GRUAN Site Ny-Ålesund

ALFRED-WEGENER-INSTITUT
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- **Ny-Ålesund, Svalbard, is located in a hot spot of climate warming**
- **Radiosonde measurements are operated regularly since 1993**
- **Besides radiosondes, the site contributes to GRUAN with GNSS, lidar, ozone and water vapor sonde data**

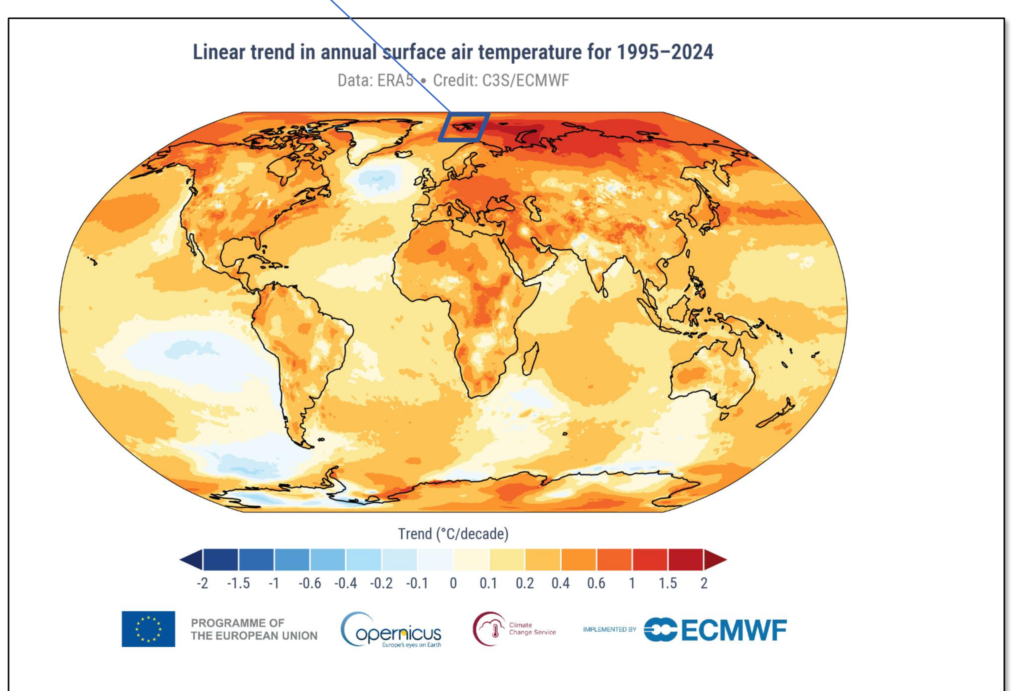


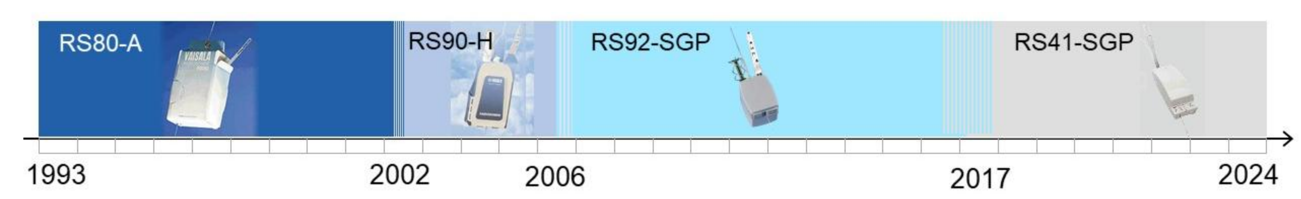
Fig.1: Trend in annual surface air temperature (°C/decade) for 1995–2024. Data source: ERA5. Credit: C3S/ECMWF.
(from: https://climate.copernicus.eu/climate-indicators/temperature)

Observed Changes

The Arctic is warming faster than the rest of the globe, due to various feedback processes between the atmosphere and the sea-ice- and snow- covered surface. However, temperature increase is also observed in the vertical: the Ny-Ålesund radiosonde profiles show a general tropospheric warming, with varying strength for the different decades, and varying intensity in the different seasons. While the autumn and winter seasons encounter a significant bottom-amplified warming of the entire troposphere, temperature increase in spring is hardly recognizable. Similar development is seen in integrated water vapor (IWV).

Homogenized Radiosonde Data Set

- more than 30 years of daily radiosonde observations allow for climate trend studies in the troposphere and lower stratosphere
- Creation of a homogeneous data series:
  - application of corrections to RS80 and RS90 data (Maturilli and Kayser, 2014)
  - assuming optimum corrections for RS92 and RS41 GRUAN data products
  - interpolation to Δz = 50m height resolution below 10km, Δz = 100m above



→ data

Fig.2: Vaisala radiosonde types used at Ny-Alesund since 1993.

Annual Temperature Trend

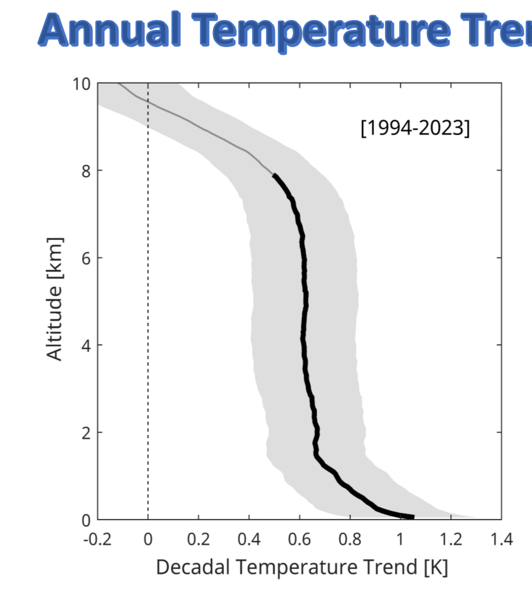


Fig.3: Decadal trend of annual mean temperature, with significance (thick black line) and 95% confidence level (grey).

Seasonal Temperature Trends

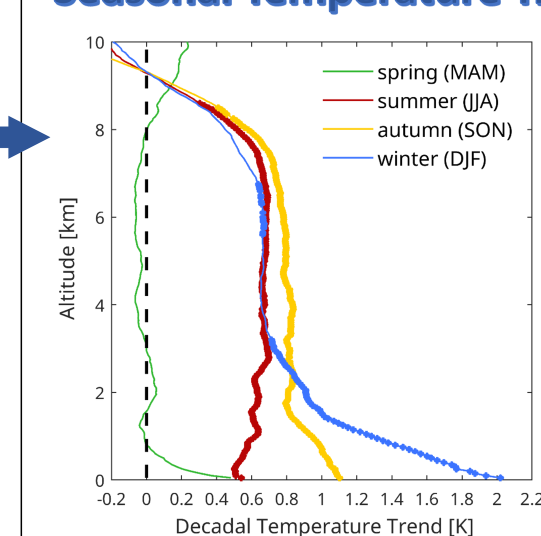


Fig.4: Decadal trend of seasonal mean temperature, with significance (thick colored lines).

Example: March — No temperature trend, but notable differences among the three decades.

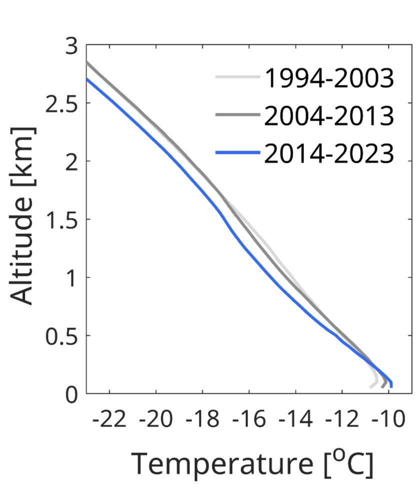


Fig.6: Decadal mean March temperature profiles from Ny-Ålesund radiosondes.

- overall warming near the ground (below ~300m)
- above ~400m, a shift toward lower temperatures becomes evident in 3rd decade

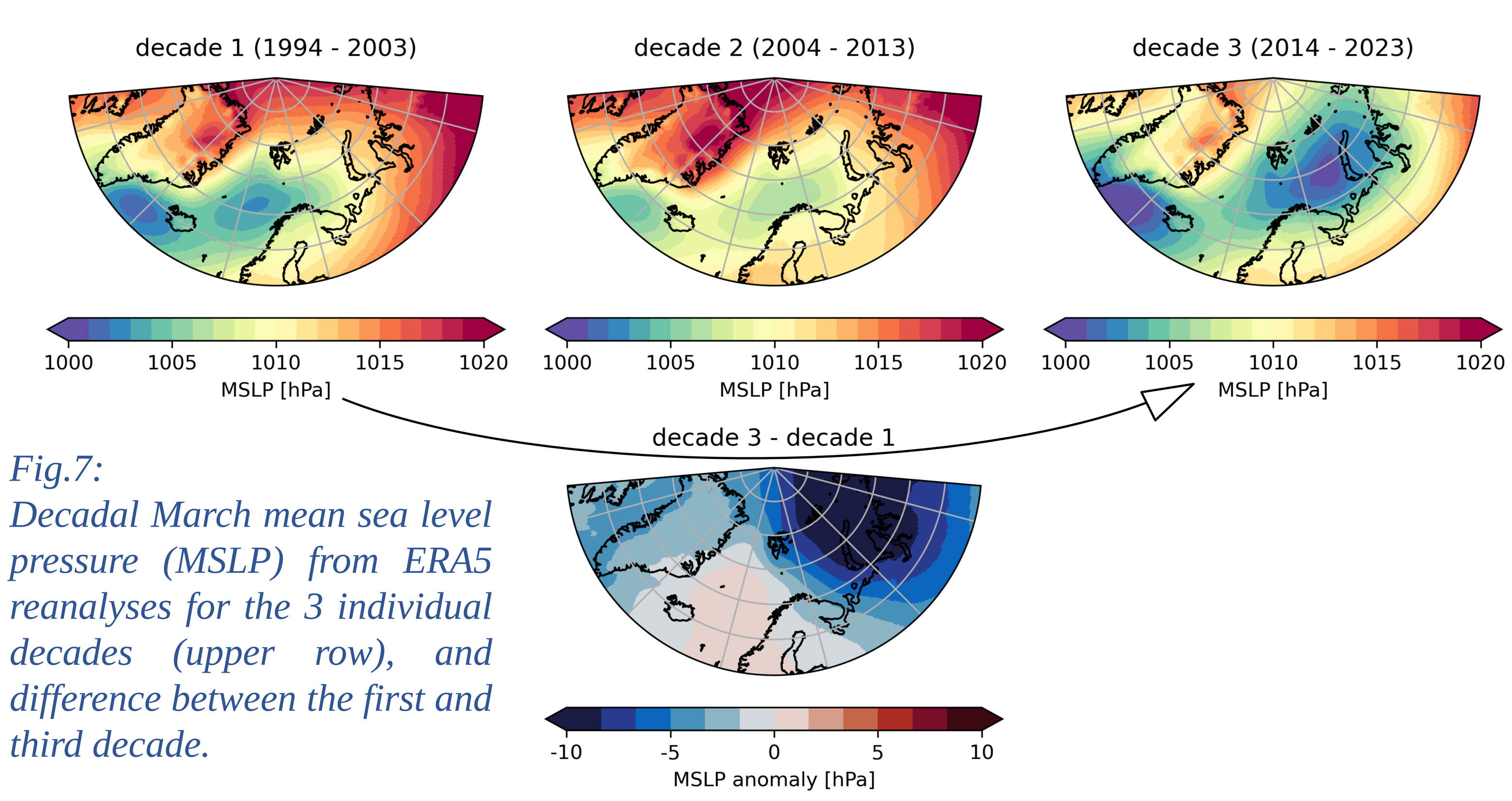


Fig.7: Decadal March mean sea level pressure (MSLP) from ERA5 reanalyses for the 3 individual decades (upper row), and difference between the first and third decade.

- Local tropospheric cooling observed despite global warming
- Decadal MSLP maps for March (Fig. 7) show a persistent low-pressure anomaly over the Barents Sea
- This anomaly drives cold air advection from the central Arctic toward Svalbard.
- Increased frequency of marine cold air outbreaks (MCAOs) in March (e.g. Dahlke et al., 2022; Slättberg et al., 2025)
- Atmospheric patterns locally suppress the broader warming trend in March

Monthly Mean Temperature Trends

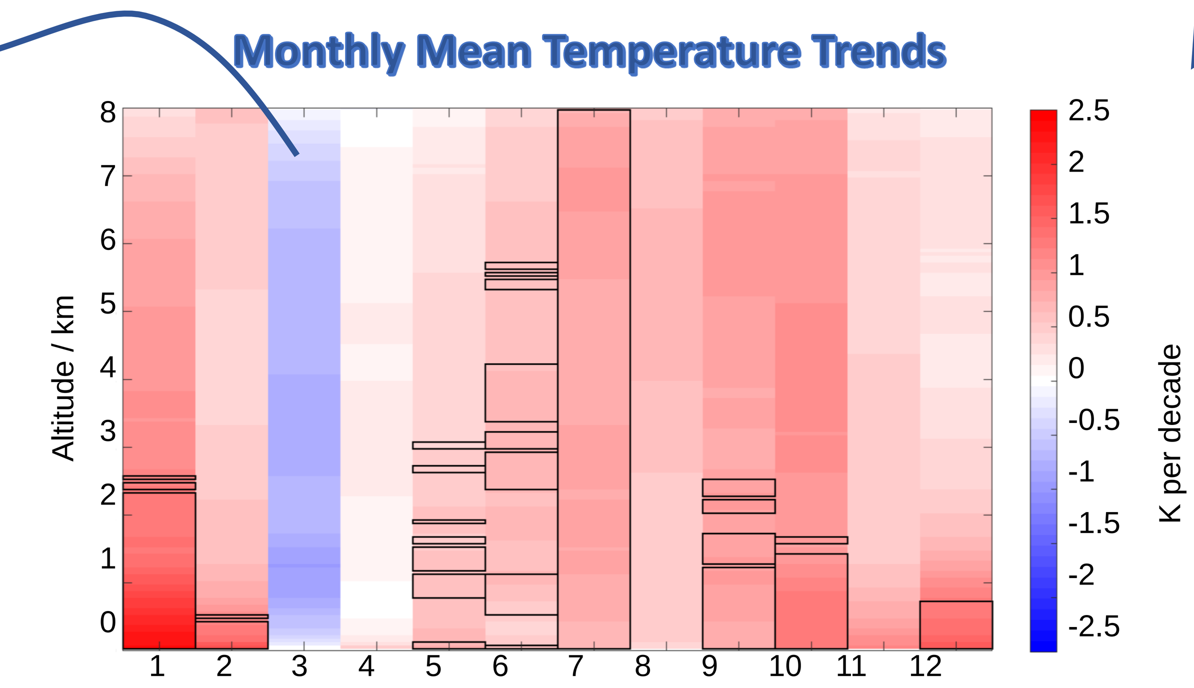


Fig.5: Decadal trend of monthly mean temperature 1994-2023 (color-coded), with significance indicated by black contour lines.

Overall, tropospheric temperature and humidity over Svalbard are related to large scale atmospheric circulation, affecting the local ambient conditions by altering clouds, radiation, and precipitation on synoptic time scales, while leading to distinct long-term trends for each season on climatic time scales.

Lidar

- Regular lidar data stream to GRUAN LC since November 2023

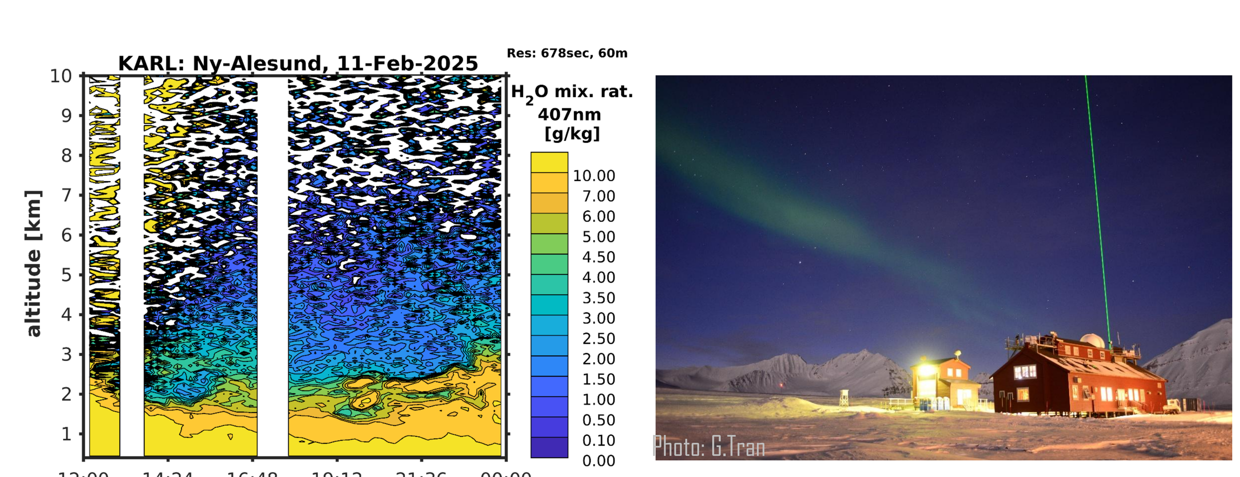


Fig.8: Lidar measurement processed with in-house developed algorithms to retrieve water vapor mixing ratio (color-coded) on 11 February 2025. Contact: Christoph.Ritter@awi.de

Water Vapor Sondes

- CFH program suspended in 2021 due to ban of R23
- Resumption of H_2O sounding program with Skydew, first regular launches planned for spring/summer 2026

Photos: Skydew test launches in Ny-Ålesund, April/May 2024

Various

- Since February 2025, we are using RS41E with biodegradable cover

… and as the trend in integrated water vapor (IWV) was mentioned:

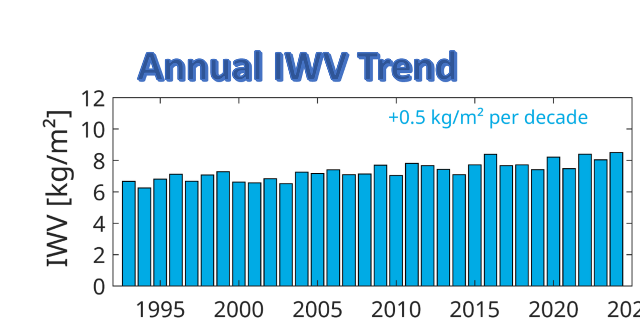


Fig.9: Annual mean IWV from radiosondes, resulting in a significant trend of +0.5 kg/m² per decade.

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References:

Maturilli and Kayser (2017) Arctic warming, moisture increase and circulation changes observed in the Ny-Ålesund homogenized radiosonde record. Theor Appl Climatol 130, 1–17 (2017). https://doi.org/10.1007/s00704-016-1864-0

Dahlke et al. (2022) Cold air outbreaks in Fram Strait: Climatology, trends, and observations during an extreme season in 2020. JGR Atmospheres, 127, e2021JD035741. https://doi.org/10.1029/2021JD035741

Slättberg et al. (2025) Fram strait marine cold air outbreaks in CARRA and ERA5: Effects on surface turbulent heat fluxes and the vertical structure of the troposphere. JGR Atmosphere,130, e2024JD042908. https://doi.org/10.1029/2024JD042908