Stratospheric HCl increasing again, caused by dynamic variability, driven by increased tropospheric wave activity

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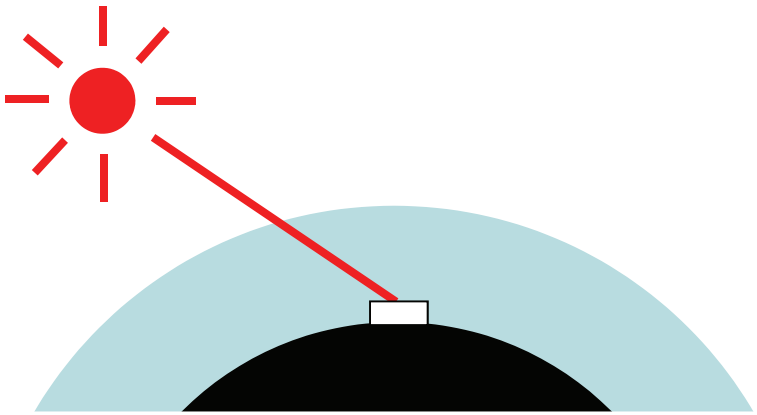
University of Bremen

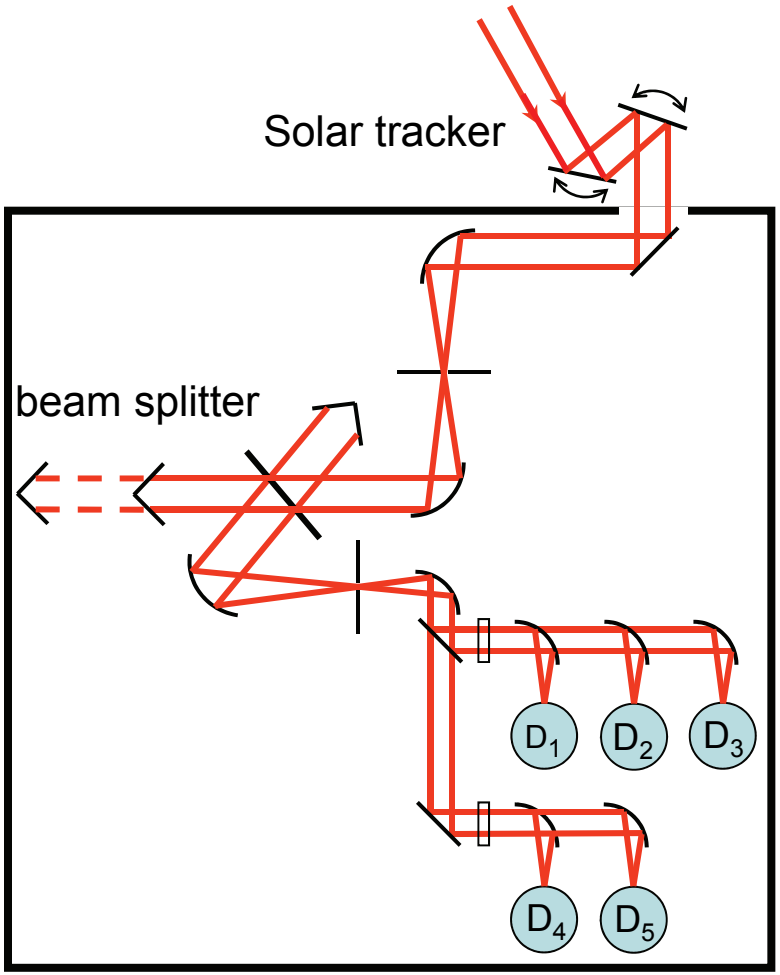
Institute of Environmental Physics

Ground based remote sensing in the infrared spectral region



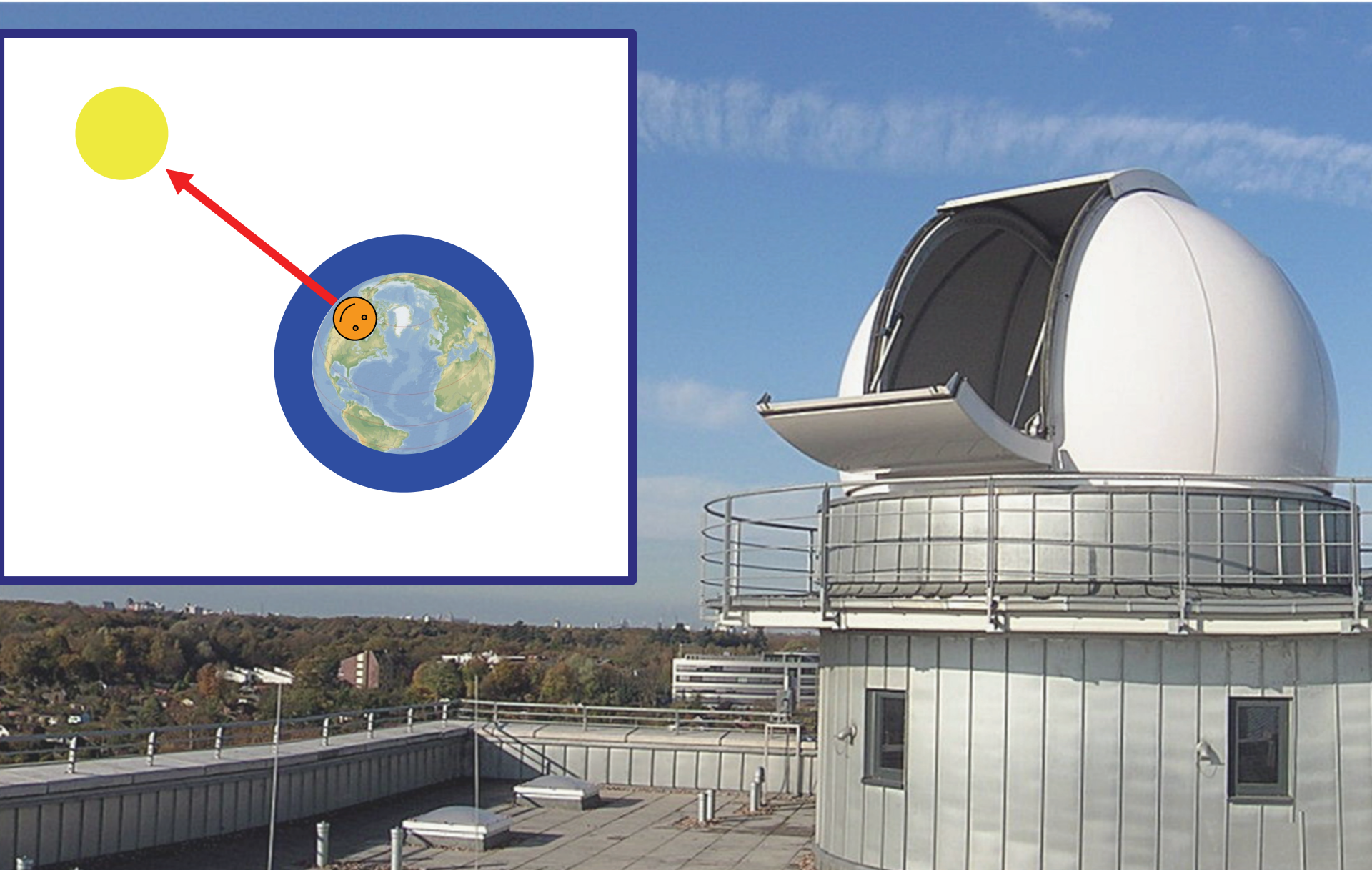
interferogram ⟷ (FT) spectrum

FTIR spectroscopy

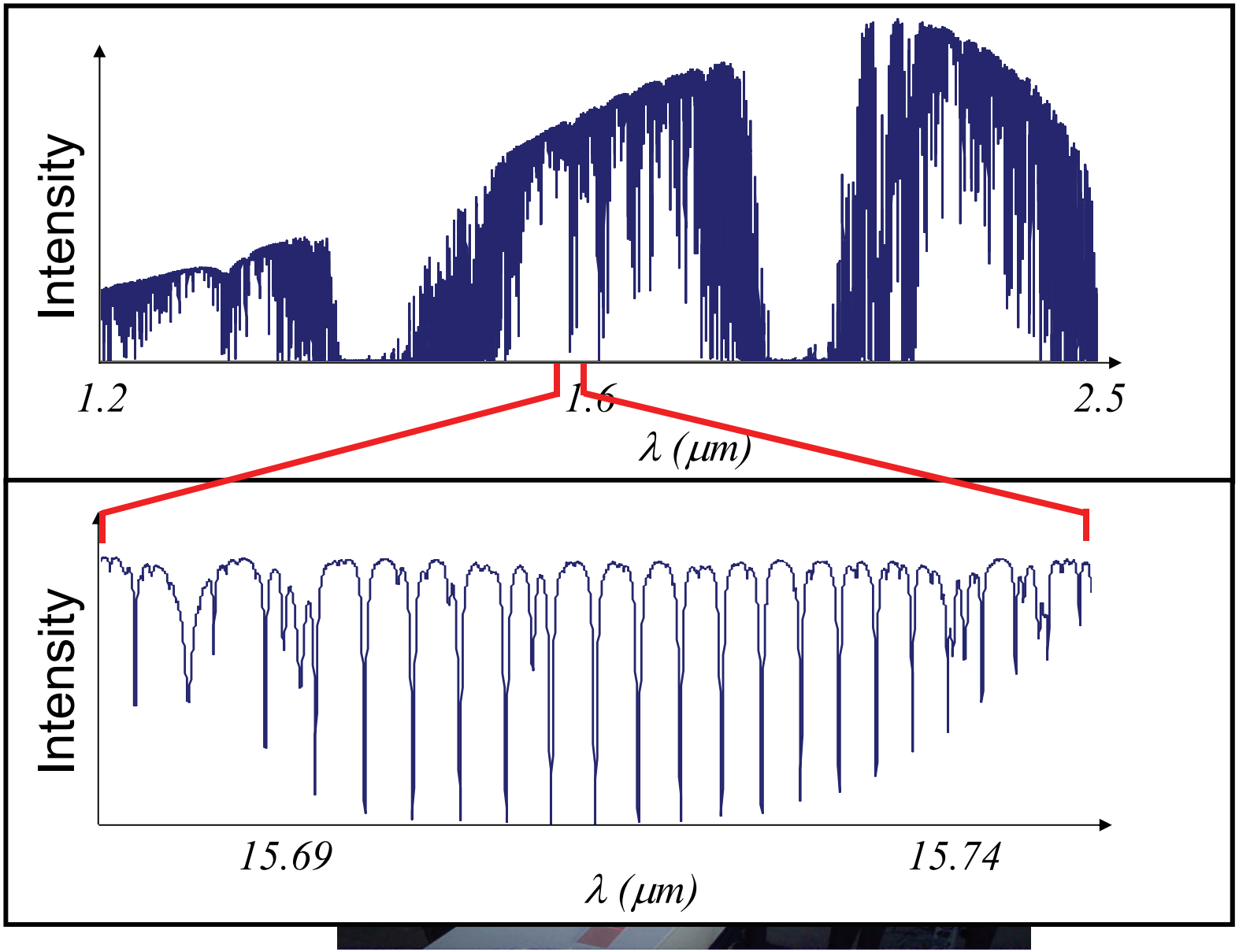


NDACC: Network for Detection of Atmospheric Composition Change
HCl, O_3, HCl, $ClONO_2$, HF, HNO_3, NO_2, CH_2O, C_2H_6, OCS, HCN, H_2O
TCCON: Total Carbon Column Observing Network
CO_2, CH_4, N_2O

Ground-based observations by the IUP



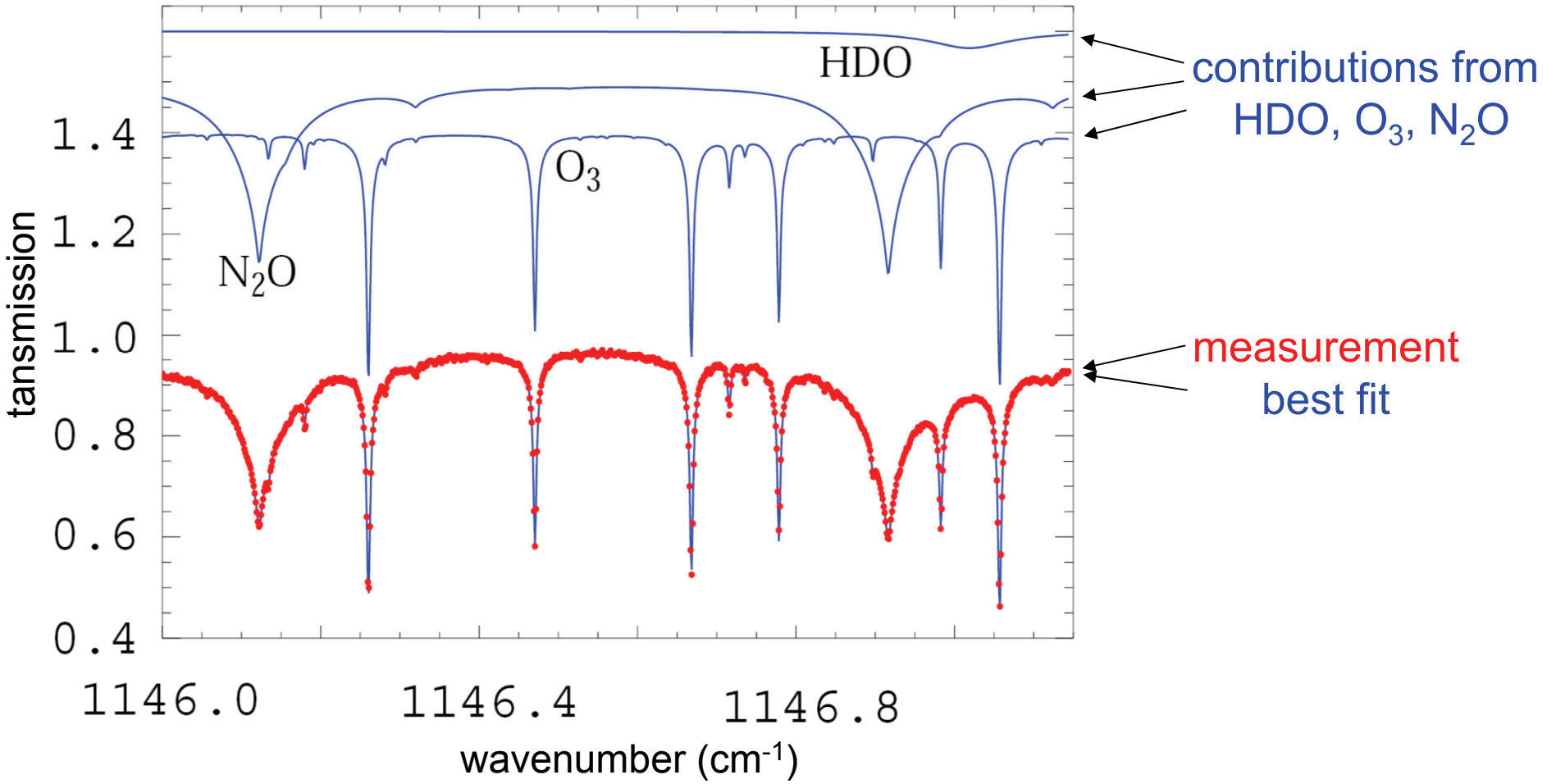
Measurements in the infrared spectral region



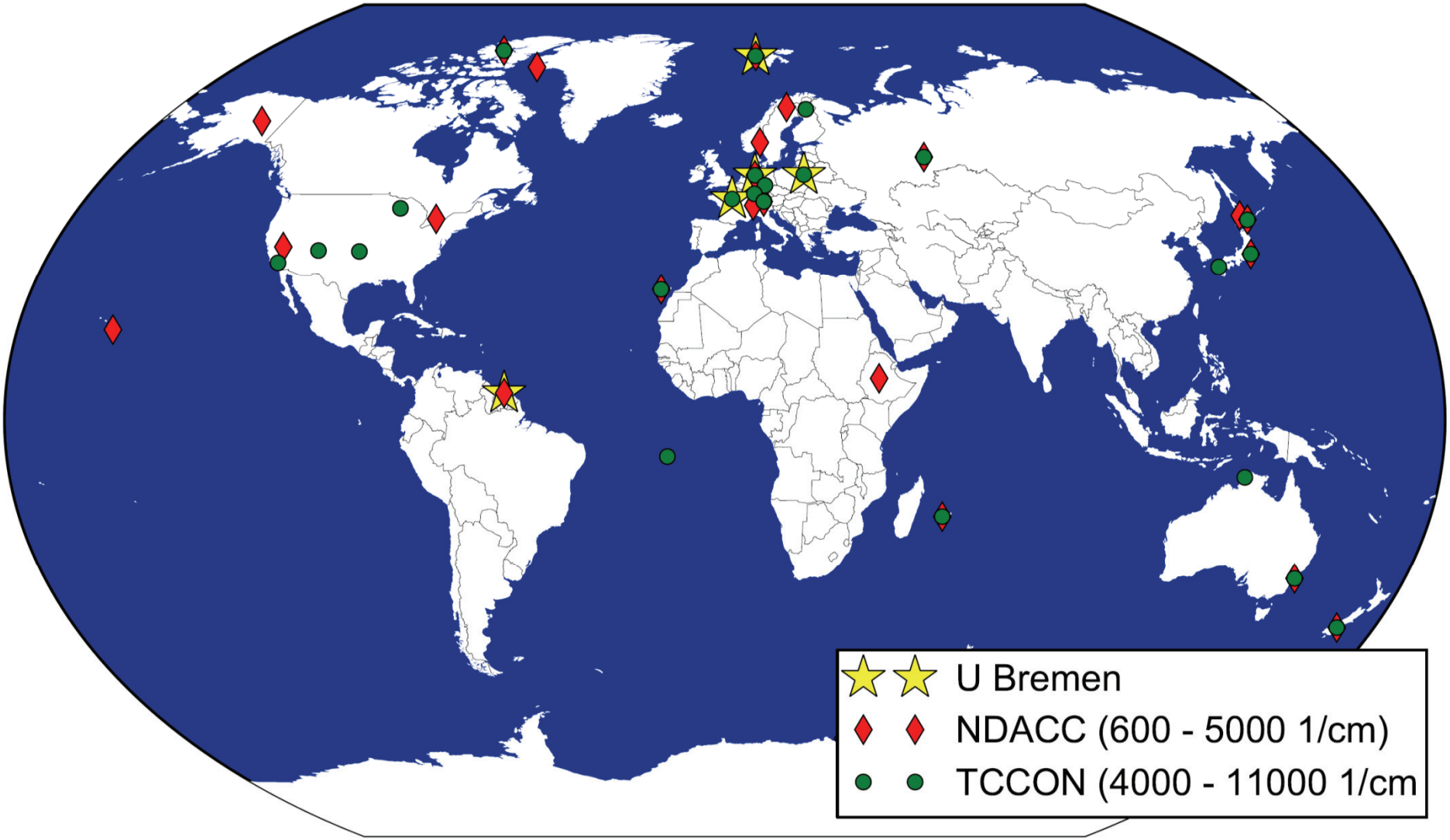
Retrieval of trace gas concentrations (total columns)

- calculate a spectrum (assumption on concentration profiles)
- residuals = measurement – simulation
- modification of assumed concentration profiles
- minimize residuals (least square method)

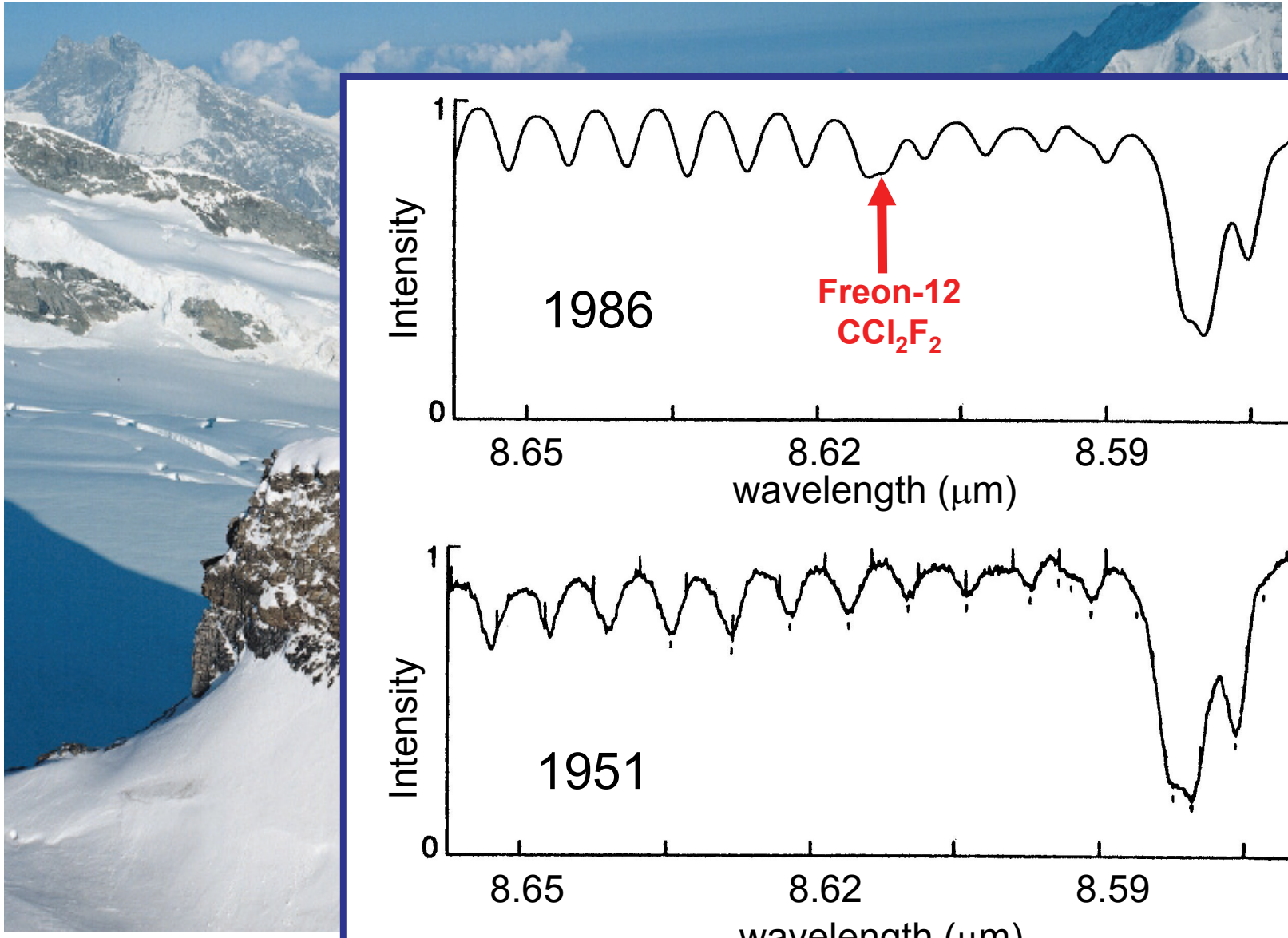
$\Rightarrow$ best fit, result for column or concentration profile



NDACC: Network for Detection of Atmospheric Composition Change
TCCON: Total Carbon Column observing Network

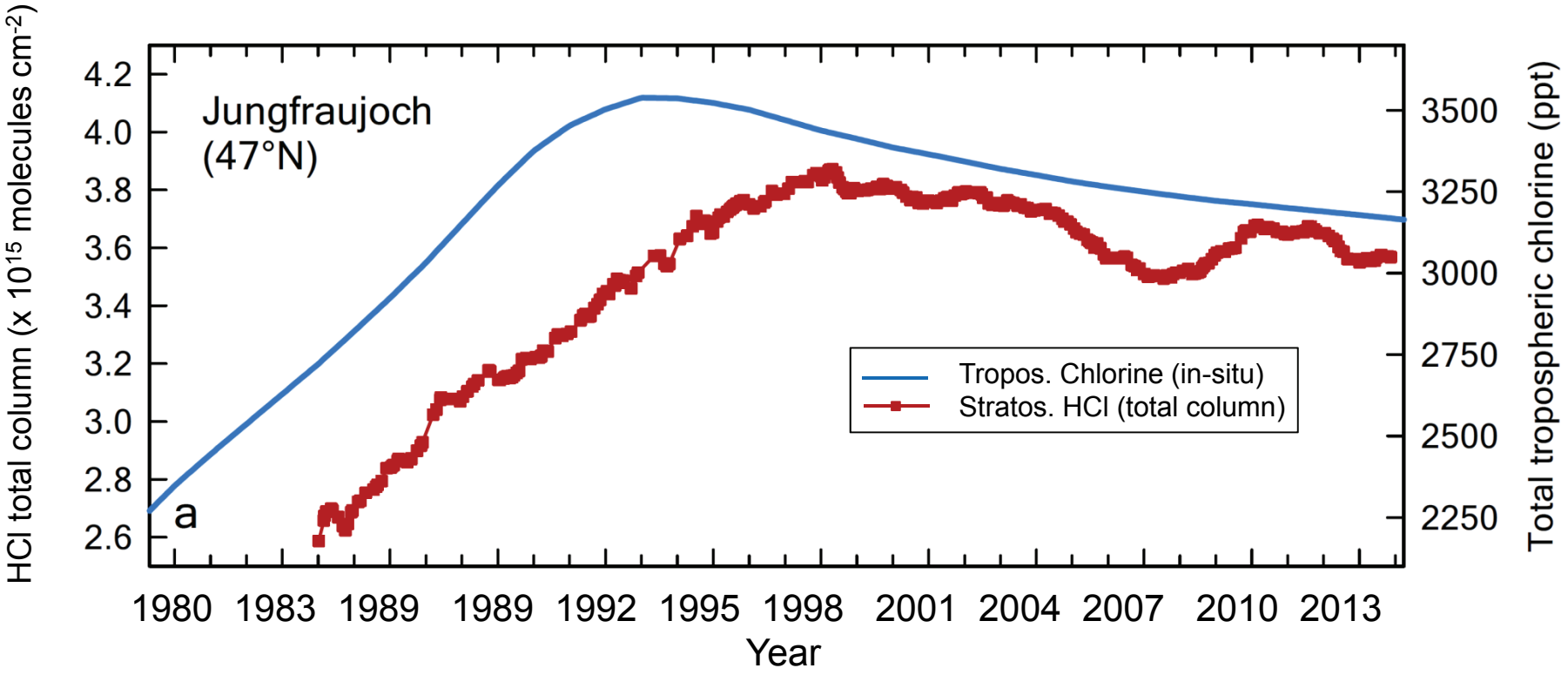


Jungfraujoch, Switzerland (47°N, 3850 m)



Spitsbergen (79°N)

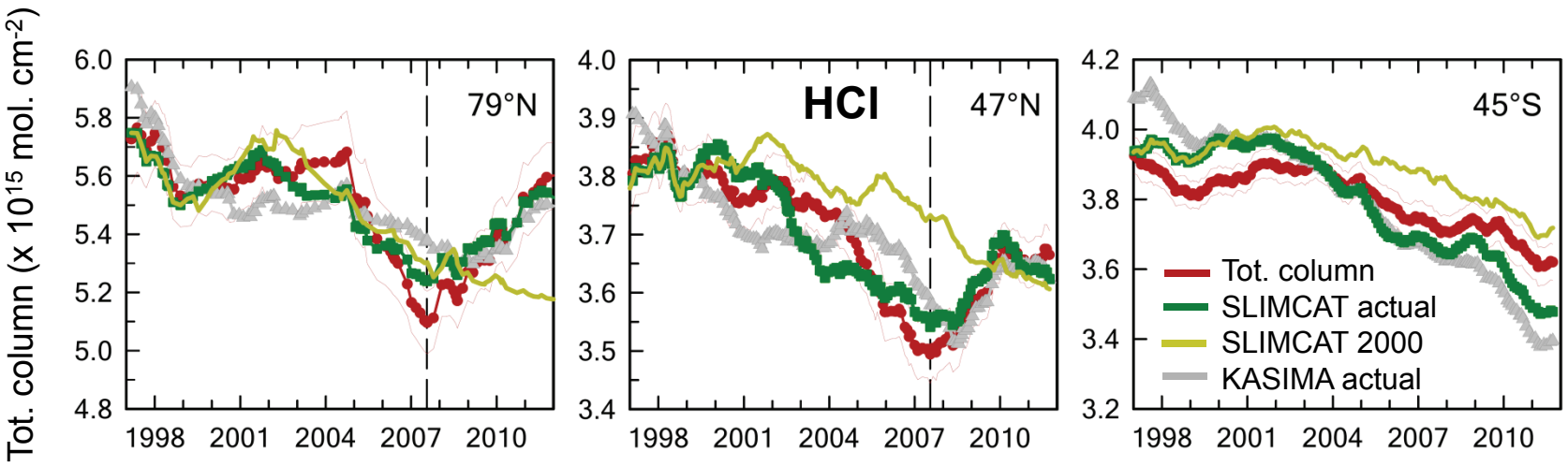
Evolution of HCl in the Earth's atmosphere



→ What is the reason for the HCl increase ?

→ Do we have to expect a new ozone hole ?

Comparison with models (SLIMCAT and KASIMA)

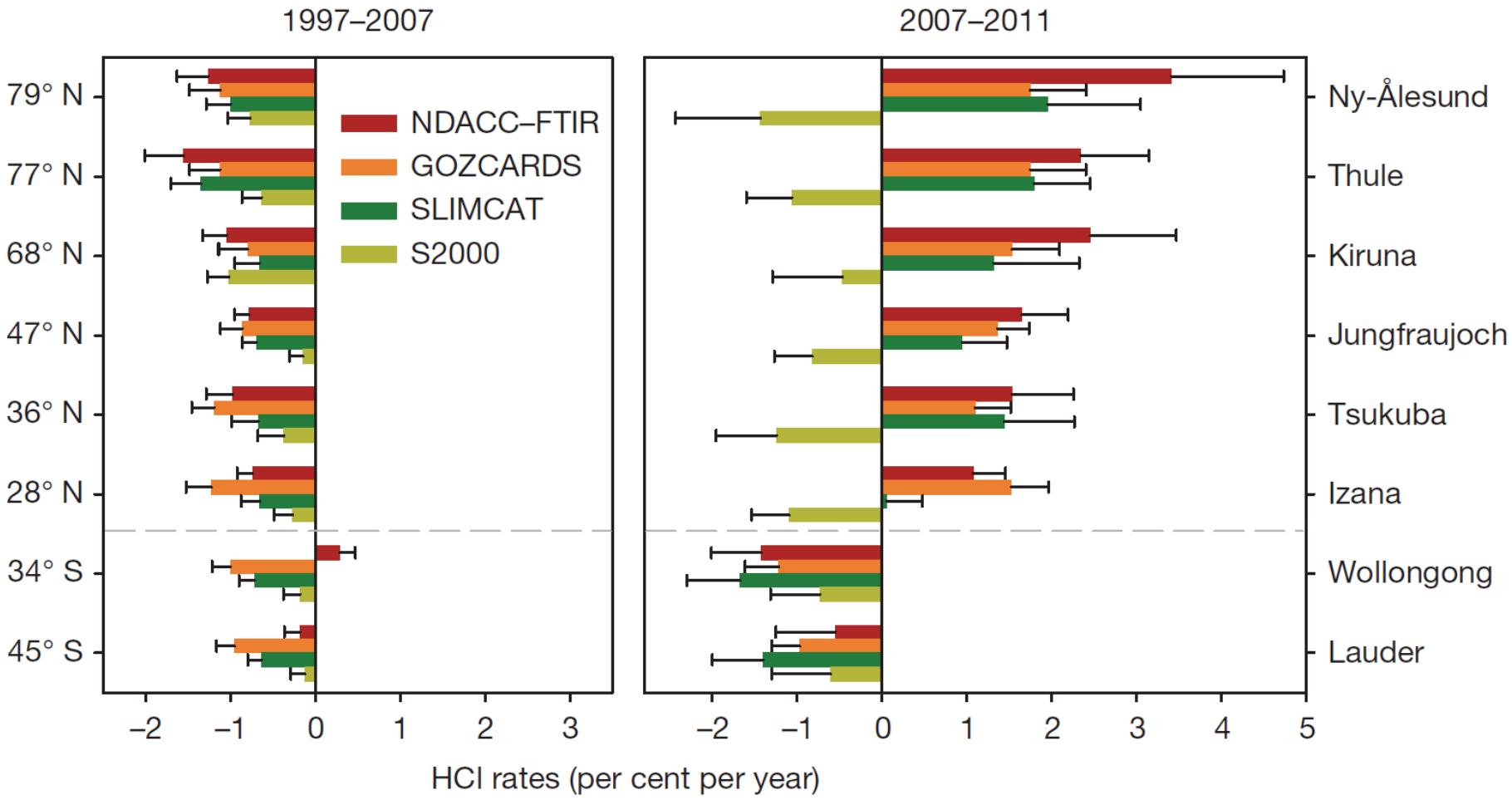


SLIMCAT and KASIMA: Chemical Transport Models

Source gas mixing ratios: WMO A1 emission scenario

Forcing: ERA-Interim meteorological fields from ECMWF

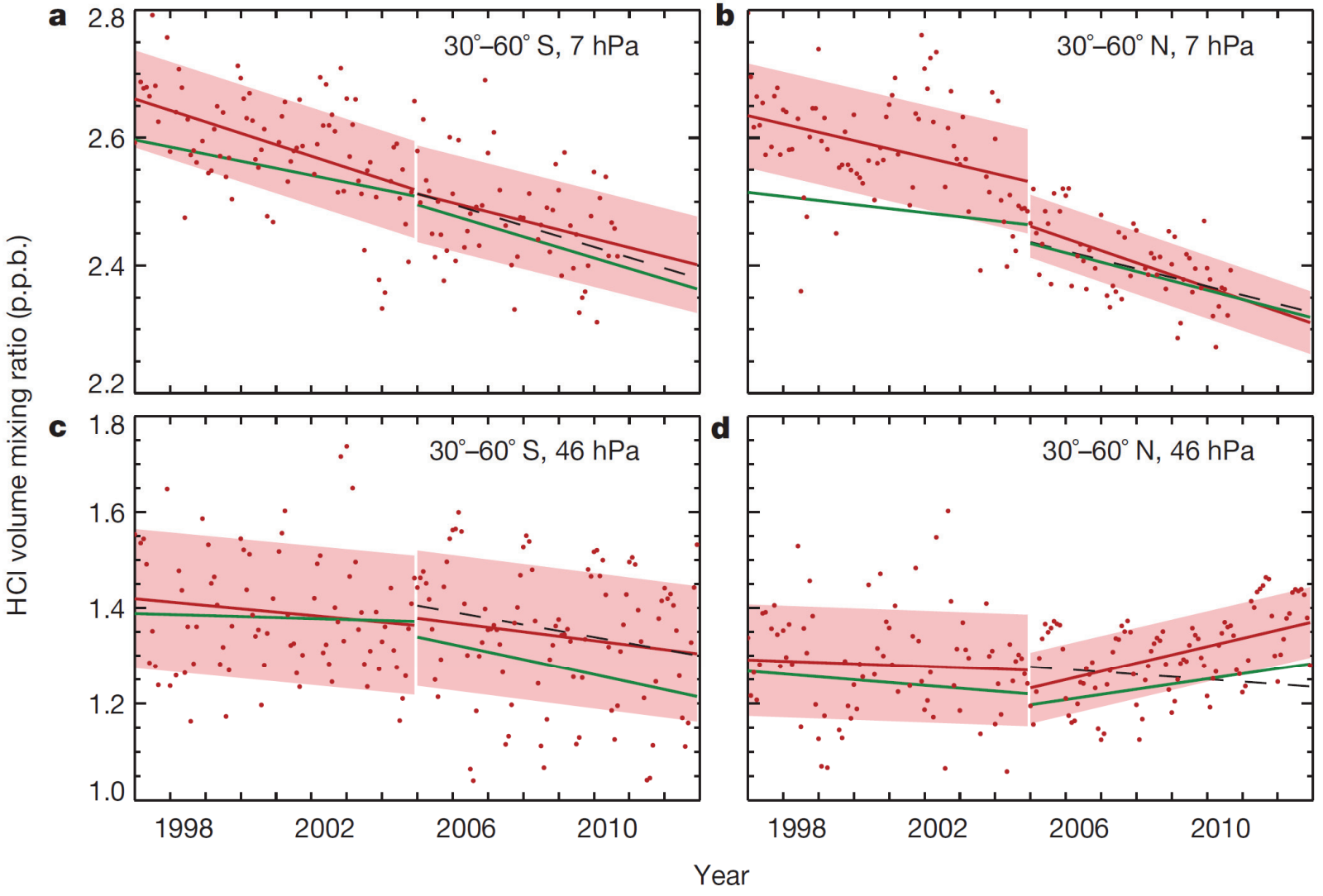
HCl relative rates of change for eight NDACC sites



GOZCARDS: Observations by HALOE (version 19), ACE/FTS (version 2.2), Aura/MLS

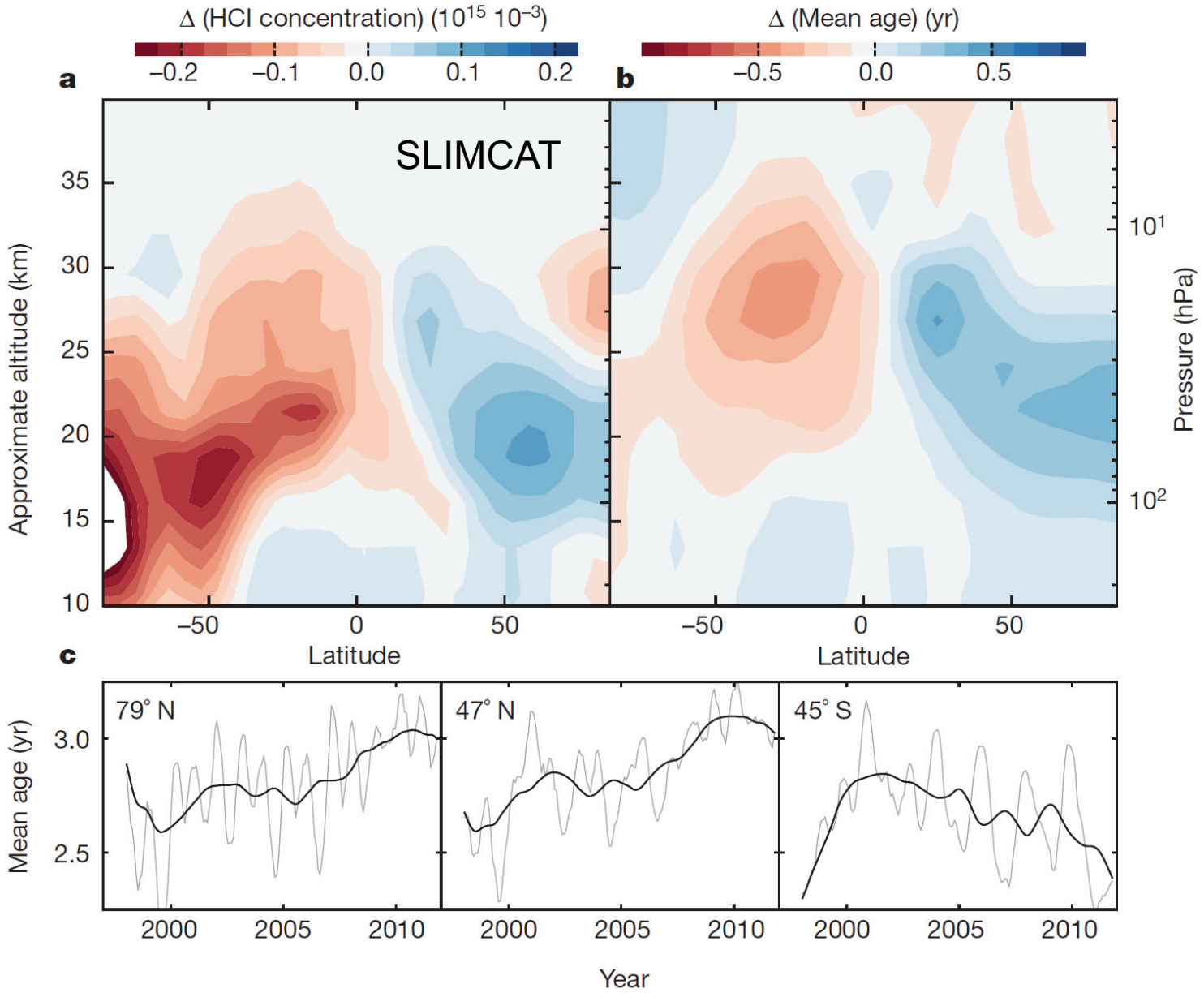
→ Observed in Northern Hemisphere since 2007

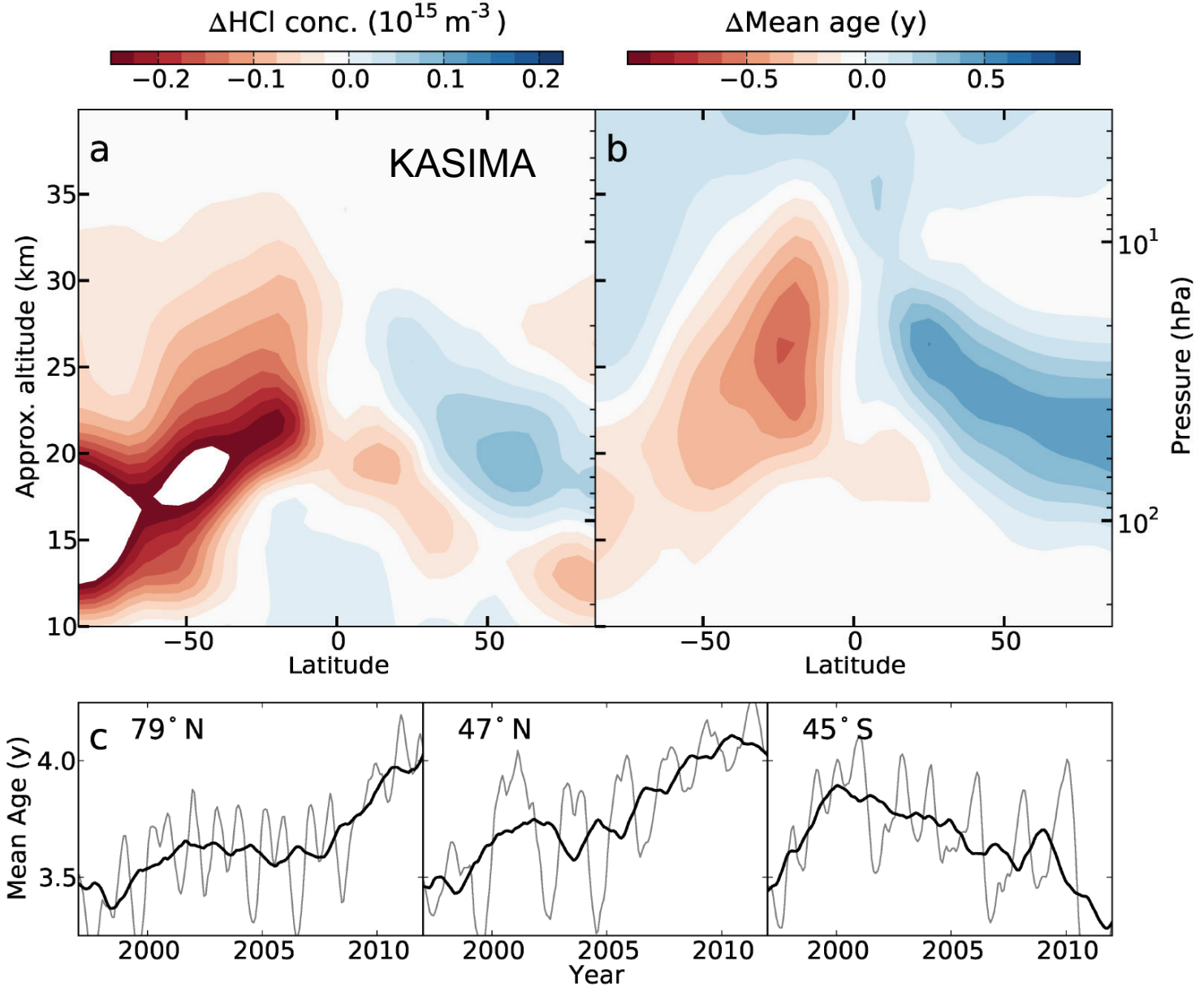
Evolution of stratospheric HCl from satellite observations (GOZCARDS)



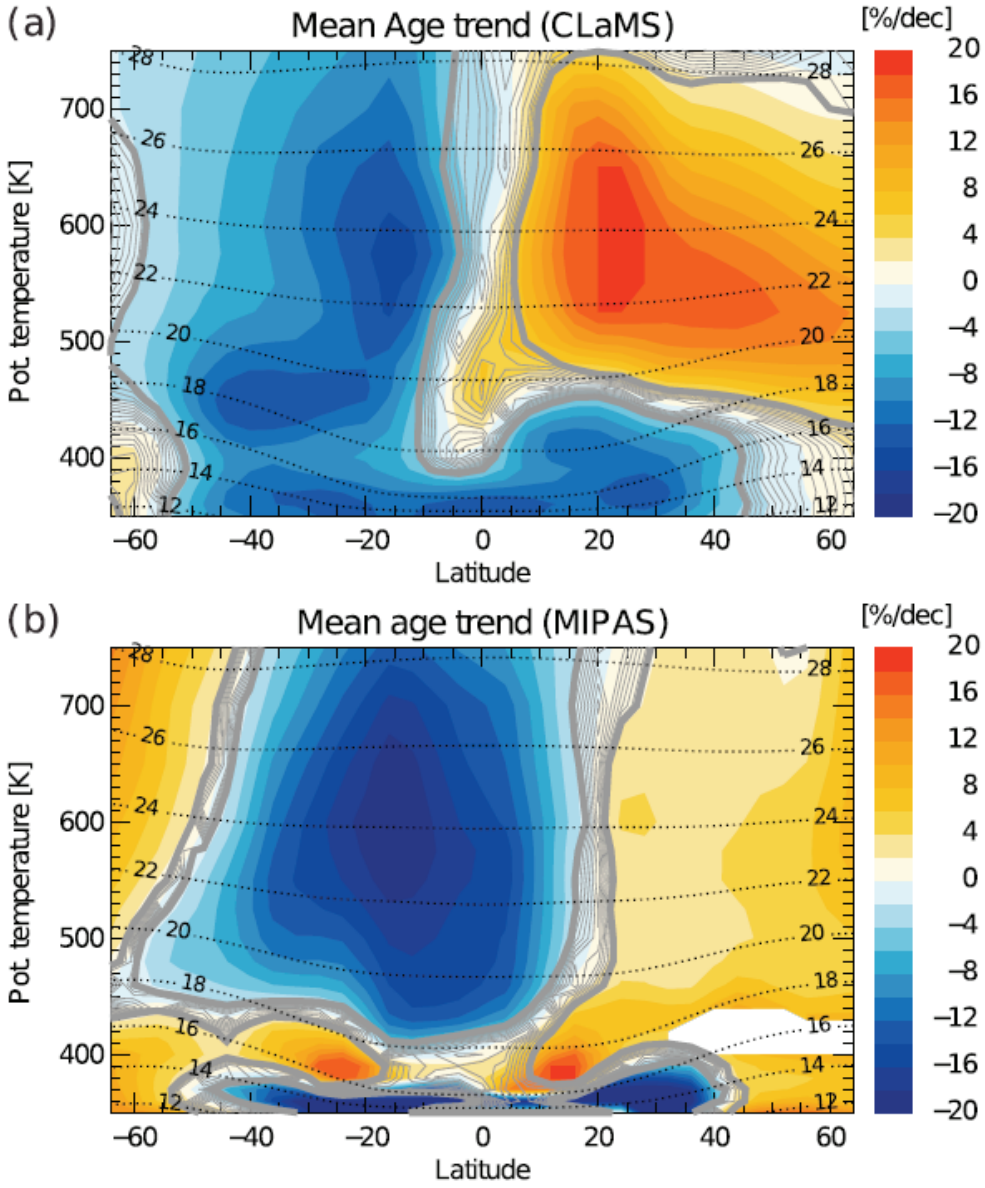
→ Occurs in lower stratosphere (~ 46 hPa, ~ 25 km)

Spatial distribution 2010/2011 to 2005/2006

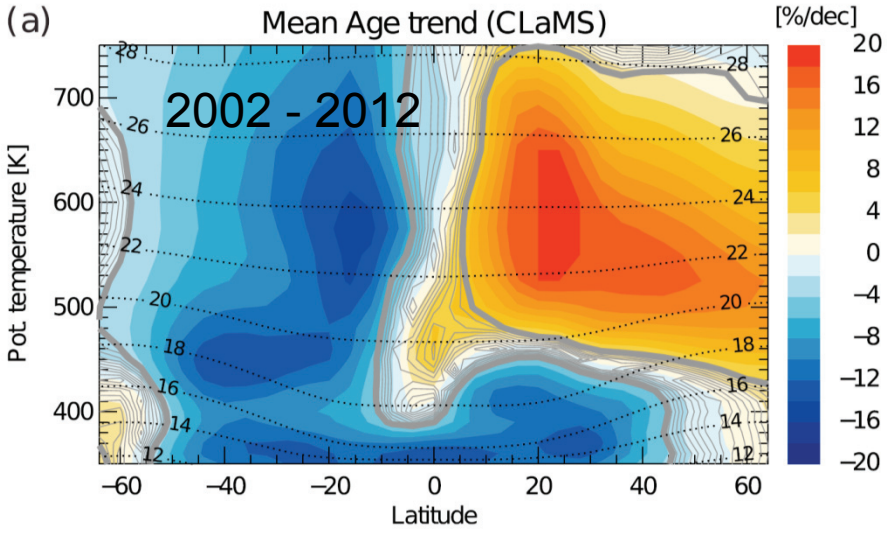


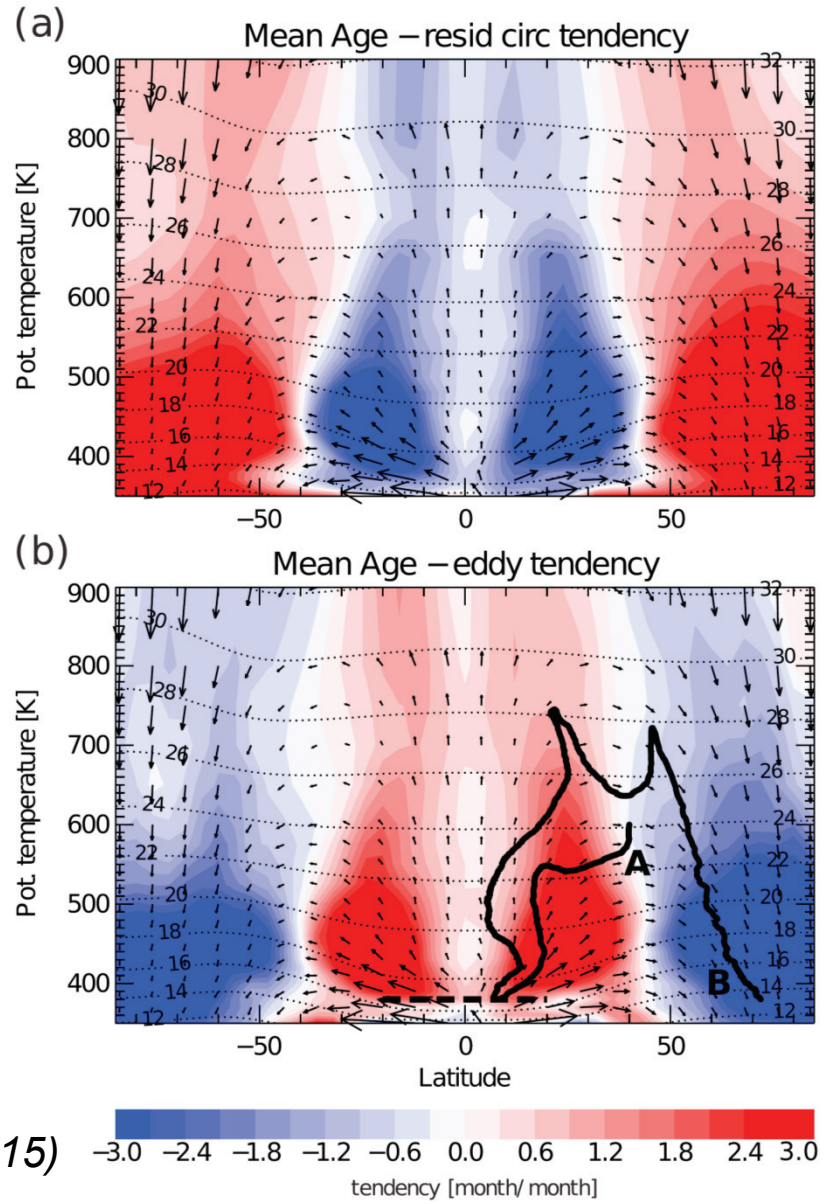

ΔHCl conc. (10^{15} m^{-3})
−0.2
−0.1
0.0
0.1
0.2
ΔMean age (y)
−0.5
0.0
0.5
a
KASIMA
b
Approx. altitude (km)
35
30
25
20
15
10
−50
0
50
Latitude
10^1
10^2
Pressure (hPa)
c
79° N
47° N
45° S
Mean Age (y)
4.0
3.5
2000
2005
2010
Year

Relative decadal change of zonal mean age of air for the period 2002–2012



(Pfloeger et al., JGR, 2015)





Competition between
- residual Circulation and
- eddy mixing

Both driven by planetary waves

More planetary waves in NH

(Pfloeger et al., JGR, 2015)

Summary and conclusions

- HCl increasing since 2007 only in NH
- increase caused by change in transport
- not clear wether natural variability or long-term trend
- competition between residual circulation and horizontal mixing
- effect on O_3 unclear, needs to be investigated by models