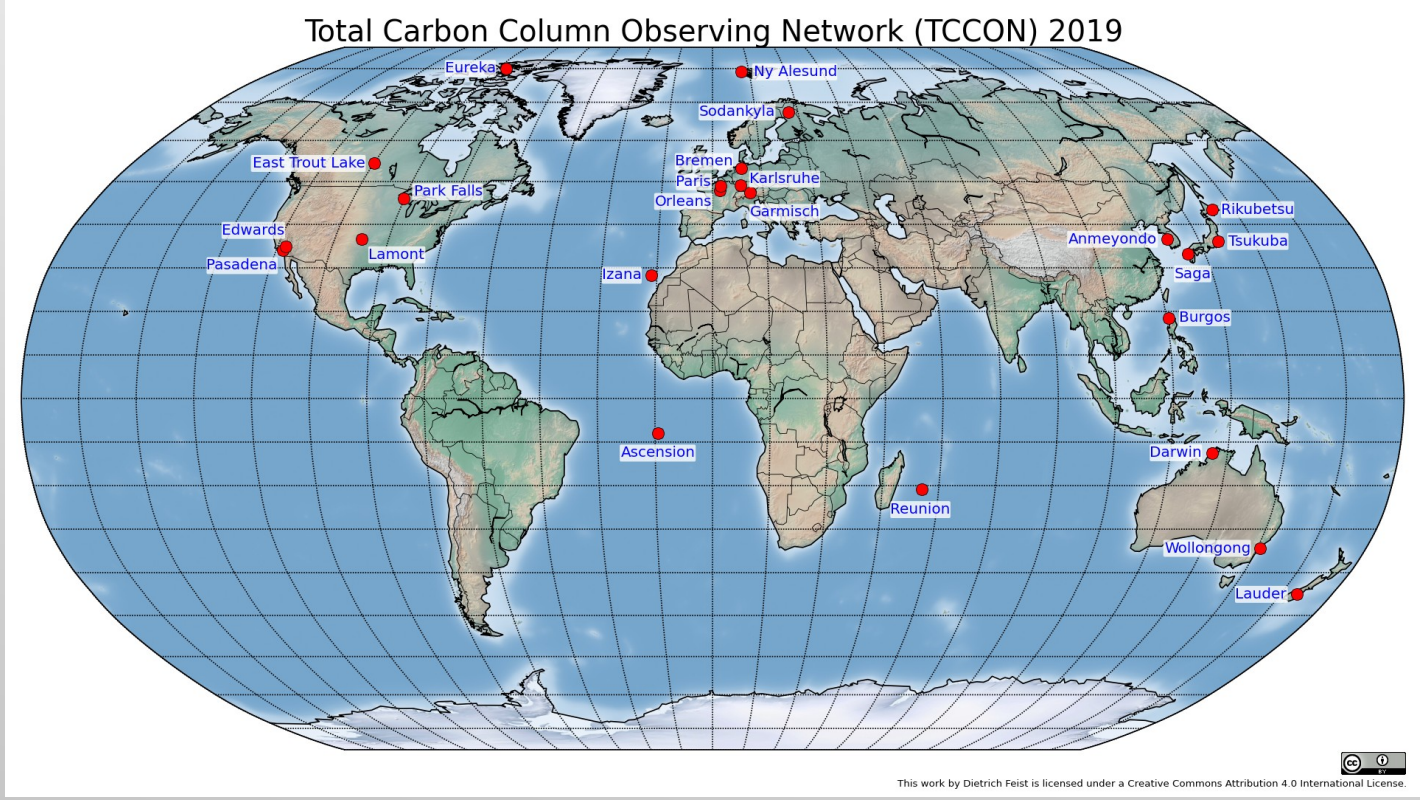
Validation of column-averaged CO2 and CH4 observations with AirCore

Presentation at ICM-13

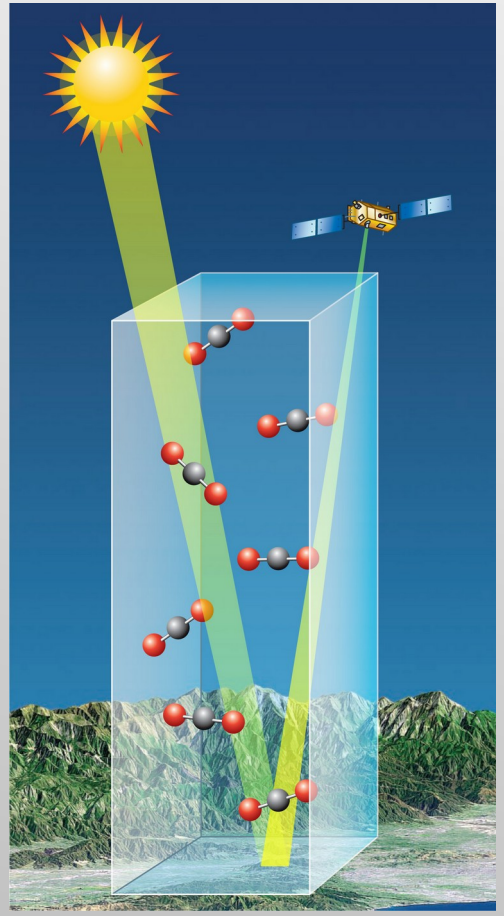
Dietrich Feist
LMU München / DLR-IPA Oberpfaffenhofen
TCCON Deputy Chair for Africa & Europe

Total Carbon Column Observing Network (TCCON)



- Network of high-resolution FTIR instruments
- 27 stations in 14 countries
- Goal: provide column-averaged mole fraction of CO2, CH4, CO, N2O, … with best achievable precision and accuracy.
- Reference for all GHG satellite missions.

Column-averaged observations



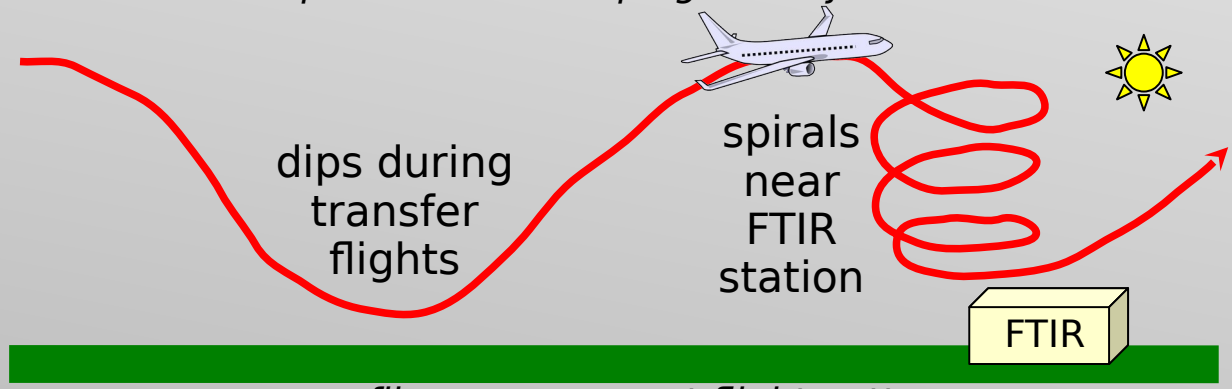
http://oco.jpl.nasa.gov/

- Covers full atmospheric column from ground to ~100 km
- Measure total column of CO2/CH4 and use total column of O2 as proxy for airmass (assuming constant mole fraction of 0.2095)
- Observed parameter is colum-averaged dry-air mole fraction => XCO2, XCH4, …

Aircraft calibration of column-averaged TCCON observations

European IMECC campaign: Learjet 35A

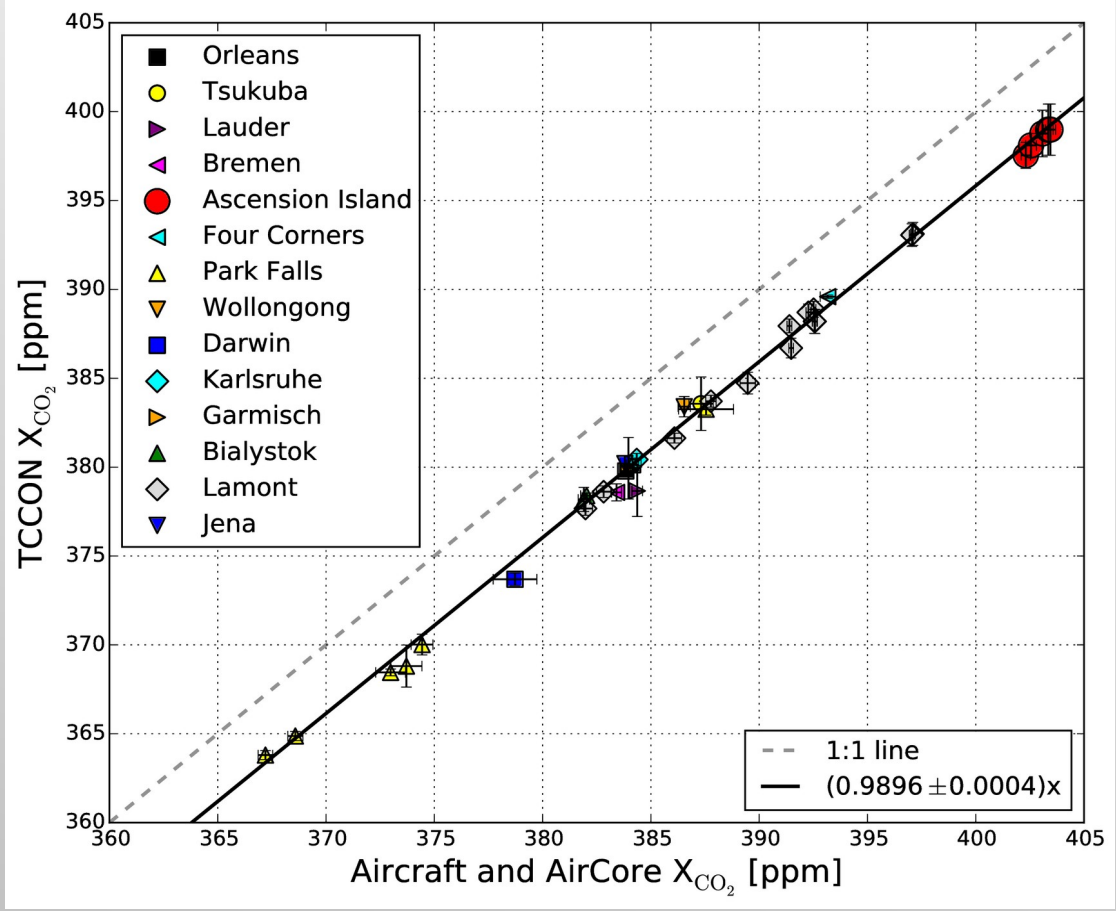
NASA ATom. DC-8



profile measurement flight patterns

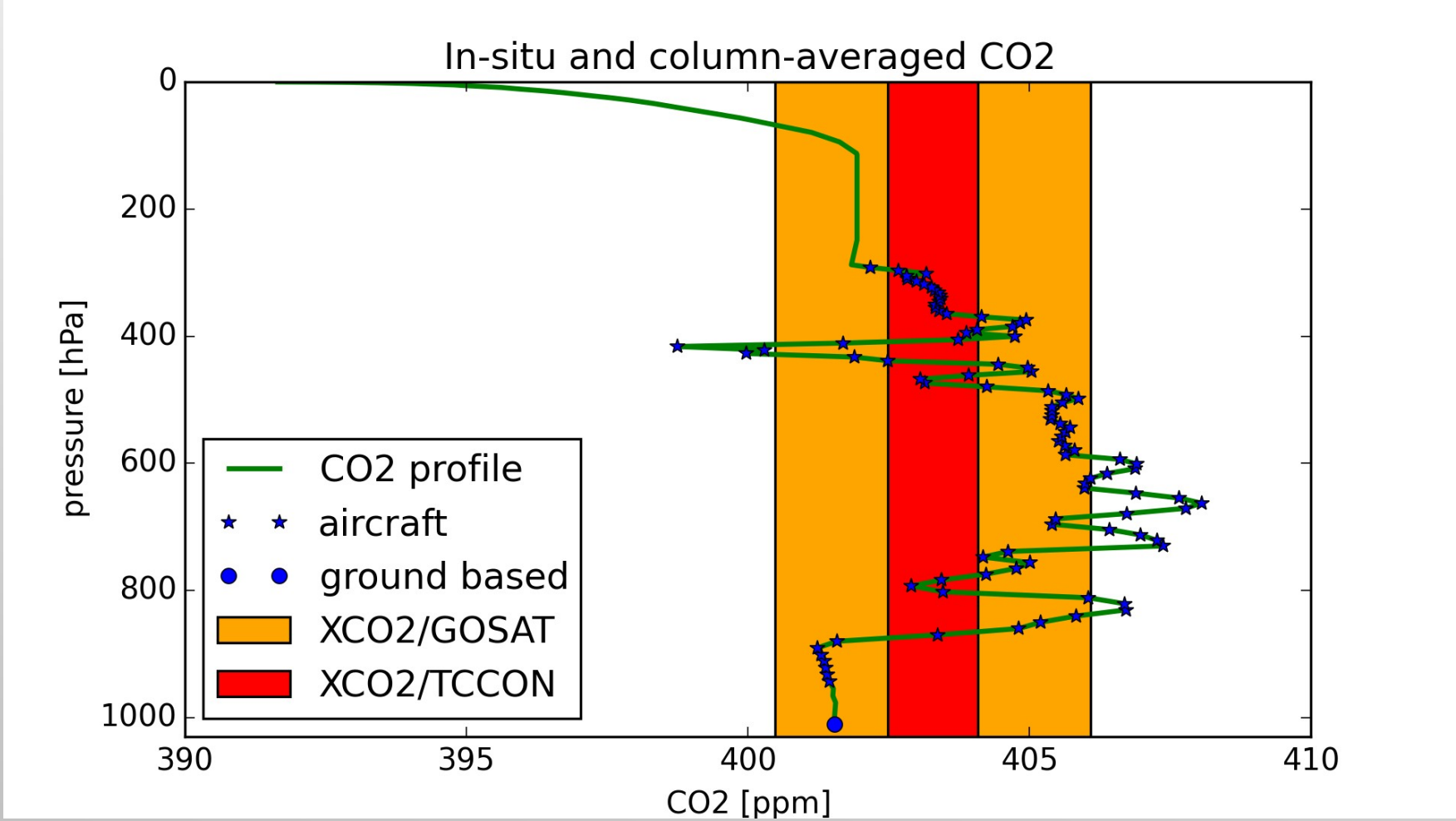
Aircraft measurements: in-situ CO2 profiles near stations from 300-12000 m (spiral) + dips during transfer flights

Total Carbon Column Observing Network (TCCON)



- TCCON stations are calibrated vs aircraft in-situ profiles
- Calibration provides network-wide scaling factor from spectroscopic scale to WMO in-situ scale
- Very consistent over many years and different continents
- TCCON provides link between in-situ networks and satellites

Column-averaged vs in-situ observations



Closing the aircraft gap

- Aircraft profiles miss ~20-30% of the total column above maximum and below minimum flight altitude.
- Precise CO2 instruments are too heavy for ballon observations.
- Solution: take an air sample with a balloon and analyze it on the ground.
- Challenge: Need to recover the payload in time.

AirCore principle

• Long (over 100m) stainless steel tube treated with Suflinert® coating to avoid interactions with gas

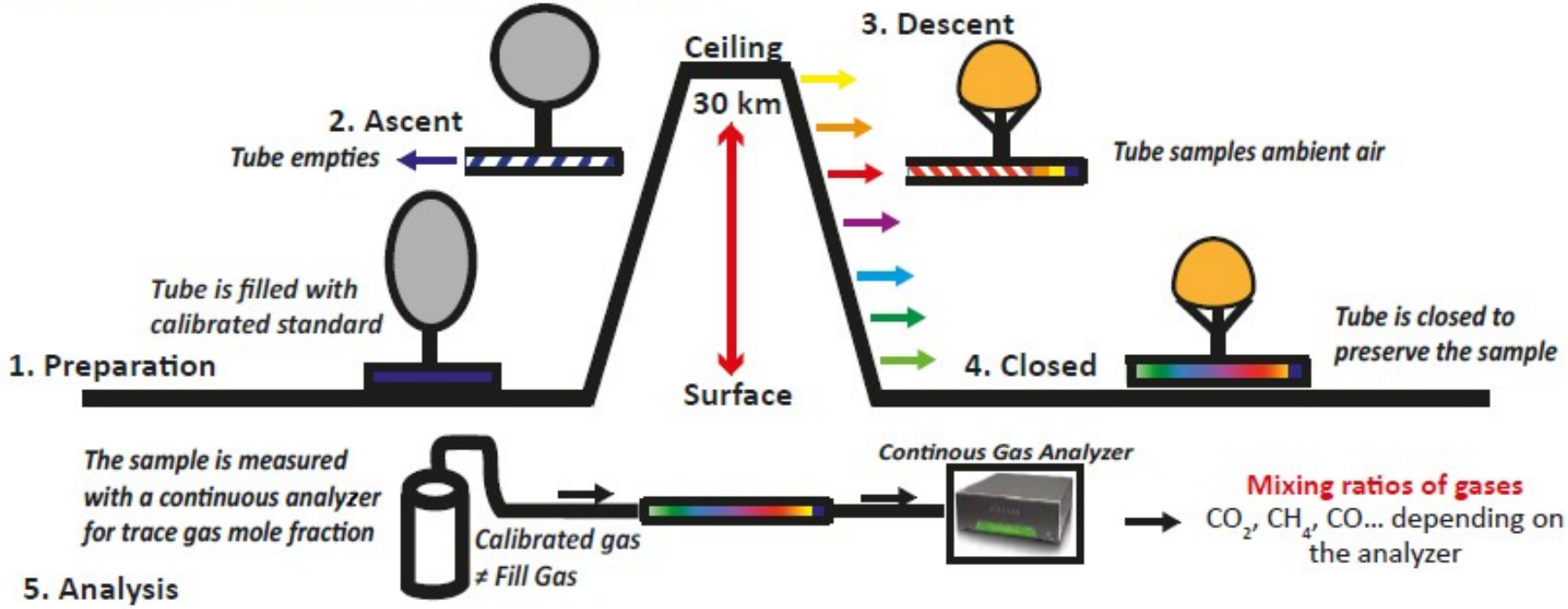
+

electronic data

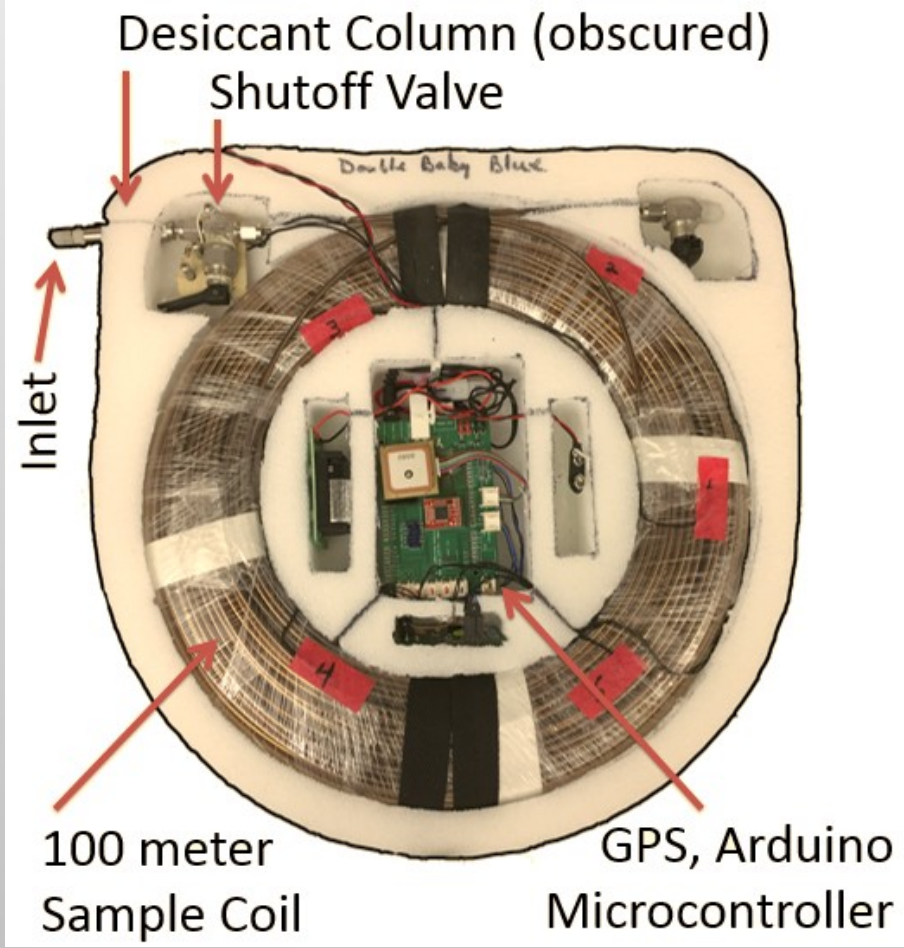
Required flight parameters:

- Ambient Pressure
- Ambient T, Coil Temperature
- GPS data…

The AirCore principle in 5 easy steps

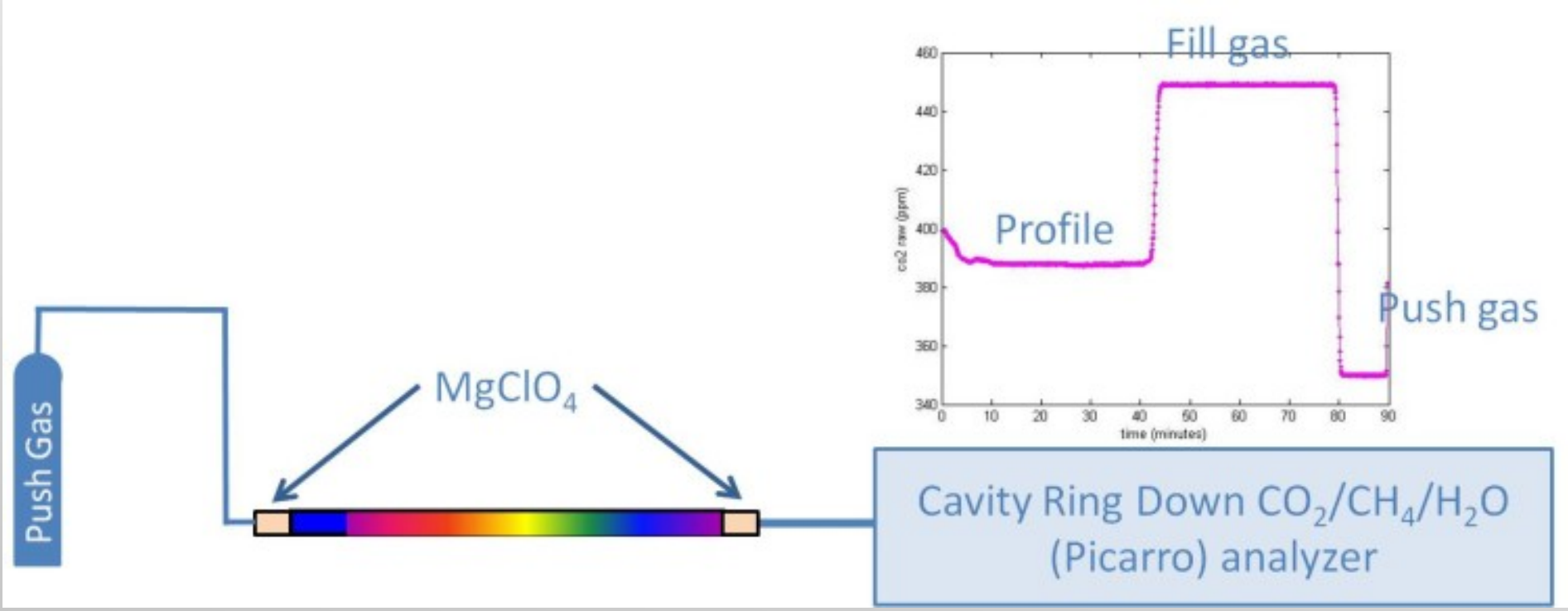


AirCore instrument design



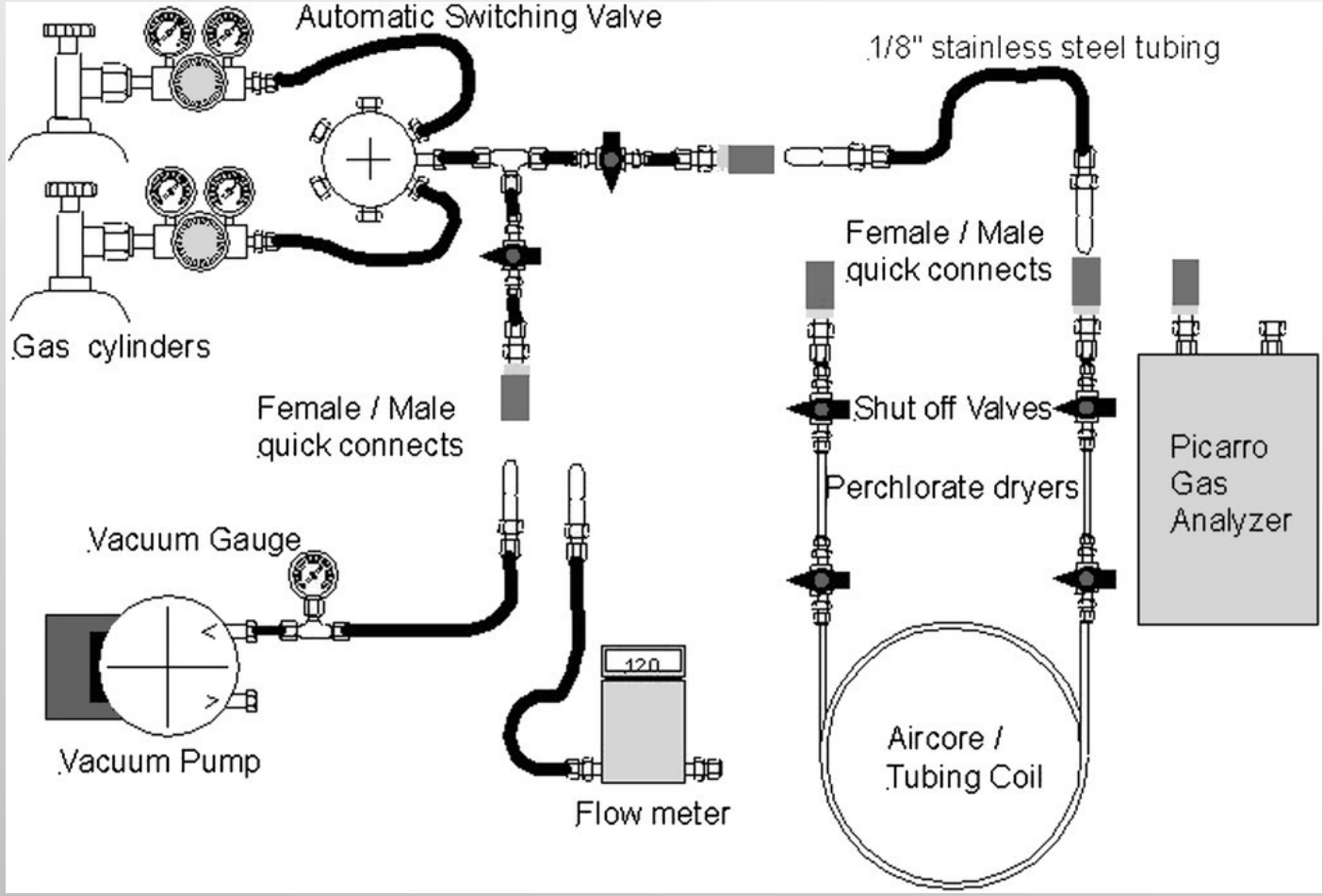
- Original AirCore design developed by CIRES, NOAA/ESRL and CUNY in 2010.
- Karion, Anna, Colm Sweeney, Pieter Tans, and Timothy Newberger. " AirCore: An Innovative Atmospheric Sampling System", Journal of Atmospheric and Oceanic Technology 27, 11 (2010): 1839-1853 https://doi.org/10.1175/2010JTECHA1448.1

Post-flight analysis on the ground



AirCore sampling coil

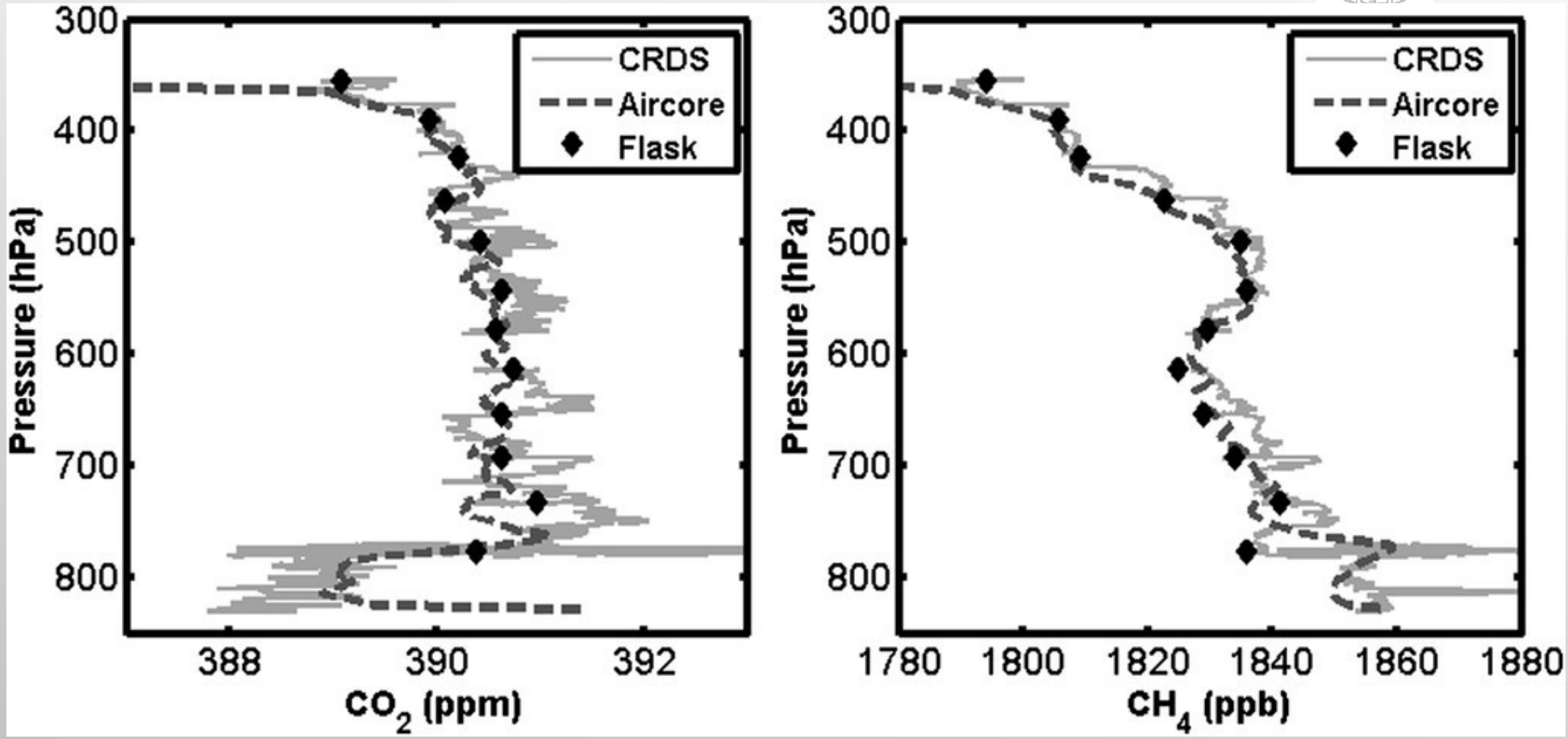
AirCore lab testing and calibration equipment



From:

Karion, Anna, Colm Sweeney, Pieter Tans, and Timothy Newberger. " AirCore: An Innovative Atmospheric Sampling System", Journal of Atmospheric and Oceanic Technology 27, 11 (2010): 1839-1853 https://doi.org/10.1175/2010JTECHA1448.1

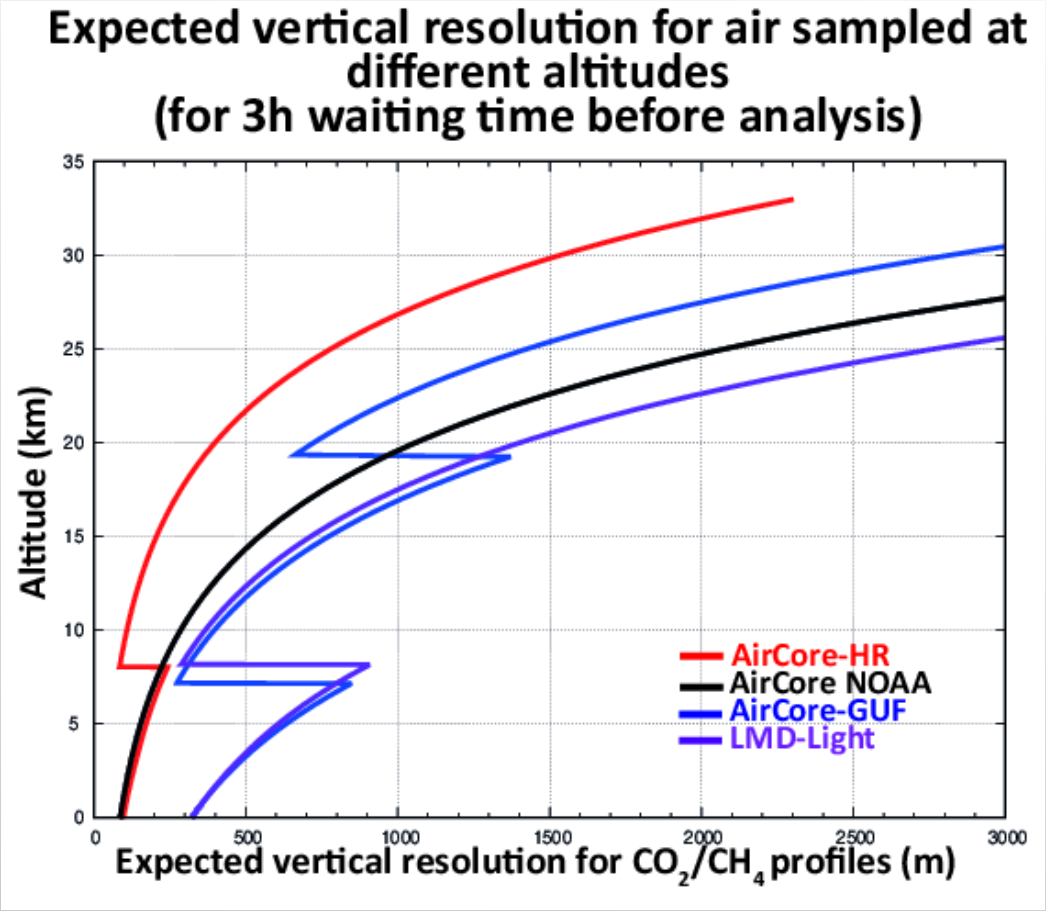
AirCore profiles (original system)



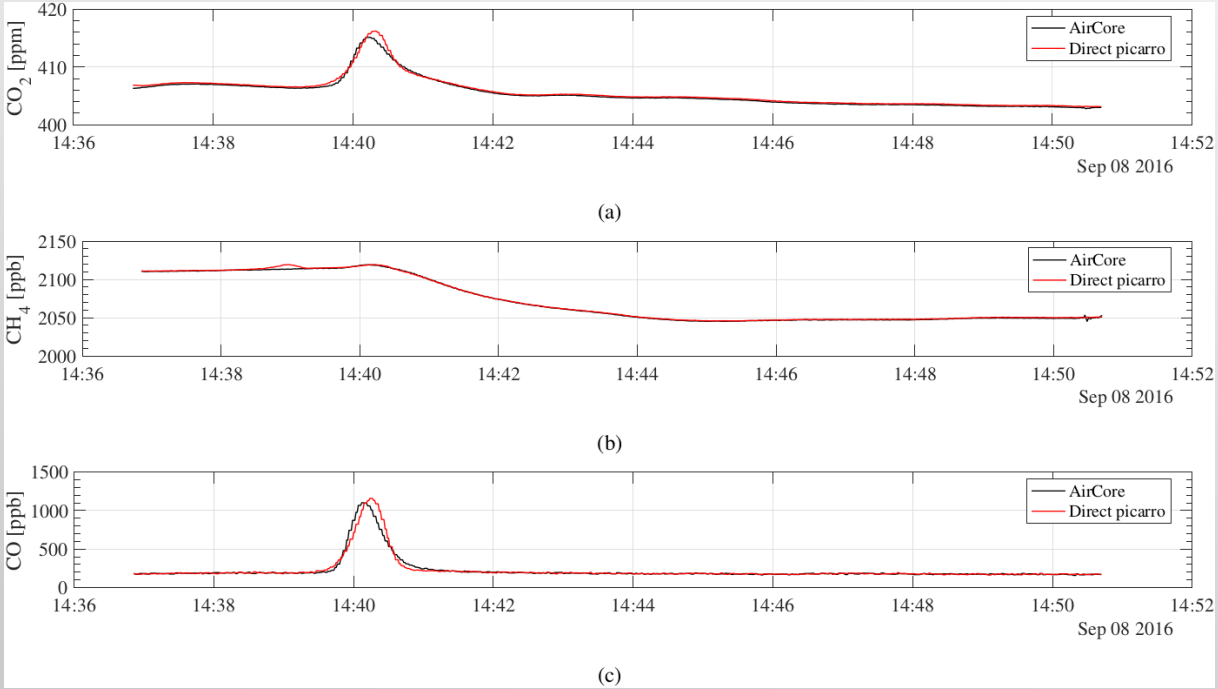
From: Karion et al. 2010

AirCore developments: lightweight instruments and optimized altitude resolution

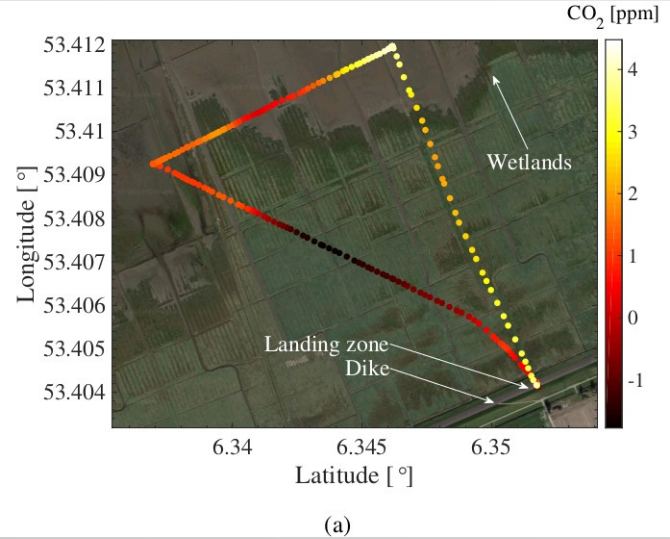
AirCore Light



UAV based AirCore system by Univ. Groningen



Andersen et al. Atmos. Meas. Tech., 11, 2683–2699, 2018 https://doi.org/10.5194/amt-11-2683-2018



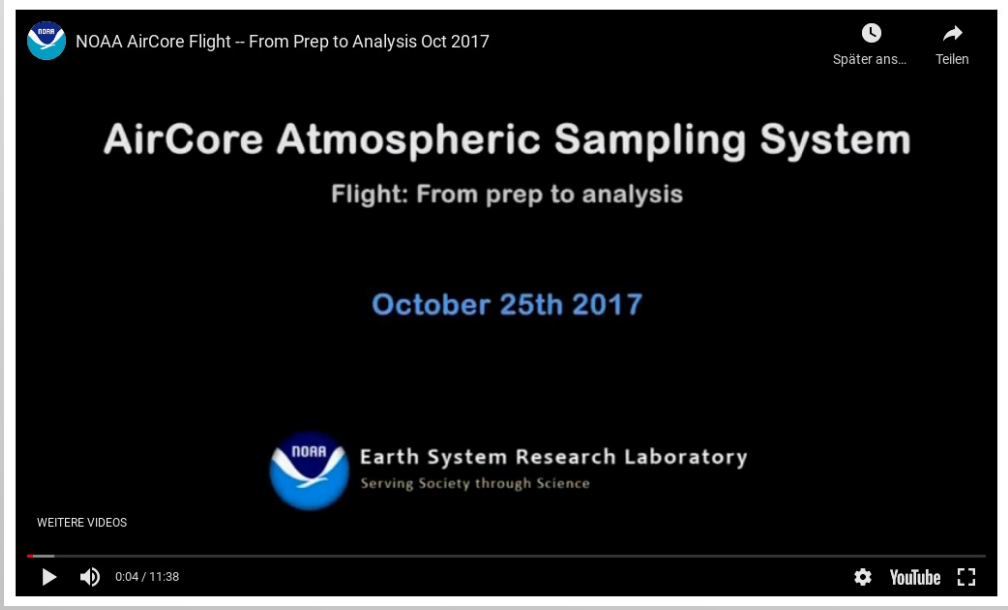
Direct comparison with Picarro analyzer.

Conclusions

- Aircraft in-situ observations that are used for the cal/val of column-averaged satellite or ground remote sensing GHG observations can only cover about 70-80% of the column.
- AirCore has become a very valuable and versatile platform to collect samples of atmospheric CO2 and CH4 profiles for the whole column.
- Current improvemens of the AirCore system target smaller balloons as well as other platforms like small aircraft and UAVs. There are also developments towards higher vertical resolution (mainly on larger balloon platforms).
- The instrument needs to be recovered for analysis.
- Due to ATC regulations and the need for recovery, AirCore are optimal for regions with little air traffic, flat topography, low population density and far from the coast.

Further contacts and information

- USA: NOAA/ESRL (Colm Sweeney)
- Europe: Univ. Groningen NL (Huilin Chen), FMI Sodankylä (Rigel Kivi)



https://youtu.be/B11uWltqwFQ