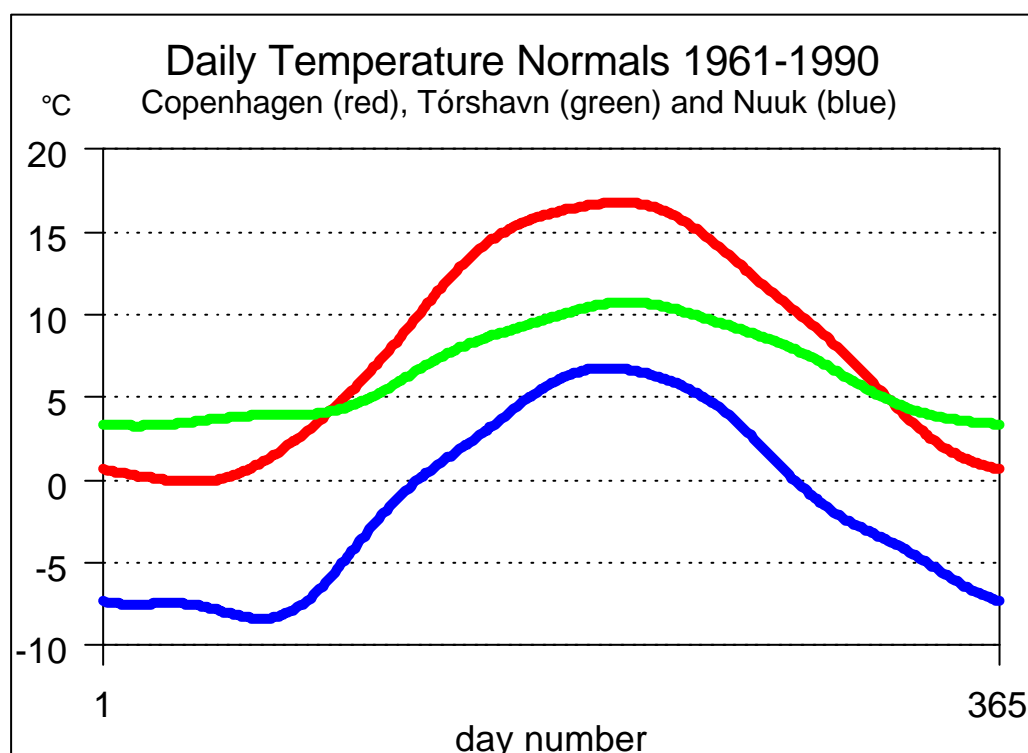# DANISH METEOROLOGICAL INSTITUTE

——— TECHNICAL REPORT (ONLINE) ———
00-17

Daily Temperature Normals
- Denmark, The Faroe Islands and Greenland

Daglige temperaturnormaler
- Danmark, Færøerne og Grønland

John Cappelen and Ellen Vaarby Laursen

Daily Temperature Normals 1961-1990
Copenhagen (red), Tórshavn (green) and Nuuk (blue)

COPENHAGEN 2000

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The daily temperature normals

In the attached data files you can find daily temperature normals, mainly from the period 1961-1990 (climatological standard normal period specified by the World Meteorological Organization (WMO)), from several sites in Denmark, The Faroe Islands and Greenland. The daily temperature normals are available in two different forms. On the one hand as "raw" calculated daily averages over the whole period and on the other hand as "smoothed" daily figures.

In appendix you can find basic information about the different observation sites and a description of contents and format of the data files following this report.

Methods of calculation

Quality-checked temperature series with an observation of the temperature every 3 hour the clock around form the backbone of the calculations; see table for a list of observations sites/periods used.

The first step in the process is to calculate daily averages for the "meteorological day" using all 8 observations every day. This is done from 06 UTC, i.e. Danish time 08 or 07 a.m. depending on summer or winter time, thus ending 06 UTC the following day (this particular 06 observation is not included). The value is always assigned to the date on which the meteological day ends. Some rules accounts for that calculation - there must be at least 4 observations within a day and not more than 2 observations in a row must be missing. Otherwise the daily values can be calculated using the daily maximum and minimum temperature observed during the 24 hours [tmax + tmin]/2. If neither of this can be done the value will be blank (in this report this has been an extremely rare event).

The next step is to calculate the daily averages over the whole period i.e. 1961-1990. A special case is 29 February - the values of the average daily temperature that day are always set to the same value as 1 March.

Stat no.	Name	First year	Last year
4210	UPERNAVIK	1961	1990
4220	AASIAAT	1961	1990
4221	ILULISSAT LUFTHAVN	1992	1999
4230	SISIMIUT	1961	1990
4231	KANGERLUSSUAQ	1974	1999
4250	NUUK	1961	1990
4260	PAAMIUT	1961	1990
4272	QAQORTOQ	1961	1990
4339	ITTOQQORTOORMIIT	1961	1990
4360	TASIILAQ	1961	1990
6009	AKRABERG FYR	1961	1990
6010	VAGA FLOGHAVN	1970	1999
6011	TORSHAVN	1961	1990
6030	FSN ÅLBORG	1961	1990
6060	FSN KARUP	1961	1990
6070	FSN TIRSTRUP	1961	1990
6110	FSN SKRYDSTRUP	1961	1990
6120	ODENSE LUFTHAVN	1961	1990
6180	KØBENHAVNS LUFTHAVN	1961	1990
6190	BORNHOLMS LUFTHAVN	1961	1990
31351	ABED II	1971	1998

Smoothing

In order to minimise the effect of extreme events during the period i.e. a extremely cold January, a smoothing technology has been performed.

The smoothed version of the curve of daily temperature normals is made by Fourier analysis. The smoothed temperature normal values are calculated as the Fourier series of the original 'raw' series of daily temperature normals using the first five Fourier components. Using the first five components have been found to give satisfactory results both statistically and climatologically.

The formulas are:

The series of daily temperature normals (T_{norm}) from i = day 1 to day 365 are calculated as the mean over the period of n years:

$$T_{norm}(i) = 1/n \sum_{j=1}^{n} T_j(i), \quad i = 1,....,365, \quad n = \text{number of years in normal period.}$$

The Fourier components to the Fourier series of $T_{norm}(i)$ are:

$$a_0 = 1/T \int_{0}^{T} T_{norm}(i) \, \delta i,$$

$$a_n = 2/T \int_{0}^{T} T_{norm}(i) \cos n\omega i \, \delta i,$$

$$b_n = 2/T \int_{0}^{T} T_{norm}(i) \sin n\omega i \, \delta i,$$

where   i = daynumber, T = 365 days, $\omega = 2\pi/T$.

For the smoothed version, $T_{norm\text{-}smooth}(i)$, the first five Fourier components are used:

$$T_{norm\text{-}smooth}(i) = a_0 + a_1 \cos\omega i + b_1 \sin\omega i + ... + a_5 \cos\omega i + b_5 \sin\omega i,$$

where   i = daynumber, $\omega = 2\pi/T$, T = 365 days.

The figure illustrates the connection between the smoothed and the raw daily temperature normals. The figure shows the daily temperature in January for the station 06030 Aalborg though the period 1961-1990 together with both the smoothed (red square) and the raw (green dot) normals. To have the perspective of temperature variations during the same month the daily temperatures of January 1982 (containing the coldest daily January value for Aalborg during the 1961-1990 period) have been drawn with a thin blue line.

06030 Ålborg: January dates
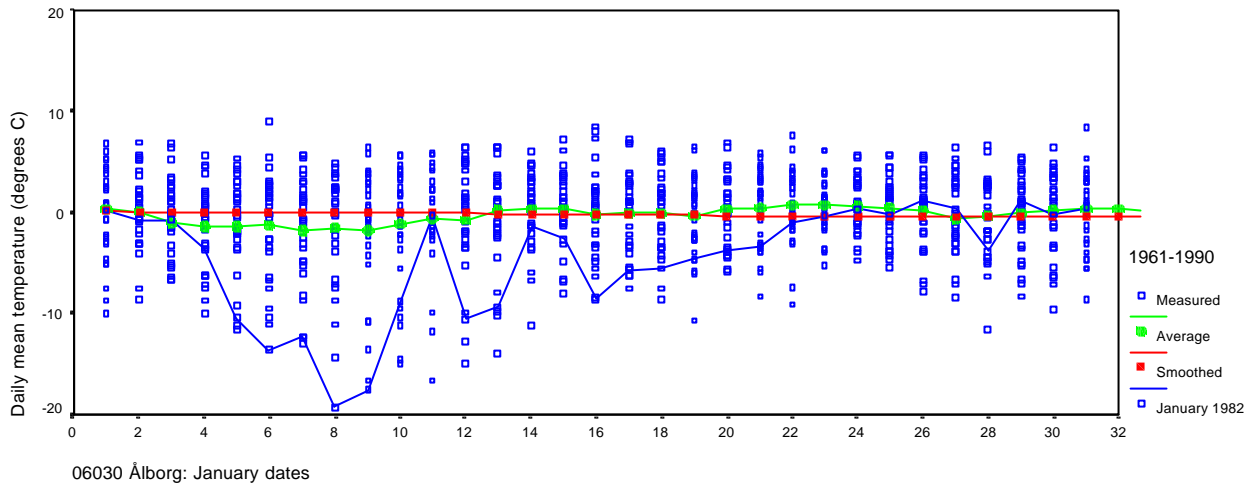
Daglige temperaturnormaler

Rapportens tilhørende datafiler indeholder daglige temperaturnormaler - hovedsaglig fra perioden 1961-1990 (standardnormalperiode er specificeret af World Meteorological Organization (WMO)) - fra flere observationssteder i Danmark, på Færøerne og i Grønland. De daglige temperaturnormaler er tilgængelige i 2 forskellige former - dels som "rå" beregnede gennemsnitlige daglige værdier over perioden dels som "glattede" værdier.

I appendix kan findes basisinformation omkring de forskellige observationssteder ligesom en beskrivelse af indhold og format af rapportens tilhørende datafiler findes her.

Beregningsmetode
Beregningsgrundlaget består af kvalitetscheckede serier af 3 timers temperaturdata observeret hver 3. time døgnet rundt; se observationssteder/perioder benyttet i denne rapport i tabellen nedenfor.

Det første trin i beregningen af den daglige middeltemperatur er at aflede værdier for de såkaldte "meteorologiske døgn" for hele perioden ved at benytte alle 8 observationer hver dag . Det er gjort fra 06 UTC (klokken 8 eller 7 dansk tid afhængig af sommer- eller vintertid) til 06 UTC den efterfølgende dag (denne 06 observation er ikke medtaget). Værdien er afsat hvor det "meteorologiske døgn" slutter. Der benyttes regler for denne beregning - der skal forefindes mindst 4 observationer pr meteorologisk døgn og højst 2 må mangle i træk. Hvis dette ikke er opfyldt kan den daglige middeltemperatur beregnes ved at benytte de daglige maksimum og minimumtemperatur, hvis disse findes [tmax+tmin/2]. Hvis intet af dette er opfyldt efterlades værdien blank (dette er forekommet yderst sjældent i denne rapports materiale).

Det næste trin er at beregne de daglige gennemsnitstemperaturer over hele perioden fx 1961-1990. 29. februar behandles særskilt - denne dags middeltemperatur taget over hele perioden er som standard sat til værdien fra 1. marts.

Stat no.	Name	First year	Last year
4210	UPERNAVIK	1961	1990
4220	AASIAAT	1961	1990
4221	ILULISSAT LUFTHAVN	1992	1999
4230	SISIMIUT	1961	1990
4231	KANGERLUSSUAQ	1974	1999
4250	NUUK	1961	1990
4260	PAAMIUT	1961	1990
4272	QAQORTOQ	1961	1990
4339	ITTOQQORTOORMIIT	1961	1990
4360	TASIILAQ	1961	1990
6009	AKRABERG FYR	1961	1990
6010	VAGA FLOGHAVN	1970	1999
6011	TORSHAVN	1961	1990
6030	FSN ÅLBORG	1961	1990
6060	FSN KARUP	1961	1990
6070	FSN TIRSTRUP	1961	1990
6110	FSN SKRYDSTRUP	1961	1990
6120	ODENSE LUFTHAVN	1961	1990
6180	KØBENHAVNS LUFTHAVN	1961	1990
6190	BORNHOLMS LUFTHAVN	1961	1990
31351	ABED II	1971	1998

Udjævning

For at minimere effekterne fra ekstreme perioder fx en usædvanlig kold januar, er der brugt en udjævningteknik på data.

Den udjævnede version af kurven over daglige temperaturnormaler er fundet ved Fourier analyse. De udjævnede temperaturnormalværdier findes som Fourier rækken for den oprindelige serie af daglige temperaturnormaler, beregnet ud fra rækkens første fem Fourier komponenter. Ud fra både statistiske og klimatologiske overvejelser er det fundet tilfredsstillende at anvende de første fem komponenter.

Formlerne er:

Rækken af daglige temperaturnormaler (T_{norm}) fra i = dag 1 til dag 365 beregnes som middelværdien over normalperioden på n år:

$$T_{norm}(i) = 1/n \sum_{j=1}^{n} T_j(i), \quad i = 1,....,365, \quad n = \text{antal år i normalperioden.}$$

Fourier komponenterne til Fourier rækken for $T_{norm}(i)$ er:

$$a_0 = 1/T \int_0^T T_{norm}(i) \, \delta i,$$

$$a_n = 2/T \int_0^T T_{norm}(i) \cos n\omega i \, \delta i,$$

$$b_n = 2/T \int_0^T T_{norm}(i) \sin n\omega i \, \delta i,$$

hvor   i = dagsnummeret, T = 365 dage, $\omega = 2\pi/T$.

Til den udjævnede, 'glattede', version, $T_{norm-glat}(i)$, benyttes de første fem Fourier komponenter:

$$T_{norm-glat}(i) = a_0 + a_1 \cos\omega i + b_1 \sin\omega i + ... + a_5 \cos\omega i + b_5 \sin\omega i,$$

hvor   i = dagsnummeret, $\omega = 2\pi/T$, T = 365 dage.

Figuren illustrerer forbindelsen mellem de udjævnede og de 'rå' daglige temperaturnormaler. Figuren viser daglig januar temperatur fra station 06030 Aalborg gennem normalperioden, 1961-1990, sammen med både de udjævnede (rød firkant) og de 'rå' (grøn prik) temperatur normaler. For at vise temperaturvariationen indenfor samme måned er de daglige temperaturer fra januar 1982 (der indeholdt periodens laveste januar dagsmiddeltemperatur i Aalborg) blevet kædet sammen med en tynd blå streg.

06030 Ålborg: January dates
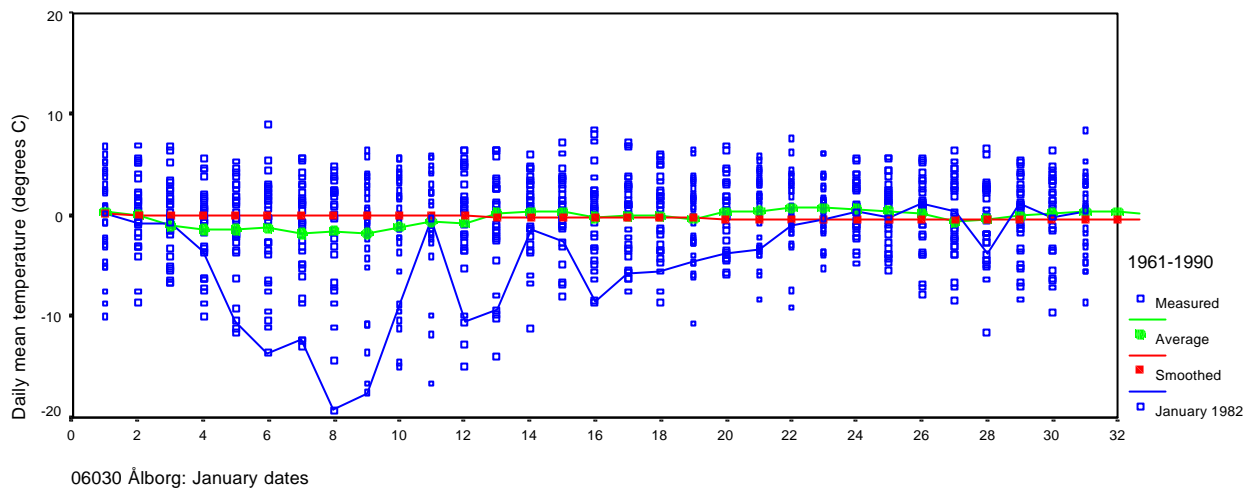
Appendix 1.

Data files/Datafiler

The datafiles are:

- fixed ASCII format data files named <country code>_norm_<data type>.dat containing daily normals, "raw" and "smoothed" values
- fixed ASCII format file named station.dat containing a station catalogue
- finally, an ASCII text format file named readme.txt

Data may only be used with proper reference to the accompanying report (Cappelen, John and Ellen Vaarby Laursen, 2000. Daily Temperature Normals - Denmark, The Faroe Islands and Greenland. DMI Technical Report (online) 00-17).

Datafilerne er:

- ASCII datafiler med fast format <landekode>_norm_<datatype>.dat indeholdende daglige normaler, både "rå" og "glattede" middelværdier
- ASCII datafil med fast format station.dat med oplysninger om stationerne
- ASCII tekstfil readme.txt

Data må kun benyttes, hvis der samtidig angives reference til rapporten (Cappelen, John and Ellen Vaarby Laursen, 2000. Daily Temperature Normals - Denmark, The Faroe Islands and Greenland. DMI Technical Report (online) 00-17).

Station file/Stationsfil: station.dat

The station catalogue contained in the file station.dat describes the station no., name, position, elevation and first and last year of the temperature series in this report. Each record in the file contains information about one station. The file is sorted by station no. and has the following layout:

Stationskataloget i filen station.dat beskriver stationsnummer, stationsnavn, position, højde over havet samt det første og det sidste år i de temperaturserier, der er medtaget i denne rapport. Hver linie i filen repræsenterer en station. Filen er sorteret efter stationsnummer og har følgende layout:

Position	Format	Description
1-6	F6.0	Station no.
7-36	A30	Station name
37-38	F2.0	Latitude (degrees)
39-40	F2.0	Latitude (minutes)
41-41	A1	Northern (N) or Southern (S) hemisphere
42-43	F2.0	Longitude (degrees)
44-45	F2.0	Longitude (minutes)
46-46	A1	East (E) or West (W) of Greenwich
47-50	F4.0	Elevation (metres above mean sea level)
51-56	F6.0	First year in the data series
57-62	F6.0	Last year in the data series

Data files/Datafiler: <country code>_norm_<data type>.dat

Daily temperature normals for all the stations presented in the file station.dat. The files are sorted by station no. in the following format.

Daglige temperatur normaler for de stationer der findes i filen station.dat. Filerne er sorteret efter stationsnummer og har nedenstående format:

Position	Format	Description
1-5	F5.0	Station no.
6-10	F5.0	Month
11-15	F5.0	Day
16-21	F6.1	Value (degrees Celsius to one decimal place)