Updating the weather data for design

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Messured data 2001-2019

- Measurements by Danish Meteorological Institute
- Weather satiation Sjælsmark. north of Copenhagen
- Used to generate extreme weather files. i.e. 12 extreme months in terms of: heat. cold. sunny and cloudy
- Used for prediction of future climate in 2050’ies and 2090’ies using IPCC scenario RCP8.5. assuming ‘business-as-usual’

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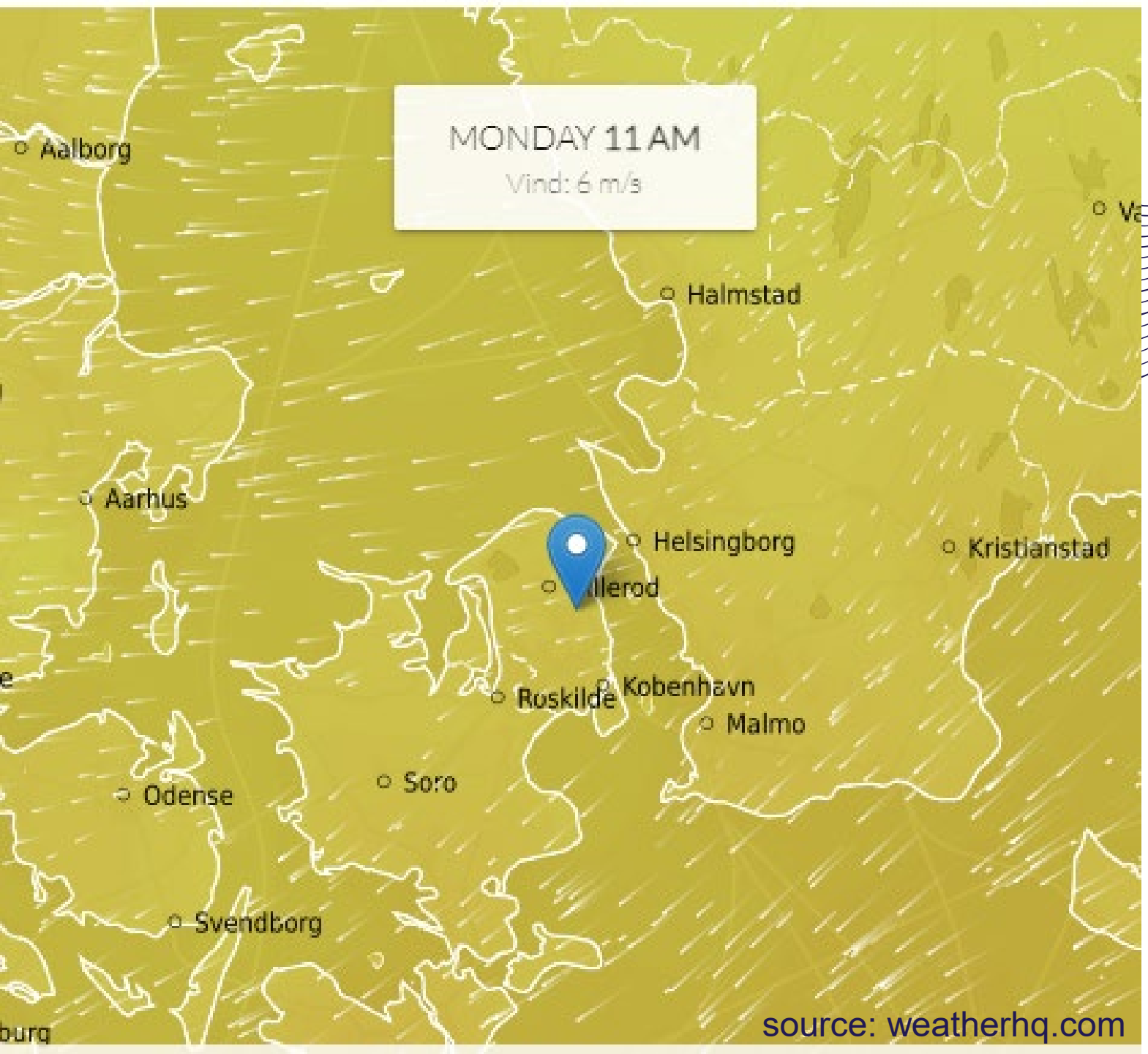

Data

- Measurements at Sjælsmark supplemented by data from nearby stations to include missing data

Extreme temperatures

- Hottest and coldest year was combined as the 12 months with the highest and lowest average temperature
- To be used to analyse a building's resilience against extreme temperatures
- Should be used in combination with weather data selected as 12 sunniest/cloudiest months

Temp	Jan	Feb	Mar	Apr	Maj	Jun	Jul	Aug	Sep	Okt	Nov	Dec
2001	1,7	0,3	1,0	5,9	12,0	13,3	18,1	17,2	12,4	11,8	4,7	0,3
2002	2,1	4,0	4,1	7,1	12,9	15,9	17,7	19,8	14,1	6,6	4,0	-0,4
2003	-0,2	-1,9	3,2	6,7	11,9	16,0	18,1	17,6	13,9	5,8	6,5	3,7
2004	-1,3	1,3	3,5	7,9	11,6	13,6	15,1	17,8	13,6	9,4	4,8	3,3
2005	3,0	-0,2	1,0	7,6	11,0	14,0	17,1	15,1	13,9	10,4	5,4	1,9
2006	-1,6	-0,2	-1,2	5,9	11,4	15,9	20,2	16,9	16,1	11,8	7,4	6,7
2007	**4,4**	1,5	6,2	9,0	12,3	16,4	15,8	17,1	12,8	8,1	4,8	3,4
2008	3,7	**4,4**	3,5	7,4	12,2	15,1	17,8	16,6	12,8	9,2	5,8	2,4
2009	0,4	0,0	3,4	9,6	11,6	14,1	17,8	17,5	14,3	7,3	7,1	0,7
2010	-3,6	-1,9	2,5	7,1	9,5	14,3	19,3	16,6	12,6	8,0	2,7	-4,3
2011	-0,3	-0,7	2,7	10,0	11,6	15,5	17,1	16,3	14,0	9,5	6,7	4,0
2012	1,9	-1,2	5,5	6,3	12,6	13,2	16,6	16,8	13,1	8,4	6,1	0,1
2013	-0,4	-0,8	-1,0	6,0	12,9	15,1	17,6	17,1	12,6	11,0	5,7	4,8
2014	1,3	3,8	5,9	9,2	12,3	15,3	20,0	16,2	14,4	11,7	7,7	2,7
2015	2,8	1,8	4,7	7,5	10,1	13,4	16,4	17,6	13,4	9,3	6,9	6,3
2016	-0,2	2,3	3,4	6,8	13,8	16,7	17,0	16,2	15,9	8,7	4,1	4,3
2017	0,8	1,8	4,7	6,5	12,4	15,6	15,7	16,1	13,1	10,7	5,1	3,3
2018	2,3	-1,4	-0,2	9,0	15,2	17,2	20,0	17,9	14,1	10,1	5,7	3,8
2019	1,4	4,2	5,1	8,3	10,4	17,6	17,2	17,5	13,3	9,2	6,0	4,4

°C

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Extreme solar irradiation

- Sunniest and cloudiest year was combined as the 12 months with the highest and lowest average solar irradiation
- To be used to analyse a building's resilience against extreme solar irradiation
- Should be used in combination with weather data selected as 12 hottest/coldest months

GlobRad	Jan	Feb	Mar	Apr	Maj	Jun	Jul	Aug	Sep	Okt	Nov	Dec
2001	11.2	36.7	72.9	96.6	174.8	172.6	186.3	123.0	67.2	37.1	24.2	8.2
2002	13.6	30.4	90.3	97.2	149.6	183.0	153.3	144.2	106.0	45.3	15.8	8.3
2003	14.1	35.9	88.6	131.3	150.2	168.7	167.2	139.6	90.2	50.1	11.6	7.5
2004	15.1	30.7	68.8	122.7	150.5	131.3	125.2	126.1	88.9	37.2	17.3	7.0
2005	17.!	29.5	82.4	124.2	144.8	158.5	146.1	117.7	84.4	54.0	17.8	9.6
2006	14.3	25.2	73.0	83.3	159.2	181.3	198.9	119.9	101.9	42.4	18.2	9.0
2007	13.3	22.2	84.6	142.3	154.1	153.0	134.5	130.3	83.7	54.2	20.3	7.1
2008	9.6	29.1	72.7	128.2	204.8	191.1	190.6	116.1	85.6	49.7	14.7	8.4
2009	13.2	30.8	65.3	158.4	170.3	196.3	164.9	143.8	93.6	49.6	11.6	10.3
2010	17.4	26.0	72.9	123.1	119.4	173.5	181.8	116.8	91.4	52.4	17.8	13.8
2011	18.2	30.4	76.1	136.5	172.6	184.2	137.1	121.0	86.0	54.4	17.1	10.2
2012	17.1	39.1	85.1	106.4	172.5	145.3	164.5	140.4	77.9	43.5	15.4	8.7
2013	17.6	29.2	97.3	132.5	161.3	177.6	186.3	143.8	95.4	47.2	18.0	9.6
2014	7.9	30.6	80.5	124.9	168.4	176.5	187.3	136.2	97.1	37.6	13.5	10.4
2015	11.9	26.5	69.5	136.8	154.7	167.6	168.0	155.5	93.8	42.4	16.9	9.5
2016	15.3	34.1	66.5	107.0	196.8	179.6	159.1	135.9	102.7	40.7	24.1	11.2
2017	16.2	28.2	70.5	115.3	168.0	163.4	146.3	133.9	81.1	37.4	18.8	10.0
2018	11.0	35.6	58.0	118.2	189.1	190.9	190.9	122.4	81.1	49.1	17.5	7.3
2019	14.4	31.3	62.1	144.0	146.3	180.7	162.8	130.1	70.5	41.8	12.4	9.6

kWh/m²

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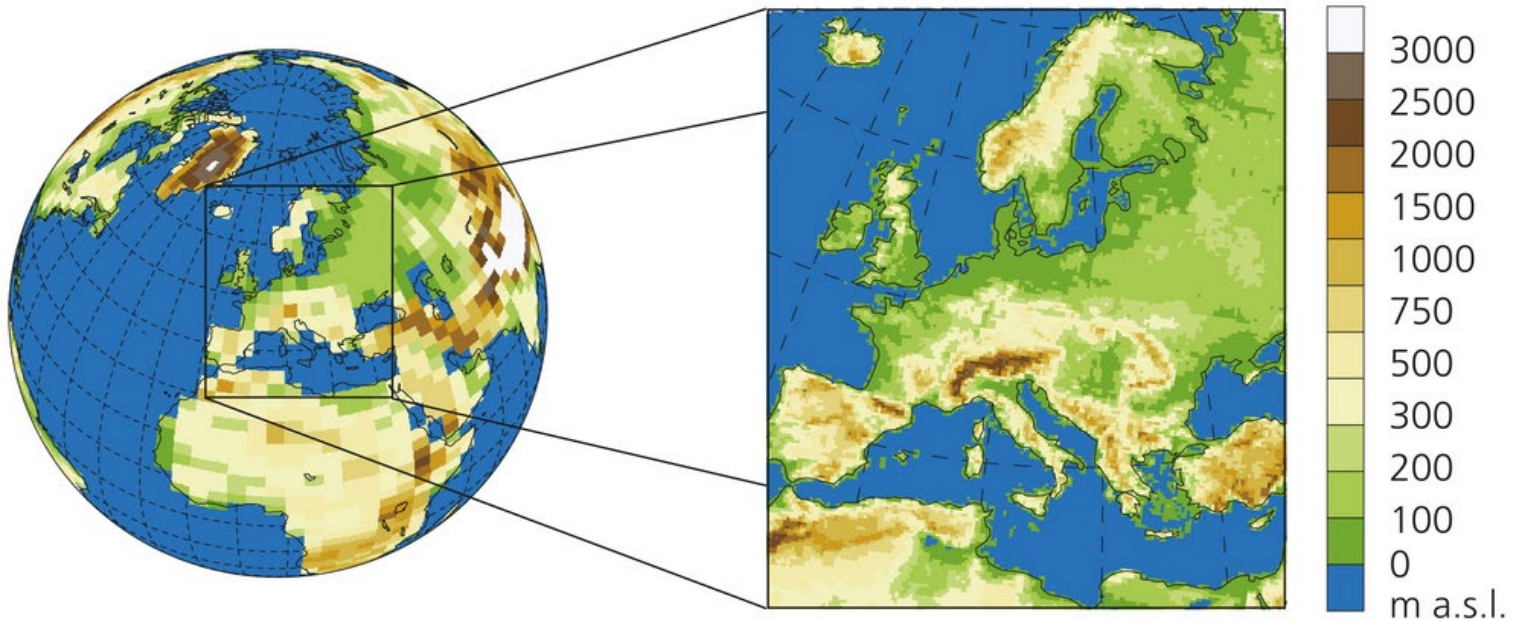
Normal and extreme years

- Hot and cold years deviates significantly from current Design Reference Year in temperature while solar irradiation deviates more
- Sunny and cloudy years show almost same average as current DRY
- Solar irradiation deviates up to 23.7 %, most for the sunny and cloudy years

	DRY 2010	Hot	Cold	Sunny	Cloudy
Avg. temperature [°C]	8.1	11.7	5.8	8.0	8.2
Max temperature [°C]	27.7	31.2	26.3	30.1	28.2
Min temperature [°C]	-15.0	-10.0	-17.3	-17.3	-8.7
Solar irradiation on horz. [kWh]	1030.1	1137.2	856.1	1265.5	786.2



Projection of climate data

- NETCDF4 CORDEX data was used as basis for the projections
- Data was adjusted to local conditions based on 19 years measured data
- In the CORDEX experiment, it is possible to scale from the global grid (150-600 km²) to regional grid (max 100 km²)
- Further correction is done using a bias correction based on projections in the measured data

Some issues

- CORDEX data do not contain information about the wind direction – data has thus been supplemented with this information from historical measurements
- Atmospheric pressure was not measured in the first years of the measuring period, hence the projected value of this parameter is uncertain
- Projected climate data should be considered as Typical Meteorological Years (TMY) and do thus not contain extremes that must expected of the future data

Projected climate data vs DRY

- It seems that temperatures will rise towards the end of the century
- Direct solar radiation will drop by approx. 12% while diffuse irradiation will increase – more clouds
- Total solar incidence decreases from 1038 (DRY) to 998 (2050'ies) and 909 (2090'ies) – all expressed as kWh/m²yr
- In this model, wind speeds seems decrease
- To be used in analyses of building's resilience towards future climate changes

		Temp.	Wind-speed	Atm.press.	Moisture	Global rad.	Diffuse rad.
		[°C]	[m/s]	[hPa]	[%]	[W/m²]	[W/m²]
DRY	Min	-15	0	972.8	24	0	0
	Mean	8.1	4.4	1012.7	82.7	118.5	59.8
	Max	27.7	13.8	1038.4	100	863	398.2
2050'ies	Min	-8.8	0	979.4	30.9	0	0
	Mean	9.7	3.1	1013.2	82.7	113.6	62.6
	Max	30	12.3	1046.3	100	917.9	373
2090'ies	Min	-8.5	0	957.5	30	0	0
	Mean	11.3	3.3	1012.2	83.8	103.4	60.4
	Max	29.7	12.6	1040.5	100	895.4	372.6

Climate data files

- Climate data files have been generated for:
  - Be-tool - used for building permit applications and proof of thermal indoor climate in residential buildings
  - BSim – dynamic simulations of buildings and installations, commonly used for proof of thermal indoor climate in non-residential buildings
  - EneergyPlus – dynamic simulations of buildings and installations, often used to proof of daylight conditions in non-residential buildings