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Meteorological
Institute

National Report on Global Climate Observing Systems (GCOS) in Denmark, Greenland and the Faroe Islands 2022

- Status report on national GCOS activities

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Annex E Denmark's report on systematic climate observations for the global climate observing system (GCOS)

DENMARK'S REPORT ON SYSTEMATIC CLIMATE OBSERVATIONS FOR THE GLOBAL CLIMATE OBSERVING SYSTEM (GCOS) IN CONNECTION WITH THE EIGHTH NATIONAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

from

National Report on Global Climate Observing Systems (GCOS) in Denmark, Greenland and the Faroe Islands 2022

Status report on national GCOS activities

Compiled by Caroline Drost Jensen and Tina Christensen,
Danish Meteorological Institute (DMI)

2022

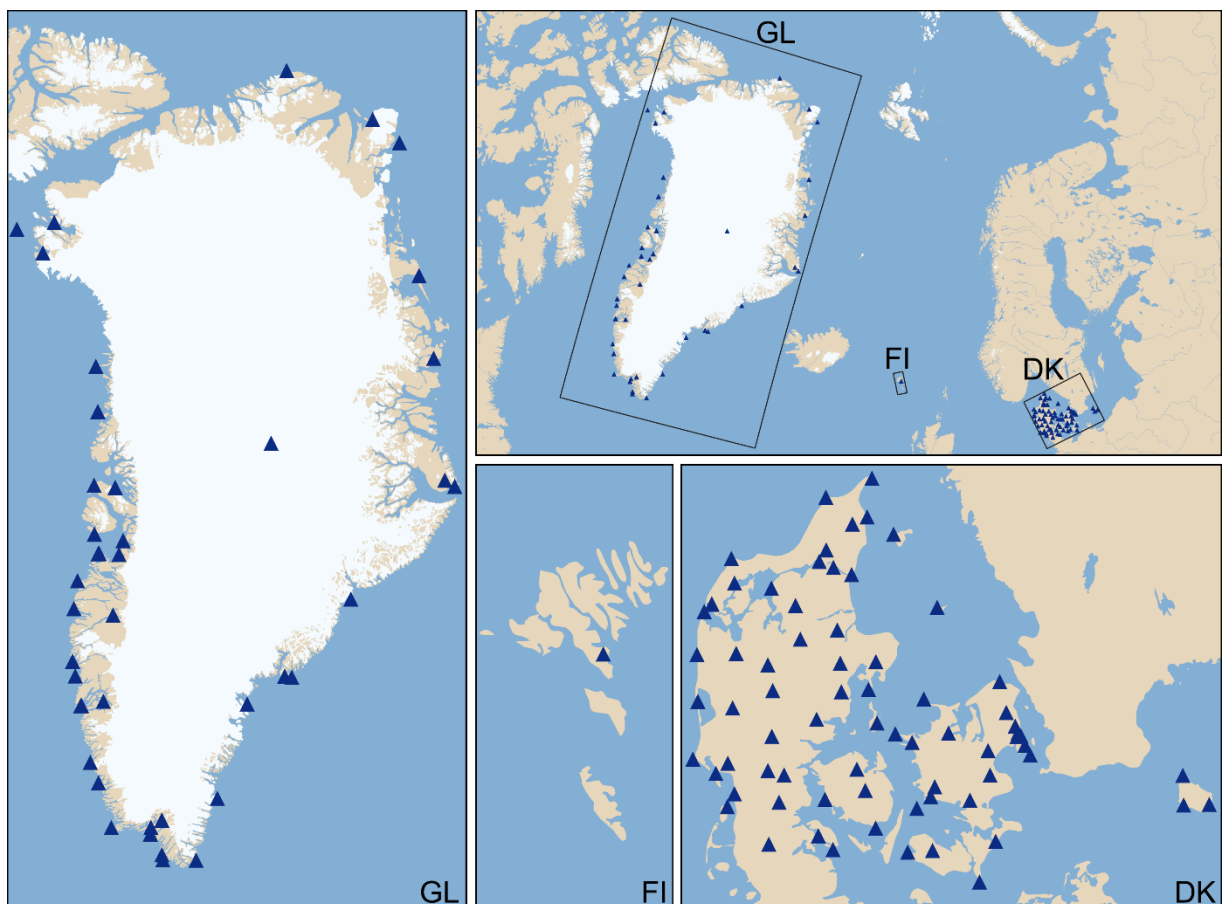


Figure 1: Overview of meteorological landbased stations in Denmark, Greenland and the Faroe Islands. Meteorological station types include Synop, Radiosonde and GIWS (Greenland Isolated Weather Station).

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Disclaimer

The information in this report represents the best knowledge available to the compiling editor by the time of issue.

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Introduction

This status report has been prepared to give an update on the Danish contribution to the systematic climate observations in the Global Climate Observing System (GCOS) as of 1th of January 2022.

The present report is an update of the first report based on the reporting guidelines contained in decision 11/CP.13, by the United Nations Framework Convention on Climate Change (UNFCCC) Subsidiary Body for Scientific and Technological Advice (SBSTA) focussing on Essential Climate Variables. The report was first issued in 2008 titled “National Report on Global Climate Observing Systems (GCOS) in Denmark, Greenland and the Faroe Islands 2008” and later updated and reprinted in 2013 in the DMI report series “Danish Climate Centre Report” as number 11-04 and 13-05. In 2017, a new publication in the series was published with the name “National Report on Global Climate Observing Systems in Denmark, Greenland and the Faroe Islands 2017”. This report was then reprinted as a DMI-report with the number 17-23.

The purpose of this report is to provide an overview of the national Global Climate Observing Systems (GCOS) for the use of the Secretariat of CGOS for its detailed progress report on the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC.

1 Common Issues

1.1 NATIONAL COORDINATION

Climate research and the generation of climate-related observations are carried out by various government departments in order for them to meet their responsibilities.

The Danish Meteorological Institute (DMI) represents Denmark in the World Meteorological Organization (WMO) and DMI holds the role of National GCOS Focal Point. Up until 2018, DMI also undertook the role as national focal point/coordinator for GCOS (NFP-GCOS), with the Terms of Reference to undertake GSN and GUAN issues related to data availability, exchange and quality. However, since 2019, Denmark no longer has a national GCOS coordinator, only the national GCOS Focal Point.

1.2 EFFORTS UNDERTAKEN TO ENSURE HIGH-QUALITY CLIMATE DATA RECORDS.

A number of agencies in Denmark engage in the systematic observation of elements of the climate system. Invariably, the capture, quality control and archiving of such data are designed to meet the integrated needs of these agencies, which derives from their overall missions.

Typically, the drivers for long-term systematic observation of environmental or ecological characteristics arise from an operational, regulatory or research need. Examples of the former are to be found in the capture of meteorological data for predictive and statistical services by DMI. The resulting observation programmes tend to be long term, but the resulting individual data may be seen as perishable and focus might not always be on maintaining stability and reliability in the records. The general need for systematic and reliable time series is

increasingly being understood in the scientific community and incorporated in the collection and data processing procedure.

In this report, relevant climate observations for Denmark, Greenland and the Faroe Islands will be described.

1.3 EFFORTS UNDERTAKEN TO ENSURE THE DATA EXCHANGE AND AVAILABILITY

Data from DMI's stations are available through www.dmi.dk/frie-data/ where it can be downloaded for free through an API. The data include raw observations, quality-controlled climate data, radar data all from DMI's stations in Denmark and Greenland. Third-party data such as data from the Faroe Islands are not available through the API. By the end of 2022, forecast data will also become available through DMI's APA. DMI's data can also be visualized on <https://www.dmi.dk/vejrkiv/>.

If data is shared through other centers, such as GCOS, data is also available through these centers.

Additionally, DMI Earth System data and products are exchanged with WMO Members following the terms of WMO Resolution 1, WMO unified Policy for the International Exchange of Earth System Data.

Such data are freely available without charge (i.e. at no other cost than the cost of reproduction and delivery, without charge for the data and products themselves and with no condition on their use)

2 Atmospheric Essential Climate Variables (ECV)

2.1 GENERAL INFORMATION

Denmark participates fully in the GCOS Surface Network (GSN) and the GCOS Upper Air Network (GUAN), and in the Global Ozone Observing System (GO3OS) as part of the Global Atmospheric Watch (GAW).

2.2 CONTRIBUTIONS TO THE GCOS NETWORKS FROM INTERNATIONAL RELEVANT STATIONS

2.2.1 Contributions to the GCOS Surface Network (GSN)

The seven designated GSN stations in Denmark, Greenland and on the Faroe Islands are all run by DMI and include (Numbers are WMO station numbers):

Greenland:	4211 Upernavik, 4250 Nuuk, 4320 Danmarkshavn 4360 Tasiilaq, 4390 Ikerasassuaq (Prins Christian Sund);
The Faroe Islands;	6011 Tórshavn
Denmark:	6186 Copenhagen.

All of these stations currently meet the required standard for surface observation.

2.2.2 Contributions to the GCOS Upper Air Network (GUAN)

Only one GUAN station is designated for Denmark, Greenland and the Faroe Islands:

WMO nr. 4270 Narsarsuaq, Greenland.

The station is run by DMI and is operated in accordance with the required standard.

2.2.3 Contributions to the Global Atmosphere Watch (GAW)

As part of the GAW programme, Denmark contributes to the Global Ozone Observing System (GO3OS) with two stations in Greenland and one in Denmark.

The stations in Greenland are: Kangerlussuaq and Ittoqqortoormiit.

The station in Denmark is located in Copenhagen.

The stations in Greenland are Arctic stations in the Network for the Detection of Atmospheric Composition Change (NDACC) that is supported by the International Ozone Commission.

TABLE 1A. NATIONAL CONTRIBUTIONS TO THE SURFACE-BASED ATMOSPHERIC ESSENTIAL CLIMATE VARIABLES

Contributing networks specified in the GCOS implementation plan	ECVs ^a	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2023	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Surface Network (GSN)	Air temperature	7	7	7	7	7
	Precipitation	5	5	5	5	5
Full World Weather Watch/Global Observing System (WWW/GOS) surface network (RBSN stations)	Air temperature, air pressure, wind speed and direction, water vapour	37	37	37	37	37
	Precipitation	17	17	17	17	Not known
Baseline Surface Radiation Network (BSRN)	Surface radiation	0	0	0	0	0
Solar radiation and radiation balance data (RBSN stations)	Surface radiation	0	0	0	0	Not known
Ocean drifting buoys	Air temperature, air pressure	0 (note1)	0 (note1)	0 (note1)	0 (note1)	0 (note1)
Moored buoys	Air temperature, air pressure	0	0	0	0	0
Voluntary Observing Ship Climate Project (VOSCLIM)	Air temperature, air pressure, wind speed and direction, water vapour	0	0	0	0	0
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, wind speed and direction, air pressure	0	0	0	0	0
	Precipitation	0	0	0	0	0

Note 1: Denmark (DMI) participates in the EUMETNET programme SURFMAR, which operates approximately 80 drifting buoys.

TABLE 1B. NATIONAL CONTRIBUTIONS TO THE UPPER-AIR ATMOSPHERIC ESSENTIAL CLIMATE VARIABLES

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2023	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Upper Air Network (GUAN)	Upper-air temperature, upper-air wind speed and direction, upper-air water vapour	1	1	1	1	1
Full WWW/GOS Upper Air Network	Upper-air temperature, upper-air wind speed and direction, upper-air water vapour	6	6	6	6	6

TABLE 1C. NATIONAL CONTRIBUTIONS TO THE ATMOSPHERIC COMPOSITION

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2023	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
World Meteorological Organization/ Global Atmosphere Watch (WMO/GAW) Global Atmospheric CO ₂ & CH ₄ Monitoring Network	Carbon dioxide	0	0	0	0	0
	Methane	0	0	0	0	0
	Other greenhouse gases	0	0	0	0	0
WMO/GAW ozone sonde network ^a	Ozone	1	1	1	1	1
WMO/GAW column ozone network ^b	Ozone	3	3	3	3	3
WMO/GAW Aerosol Network	Aerosol optical depth	3	3	3	3	3
	Other aerosol properties	3	3	3	3	3

2.3 SATELLITE OBSERVATIONS AS BASE FOR ATMOSPHERE RELATED ECV OBSERVATIONS

Denmark is member state in EUMETSAT and ESA.

Especially through EUMETSAT, Denmark takes functional part in activities related to the utilization of satellite data in analyses related to ECVs and climate monitoring.

The table below is indicating **in blue** areas where the Danish participation is more significant.

TABLE 2. GLOBAL PRODUCTS REQUIRING SATELLITE OBSERVATIONS – ATMOSPHERIC ESSENTIAL CLIMATE VARIABLES

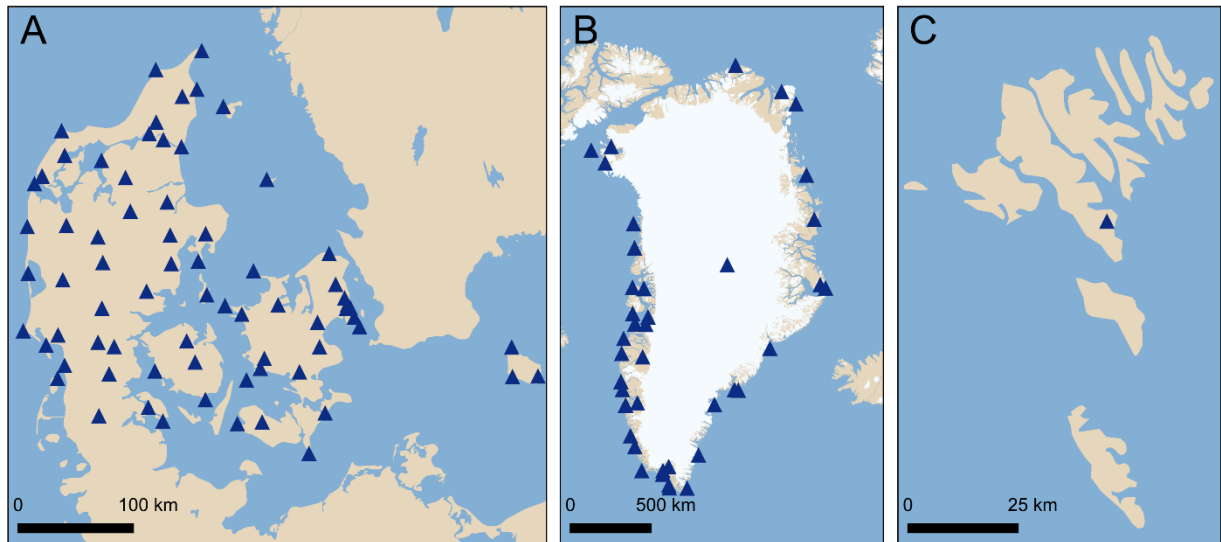
ECVs/ Global products requiring satellite observations	Fundamental climate data records required for product generation (from past, current and future missions)
Surface wind speed and direction Surface vector winds analyses, particularly from reanalysis	Passive microwave radiances and scatterometry
Upper-air temperature Climate data records for tropospheric and stratospheric temperature profiles using data from GNSS radio occultation measurements EUMETSAT ROM-SAF	GNSS radio occultation measurements
Water vapour Climate data records for tropospheric humidity profiles using data from GNSS radio occultation EUMETSAT ROM-SAF	GNSS radio occultation measurements
Ozone Profiles and total column of ozone, global UV indices EUMETSAT O3M-SAF	UV/VIS and IR microwave radiances
Upper-air temperature and water vapor Climate data records of upper-air temperature and water vapor under GCOS Reference Upper Air Network (GRUAN) The climate data records utilize satellite data from EUMETSAT.	GNSS radio occultation measurements
Water vapor climate data record under GEWEX Water Vapor Assessment (G-VAP). The reference data set utilizes satellite data from EUMETSAT.	GNSS radio occultation measurements
Upper-air wind Upper-air wind analyses, particularly from reanalysis	VIS/IR imagery, Doppler wind lidar
Atmospheric reanalyses	Fundamental CDR's and products derived from a variety of satellites and other instruments.

2.4 OTHER NETWORKS FOR MONITORING WEATHER AND ATMOSPHERIC COMPOSITION.

2.4.1 Climatological/meteorological surface stations

DMI operates and receives data from a network of more than 100 automatic meteorological stations in Denmark, Greenland and on the Faroe Islands. Measurements are made in accordance with the WMO recommendations.

FIGURE 1: DMI'S NETWORK OF WEATHER STATIONS (SYNOP, RADIOSONDE AND GREENLAND ISOLATED WEATHER STATIONS (GIWS) IN DENMARK, GREENLAND AND THE FAROE ISLANDS. PLEASE NOTICE THAT SOME SYNOP WEATHER STATIONS ARE OWNED BY A THIRD PARTY.



As of 2001, a special dedicated network of (manual) stations for climatological observations has been discontinued, due to the convergence between the different network technologies. The objective behind this decision was to eliminate human errors, to benefit from potential savings due to this rationalisation, and to reach a higher observation frequency. Climatological data are now obtained from the automatic network described above.

Climatological data are collected to define the climate in Denmark, Greenland and on the Faroe Islands and to create a national database for a wide range of enquiries and research activities. Climatological work mainly consists of quality control and preparing statistics based on the quality-controlled data. Furthermore, it includes the calculation of e.g. decadal averages or standard climatological normals.

Substantial recorded data are needed to establish reliable averages and trends. The daily inflow of data from Denmark, Greenland and the Faroe Islands is around 100,000 observations, and the central database at DMI currently contains more than 300,000,000 observations. Some of the recorded data are from as early as 1872.

A monthly summary is prepared for three stations in Denmark, one on the Faroe Islands and eight in Greenland using the CLIMAT format. These data are routinely submitted via the GTS.

2.4.2 Precipitation observation networks (stations and radar)

For national purposes, more data concerning precipitation is needed than can be provided from the overall surface climatological and meteorological network described above. In Denmark the precipitation observation network consists of approximately 280 stations, all automatic. Half of this network is jointly operated by DMI and The Water Pollution Committee of the Society of Danish Engineers (Spildevandskomitéen - SVK), the other half is owned and operated by DMI.

Information on precipitation can also be obtained from weather radar data. In Denmark, DMI runs a network of five weather radars which provides 100% coverage of Danish land areas and coastal marine areas. The network's geographical coverage is unsurpassed, and hence provides detailed information about precipitation on national and local scales. By calibrating radar data against point measurements of precipitation the latest scientific results show a high absolute accuracy.

During wintertime, a network of around 70 manual snow depth stations is operated in Denmark, reporting once a day.

In Greenland, precipitation is measured at 11 locations (5 automatic stations, 6 manual stations). DMI has also received precipitation data from one automatic station on the Faroe Islands (Tórshavn).

2.4.3 Surface radiation observation networks

Radiation is measured as 10-minute mean values of global radiation at the DMI operated weather station.

2.4.4 Solar ultraviolet (UV) radiation and stratospheric ozone stations

Solar Ultraviolet (UV) radiation at different wavelengths is measured by DMI at one station in Greenland, Kangerlussuaq. In addition, DMI performs daily measurements of total ozone at Copenhagen, Kangerlussuaq, and weekly ozone soundings at Ittoqqortoormiit.

DMI provides near real time global UV-indices as part of the EUMETSAT O3M-SAF.

2.4.5 Upper air strata measurements – Radio sounding observations

DMI runs radio sounding stations at the following five locations: Danmarkshavn, Ittoqqortoormiit, Tasiilaq, Narsarsuaq and Asiaat (Greenland). One radio sounding station is located in Tórshavn (the Faroe Islands) and is operated by the Faroese Meteorological Organisation. The Danish Meteorological Institute disseminates radio sounding data from Tórshavn. Two soundings are made every day at all of the above stations.

2.4.6 Ice observations

DMI has collected and archived ice information since 1893. Monthly summaries are available up to 1981.

Since 1959, special emphasis has been on the waters south of Cape Farewell (the southern tip of Greenland) for support of navigation safety in a region with icebergs year-round and seasonal multi-year sea ice. 2-7 times a week routine ice maps for all Greenland Waters are prepared. The ice maps contain detailed information on the relevant ice conditions and they are prepared depending on season and shipping. All ice maps produced since 1996 are archived and available in vector graphic format.

2.4.7 Climatological data sets

Over the years, DMI has established and maintained a number of very long climatological data series representing Denmark, Greenland and the Faroe Islands. The data series cover different time periods.

The long daily time series include: precipitation, temperature, atmospheric pressure and cloud cover for a number of Danish locations as well as precipitation and temperatures for two Greenland stations 1874-2021.

The long monthly and annual time series include temperature, precipitation, sunshine, atmospheric pressure, cloud cover and snow. For Greenland and the Faroe Islands, the long monthly time series include temperature, precipitation, atmospheric pressure, cloud cover and snow. However, snow observations in Greenland and the Faroe Islands are no longer carried out.

DMI also maintains a long annual time series for Denmark of temperatures, precipitation, hours of sunshine and cloud cover given as a national averages.

All datasets mentioned above are freely available through the annually updated DMI Reports available through www.dmi.dk.

2.4.8 Air quality monitoring

Air pollution is continuously monitored in both urban and rural areas across Denmark and at one station in Greenland. This monitoring network is operated by Department of Environmental Sciences at Aarhus University and measures a wide range of pollutants:

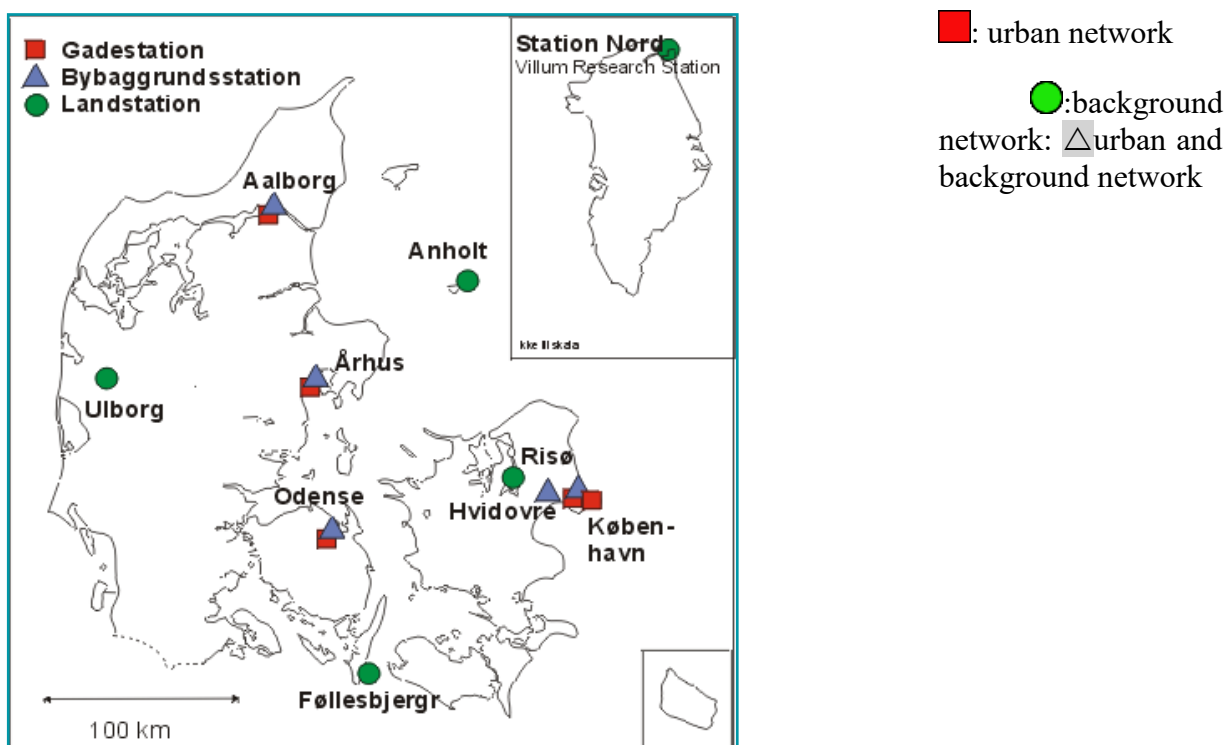
- Nitrogen monoxide (NO)
- Nitrogen dioxides (NO₂)
- Ozone (O₃)
- Sulphur dioxide (SO₂)
- Particulate matter (PM₁₀ and PM_{2.5})
- The chemical composition of particles (sulphate, sea salt, heavy metals etc.)
- Nitrogen compounds (ammonia (gas), particulate ammonium, sum of nitric acid and particulate nitrate)
- Carbon monoxide (CO)

The measurement program varies for the different measurement stations.

The measurements are combined with model calculations of air quality in order to obtain a better spatial coverages of the monitoring program.

Figure 4 shows the types and distribution of air quality monitoring stations across Denmark and in Greenland.

FIGURE 4 – NATIONAL NETWORK OF AIR QUALITY MONITORING STATIONS IN DENMARK OPERATED BY DEPARTMENT OF ENVIRONMENTAL SCIENCES AT AARHUS UNIVERSITY



http://www2.dmu.dk/1_Viden/2_miljoe-tilstand/3_luft/4_maalinger/5_maaleprogrammer/oversigtskort.asp

3 Oceanic essential climate variables (Oceanic ECV)

3.1 NATIONAL CONTRIBUTION TO OCEANOGRAPHIC ECV

Oceanographic observations for GCOS are based on the GOOS climate module for the open ocean, which comprises the following programmes: drifting and moored buoy programmes managed by the DBCP (Data Buoy Co-operation Panel), the Ship of Opportunity Programme (SOOP), the Argo array of profiling floats, the Global Sea Level Observing System (GLOSS), the Voluntary Observing Ships Programme (VOS) and the Automated Shipboard Aerological Programme (ASAP).

Denmark participates in the ASAP programmes as described in paragraph 3.2.

TABLE 3A. NATIONAL CONTRIBUTIONS TO THE OCEANIC ESSENTIAL CLIMATE VARIABLES – SURFACE

Contributing Networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2023	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
Global surface drifting buoy array on 5x5 degree resolution	Sea surface temperature, sea level pressure, position-change based current	0 (note 2)	0 (note 2)	0 (note 2)	0 (note 2)	0 (note 2)
GLOSS Core Sea-level Network	Sea level	0	0	0	0	0
Voluntary observing ships (VOS)	All feasible surface ECVs	3 (note 2)	3 (note 2)	3 (note 2)	3 (note 2)	3 (note 2)
Ship of Opportunity Programme	Sea surface temperature	1	?	2	1	1
Observing ships (ship4SST)	Sea surface temperature	1	1	1	1	1

Note 2: Denmark (DMI) participates in the EUMETNET programme SURFMAR, which operates approximately 80 drifting buoys and 10 voluntary observing ships (VOS) of which DMI maintains 3.

TABLE 3B. NATIONAL CONTRIBUTIONS TO THE OCEANIC ESSENTIAL CLIMATE VARIABLES – WATER COLUMN

Contributing Networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2023	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
Global reference mooring network	All feasible surface and subsurface ECVs	0	0	0	0	0
Global tropical moored buoy network	All feasible surface and subsurface ECVs	0	0	0	0	0
Argo network	Temperature, salinity, current	0	0	0	0	0
Carbon inventory survey lines	Temperature, salinity, ocean tracers, biogeo-chemistry variables	0	0	0	0	0

3.2 AUTOMATED SHIPBOARD AEROLOGICAL PROGRAMME (ASAP).

The E-ASAP (Eucos ASAP) in its present form began in the mid-1980s.

The programme's objective is to record profile data from the upper air strata in ocean areas using automated sounding systems carried on board merchant ships plying regular ocean routes. Several national meteorological services operate ASAP units and the collected data are made available in real time via GTS. ASAP data are archived alongside other radio sounding data by many national meteorological services. ASAP is an important contribution to both the WWW and GCOS.

Denmark operates three ASAP units mounted on ships plying fixed routes from Denmark to Greenland.

3.3 SATELLITE OBSERVATIONS AS BASE FOR OCEANIC ECV OBSERVATIONS

Denmark is member state in EUMETSAT and ESA.

Especially through EUMETSAT Denmark takes functional part in activities related to the utilization of satellite data in analyses related to ECVs (according to GCOS implementation plan 2022) and climate monitoring.

The table below is indicating **in blue** areas where the Denmark participation is more significant.

TABLE 4. GLOBAL PRODUCTS REQUIRING SATELLITE OBSERVATIONS – OCEANS

ECVs/ Global products requiring satellite observations	Fundamental climate data records required for product generation (from past, current and future missions)
Sea Surface Temperature Sea surface temperature OSISAF, EUMETSAT Copernicus Marine Service	Single and multi-view IR and microwave imagery
Sea Ice Sea ice concentration OSISAF, EUMETSAT	Microwave imagery
Sea Ice Sea ice surface temperature OSISAF, EUMETSAT Copernicus Marine Service Copernicus Climate Change Service	IR imagery
Sea Ice Sea ice drift OSISAF, EUMETSAT	IR and visible imagery
Sea Ice Snow depth on sea ice R&D	Laser or radar altimetry, thermal IR and microwave imagery
Sea Ice Sea ice thickness R&D	Laser or radar altimetry, thermal IR and microwave imagery
Sea Level Sea level and variability of its global mean	Altimetry
Sea State Wave height and other measures of sea state (wave direction, wavelength, time period)	Altimetry
Ocean Salinity Research towards the measurement of changes in sea surface salinity	Microwave radiances
Ocean Reanalyses Altimeter and ocean surface satellite measurements EUMETSAT OSISAF	Key FCDRs and products identified in this report, and other data of value to the analyses

3.4 ADDITIONAL NATIONAL OCEANOGRAPHIC MONITORING

3.4.1 Sea temperatures

Denmark has a network for the collection of sea temperatures at 24 coastal stations around Denmark. The stations are operated by DMI, the Danish Coastal Authority, and local authorities respectively. Data are available from each of the responsible bodies. Furthermore, sea surface temperatures are monitored using satellites, and DMI prepares daily maps for the North Sea and Baltic Sea areas.

3.4.2 National tide gauge network

In Denmark an extensive national network of tide gauges is operated jointly by DMI, local authorities and the Danish Coastal Authority. The network consists of approximately 90 automatic stations.

In Greenland a tide gauge stations are operated by DTU-Space/National Space Institute (<https://intaros.nersc.no/content/07-dtu>).

Data are available from the responsible bodies.

3.4.3 Hydrographic and marine surveys

The Danish Centre for Environment and Energy (DCE), has the overall responsibility for surveillance of the Danish waters. Surveillance of fjords and coastal waters is carried out by the regional authorities, while DCE is responsible for mapping the open waters.

All of the surveys are part of the Danish nationwide monitoring programme NOVANA.

All marine NOVANA data (regional and state) are collected annually in the national marine database (MADS), by DCE.

The Danish Technical University (DTU AQUA) carries out yearly surveys in Danish waters, primarily in the North Sea and the Baltic Sea. Relevant oceanographic parameters are measured and recorded for these areas.

Furthermore, DMI is involved in research driven monitoring programmes.

4 Terrestrial Essential Climate Variables (ECV)

4.1 GENERAL INFORMATION

The terrestrial observation system is not as well established as the atmospheric or the oceanographic one. The reason is that most of the terrestrial observations are not part of international observation routines with a regular/daily exchange of data.

4.2 GLOBAL TERRESTRIAL NETWORK – HYDROLOGY (GTN-H)

The GTN-H is a joint effort of the World Meteorological Organization / Climate and Water Department (WMO/CLW), the GCOS, and the Global Terrestrial Observing System (GTOS12), co-sponsored by WMO, UNESCO, ICSU, UNEP and FAO.

GTN-H represents the observational arm of the Group on Earth Observations / Integrated Global Water Cycle Observations Theme (GEO/IGWCO).

The following hydrological variables have been identified as essential for the GTN-H13 network:

Precipitation, river discharge, groundwater, water vapour, lake level/area, isotopic composition, soil moisture, water use, snow cover, glaciers and ice caps, evapotranspiration, water quality/ biogeochemical fluxes.

For most of the variables a global network is defined and a contact established.

The **Global Precipitation Climate Centre (GPCC)** based at German Meteorological Institute/Deutsche Wetterdienst (DWD) and operating under the auspices of the World Meteorological Organization (WMO), as well as **Global Runoff Data Centre (GRDC)**, based at the Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology, BfG) in Koblenz, Germany, and operating under the auspices of the World Meteorological Organization (WMO), are both parts of the GTN-H Panel and represent their respective networks on precipitation and river discharge.

DMI contributes to GPCC with precipitation data, and DCE is reporting to GRDC under GTN-R (see paragraph 4.3).

4.3 GLOBAL TERRESTRIAL NETWORK FOR RIVER DISCHARGE (GTN-R)

DCE is reporting to the Global Runoff Data Centre (GRDC), based at the Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology, BfG) in Koblenz, Germany, and operating under the auspices of the World Meteorological Organization (WMO).

GTN-R is a GRDC contribution to the Implementation Plan for the Global Observing System for Climate and to GTN-H.

Denmark is reporting 31 stations as shown in Table 5.

4.4 GLOBAL TERRESTRIAL NETWORK FOR LAKES (GTN-L)

As with several other data types, lake level data are recorded by both local authorities as well as at national level.

DCE is operating a database, from which national and part of local data from lakes may be available upon request.

4.5 GLOBAL TERRESTRIAL NETWORK ON GLACIERS (GTN-G)

The Geological Survey of Denmark and Greenland (GEUS), is monitoring the mass-balance of the Greenland ice sheet.

In 2007, Denmark launched the Programme for Monitoring of the Greenland Ice Sheet (PROMICE) to assess the mass loss of the Greenland ice sheet. The two major contributors to the ice sheet mass loss are surface melt and a larger production of icebergs through faster ice flow. PROMICE focuses on both processes. Ice movement and discharge are tracked by satellites and GPS. The surface mass balance is monitored by a network of weather stations in the melt zone of the ice sheet.

The Greenland Climate Network (GC-Net) was established in 1995, to obtain knowledge of the mass gain and climatology of the ice sheet. The programme was funded by the USA until 2020, at which point Denmark assumed responsibility for the operation and maintenance of the weather station network. The snowfall and climatology are monitored by a network of weather stations in the accumulation zone of the ice sheet, supplemented by satellite-derived data products.

Together, the two monitoring programmes deliver data about the mass balance of the Greenland ice sheet in near real-time (<https://promice.org>).

GEUS also operates the GlacioBasis monitoring programme at three local glaciers within the GEM (Greenland Ecosystem Monitoring) framework.

In total the networks operate 40 on ice weather stations in Greenland, as shown in Table 5.

The PROMICE and GEM stations are part of the CryoNet within WMO GWC.

4.6 GLOBAL TERRESTRIAL NETWORK FOR PERMAFROST (GTN-P)

Soil or rock that is permanently frozen throughout the year is called permafrost.

Permafrost is present in Greenland, and monitored at selected sites as part of (primary) individual research projects.

Permafrost temperature for Zackenberg is reported under the auspices of Greenland Ecosystem Monitoring and for a number of locations in GTN-P.

TABLE 5. NATIONAL CONTRIBUTIONS TO THE TERRESTRIAL DOMAIN ESSENTIAL CLIMATE VARIABLES

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2023	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS baseline river discharge network (GTN-R)	River discharge	31	31	31	31	31
GCOS Baseline Lake Level/Area/Temperature Network (GTN-L)	Lake level/area/temperature	0	0	0	0	0
WWW/GOS synoptic network (RBSN stations)	Snow cover	3	3	3	3	Not known
GCOS glacier monitoring network (GTN-G)	Glaciers mass balance and length, also ice sheet mass balance	40	N/A	40	Data are available via www.promice.org	Not known
GCOS permafrost monitoring network (GTN-P)	Permafrost borehole temperatures and active layer thickness	0	0	0	0	0

4.7 SATELLITE OBSERVATIONS AS BASE FOR TERRESTRIAL RELATED ECV OBSERVATIONS

Denmark is member state in EUMETSAT and ESA.

Especially through EUMETSAT Denmark takes functional part in activities related to the utilization of satellite data in analyses related to ECVs and climate monitoring.

At present DMI does not operate any activities in the areas shown in Table 6.

TABLE 6. GLOBAL PRODUCTS REQUIRING SATELLITE OBSERVATIONS – TERRESTRIAL

ECVs/ Global products requiring satellite observations	Fundamental climate data records required for product generation (from past, current and future missions)
Lakes Maps of lakes, lake levels, surface temperatures of lakes in the Global Terrestrial Network for Lakes	VIS/NIR imagery and radar imagery, altimetry, high-resolution IR imagery
Glaciers and ice caps Maps of the areas covered by glaciers other than ice sheets, ice sheet elevation changes for mass balance determination	High-resolution VIS/NIR/SWIR optical imagery, altimetry
Snow cover Snow areal extent	Moderate-resolution VIS/NIR/IR and passive microwave imagery
Albedo Directional hemispherical (black sky) albedo	Multispectral and broadband imagery
Land cover Moderate-resolution maps of land-cover type, high-resolution maps of land-cover type, for the detection of land-cover change	Moderate-resolution multispectral VIS/NIR imagery, high-resolution multispectral VIS/NIR imagery
fAPAR Maps of fAPAR	VIS/NIR imagery
LAI Maps of LAI	VIS/NIR imagery
Biomass Research towards global, above ground forest biomass and forest biomass change	L band/P band SAR, Laser altimetry
Fire disturbance Burnt area, supplemented by active fire maps and fire radiated power	VIS/NIR/SWIR/TIR moderate-resolution multispectral imagery
Soil moisture Research towards global near-surface soil moisture map (up to 10 cm soil depth)	Active and passive microwave

5 Additional information

5.1 DETAILED REPORTING

Denmark provided a detailed report as part of “Denmark’s Fifth National Communication on Climate Change under the United Nations Framework Convention on Climate Change and the Kyoto Protocol” to the UNFCCC in 2009.

5.2 WMO RA VI PILOT REGIONAL CLIMATE CENTRES NETWORK (RCC-NETWORK) AND EUROPEAN CLIMATE ASSESSMENT & DATASET (ECA&D)

Through DMI’s active participation in the EUMETNET Expert Team Climate (former EUMETNET programme ECSN (European Climate Support Network)) Denmark contributes very actively to the European Climate Assessment & Dataset (ECA&D) <http://eca.knmi.nl/> – at present the most comprehensive climate dataset and analysis for Europe.

ECA&D forms the backbone of the climate data node in the Regional Climate Centre (RCC) [“The Regional Climate Centre Node on Climate Data”] (RCC-CD for WMO Region VI (Europe and the Middle East)) since 2010.

In addition to the cooperation on data, DMI contributes active to The Regional Climate Centre Node on Climate Monitoring”] (RCC-CM for WMO Region VI (Europe and the Middle East)) providing national climate monitoring products and information.

The data and information products contribute to the Global Framework for Climate Services (GFCS).