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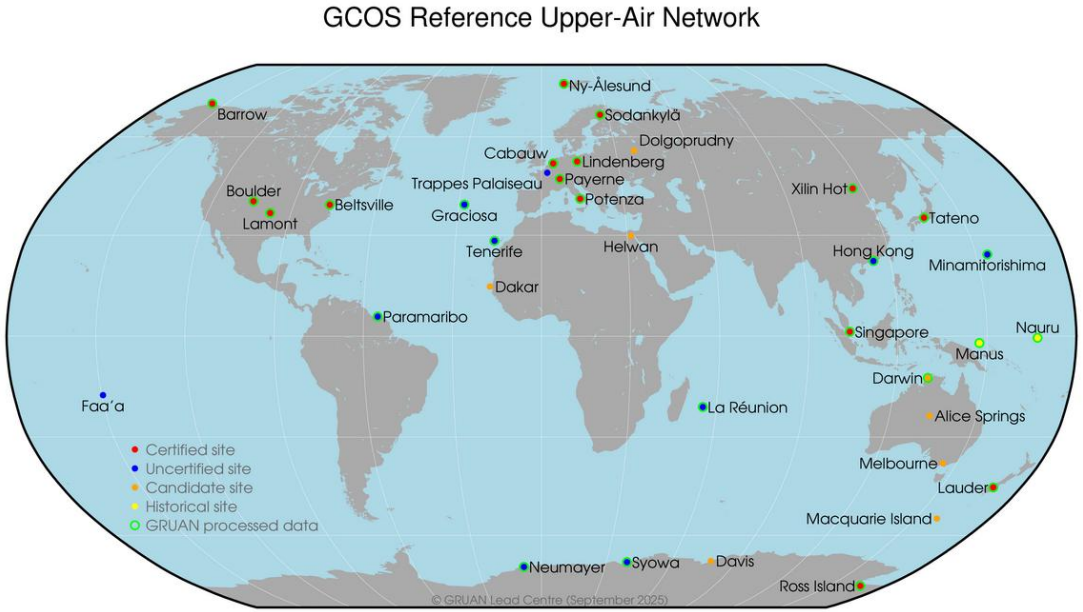
Research Activities at the Sodankylä site

Presented by Rigel Kivi, FMI

GRUAN ICM-16, 17.11.2025

GRUAN Sodankylä



- UTLS water vapor: CFH, Flash-B, NOAA, RS92, RS41, iMet, campaigns with other equipment.
- CFH- LN2 flight at Sodankylä in Feb 2024
- Water vapor isotopologues in 2022 and 2024
- CH4 profile observations using AirCore
- CH4 observation using sampling bags
- Column CH4 using ground based FTIR
- Ozonesondes
- Aerosol sondes, COBALD
- Geiger counters
- Drones equipped with flasks and sampling bags
- Present and upcoming field campaigns





Arctic Space Centre in Sodankylä is operated by the Finnish Meteorological Institute. Location of the site is 67.4 °N, 26.6 °E, 179 m altitude. Networks: GRUAN, TCCON, NDACC, ICOS, AERONET, GAW, WOUDC, EUBREWNET, SAOZ, etc.

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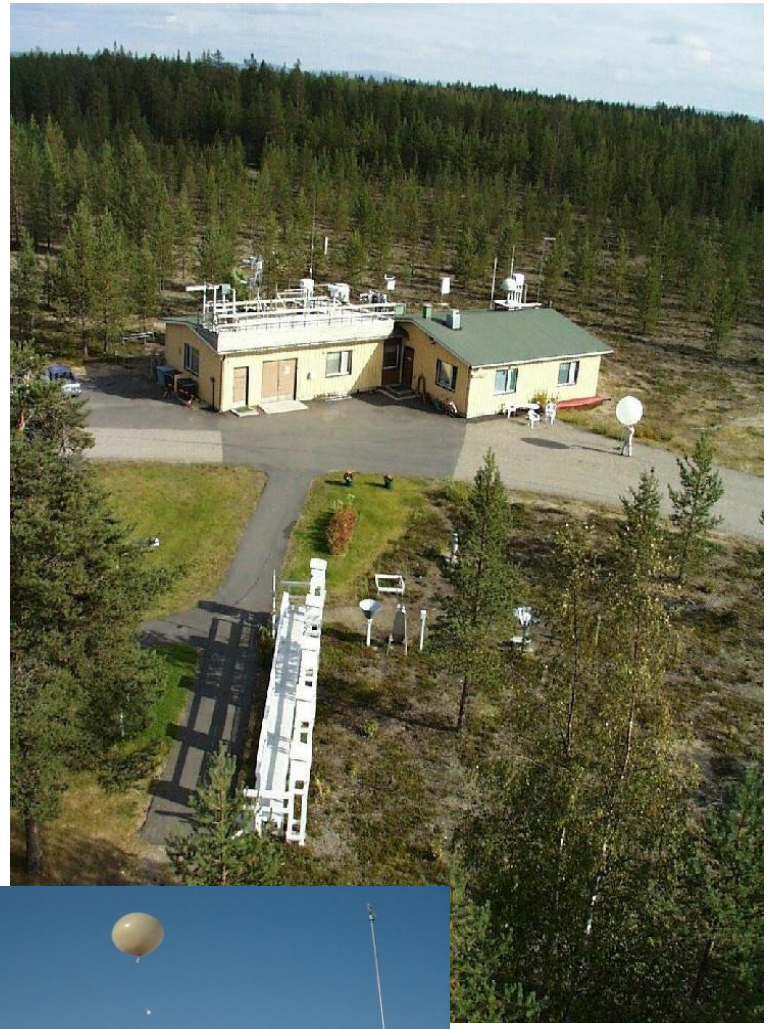
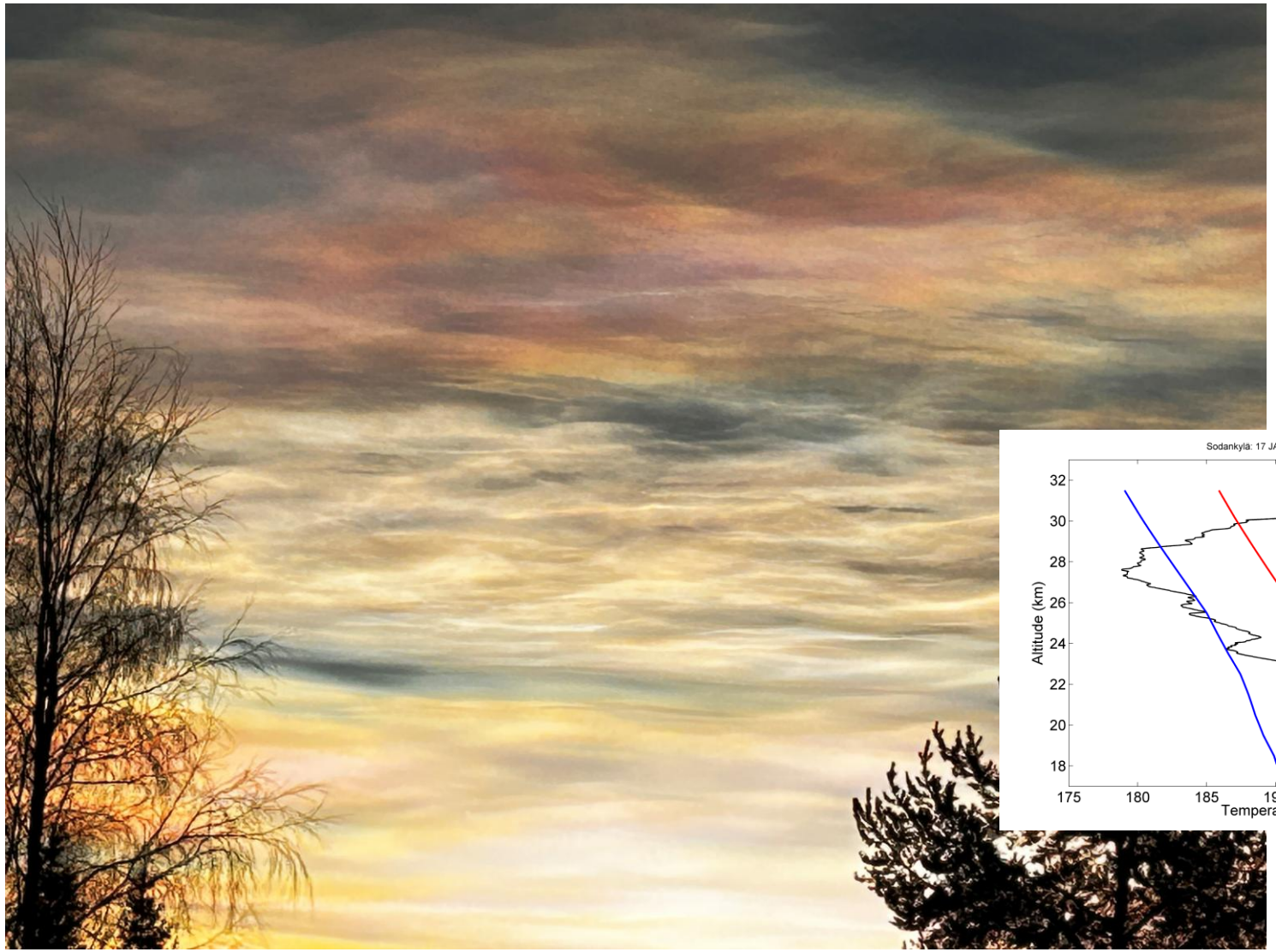


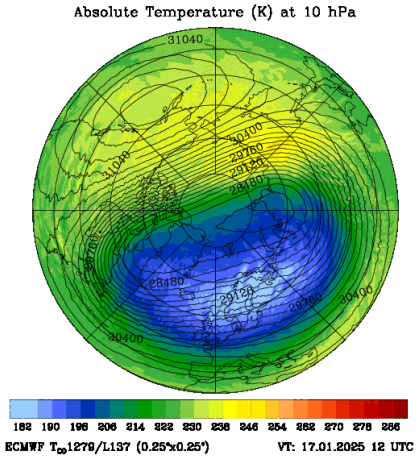
Observations at Sodankylä since 1856

- First thermo-/barometer-based records in 1856
- Met station during the 1st IGY 1882/83
- Continuous weather records since 1908
- Radiosondes since 1949, more than **58 000** radiosondes
- Solar radiation observations since 1957/58 (1st IPY)
- Radioactivity monitoring since 1963
- Air quality observations since 1970s
- Ozonesondes and Brewer 1988
- SAOZ since 1990
- First Lidar campaign in 1991/1992
- Stratospheric Aerosol sondes since 1994
- Radioactivity sondes since 1995
- Frost Point Hygrometers since 1996
- RS92 since 2004, RS41 started in April 2017
- Automated sonde launches since 2005
- TCCON FTS started in 2009
- AirCore GHG since 2013
- ESA FRM4GHG project 2017-
- Drone-based AirCore in July-August 2018
- Drone-based SIF in summer 2019
- Water vapor isotopologues sampler since 2021

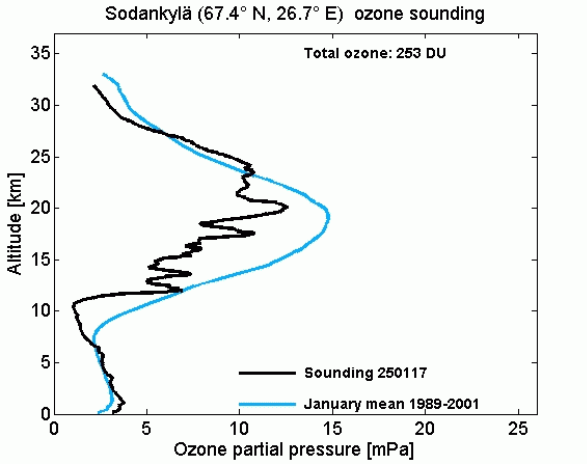
Polar Stratospheric Clouds (PSCs) observed at Sodankylä in January 2025



PSCs over Sodankylä, Photo: Rigel Kivi, FMI



ECMWF Temperatures @ 10 hPa, ©Andreas Dörnbrack, DLR



Temperature (Tice (blue), TNAT (red), T (black line)), min **T=-94.3 C** at 27.6 km; and Ozonesonde profile over Sodankylä on January 17, 2025

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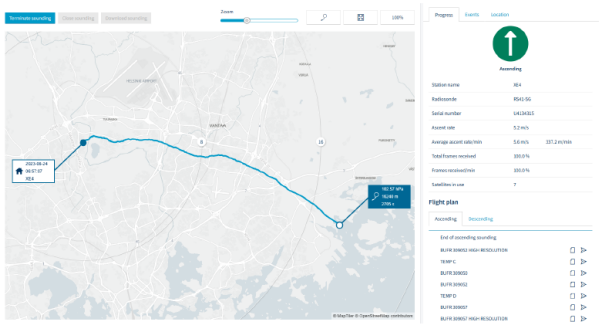
Vaisala MW51 and MW41, ozone

VAISALA

Cirrus Sounding System MW51

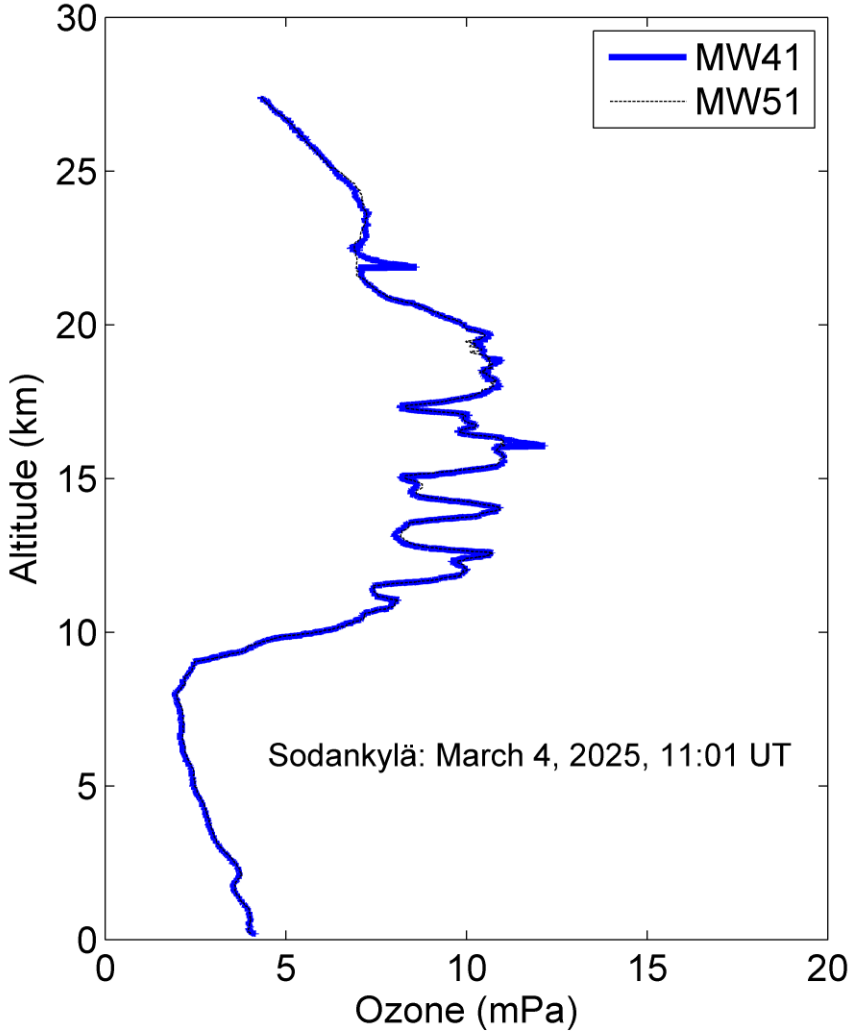


Features

- Consistent, high-quality data
- Easy to operate
- Receive data from several radiosondes simultaneously
- Long telemetry range
- Inbuilt security with regular updates
- Compact design supports portable applications

Vaisala Cirrus® Sounding System MW51 is the foundation of modern meteorological upper-air observations.

MW51 system



Dual ozonesonde flight on March 4, 2025

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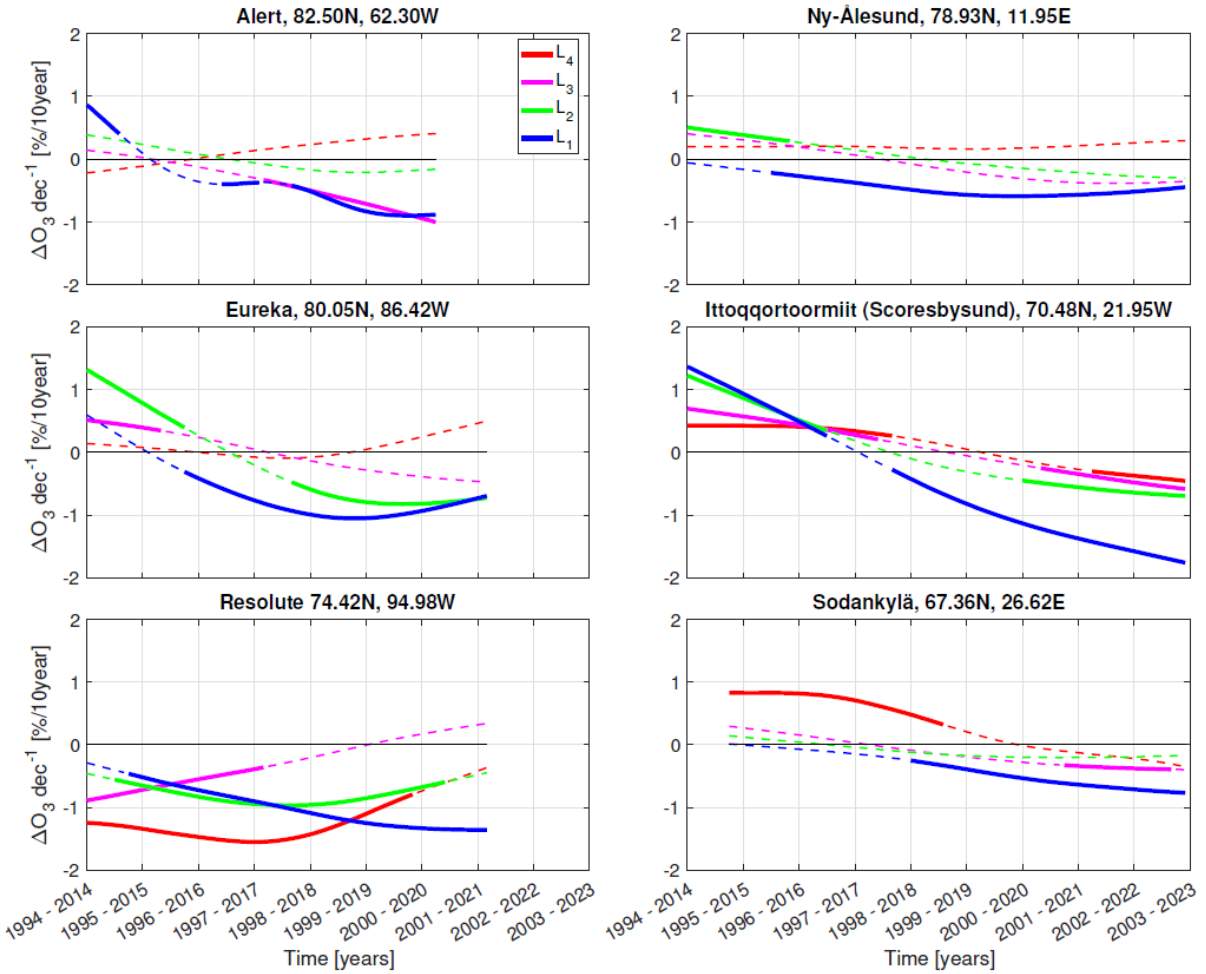
Time-varying trends from Arctic ozonesonde time series

- Dynamic Linear Model is used to derive time-varying trends over 20-year periods in the Arctic ozone time series, measured in-situ by ozonesondes from 6 stations, from 1994 to 2022.
- The model accounts for seasonality, external forcing and 1st-order correlation in the residuals. As proxies for the external forcing, we have used tropopause pressure, eddy heat flux, the volume of polar stratospheric clouds multiplied by effective equivalent stratospheric chlorine, and solar flux at 10.7cm for the 11-year solar cycle.
- The results indicate that though significant positive trends have been detected prior to 2017 at some stations, there are no statistically significant positive trends after 2017. Moreover, at a number of stations the trends after 2019 are rather negative and significant, varying between -0.30±0.25 and -1.00±0.85% per decade. The Arctic troposphere exhibited only statistically significant negative trends over 20-year periods ending in 2017 or later, varying between -0.31±0.27 and -1.76±0.41% per decade. These results highlight the importance of continued monitoring of the Arctic ozone.



Nilsen, K., Kivi, R., Laine, M. *et al.* Time-varying trends from Arctic ozonesonde time series in the years 1994–2022. Scientific Reports **14**, 27683 (2024). https://doi.org/10.1038/s41598-024-75364-7

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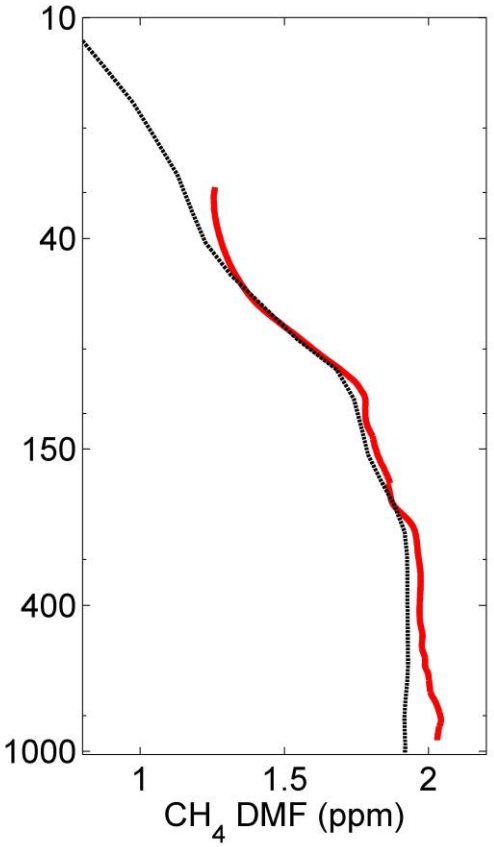
AirCore observations

- At Sodankylä we have performed AirCore observations during all seasons, since September 2013. Collaboration with Groningen University. AirCore at the site of FTIRs (COCCON, TCCON, NDACC).
- The AirCore sampler at Sodankylä is built as a stainless steel tubing of about 100 m long. It is possible to measure profiles with vertical resolution of 5 mb in the stratosphere and 15 mb in the troposphere.
- The system also involves a data acquisition unit to store pressure and temperature during an AirCore flight, a Vaisala RS92 radiosonde, a transponder and a GNSS positioning device.
- AirCore is flown using a meteorological balloon. Shortly after landing we have analysed the sample using a Picarro G2401 gas analyser.

Tukiainen et al., 2016, Mrozek et al., 2016, Paul et al., 2016; Kivi and Heikkinen, 2016; Sha et al. 2020, Tu et al., 2020, Hooghiem et al., 2018; 2020; 2025; Schneider et al., 2022; Zhou et al., 2022, Laughner et al., 2023; Laughner et al., 2024; Sha et al., 2024; Zanchetta et al., 2025; Hachmeister et al., 2025.



July 1, 2025 AirCore CH4, dotted line is GGG2020 a priori.

AirCore and FTS instruments.

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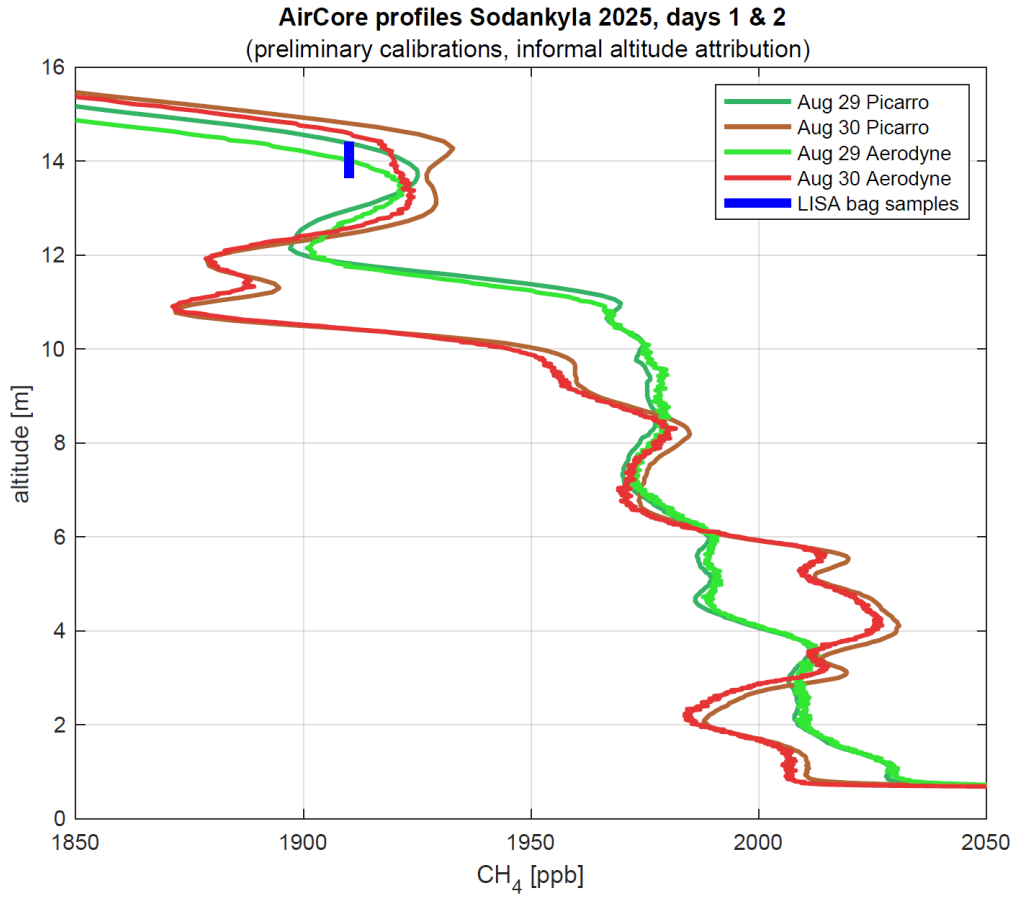
AirCore observations in 2025



Left: Dual AC and LISA flight on 29 and 30-AUG-2025; figure courtesy van Heuven, Groningen University. **Right**: AirCore balloon filling on 31-AUG-2025, photo: Rigel Kivi.

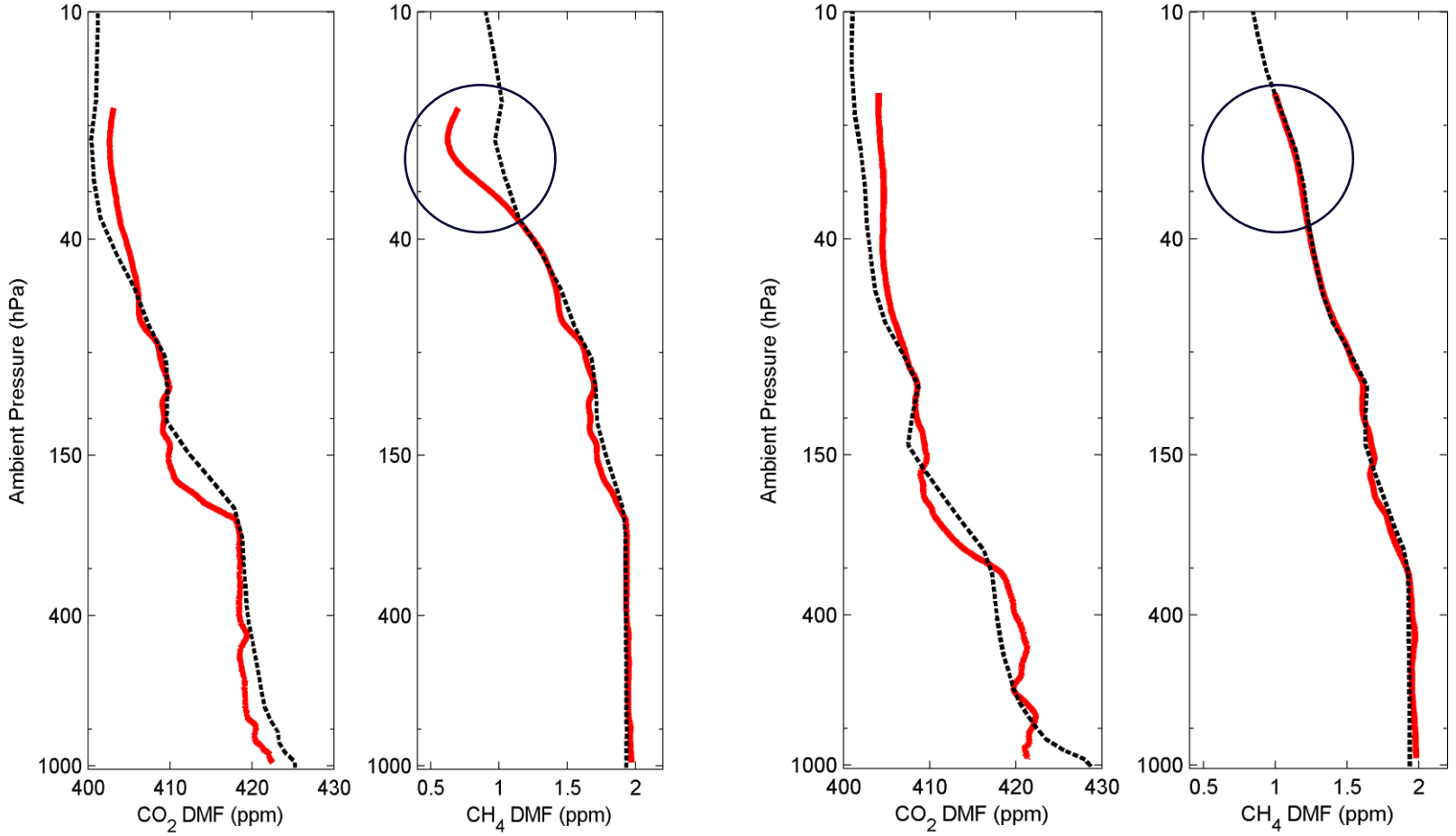
Payload recovery

July 3, 2025

July 3, 2025

Aug 22, 2025

AirCores in the stratosphere



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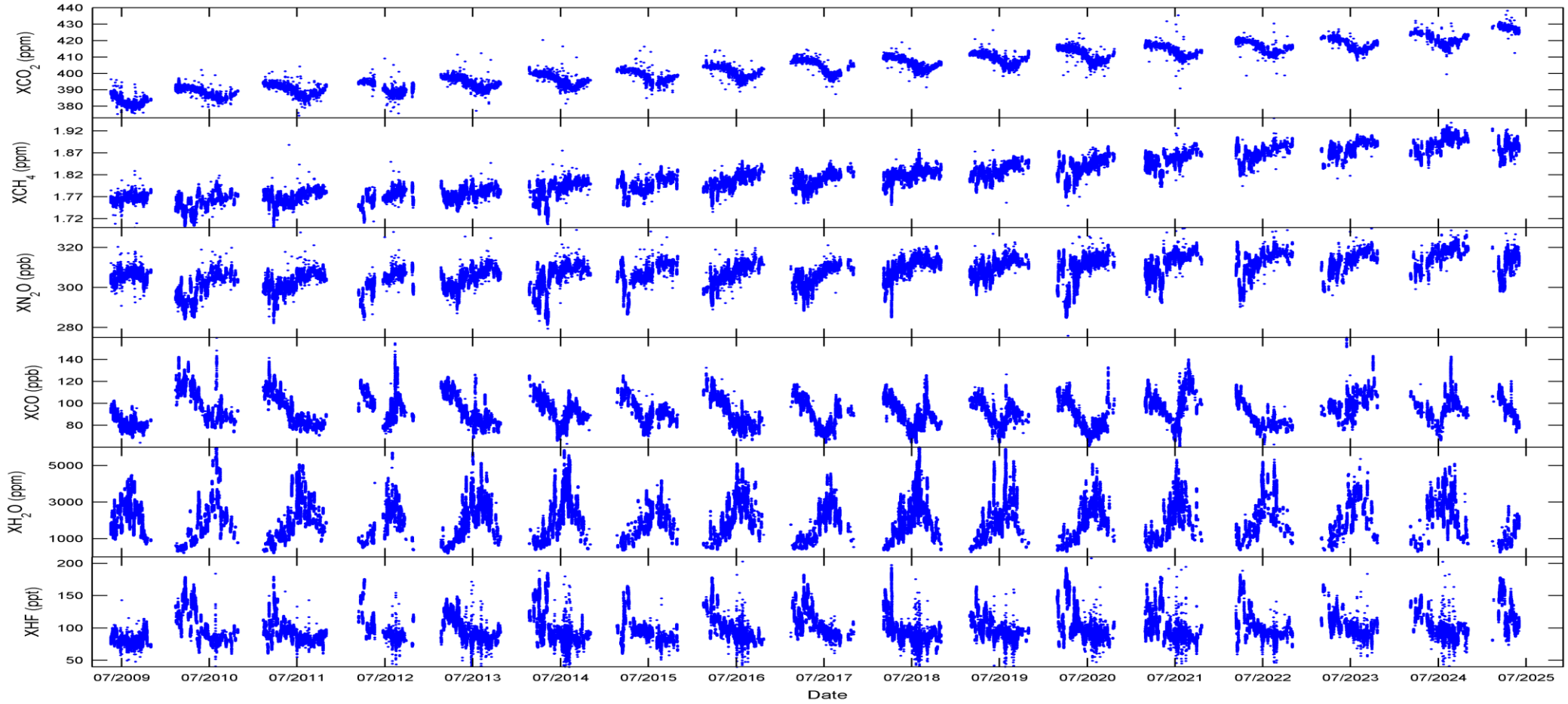
AirCore profiles of CO_2 and CH_4 (red) versus TCCON GGG2020 (dashed line, Laughner et al., AMT 2023) a priori profiles. Left: measurements taken at Sodankylä on 19 April 2021. Right: AirCore measurements and a priori profiles on 26 April 2021.

TCCON Sodankylä

Bruker *IFS 125HR* with *A547N* solar tracker.
Detectors:
RT-InGaAs: *12800 - 4000 cm^{-1}*
RT-Si: *25000 - 9000 cm^{-1}*
LN-InSb: *10000 - 1850 cm^{-1}*

In operation since FEB-2009



Column-averaged dry air mole fractions at Sodankylä since 2009. Updated from Kivi and Heikkinen (2016), using GGG2020 retrieval (Laughner et al., ESSD 2024).

Summary

Profile observations have included:

- Radiosondes, RS41, RS92 etc. Autosonde for regular flights, p, T, U, wind.
- CFH, cryogenic frost-point hygrometer
- aerosol BKS
- Water vapor isotopologues
- AirCore flights, CO2, CH4, N2O, CO, etc.
- Geiger Counters
- Ozonesondes

New field campaigns in planning, for example water vapor UTLS studies

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- Nilsen, K., Kivi, R., Laine, M. et al. Time-varying trends from Arctic ozonesonde time series in the years 1994–2022. Sci Rep 14, 27683 (2024). https://doi.org/10.1038/s41598-024-75364-7
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ESA/FMI Sodankylä Supersite project started on September 1, 2025