The Kingdom of Denmark – Climate.

Greater Denmark, covering the entire Kingdom, has a land area of 2.2 million km², of which Greenland constitutes the majority.

Mainland Jutland

Figure 1 Monthly Mean Central England Temperature (°C). Three summer months and three winter months are shown separately. During The Little Ice Age in particular more cold winters appear. The temperature drop at the end of the 17th century and The Maunder Minimum are almost simultaneous. UK Mean 1659-1750: 9,0 °C; 1659-2018: 9,3 °C and 1919-2018: 9,7 °C ~ +0,3 °C in 100 years. DK Mean 1919-2018: 7,9 °C.

Compared to other areas at the same latitude, the climate of mainland Jutland is relatively warm. This is due to the warm North Atlantic Drift. Our climate is heavily influenced by the proximity to sea. We have a saying, that we get our weather from the west - from nearby England. A series of instrumental temperatures goes...
almost 400 years back in Central England. This temperature series is maintained by the Met Office Hadley Center in the UK and reproduced below. For comparison temperatures for Jutland with islands are inserted. Because the series goes back so far, it includes the last half of the 4-500-year cold period referred to as the Little Ice Age. The Modern Warm Period seems to begin after 1900 and it is not until the late 70s that we see a rapid temperature rise. We must go back to 1700 to see a faster and longer-lasting rise. Already in the 70s, Danish paleoclimatologist Willi Dansgaard predicted that we would reach the bottom of a cold valley around 1980-1985 followed by a smaller warm peak around 2010-2015.

The average temperature for the entire period is 9.3 °C with an increase of 0.3 °C in 100 years. The current rapid temperature rise beginning 1980s seems to have peaked. In the past two years (2017-18), DMI reports no net loss from our Greenland icecap.

We can only hope that the Modern Warming Period will last. Reasoned expectations for the North Atlantic, however, supports this hope.

**Greenland**

![Greenland](image)

*Figure 2 In order to put the timeline in perspective a few local historical events have been added to the original figure published 2011. The rhythmic changes revealed by Ole Humlum et al. is presented as the green curve. The future’s not ours to see. Nevertheless, the green curve represents an educated guess.*

Although our northern Atlantic islands enjoy the same warm North Atlantic Drift, the weather is so cold and the summers so short that the snow does not completely melt. Willi Dansgaard, a Danish paleoclimatologist
was the first to demonstrate that measurements of the trace isotopes oxygen-18 and deuterium in accumulated glacier ice could be used as an indicator of past climate. The last 4,000 years of the reconstructed Greenland Ice Sheet Project 2 (GISP2) surface temperature series from central Greenland is reproduced credibly by Professor Ole Humlum. With Fourier and wavelet analysis he has revealed rhythmic changes summarized below.

The present interglacial time has so far lasted for 12,000 years with alternating warm and cold periods. The pattern revealed by Ole Humlum et al., gives us the hope that our current Modern Warm Period will last a few hundred years yet.

**Sea Level.**

![Sea Level Graph](image)

*Figure 3 The recent increase in southern water level since 1980 corresponds to 12-18 cm in a hundred years and is probably linked to the temperature rise, we have experienced in the same period. Possibly they both have peaked now. GPS stations near harbor tide gauges measure land lift given in the title. The Thule graph is scaled differently to bring it into the picture. The graphs are 11-year moving averages.*

Warmer weather is likely to be followed by higher sea levels. For Port of Copenhagen and Esbjerg we have water level measurements back to 1889.

Our North Atlantic tidal gauge measurements are not that complete. Torshavn and nearby Reykjavik have similar sea level rise as Copenhagen but practically no tectonic uplift. Our northernmost station in Thule, Greenland shows very fast land elevation and even faster drop in sea level, but PSMSL calls for extreme caution when using the Thule tide gauge data. The measurements of tidal levels and changes – even
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corrected for vertical GPS velocity – differ quite a lot throughout the Kingdom. It is, however, the current sea level that matters to the coastal population and most rises are in the range of 5-15 cm in a hundred years.

Storms.

Since 1891 only 13 strong storms/hurricanes category 4 (> 28,5 m/s) have been recorded. Category 3 is below 26,5 m/s, Category 2 is below 24,5 m/s and Category 1 is below 21 m/s.

The Danish storms are categorized without calculating their energy. An index that combines the numbers of storms and how intense they became is calculated for each year by summing category numbers. The graph shows a moving 11-year average. A few years stand out as particularly stormy - otherwise no trend in storm intensity is detected by calculation in this manner.

Precipitation

Precipitation is sufficient to maintain groundwater reservoirs. The groundwater is lying high most places. During drought periods, farmers can irrigate. Potato growers irrigate every year to be in control of the harvest.

Sunshine

The sun is shining enough to make photovoltaic plants profitable. Several plants built in 2017-18 provide each 25 MWh annually.

Sunshine and temperature appear to vary synchronously on an annual basis. It will not be surprising if the context turns out to be real.
Population

Population figures before the first census 1769 are very uncertain. From the end of the Dark Age about 650AD, the population numbers are estimated to have risen from half a million to one million during the Medieval Warm Period, again falling during the less fertile Little Ice Age.

This indicates a population of one million as just sustainable by agriculture. Energy imports in the form of feed and fertilizer from North and South America enable population growth after 1750 - later enhanced by the introduction of fossil fuels. By supplementing photosynthesis with present level of renewable energy the sustainable population has been doubled since 1750.

Human overpopulation occurs when the ecological footprint of the population exceeds the carrying capacity of the land. This is traditionally related to food, but lately also to renewable energy. With present Danish fertility rate of 1.71 and no immigration the Danish population will decline and reach sustainability in 200 years. With a South European fertility rate of 1.33 it will take less than a 100 years. With present immigration the population will incline forever.
Crop yields

Potatoes are not only a staple food but the basis for the most rewarding farming in Jutland. The potato thrives best in a temperate climate. Breeding and better cultivation methods have raised crop yield per hectare and at the same time the starch content of factory potatoes has been raised to 19½ % in average dry starch matter.

It is too early to say if the yield is also affected by the recent warming - in Greenland it does. Higher carbon dioxide may also beneficial.

Energy Procurement.

Weather makes heating our homes needed. Despite our high latitude, about 120 kWh of photovoltaic energy can be produced per m² in Jutland. It is windy and newer turbines generate on an annual basis 4.100 MWh per installed MW ~ 47% efficiency. The biggest shortcoming of both forms of energy is the lack of temporary storage. This need becomes increasingly urgent as the renewable energy is expanded. Our total energy consumption is about 780 PJ/year ~ 137 GJ/person (38.000 kWh/person). To achieve sustainability, the production of renewable energy must triple. Just in order to keep pace with population growth, 330 MW wind turbines corresponding to the installation of our largest offshore wind park at Krieger’s Flak every two years.
State of the Climate

The medieval warmth was a prosperous period with a growing population. It enabled the expansion of Viking activities and gave Cnut the Great the strength to establish a North Sea Empire. The following Little Ice Age brought us colder winters and frequent crop failures with population decline. The current Modern Warm Period has brought this to an end.

Weather is highly variable from arctic in the north to temperate in the south. In Jutland it is mild, fertile and stable. Famine does not occur, and Danes produce food three times more than for ourselves. The harvest fluctuates moderately and without past crop failures. The potato crop has improved – even Greenland potato growers enjoy. Hurricanes are experienced in average one out of ten years. Precipitation has risen over a hundred years from approx. 650 to 750 mm / year and local cloudbursts are rare.

Climate Policy

Public institutions share views and policies with the IPCC (the Intergovernmental Panel on Climate Change) and with them many solidarity people. Others see Galileo Galilei as the first victim of consensus among the scholars and will ward off anything like it again. "In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual" (Galileo Galilei 1632). They like to see the changeability of the past examined better and causes quantified. Our Kingdom is great and immense, and we have credible scientists qualified for the task.

Climate policy aims for energy sustainability without addressing human overpopulation as the real culprit.

Lars Thomsen, April 15, 2019