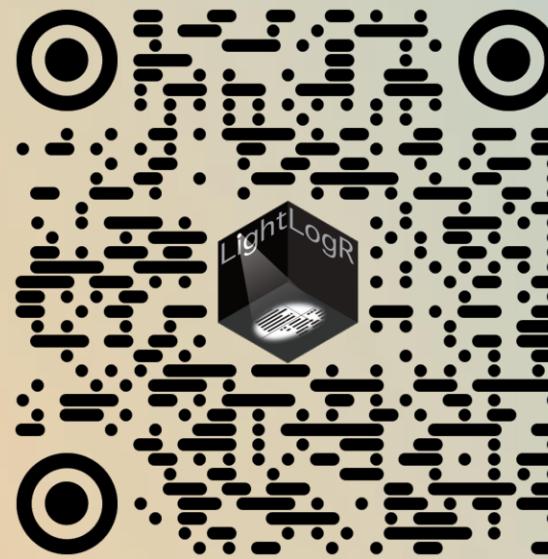
Manuel Spitschan

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

The screenshot shows the JOSS (Journal of Open-Source Software) paper page for LightLogR. The title is "LightLogR: Reproducible analysis of personal light exposure data". It lists three authors: Johannes Zauner, Steffen Hartmeyer, and Manuel Spitschan. The paper was submitted on October 7, 2024, and published on March 13, 2025. The DOI is 10.21105/joss.07601. The summary discusses the importance of personal light exposure in health research and the challenges of analyzing data from wearables. The package provides tools for importing, processing, and visualizing this data. The paper is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0). A figure titled "Figure 1: LightLogR logo" is shown at the bottom.

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



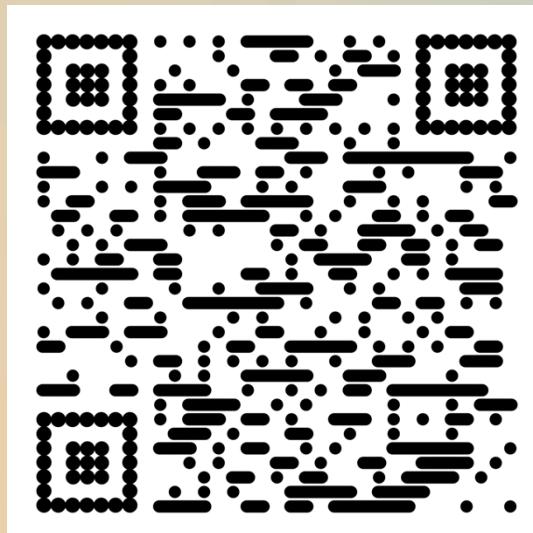
johannes.zauner@tum.de



JZauner

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
- Speccy
- 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
MY004_2023-11-20_2023-12-20_43605.csv
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
MY009_2023-11-20_2023-12-20_43316.csv
MY010_2023-11-29_2023-12-08_13061.csv
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
MY012_2023-11-22_2023-12-23_43996.csv
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
MY016_2023-12-11_2023-12-29_25488.csv
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_2023-11-29_2023-12-13_20412.csv
MY019_2023-12-13_2023-12-29_22940.csv
MY020_2023-11-29_2023-12-11_16604.csv

1	datetime, 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, 450, 455, 460, 465, 470, 475, 480, 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535, 540, 545, 550, 555, 560, 565, 570, 575, 580, 585, 590, 595, 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685, 690, 695, 700, 705, 710, 715, 720, 725, 730, 735, 740, 745, 750, 755, 760, 765, 770, 775, 780, 785, 790, 795, 798, 800, 802, 804, 806, 808, 810, 812, 814, 816, 818, 820, 822, 824, 826, 828, 830, 832, 834, 836, 838, 840, 842, 844, 846, 848, 850, 852, 854, 856, 858, 860, 862, 864, 866, 868, 870, 872, 874, 876, 878, 880, 882, 884, 886, 888, 890, 892, 894, 896, 898, 900, 902, 904, 906, 908, 910, 912, 914, 916, 918, 920, 922, 924, 926, 928, 930, 932, 934, 936, 938, 940, 942, 944, 946, 948, 950, 952, 954, 956, 958, 960, 962, 964, 966, 968, 970, 972, 974, 976, 978, 980, 982, 984, 986, 988, 990, 992, 994, 996, 998, 999, 1000, 1001, 1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009, 1010, 1011, 1012, 1013, 1014, 1015, 1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1027, 1028, 1029, 1030, 1031, 1032, 1033, 1034, 1035, 1036, 1037, 1038, 1039, 1040, 1041, 1042, 1043, 1044, 1045, 1046, 1047, 1048, 1049, 1050, 1051, 1052, 1053, 1054, 1055, 1056, 1057, 1058, 1059, 1060, 1061, 1062, 1063, 1064, 1065, 1066, 1067, 1068, 1069, 1070, 1071, 1072, 1073, 1074, 1075, 1076, 1077, 1078, 1079, 1080, 1081, 1082, 1083, 1084, 1085, 1086, 1087, 1088, 1089, 1090, 1091, 1092, 1093, 1094, 1095, 1096, 1097, 1098, 1099, 1099, 1100, 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109, 1110, 1111, 1112, 1113, 1114, 1115, 1116, 1117, 1118, 1119, 1120, 1121, 1122, 1123, 1124, 1125, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 1135, 1136, 1137, 1138, 1139, 1140, 1141, 1142, 1143, 1144, 1145, 1146, 1147, 1148, 1149, 1150, 1151, 1152, 1153, 1154, 1155, 1156, 1157, 1158, 1159, 1160, 1161, 1162, 1163, 1164, 1165, 1166, 1167, 1168, 1169, 1170, 1171, 1172, 1173, 1174, 1175, 1176, 1177, 1178, 1179, 1180, 1181, 1182, 1183, 1184, 1185, 1186, 1187, 1188, 1189, 1190, 1191, 1192, 1193, 1194, 1195, 1196, 1197, 1198, 1199, 1199, 1200, 1201, 1202, 1203, 1204, 1205, 1206, 1207, 1208, 1209, 1209, 1210, 1211, 1212, 1213, 1214, 1215, 1216, 1217, 1218, 1219, 1219, 1220, 1221, 1222, 1223, 1224, 1225, 1226, 1227, 1228, 1229, 1229, 1230, 1231, 1232, 1233, 1234, 1235, 1236, 1237, 1238, 1239, 1239, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1249, 1249, 1250, 1251, 1252, 1253, 1254, 1254, 1255, 1256, 1257, 1258, 1258, 1259, 1259, 1260, 1261, 1262, 1263, 1263, 1264, 1265, 1266, 1266, 1267, 1268, 1268, 1269, 1269, 1270, 1271, 1271, 1272, 1272, 1273, 1273, 1274, 1274, 1275, 1275, 1276, 1276, 1277, 1277, 1278, 1278, 1279, 1279, 1280, 1280, 1281, 1281, 1282, 1282, 1283, 1283, 1284, 1284, 1285, 1285, 1286, 1286, 1287, 1287, 1288, 1288, 1289, 1289, 1290, 1290, 1291, 1291, 1292, 1292, 1293, 1293, 1294, 1294, 1295, 1295, 1296, 1296, 1297, 1297, 1298, 1298, 1299, 1299, 1300, 1300, 1301, 1301, 1302, 1302, 1303, 1303, 1304, 1304, 1305, 1305, 1306, 1306, 1307, 1307, 1308, 1308, 1309, 1309, 1310, 1310, 1311, 1311, 1312, 1312, 1313, 1313, 1314, 1314, 1315, 1315, 1316, 1316, 1317, 1317, 1318, 1318, 1319, 1319, 1320, 1320, 1321, 1321, 1322, 1322, 1323, 1323, 1324, 1324, 1325, 1325, 1326, 1326, 1327, 1327, 1328, 1328, 1329, 1329, 1330, 1330, 1331, 1331, 1332, 1332, 1333, 1333, 1334, 1334, 1335, 1335, 1336, 1336, 1337, 1337, 1338, 1338, 1339, 1339, 1340, 1340, 1341, 1341, 1342, 1342, 1343, 1343, 1344, 1344, 1345, 1345, 1346, 1346, 1347, 1347, 1348, 1348, 1349, 1349, 1350, 1350, 1351, 1351, 1352, 1352, 1353, 1353, 1354, 1354, 1355, 1355, 1356, 1356, 1357, 1357, 1358, 1358, 1359, 1359, 1360, 1360, 1361, 1361, 1362, 1362, 1363, 1363, 1364, 1364, 1365, 1365, 1366, 1366, 1367, 1367, 1368, 1368, 1369, 1369, 1370, 1370, 1371, 1371, 1372, 1372, 1373, 1373, 1374, 1374, 1375, 1375, 1376, 1376, 1377, 1377, 1378, 1378, 1379, 1379, 1380, 1380, 1381, 1381, 1382, 1382, 1383, 1383, 1384, 1384, 1385, 1385, 1386, 1386, 1387, 1387, 1388, 1388, 1389, 1389, 1390, 1390, 1391, 1391, 1392, 1392, 1393, 1393, 1394, 1394, 1395, 1395, 1396, 1396, 1397, 1397, 1398, 1398, 1399, 1399, 1400, 1400, 1401, 1401, 1402, 1402, 1403, 1403, 1404, 1404, 1405, 1405, 1406, 1406, 1407, 1407, 1408, 1408, 1409, 1409, 1410, 1410, 1411, 1411, 1412, 1412, 1413, 1413, 1414, 1414, 1415, 1415, 1416, 1416, 1417, 1417, 1418, 1418, 1419, 1419, 1420, 1420, 1421, 1421, 1422, 1422, 1423, 1423, 1424, 1424, 1425, 1425, 1426, 1426, 1427, 1427, 1428, 1428, 1429, 1429, 1430, 1430, 1431, 1431, 1432, 1432, 1433, 1433, 1434, 1434, 1435, 1435, 1436, 1436, 1437, 1437, 1438, 1438, 1439, 1439, 1440, 1440, 1441, 1441, 1442, 1442, 1443, 1443, 1444, 1444, 1445, 1445, 1446, 1446, 1447, 1447, 1448, 1448, 1449, 1449, 1450, 1450, 1451, 1451, 1452, 1452, 1453, 1453, 1454, 1454, 1455, 1455, 1456, 1456, 1457, 1457, 1458, 1458, 1459, 1459, 1460, 1460, 1461, 1461, 1462, 1462, 1463, 1463, 1464, 1464, 1465, 1465, 1466, 1466, 1467, 1467, 1468, 1468, 1469, 1469, 1470, 1470, 1471, 1471, 1472, 1472, 1473, 1473, 1474, 1474, 1475, 1475, 1476, 1476, 1477, 1477, 1478, 1478, 1479, 1479, 1480, 1480, 1481, 1481, 1482, 1482, 1483, 1483, 1484, 1484, 1485, 1485, 1486, 1486, 1487, 1487, 1488, 1488, 1489, 1489, 1490, 1490, 1491, 1491, 1492, 1492, 1493, 1493, 1494, 1494, 1495, 1495, 1496, 1496, 1497, 1497, 1498, 1498, 1499, 1499, 1500, 1500, 1501, 1501, 1502, 1502, 1503, 1503, 1504, 1504, 1505, 1505, 1506, 1506, 1507, 1507, 1508, 1508, 1509, 1509, 1510, 1510, 1511, 1511, 1512, 1512, 1513, 1513, 1514, 1514, 1515, 1515, 1516, 1516, 1517, 1517, 1518, 1518, 1519, 1519, 1520, 1520, 1521, 1521, 1522, 1522, 1523, 1523, 1524, 1524, 1525, 1525, 1526, 1526, 1527, 1527, 1528, 1528, 1529, 1529, 1530, 1530, 1531, 1531, 1532, 1532, 1533, 1533, 1534, 1534, 1535, 1535, 1536, 1536, 1537, 1537, 1538, 1538, 1539, 1539, 1540, 1540, 1541, 1541, 1542, 1542, 1543, 1543, 1544, 1544, 1545, 1545, 1546, 1546, 1547, 1547, 1548, 1548, 1549, 1549, 1550, 1550, 1551, 1551, 1552, 1552, 1553, 1553, 1554, 1554, 1555, 1555, 1556, 1556, 1557, 1557, 1558, 1558, 1559, 1559, 1560, 1560, 1561, 1561, 1562, 1562, 1563, 1563, 1564, 1564, 1565, 1565, 1566, 1566, 1567, 1567, 1568, 1568, 1569, 1569, 1570, 1570, 1571, 1571, 1572, 1572, 1573, 1573, 1574, 1574, 1575, 1575, 1576, 1576, 1577, 1577, 1578, 1578, 1579, 1579, 1580, 1580, 1581, 1581, 1582, 1582, 1583, 1583, 1584, 1584, 1585, 1585, 1586, 1586, 1587, 1587, 1588, 1588, 1589, 1589, 1590, 1590, 1591, 1591, 1592, 1592, 1593, 1593, 1594, 1594, 1595, 1595, 1596, 1596, 1597, 1597, 1598, 1598, 1599, 1599, 1600, 1600, 1601, 1601, 1602, 1602, 1603, 1603, 1604, 1604, 1605, 1605, 1606, 1606, 1607, 1607, 1608, 1608, 1609, 1609, 1610, 1610, 1611, 1611, 1612, 1612, 1613, 1613, 1614, 1614, 1615, 1615, 1616, 1616, 1617, 1617, 1618, 1618, 1619, 1619, 1620, 1620, 1621, 1621, 1622, 1622, 1623, 1623, 1624, 1624, 1625, 1625, 1626, 1626, 1627, 1627, 1628, 1628, 1629, 1629, 1630, 1630, 1631, 1631, 1632, 1632, 1633, 1633, 1634, 1634, 1635, 1635, 1636, 1636, 1637, 1637, 1638, 1638, 1639, 1639, 1640, 1640, 1641, 1641, 1642, 1642, 1643, 1643, 1644, 1644, 1645, 1645, 1646, 1646, 1647, 1647, 1648, 1648, 1649, 1649, 1650, 1650, 1651, 1651, 1652, 1652, 1653, 1653, 1654, 1654, 1655, 1655, 1656, 1656, 1657, 1657, 1658, 1658, 1659, 1659, 1660, 1660, 1661, 1661, 1662, 1662, 1663, 1663, 1664, 1664, 1665, 1665, 1666, 1666, 1667, 1667, 1668, 1668, 1669, 1669, 1670, 1670, 1671, 1671, 1672, 1672, 1673, 1673, 1674, 1674, 1675, 1675, 1676, 1676, 1677, 1677, 1678, 1678, 1679, 1679, 1680, 1680, 1681, 1681, 1682, 1682, 1683, 1683, 1684, 1684, 1685, 1685, 1686, 1686, 1687, 1687, 1688, 1688, 1689, 1689, 1690, 1690, 1691, 1691, 1692, 1692, 1693, 1693, 1694, 1694, 1695, 1695, 1696, 1696, 1697, 1697, 1698, 1698, 1699, 1699, 1700, 1700, 1701, 1701, 1702, 1702, 1703, 1703, 1704, 1704, 1705, 1705, 1706, 1706, 1707, 1707, 1708, 1708, 1709, 1709, 1710, 1710, 1711, 1711, 1712, 1712, 1713, 1713, 1714, 1714, 1715, 1715, 1716, 1716, 1717, 1717, 1718, 1718, 1719, 1719, 1720, 1720, 1721, 1721, 1722, 1722, 1723, 1723, 1724, 1724, 1725, 1725, 1726, 1726, 1727, 1727, 1728, 1728, 1729, 1729, 1730, 1730, 1731, 1731, 1732, 1732, 1733, 1733, 1734, 1734, 1735, 1735, 1736, 1736, 1737, 1737, 1738, 1738, 1739, 1739, 1740, 1740, 1741, 1741, 1742, 1742, 1743, 1743, 1744, 1744, 1745, 1745, 1746, 1746, 1747, 1747, 1748, 1748, 1749, 1749, 1750, 1750, 1751, 1751, 1752, 1752, 1753, 1753, 1754, 1754, 1755, 1755, 1756, 1756, 1757

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



script

Paper_RPG_ASEAN - RStudio

import_demo.R*

```
2 #40 files across 19 participants:
3 files <- list.files(path = "data", full.names = TRUE)
4 #timezone
5 tz <- "Asia/Kuala_Lumpur"
6 #id pattern in filename
7 id.pattern <- "MY[0-9]{3}"
8
9 #import
10 ll_data <- import$Speccy(files, tz = tz, auto.id = id.pattern)
```

Environment History Connections Tutorial

R Global Environment

Data

ll_data 733908 obs. of 92 variables

Values

files chr [1:40] "data/MY001_2023-11-22_2023-12-22_43332.csv..."
id.pattern "MY[0-9]{3}"

Files Plots Packages Help Viewer Presentation

Console Terminal Background Jobs

R 4.4.0 · ~/Documents/Arbeit/12-TUM/WP.2.3_Software/Case_Studies/Paper_RPG_ASEAN/

Successfully read in 733'908 observations across 19 Ids from 40 Speccy-file(s).

Timezone set is Asia/Kuala_Lumpur.

The system timezone is Europe/Berlin. Please correct if necessary!

First Observation: 2023-11-20 10:13:58

Last Observation: 2023-12-30 00:30:00

Timespan: 40 days

Observation intervals:

Id	interval.time	n	pct
1 MY001	60s (~1 minutes)	43330	100%
2 MY001	65s (~1.08 minutes)	1	0%
3 MY002	59s	1	0%
4 MY002	60s (~1 minutes)	22189	100%
5 MY002	61s (~1.02 minutes)	1	0%
6 MY002	9978s (~2.77 hours)	1	0%
7 MY002	17965s (~4.99 hours)	1	0%
8 MY002	32323s (~8.98 hours)	1	0%
9 MY002	1202366s (~1.99 weeks)	1	0%
10 MY003	60s (~1 minutes)	43195	100%

i 35 more rows
i Use `print(n = ...)` to see more rows

Dec 01 Dec 15 Jan (

Datetime

Dataset intervals, with times of implicit missing data .



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



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

shows whether the dataset has gaps

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

country	year	cases	population
Afghanistan	1999	745	1937071
Afghanistan	2000	2666	2095360
Brazil	1999	31737	17206362
Brazil	2000	80488	17404898
China	1999	214258	127215272
China	2000	21666	128028583

variables

country	year	cases	population
Afghanistan	1999	745	1937071
Afghanistan	2000	2666	2095360
Brazil	1999	31737	17206362
Brazil	2000	80488	17404898
China	1999	214258	127215272
China	2000	21666	128028583

observations

country	year	cases	population
Afghanistan	1999	745	1937071
Afghanistan	2000	2666	2095360
Brazil	1999	31737	17206362
Brazil	2000	80488	17404898
China	1999	214258	127215272
China	2000	21666	128028583

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
```

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

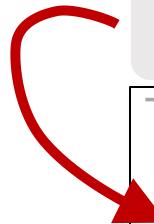


```
data |> has_gaps() # shows whether the dataset has gaps
```

```
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	%	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 52m	11.0%	15h 52m	11.0%	0s	0.0%				



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
```

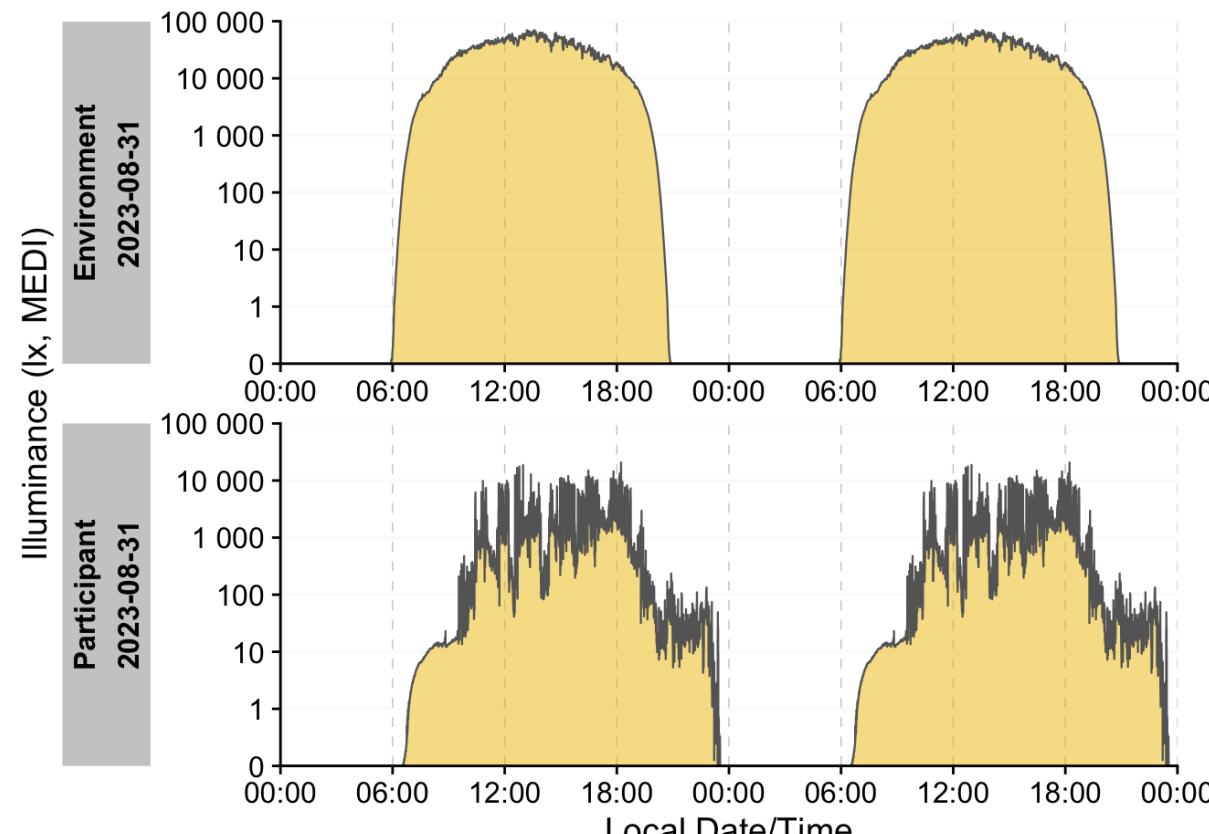
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



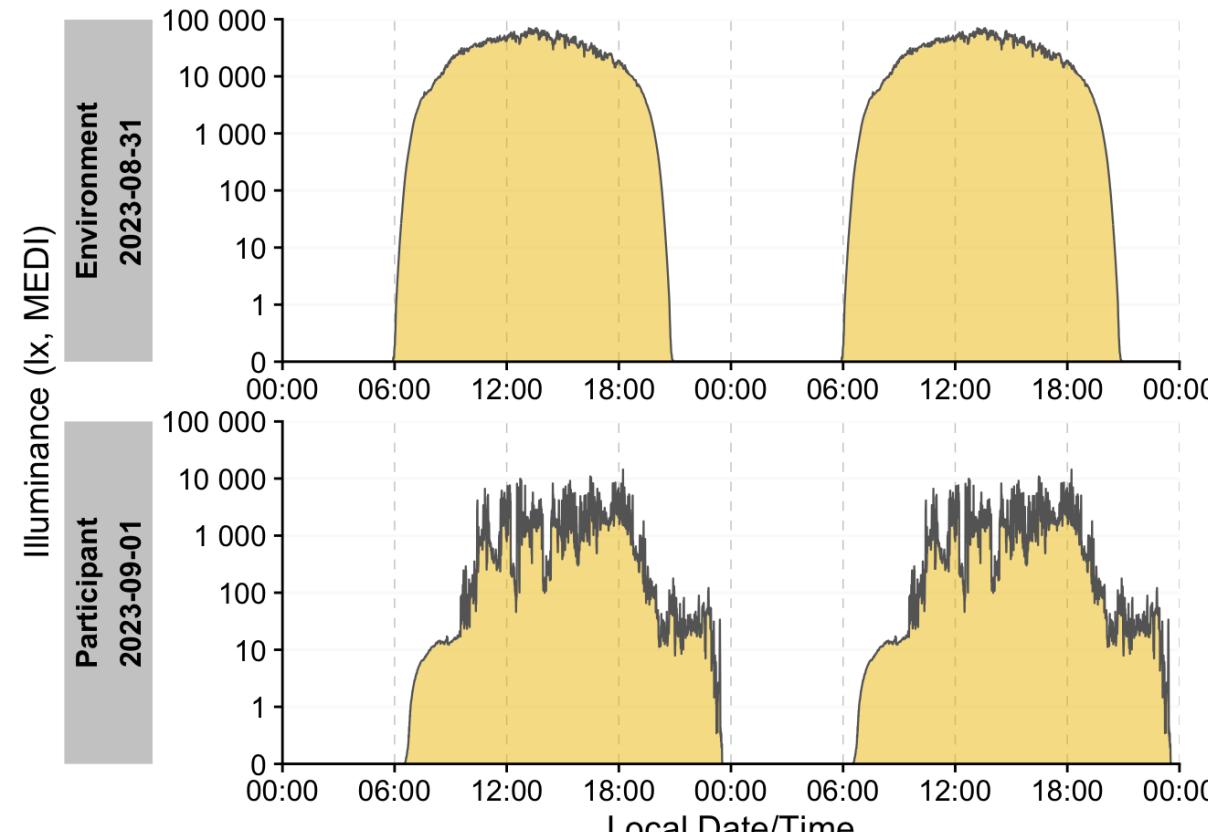
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



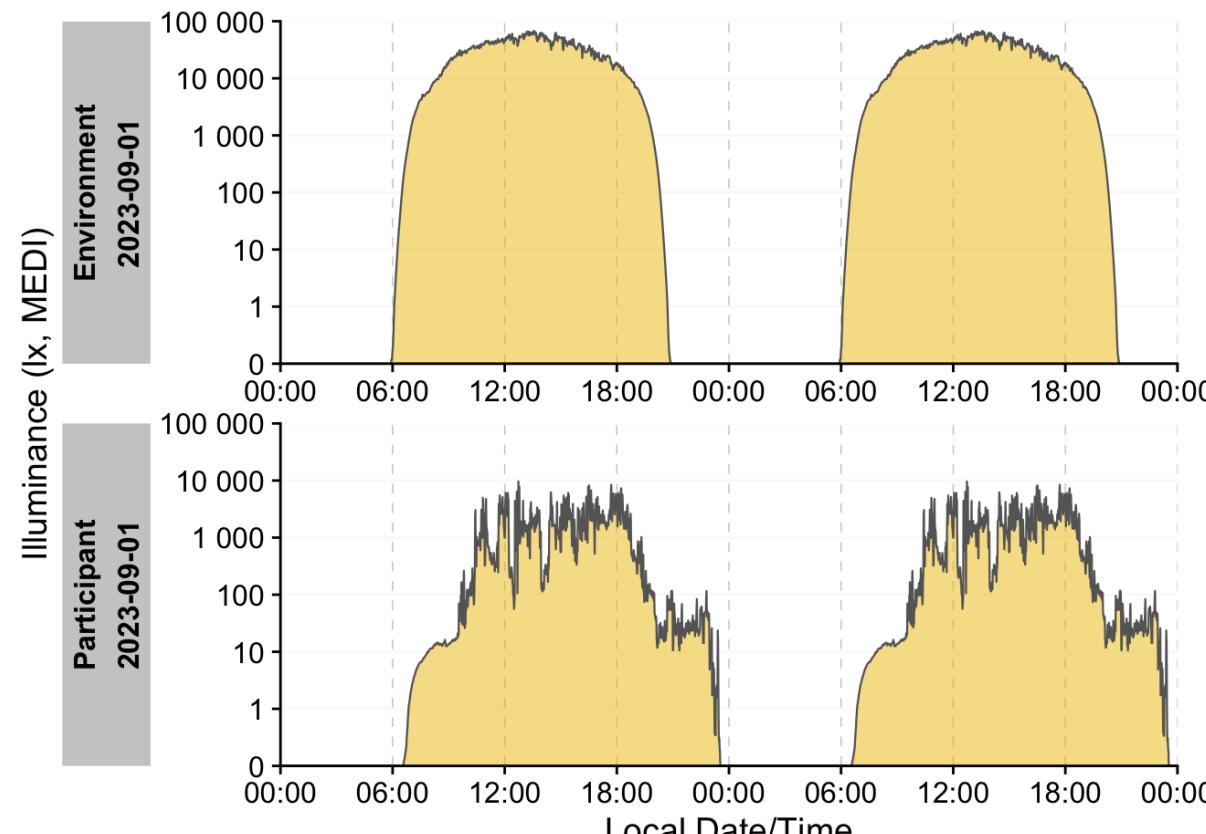
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



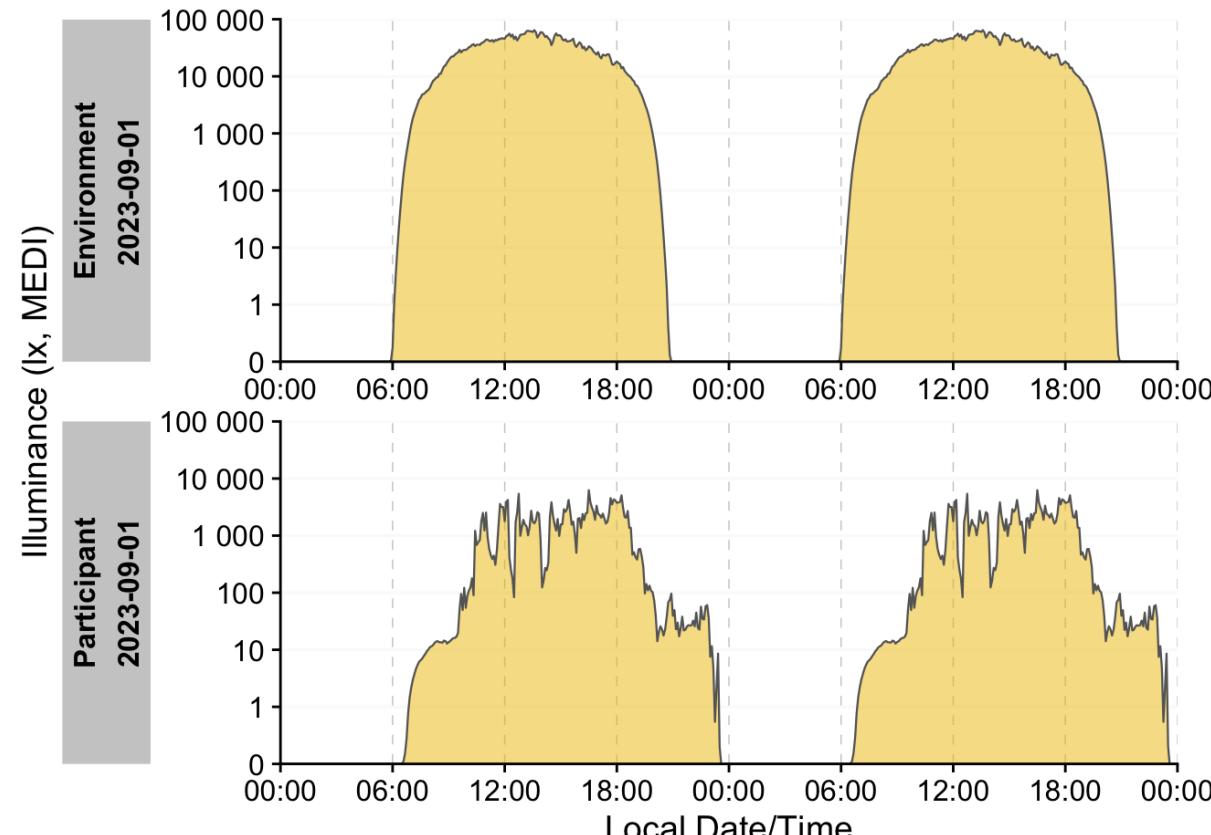
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



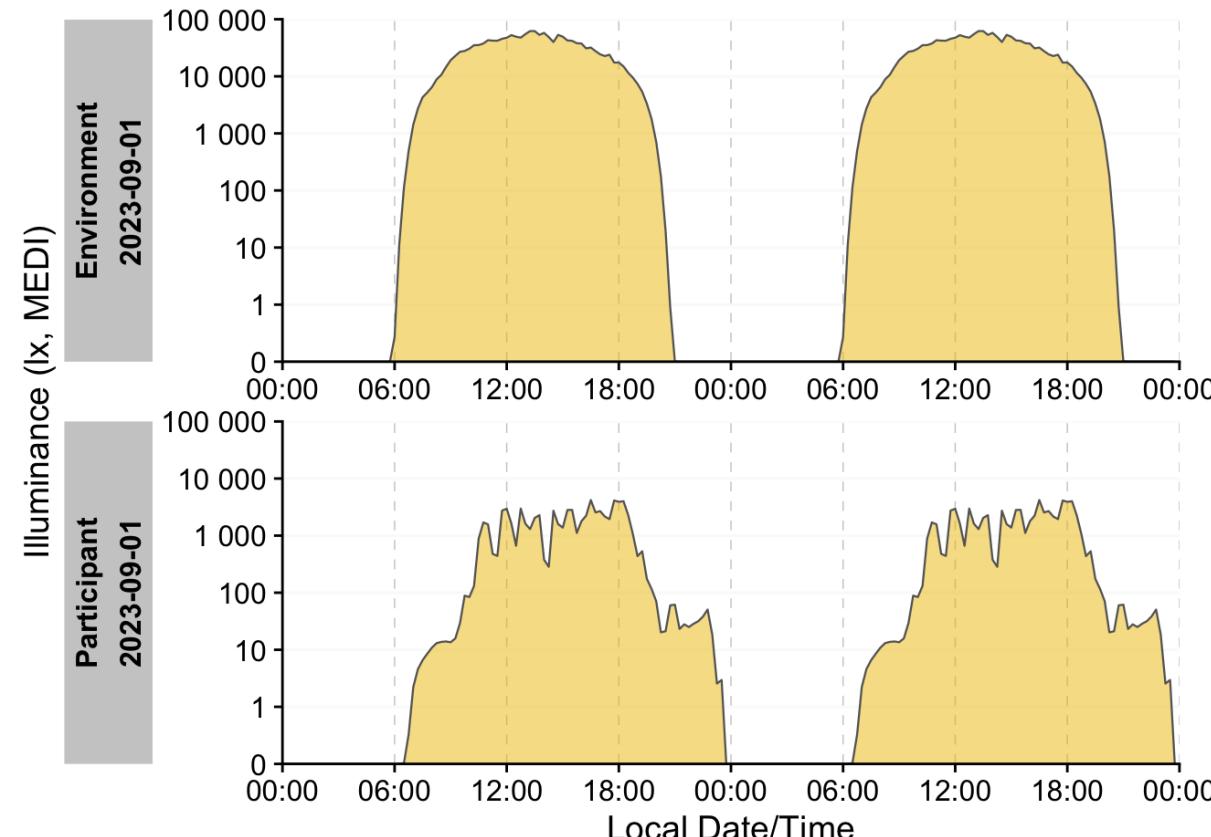
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



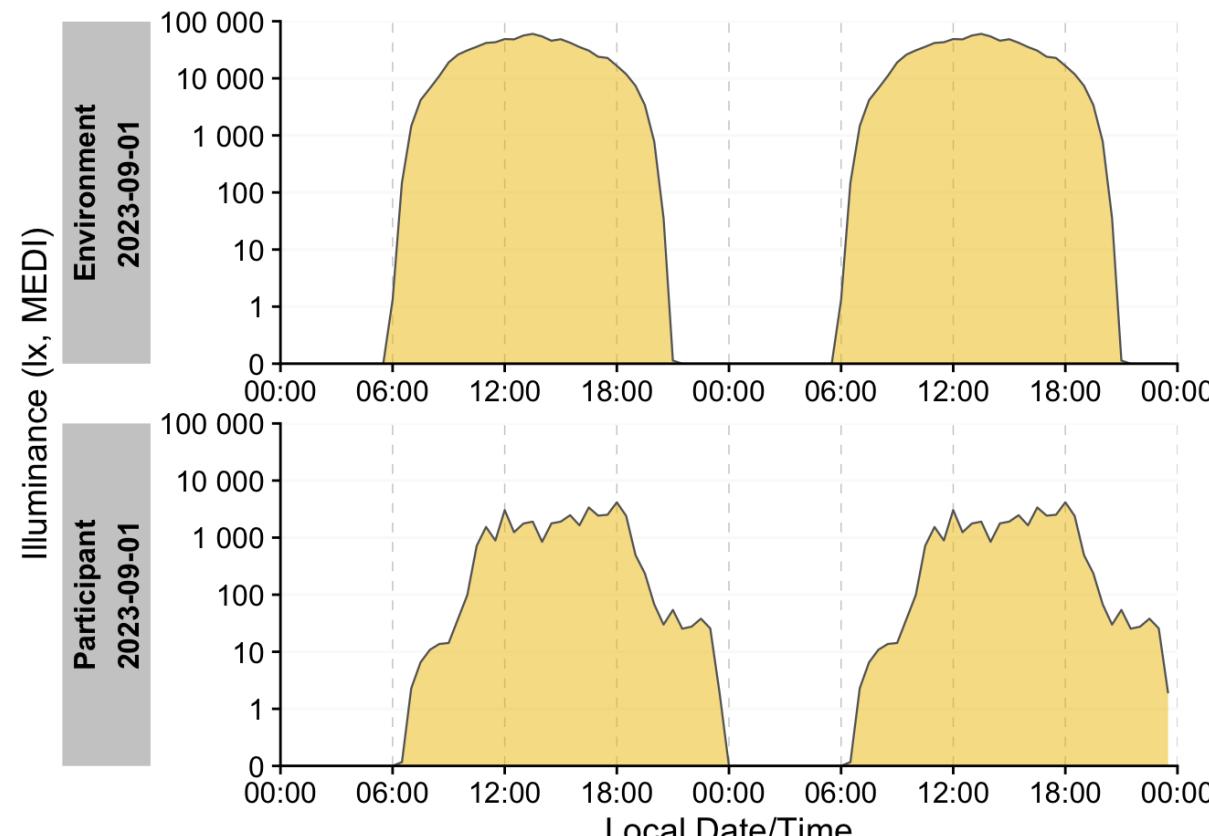
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



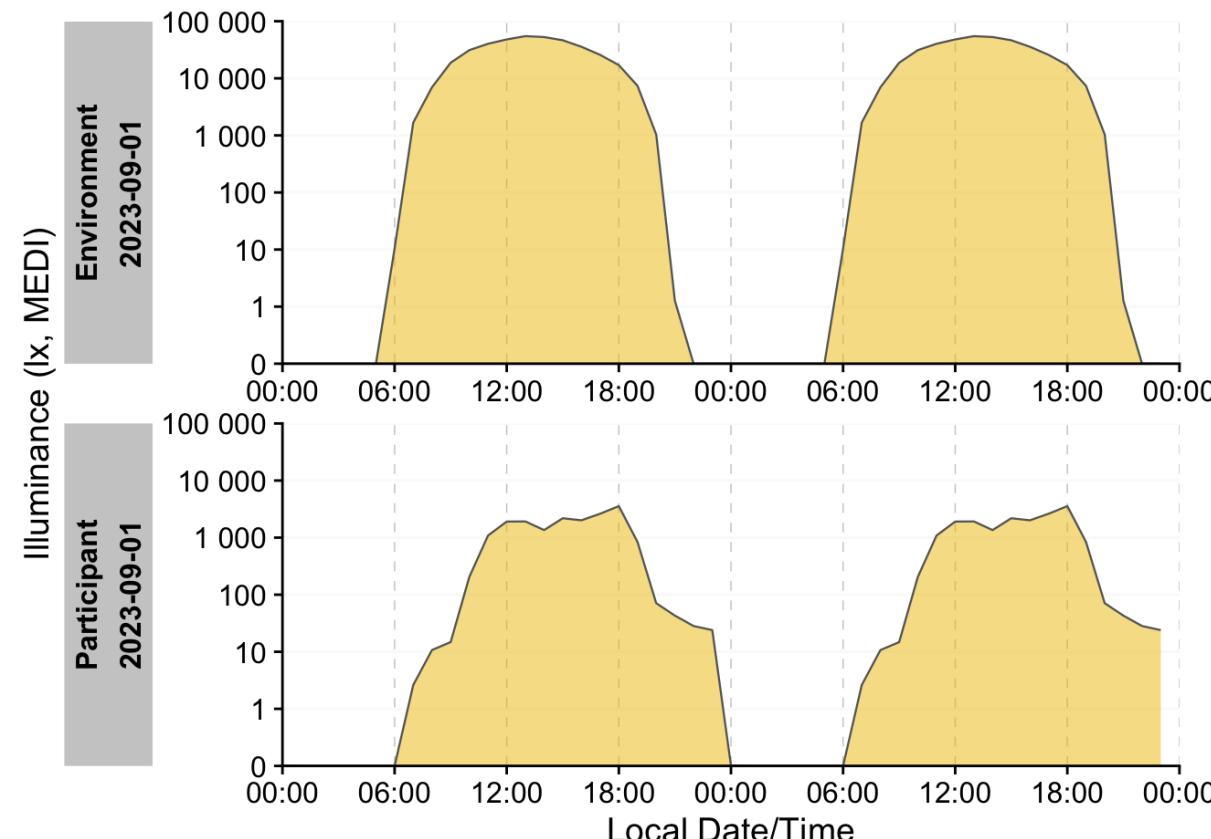
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



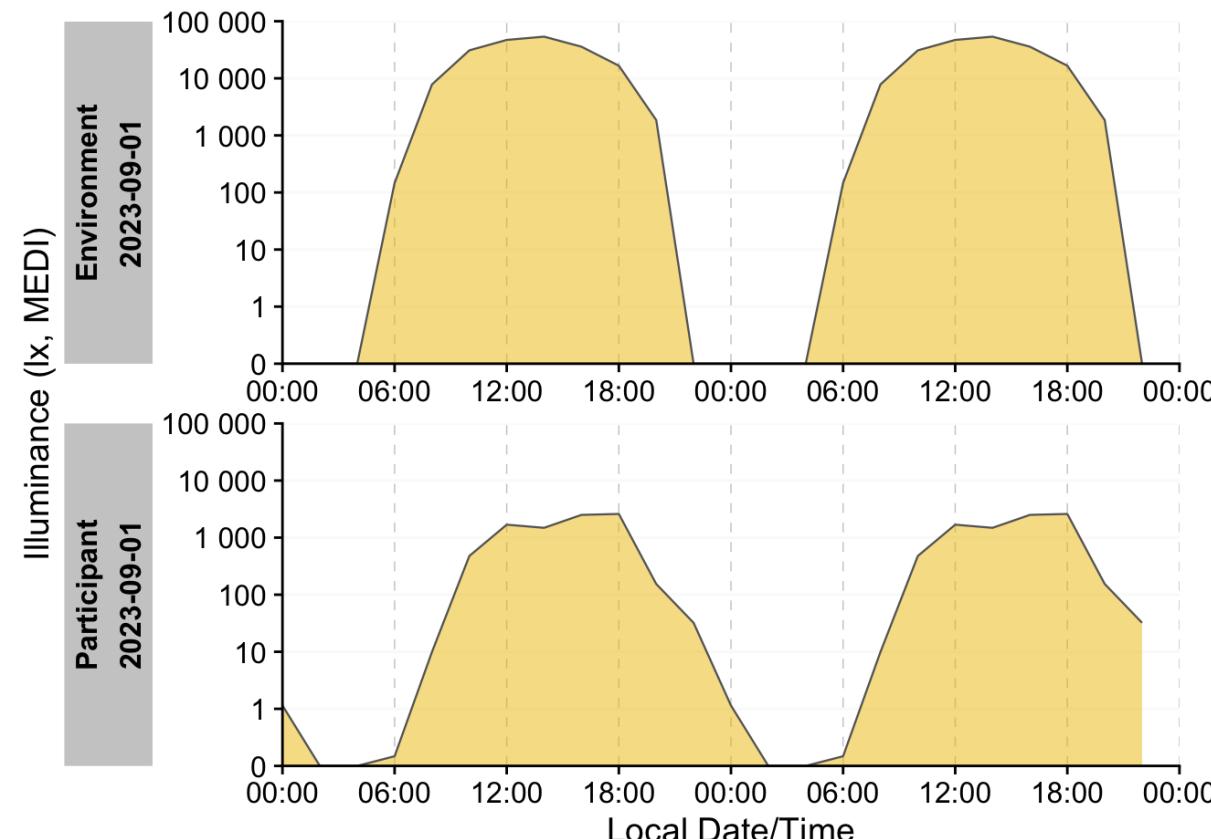
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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

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

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



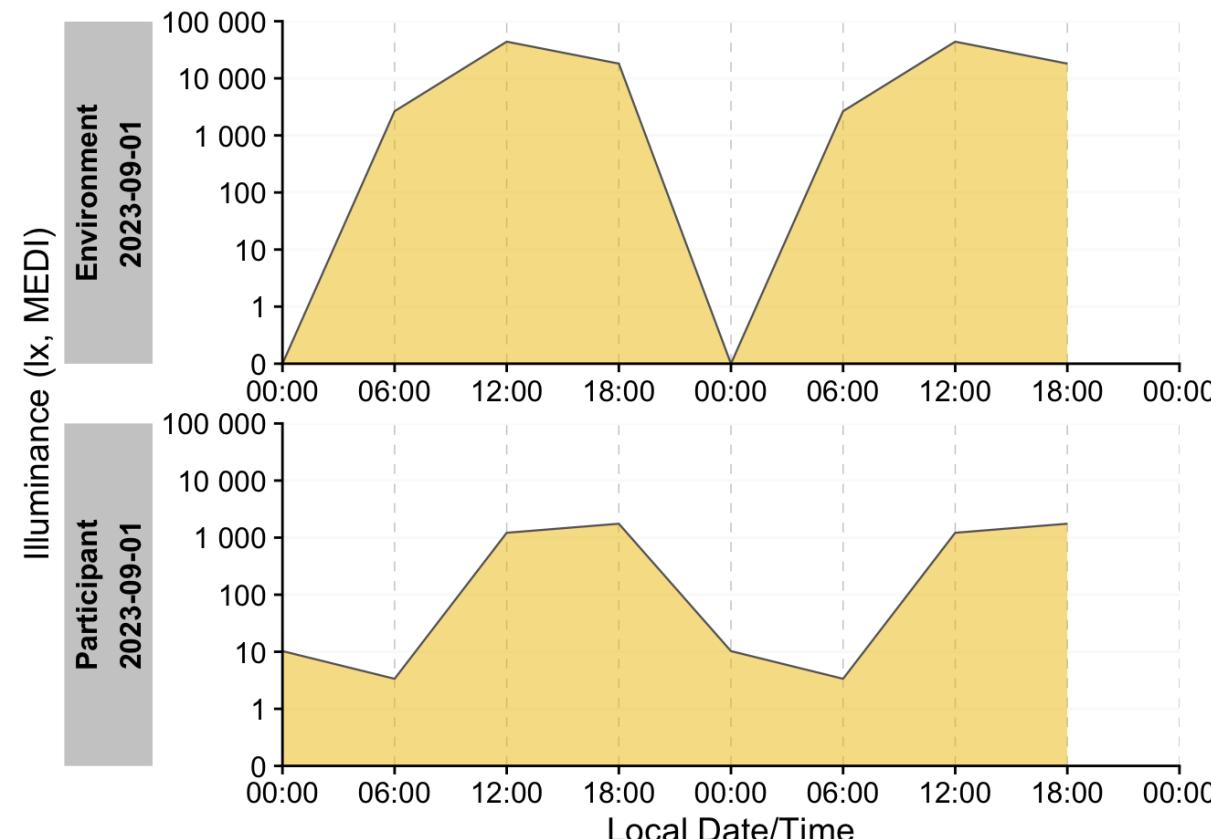
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
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)
```

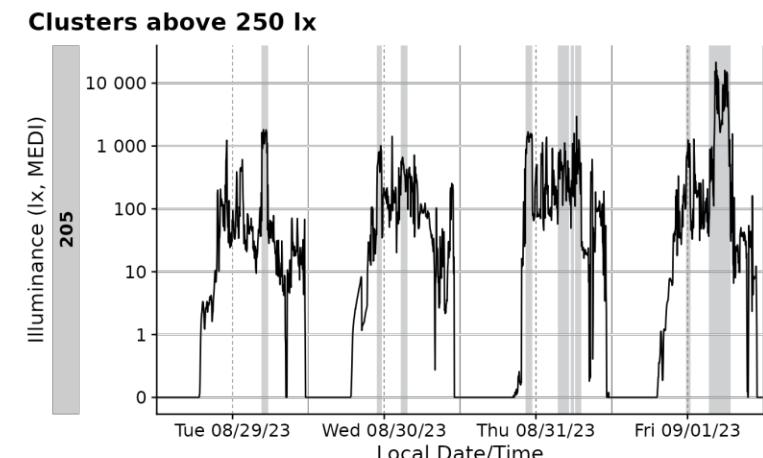
```
data |> aggregate_Datetime() # condense observation intervals into new bins
```

```
data |>  
  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



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
```

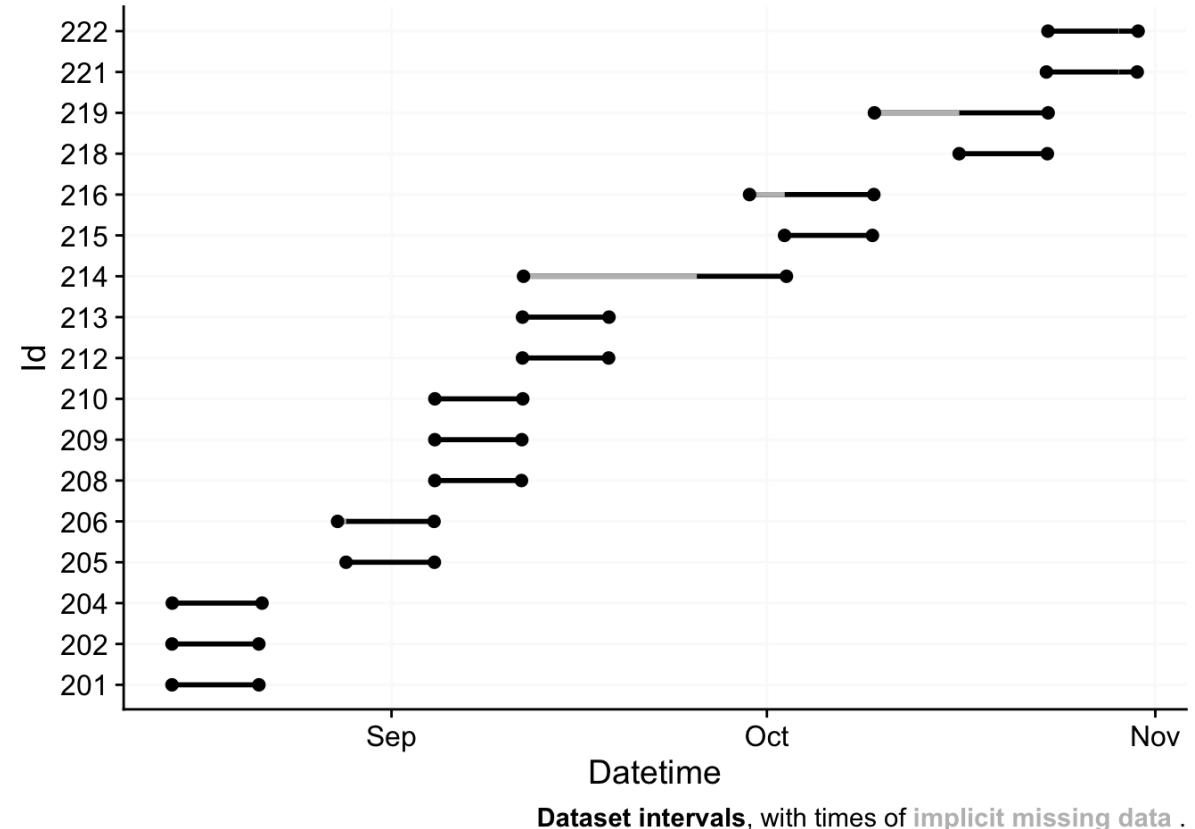
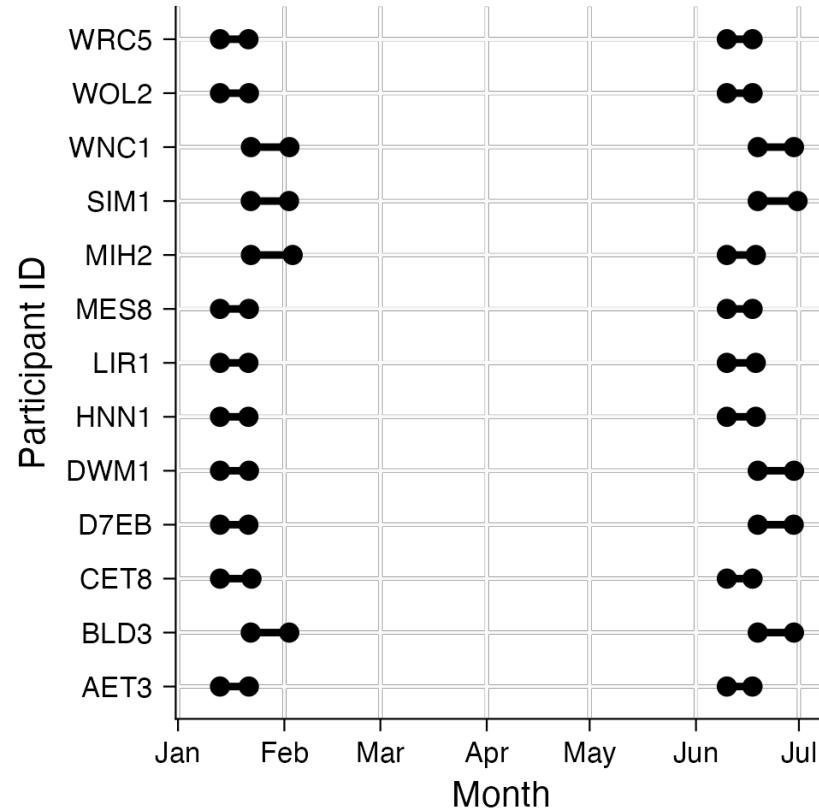


```
data |> Brown_rec() / _check() / _cut() # work with Brown et al. 2022 recommendations
```

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

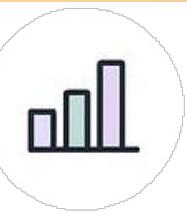


```
data |> gg_overview()
```



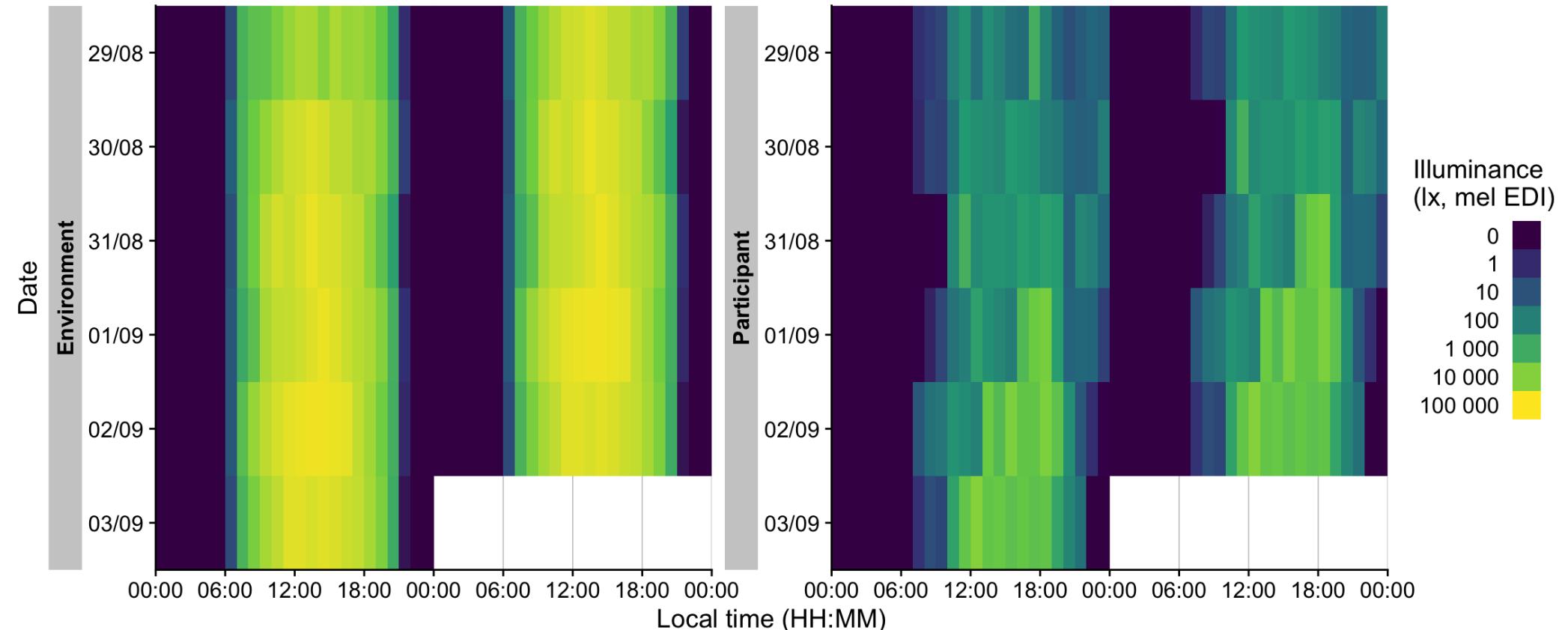
Dataset intervals, with times of implicit missing data .

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



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

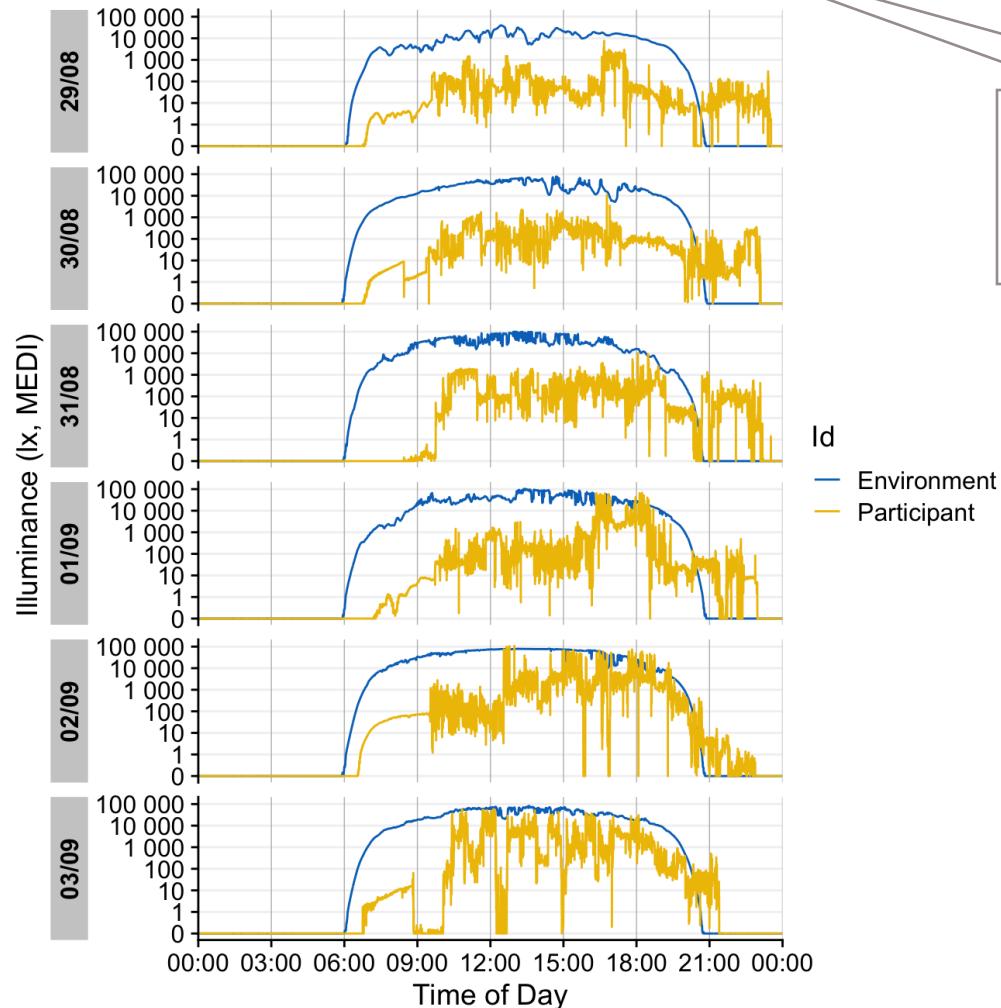
Shows the next day
to visualize patterns
across midnight



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

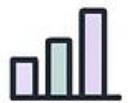


```
data |> gg_day(aes_col = Id)
```

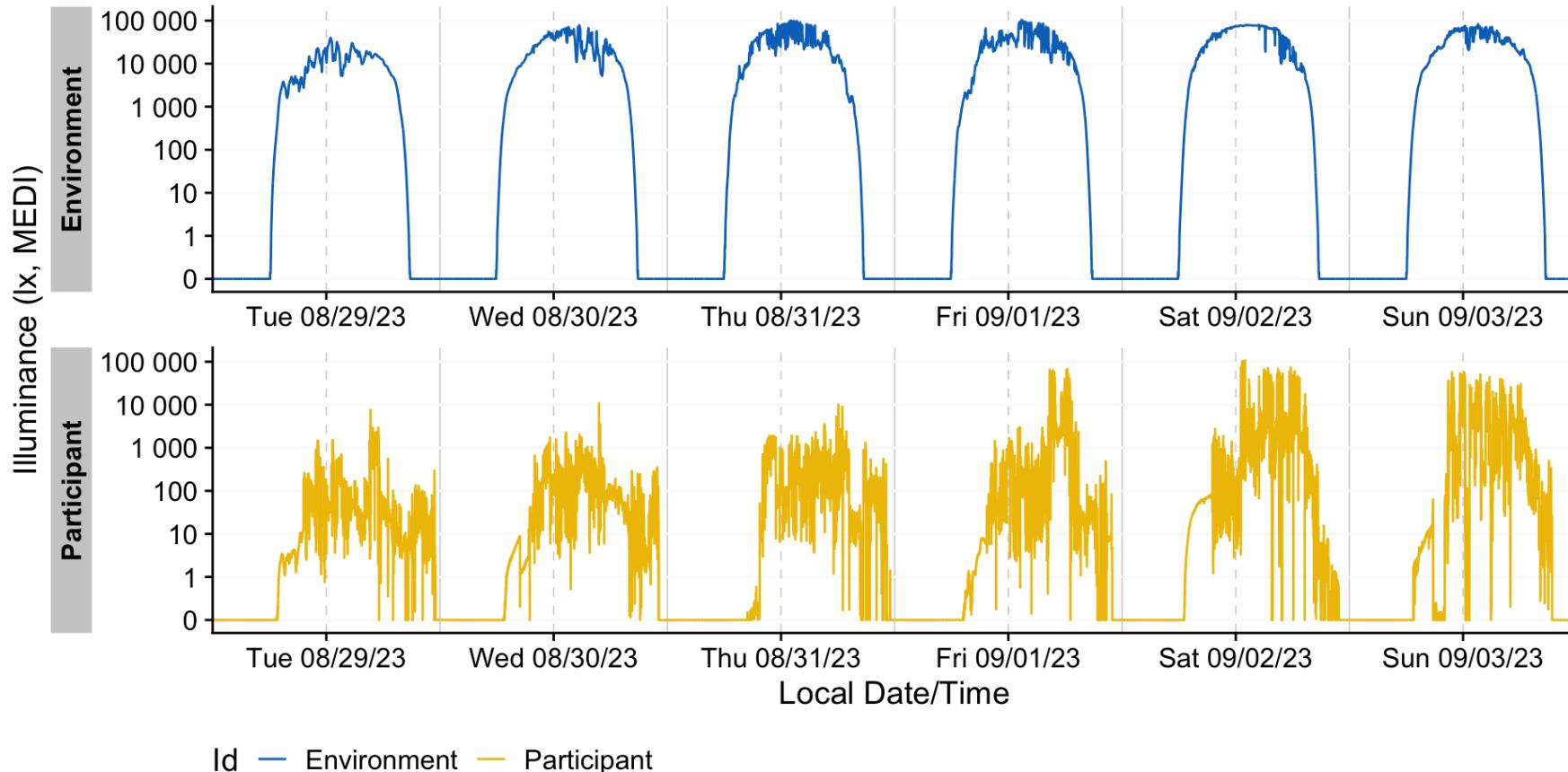


Sets individual colors
for every Id

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

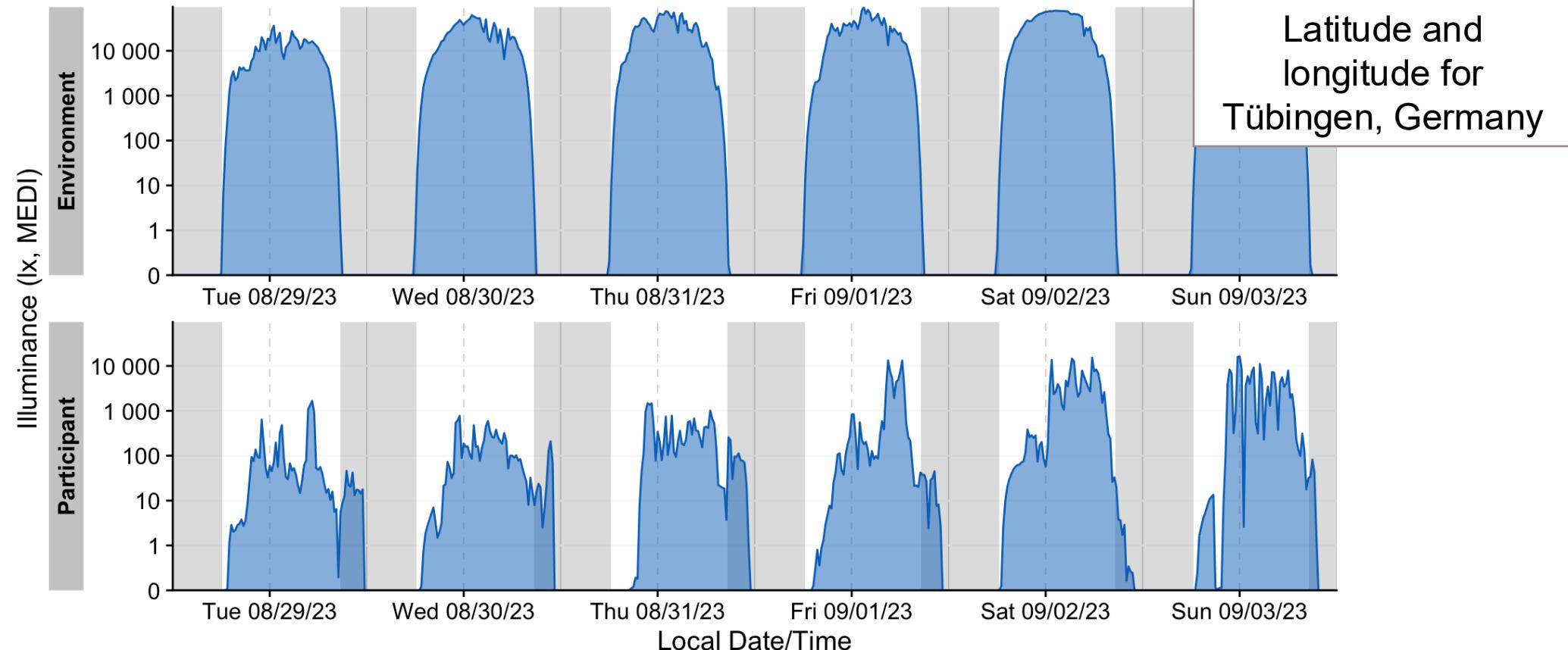


```
data |> gg_days(aes_col = Id)
```



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))
```



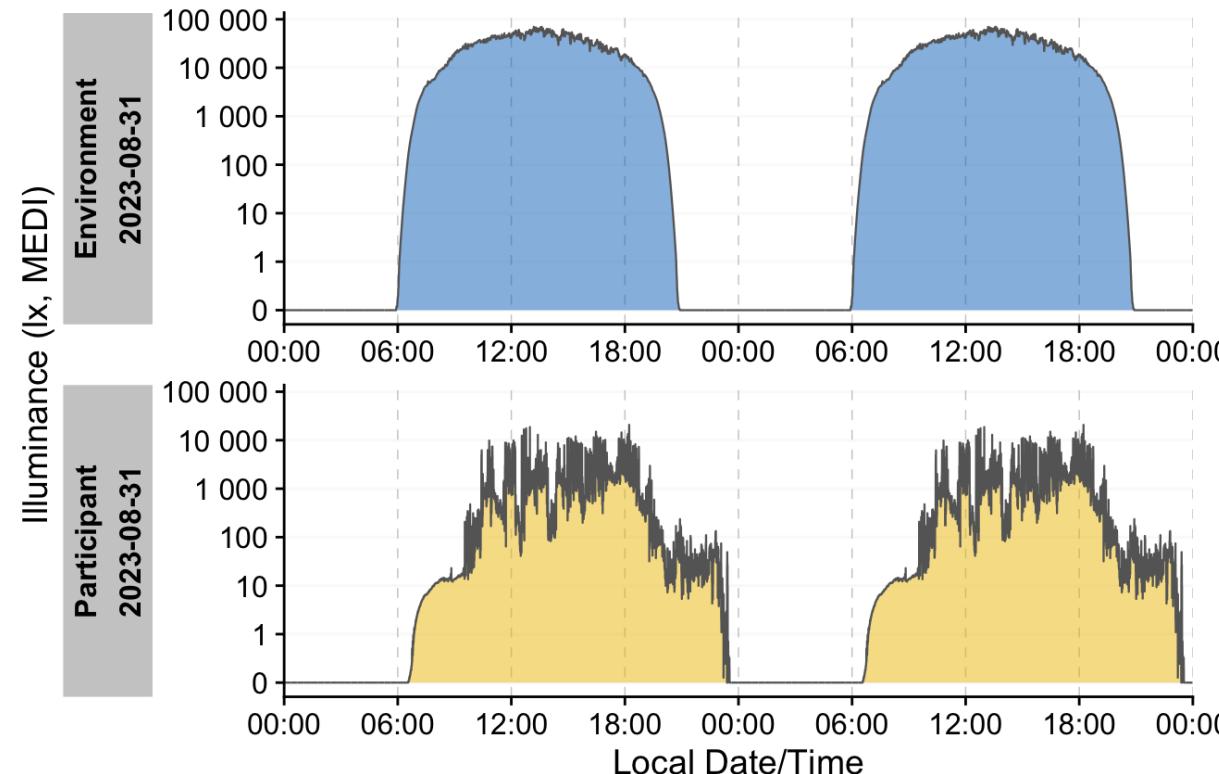
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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



Condenses data into
a single day per
group



Id Environment Participant

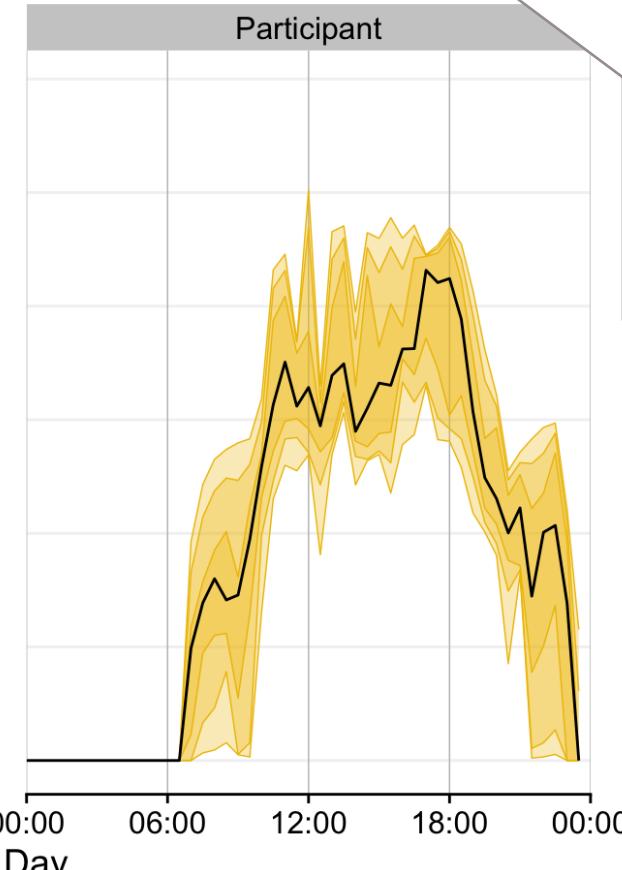
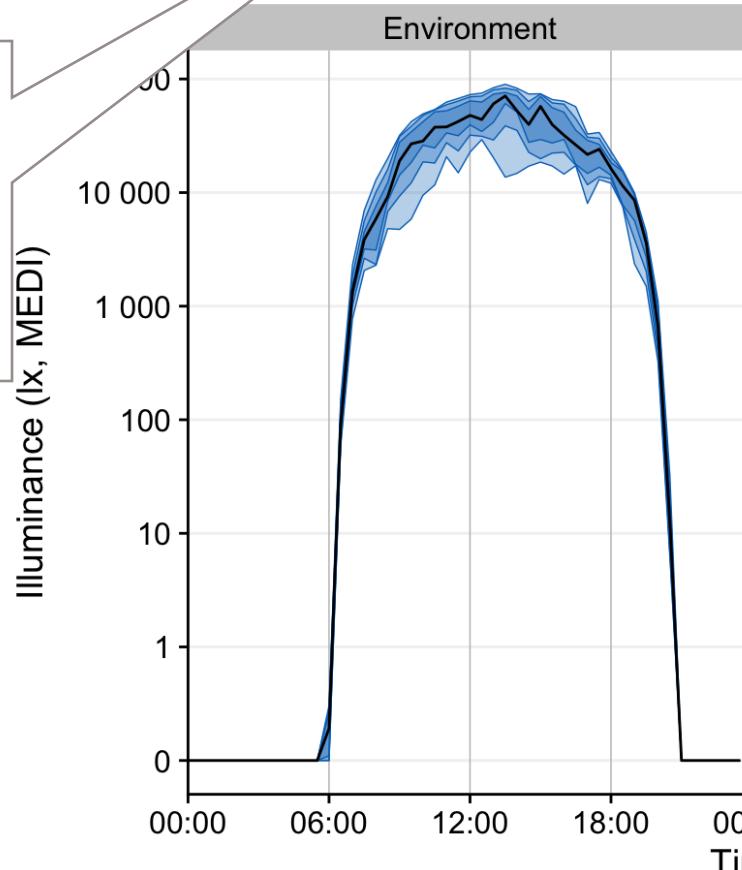
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
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

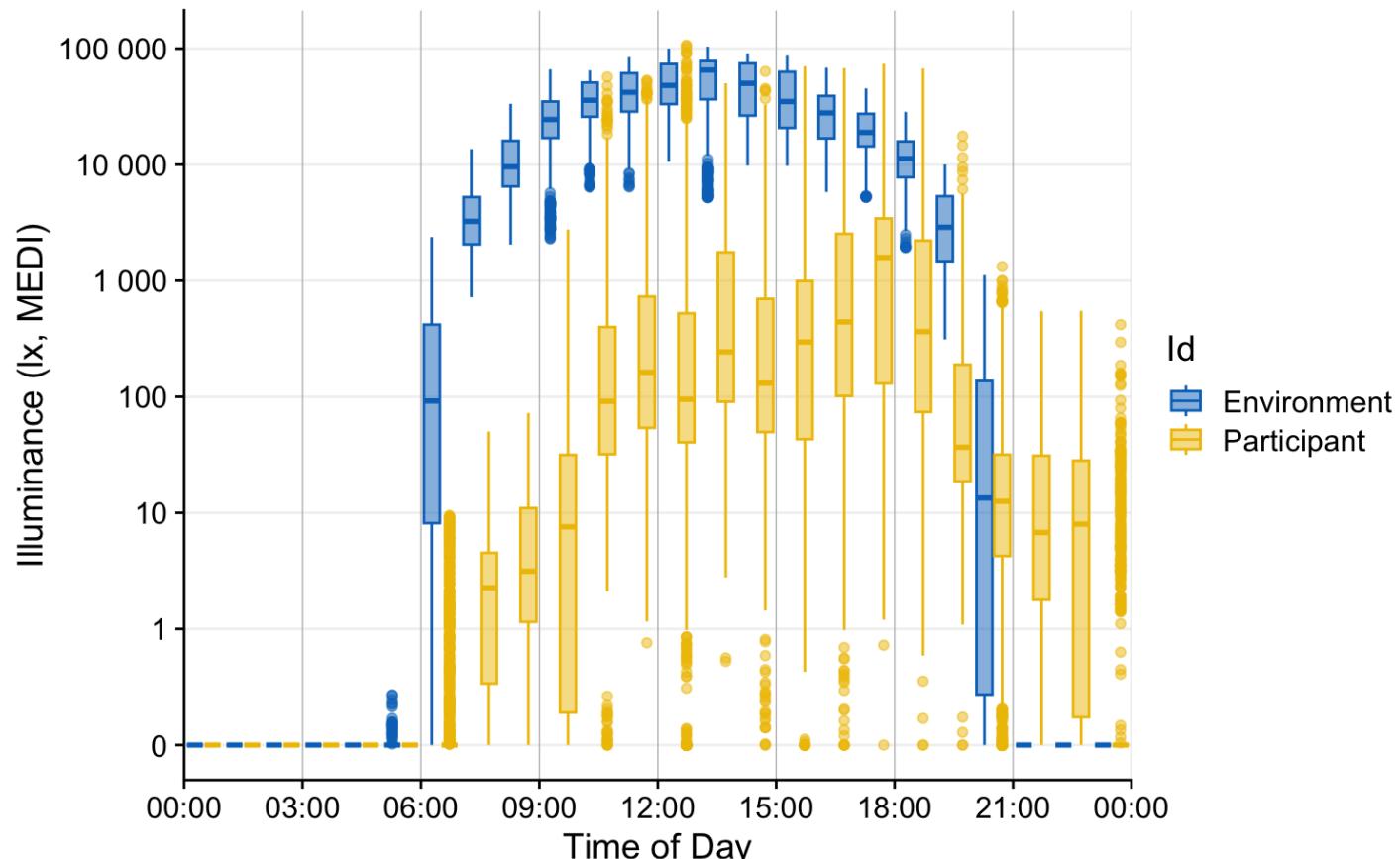


Not a LightLogR function = not a problem
-> Interfaces nicely with standard plot library

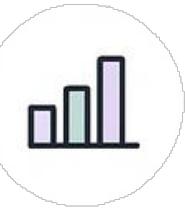
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation

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

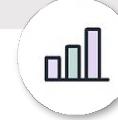
Adds a new column
with 1hour sections



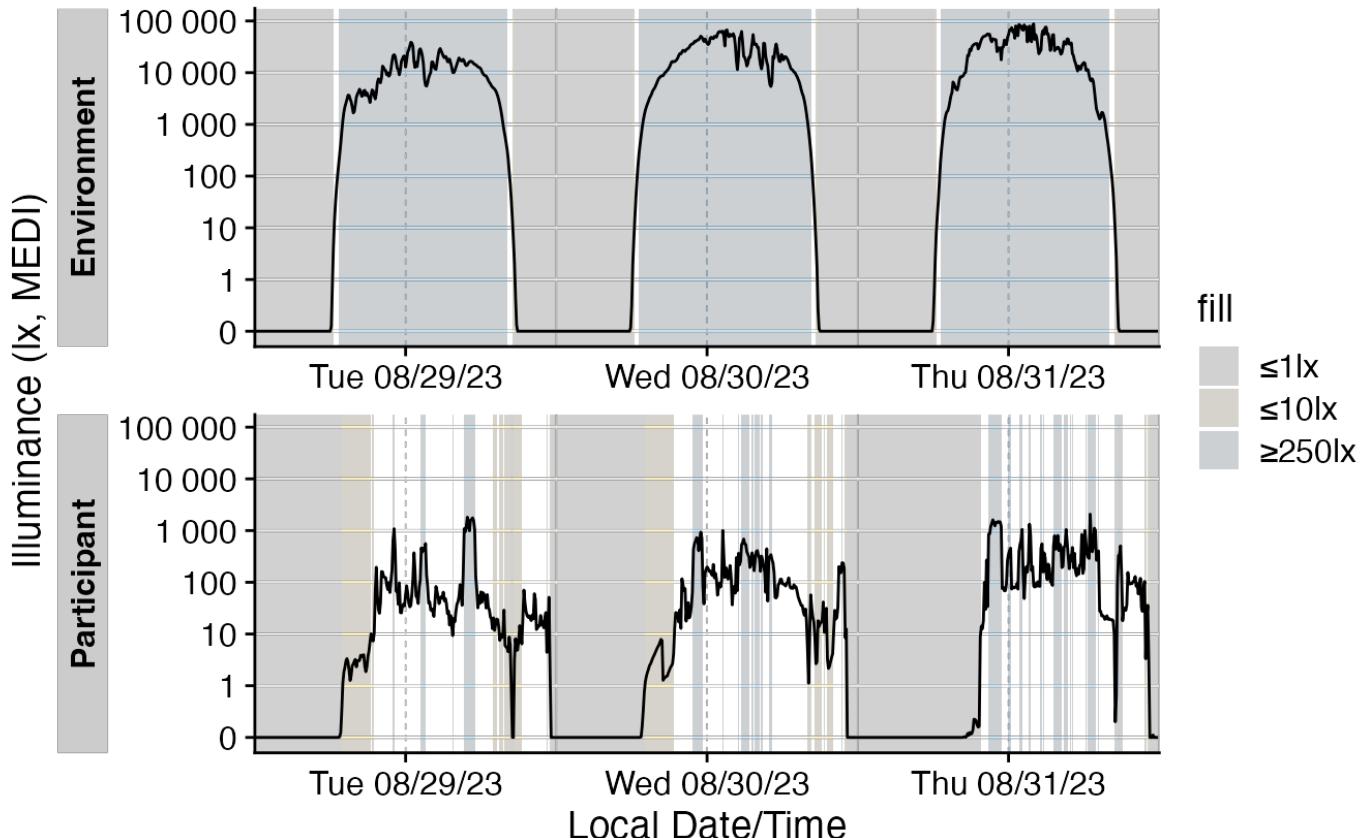
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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



adds a new column
'state'



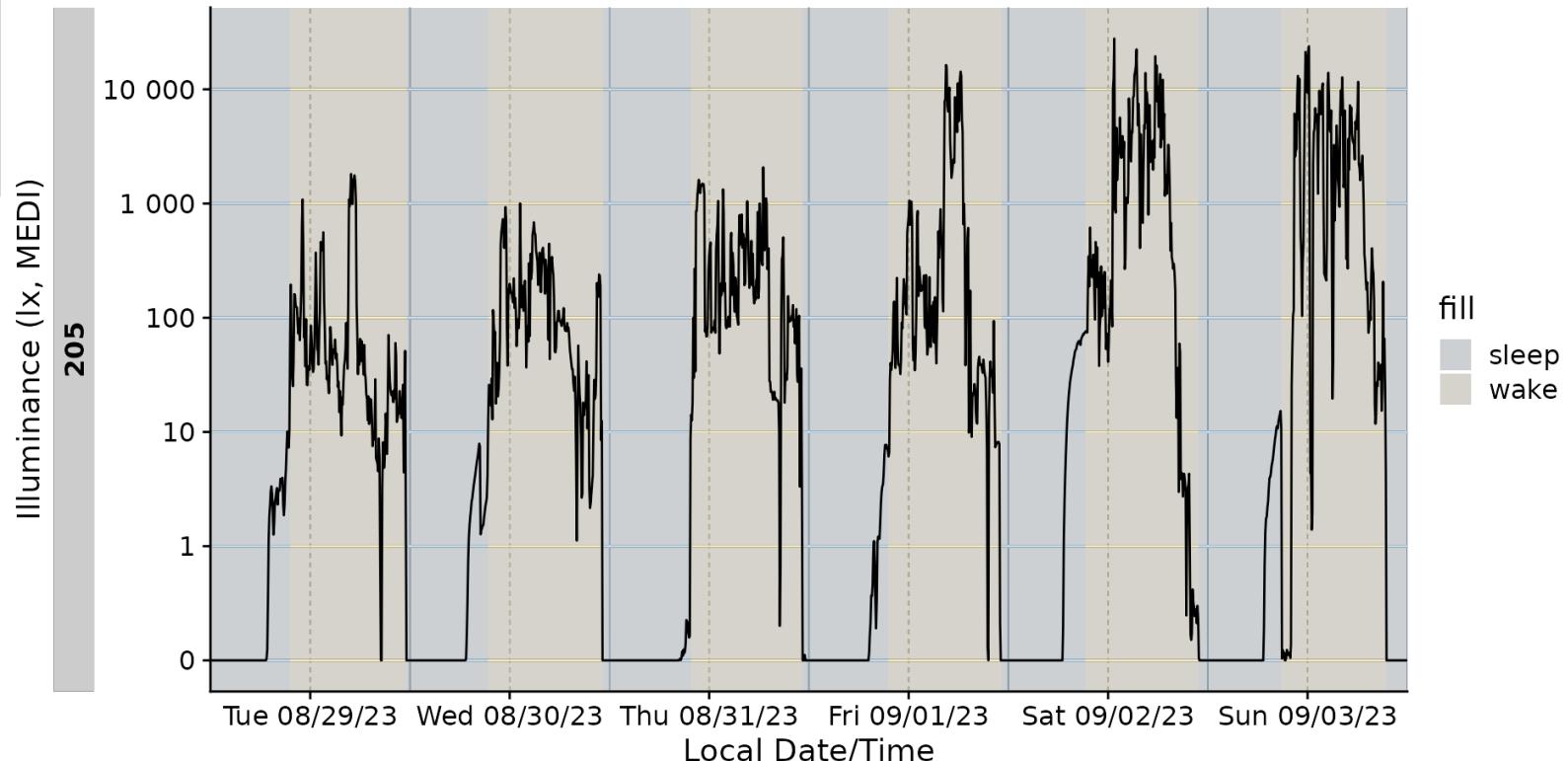
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



```
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

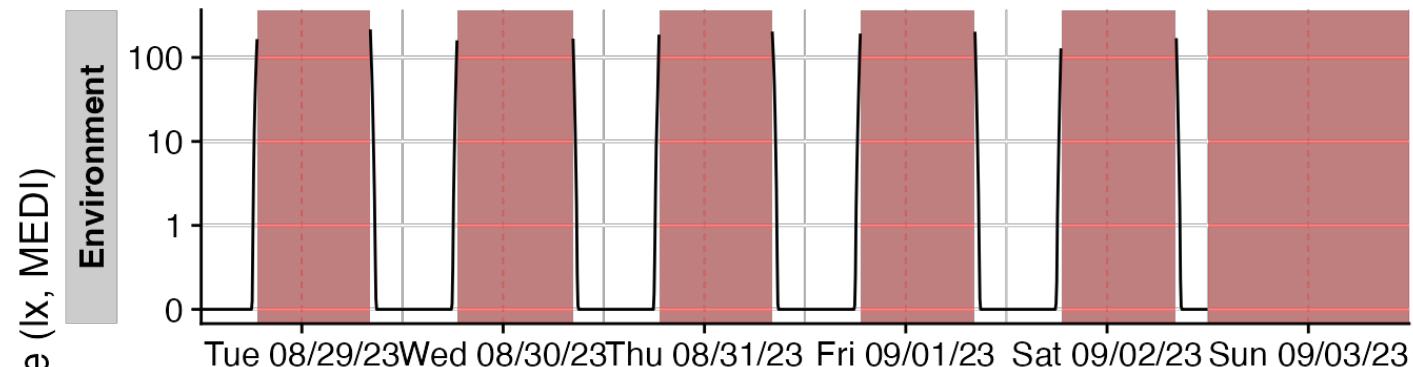


```
data |> ... |> gg_gaps(MEDI)
```



Throw data above a given threshold away

Gaps in the data (red)

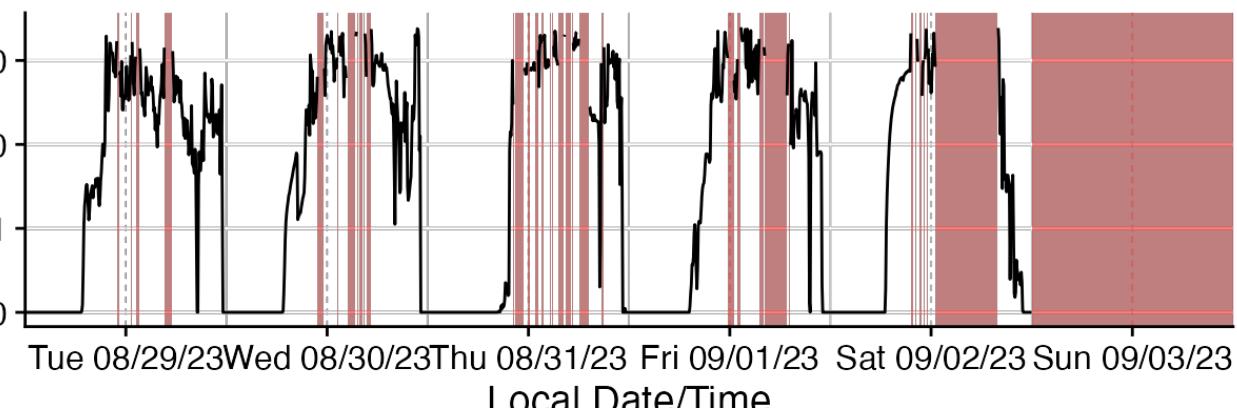


Will only show groups that have gaps

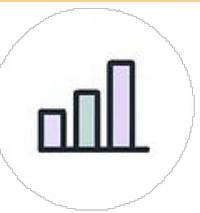
Participant

Environment

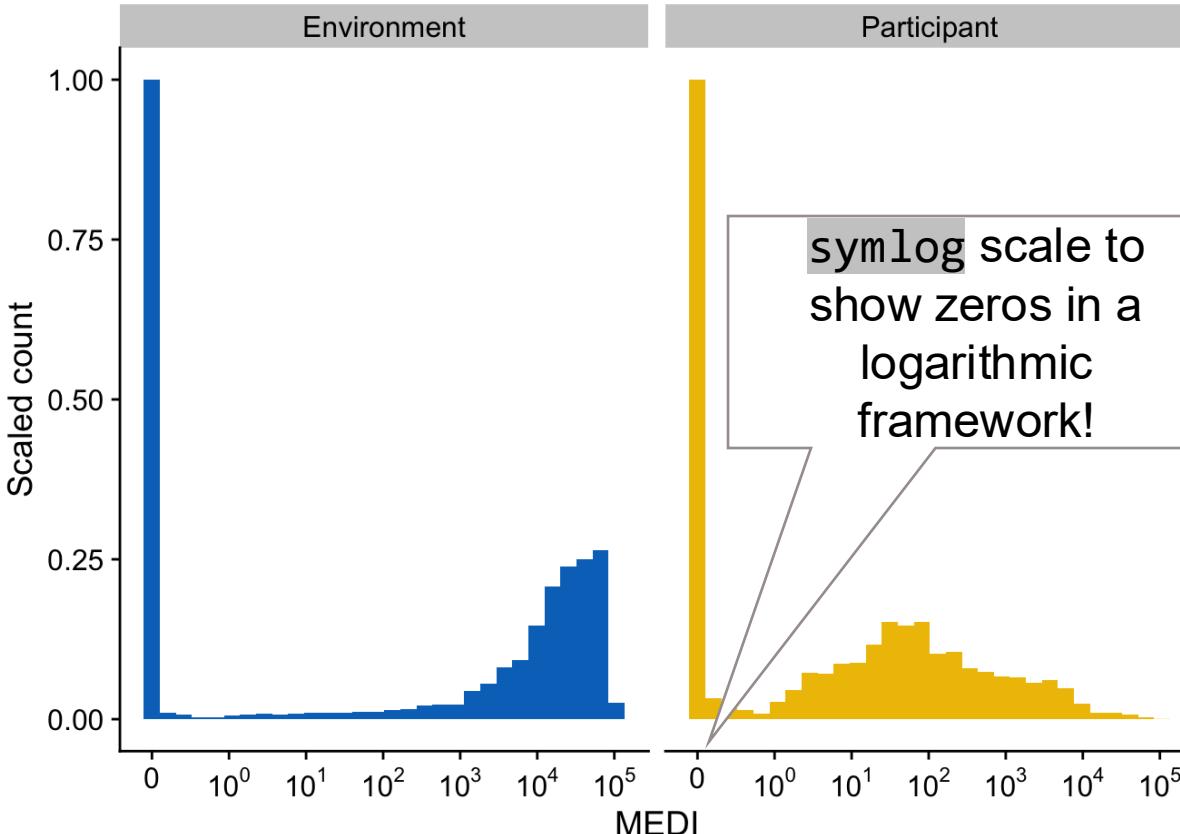
Illuminance (lx, MEDI)



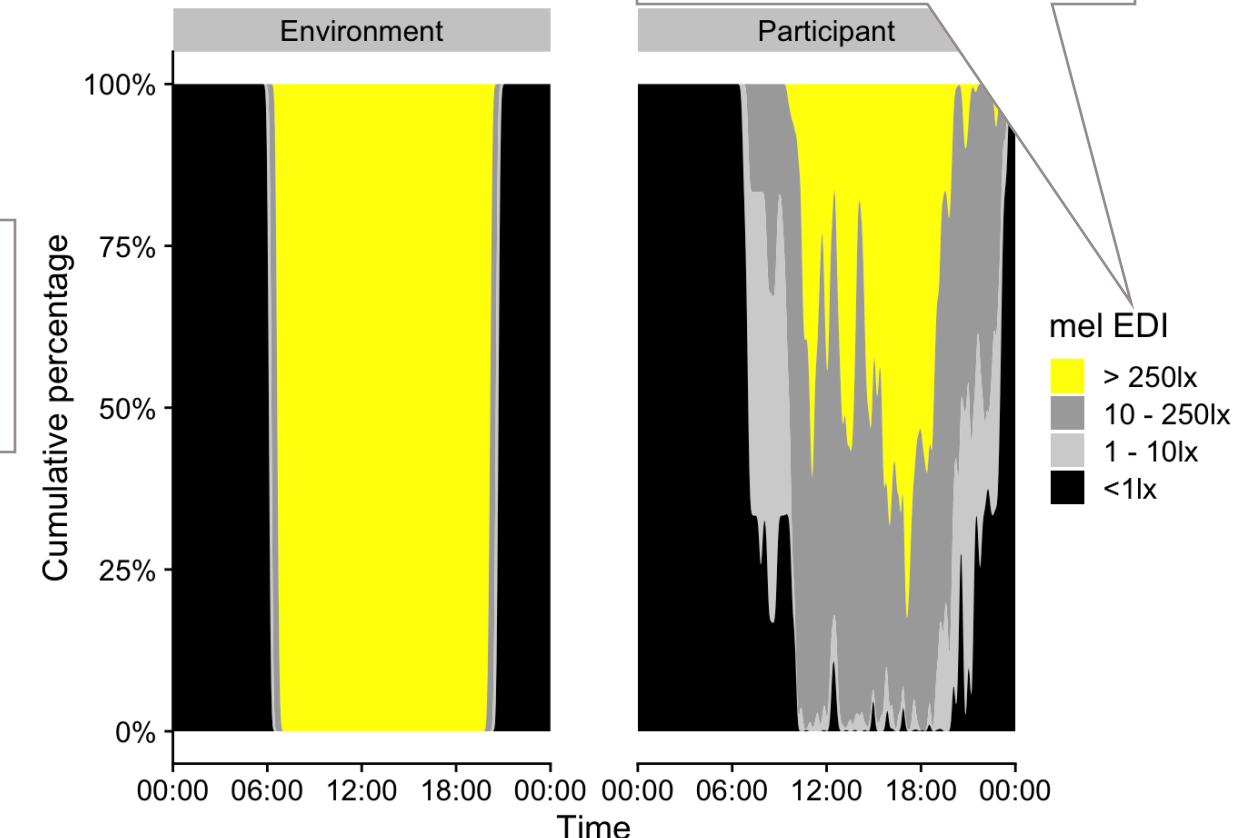
LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



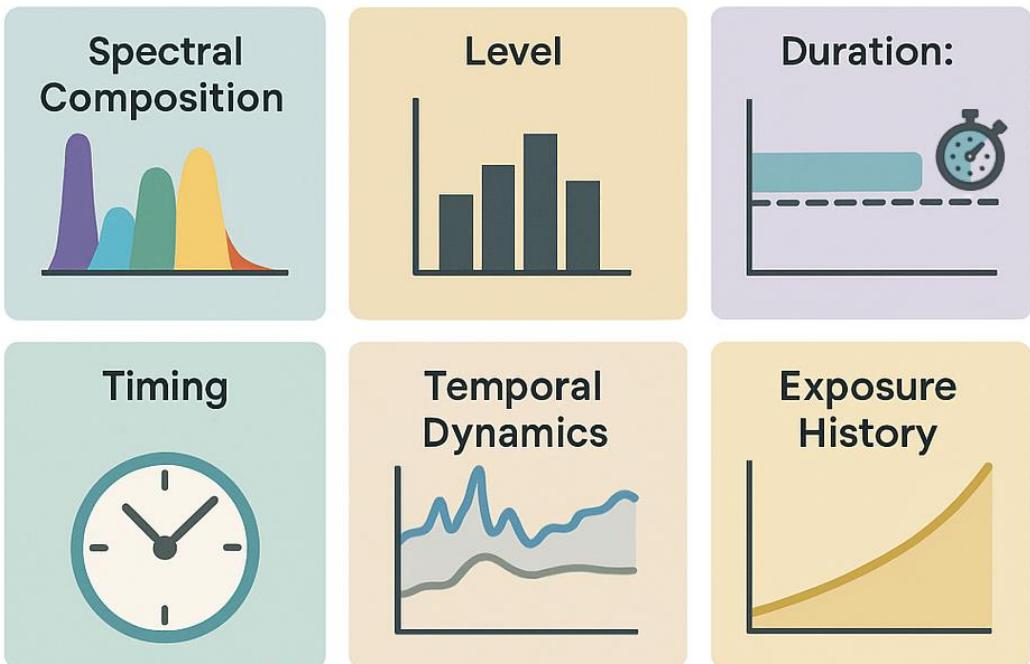
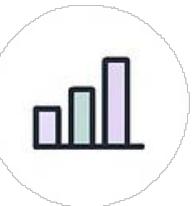
These are standard visualizations that use LightLogRs functionality in parts



`cut_Brown()` facilitates these and other dividers

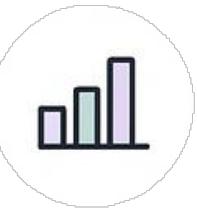


LightLogR enables reproducible data analysis from many light logger models, including visualizations and metric calculation



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	
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)  
  )
```

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)

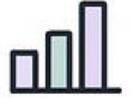
Add weekday information and get outputs for each participant and day

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

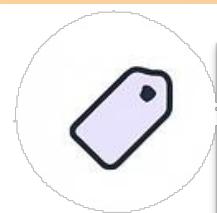


```
data |>  
  add_Date_col(group_by = TRUE) |>  
  summarize(  
    duration_above_threshold(MEDI, Datetime, "above", 250, as.df = TRUE),  
    bright_dark_period(MEDI, Datetime, "brightest", "10 hours", loop = TRUE),  
    ...  
  )
```

Add as many metrics as needed

	Malaysia			Switzerland			n	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



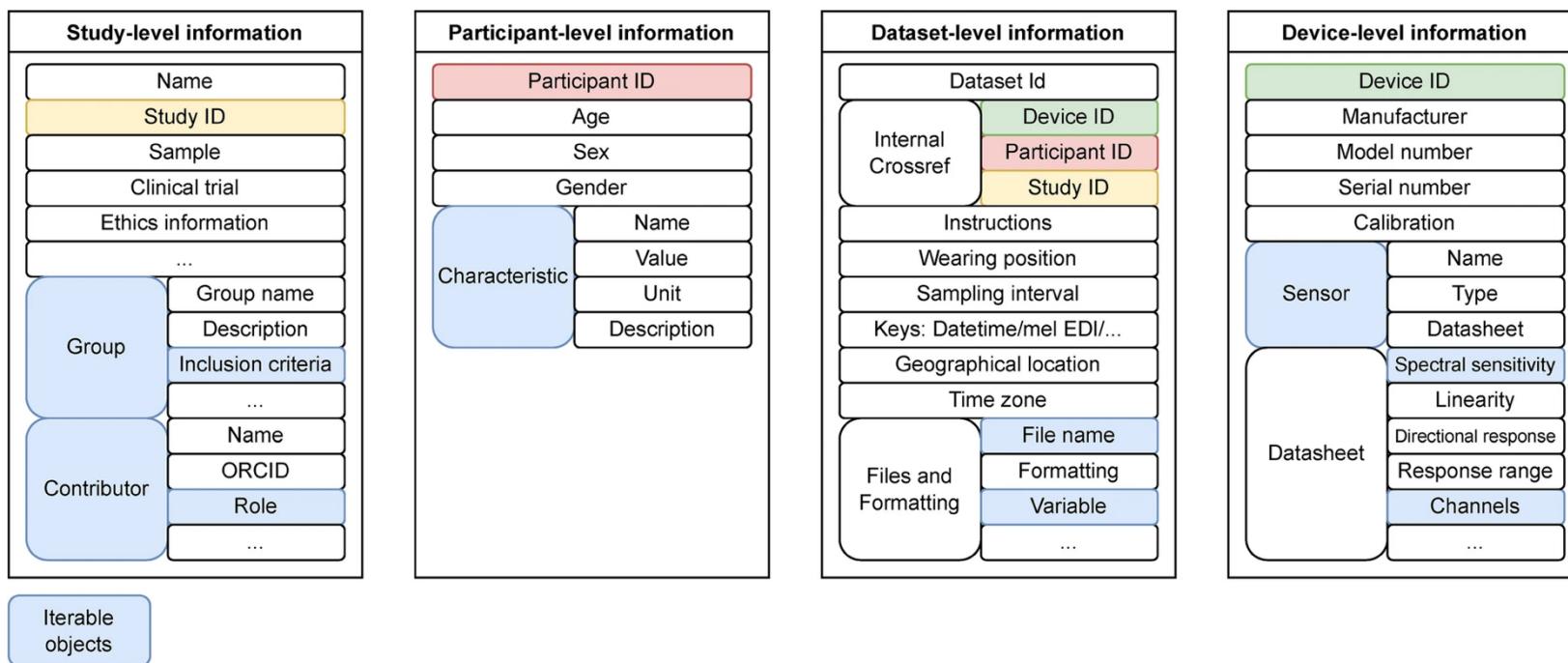
SOFTWARE Open Access

Check for updates

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}, Nayantara 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>



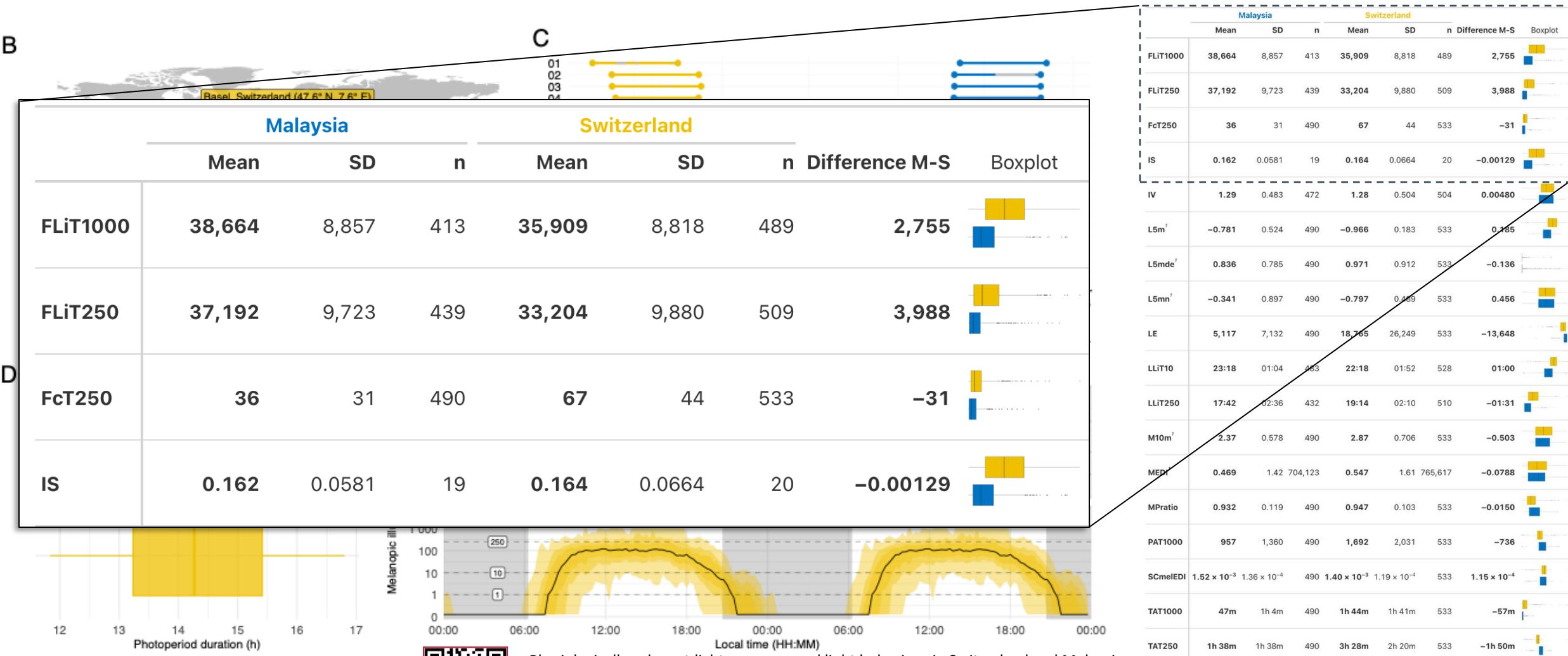
Developing toolsets to access LightLogRs core functionality without programming are on the way. Data glance as proof-of-concept.



https://tscnlab.shinyapps.io/MeLiDos_Data_Glance/



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



	Malaysia			Switzerland			n	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		
IV	1.29	0.483	472	1.28	0.504	504	0.00480		
L5m ^t	-0.781	0.524	490	-0.966	0.183	533	0.185		
L5md ^t	0.836	0.785	490	0.971	0.912	533	-0.136		
L5mn ^t	-0.341	0.897	490	-0.797	0.269	533	0.456		
LE	5,117	7,132	490	18,765	26,249	533	-13,648		
LLiT10	23:18	01:04	483	22:18	01:52	528	01:00		
LLiT250	17:42	02:36	432	19:14	02:10	510	-01:31		
M10m ^t	2.37	0.578	490	2.87	0.706	533	-0.503		
MEDI	0.469	1.42	704,123	0.547	1.61	765,617	-0.0788		
MPratio	0.932	0.119	490	0.947	0.103	533	-0.0150		
PAT1000	957	1,360	490	1,692	2,031	533	-736		
SCmelEDI	1.52×10^{-3}	1.36×10^{-4}	490	1.40×10^{-3}	1.19×10^{-4}	533	1.15×10^{-4}		
TAT1000	47m	1h 4m	490	1h 44m	1h 41m	533	-57m		
TAT250	1h 38m	1h 38m	490	3h 28m	2h 20m	533	-1h 50m		
TATd250	1h 36m	1h 36m	490	3h 25m	2h 18m	533	-1h 49m		
TBTe10	2h 32m	1h 5m	490	2h 39m	1h 1m	533	-7m		

^t values were log10 transformed



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!