Ground-based total column measurements of greenhouse gases using the solar absorption spectrometry

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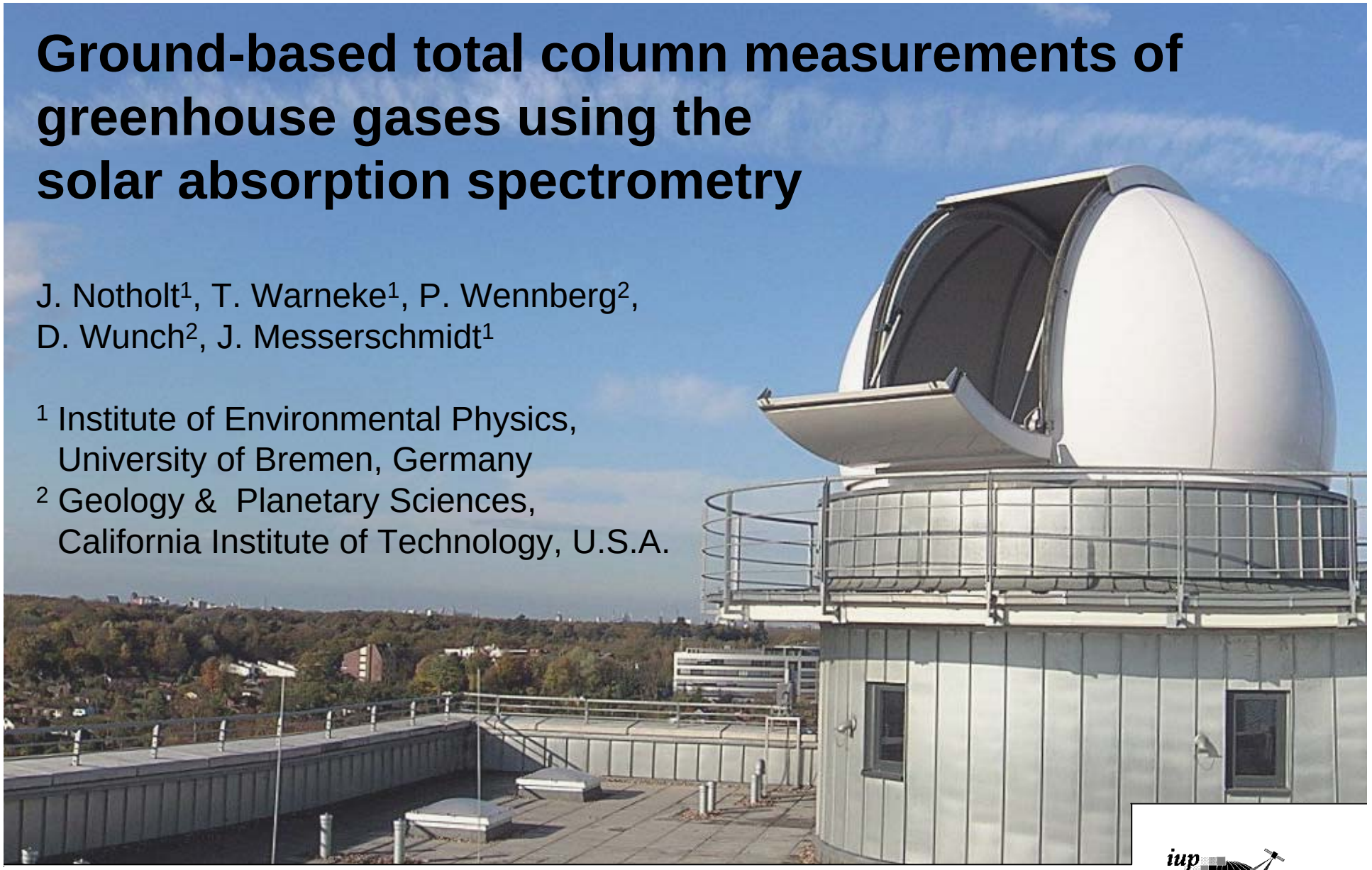
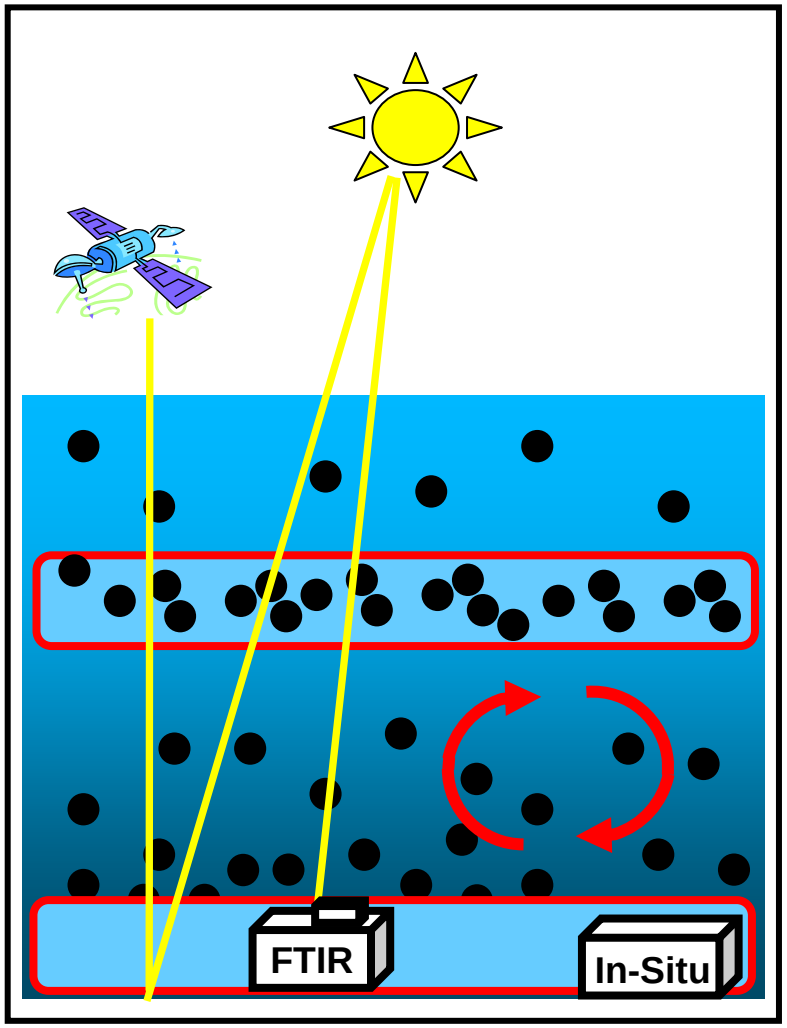


University of Bremen

Institute of Environmental Physics

Greenhouse gas observations



***In-situ* surface networks**

- high accuracy
- sample surface air
- long-term data record
- vertical mixing must be known

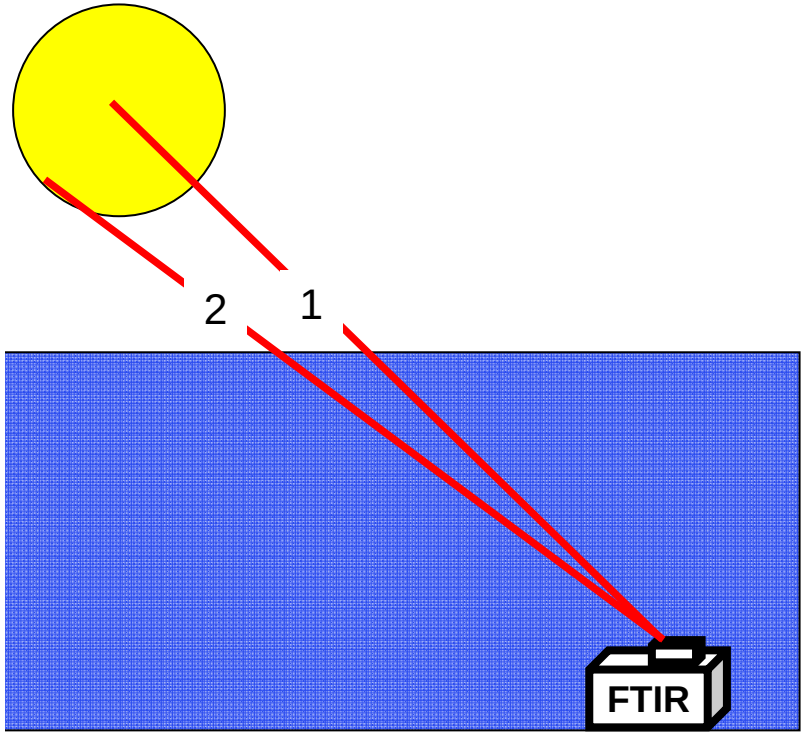
total column measurements

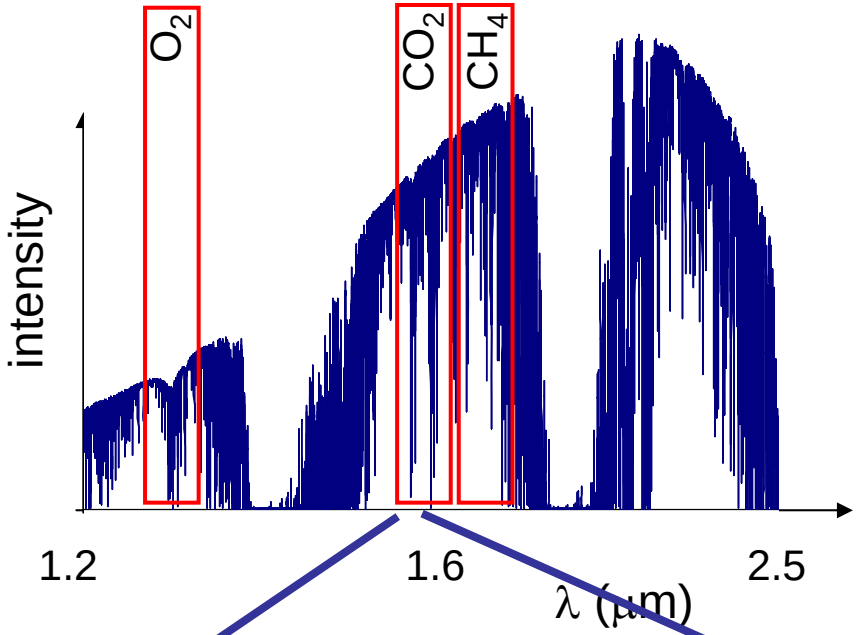
- sample whole atmosphere
- much less sensitive to vertical transport
- optimal for satellite validation
  OCO, GOSAT, SCIAMACHY

tasks

- remote sensing data must have a sufficient accuracy
- remote sensing data must be linked to long-term surface networks

Remote sensing in the near infrared spectral region

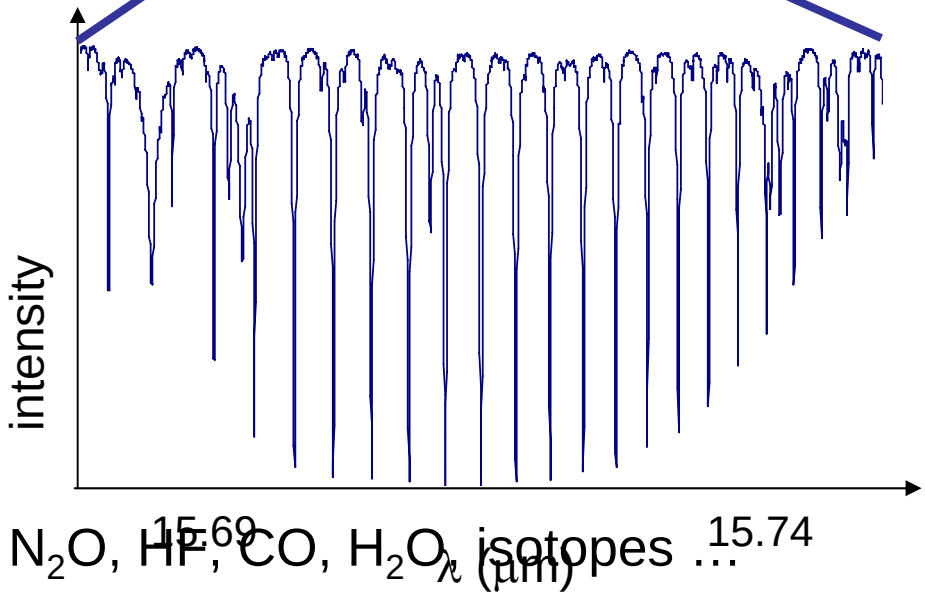




$CO_2(2) > CO_2(1)$

$O_2(2) > O_2(1)$

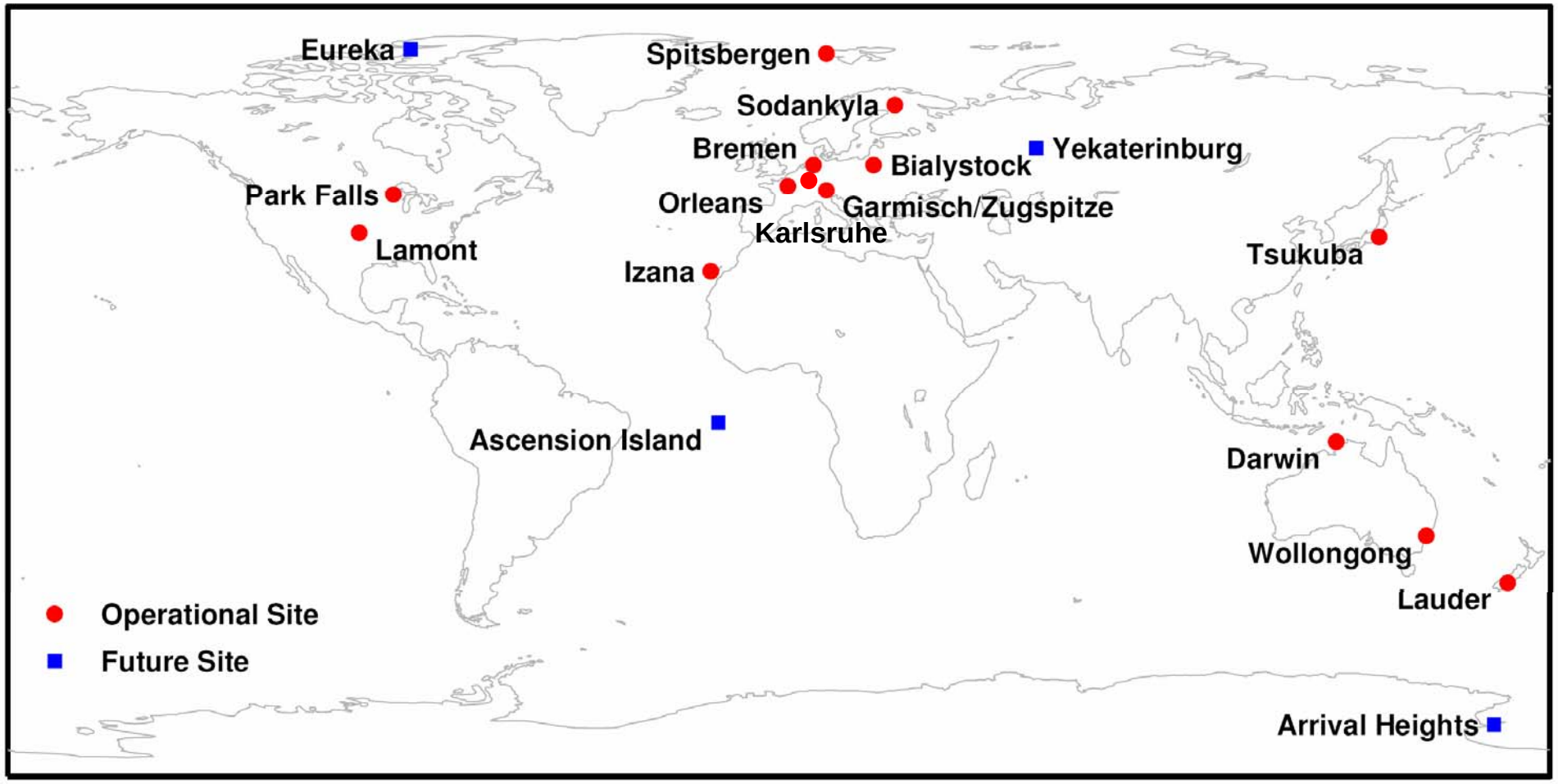
$XCO_2(2)=X$



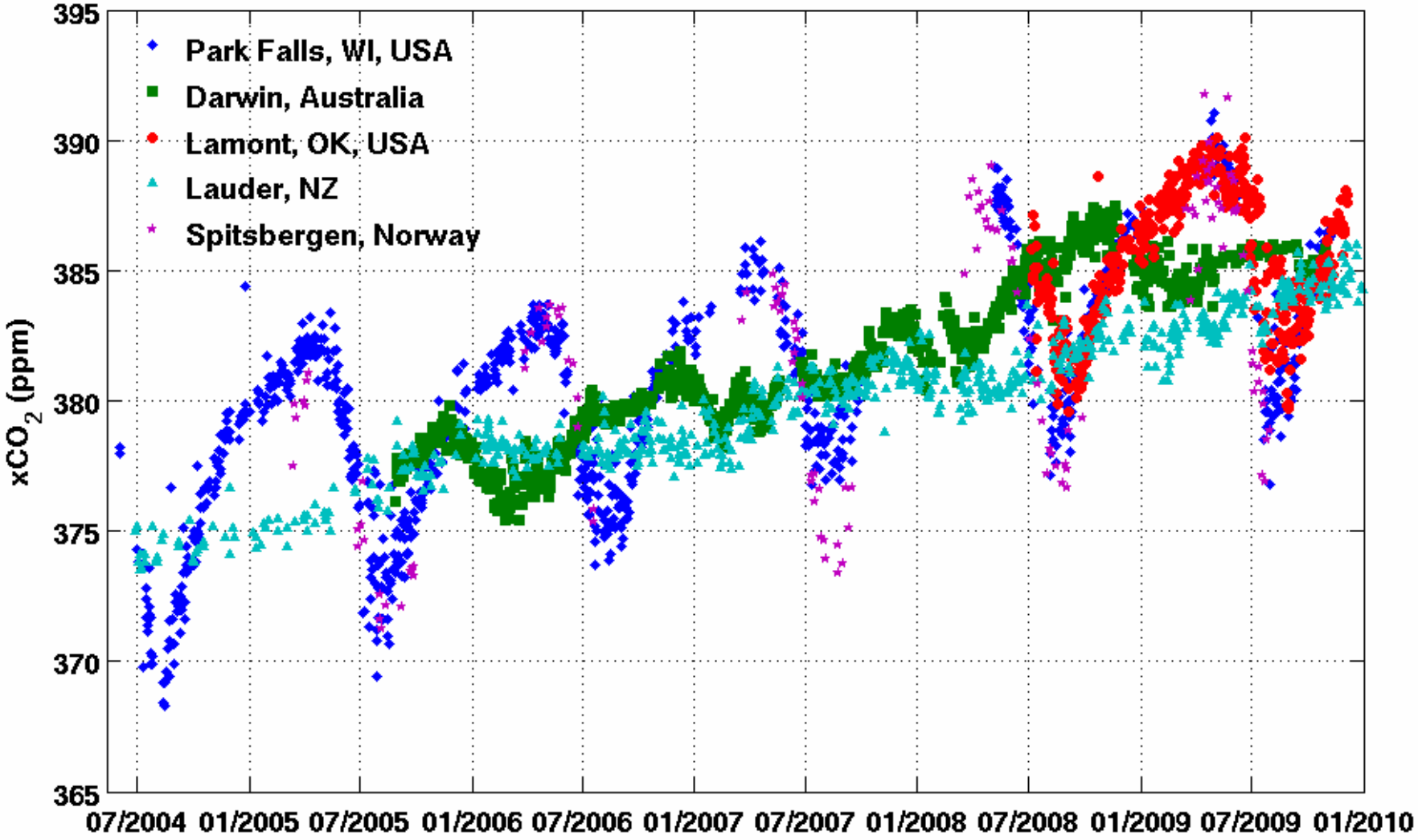
More trace gases in NIR: N_2O, HF, CO, H_2O, isotopes …

TCCON (Total Carbon Column Observing Network)

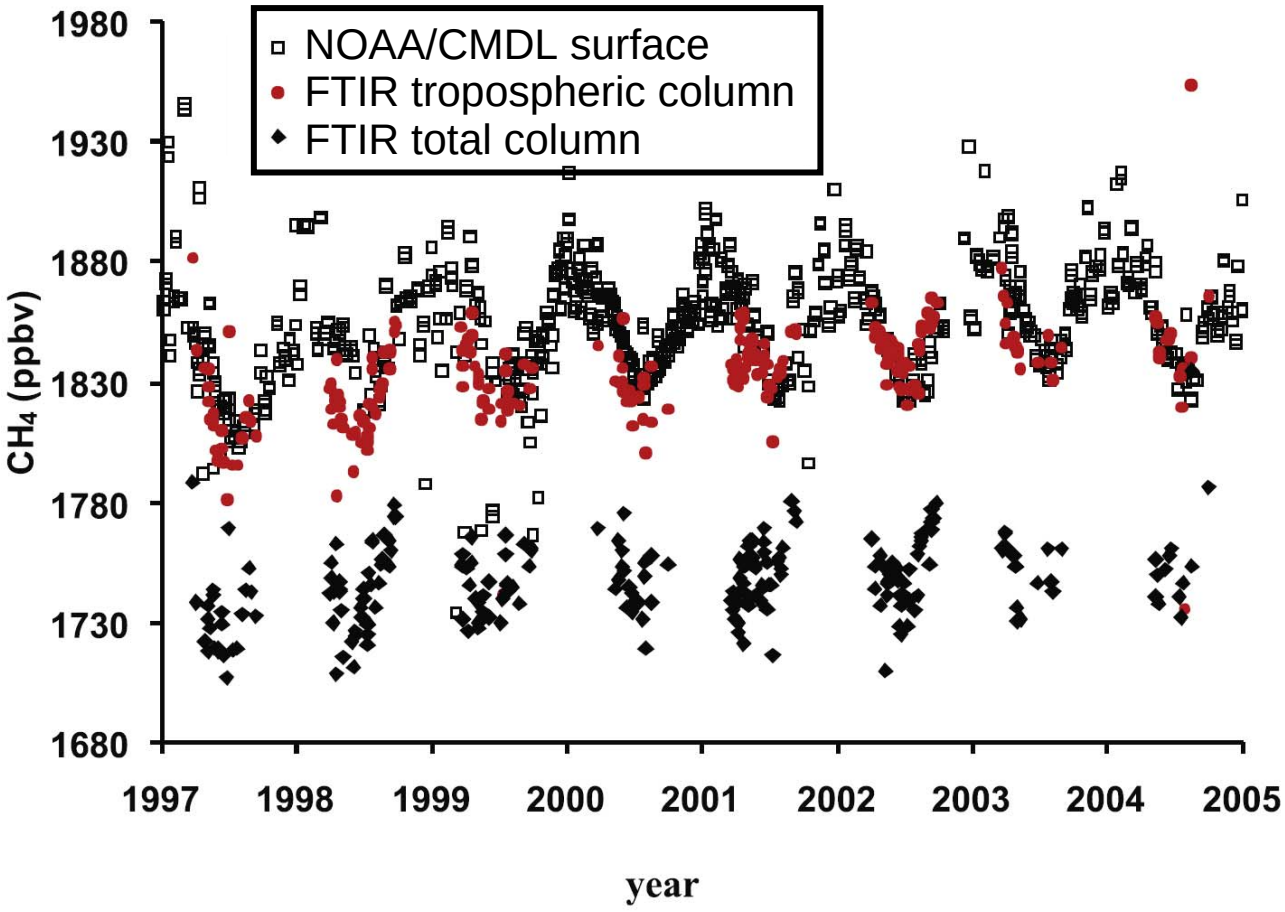
Network agrees partly with NDACC (Network for Detection of Atmospheric Composition Change), both accepted within GAW/WMO

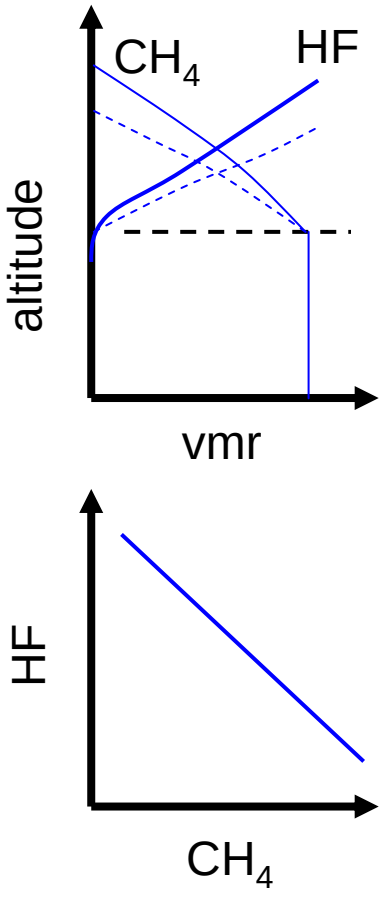


TCCON measurements of CO_2



TCCON measurements of CH_4 (total and tropospheric column)

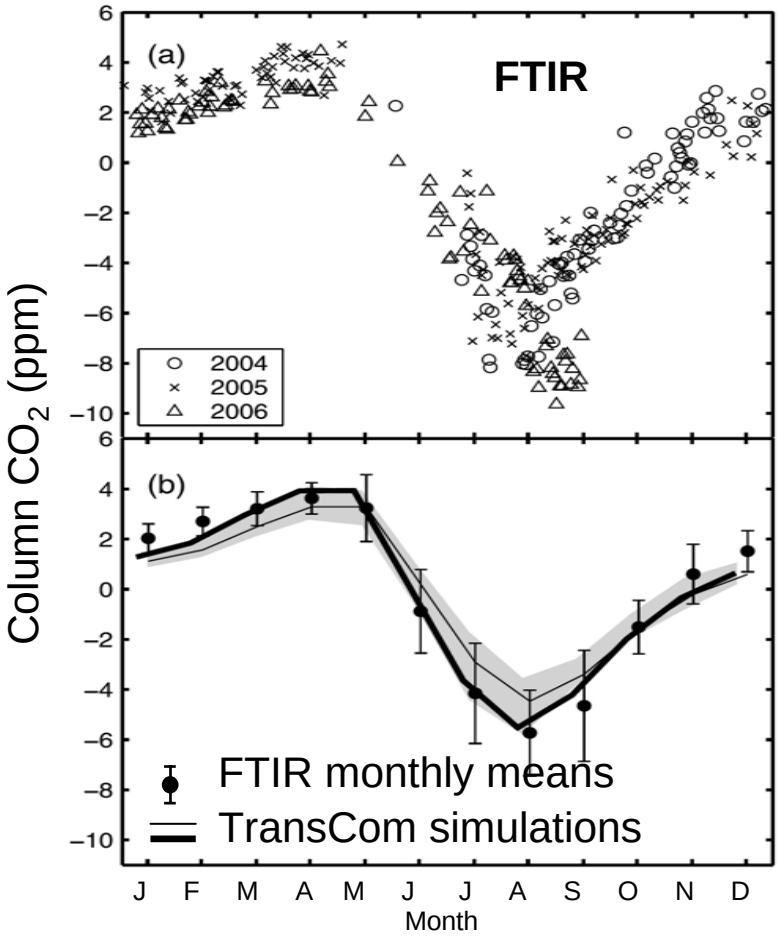




correlation CH_4 : HF used to get averaged tropospheric CH_4

impact of vertical transport

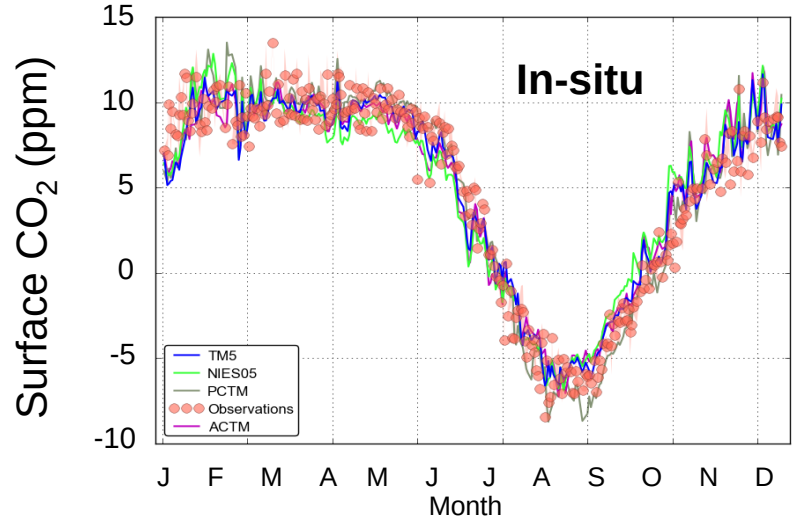
Park Falls (46°N)

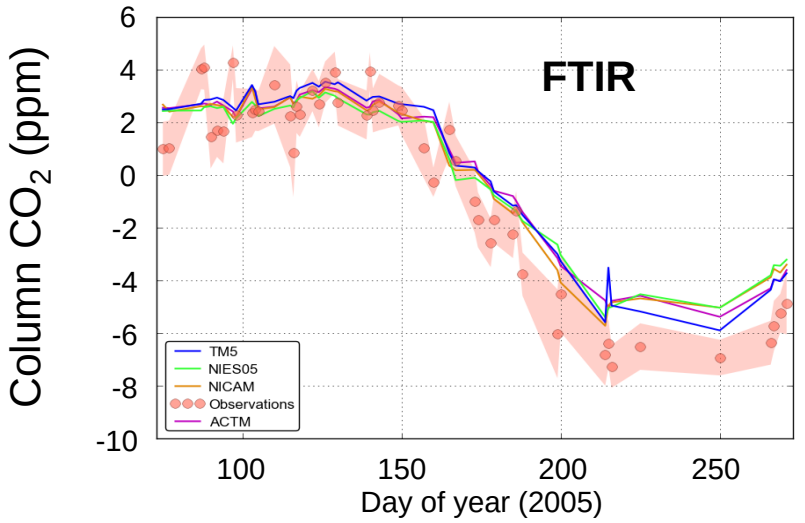


Total column + aircraft profiles:
Net ecosystem exchange 25% larger

(Yang et al., New constraints on Northern Hemisphere growing season net flux, GRL 2007)

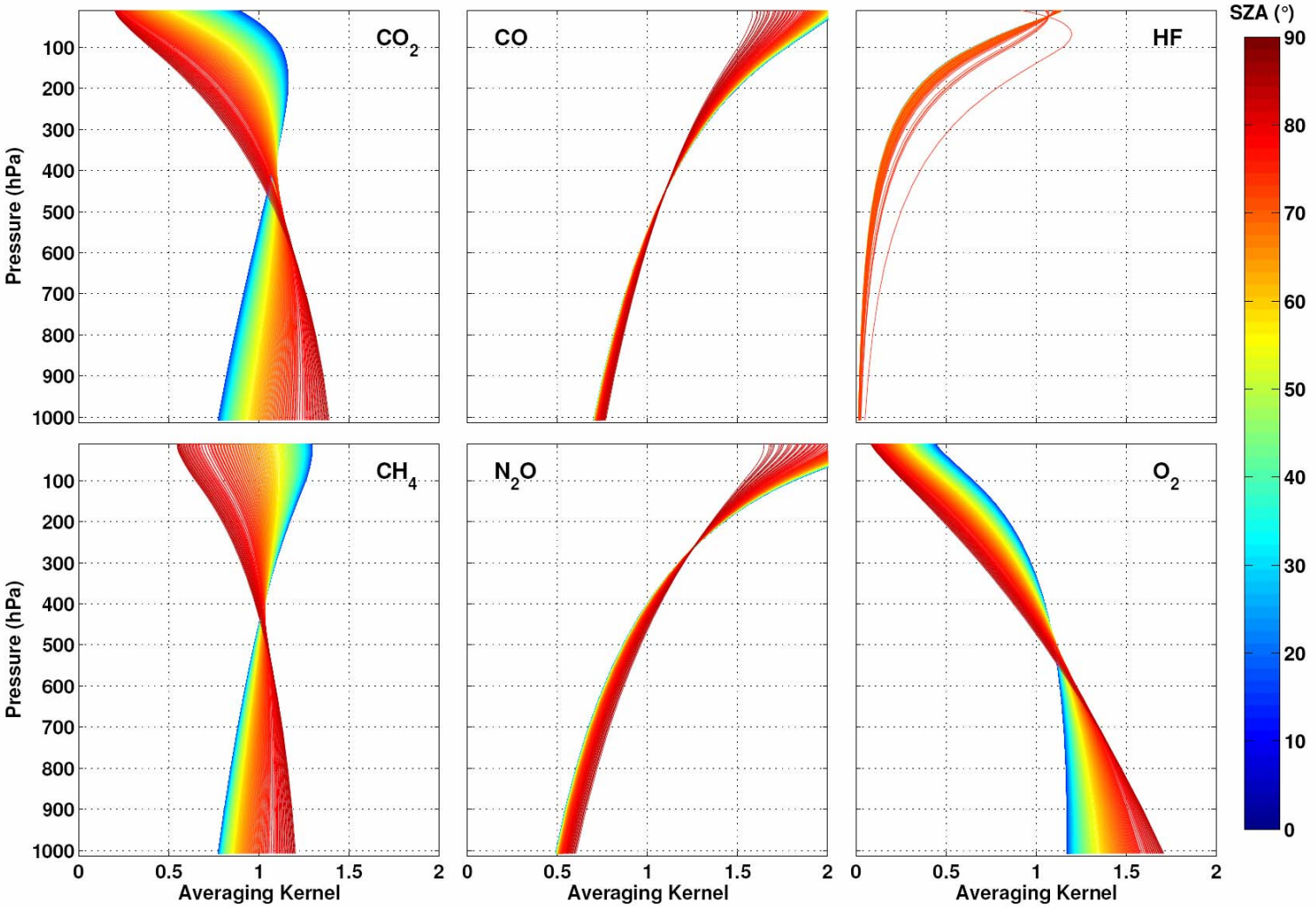
Ny-Ålesund (79°N)





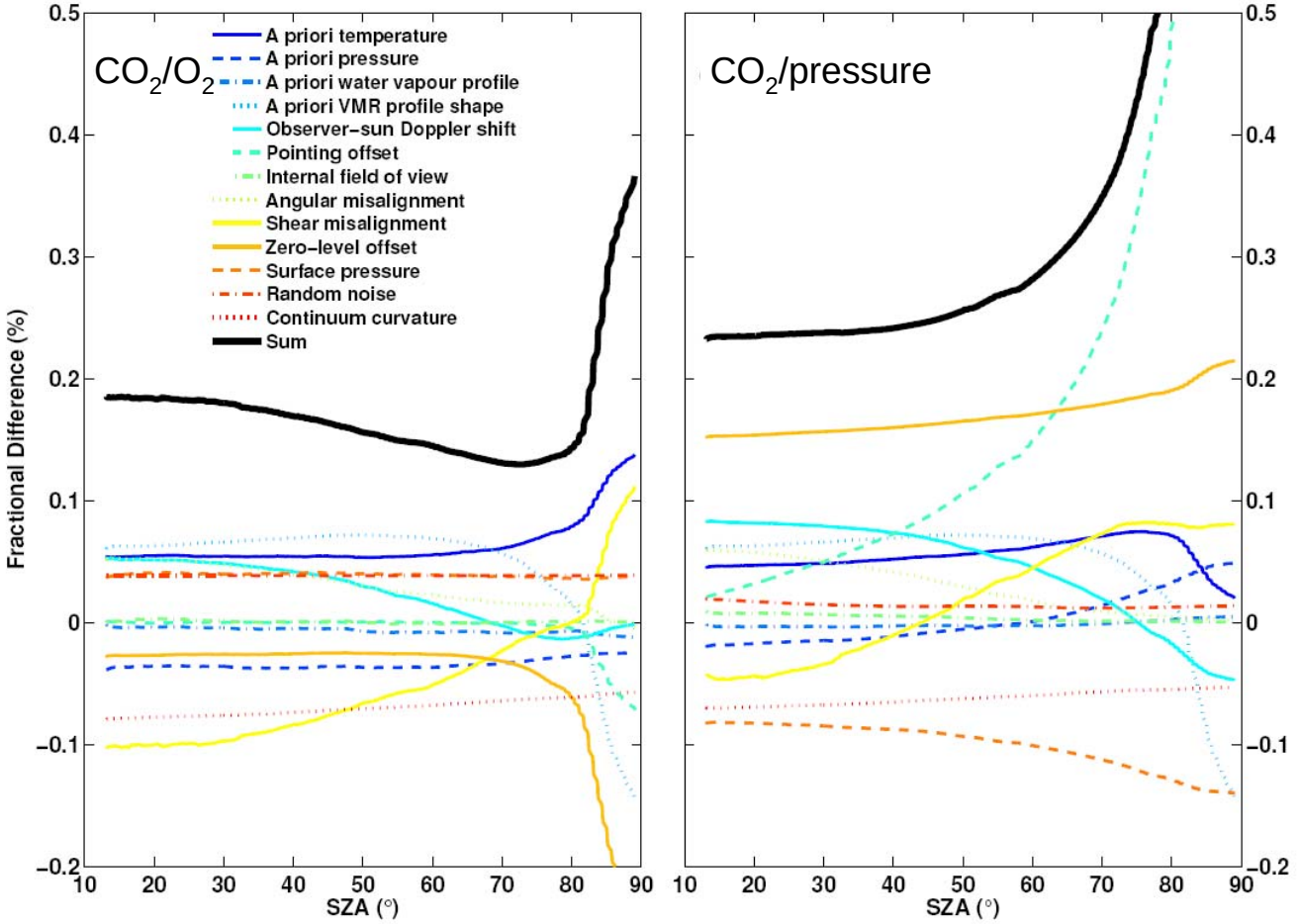
(Houweling et al., preliminary results from GOSAT RA PI meeting, Kyoto, Jan2010)

Sensitivity 1: Averaging kernels



Good sensitivity for whole atmospheric column

Sensitivity 2: Error budget



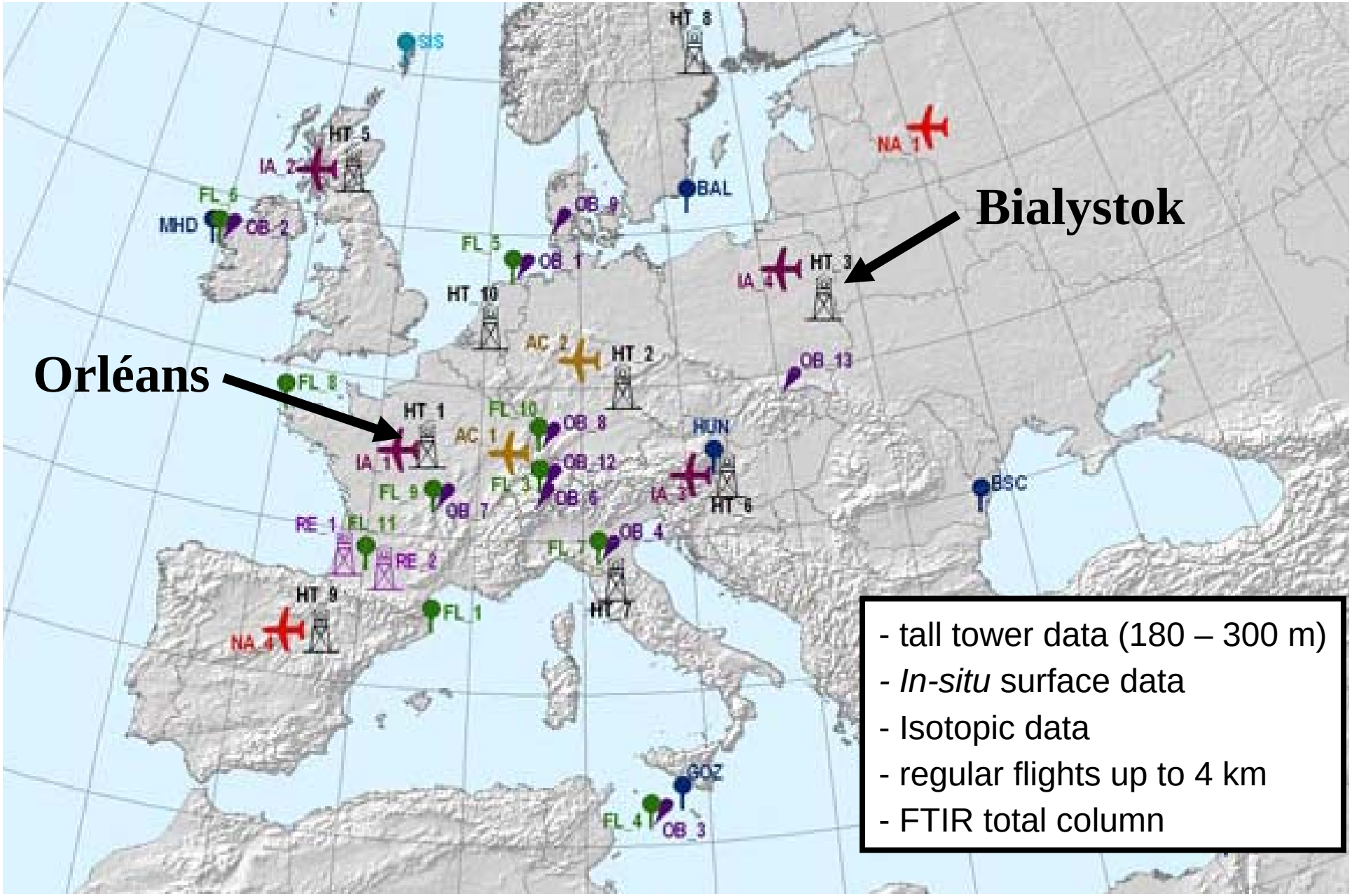
Error < 0.2%

- continuum curvature
- a priori uncertanties
- misalignment

Error ≈ (0.23 – 0.34

- zero-level offset
- surface pressure
- suntracker pointing error

EU-projects for integration of total column data at two tall tower *in-situ* sites (GEOMON and IMECC)



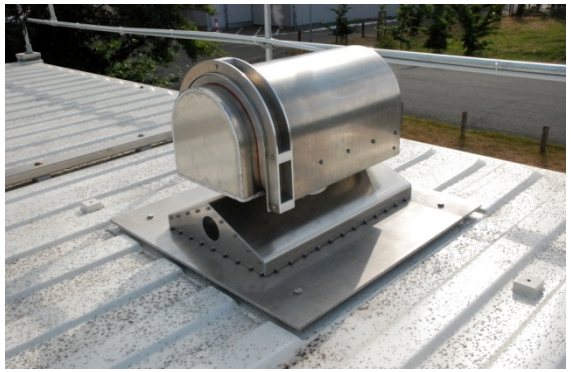
Hardware - Outside

Weather station

temperature-
and
humidity sensor

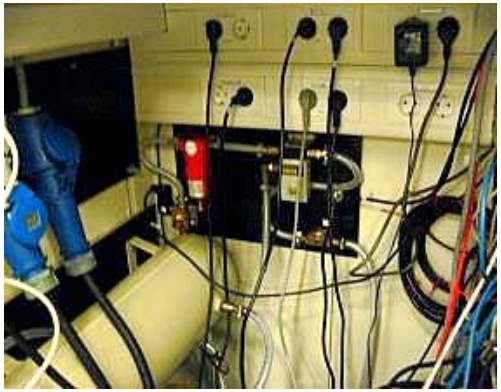
rainsensor

solartracker

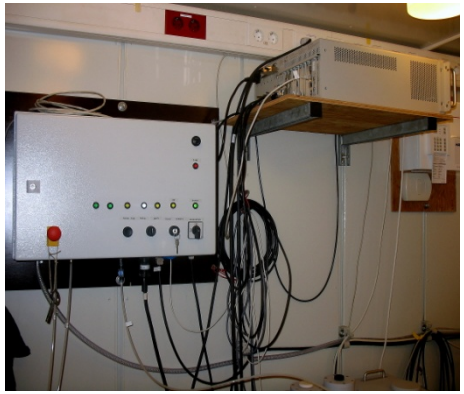


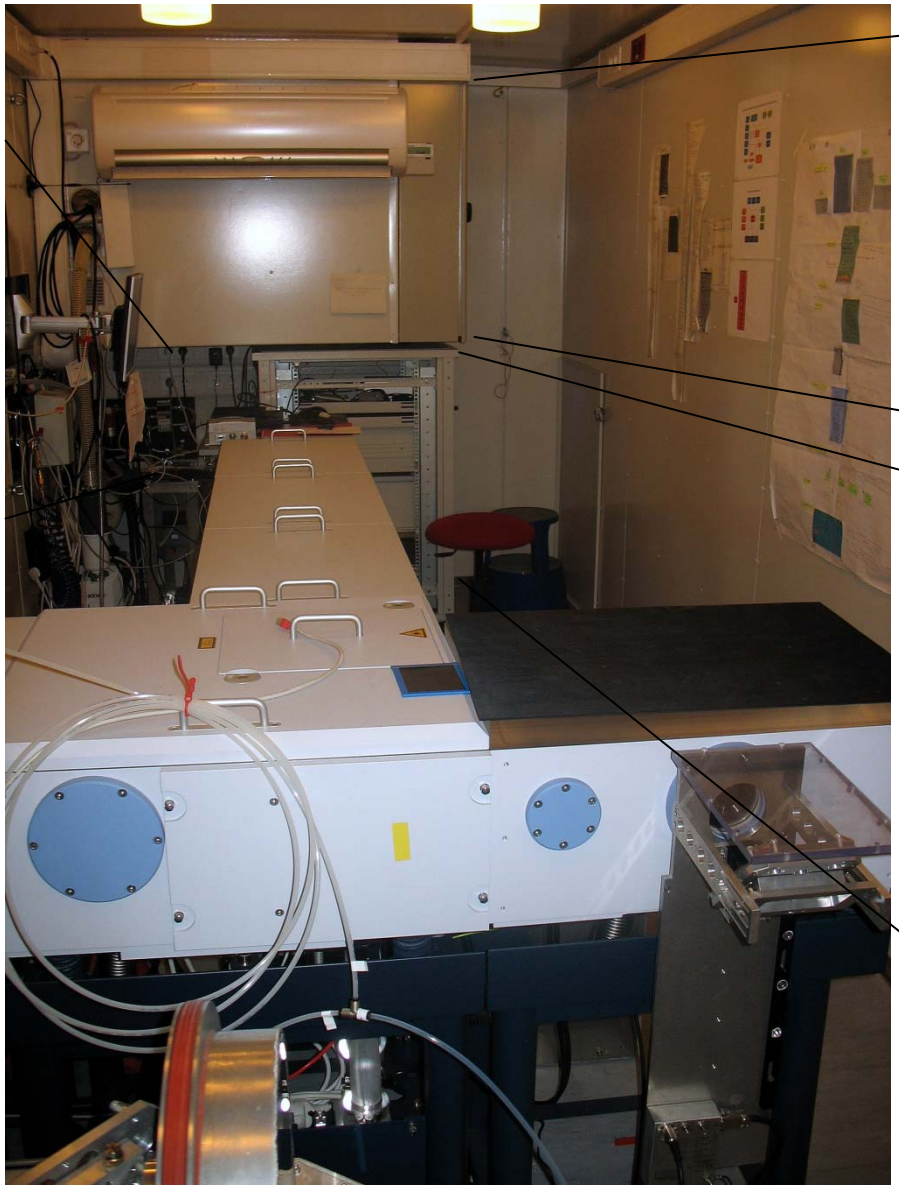
Hardware - Inside

Electronics,
Compressor,
Vacuumpump



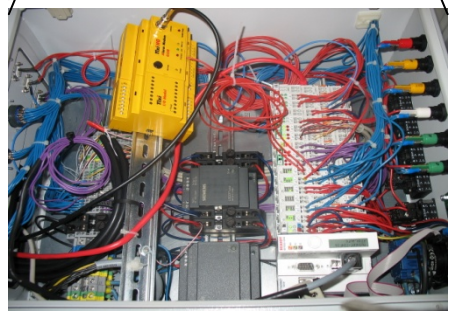
Solartracker
control cabinet





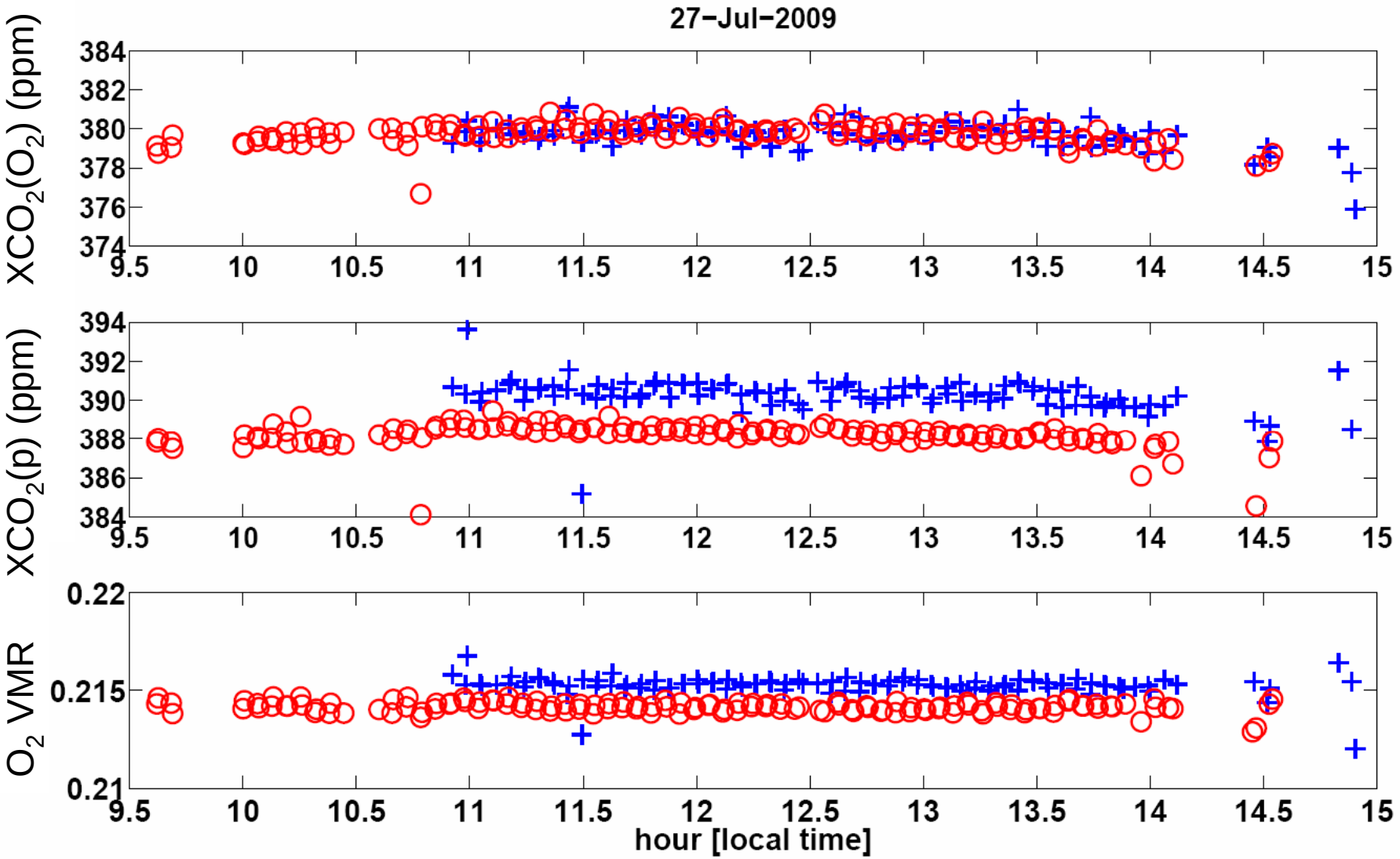
Control cabinet

PLC, UPS, Tapes

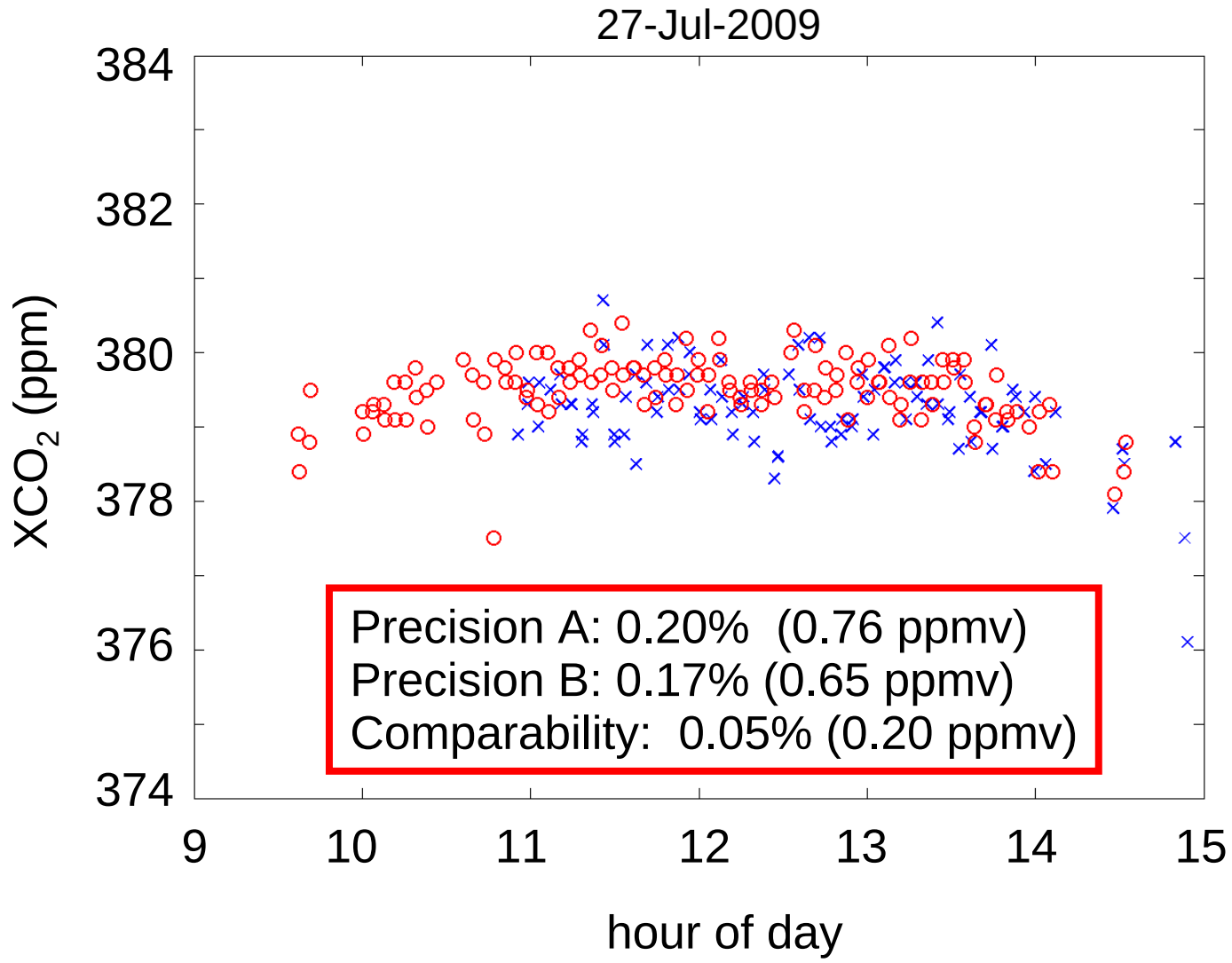


Investigate comparability in Bremen

Comparison of two instruments

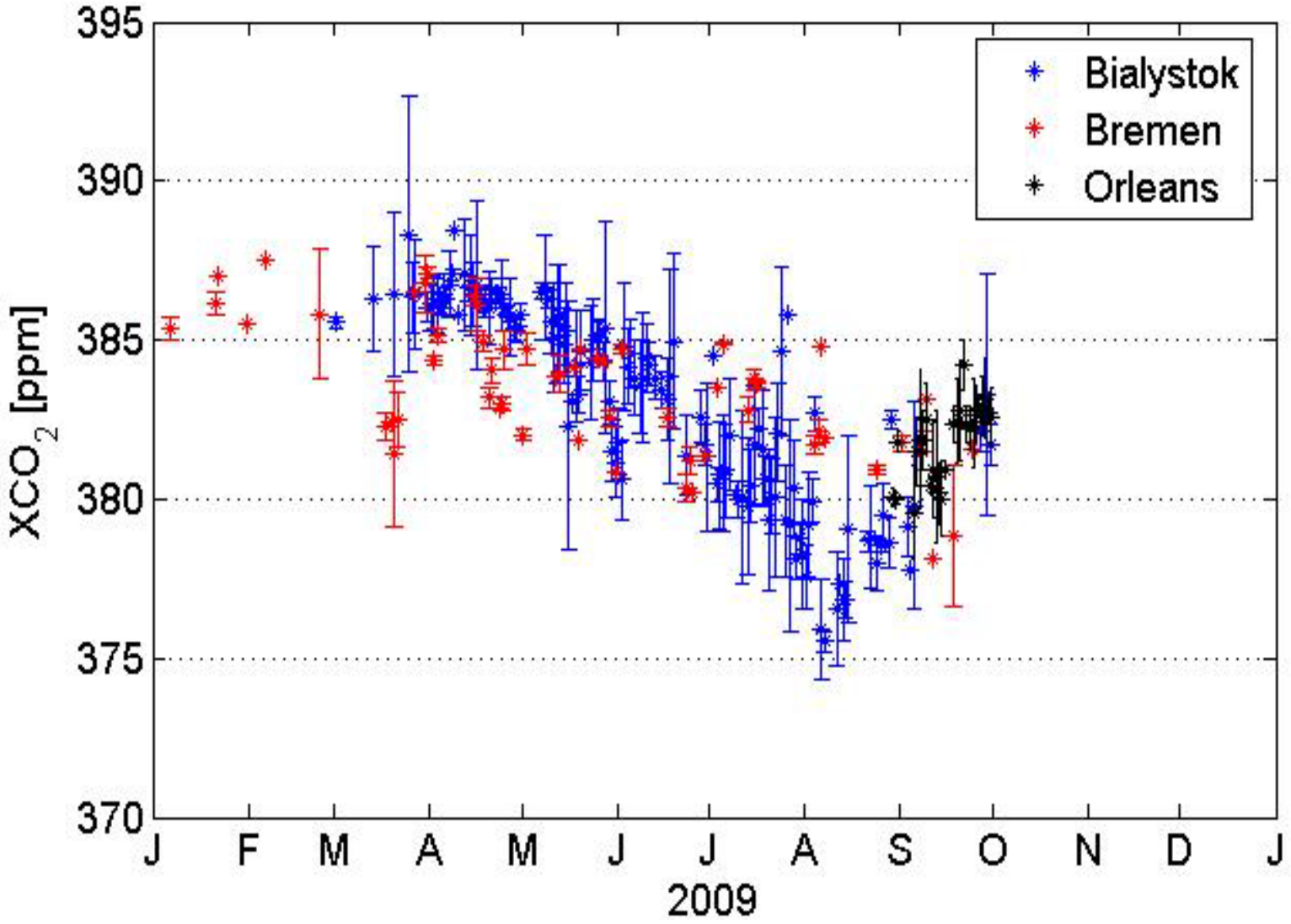


XCO_2 enlarged

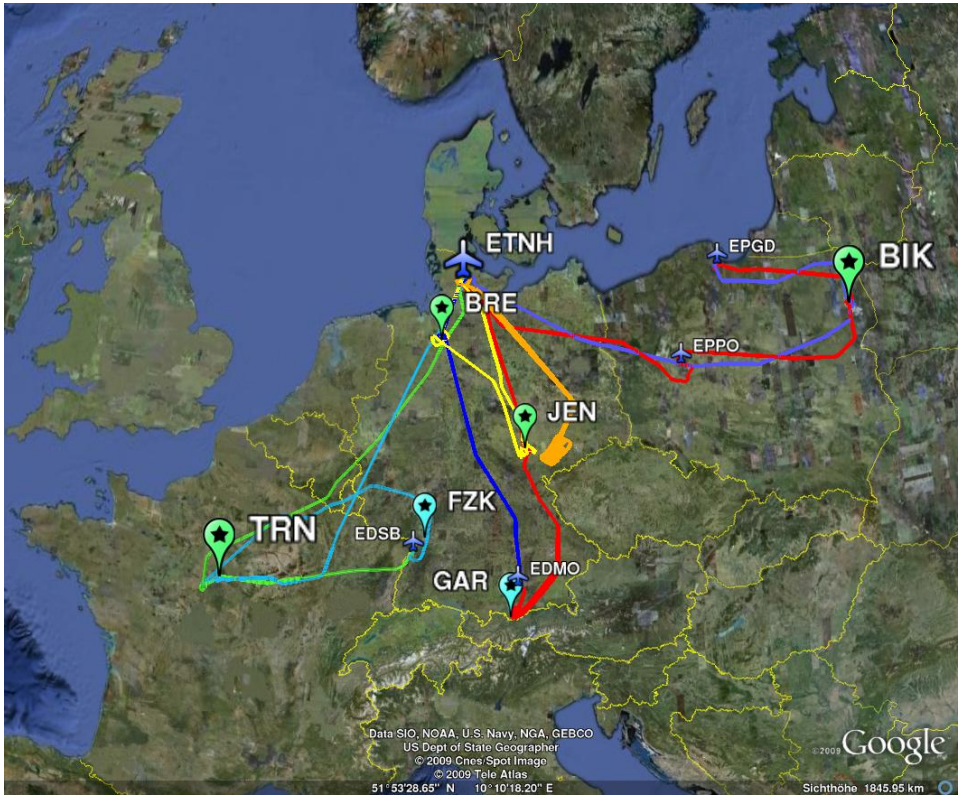


Setup in Bialystok/Poland and Orleans/France

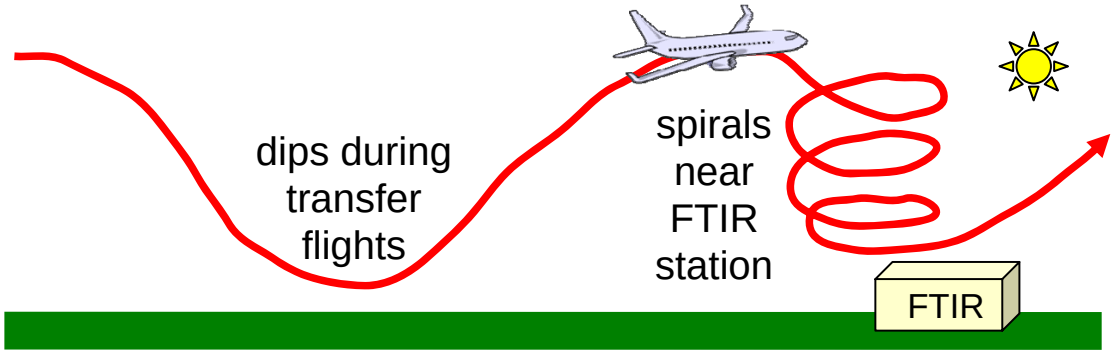
First results



Aircraft validation campaign 2009 (IMECC)

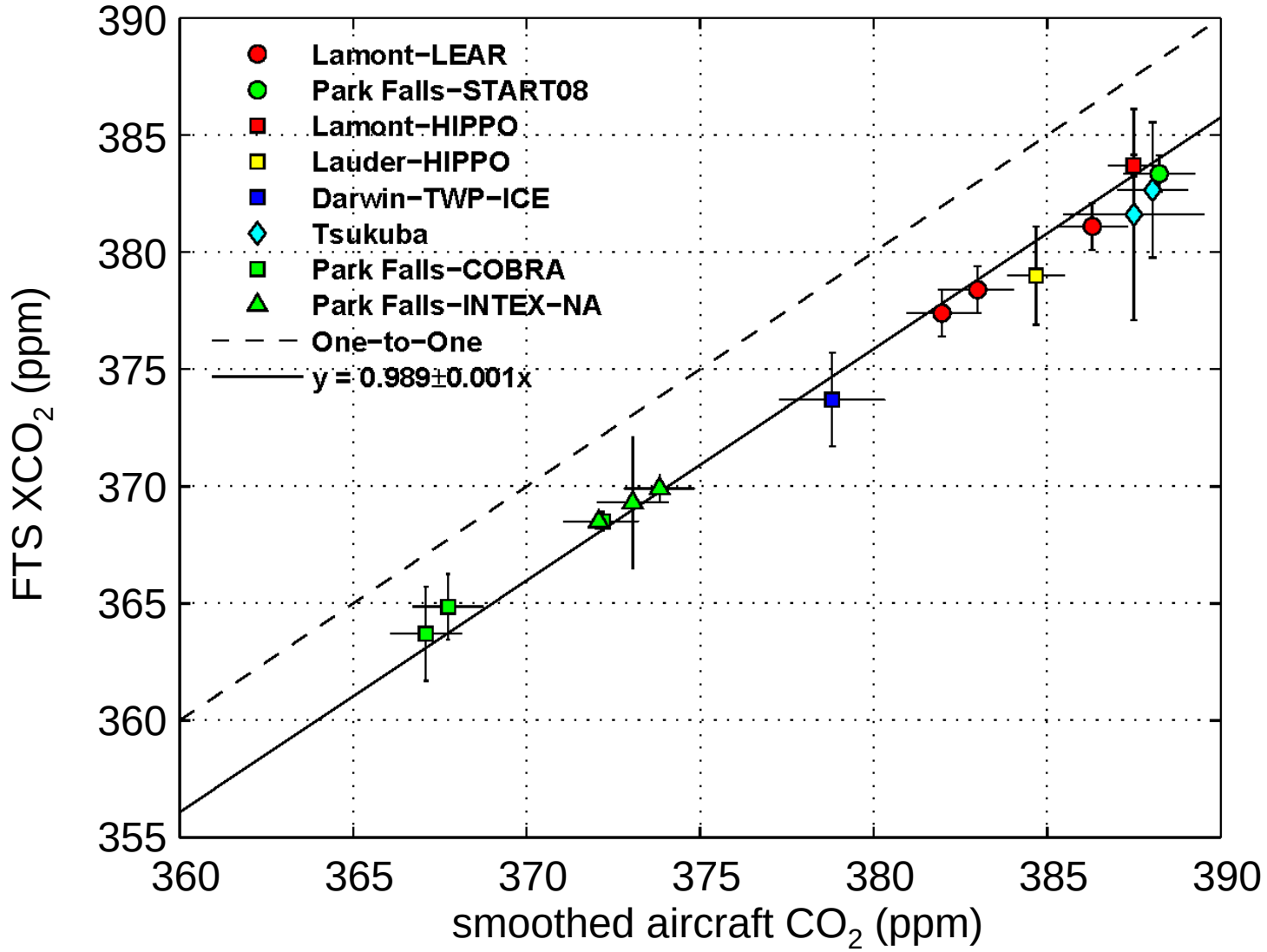


- **Purpose:** validation of European FTIR total column XCO_2 stations
- **Aircraft measurements:** in-situ CO_2 profiles near stations from **300-12000 m** (spiral) + dips during transfer flights
- **Schedule:** September 30 to October 9, 2009
- **Platform:** Learjet 35A operated by Enviscope/GfD



(courtesy of D. Feist, MPI-BGC)

Previous aircraft calibrations

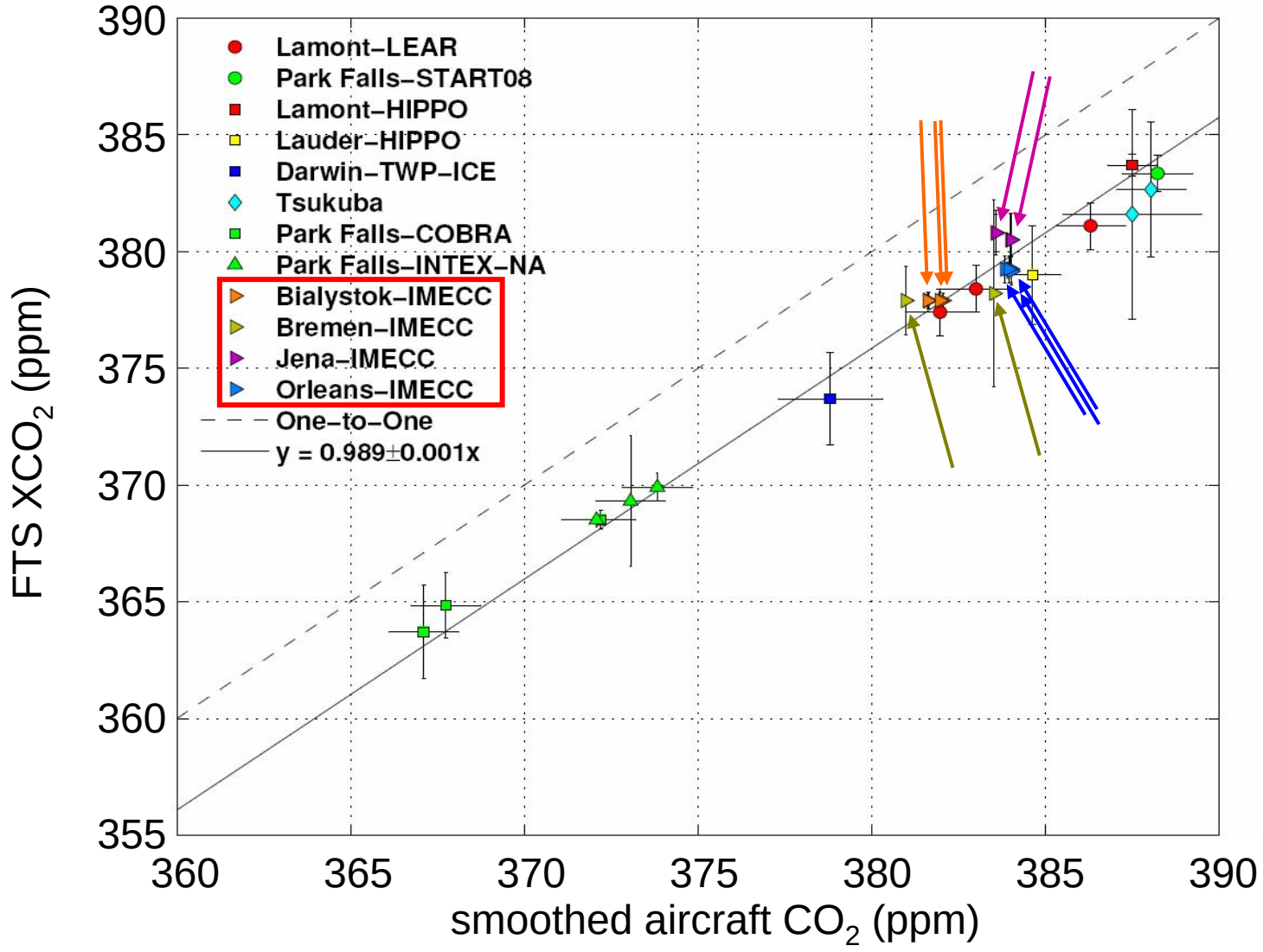


(HIPPO-data: S. Wofsy, preliminary results)

Bialystok, Polen (53°N, 23°E)

Cristoph Gerbig and Olaf Kolle

Previous aircraft calibrations + European campaign



(HIPPO-data: S. Wofsy, preliminary results)

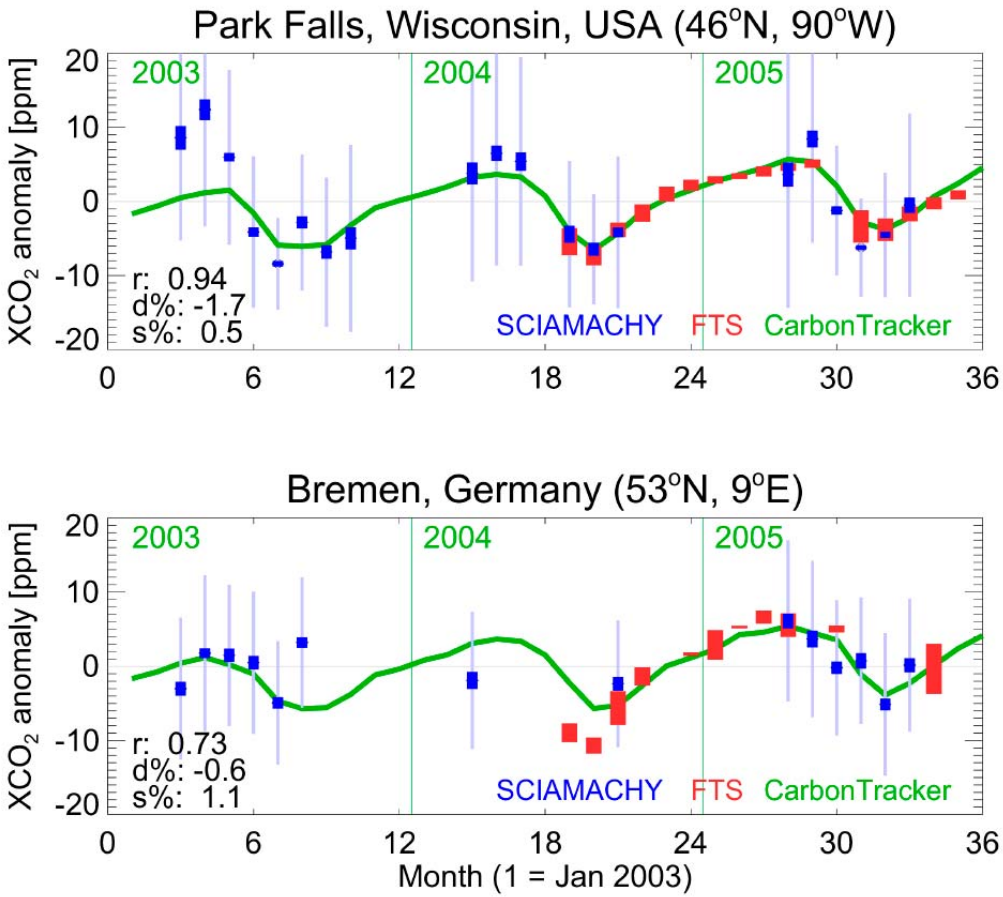
Comparison satellite – TCCON

Total column (NIR)

- ~~OCO: 2009 – 2010~~
- OCO-2: 2012 – 2014 ?
- Sciamachy: 2003 – 2013
- GOSAT: 2009 – 2013

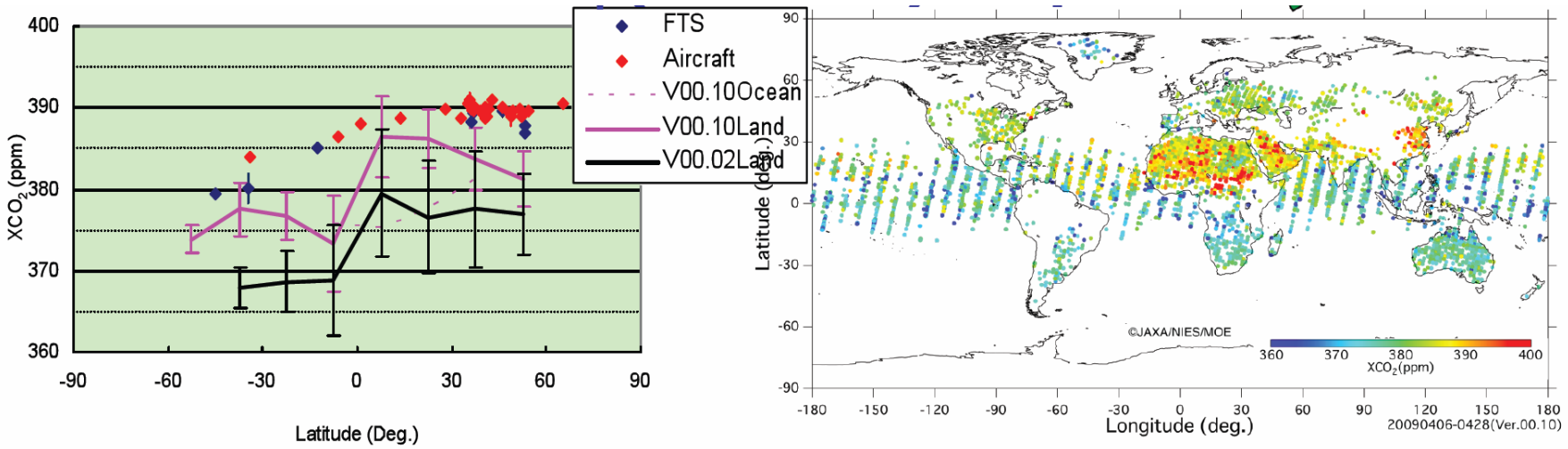
Upper troposphere (TIR)

- TOVS
- AIRS
- IASI



(Buchwitz et al., ACP 2007)

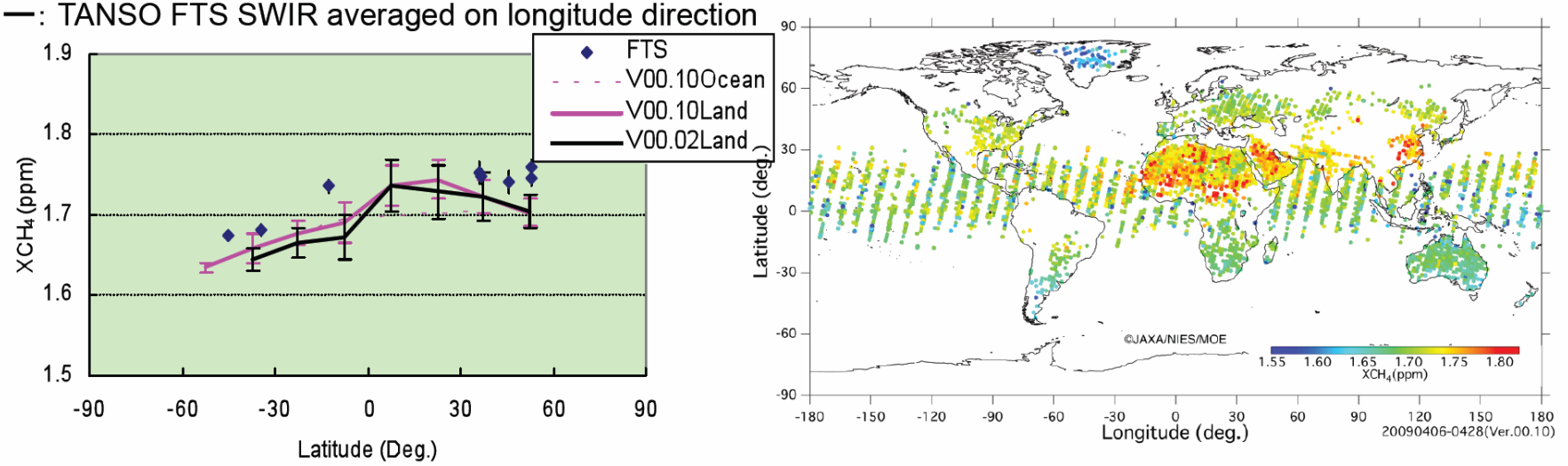
GOSAT validation (preliminary results)



◆: ground-based FTS(GOSAT overpass ± 30 min)

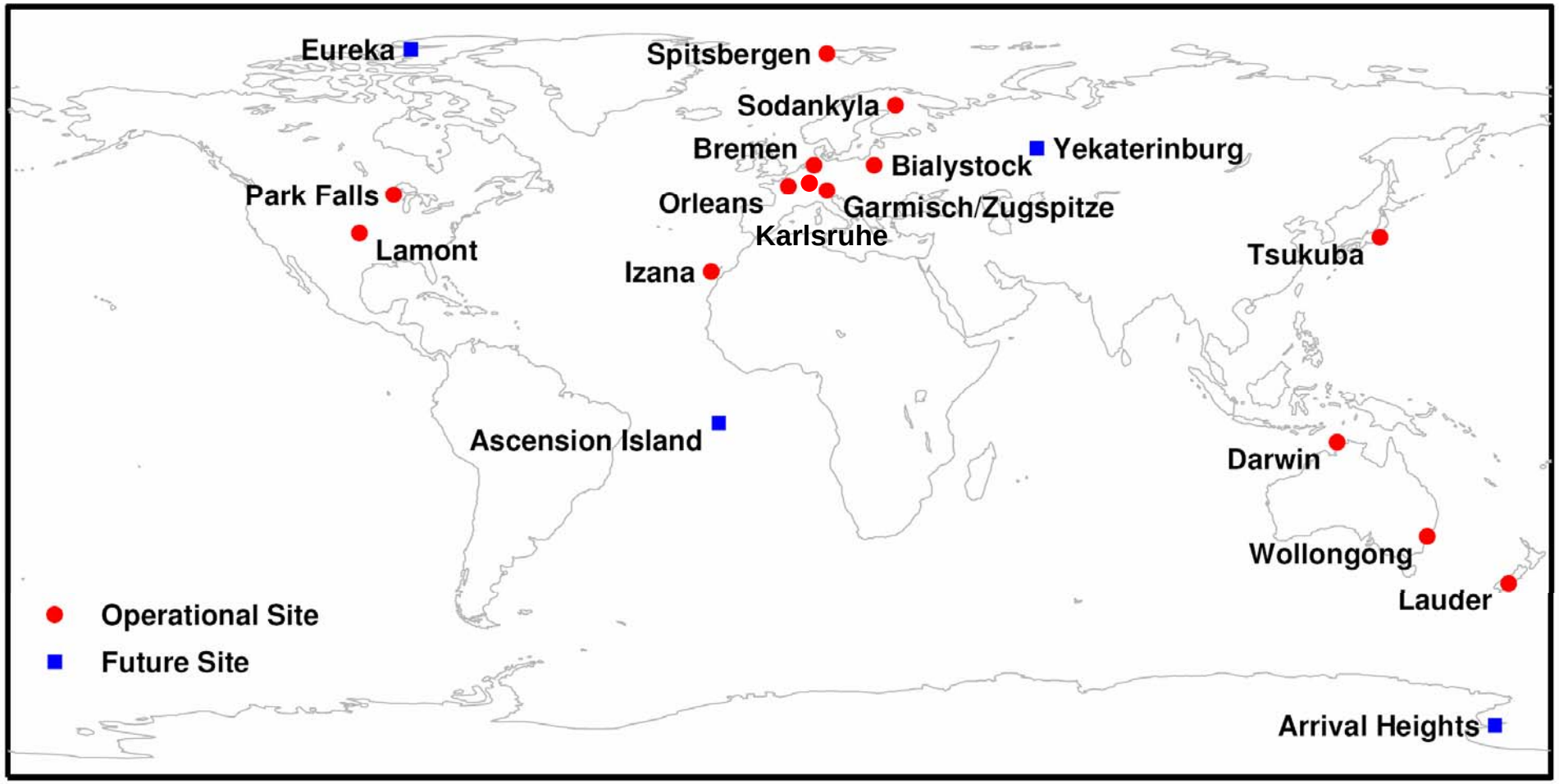
◆: aircraft (CONTARIL +NOAA)

—: TANSO FTS SWIR averaged on longitude direction

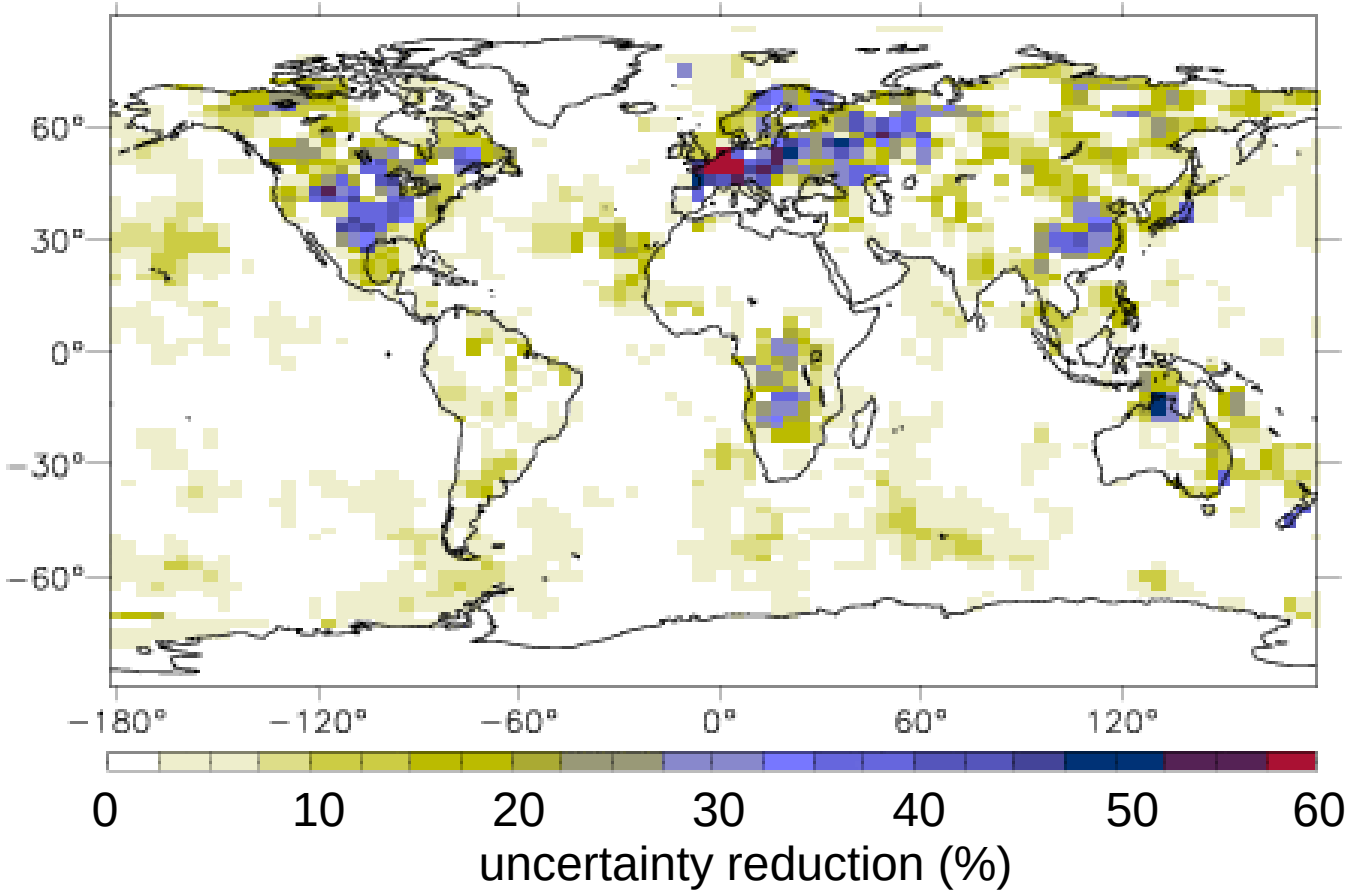


(courtesy of Isamu Morino and Osamu Uchino, NIES)

Uncertainty reduction for inversion studies using all TCCON stations (operational + future sites)



Uncertainty reduction for weekly fluxes



- Measurements: every 30 min, solar zenith angles < 80°
- Measurement precision set to 2 ppm
- ORCHIDEE model for a-priori information

Example model: 5 g m^{-2} dy^{-1}; inversion: 3 g m^{-2} dy^{-1}; uncertainty reduction: 40%

(Chevallier and Rayner, LSCE, France)

Summary and conclusions

- Ground-based solar absorption spectrometry in the near-infrared has the required precision (<0.25%) and comparability (0.05%) for long-term monitoring of greenhouse gases
- Satellite XCO_2 and XCH_4 data can be calibrated against the WMO standard using ground-based solar absorption FTIR-spectrometry as a transfer standard
- Within the EU-projects GEOMON and IMECC two of the main European in-situ sites have been upgraded with FTIR-spectrometers, providing the backbone for the integration of the satellite measurements in the existing in European in-situ network
- Surface in-situ networks **+** satellites **+** TCCON allow to investigate carbon budget on global scale and determine sources and sinks of carbon gases
- Funding for the FTIR-observations is short-term, which could result in discontinuous time-series in the future.

Acknowledgement

- EU projects GEOMON and IMECC, DFG, Senate of Bremen
- CONTRAIL (JAL project)
- NOAA ERSL
- GOSAT team.