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2001 – 2010 Danish Design Reference Year

Reference Climate Dataset for Technical Dimensioning in Building, Construction and other Sectors

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Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Grunnet Wang, P., Scharling, M., Pagh Nielsen, K., Kern-Hansen, C., & Wittchen, K. B. (2013). *2001 – 2010 Danish Design Reference Year: Reference Climate Dataset for Technical Dimensioning in Building, Construction and other Sectors*. Danmarks Meteorologiske Institut. DMI Technical Report No. 13-19 <http://www.dmi.dk/laerom/generelt/dmi-publikationer/2013/>

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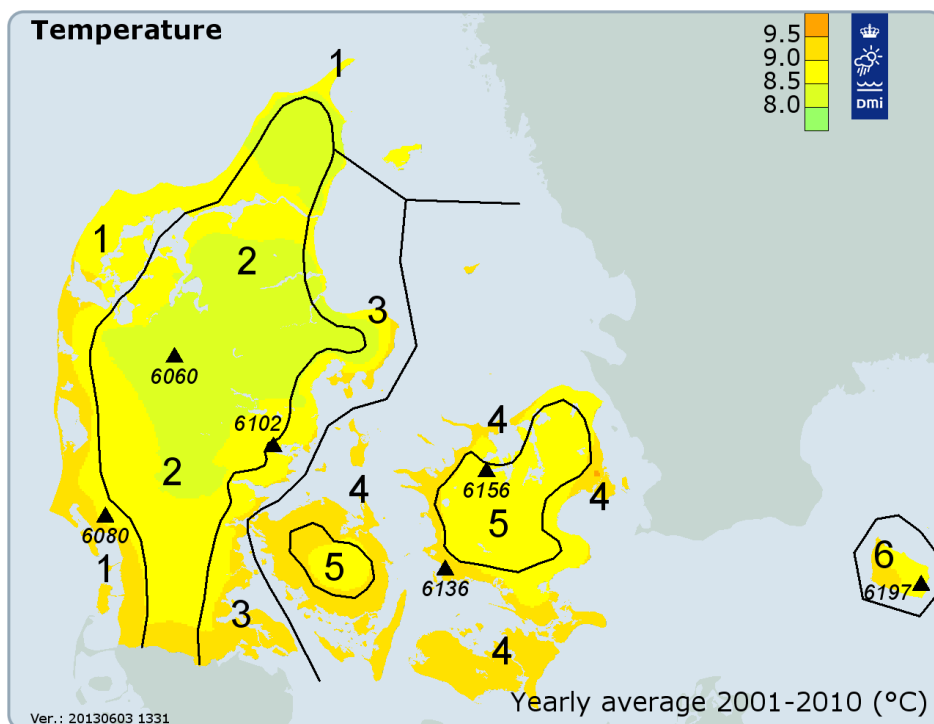
Danish Ministry of Climate, Energy and Building

Technical Report 13-19

2001– 2010 Danish Design Reference Year

- Reference Climate Dataset for Technical Dimensioning in Building, Construction and other Sectors

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Copenhagen 2013



Colophon

Serial title:

Technical Report 13-19

Title:

2001 – 2010 Danish Design Reference Year

Subtitle:

Reference Climate Dataset for Technical Dimensioning in Building, Construction and other Sectors

Authors:

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Responsible institution:

Danish Meteorological Institute

Language:

English

Url:

<http://www.dmi.dk/fileadmin/Rapporter/TR/tr13-19.pdf>

Website:

www.dmi.dk

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Front page figure:

Yearly average air temperature 2001 - 2010



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Abstract

This report presents the Danish Design Reference Year based on observed data from 2001 – 2010. In various sectors - i.e. building and construction, energy, etc. - the climate and weather usually plays a part in a given project. The Danish Design Reference Year dataset is a collection of data series for eleven specific parameters, that each represents a *typical* year in Denmark. The uses of the dataset may vary from simulations to statistical analysis, graphical overviews etc.

The Danish land areas have been sectionalized into five to six climatological zones depending on the parameter, each characterized by distinct diurnal and yearly variations. The dataset consists of observed data from one station located within and representing each zone.

The parameters included in the dataset are temperature, relative humidity, wind speed and direction, atmospheric pressure, global radiation, cloud cover, soil temperature, sea temperature, diffuse irradiance and illuminance. The time resolution is hourly except for soil temperature where the resolution is daily values.

In addition to the complete Danish Design Reference Year dataset, a subset specifically selected to be used for energy performance calculations for obtaining a building permit is included.



Preface

This report presents the collective Danish Reference Year dataset, previously published in the two distinct reports in Danish language only:

[1] *DMI Technical Report 12-17: 2001-2010 Design Reference Year for Denmark*, by Peter Riddersholm Wang, Mikael Scharling and Kristian Pagh Nielsen, 2012

[2] *DMI Technical Report 13-18: 2001-2010 Dansk Design Reference Year – Supplerende datasæt*, by Peter Riddersholm Wang, Mikael Scharling Kim Bjarne Wittchen and Claus Kern-Hansen, 2013

Both projects were funded by the Danish Energy Agency, and the process involved the following collaborators:

- Danish Energy Agency
- Danish Meteorological Institute
- Danish Building Research Institute, Aalborg University
- Technical University of Denmark

1. Introduction

The Danish Design Reference Year (DRY) was last published in 1995 [3], presenting various climate data from the period 1975 – 1989. It is well known, that the climate of Denmark has since changed, hence the need for an updated reference dataset.

The purpose was – and still is – to produce a dataset from climate data, designed specifically to be used as input data for computer simulations of technical dimensioning i.e. in the energy and construction sector.

As part of this, a new dataset to be used for energy performance calculations for obtaining a building permit [4] is presented. Given the general rule that similar conditions apply for all locations in Denmark, it was decided that one dataset should represent the whole Denmark in this regard. This dataset should best represent most of the population in Denmark, and datasets from the three stations Holbæk Flyveplads, DMI and Sjælsmark were chosen.

In 2012 the project “Solar Resource Assessment in Denmark” [5] resulted in the above mentioned report [1], presenting an updated DRY dataset aimed at the solar energy sector in Denmark, including the parameters global radiation, relative humidity, temperature, wind speed, diffuse irradiance and illuminance. The project was funded by the Danish Energy Agency.

It was since expanded in 2013 with more parameters - still funded by the Danish Energy Agency – and published in a separate report [2], with a supplementary dataset consisting of the parameters wind direction, atmospheric pressure, cloud cover, sea temperature and soil temperature.

The present report presents the collective DRY dataset from the two reports. It is a collection of hourly (for ten parameters) and daily (for one parameter) climate data, spanning one calendar year for all eleven parameters and various locations across the country. It is constructed from monthly data from assorted years during the period 2001 – 2010, resulting in a complete calendar year of data.

Where the previously used DRY dataset consisted of data from two locations in Denmark, the updated dataset presented in this report has been expanded to cover five to six climatological zones in Denmark, each characterized by distinct diurnal and yearly variations. The zones each represent the climatological variations in a given area of Denmark for each of the eleven parameters, making it possible to tune the derived calculations depending on location.

The present report contains the following information on the DRY dataset:

- station metadata
- maps with zonal sections and station positions
- time series plots
- tables with simple statistical information
- attached .csv files with the hourly (daily) dataset



2. Data

The dataset consists of observations from the DMI station network, and has undergone a series of calculations and quality control procedures to meet specific requirements for the DRY dataset.

Parameters

The dataset include one year of hourly data for the following parameters:

- temperature (°C)
- relative humidity (%)
- wind speed (m/s)
- wind direction (°)¹
- atmospheric pressure (hPa)
- global radiation (W/m²)
- cloud cover (%)
- sea temperature (°C)
- diffuse irradiance (W/m²)
- illuminance (lux)

and one year of daily data for:

- soil temperature (°C)

Since diurnal variations in soil temperature in 1m depth are negligible, only daily mean values are included in the dataset for this parameter.

Interpolated values

Missing and/or erroneous values have been replaced with interpolated values from the nearest stations, which ensure complete time series. Interpolated values are clearly flagged, see section 18.

The reference year

As described above, the dataset contains one year of hourly or daily data. The dataset is not measured continuously throughout a specific year; rather it is constructed from monthly data from different years. Each month has been selected with the climatological premises in mind, that it should exhibit *typical* climatological variation. This means no extremes, yet some variation is indeed tolerated.

The reference year is constructed from twelve typical months during 2001 – 2010 and is shown below.

month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
year	2009	2009	2006	2010	2006	2005	2009	2009	2009	2008	2010	2009

Zones

In the same way that the reference year must represent a typical climatological year, each parameter must also exhibit typical climatological variations across the country. Consequently, Denmark has been sectionalized into five to six climatological zones depending on the parameter, each characterized by distinct diurnal and yearly variations, i.e. coastal areas might have very different diurnal variation than inland areas in spite of similar monthly averages.

The dataset consists of observed data from one station located within and representing each zone. When choosing a station to represent each zone, two main criteria needed to be fulfilled: firstly the location of the station should best represent the climatology in the zone and secondly the regularity of the observations should be as high as possible.

¹ 0° is quiet, 360° is wind from north, 90° is wind from east etc.

3. How to use the dataset

Using the dataset for a given location, one needs to determine – for each parameter – in which zone the location is situated. This can be done by inspecting the maps for each parameter in the following sections. When the zones are determined, the corresponding stations can be looked up in the station tables.

As an example, assume a building project in Hillerød needs to assess the corresponding datasets for temperature, wind speed, atmospheric pressure and global radiation for that specific location:



Looking through the maps and tables in the following sections, the zones and stations can be presented:

parameter	zone	station name	station no.
temperature	5	Holbæk Flyveplads	6156
wind speed	4	Holbæk Flyveplads	6156
atmospheric pressure	4	Holbæk Flyveplads	6156
global radiation	5	Sjælsmark	6188

After downloading the dataset, the data series can easily be assessed in the files:

DRY_temperature_hourly_6156.csv
DRY_wind_speed_hourly_6156.csv
DRY_pressure_hourly_6156.csv
DRY_global_radiation_hourly_6188.csv



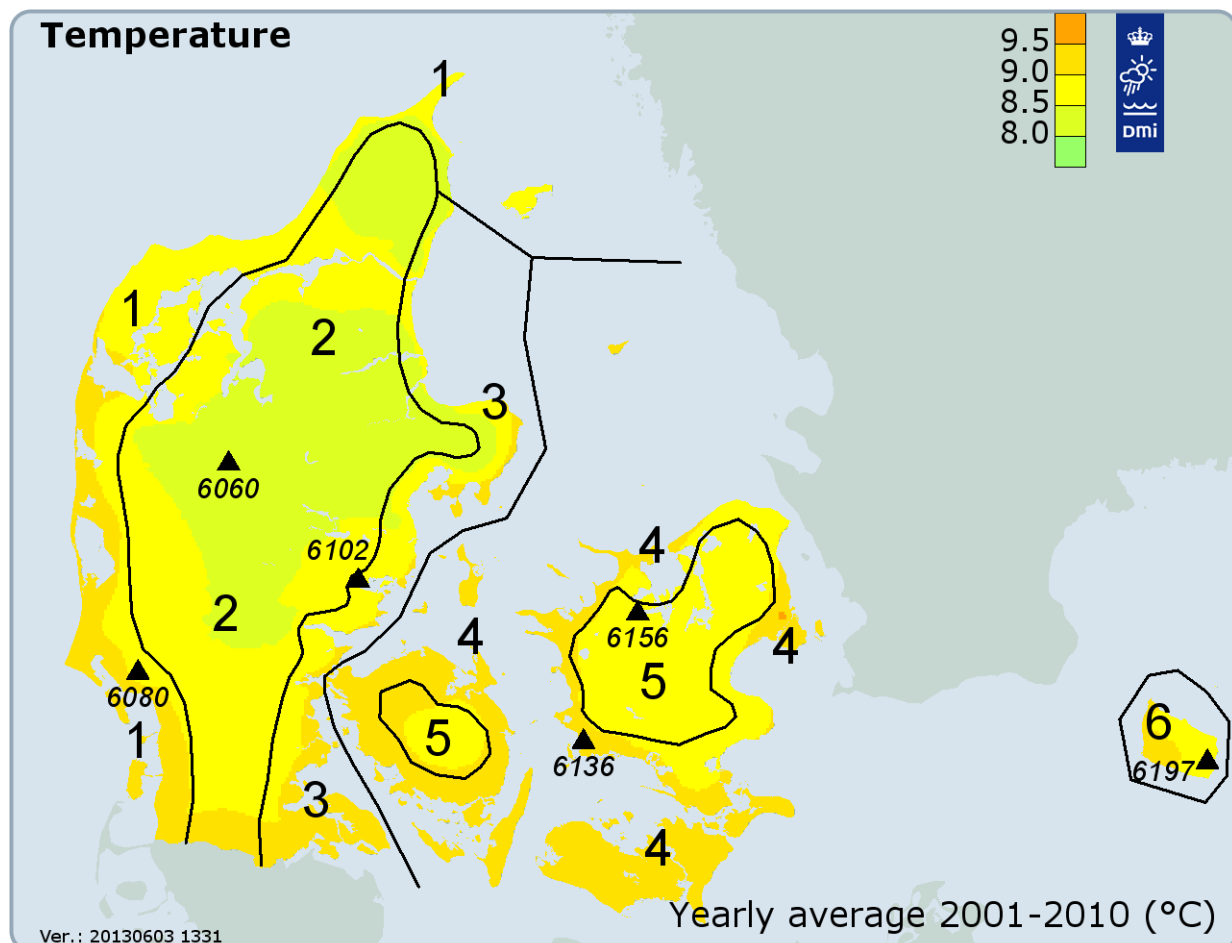
4. Temperature

Data

The temperature dataset consists of hourly mean values from six stations.

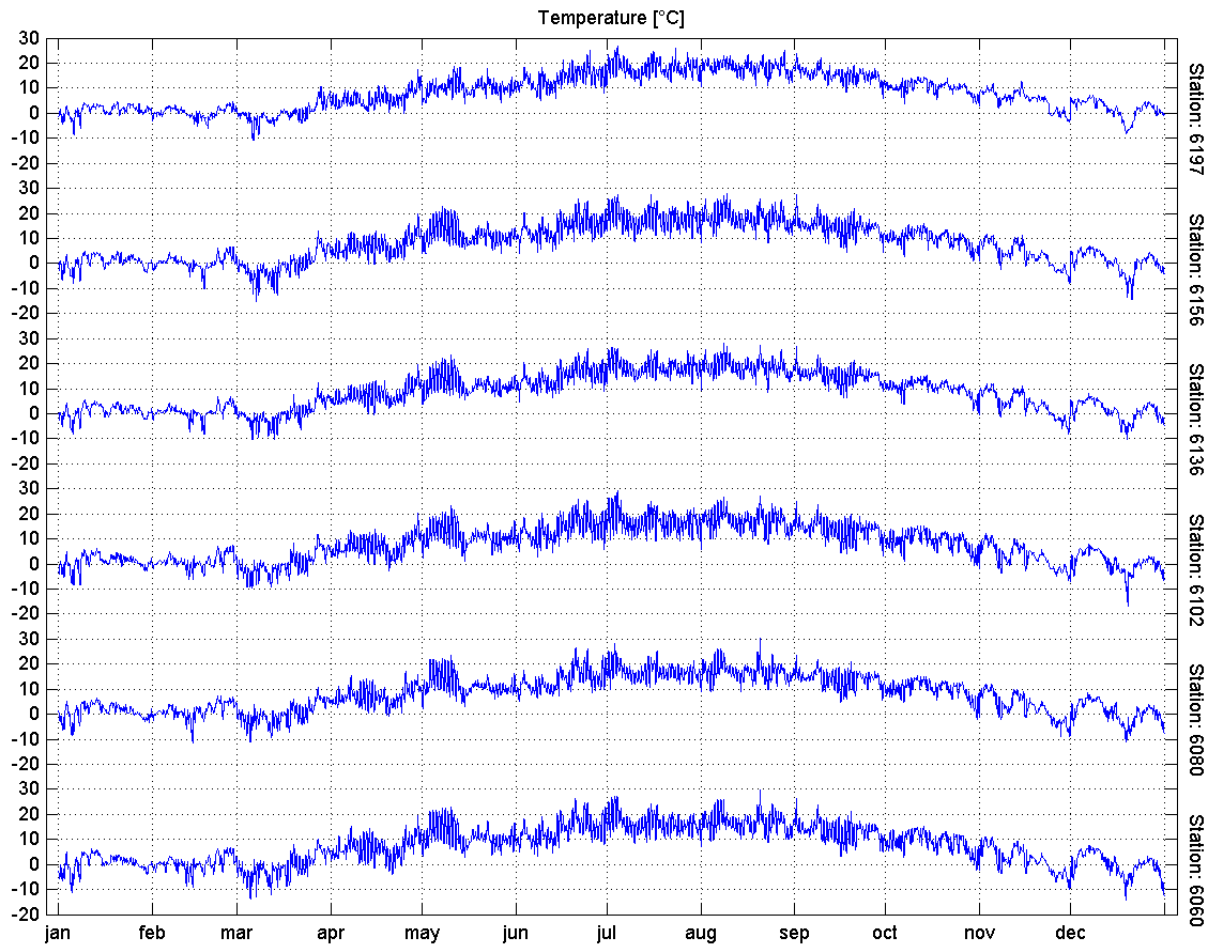
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Esbjerg Lufthavn	6080	55.528065	8.563086	Westcoast of Jutland
2	Flyvestation Karup	6060	56.293420	9.113890	Inland parts of Jutland
3	Horsens/Bygholm	6102	55.868000	9.786903	Eastcoast of Jutland
4	Tystofte	6136	55.246502	11.328447	Coastal parts of Sealand and Funen plus Lolland-Falster, Langeland and Møn
5	Holbæk Flyveplads	6156	55.735783	11.603472	Central parts of Funen and Sealand
6	Nexø Vest	6197	55.055748	15.095350	Bornholm





Time series



Statistics

		Temperature (°C)												
station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
6060	min	-11.3	-9.0	-13.8	-3.8	2.9	3.2	8.4	6.9	3.3	-2.3	-9.8	-14.3	-14.3
	mean	0.6	0.5	-0.9	6.6	11.4	13.8	16.3	16.7	13.4	8.8	1.9	0.1	7.5
	max	6.3	6.6	10.2	19.6	23.0	26.3	27.3	29.7	26.4	15.2	11.0	7.7	29.7
6080	min	-8.4	-11.6	-10.9	-0.9	2.3	5.2	9.9	8.8	4.7	-2.3	-8.9	-11.0	-11.6
	mean	1.1	1.4	0.1	7.2	11.8	13.8	17.0	17.1	14.0	10.0	3.0	0.9	8.2
	max	6.4	7.2	10.6	16.9	23.4	26.3	28.1	30.3	23.4	15.4	12.1	8.6	30.3
6102	min	-8.4	-6.1	-9.5	-2.6	0.9	2.8	9.0	5.9	3.0	-1.9	-7.0	-16.7	-16.7
	mean	0.9	1.1	-0.2	7.1	11.2	14.0	16.8	17.0	13.7	9.0	3.0	0.7	7.9
	max	6.0	7.5	11.9	20.1	23.4	25.8	29.1	27.2	25.0	15.1	12.1	8.0	29.1
6136	min	-8.2	-8.3	-10.1	-0.3	3.7	4.6	12.1	8.7	6.4	-0.6	-8.2	-10.3	-10.3
	mean	1.0	0.8	-0.1	7.6	11.7	14.6	18.5	18.5	15.2	10.3	3.8	1.2	8.6
	max	5.4	6.9	12.3	19.5	23.4	26.1	26.4	28.1	26.7	15.3	12.1	8.0	28.1
6156	min	-7.8	-10.3	-15.0	-0.4	4.0	4.2	8.8	8.2	4.5	1.0	-7.8	-14.3	-15.0
	mean	0.7	0.4	-0.7	7.1	11.5	14.2	17.8	17.9	14.5	9.8	3.4	0.7	8.1
	max	4.9	6.7	13.1	19.7	22.6	25.8	27.5	27.7	27.3	15.9	11.7	6.9	27.7
6197	min	-8.7	-6.2	-10.8	-0.3	3.4	5.0	11.1	10.5	5.8	2.7	-3.6	-8.2	-10.8
	mean	1.1	0.3	0.0	5.9	10.1	13.9	18.0	18.2	15.3	10.3	5.3	1.8	8.4
	max	4.5	4.4	10.6	17.2	18.5	25.3	26.7	25.0	23.6	14.4	12.6	7.2	26.7



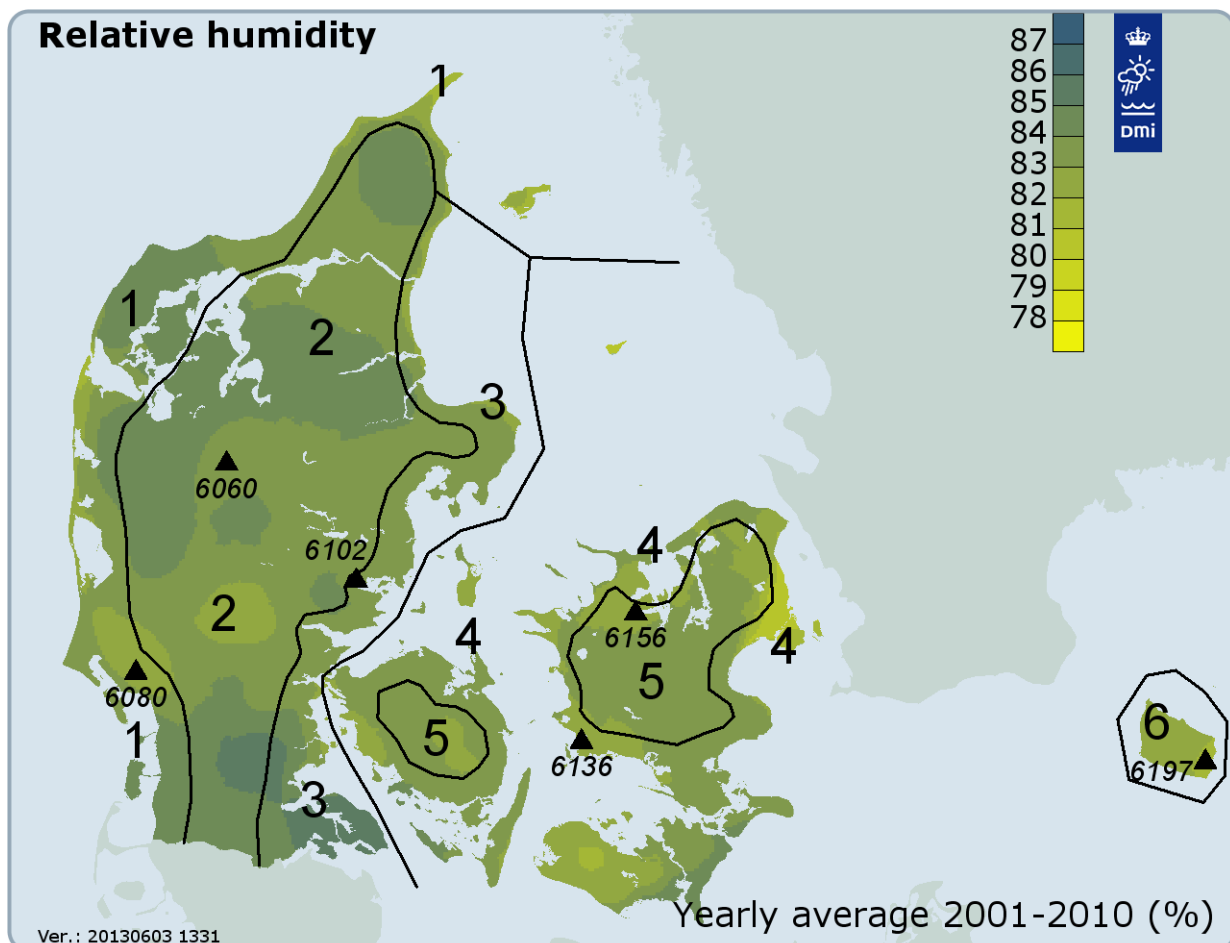
5. Relative humidity

Data

The relative humidity dataset consists of hourly mean values from six stations.

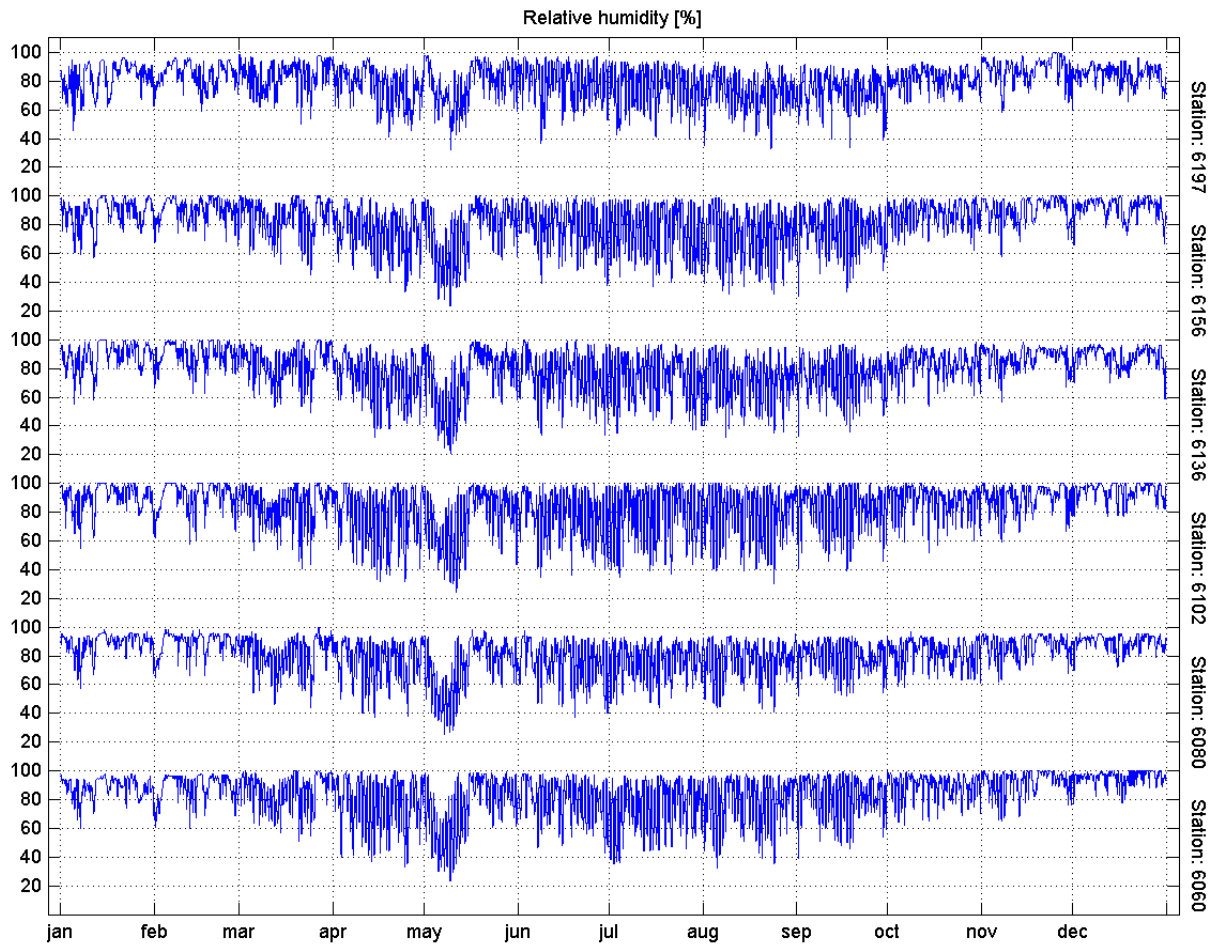
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Esbjerg Lufthavn	6080	55.528065	8.563086	Westcoast of Jutland
2	Flyvestation Karup	6060	56.293420	9.113890	Inland parts of Jutland
3	Horsens/Bygholm	6102	55.868000	9.786903	Eastcoast of Jutland
4	Tystofte	6136	55.246502	11.328447	Coastal parts of Sealand and Funen plus Lolland-Falster, Langeland and Møn
5	Holbæk Flyveplads	6156	55.735783	11.603472	Central parts of Funen and Sealand
6	Nexø Vest	6197	55.055748	15.095350	Bornholm





Time series



Statistics

		Relative humidity (%)												
station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
6060	min	60	60	51	33	24	43	35	32	39	62	65	77	24
	mean	89	89	86	77	75	80	75	78	83	90	93	95	84
	max	98	98	100	100	99	99	97	98	99	100	100	100	100
6080	min	57	65	44	37	25	37	44	41	52	58	62	70	25
	mean	89	89	82	77	72	76	77	76	79	83	87	90	81
	max	98	99	99	94	98	98	94	95	94	97	95	96	99
6102	min	55	58	41	32	24	35	35	30	39	52	59	77	24
	mean	91	92	85	78	76	77	80	79	83	89	91	95	85
	max	100	100	100	100	100	100	100	100	100	100	100	100	100
6136	min	55	63	49	32	21	34	35	32	33	54	57	59	21
	mean	89	91	84	74	74	76	75	72	75	83	88	89	81
	max	100	100	100	97	99	100	97	96	97	98	98	97	100
6156	min	57	65	45	33	24	38	37	32	30	62	58	66	24
	mean	89	91	85	76	75	79	77	73	78	88	91	92	83
	max	100	100	100	99	100	100	99	99	99	100	100	100	100
6197	min	46	59	50	41	32	37	40	33	34	64	58	66	32
	mean	83	85	84	77	78	80	77	73	74	82	88	85	80
	max	96	96	99	96	98	97	94	93	92	93	100	96	100

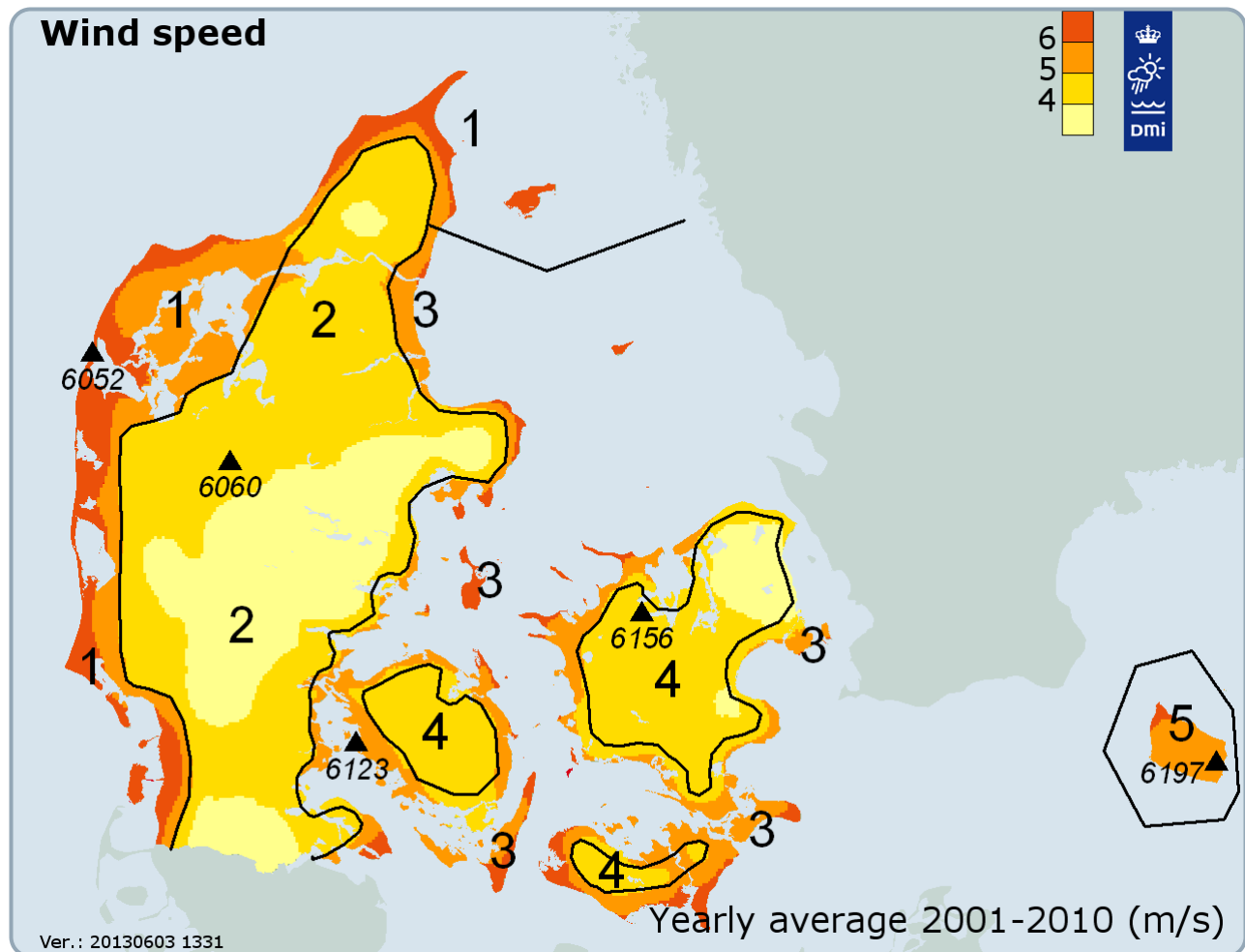
7. Wind speed

Data

The wind speed dataset consists of hourly mean values from five stations.

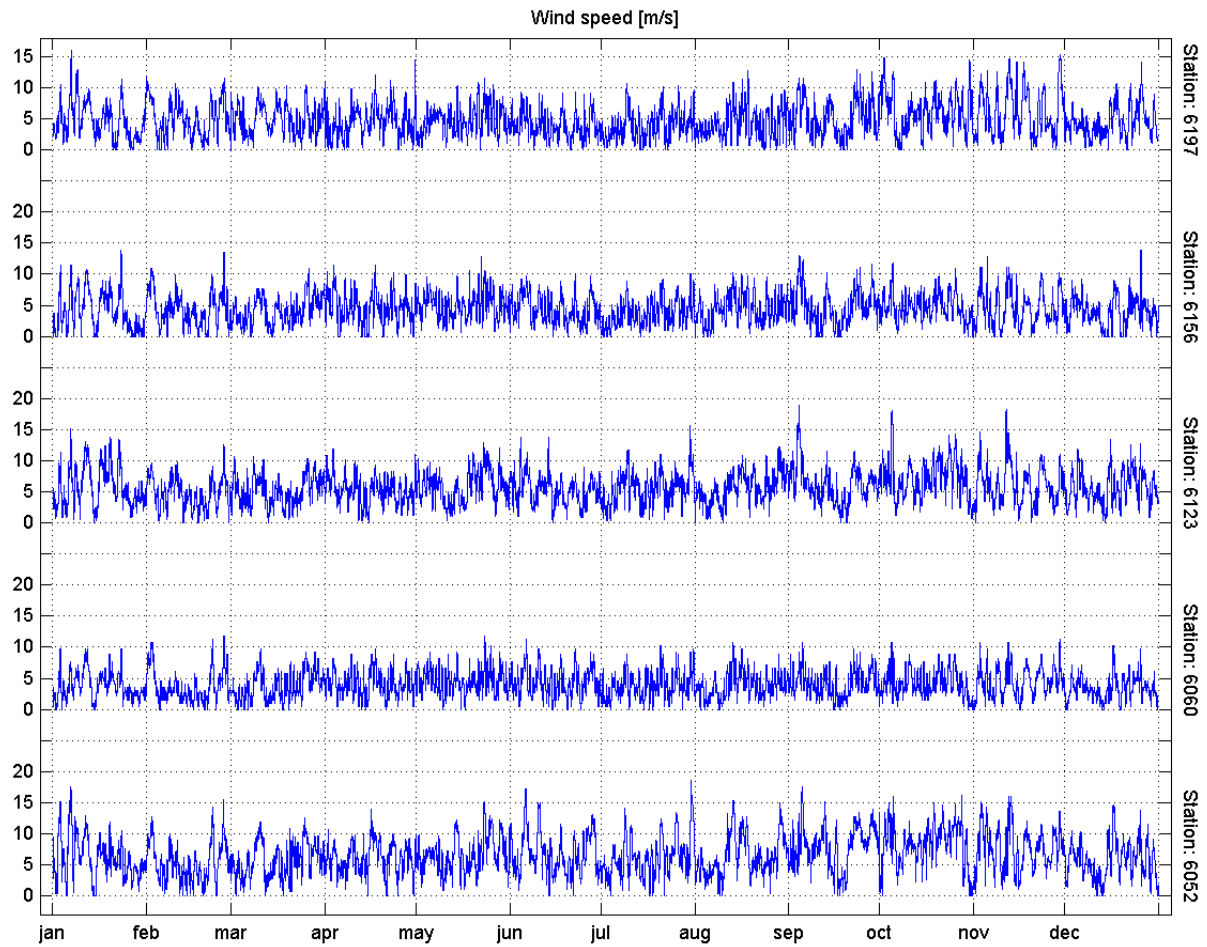
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Thyborøn	6052	56.706764	8.214873	Westcoast of Jutland
2	Flyvestation Karup	6060	56.293420	9.113890	Inland parts of Jutland
3	Assens/Thorø	6123	55.244377	9.888199	Eastcoast of Jutland, coastal parts of Funen and Lolland-Falster plus Langeland and Møn
4	Holbæk Flyveplads	6156	55.735783	11.603472	Inland parts of Sealand, Funen and Lolland-Falster
5	Nexø Vest	6197	55.055748	15.095350	Bornholm





Time series



Statistics

		Wind speed (m/s)												
station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
6052	min	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
	mean	6.1	5.2	5.6	5.9	6.7	6.7	6.1	6.4	8.0	8.3	7.6	5.7	6.5
	max	17.6	15.4	12.6	13.9	15.1	17.2	18.6	15.3	17.5	16.2	16.0	14.6	18.6
6060	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	3.8	3.7	3.7	4.1	4.6	4.3	3.7	3.8	4.2	4.2	4.5	3.4	4.0
	max	9.8	11.8	9.8	9.8	11.8	11.3	10.3	10.8	10.8	10.8	11.3	10.3	11.8
6123	min	0.0	0.0	0.0	0.0	0.4	0.0	0.3	0.0	0.0	0.7	0.0	0.0	0.0
	mean	6.0	4.9	5.1	5.2	6.0	5.3	5.6	5.6	6.2	7.2	6.1	5.6	5.7
	max	15.1	12.5	10.7	11.9	13.0	13.8	15.6	12.3	18.9	18.0	18.2	13.5	18.9
6156	min	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	4.2	4.3	4.2	4.6	5.0	4.4	3.7	4.4	4.7	4.8	4.6	4.0	4.4
	max	13.8	13.5	10.9	11.5	12.8	9.9	10.0	10.3	13.0	11.8	12.9	13.8	13.8
6197	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	4.8	5.0	5.0	4.6	4.8	4.0	3.9	4.4	5.2	6.1	6.1	4.5	4.9
	max	16.0	11.7	10.9	14.5	11.5	9.4	10.7	12.8	12.9	14.8	15.3	14.1	16.0

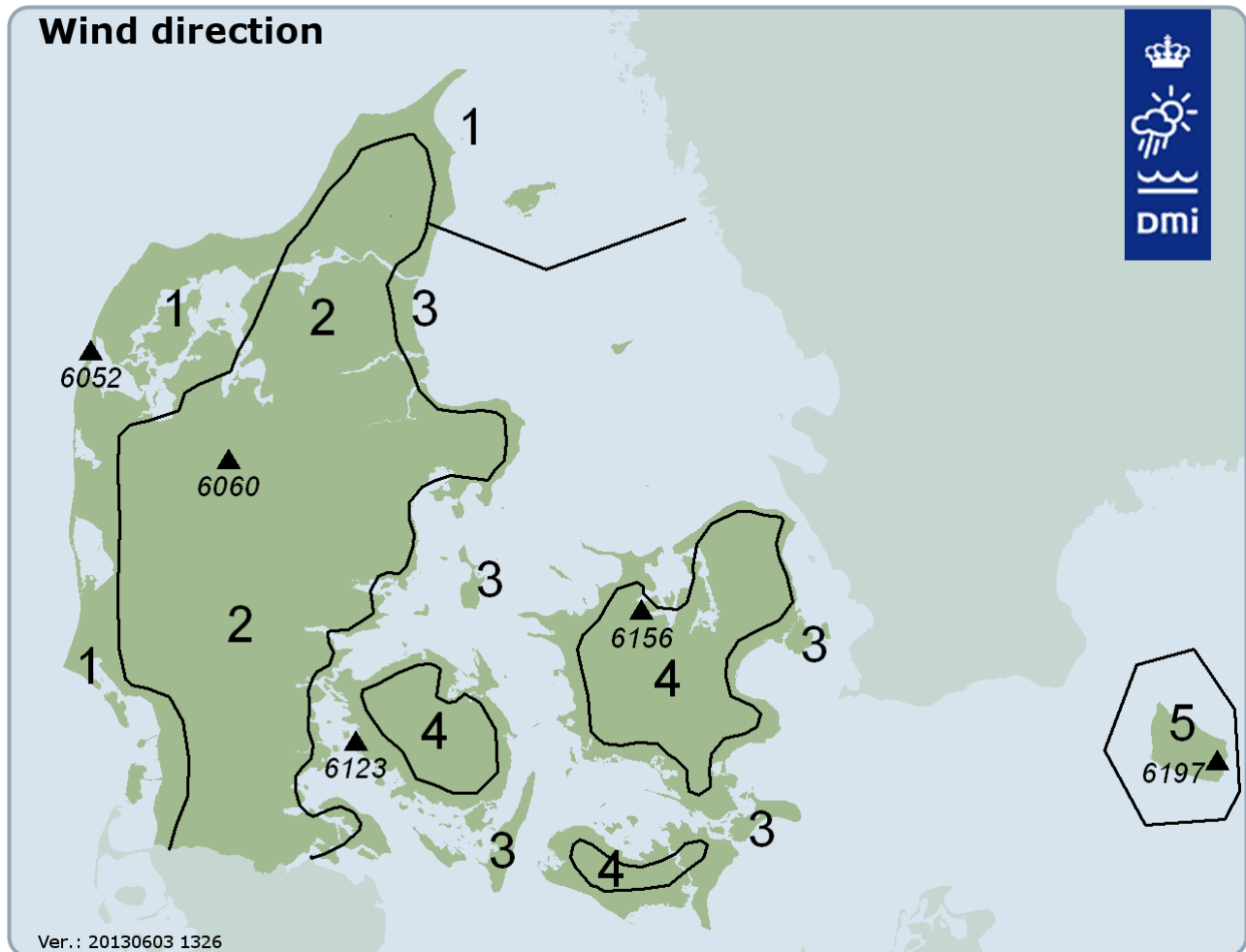
8. Wind direction

Data

The wind direction² dataset consists of hourly mean values from five stations.

Stations and zones

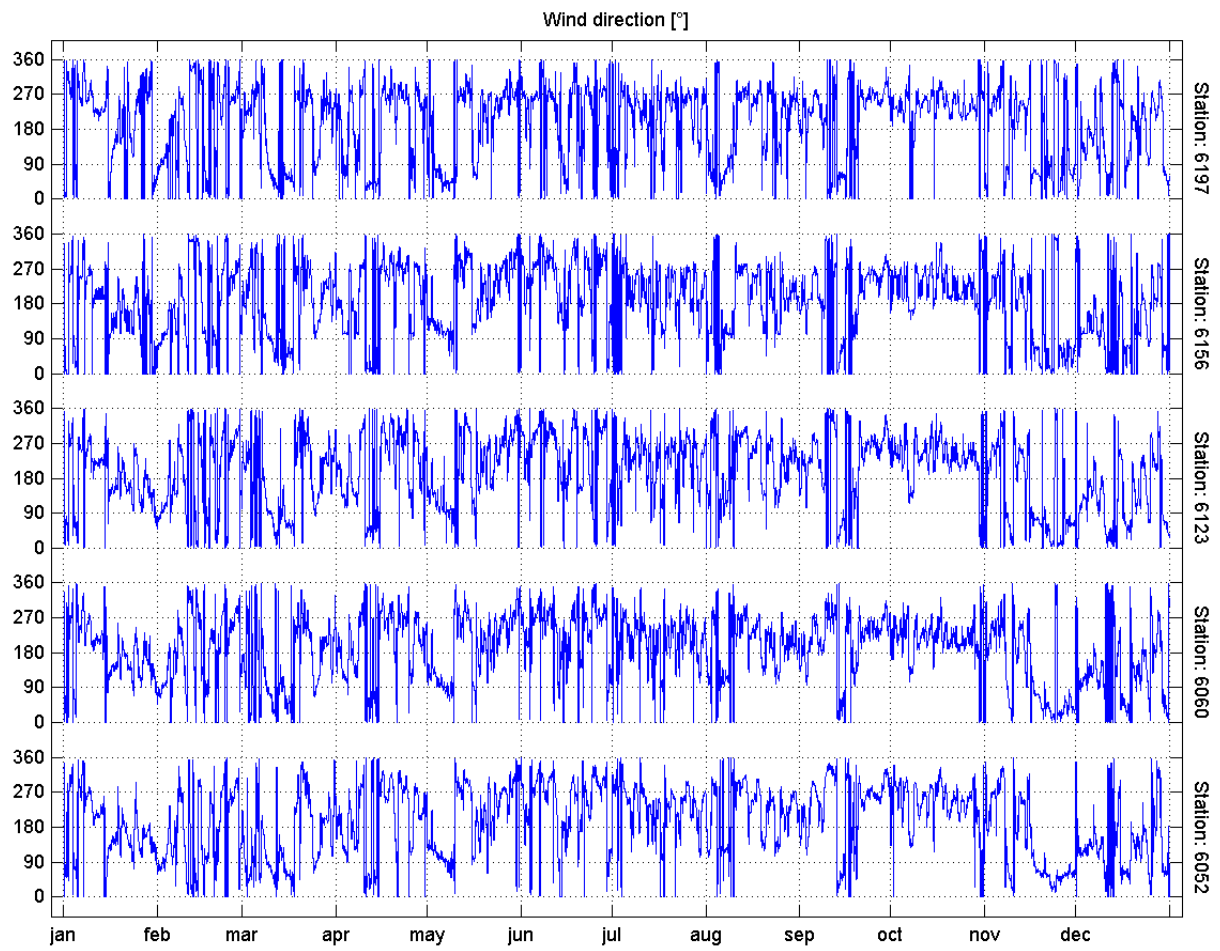
Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Thyborøn	6052	56.706764	8.214873	Westcoast of Jutland
2	Flyvestation Karup	6060	56.293420	9.113890	Inland parts of Jutland
3	Assens/Thorø	6123	55.244377	9.888199	Eastcoast of Jutland, coastal parts of Funen and Lolland-Falster plus Langeland and Møn
4	Holbæk Flyveplads	6156	55.735783	11.603472	Inland parts of Sealand, Funen and Lolland-Falster
5	Nexø Vest	6197	55.055748	15.095350	Bornholm



² 0° is quiet, 360° is wind from north, 90° is wind from east etc.



Time series



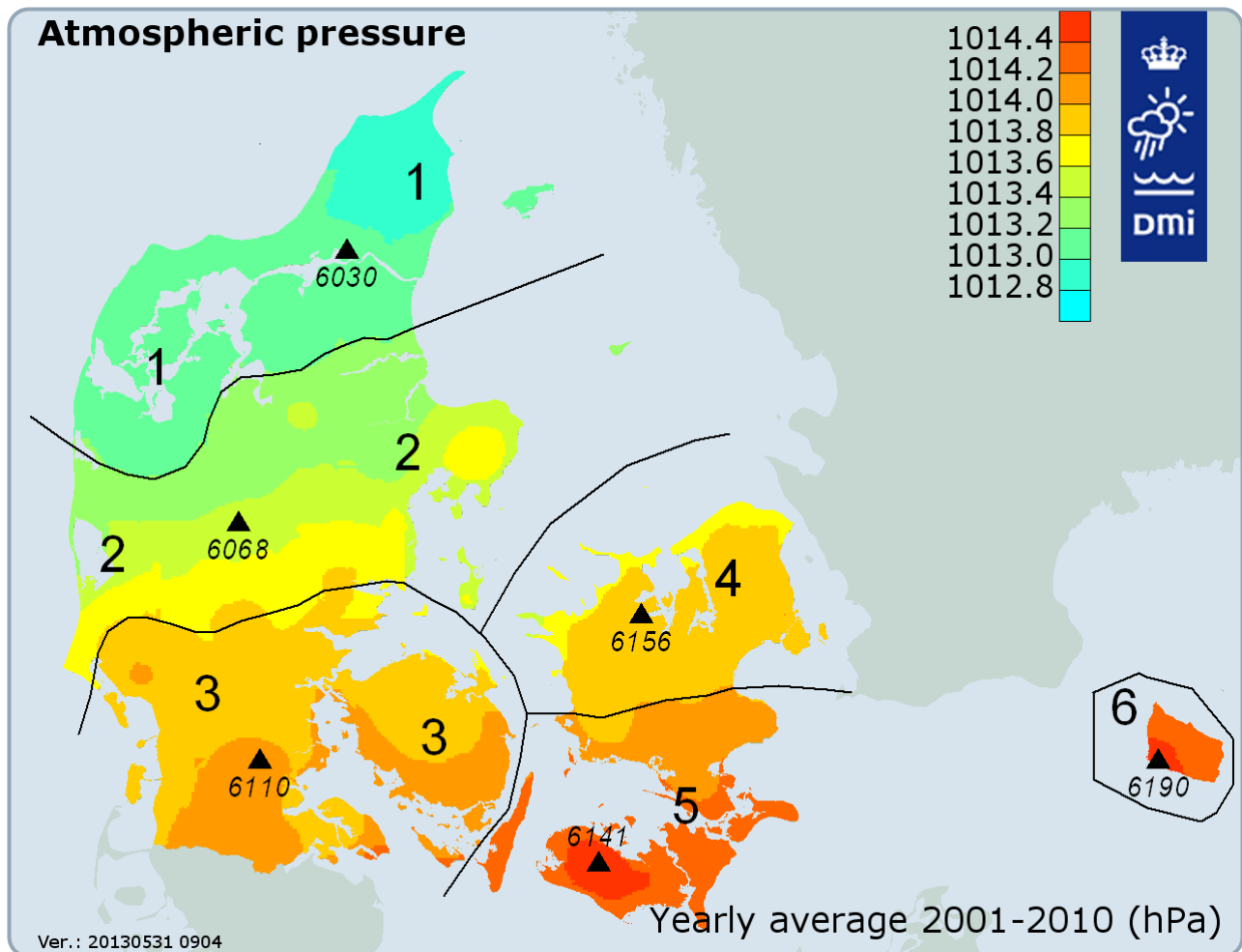
9. Atmospheric pressure

Data

The atmospheric pressure dataset consists of hourly mean values from six stations.

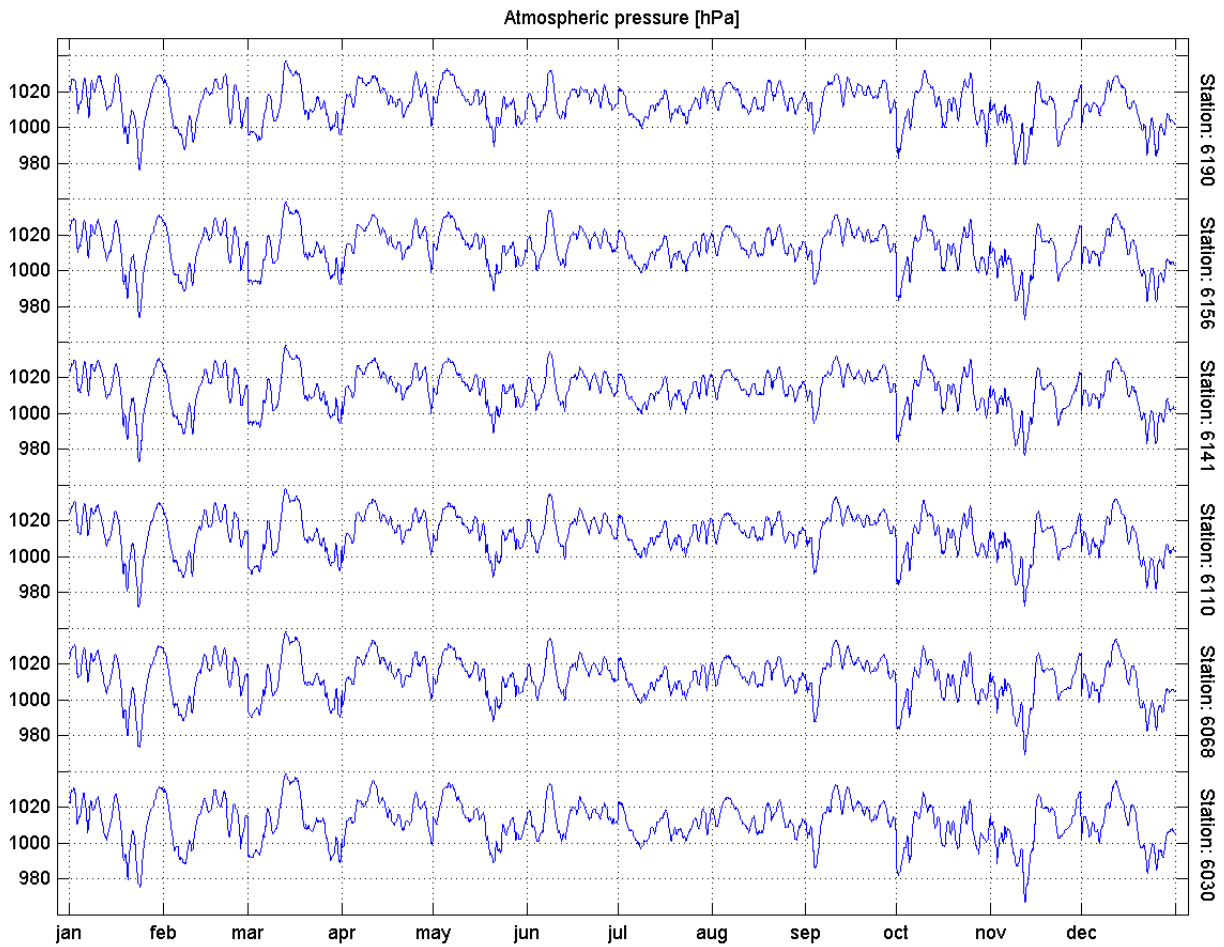
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Flyvestation Ålborg	6030	57.096270	9.850513	Northern Jutland
2	Isevad	6068	56.093853	9.181064	Central Jutland
3	Flyvestation Skrydstrup	6110	55.225166	9.263362	Funen and southern Jutland
4	Abed	6141	54.827430	11.329017	North- and western Sealand
5	Holbæk Flyveplads	6156	55.735783	11.603472	Southern Sealand plus Langeland, Møn and Lolland/Falster
6	Bornholms Lufthavn	6190	55.067730	14.749393	Bornholm





Time series



Statistics

Atmospheric pressure (hPa)

station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
6030	min	975	988	989	997	989	1000	997	1001	986	982	967	983	967
	mean	1012	1012	1011	1017	1013	1015	1009	1014	1016	1007	1006	1009	1012
	max	1031	1030	1039	1035	1034	1034	1023	1026	1033	1028	1029	1035	1039
6068	min	974	989	990	997	988	1000	998	1003	988	983	969	982	969
	mean	1013	1012	1010	1018	1013	1016	1010	1015	1018	1009	1006	1008	1012
	max	1031	1030	1038	1033	1031	1035	1024	1025	1033	1030	1026	1034	1038
6110	min	972	989	991	998	988	999	999	1005	991	984	973	982	972
	mean	1013	1012	1010	1019	1014	1017	1011	1016	1019	1011	1006	1008	1013
	max	1031	1030	1038	1032	1030	1035	1023	1025	1033	1031	1026	1032	1038
6141	min	973	988	992	999	989	1001	1000	1007	995	984	977	983	973
	mean	1015	1012	1011	1019	1014	1017	1011	1016	1019	1012	1005	1009	1013
	max	1031	1030	1038	1031	1031	1034	1023	1026	1032	1033	1026	1031	1038
6156	min	974	989	992	999	989	1000	999	1005	993	984	973	983	973
	mean	1014	1012	1011	1018	1014	1016	1010	1015	1018	1010	1005	1009	1013
	max	1031	1029	1038	1031	1033	1034	1023	1026	1032	1031	1027	1032	1038
6190	min	976	987	993	1001	990	1003	1000	1007	997	983	979	984	976
	mean	1015	1012	1011	1019	1015	1016	1012	1017	1018	1012	1005	1009	1013
	max	1030	1030	1037	1031	1033	1032	1023	1027	1030	1032	1026	1029	1037



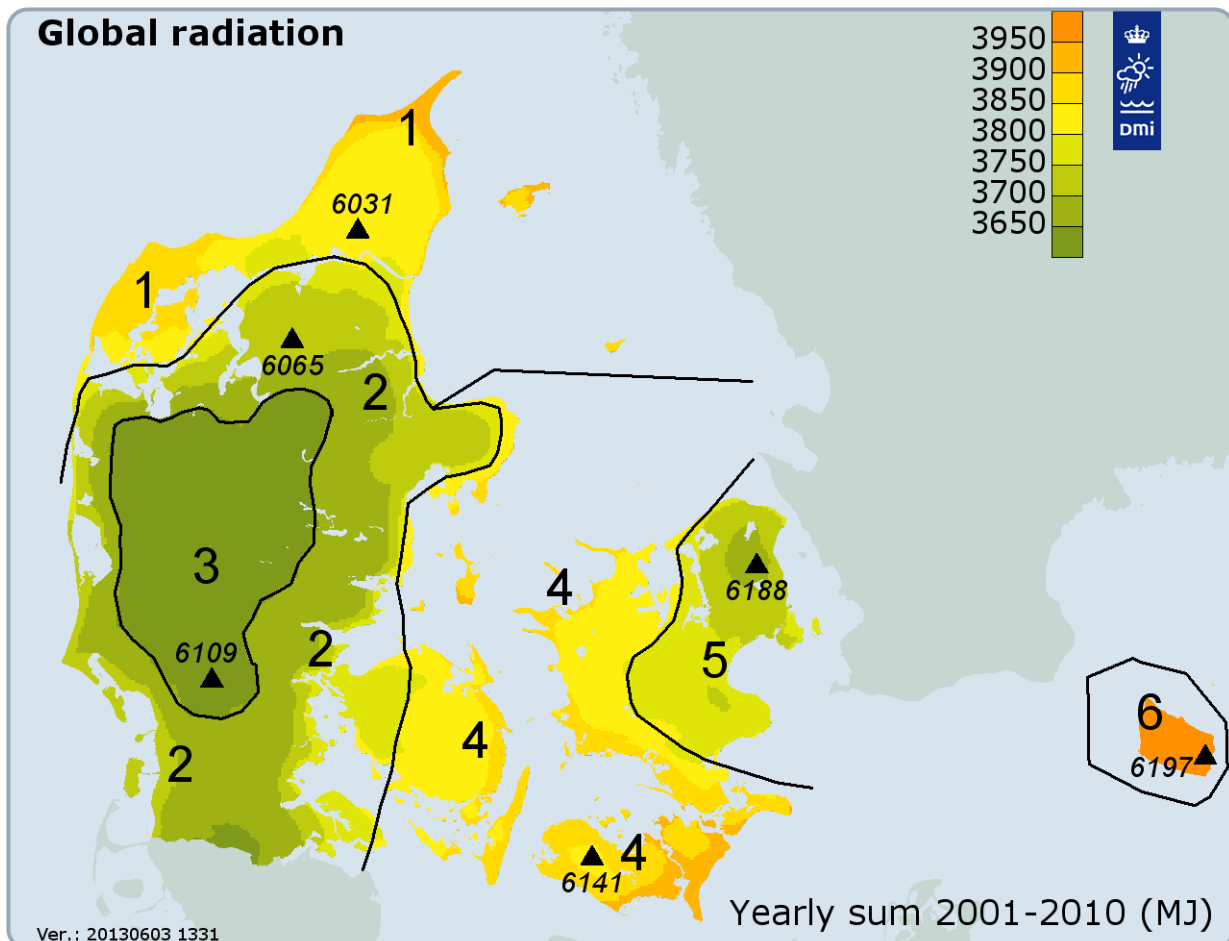
10. Global radiation

Data

The global radiation dataset consists of hourly mean values from six stations.

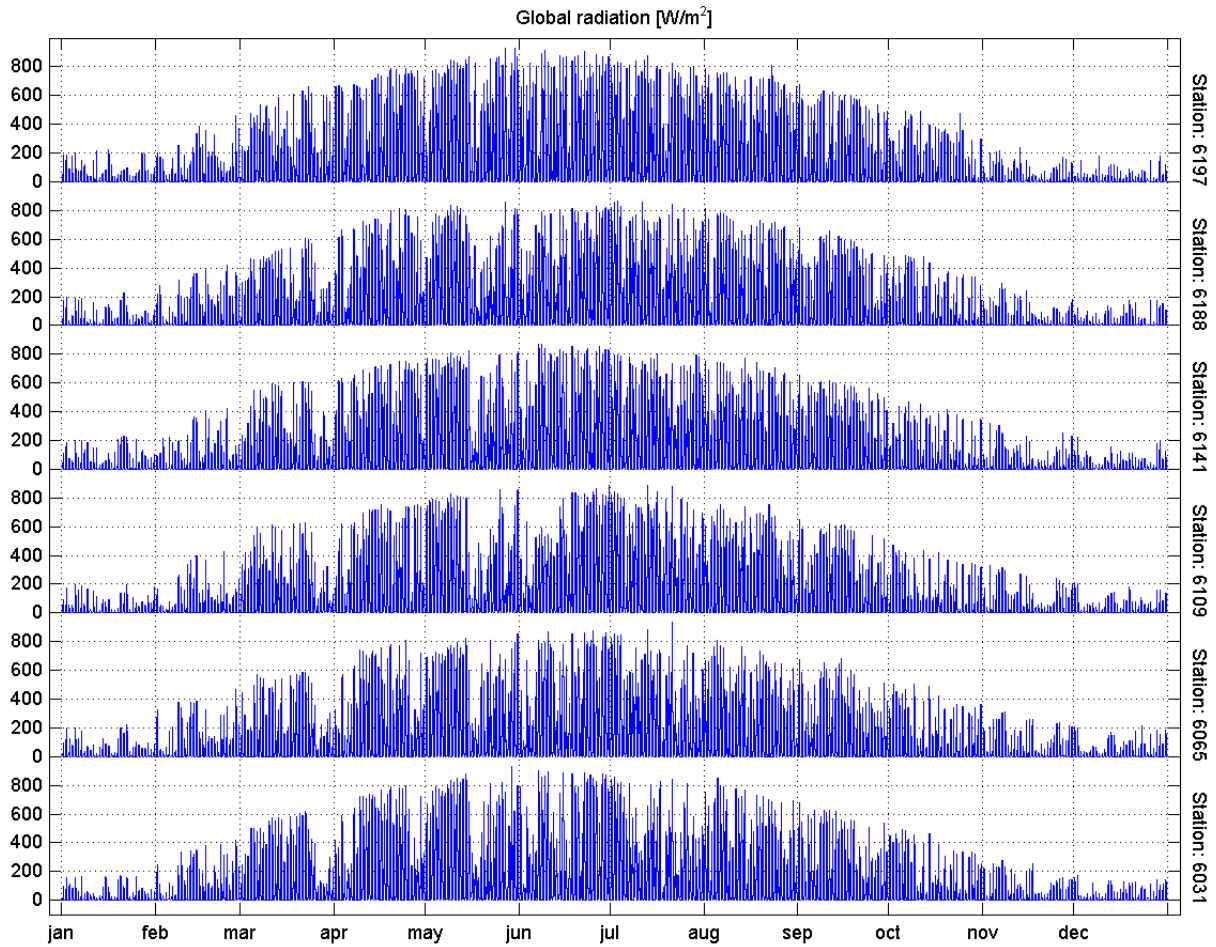
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Tylstrup	6031	57.185184	9.952632	Northern Jutland
2	Års Syd	6065	56.755825	9.506744	Western, easterne, and southern Jutland plus western Funen
3	Askov	6109	55.471485	9.112319	Inland parts of Jutland
4	Abed	6141	54.827430	11.329017	Eastern Funen, Western Sealand, Lolland-Falster, Langeland, Møn
5	Sjælsmark	6188	55.876457	12.412090	Eastern Sealand
6	Nexø Vest	6197	55.055748	15.095350	Bornholm





Time series



Statistics

		Global radiation (W/m^2)												
station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
6031	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	14	45	109	178	220	232	200	180	121	65	27	14	117
	max	173	415	618	796	931	902	857	848	675	496	276	169	931
6065	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	16	45	101	167	208	224	206	180	126	68	30	17	116
	max	222	467	589	809	856	873	932	808	681	502	313	217	932
6109	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	16	39	101	168	197	224	222	179	125	59	29	15	115
	max	198	425	626	752	857	884	885	757	646	470	328	211	885
6141	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	22	40	99	179	213	256	223	188	137	62	25	14	122
	max	232	426	611	753	827	871	800	771	656	469	317	225	871
6188	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	18	46	98	171	214	220	222	193	130	67	25	14	118
	max	226	418	605	811	859	825	863	815	677	483	296	177	863
6197	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	19	42	109	196	244	266	238	216	138	65	19	12	131
	max	224	464	662	791	933	912	877	814	675	491	236	180	933



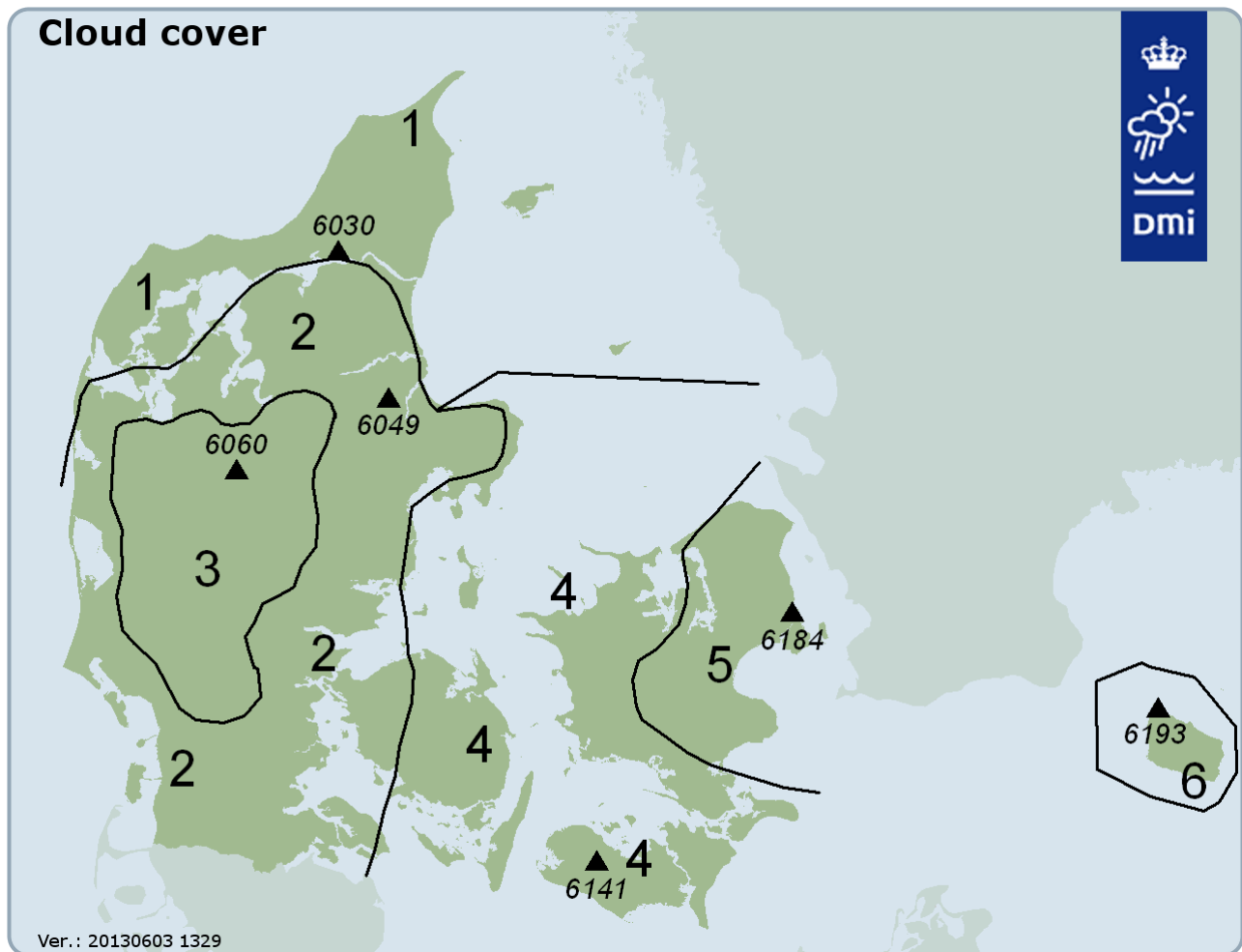
11. Cloud cover

Data

The cloud cover dataset consists of hourly mean values from six stations.

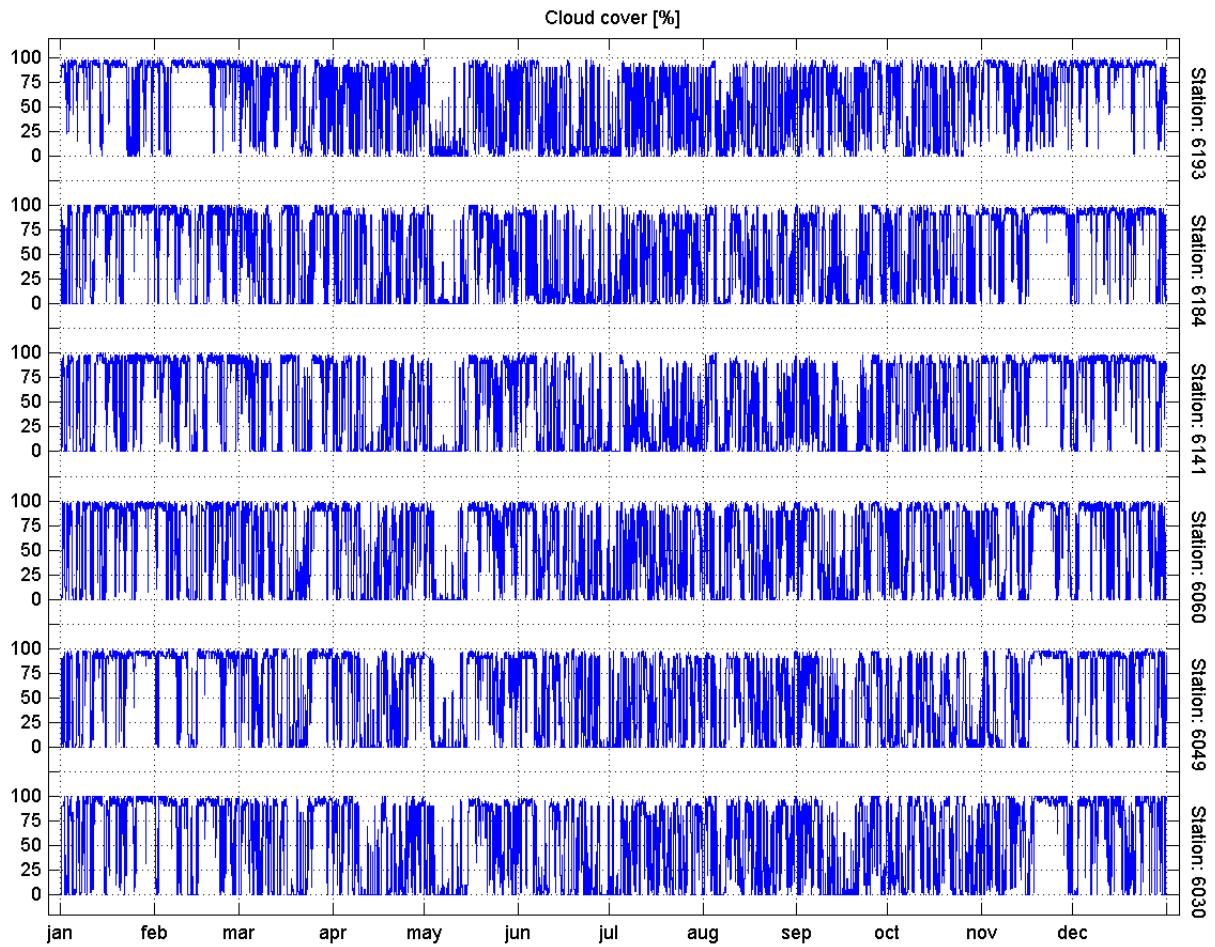
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Flyvestation Ålborg	6030	57.096270	9.850513	Northern Jutland
2	Hald Vest	6049	56.560425	10.092886	Western, easterne, and southern Jutland plus western Funen
3	Flyvestation Karup	6060	56.293420	9.113890	Inland parts of Jutland
4	Abed	6141	54.827430	11.329017	Eastern Funen, Western Sealand, Lolland-Falster, Langeland, Møn
5	DMI	6184	55.716053	12.562150	Eastern Sealand
6	Hammer Odde Fyr	6193	55.297993	14.771835	Bornholm





Time series



Statistics

station		Cloud cover (%)												Year
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
6030	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	76	70	55	43	45	45	47	50	42	48	70	68	55
	max	100	100	100	100	100	98	100	100	100	100	100	100	100
6049	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	76	77	61	49	51	51	47	48	42	30	61	73	55
	max	100	100	100	98	98	100	98	98	100	98	100	100	100
6060	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	75	69	59	50	52	48	49	53	47	55	67	70	58
	max	100	100	100	100	100	100	98	98	100	100	100	100	100
6141	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	68	73	60	37	44	39	26	37	33	54	78	79	52
	max	100	100	100	98	98	100	98	100	98	98	100	100	100
6184	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	73	72	56	45	42	28	45	41	46	52	80	79	55
	max	100	100	100	98	100	100	100	100	100	100	100	100	100
6193	min	0	0	0	0	0	0	0	0	0	0	0	2	0
	mean	77	85	62	58	38	40	46	43	56	52	73	85	59
	max	98	100	100	98	100	100	98	97	98	98	98	100	100



12. Soil temperature

Data

The soil temperature dataset consists of modelled daily mean values from six stations.

Model

Since soil temperature in 1m depth changes slowly, the soil temperature is modelled as daily values. The temperature is modelled from measurements of soil temperature in 30 cm depth.

The climatological zones are identical to those of air temperature.

The model is chosen by the Danish Building Research Institute and is described in *Varmetab fra fjernvarmeledninger*, by B. Kvisgaard og S. Hadvig, 1980 [6] by the formulas:

$$T_D = T_{mean} + (T_{30f} - T_{mean}) \cdot e^{(-D\sqrt{\pi/(a\tau_0)})}$$

where

$$T_{30f} = T_{30cm} \text{ at time } \tau - D\sqrt{\tau_0/(4a\pi)}$$

and

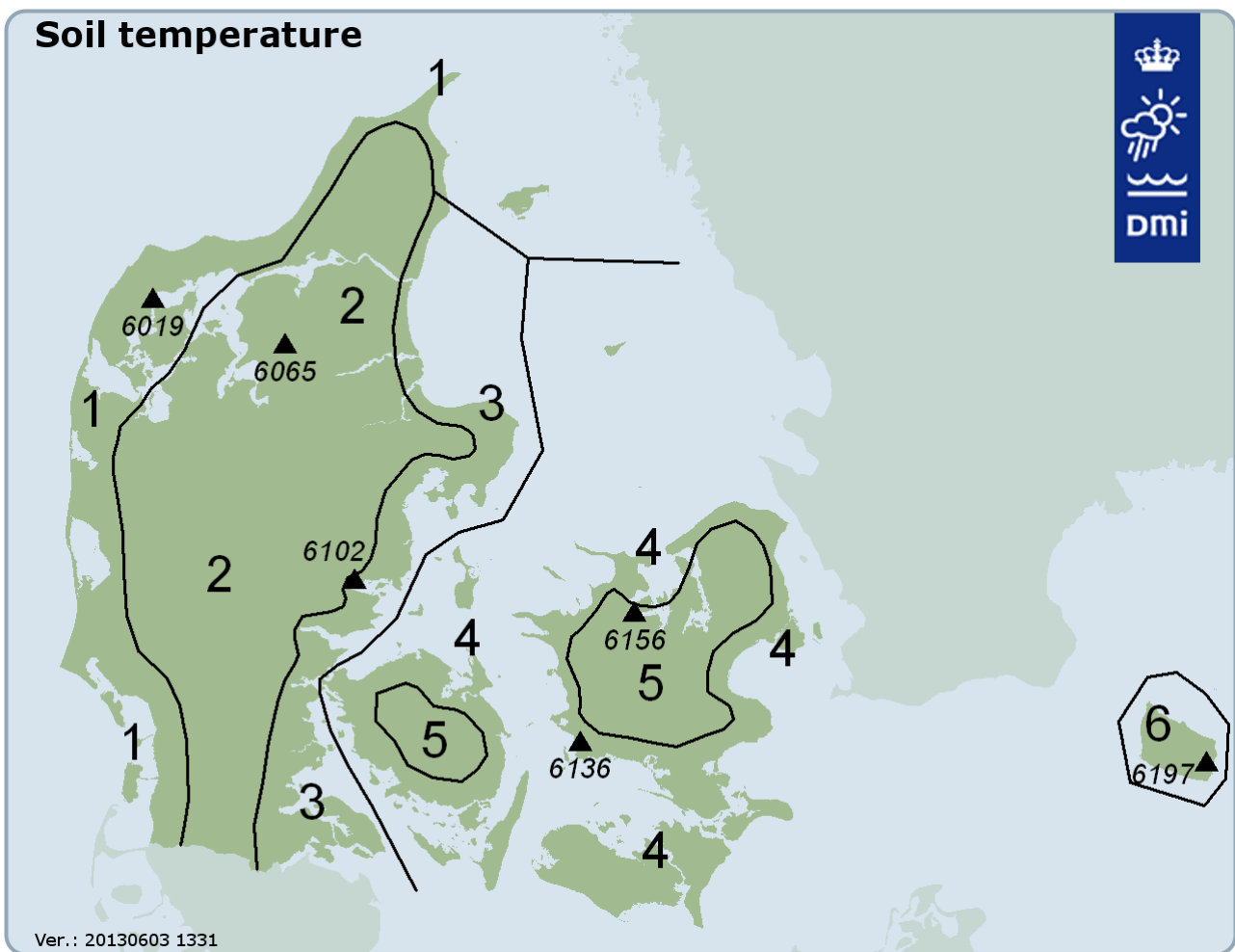
T_D	soil temperature in 1m depth ³
T_{mean}	yearly mean temperature in 30 cm depth
T_{30cm}	temperature in 30 cm depth
D	depth
τ	time in seconds after Jan. 1. 00:00
τ_0	period in seconds ($\sim 3,15 \cdot 10^7$ s)
a	soil temperature conductivity ($8,0 \cdot 10^{-7} \frac{m}{s}$)

³ Since the soil temperature in 30 cm depth is input to the model, a depth of 70 cm has been used.



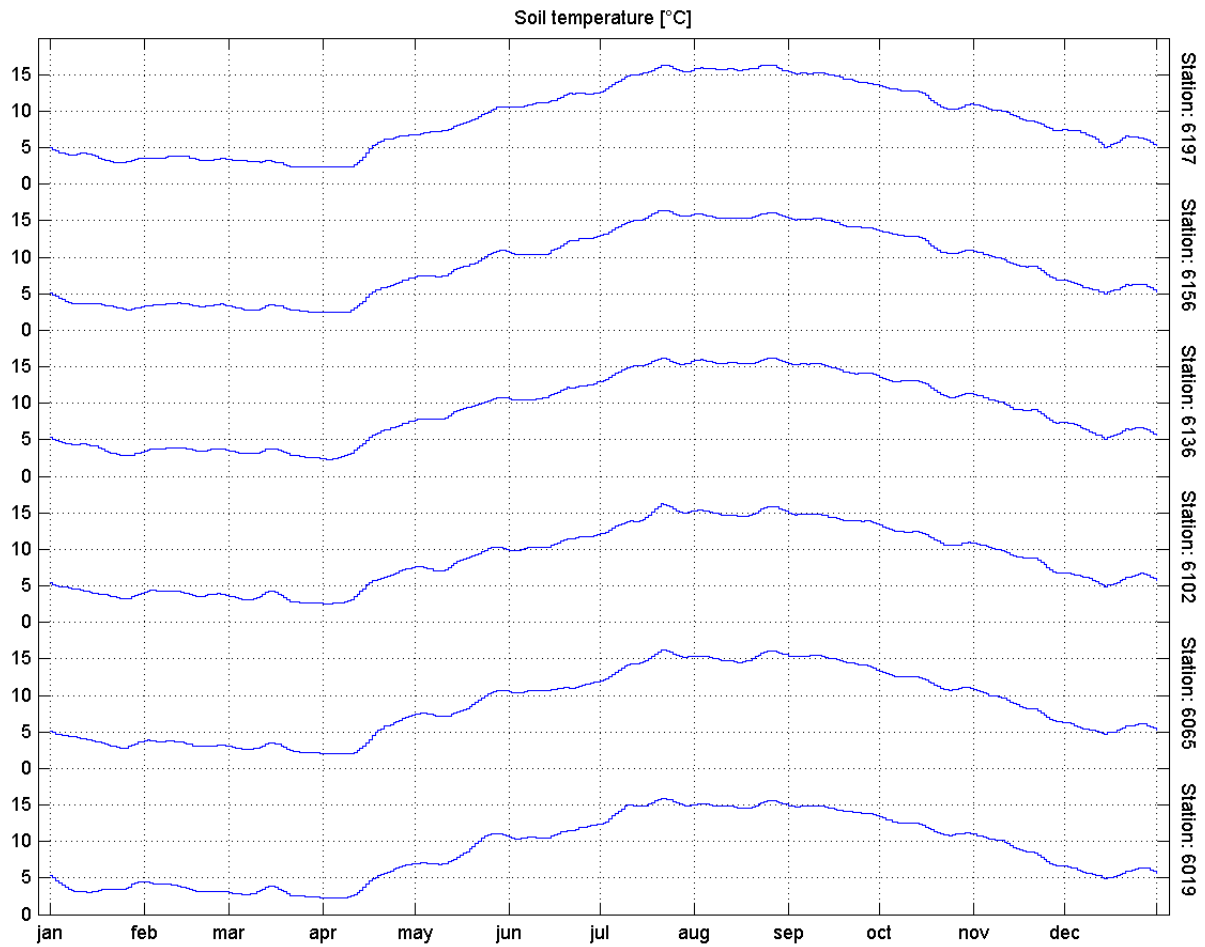
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Silstrup	6019	56.929203	8.641048	Westcoast of Jutland
2	Års Syd	6065	56.755825	9.506744	Inland parts of Jutland
3	Horsens/Bygholm	6102	55.868000	9.786903	Eastcoast of Jutland
4	Tystofte	6136	55.246502	11.328447	Coastal parts of Sealand and Funen plus Lolland-Falster, Langeland and Møn
5	Holbæk Flyveplads	6156	55.735783	11.603472	Central parts of Funen and Sealand
6	Nexø Vest	6197	55.055748	15.095350	Bornholm





Time series



Statistics

		Soil temperature (°C)												
station		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	year
6019	min	3.0	3.1	2.3	2.3	6.8	10.3	12.4	14.5	13.5	10.8	6.6	4.9	2.3
	mean	3.7	3.6	2.9	4.3	8.6	11.1	14.7	15.0	14.4	11.9	8.9	5.8	8.8
	max	5.3	4.5	3.9	6.9	11.1	12.3	15.9	15.6	14.9	13.4	11.0	6.6	15.9
6065	min	2.8	3.0	2.0	2.0	7.1	10.3	12.0	14.5	13.5	10.7	6.3	4.7	2.0
	mean	3.8	3.4	2.7	4.1	8.5	10.9	14.5	15.2	14.8	11.9	8.6	5.6	8.7
	max	5.1	3.9	3.5	7.3	10.7	11.9	16.2	16.1	15.5	13.3	10.8	6.3	16.2
6102	min	3.2	3.6	2.6	2.5	7.0	9.8	12.1	14.5	13.5	10.5	6.8	4.9	2.5
	mean	4.1	4.0	3.2	4.9	8.6	10.8	14.4	15.1	14.3	11.7	9.0	6.0	8.9
	max	5.4	4.4	4.3	7.5	10.3	12.0	16.2	15.9	15.0	13.3	10.8	6.7	16.2
6136	min	2.8	3.4	2.4	2.3	7.7	10.4	13.0	15.4	13.8	10.8	7.3	5.1	2.3
	mean	3.9	3.7	3.1	4.9	9.1	11.4	15.0	15.7	14.8	12.2	9.3	6.2	9.1
	max	5.3	3.9	3.8	7.6	10.8	12.9	16.1	16.2	15.5	13.6	11.2	7.4	16.2
6156	min	2.8	3.2	2.4	2.4	7.3	10.3	13.0	15.3	13.8	10.5	6.9	5.0	2.4
	mean	3.6	3.5	2.9	4.5	8.8	11.3	15.1	15.6	14.7	12.0	8.9	5.9	8.9
	max	5.1	3.8	3.5	7.2	10.9	12.9	16.4	16.1	15.3	13.6	10.8	6.8	16.4
6197	min	3.0	3.2	2.3	2.3	6.7	10.5	12.6	15.5	13.6	10.2	7.3	5.0	2.3
	mean	3.7	3.6	2.8	4.4	8.4	11.6	15.0	15.8	14.7	11.8	9.1	6.3	9.0
	max	5.0	3.9	3.4	6.7	10.6	12.5	16.3	16.2	15.4	13.5	10.9	7.5	16.3

13. Sea temperature

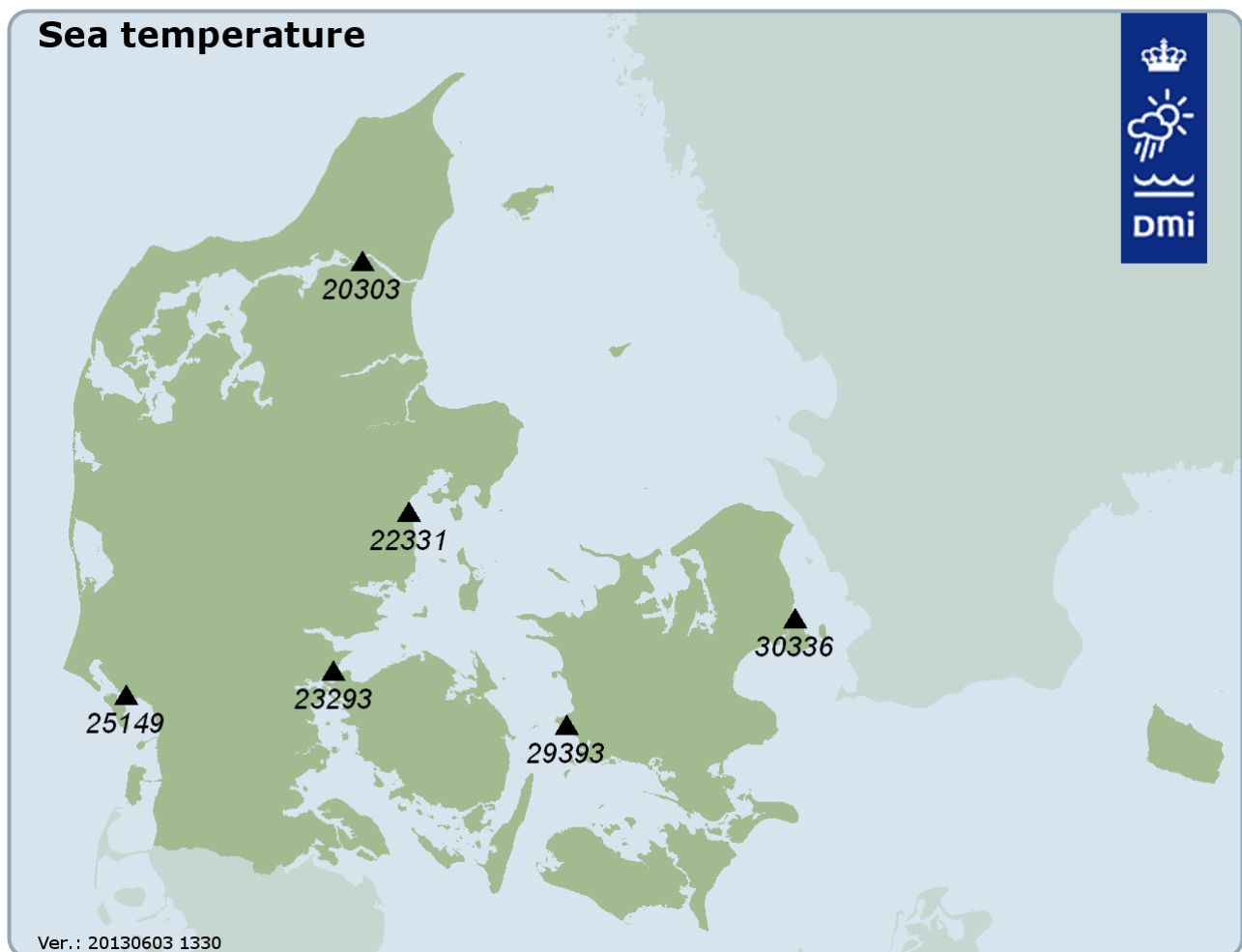
Since the dataset for sea temperature is measured in harbour basins, there are no zonal sections. The dataset from the harbour basins does not represent climatological variations in sea temperature, rather it describes the temperature variations within each basin.

Data

The sea temperature dataset consist of hourly mean values from six harbour basins.

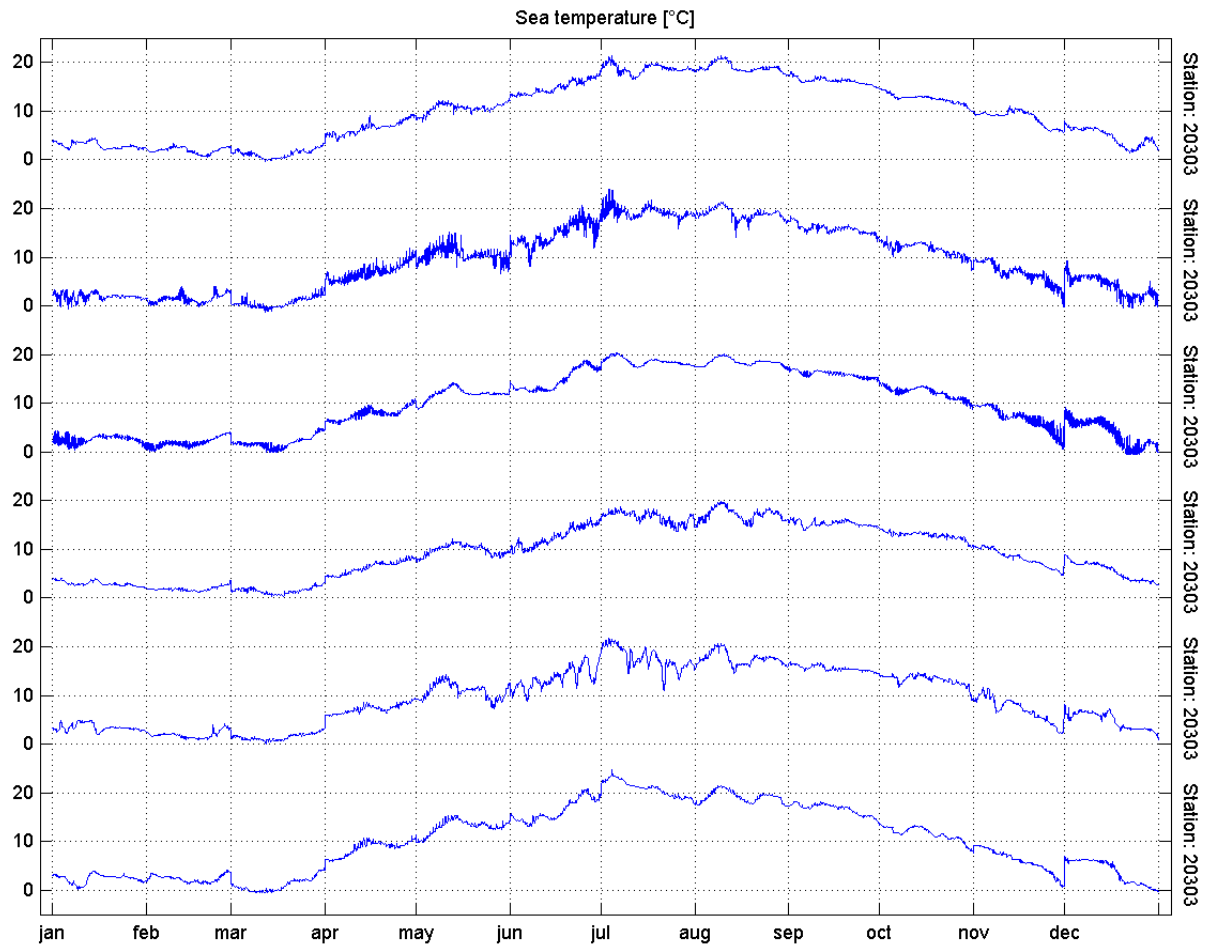
Stations

Station name	Station no.	Latitude (°)	Longitude (°)
Ålborg Harbour	20303	57.048770	9.941374
Århus Harbour	22331	56.146675	10.222569
Fredericia Harbour	23293	55.560165	9.753185
Esbjerg Harbour	25149	55.460170	8.439694
Korsør Harbour	29393	55.331493	11.140914
Københavns Harbour	30336	55.704410	12.598961





Time series



Statistics

		Sea temperature (°C)												
station		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	year
20303	min	0.2	1.2	-0.5	5.9	9.6	13.0	17.7	17.2	13.4	7.7	0.7	-0.2	-0.5
	mean	2.4	2.4	1.1	8.6	13.0	16.4	20.9	19.2	16.6	11.6	6.0	3.9	10.2
	max	3.8	4.2	4.6	11.3	15.4	20.7	24.7	21.4	18.2	13.8	9.3	6.9	24.7
22331	min	2.0	0.9	0.0	5.7	7.3	8.8	10.9	14.5	14.3	9.0	2.2	0.9	0.0
	mean	3.4	1.9	1.5	7.3	10.9	13.6	17.6	17.5	15.6	13.2	7.1	4.8	9.6
	max	5.1	4.2	3.2	9.5	14.3	18.3	21.7	20.7	17.0	14.8	11.6	8.1	21.7
23293	min	2.0	1.0	0.4	4.2	7.3	9.0	13.5	14.5	13.8	10.1	4.6	2.7	0.4
	mean	3.0	1.9	1.5	6.3	9.9	12.6	16.5	17.2	15.3	12.8	8.2	5.6	9.3
	max	4.1	3.5	3.2	8.6	12.2	16.5	18.7	19.9	16.6	14.3	10.8	8.9	19.9
25149	min	0.4	0.1	-0.1	5.7	8.8	12.2	17.3	16.8	14.3	8.7	0.6	-0.6	-0.6
	mean	2.5	1.9	1.9	7.9	11.9	14.8	18.6	18.4	15.9	12.1	6.8	3.7	9.7
	max	4.4	4.1	4.9	10.9	14.2	18.9	20.4	20.1	17.4	14.2	9.9	9.1	20.4
29393	min	-0.6	-0.1	-1.3	4.1	6.6	8.1	15.9	14.0	13.1	7.3	-0.2	-0.5	-1.3
	mean	1.9	1.5	0.6	6.9	10.6	14.7	19.2	18.9	15.8	11.6	6.7	4.1	9.4
	max	3.4	4.0	3.9	11.8	15.2	20.6	23.9	21.3	18.4	14.2	10.0	9.2	23.9
30336	min	2.0	0.6	-0.3	3.8	7.7	12.9	16.6	17.2	14.7	9.8	5.5	1.5	-0.3
	mean	3.0	1.9	1.3	6.6	10.6	14.9	18.7	19.0	16.2	12.5	8.6	4.7	9.9
	max	4.4	3.3	3.4	9.4	12.3	18.3	21.3	21.3	18.0	14.7	11.0	7.9	21.3

14. Diffuse irradiance

Diffuse horizontal irradiance is composed of the indirect radiation part of the global radiation, i.e. the radiation that is backscattered from the atmosphere, clouds etc.

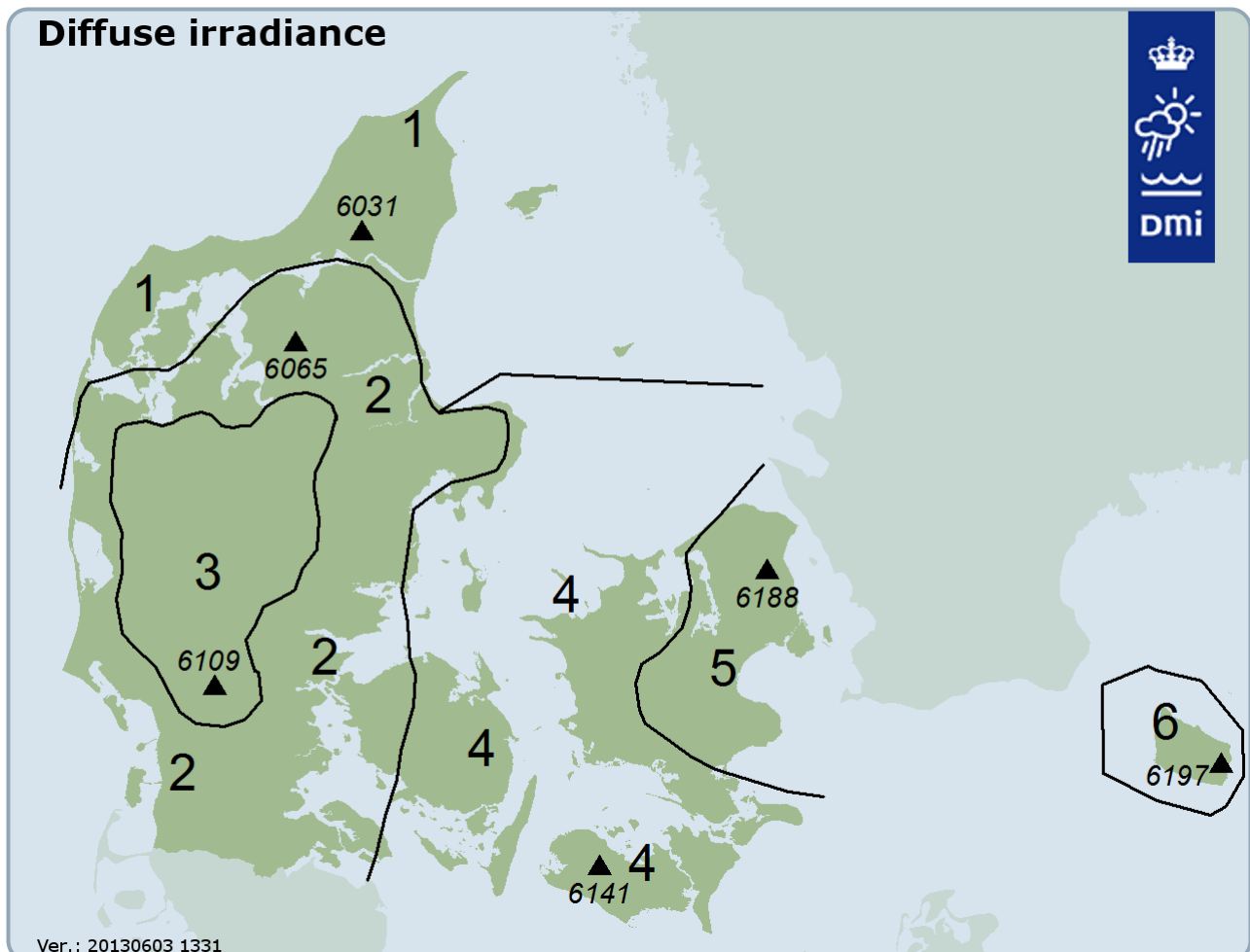
The Technical University of Denmark has developed the method used to model the diffuse irradiance from the global radiation, see [7].

Data

The diffuse irradiance dataset consists of hourly mean values from six stations.

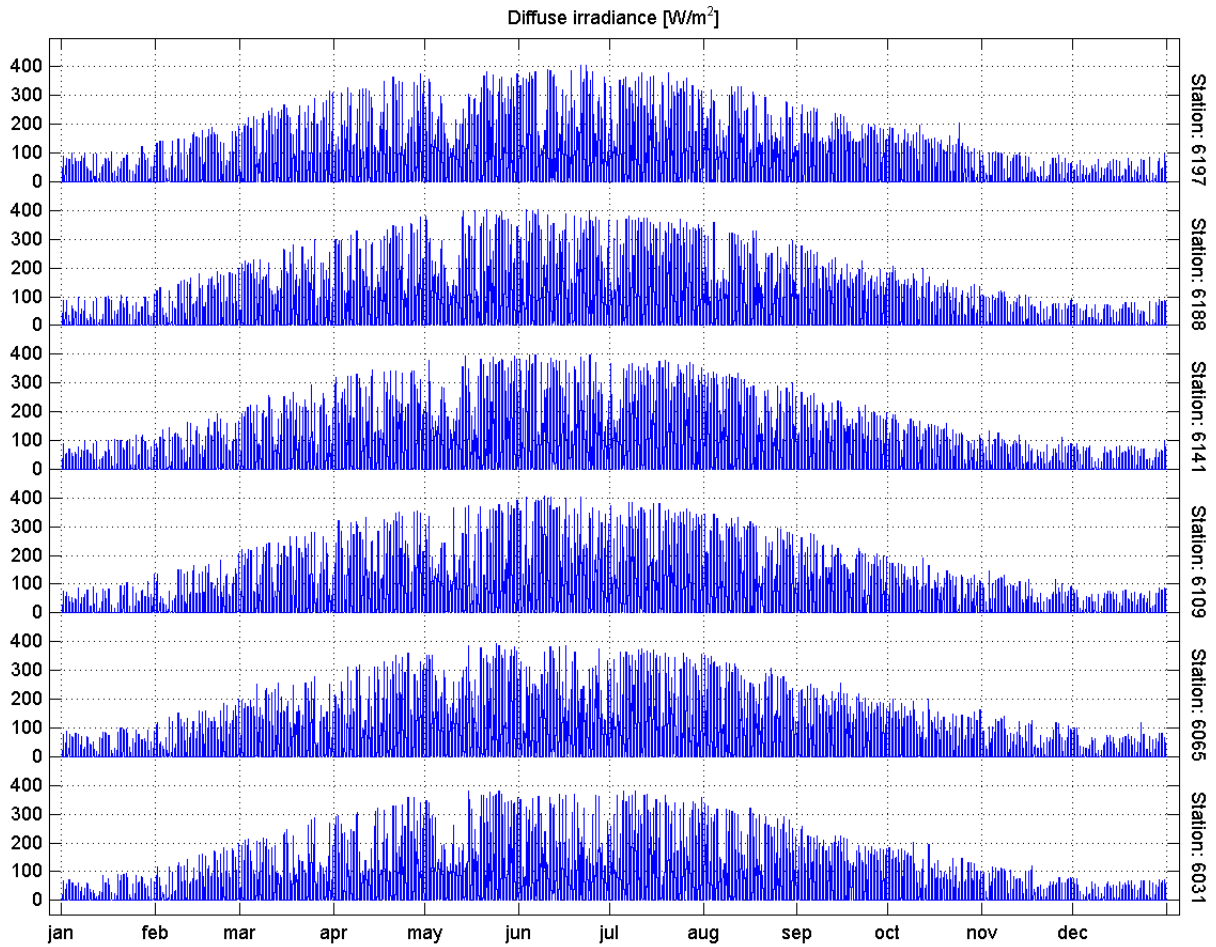
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Tylstrup	6031	57.185184	9.952632	Northern Jutland
2	Års Syd	6065	56.755825	9.506744	Western, easterne, and southern Jutland plus western Funen
3	Askov	6109	55.471485	9.112319	Inland parts of Jutland
4	Abed	6141	54.827430	11.329017	Eastern Funen, Western Sealand, Lolland-Falster, Langeland, Møn
5	Sjælsmark	6188	55.876457	12.412090	Eastern Sealand
6	Nexø Vest	6197	55.055748	15.095350	Bornholm





Time series



Statistics

		Diffuse irradiance (W/m^2)												
station		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	year
6031	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	11	28	50	75	98	93	105	80	55	33	16	9	54
	max	96	200	289	360	380	371	379	336	257	203	122	76	380
6065	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	12	29	52	80	105	101	109	83	60	35	18	11	58
	max	99	199	279	361	393	388	375	351	257	201	141	117	393
6109	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	12	26	53	82	95	114	108	86	59	32	18	11	58
	max	135	205	282	353	393	408	386	344	276	190	147	87	408
6141	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	15	28	54	85	103	110	112	87	59	33	16	11	59
	max	117	192	293	346	394	398	379	339	269	191	134	99	398
6188	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	13	30	55	83	102	113	112	81	58	34	17	11	59
	max	108	199	300	376	403	405	381	359	277	206	119	91	405
6197	min	0	0	0	0	0	0	0	0	0	0	0	0	0
	mean	14	30	59	81	94	103	105	77	58	34	14	10	57
	max	121	192	317	376	384	405	381	332	268	206	105	98	405



15. Illuminance

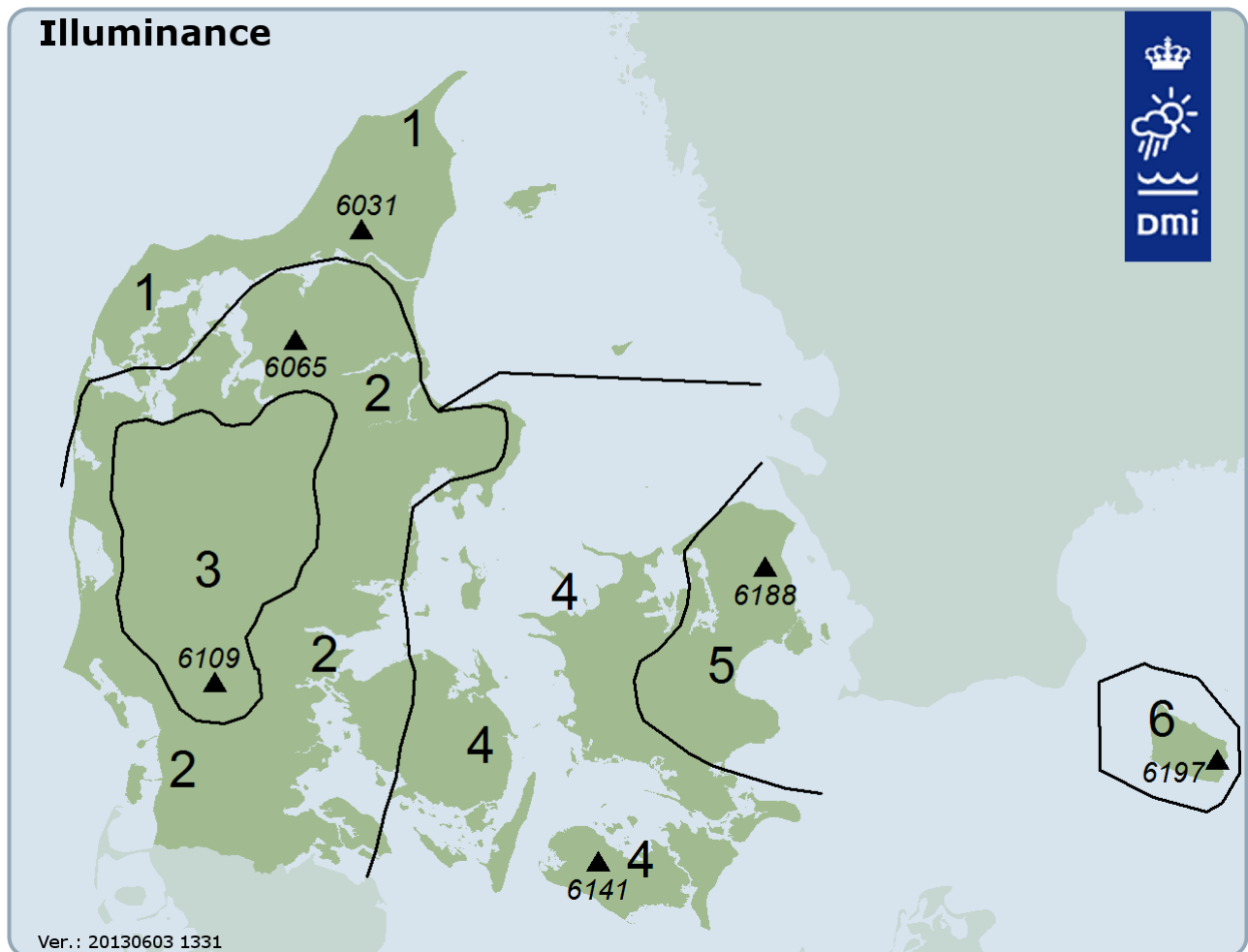
Modelled values of solar illuminance are presented below. The correlation between illuminance and global radiation is a function of the water content of clouds. The values have been calculated by The Danish Meteorological Institute [1, 8].

Data

The illuminance radiation dataset consists of hourly mean values from six stations.

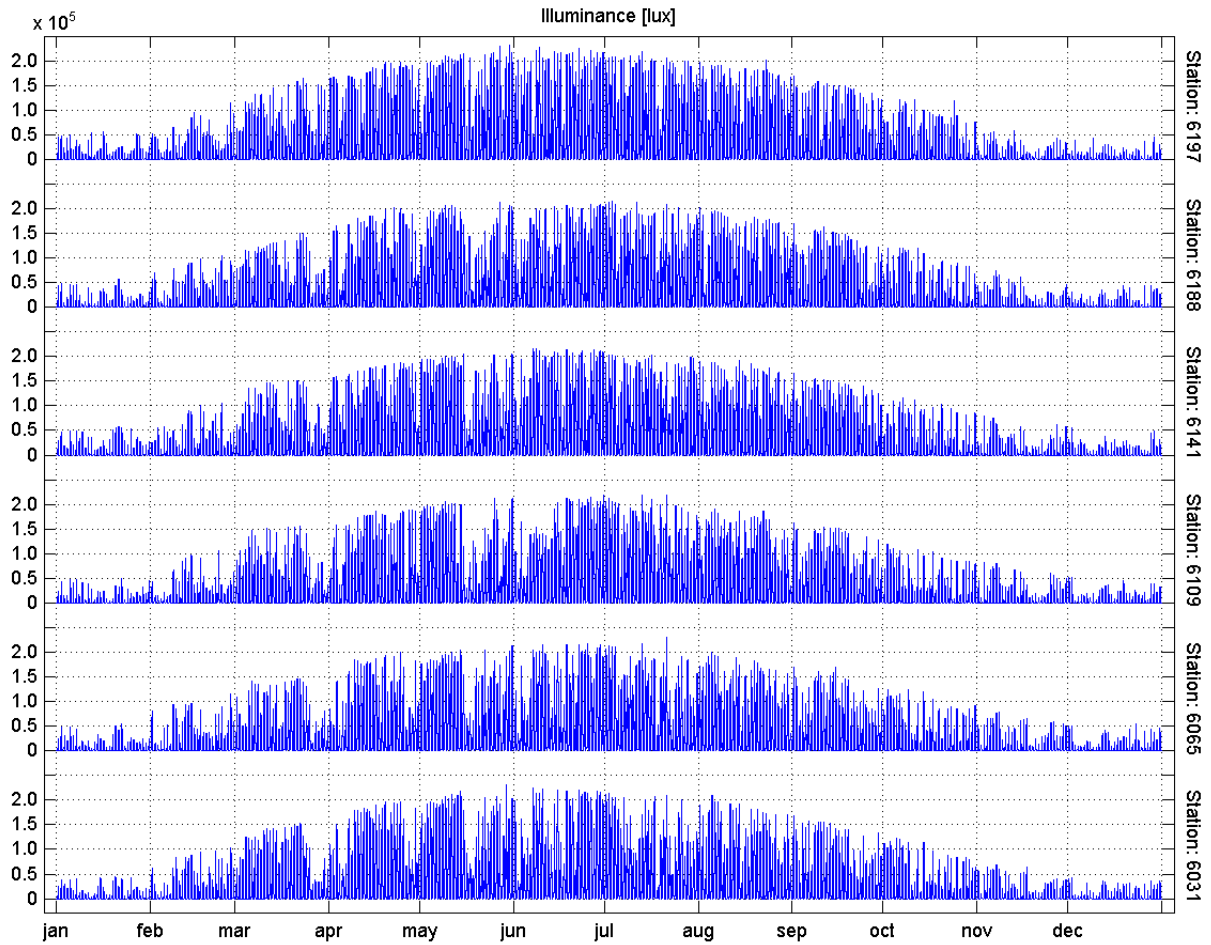
Stations and zones

Zone	Station name	Station no.	Latitude (°)	Longitude (°)	Area
1	Tylstrup	6031	57.185184	9.952632	Northern Jutland
2	Års Syd	6065	56.755825	9.506744	Western, eastern, and southern Jutland plus western Funen
3	Askov	6109	55.471485	9.112319	Inland parts of Jutland
4	Abed	6141	54.827430	11.329017	Eastern Funen, Western Sealand, Lolland-Falster, Langeland, Møn
5	Sjælsmark	6188	55.876457	12.412090	Eastern Sealand
6	Nexø Vest	6197	55.055748	15.095350	Bornholm





Time series



Statistics

		Illuminance ($\times 10^3$ lux)												
station		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	year
6031	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	1.9	5.9	14.0	22.8	28.4	29.8	26.1	23.3	15.6	8.4	3.5	1.8	15.2
	max	22.0	51.5	76.6	98.7	115.4	111.8	106.8	105.2	84.2	61.5	34.2	21.0	115.4
6065	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	2.1	5.8	13.0	21.5	27.0	29.0	26.9	23.4	16.3	8.7	3.9	2.2	15.0
	max	27.5	57.9	73.0	100.3	106.1	108.3	115.6	100.2	84.4	62.2	38.8	26.9	115.6
6109	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	2.1	5.1	13.0	21.7	25.5	29.2	28.8	23.3	16.2	7.7	3.8	1.9	14.9
	max	24.9	52.7	77.6	94.2	106.3	109.6	109.7	95.6	81.5	59.2	40.7	26.2	109.7
6141	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	2.8	5.3	12.8	22.9	27.6	32.9	29.1	24.4	17.6	8.0	3.3	1.9	15.8
	max	28.8	52.8	75.8	93.7	102.5	108.0	101.5	95.6	82.6	58.2	39.3	27.9	108.0
6188	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	2.3	6.0	12.7	22.0	27.6	28.8	28.8	24.9	16.8	8.6	3.2	1.8	15.3
	max	28.0	51.8	75.0	100.6	106.5	104.3	107.0	101.1	84.3	60.1	36.7	21.9	107.0
6197	min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	mean	2.4	5.5	14.0	24.9	31.1	34.0	30.7	27.6	17.7	8.4	2.5	1.6	16.8
	max	27.8	57.5	82.1	98.1	115.7	113.1	108.7	100.9	84.2	60.9	29.6	22.3	115.7



16. Data for Building Permit Calculations

A dataset to be used for energy performance calculations for obtaining a building permit [4] is included.

Given the general rule that similar conditions apply for all locations in Denmark, it was decided that one dataset should represent the whole Denmark in this regard. This dataset should best represent most of the population in Denmark, and datasets from the three stations Holbæk Flyveplads, DMI and Sjælsmark were chosen.

This specific dataset is a subset of the DRY dataset, and thereby does not introduce any new data.

Data

The dataset consists of hourly mean values for the parameters temperature, relative humidity, wind speed and direction, atmospheric pressure, global radiation, cloud cover, diffuse irradiance and illuminance and daily values of soil temperature.

Stations

Station name	Station no.	Latitude (°)	Longitude (°)
Holbæk Flyveplads	6156	55,735783	11,603472
DMI	6184	55.716053	12.562150
Sjælsmark	6188	55,876457	12,412090



17. Quality Control

The quality control has been performed on all data in the dataset. The general method is described below, followed by a description of special cases of quality control for cloud cover and sea temperature.

General method

The dataset has been scrutinized on two levels:

1. A spatial control for daily, monthly and yearly data, performed by a contour mapping of Danish land area
2. A visual control of the time series from each station

Erroneous values have been replaced by interpolated values from nearby stations, to make sure the dataset is complete.

Special cases

In addition to the general quality control, some special cases of quality control had to be performed for cloud cover and sea temperature, as described below.

Cloud cover

In the cloud cover dataset, some values were missing, and the following values have been replaced:

station no.	station name	period	replaced with values from	
6060	Flyvestation Karup	12.11.2010 15:00 - 17.11.2010 07:00	6049	Hald vest
6141	Abed	20.11.2010 09:00 - 22.11.2010 09:00	6184	DMI
6184	DMI	15.01.2009 15:00 - 16.01.2009 17:00	6141	Abed
6184	DMI	03.06.2005 10:00 - 28.06.2005 06:00	6141	Abed

For station 6193 Hammer Odde Fyr all data in the months January 2009, February 2009 and November 2010 have been replaced with values from January 2008, February 2008 and November 2009 respectively.

Sea temperature

For station 30336 Københavns Havn all data in November 2010 have been replaced with values from November 2008.



18. Format

The collective dataset attached to this report consists of two zip-files.

- a. The DRY dataset (TR13-19_DRY.zip)
- b. The building permit dataset (TR13-19_building_permit.zip)

a. The DRY Dataset

The DRY dataset is attached as a zip-file containing a csv-file for each station and parameter in the format:

DRY_<parameter>_hourly_<statid>.csv

Hourly values for <parameter> and <station number>
format: Station number
Timestamp in UTC⁴ format *yyyymmddhh*
Value
Quality index (1100 indicates an observed value, 1000 indicates an interpolated value)

DRY_soil_temperature_daily_<statid>.csv

Daily values for soil temperature and <station number>
format: Station number
Timestamp in UTC² format *yyyymmdd*
Value
Quality index (1100 indicates an observed value, 1000 indicates an interpolated value)

b. The Building Permit Dataset

The dataset for obtaining a building permit contains a csv-file for each parameter in the same format as in "a. The DRY Dataset".

⁴ Universal Time, Coordinated: In Denmark, UTC+2 hours corresponds to summer time (daylight savings time) and UTC+1 hour otherwise.



References

- [1] *DMI Technical Report 12-17: 2001-2010 Design Reference Year for Denmark*, by Peter Riddersholm Wang, Mikael Scharling and Kristian Pagh Nielsen, 2012
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- [3] *Design Reference Year, DRY – et nyt dansk referenceår*, by Jerry Møller Jensen og Hans Lund, 1995
- [4] *Danish Building Regulations 2010 (BR10)*, Ministry of Economic and Business Affairs, Danish Enterprise and Construction Authority, Copenhagen 2010
- [5] *Energiteknologisk udvikling- og demonstrationsprogram*, Danish Energy Agency. More information here: <http://www.ens.dk/da-dk/nyteknologi/om-eudp/sider/forside.aspx>
- [6] *Varmetab fra fjernvarmeledninger*, by B. Kvisgaard og S. Hadvig, 1980
- [7] *DTU Report R-275: Solar radiation and thermal performance of solar collectors for Denmark*, by Janne Dragsted and Simon Furbo, 2012
- [8] Please contact Kristian Pagh Nielsen, DMI, for more information on illuminance calculations.