

AWS data within information networks like WMO GCW

Mads Christian Lund, Data Scientist GEUS Glaciology & Climate

Andreas P. Ahlstrøm, Robert S. Fausto, Jason E. Box, Nanna B. Karlsson, Baptiste Vandecrux, Anja Rutishauser, Penny How, Mads C. Lund, Patrick J. Wright, Kenneth D. Mankoff, William T. Colgan, Michele Citterio, Alexandra Messerli, Kirsty Langley, Anne M. Solgaard, Signe H. Larsen, Niels J. Korsgaard, Kristian K. Kjeldsen, Rasmus B. Nielsen, Derek Houtz, Signe B. Andersen

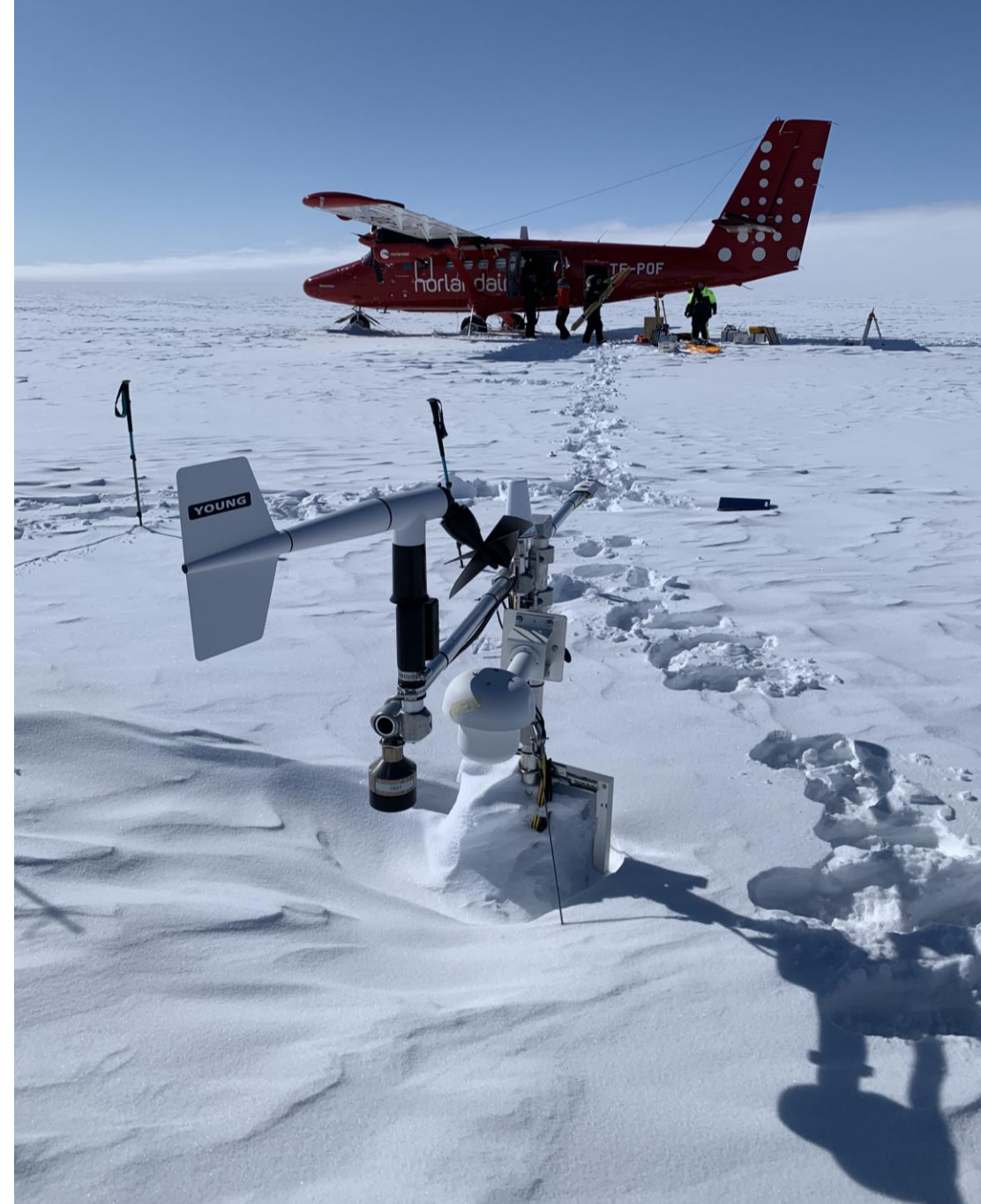


GEUS



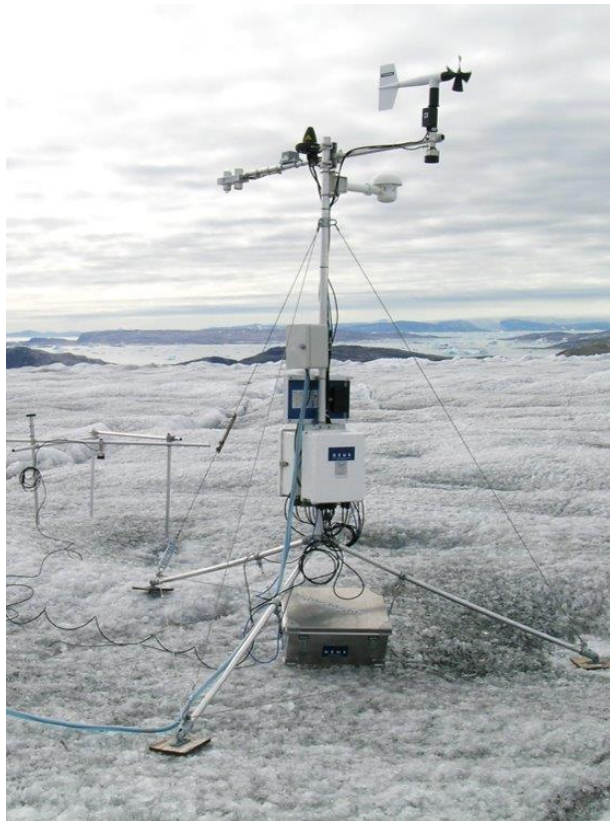
Agenda

- Automatic weather station network
 - Processing pipeline
 - Data products
- Alignment with FAIR principles
 - Metadata conventions (CF, ACDD)
 - File formats (NetCDF)
 - Data access services (THREDDS, OpeNDAP)

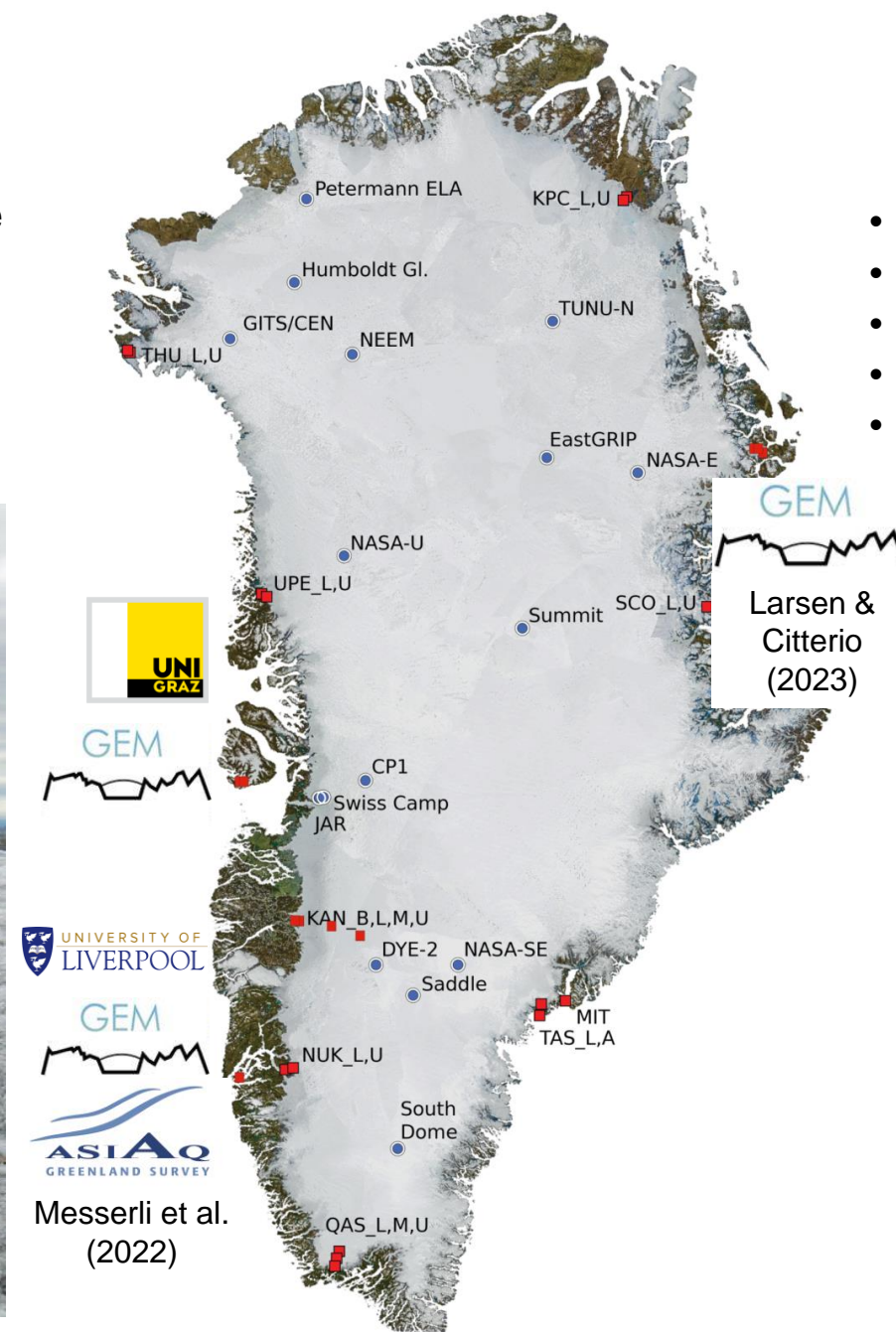


PROMICE

- Programme for Monitoring of the Greenland Ice Sheet
- Peripheral ice sheet monitoring since 2007
- One-boom tripod design
- Ablation zones



Fausto et al. (2021)



Messerli et al. (2022)

GC-NET

- Greenland Climate Network
- Interior ice sheet monitoring since 1995
- GEUS assumed responsibility in 2020
- Two-boom mast design
- Accumulation zones



Measurements

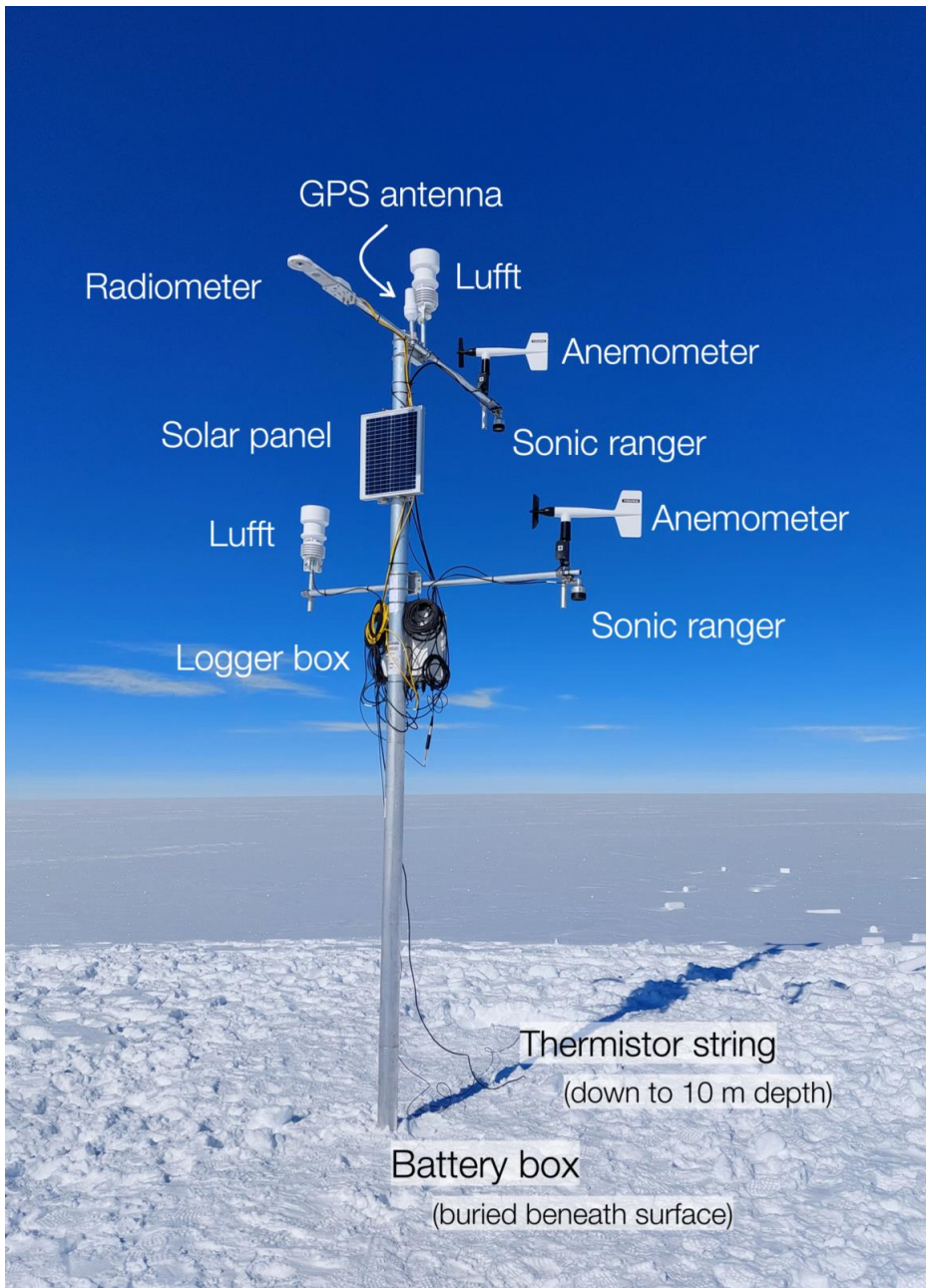


Figure: Anja Rutishauser, <https://tinyurl.com/438ruhne>

- Air temperature 🌡️
 - Relative humidity 🌧️
 - Wind speed and direction 🌬️
 - Precipitation ☁️
 - Radiation (shortwave and longwave) ☀️
 - Snow height and ablation ❄️
 - Position/elevation 📍
 - Snow/ice temperature in the upper 10 m 🌡️
- i. Hourly measurements transmitted via Iridium 📡
 - ii. 10-minute measurements collected from the field 📡

Data Processing pipeline

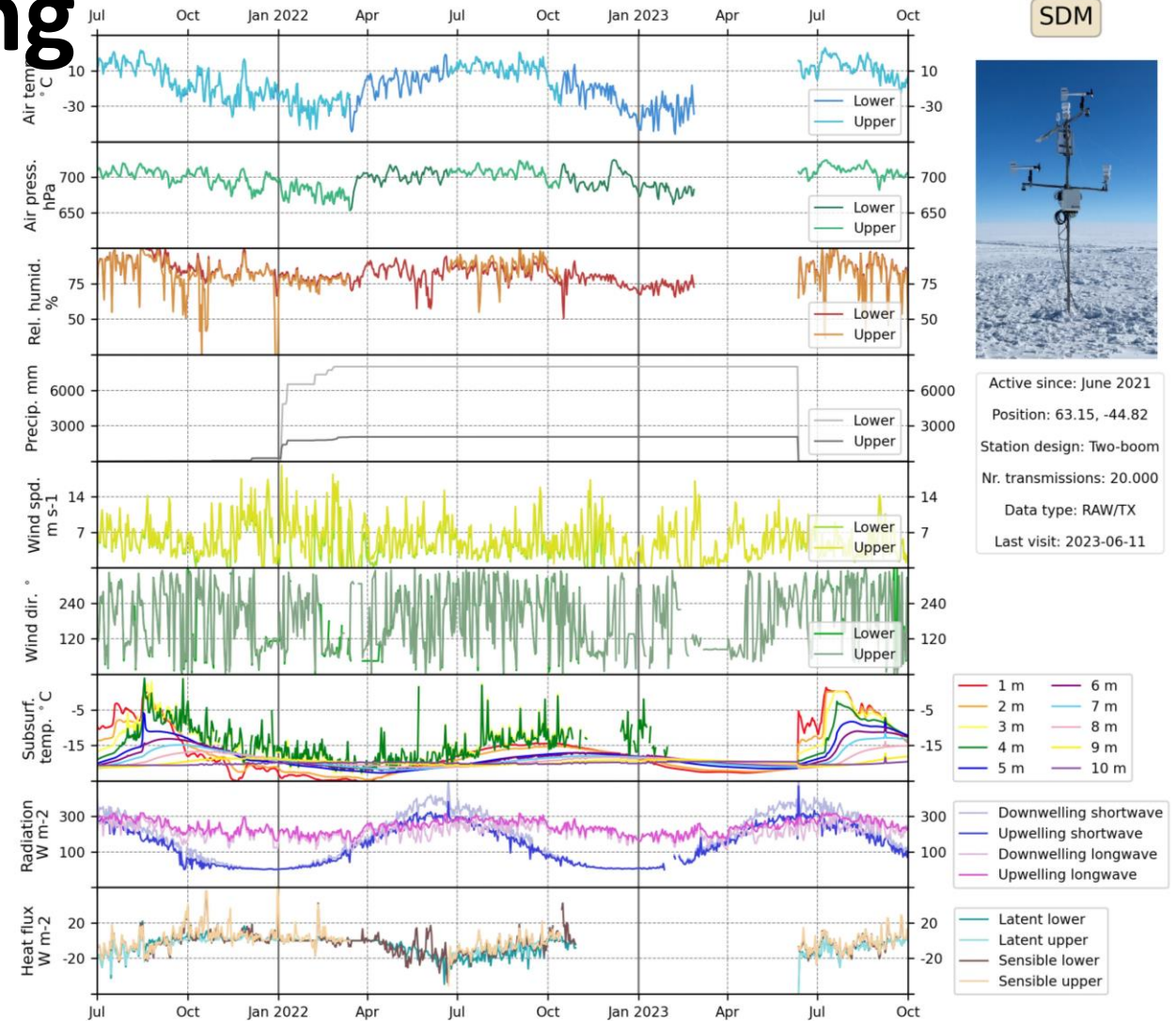
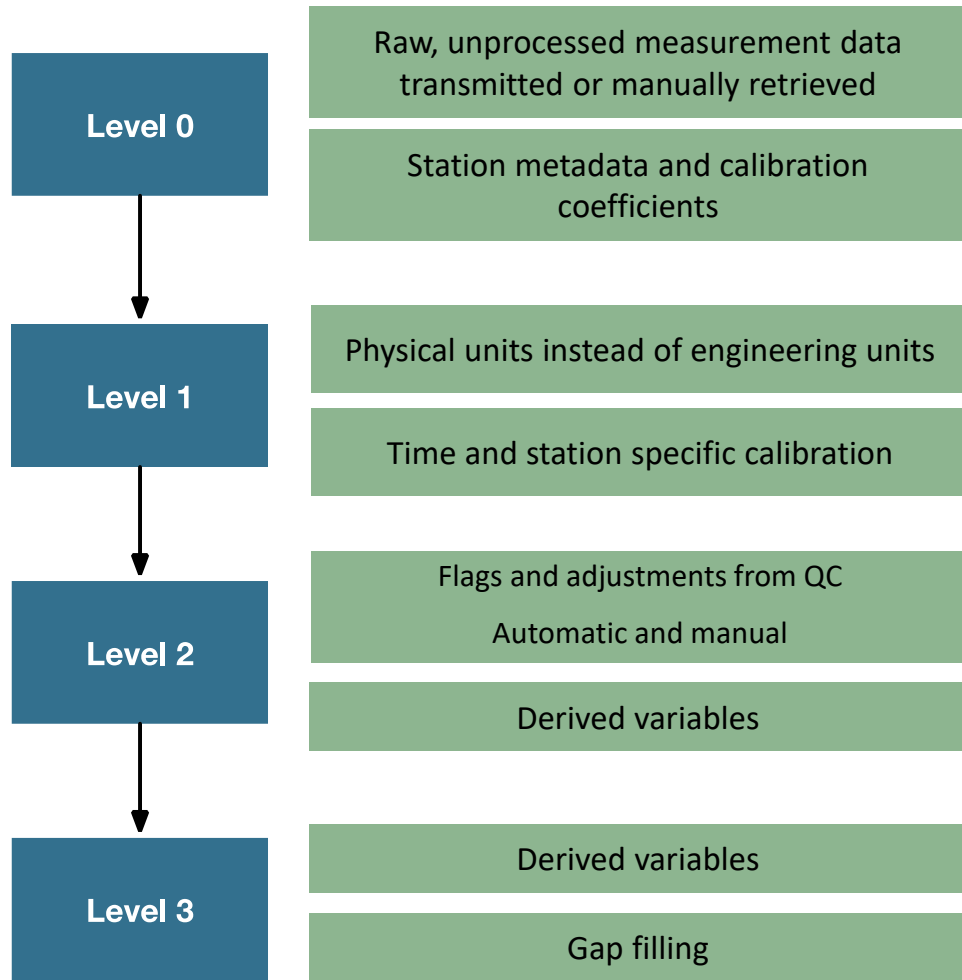
- Near real time data product
- Calibration
- Automatic quality control
- Manual asynchronous quality control
- Noise filtering
- Gap filling
- Derived variables

- Open source

PyPromice



Station Data Processing



Data Products

Site data - Level 3

- Temporal resolution: hourly, daily, and monthly averaged
- Combines data from multiple stations within the same site
- Provides a continuous dataset spanning longer periods

Station data - Level 2

- Hourly Averaged Data
- Lower latency

Fileformats

- NetCDF with dataset and variable metadata
- CSV

Metadata Conventions

CF Convention (Climate and forecast)

- Dataset metadata
- Variable names and units

ACDD (Attribute Convention for Data Discovery)

- Dataset metadata

Dataset metadata

title: AWS measurements from CEN2 station processed to level 2.
Hourly average

Institution: Geological Survey of Denmark and Greenland (GEUS)

id: dk.geus.promice.station.CEN2.L2.hourly

keywords: GCMDSK:EARTH SCIENCE > CRYOSPHERE >...

geospatial_lat_min: 77.181844

geospatial_lat_max: 77.182058

Variables

standard_name: air_pressure

long_name: Air pressure (upper boom)

units: hPa

coverage_content_type: physicalMeasurement

coordinates: time

Publishing Services

THREDDS Data Server (TDS)



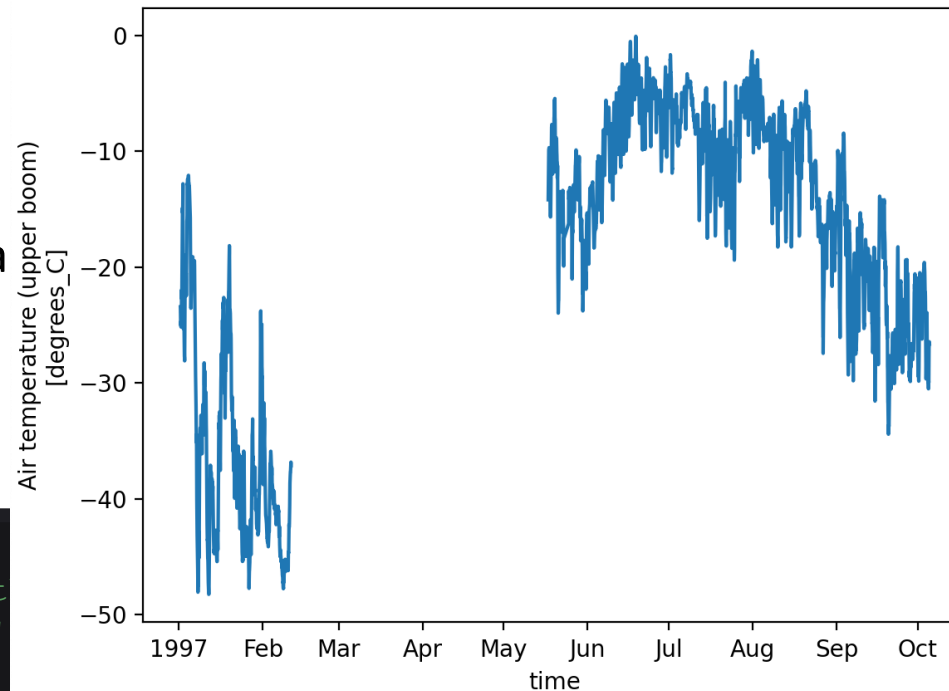
The
Dataverse[®]
Project 

The logo for The Dataverse Project. It features the word "The" in a small, grey font above the word "Dataverse" in a large, bold, orange font. Below "Dataverse" is the word "Project" in a smaller, grey font. To the right of the text is an orange icon consisting of three circles of varying sizes connected by thin lines, resembling a network or data structure.

THREDDS

- Updated hourly with near real-time data
- OPeNDAP
 - Remote access
 - NetCDF metadata
 - Query and download

```
# OPeNDAP URL for the dataset
url = 'https://thredds.geus.dk/t13sites/netcdf/hour/CEN_hour.nc'
# Open the dataset using xarray
ds = xarray.open_dataset(url)
# Slice and plot temperature for 1997
ds.sel(time='1997')['t_u'].plot()
```



THREDDS Data Server (TDS)

UCAR
COMMUNITY
PROGRAMS



unidata
Data Services and Tools for Geoscience

is.dk



Size	Last Modified
173.5 Mbytes	2024-09-02T06:19:05.787Z
171.7 Mbytes	2024-09-02T06:19:08.991Z
165.8 Mbytes	2024-09-02T05:19:55.672Z
54.05 Mbytes	2024-09-02T06:19:12.243Z
13.81 Mbytes	2024-09-02T06:19:14.435Z
171.2 Mbytes	2024-09-02T06:19:16.455Z
157.5 Mbytes	2024-09-02T06:19:20.035Z
36.29 Mbytes	2024-09-02T06:19:22.635Z
74.86 Mbytes	2024-09-02T06:19:24.667Z
70.28 Mbytes	2024-08-30T15:19:55.064Z
1.588 Mbytes	2024-09-02T06:19:26.107Z
87.28 Mbytes	2024-09-02T06:19:28.023Z
67.76 Mbytes	2024-09-02T06:19:30.187Z
66.89 Mbytes	2024-09-02T06:19:32.747Z
13.17 Mbytes	2024-09-02T06:19:34.331Z
11.20 Mbytes	2024-08-20T12:50:09.606Z

GEUS THREDDS Data Server
THREDDS Data Server Docu

KAN_B_hour.nc	36.29 Mbytes	2024-09-02T06:19:22.635Z
KAN_L_hour.nc	74.86 Mbytes	2024-09-02T06:19:24.667Z
KAN_M_hour.nc	70.28 Mbytes	2024-08-30T15:19:55.064Z
KAN_T_hour.nc	1.588 Mbytes	2024-09-02T06:19:26.107Z
KAN_U_hour.nc	87.28 Mbytes	2024-09-02T06:19:28.023Z
KPC_L_hour.nc	67.76 Mbytes	2024-09-02T06:19:30.187Z
KPC_U_hour.nc	66.89 Mbytes	2024-09-02T06:19:32.747Z
LYN_L_hour.nc	13.17 Mbytes	2024-09-02T06:19:34.331Z
LYN_T_hour.nc	11.20 Mbytes	2024-08-20T12:50:09.606Z

Dataverse

- Updated monthly with all datasets
- DOI Integration
- Target URL for the DOI address resolver

The
Dataverse[®]
Project



<https://dataverse.geus.dk>

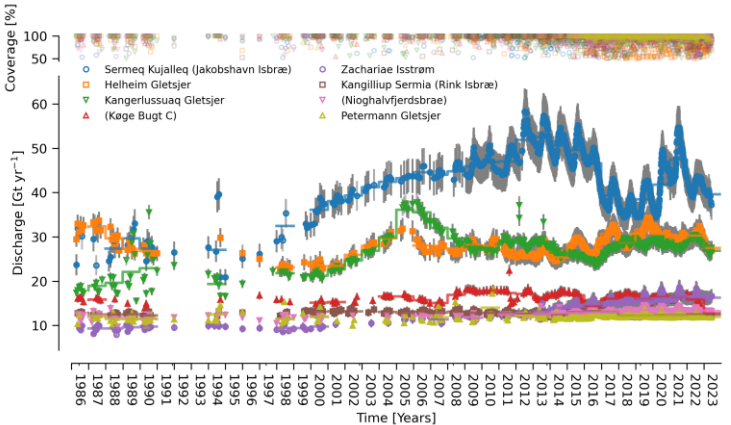
The screenshot shows the Dataverse website interface. At the top, there is a navigation bar with the Dataverse logo, a search dropdown, and links for 'User Guide', 'Support', and 'Log In'. Below the navigation bar, a dataset card is displayed for 'Automatic weather stations' by GEUS. The breadcrumb trail reads: 'GEUS Dataverse > Nature and climate > Programme for Monitoring of the Greenland Ice Sheet (PROMICE) and the Greenland Climate Network (GC-Net) > Automatic weather stations >'. The main title of the dataset is 'PROMICE and GC-Net automated weather station data in Greenland', with a 'Version 19.0' tag. A document icon is shown next to the citation text: 'How, P.; Abermann, J.; Ahlstrøm, A.P.; Andersen, S.B.; Box, J. E.; Citterio, M.; Colgan, W.T.; Fausto, R.S.; Karlsson, N.B.; Jakobsen, J.; Langley, K.; Larsen, S.H.; Lund, M.C.; Mankoff, K.D.; Pedersen, A.Ø.; Rutishauser, A.; Shield, C.L.; Solgaard, A.M.; van As, D.; Vandecrux, B.; Wright, P.J., 2022, "PROMICE and GC-Net automated weather station data in Greenland", <https://doi.org/10.22008/FK2/IW73UU>, GEUS Dataverse, V19'. To the right of the citation, there is an 'Access Dataset' dropdown menu with options for 'Contact Owner' and 'Share'. Below this, the 'Dataset Metrics' section shows '86,096 Downloads'. At the bottom of the dataset card, there are links for 'Cite Dataset' and 'Learn about Data Citation Standards'.

FAIR and interoperability with GCW

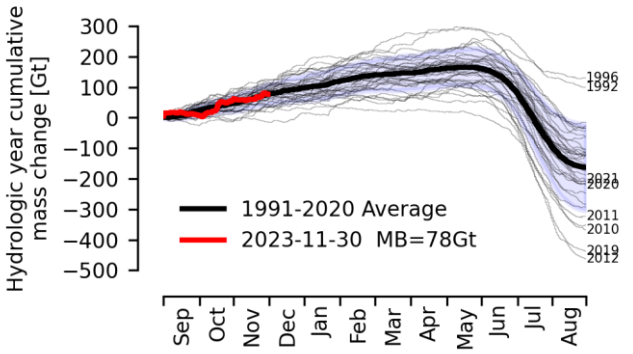
- Metadata: CF conventions and ACDD
- Dataformats: NetCDF
- Data access services: THREDDS with OPeNDAP
- Open source software: PyPromice

Data Products

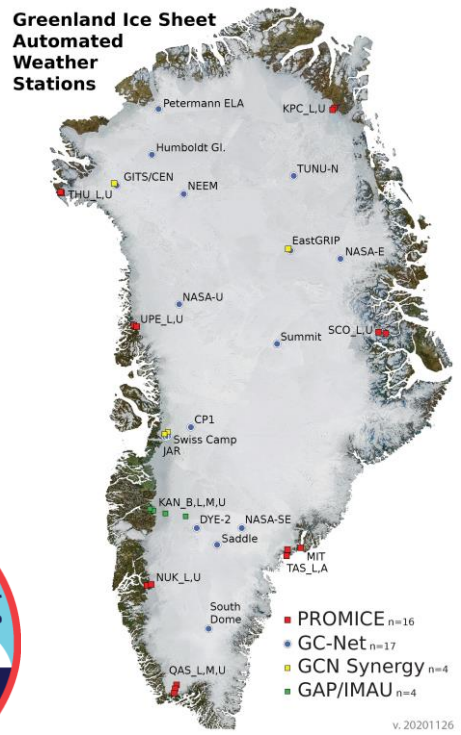
Ice Discharge



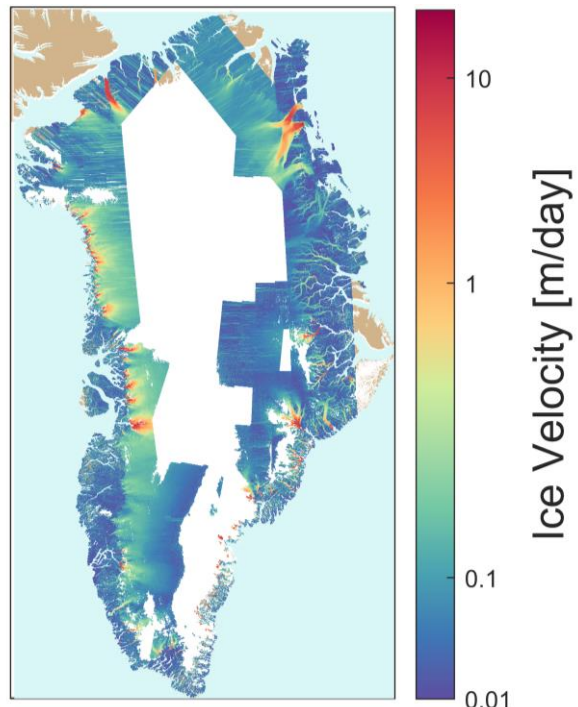
Ice Sheet Mass Balance



Automatic Weather Stations



Greenland Ice Velocity from Sentinel-1



Solgaard et al. (2023)