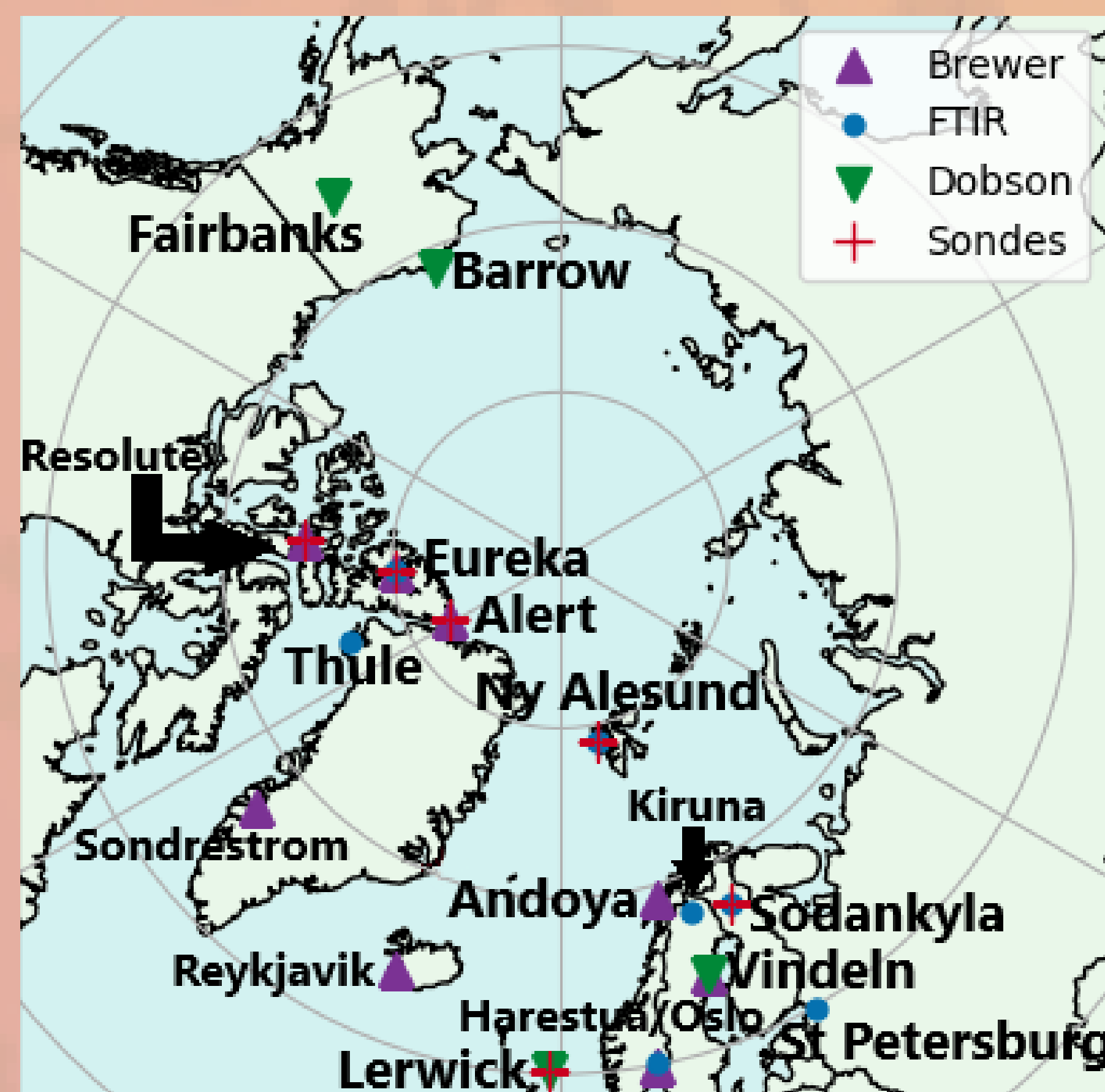


I. Context

- **1985**: Ozone hole discovered above the Antarctic
- **1987**: Montreal protocol bans CFCs production
- **2000 -** : expected debut recovery of the ozone layer
- **since 2015**: observed recovery above Antarctic in Springtime & mid-latitude

But in the Arctic: large natural uncertainties & small trends

II. Ground-based network



FTIR:

- **Total column + 4 partial columns**
- **0-45 km**

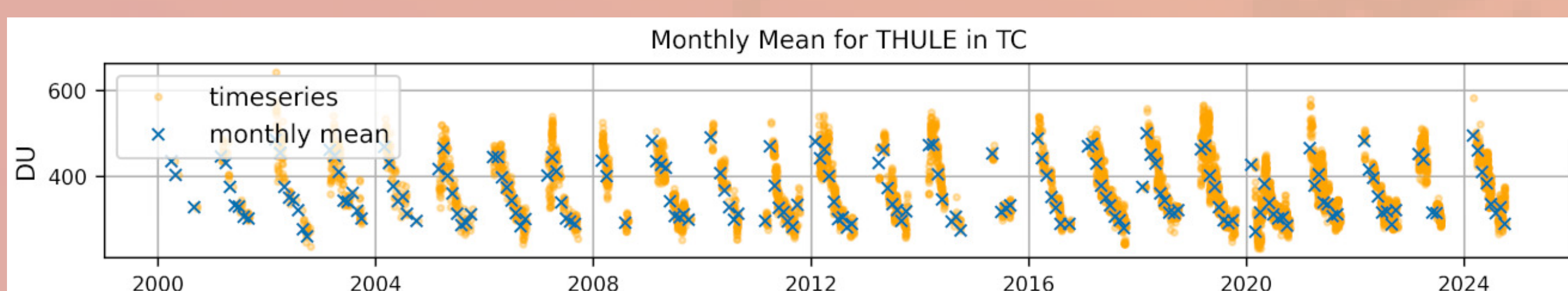
Sondes:

- **High vertical resolution profiles**
- **0-30 km**

Brewer/Dobson:

- **Only total column**

- 2000 - 2024 timeseries for 16 stations in 60° - 90° N
- Merging of datasets (anomalies) to **reduce uncertainties**



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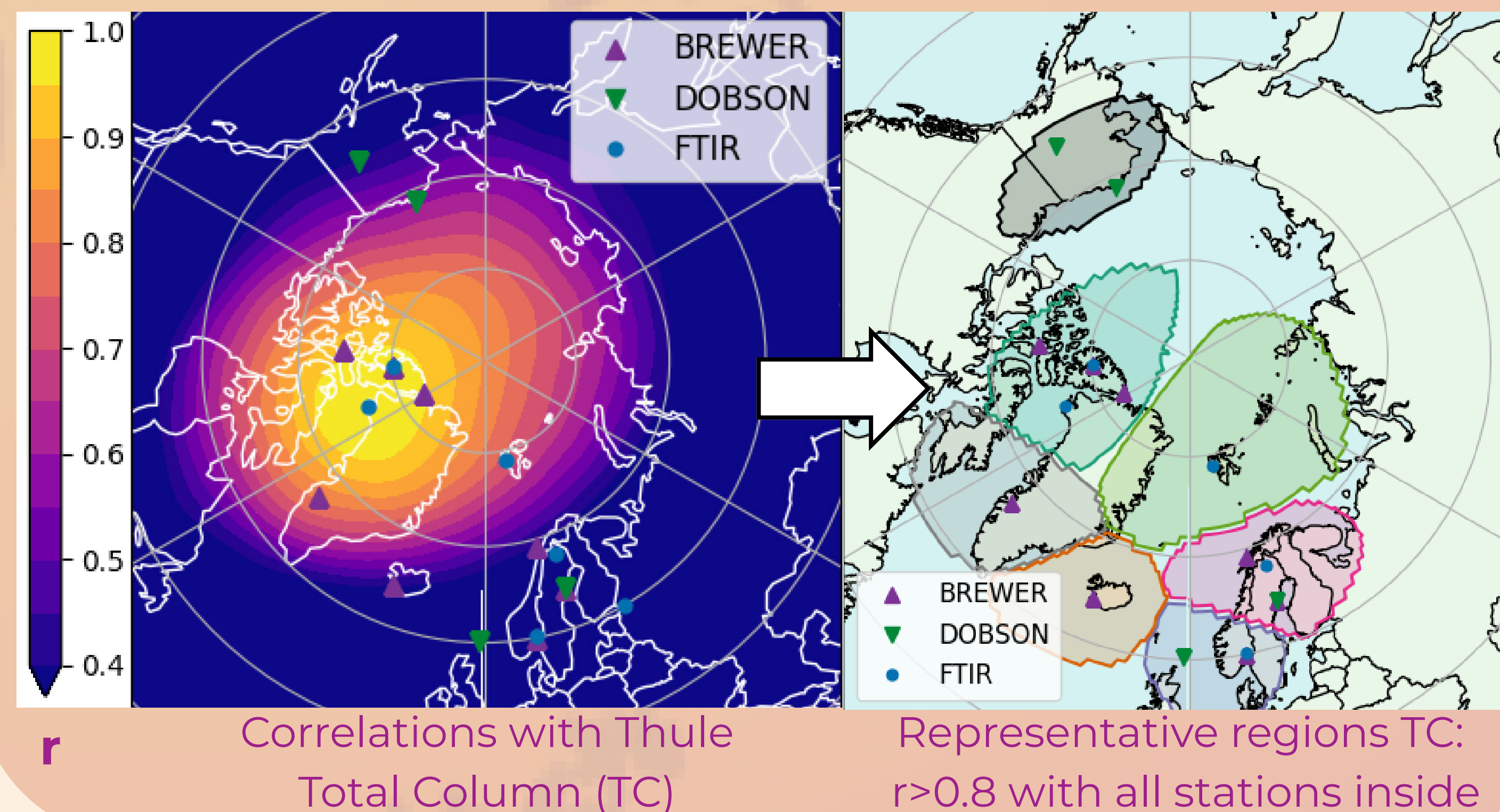
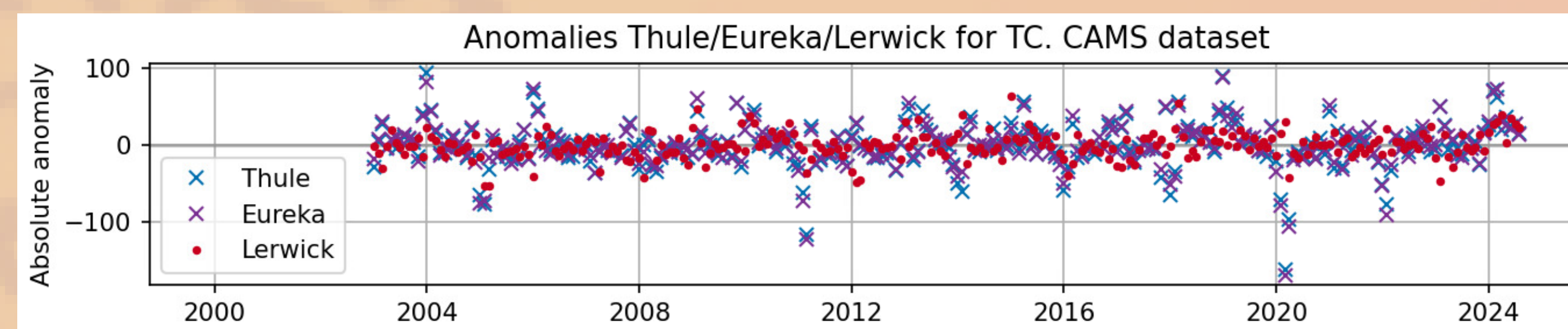
*corresponding author: caroline.jonas@aeronomie.be

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III. Representativeness of ground-based datasets

- Based on CAMS Re-analysis data
- Monthly mean ozone profiles 2003-2024
- We calculate the **Pearson coefficient r** of correlations between **deseasonalised anomalies**:

$$a_{\text{month}_j, \text{year}_i} = O_3^{\text{month}_j, \text{year}_i} - O_3^{\text{mean month}_j}$$



IV. Trend detection: Multiple Linear Regression

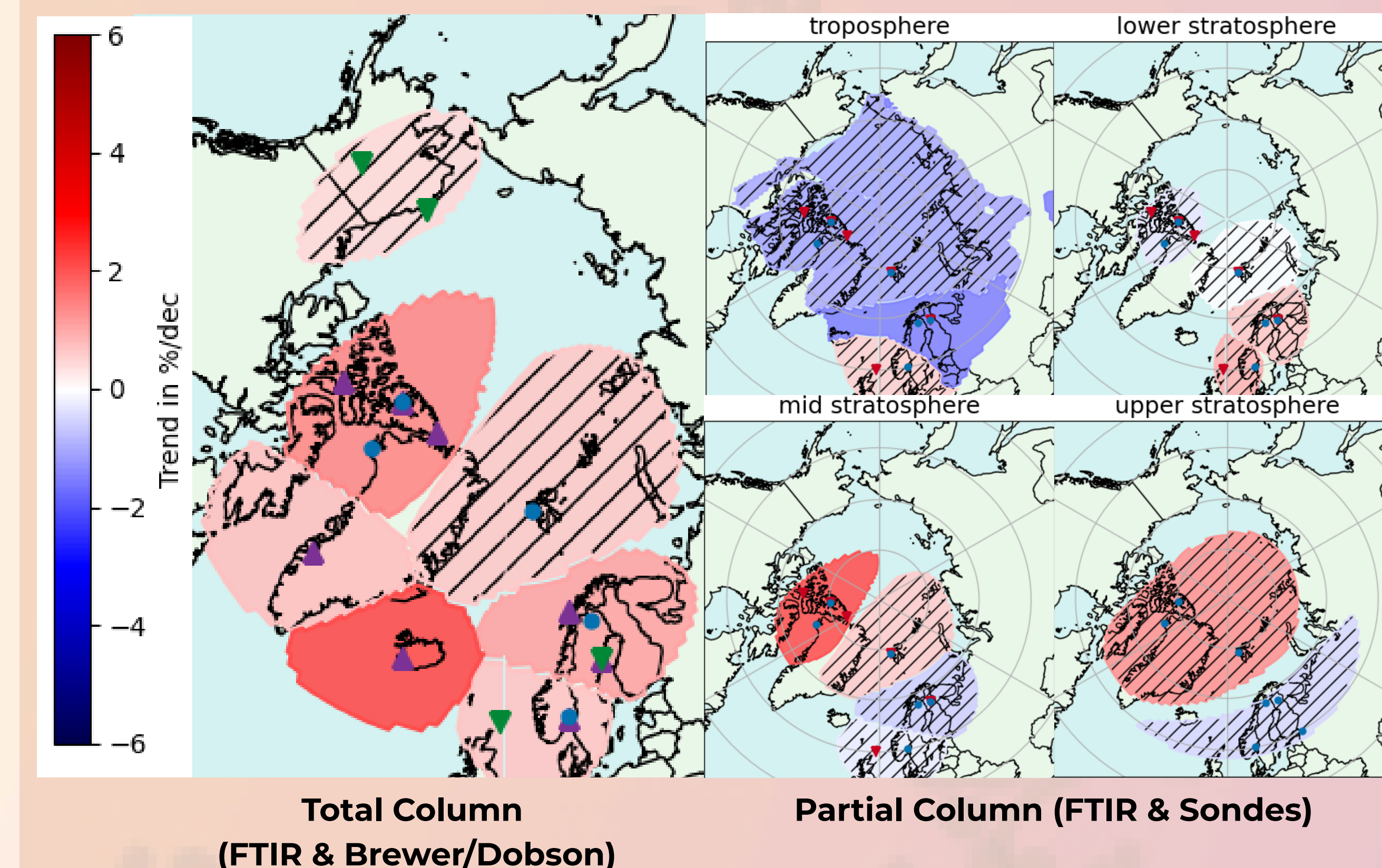
- **Reduce uncertainties** and **explain variability** using **proxies**

$$a(t) = A_1 + A_2 \cdot t + \sum_{n=3}^m A_n \cdot X_n(t) + \varepsilon(t)$$

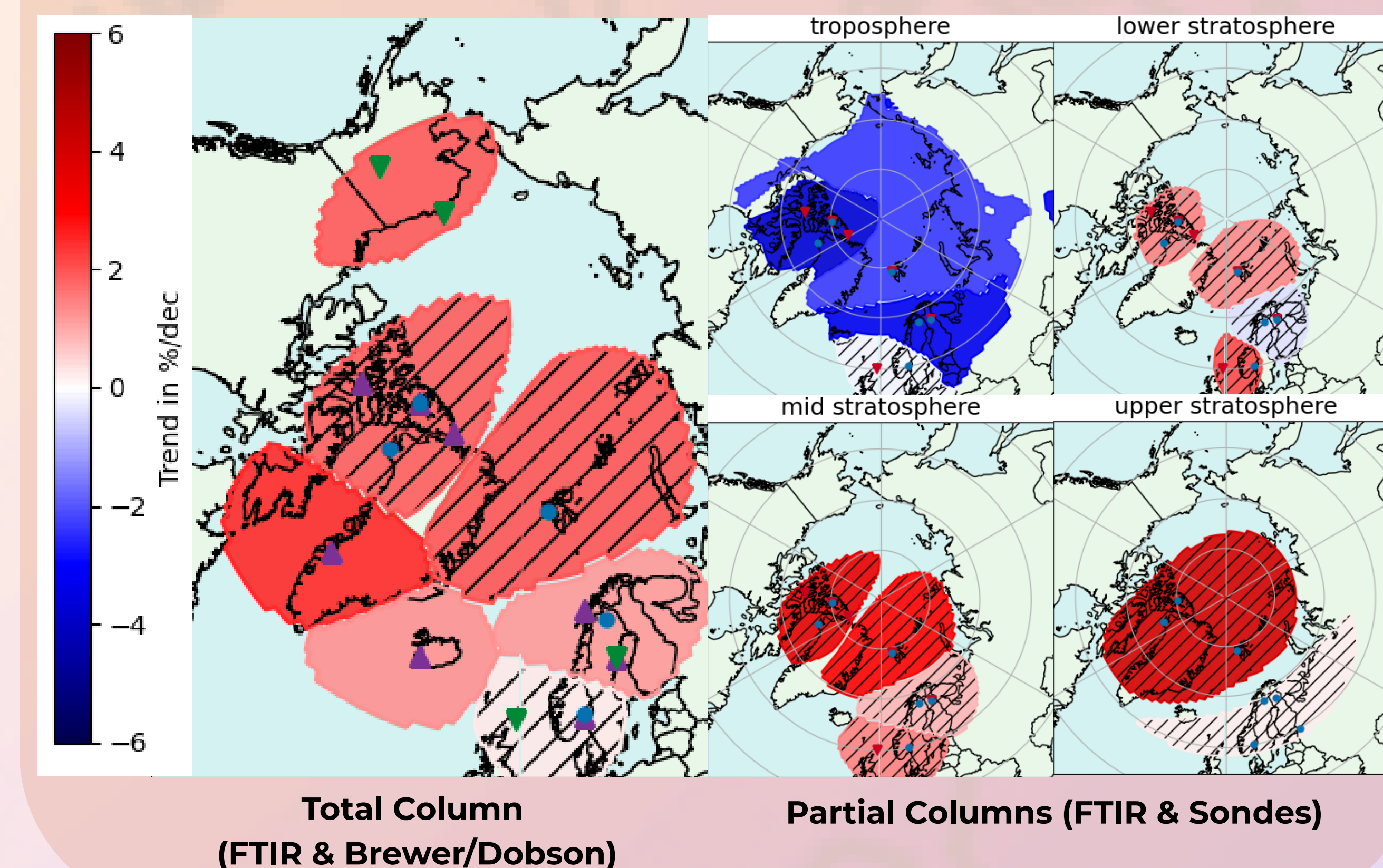
11-year solar cycle: Bremen composite Mg II index; **QBO**: Singapore windspeed at 30 and 10hPa; **ENSO**: Multivariate ENSO Index; **AO**: Arctic Oscillation Index;
BDC: Eliassen-Palm Flux at 100hPa; **VPSC**: Volume of Polar Stratospheric Clouds;
TP: Tropopause Pressure at each station location; **EL & T**: Equivalent Latitude & Temperature averaged over each stratospheric partial columns (ERA5).

V. Trend Results

Yearly trends



Spring trends



Take home message

Yes, we can detect ozone recovery with ground-based detectors in the Arctic:

- Merging reduces natural uncertainties
- **Positive regional trends** for the total column (significant) and for stratospheric columns
- **Zonal asymmetry** in mid and upper stratosphere
- **Negative trends (significant in Spring)** in troposphere