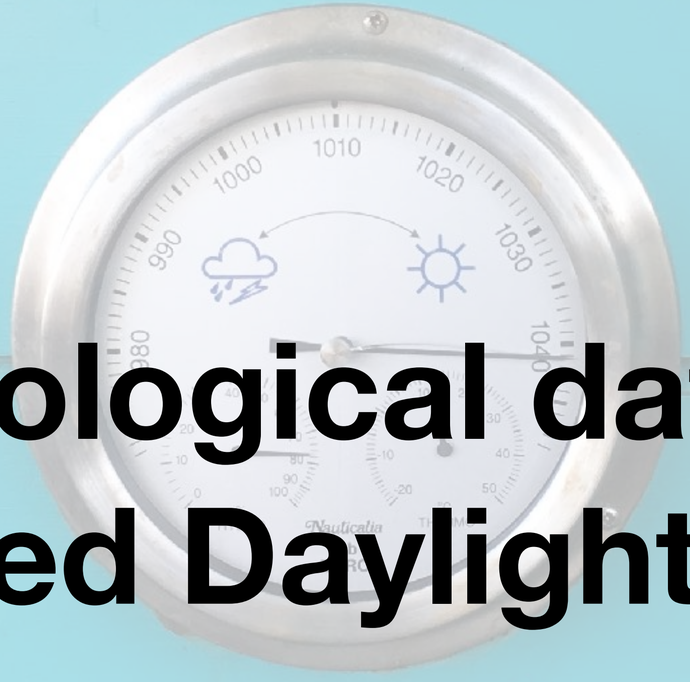


Meteorological data for Climate-Based Daylight Modelling

Eleonora Brembilla

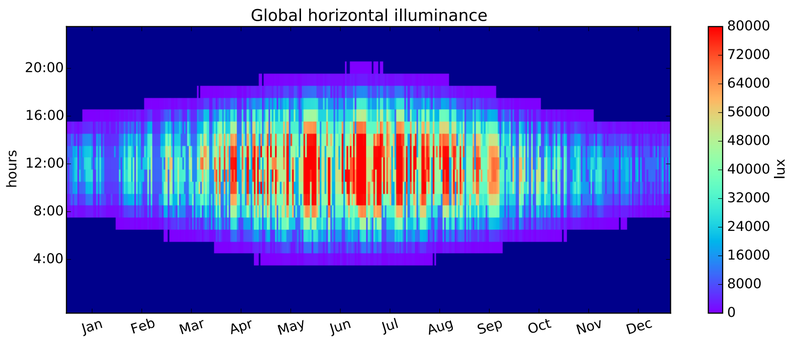
School of Architecture, Building and Civil Engineering
Loughborough University

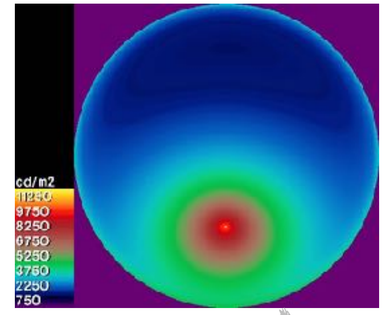
Loughborough University

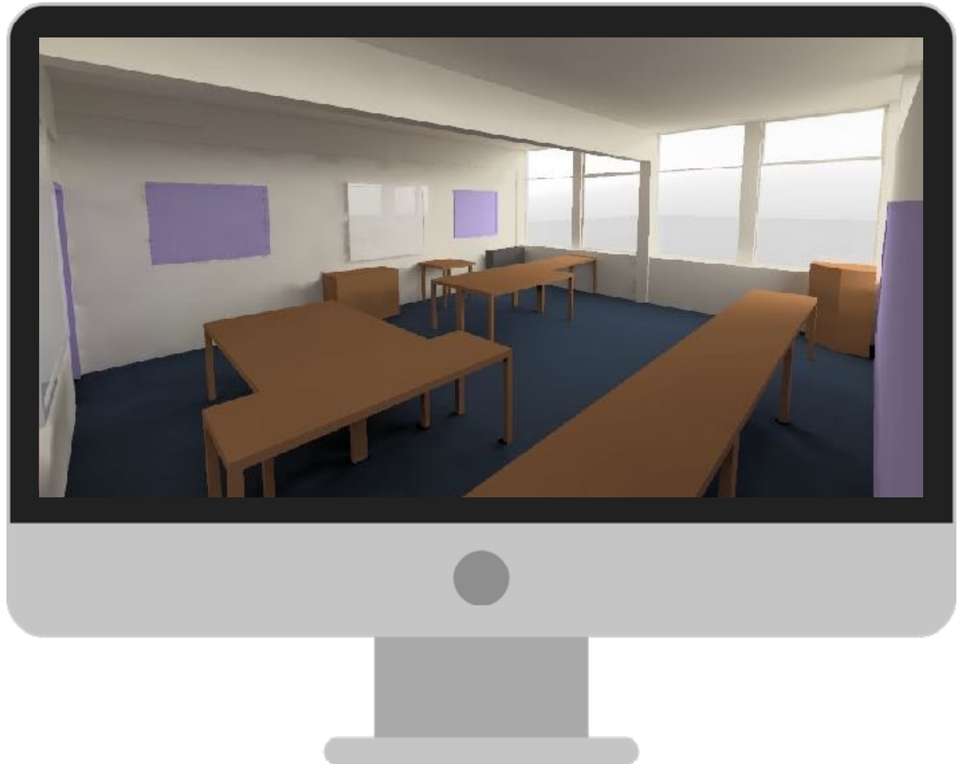
CIBSE

Climate-Based Daylight Modelling:
The assessment of the
luminous conditions within the built environment
that makes use of
representative climate data
to recreate
realistic sky luminance distributions,
at hourly or sub-hourly consecutive steps, by means of
physically accurate lighting simulation tools.

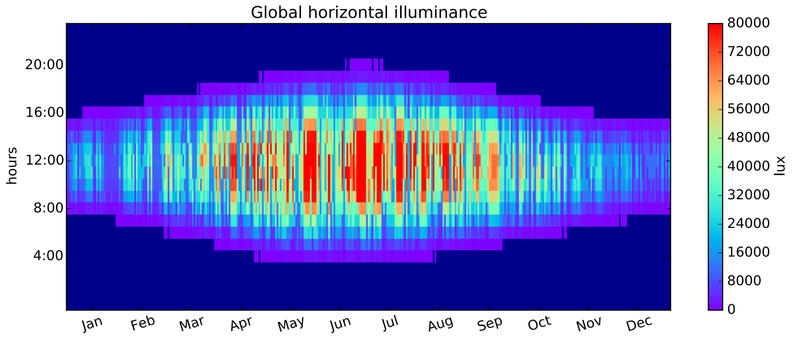
e.g. Radiance



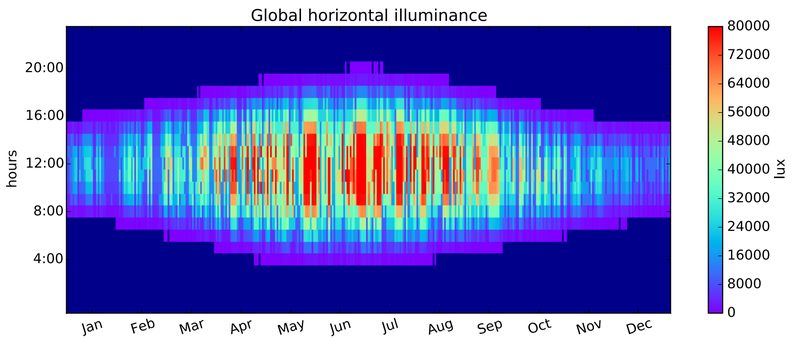




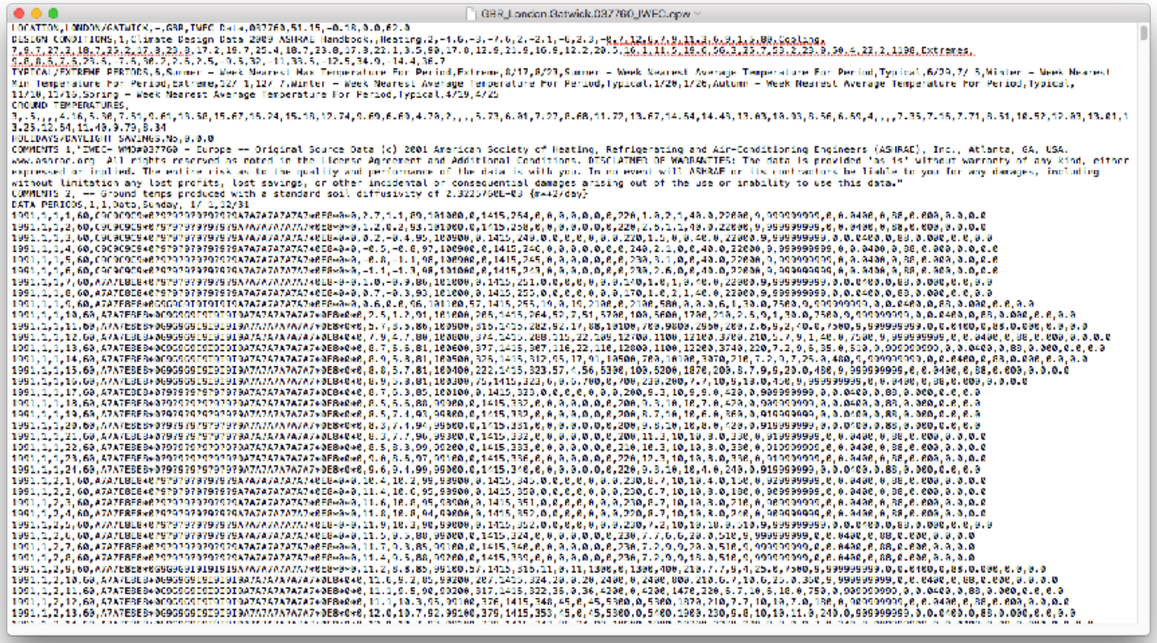
representative climate data



For Building Performance Simulation applications:
EPW (EnergyPlus Weather) format



representative climate data



- Global horizontal irradiance [W/m2]
- Direct normal irradiance [W/m2]
- Diffuse horizontal irradiance [W/m2]

- Global horizontal illuminance [klux]
- Direct normal illuminance [klux]
- Diffuse horizontal illuminance [klux]

- Cloud-Cover [0-8]
- Solar geometry

CRM (Cloud Radiation Model)
(Kasten-Czeplak 1980)

- Global horizontal irradiance [W/m2]
- Direct normal irradiance [W/m2]
- Diffuse horizontal irradiance [W/m2]
- Dew point temperature [°C]

Luminous Efficacy Model
(Perez 1990)

- Global horizontal illuminance [klux]
- Direct normal illuminance [klux]
- Diffuse horizontal illuminance [klux]

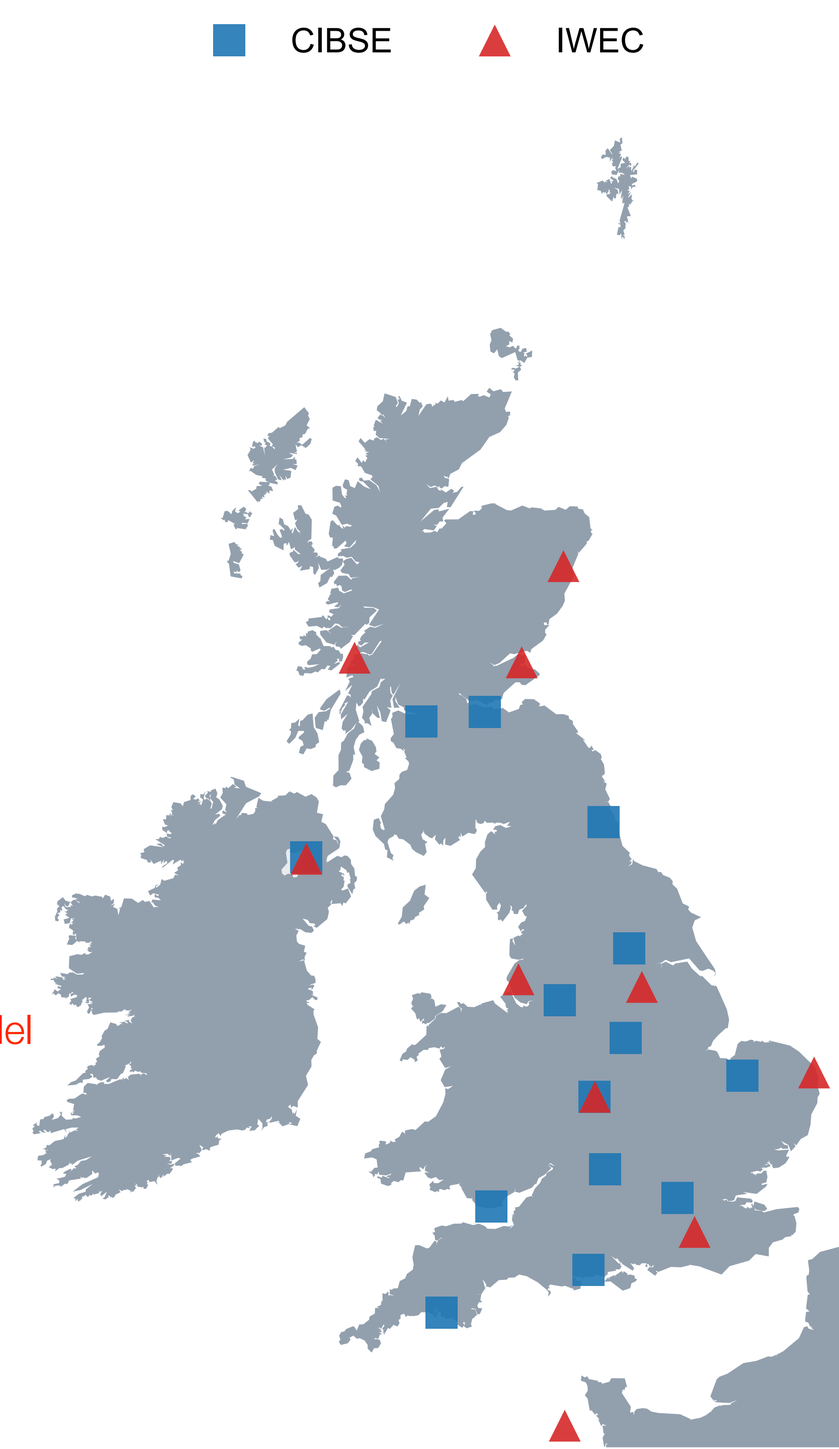
- Cloud-Cover [0-8]
- Solar geometry
- Temperature [°C]
- Dew point temperature [°C]

Kasten 1983 +
METSTAT models

- Global horizontal irradiance [W/m2]
- Direct normal irradiance [W/m2]
- Diffuse horizontal irradiance [W/m2]
- Dew point temperature [°C]

Luminous Efficacy Model
(Perez 1990)

- Global horizontal illuminance [klux]
- Direct normal illuminance [klux]
- Diffuse horizontal illuminance [klux]



0

1

2

?

/

8

(9)

www.metoffice.gov.uk/guide/weather/observations-guide/how-we-measure-cloud

CRM (Cloud Radiation Model)
(Kasten-Czeplak 1980)

Baseline Surface Radiation Network
(BSRN)

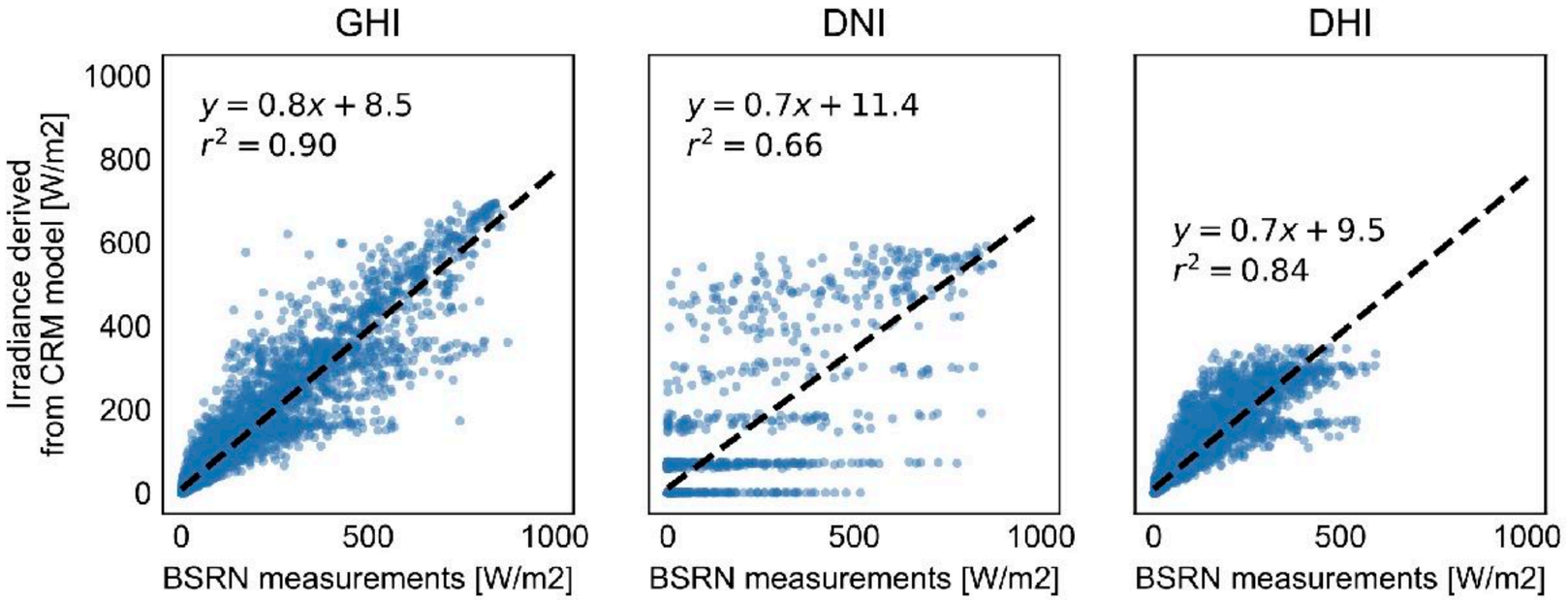
- 1-min time step
- Global horizontal and direct normal irradiance [W/m2]
- 2 UK locations: Camborne and Lerwick
- 2001-present

MIDAS
(Met Office from CEDA)

- Hourly time step
- Cloud Cover [0-9]

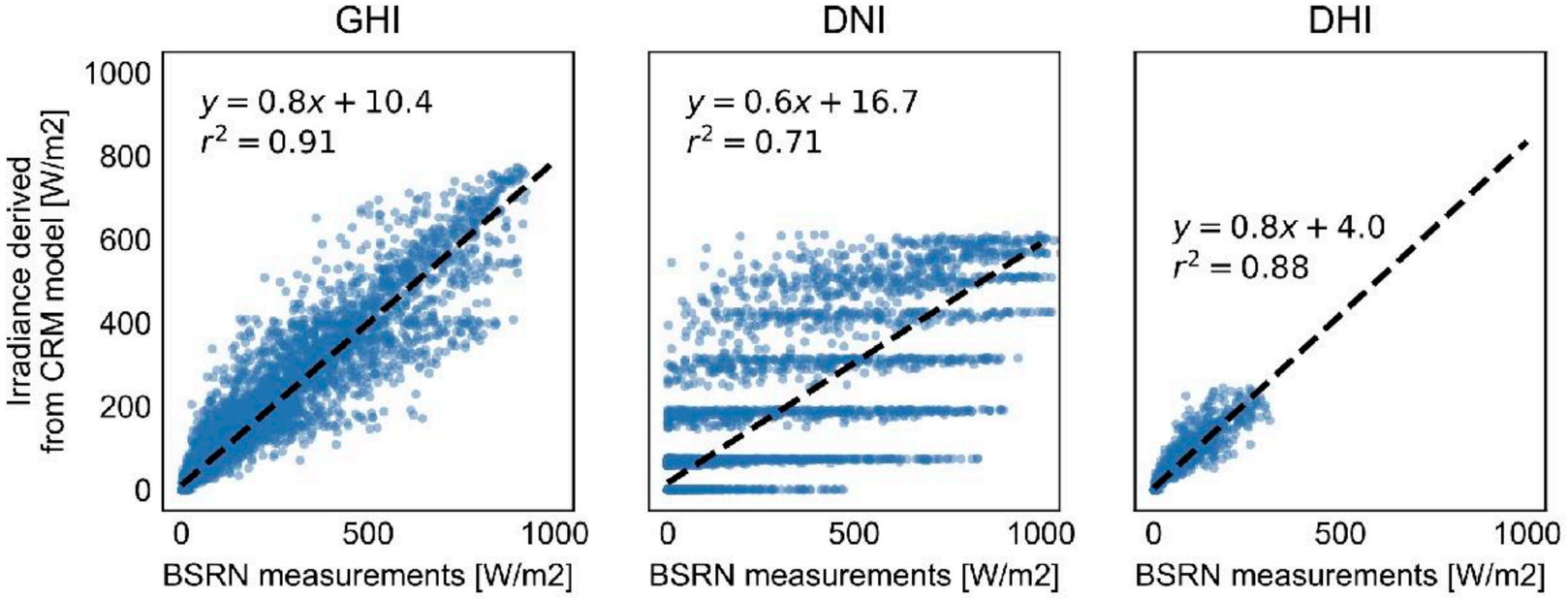
Lerwick 2016

	GHI	DNI	DHI
MBE [rMBE]	-15 W/m² [12%]	-8 W/m² [4160%]	-6 W/m² [19%]
RMSE [rRMSE]	62 W/m² [138%]	91 W/m² [29491%]	42 W/m² [132%]



Camborne 2016

	GHI	DNI	DHI
MBE [rMBE]	-17 W/m² [1.27%]	-25 W/m² [2441%]	-2 W/m² [7%]
RMSE [rRMSE]	69 W/m² [81.43%]	124 W/m² [21000%]	23 W/m² [92%]



Luminous Efficacy Model (Perez 1990)

Public Health England (PHE)

- 5-min time step
- Global horizontal illuminance [klux] and UV index
- 9 UK locations
- 2013-present

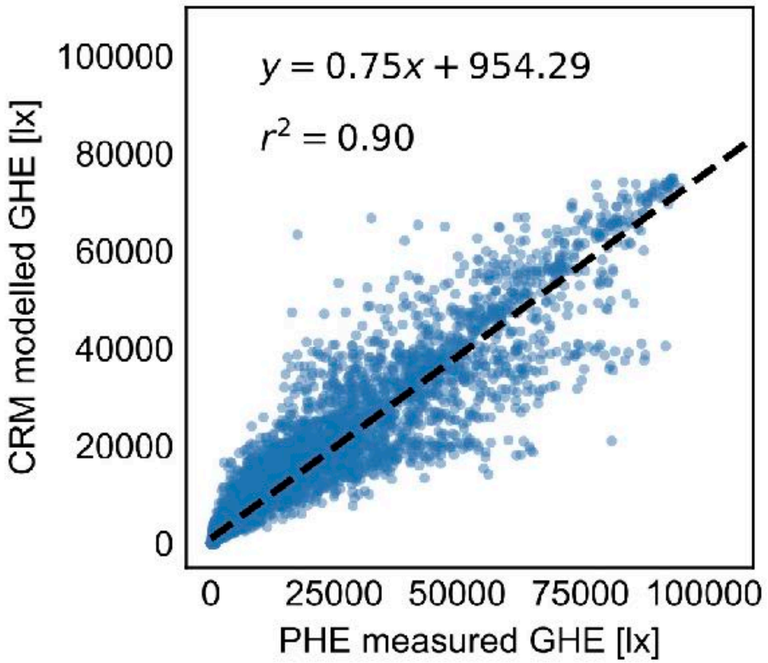
MIDAS (Met Office from CEDA)

- Hourly time step
- Cloud Cover [0-9]

Lerwick 2016

MBE = -1826.01 lx
rMBE = 7.05%

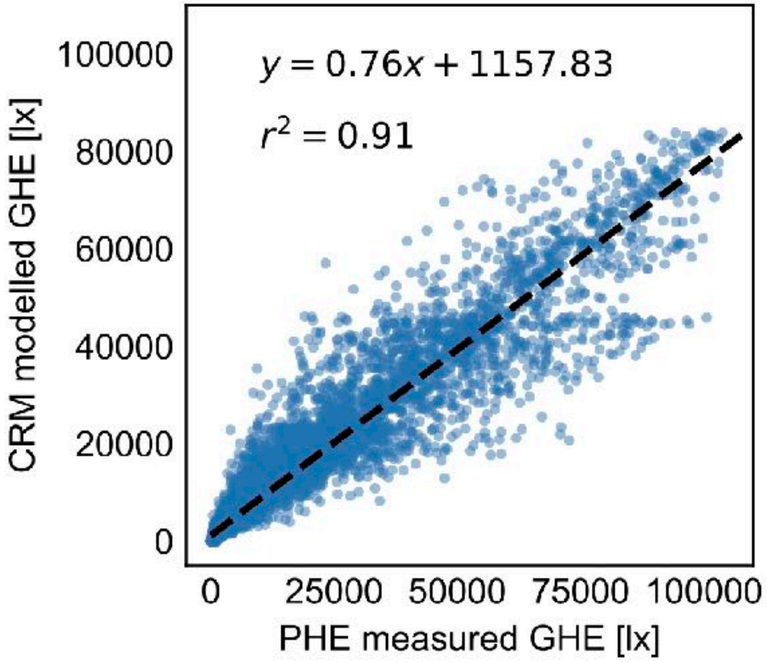
RMSE = 6900.16 lx
rRMSE = 88.47%



Camborne 2016

MBE = -2127.89 lx
rMBE = 0.48%

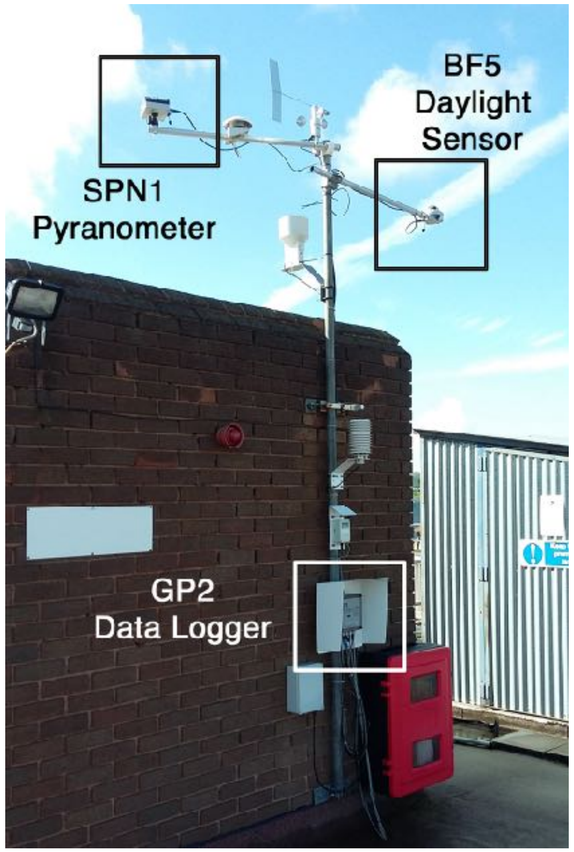
RMSE = 7732.98 lx
rRMSE = 72.98%

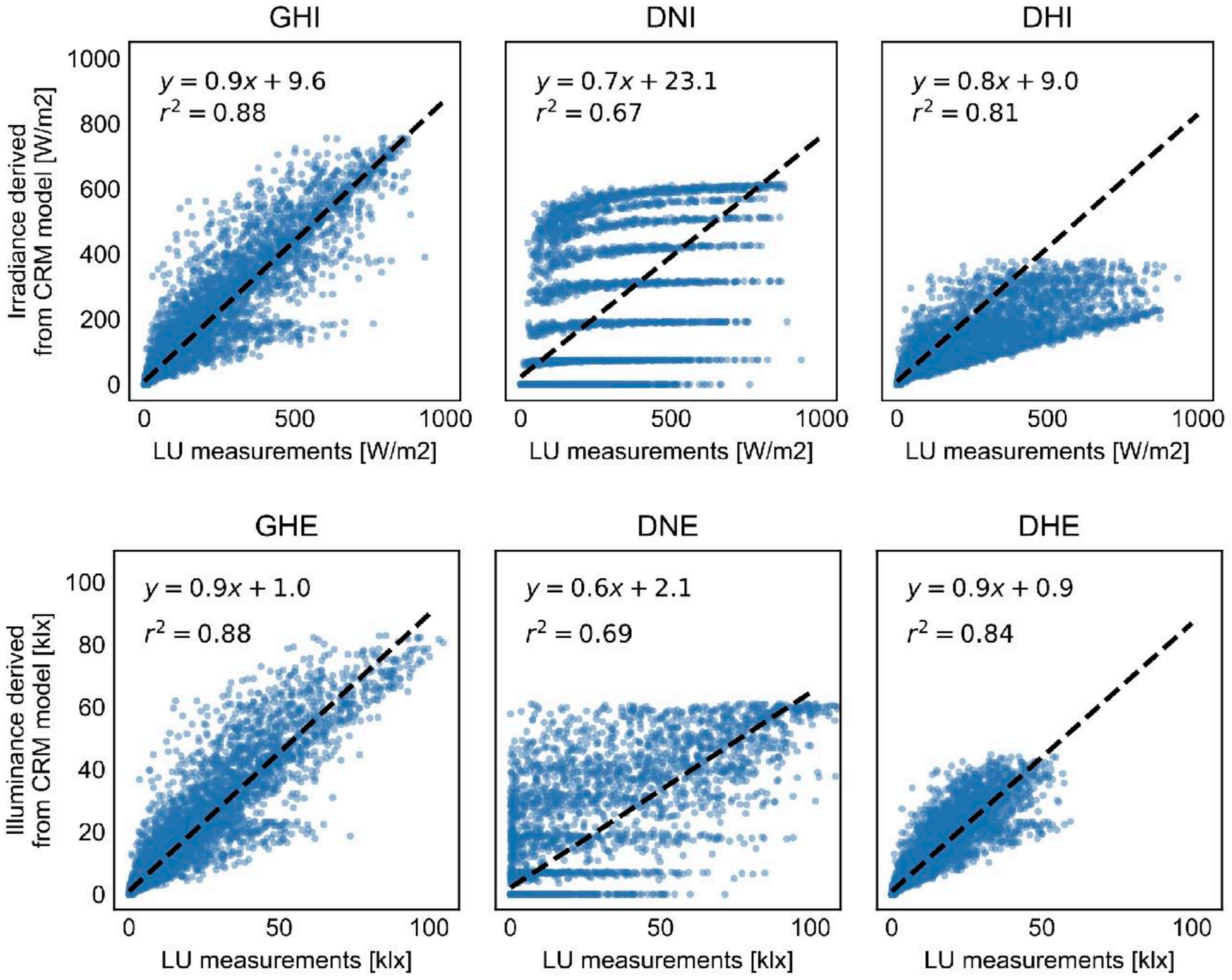


Loughborough University Delta-T measurements

- 1-min time step
- Global and diffuse horizontal illuminance [klux] and irradiance* [W/m2]
- 2 UK locations: Loughborough and Ickworth
- 2015-present

* Loughborough only

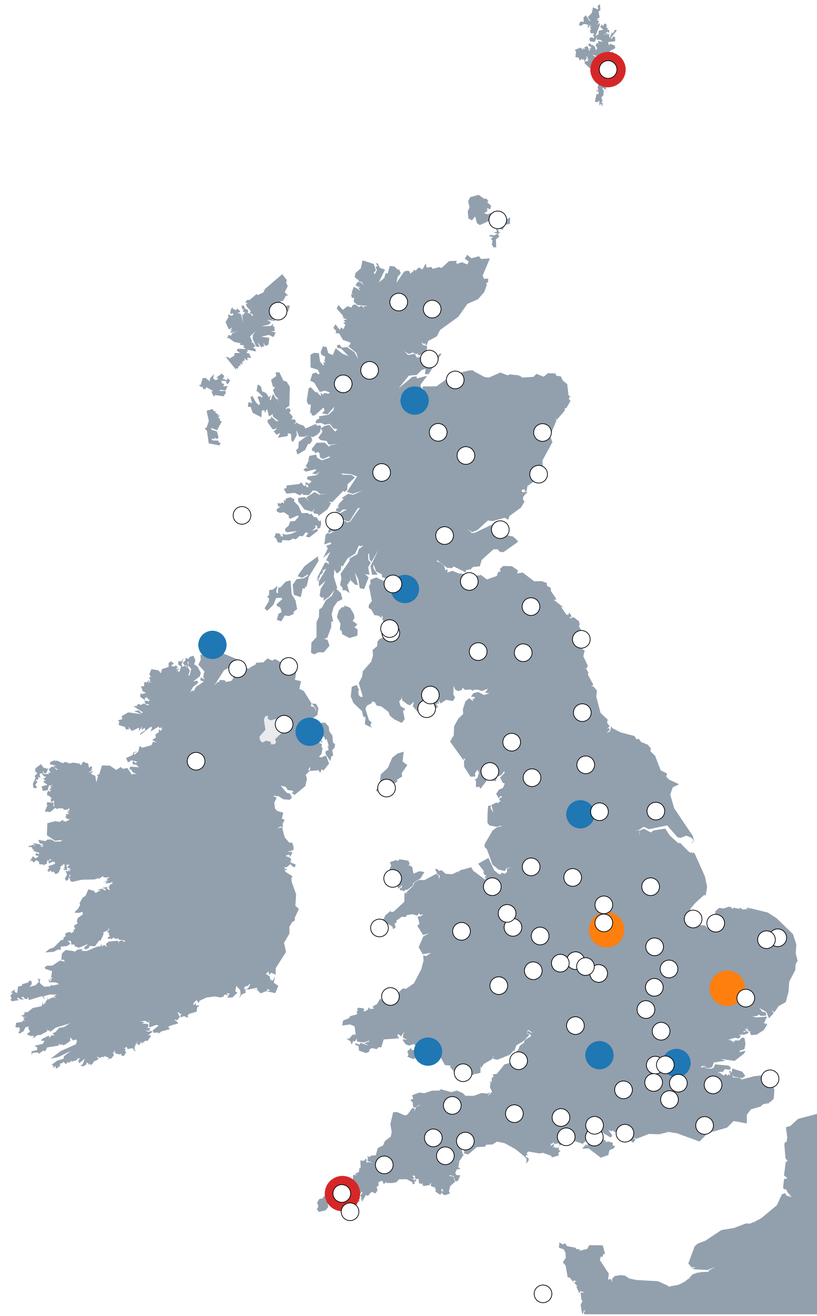


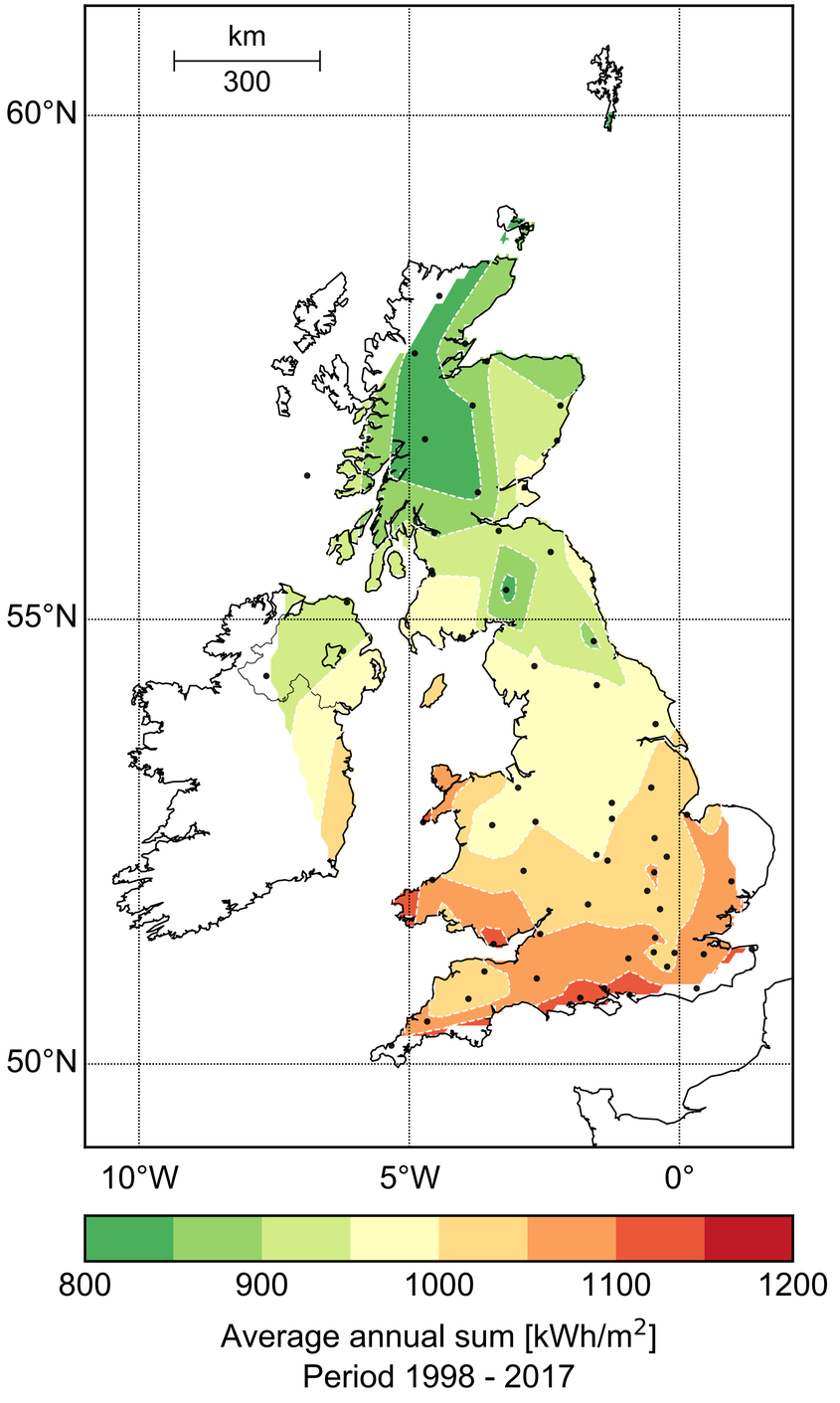

GHI
DNI
DHI
GHE
DNE
DHE
Irradiance derived from CRM model [W/m2]
Illuminance derived from CRM model [klx]
LU measurements [W/m2]
LU measurements [klx]
$y = 0.9x + 9.6$
$r^2 = 0.88$
$y = 0.7x + 23.1$
$r^2 = 0.67$
$y = 0.8x + 9.0$
$r^2 = 0.81$
$y = 0.9x + 1.0$
$r^2 = 0.88$
$y = 0.6x + 2.1$
$r^2 = 0.69$
$y = 0.9x + 0.9$
$r^2 = 0.84$
0
200
400
600
800
1000
20
40
60
80
100
50
500

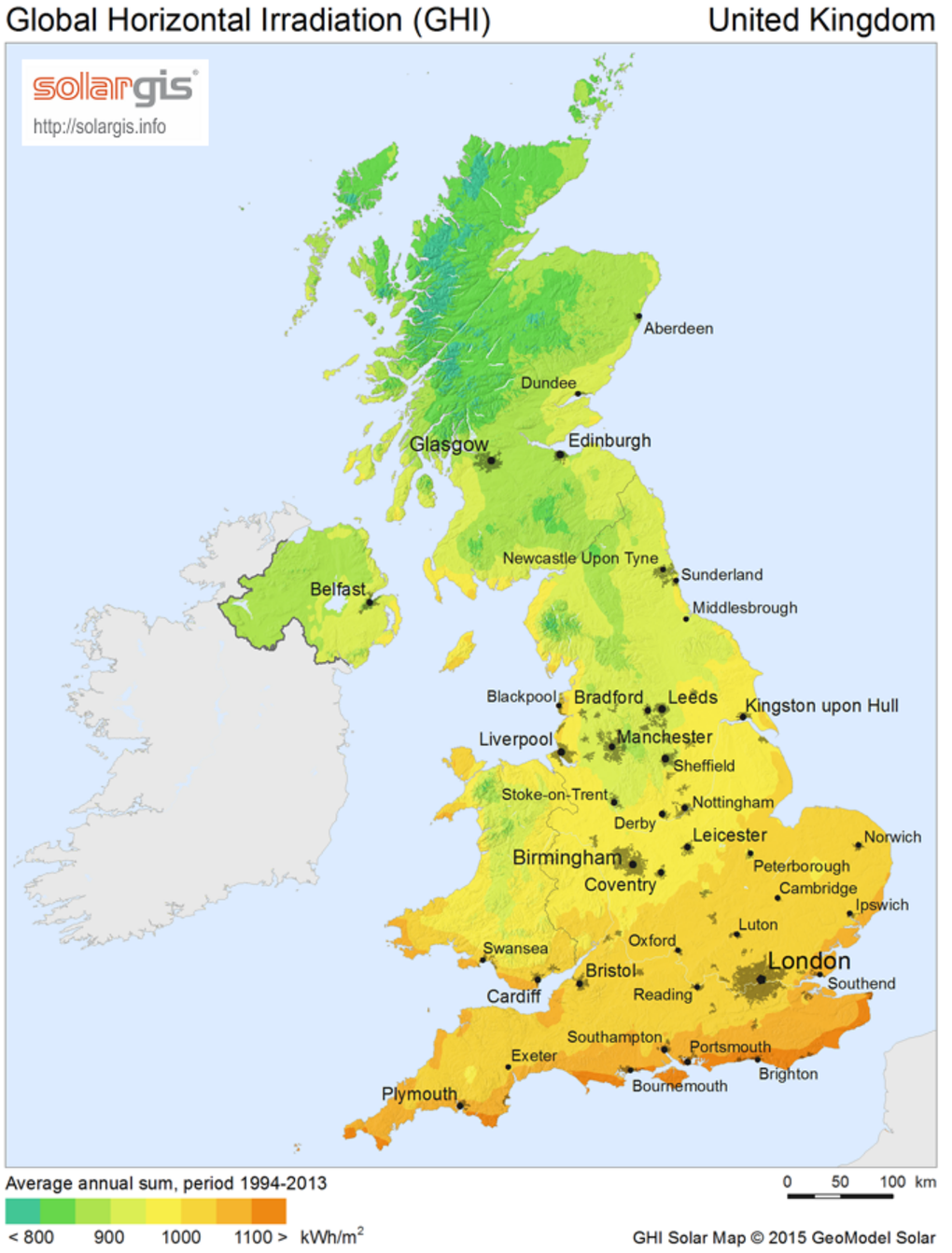
MIDAS
(Met Office from CEDA)

- Hourly time step
- Global horizontal irradiance [W/m2]
- 95 UK locations
- ~1980s - today

Diffuse horizontal irradiance / Direct normal irradiance
Erbs model (in gendaylit already)
Reindl model (Jones and Reinhart, 2017)

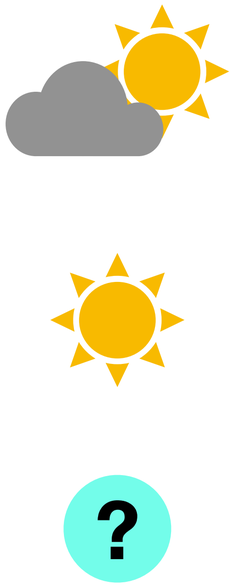



km
300
60°N
55°N
50°N
10°W
5°W
0°
800
900
1000
1100
1200
Average annual sum [kWh/m²]
Period 1998 - 2017


Global Horizontal Irradiation (GHI)
United Kingdom
solargis
http://solargis.info
Aberdeen
Dundee
Glasgow
Edinburgh
Belfast
Newcastle Upon Tyne
Sunderland
Middlesbrough
Blackpool
Bradford
Leeds
Kingston upon Hull
Liverpool
Manchester
Sheffield
Stoke-on-Trent
Nottingham
Derby
Leicester
Norwich
Birmingham
Peterborough
Coventry
Cambridge
Ipswich
Luton
Swansea
Oxford
London
Bristol
Southend
Cardiff
Reading
Southampton
Portsmouth
Exeter
Brighton
Bournemouth
Plymouth
Average annual sum, period 1994-2013
< 800
900
1000
1100 >
kWh/m²
0
50
100 km
GHI Solar Map © 2015 GeoModel Solar

CBDM within Building Performance Simulation

- Typical climate
- Extreme climate conditions
- Future climate projections



- Expected design performance
- Resilience / Worst case scenarios
- Climate change adaptation

Thank you!

Any question?