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2001 - 2010 Danish Design Reference Year. Update and supplementary datasets.

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Content

Abstract

The Danish Design Reference Year (DRY) dataset based on meteorological data from the period 2001-2010 has been updated and expanded. The DRY dataset is a yearly dataset that consists of 12 typical months and should be used as a reference for building and solar energy simulations. Since it does not include atypical months it cannot be used for simulations that should represent the variability in general meteorological conditions. For such simulations multi-year datasets should be used instead. The update of the dataset consists of corrections made to the derived solar diffuse radiation, which has been found to contain errors in the hours following sunrise and the hours preceding sunset. No updates have been made to the measured DMI meteorological data, which are as in the originally published DRY 2001-2010 dataset that was published as DMI Technical Report 13-19. The expansion of the dataset consists in that the solar direct normal radiation at the surface, and global and direct normal radiation at the top of the atmosphere have been included. Additionally, global, direct normal and diffuse illuminances at the surface have been included in the dataset. For the Danish Bulding Regulations 2018 (BR18), a single subset of the DRY 2001-2010 dataset has been made in the EnergyPlus weather data format, which is used by many daylighting software systems currently available.

1. Background

In order to have a reference dataset to simulate heat and ventilation in buildings Andersen et al. (1974) designed the reference year. This included several meteorological variables at an hourly resolution. This first reference year was made from 12 typical months of data from Flyvestation Værløse and Højbakkegård in Tåstrup during the period 1959-1969. The months were selected based on the mean values and variance of the daily average temperatures, the daily maximum temperatures and the global radiation as compared with the complete data period (Andersen et al. 1974). An improved and updated version – the Danish Design Reference Year (DRY) – was developed in the 1990s by Hans Lund at DTU. This consisted of a full year of typical meteorological data based on meteorological data from the period 1975-1989. In 2013 an updated DRY dataset for the period 2001-2010 was published by DMI in collaboration with DTU Civil Engineering and the Danish Building Research Institute. This updated DRY dataset was made with support from the EUDP programme funded by the Danish Energy Agency. It has been published as DMI Technical Report TR13-19 (Wang et al. 2013).

In the DRY 2001-2010 dataset meteorological measurements, including (solar) global radiation, from DMI stations across Denmark were included together with solar diffuse irradiances derived by DTU Civil Engineering (Dragsted et al. 2012). In DRY 2001-2010, datasets for multiple regions were made to accommodate demand from the solar energy industry. Later these data have been adopted by the building daylighting industry who found issues with the diffuse irradiances in the hours after sunrise and before sunset. These issues have now been corrected as described in detail in an updated version of the Dragsted et al. (2012; 2019) DTU Civil Engineering report R-275. Furthermore, derived direct normal solar radiation and irradiances at the top of the atmosphere have been included in the DRY 2001-2010 dataset. DMI have added derived global, diffuse and direct normal illuminances. All these additions are made following demand from the building daylighting industry. Also, this update has been made to be referenced in the 2018 edition of the Danish Building Regulations (“Bygningsreglementet”; BR18).

2. Data

All DMI measurement data in the DRY 2001-2010 dataset are unchanged from the quality-controlled data published in 2013 (Wang et al. 2013). These data include one year of hourly:

- temperature [°C]
- relative humidity [%]
- wind speed [m/s]
- wind direction [°]
- atmospheric pressure [hPa]
- global radiation [W/m^2]
- cloud cover [%]
- sea temperature [°C]

and one year of daily:

- soil temperature [°C]

The soil temperatures are measured at 1 meter depth at which intra-daily variations are negligible.

The 12 typical months used for the DRY dataset remain as before, that is:

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

The derived irradiances now include the following hourly variables:

- diffuse radiation [W/m^2]
- direct normal radiation [W/m^2]
- top of atmosphere radiation [W/m^2]
- top of atmosphere direct normal radiation [W/m^2]

Here the direct normal radiation variables are solar energy fluxes – or solar irradiances – on a surface normal with respect to the direction of the sun, while the other radiation variables are solar irradiances on a horizontal surface (Dragsted et al. 2012; 2019).

The derived illuminances include the following hourly variables:

- global illuminance [lux]
- direct normal illuminance [lux]
- diffuse illuminance [lux]

The direct normal illuminance is on a surface normal with respect to the direction of the sun, while the global and diffuse illuminances are on a horizontal surface. The global and direct normal illuminances are calculated according to Eq. 6 and Eq. 8 in Perez et al. (1990). The diffuse illuminance is calculated from these other two components. As Perez et al. (1990) we use the integrated atmospheric water vapour to derive the illuminances. Unlike them, however, we do not derive the integrated water vapour approximately from the dew point temperature. Instead we use integrated water vapour data from the nearest grid point in the ERA5 reanalysis dataset (Hersbach & Dee 2016). We also include these data in the updated DRY 2001-2010 dataset:

- integrated water vapour [kg/m^2]

All DMI measurement stations that are included, regional zones, statistics, and data formats are as described in DMI Technical Report 13-19 (Wang et al. 2013). We advise all to read the details in that report.

3. Data for Danish Building Permit Calculations

A dataset to be used for energy performance calculations for obtaining a building permit is included. This has been made in the American EnergyPlus weather (*.epw) data format. The folder and file name is:

…/data/hourly/DRY_2001-2010_epw-fil.epw

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

Under the assumption that similar conditions apply for all locations in Denmark, and to avoid confusion, it was decided that one dataset should represent all of Denmark in this regard. This dataset should best represent most of the population in Denmark, and datasets from the three stations Holbæk Flyveplads (station number 6156), DMI (station number 6184) and Sjælsmark (station number 6188) were chosen.

4. References

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5. Previous reports

Previous DMI reports can be found on: https://www.dmi.dk/publikationer/