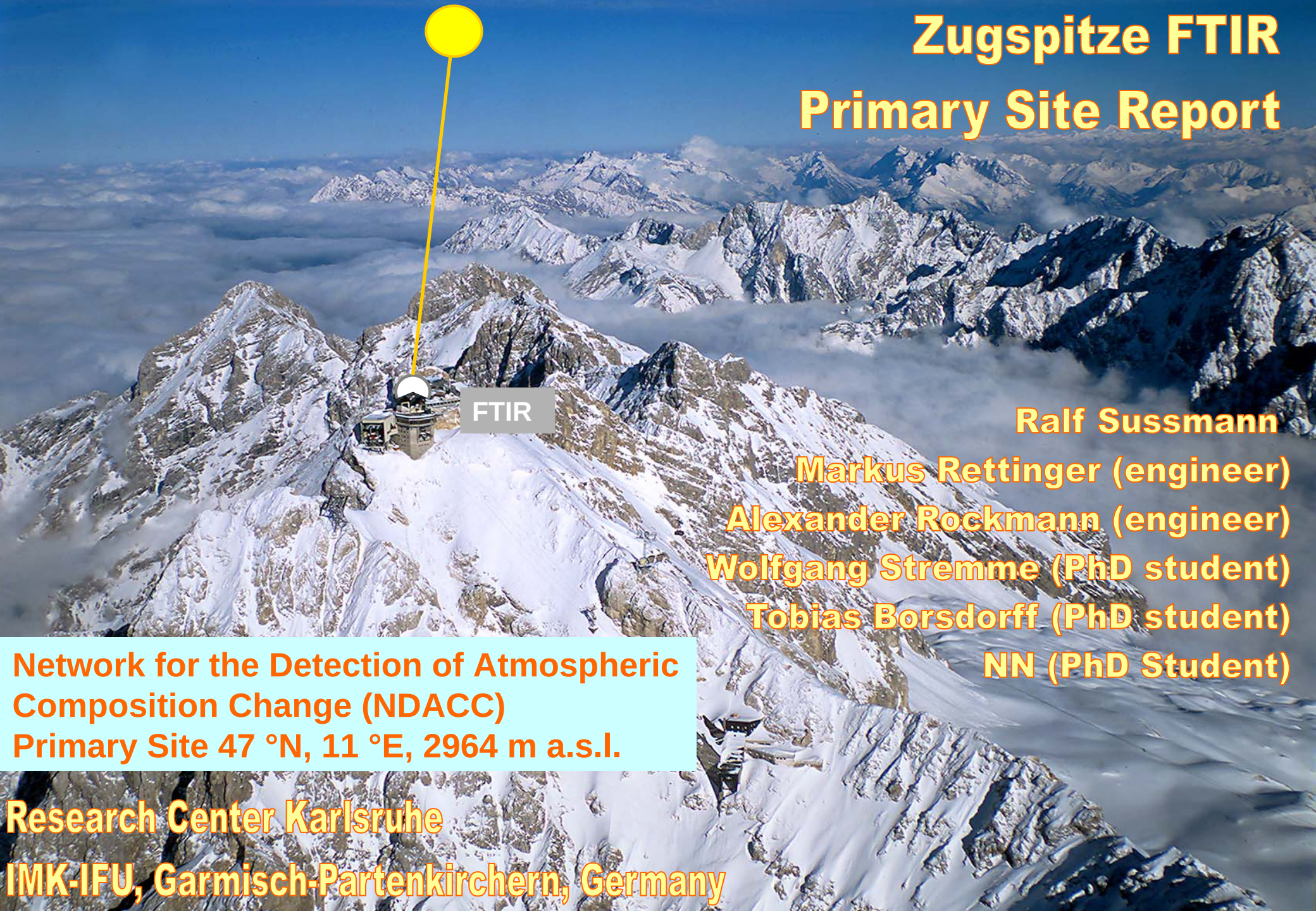


Zugspitze FTIR
Primary Site Report

Ralf Sussmann
Markus Rettinger (engineer)
Alexander Rockmann (engineer)
Wolfgang Stremme (PhD student)
Tobias Borsdorff (PhD student)
NN (PhD Student)

Network for the Detection of Atmospheric Composition Change (NDACC)
Primary Site 47 °N, 11 °E, 2964 m a.s.l.

Research Center Karlsruhe
IMK-IFU, Garmisch-Partenkirchern, Germany

Zugspitze: NDACC
operational since 1995
141 meas. days during last 12 months

O_3, $ClONO_2$, HCl, HF, COF_2, HNO_3, NO_2, CO, CH_4, N_2O, C_2H_6, CFC-22, H_2O

FTIR
IFU

Zugspitze
2964 m

Garmisch: TCCON
2004: 94 meas. days
2005: 147 meas. days
2006: 136 meas. days
2007: 42 meas. days

CH_4/O_2, CO_2/O_2

"Differential FTIR" with Zugspitze:
O_3, CO, CH_4, N_2O, C_2H_6, CFC-22, H_2O

FTIR
IFU

Garmisch
734 m

Zugspitze retrievals: SFIT2.39, batches transferred to Linux Parallel Processing

IMK-IFU Linux-Cluster

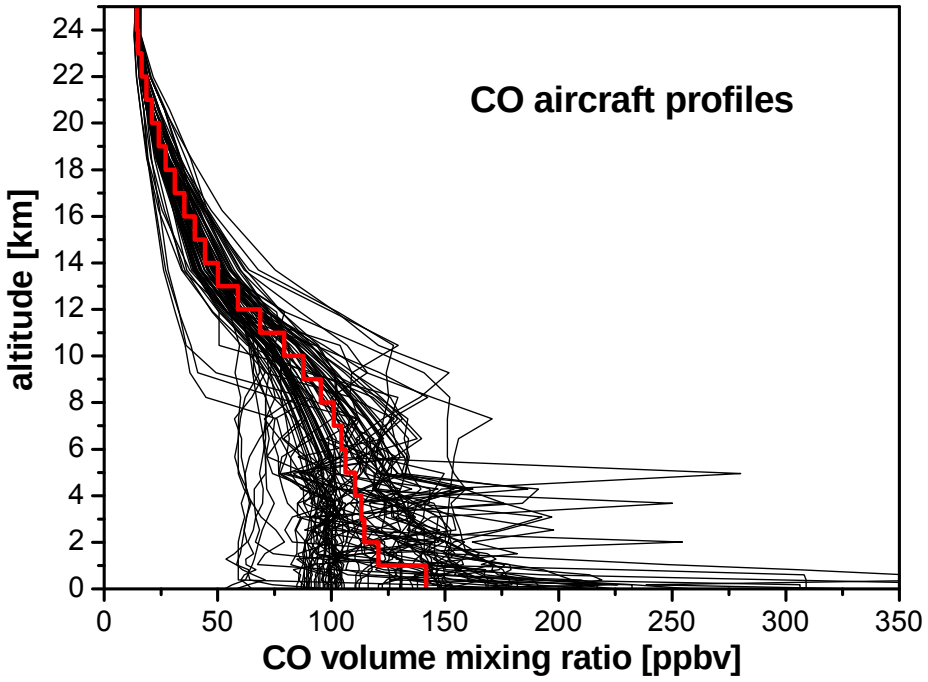
Prozessortyp	knots	communication
AMD Athlon MP 2200+	24	Myrinet 2000
Intel Xeon 3 GHz	96	Gigabit Ethernet
Intel XeonEMT64 3.2 GHz	94	Gigabit Ethernet

Software-Configuration Linux-Cluster:

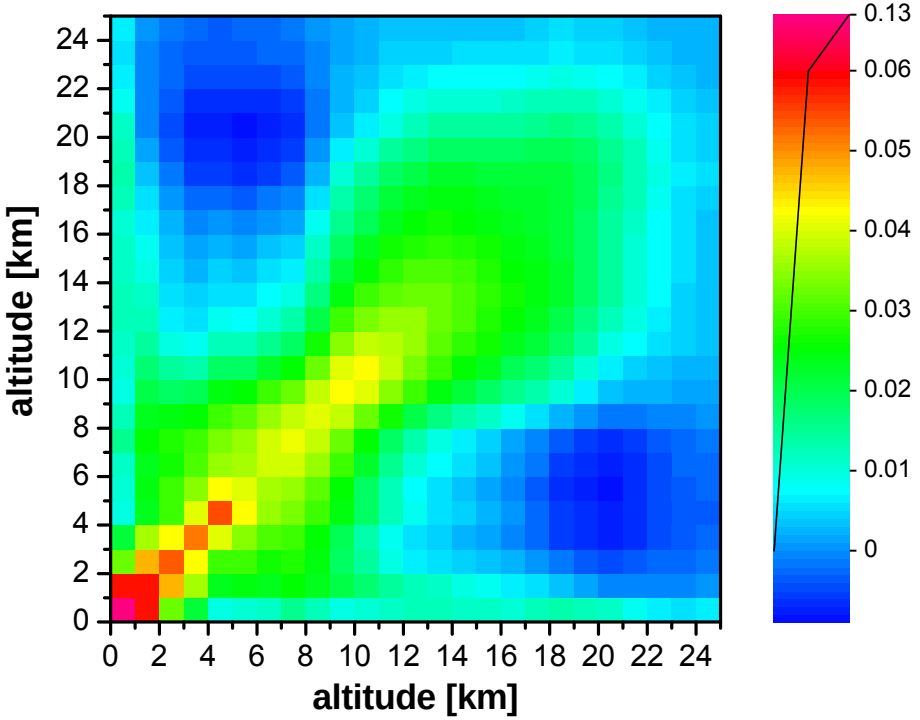
- Compiler:
  - Portland Group C/C++ und Fortran
  - INTEL C/C++ und Fortran
- Parallelisierungsmethoden
  - MPI-CH (MPI Version 1.2 & 2.0)
  - LAM-MPI
  - OpenMP (Shared Memory)
- Job-Verwaltungssystem
  - OpenPBS & Maui

Retrieval of atmospheric profiles: CO

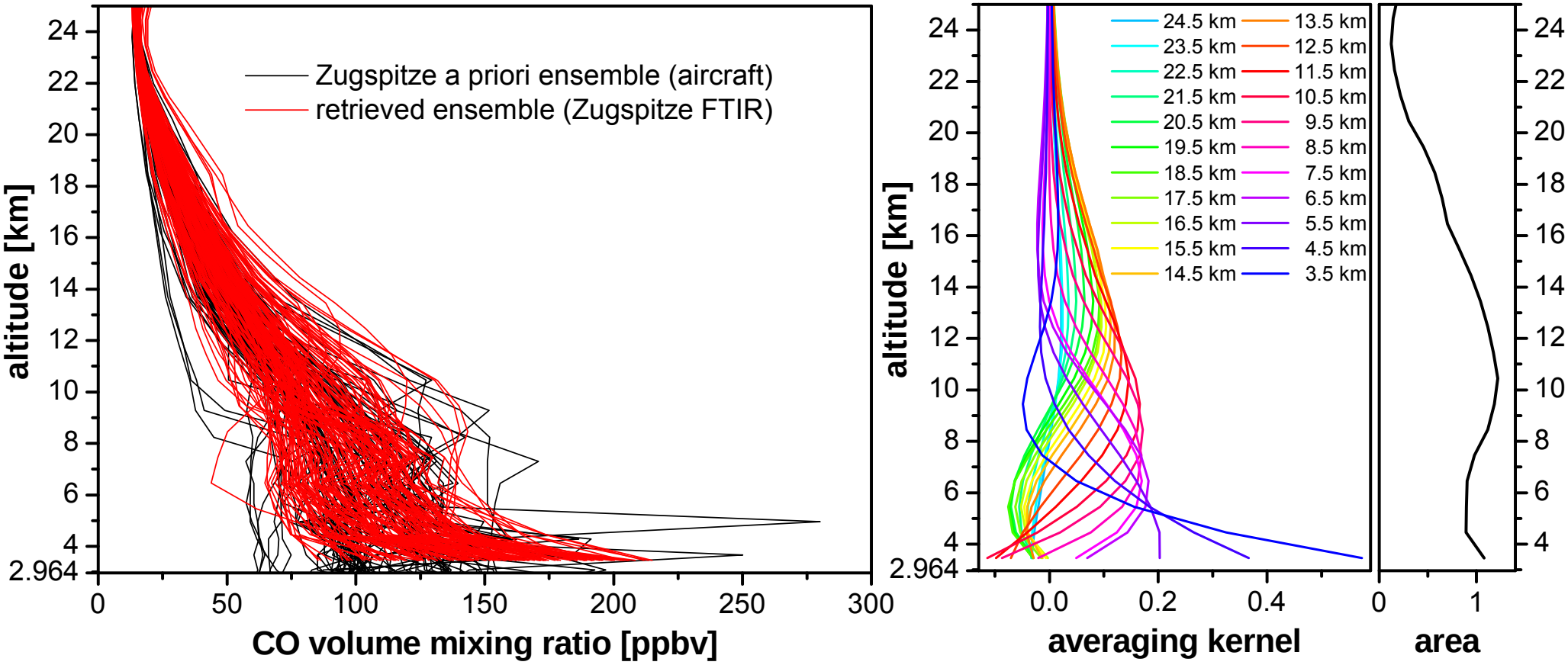
CO a priori
profile ensemble



CO a priori
covariance

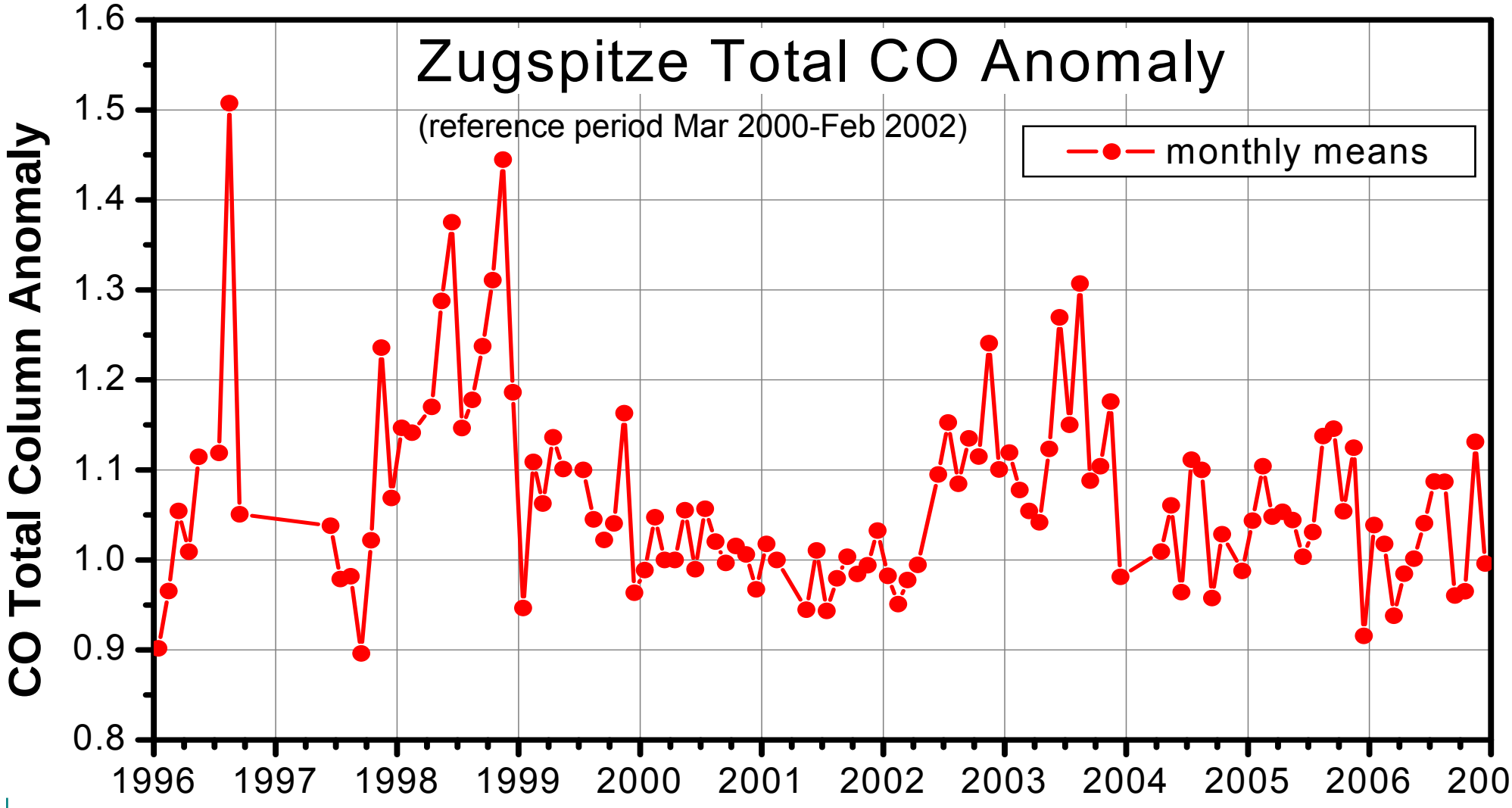


CO profiles from Zugspitze FTIR: Characterization



Research Center Karlsruhe — Ralf Sussmann

IMK-IFU Garmisch-Partenkirchen — Zugspitze Primary Site Report


Zugspitze Total CO Anomaly
(reference period Mar 2000-Feb 2002)
monthly means
CO Total Column Anomaly
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007

Primary Site Report: Zugspitze FTIR

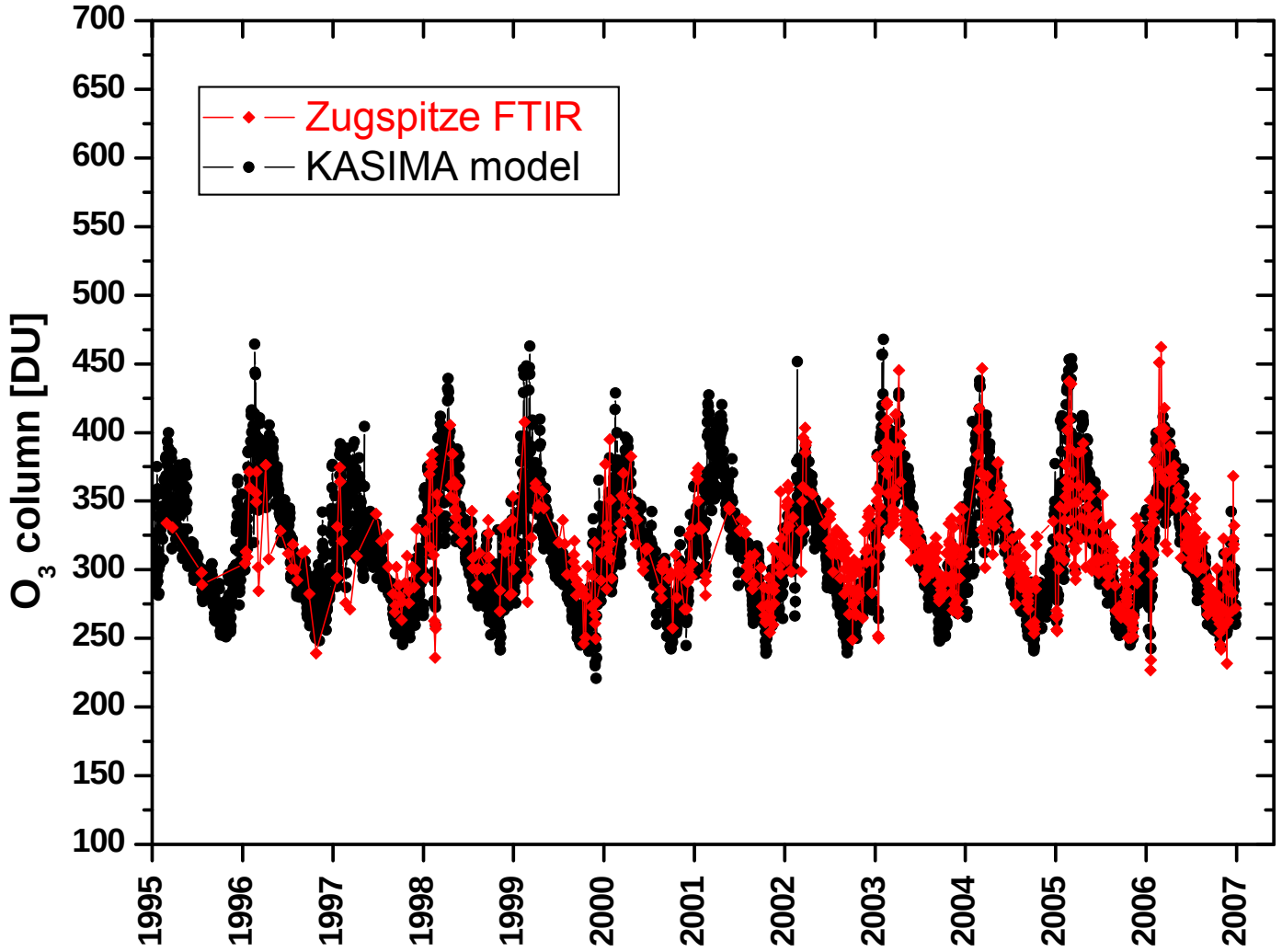
Period(s) covered in data archiving at NDACC DHF: 1995-2005
HF columns: 03/1995 - 08/2005
HCl columns: 06/1995 - 11/2001
$ClONO_2$ columns: 07/1996 - 11/2001
O_3 columns: 07/1995 - 09/2004
N_2O columns: 07/1995 - 09/2004
CH_4 columns: 03/1995 - 09/2004
CO columns: 06/1995 - 08/2005
C_2H_6 columns: 06/1995 - 09/2004

Primary Site Report: Zugspitze FTIR

Name, date, and location of last intercomparison and/or validation:

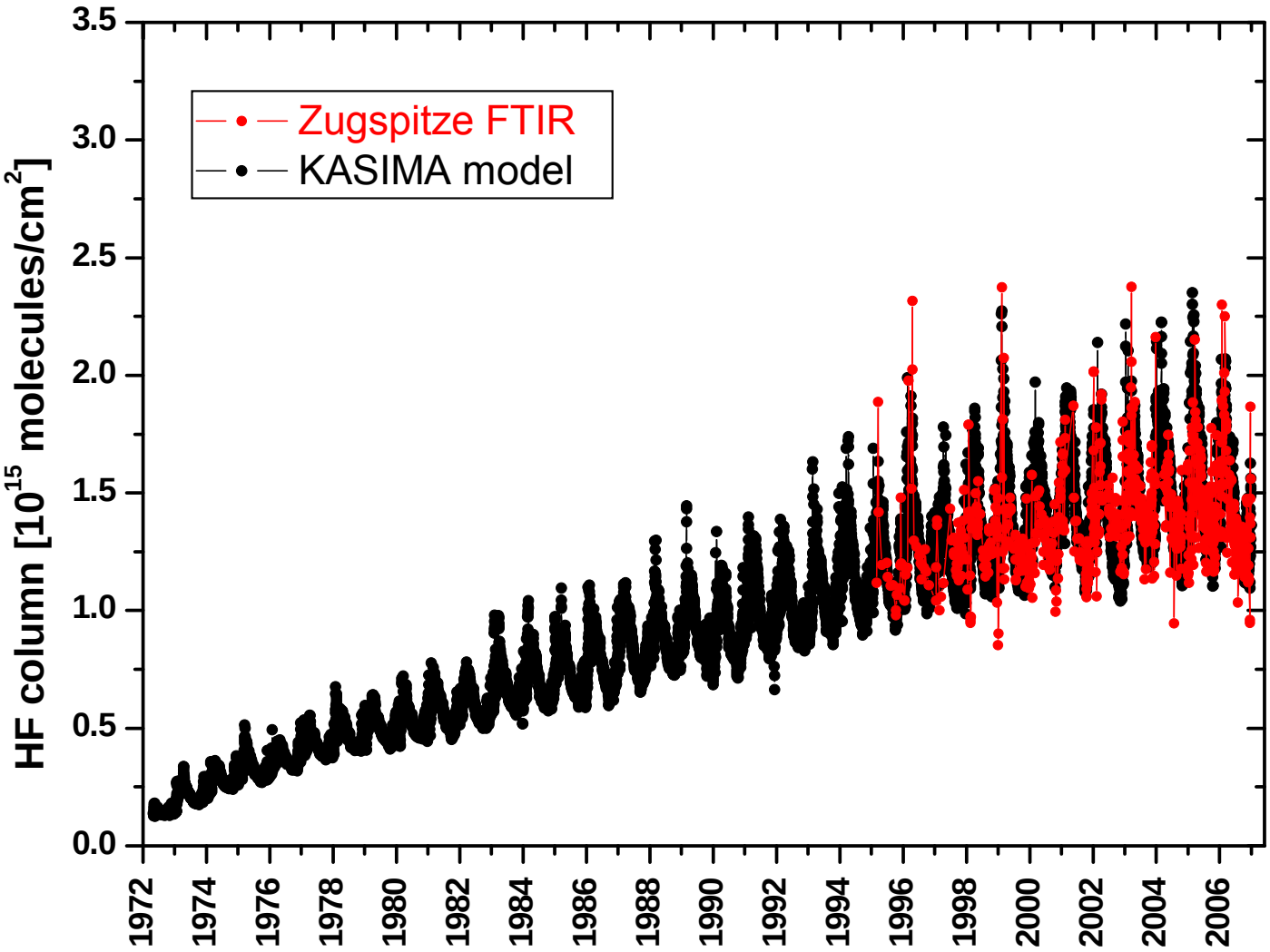
- 1996 intercomparison with Jungfraujoch: coincident measurements and blind independent analyses of HF, HCl. Agreement within 2 per cent
- In 2001 evaluation of the Zugspitze time series since 1995 of HCl and $ClONO_2$, and comparison to the Jungfraujoch series; showed very good overall agreement!
- In 2002 we compared in preparation for ENVISAT Validation columns of N_2O, CO, CH_4, NO_2, O_3 to coincident Jungfraujoch data. E.g., N_2O agreed within 1 %!
- Intense 3 months water vapor validation campaign at Zugspitze (mid Aug – mid Nov 2002) with permanent FTIR water vapor measurements compared to 4 radio sondes launched on site daily and permanent GPS water column measurements on site. Very good agreement of FTIR to sonde columns within a few per cent! Detailed FTIR validation study also relative to GPS measurements performed.
- In spring 2003 comparison of the Zugspitze time series (1996-2002) of CO to the Jungfraujoch series; showed very good overall agreement!
- N_2O trop. columns trend (1995-2004): Zugspitze 0.18 %/yr, Jungfraujoch 0.23 %/yr
- ENVISAT validation: Learned much about precision of CO, CH_4, NO_2 as measured by FTIR
- Comparison of Zugspitze HF, COF_2, HCl and $ClONO_2$ to KASIMA model

Montreal Protocol: O_3 at Zugspitze



KASIMA:
Ruhnke, Wiehle

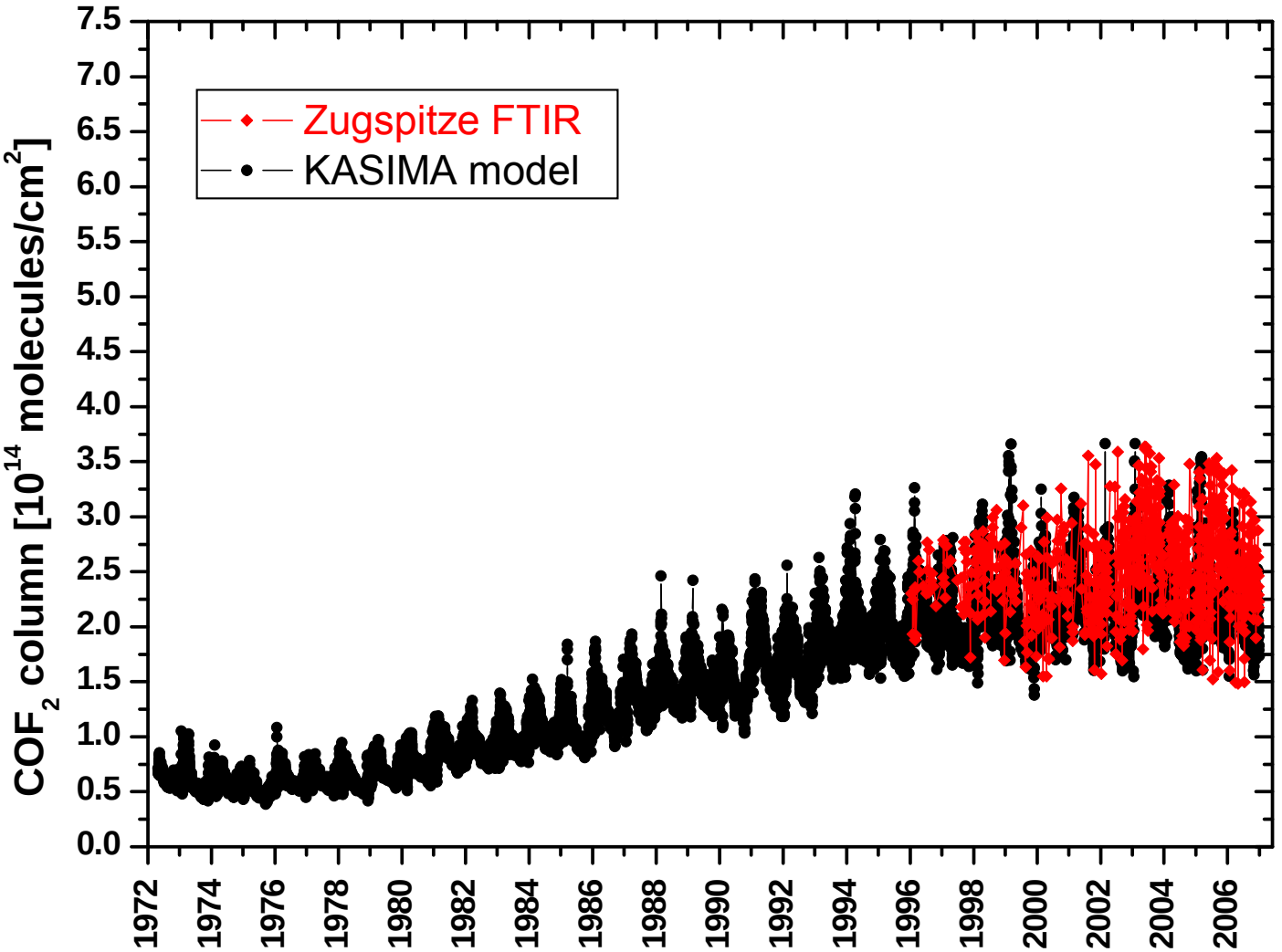
Montreal Protocol (stratospheric F_y): HF at Zugspitze



KASIMA:
Ruhnke, Wiehle

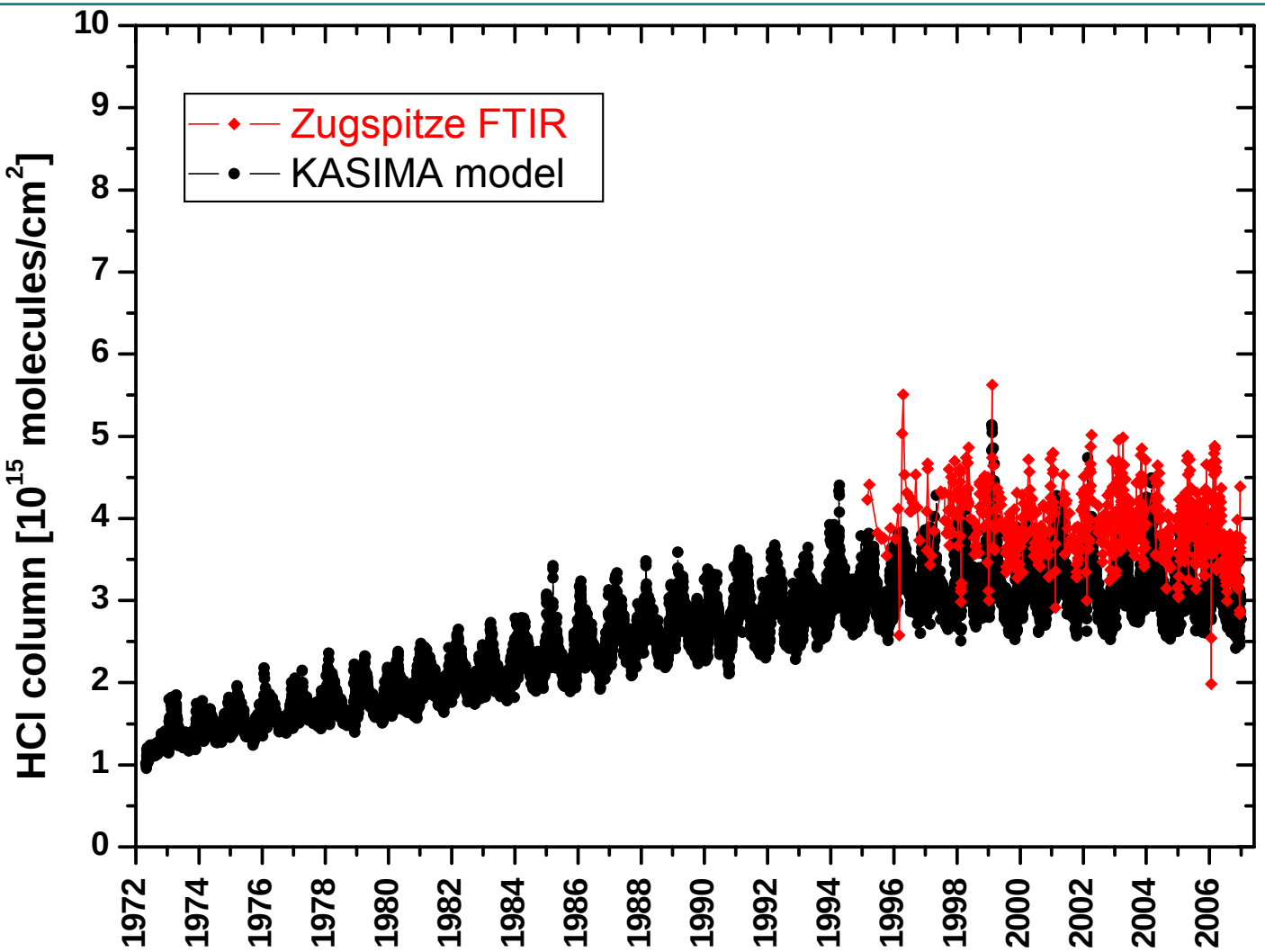
Montreal Protocol (stratospheric F_y): COF_2 at Zugspitze

KASIMA:
Ruhnke, Wiehle



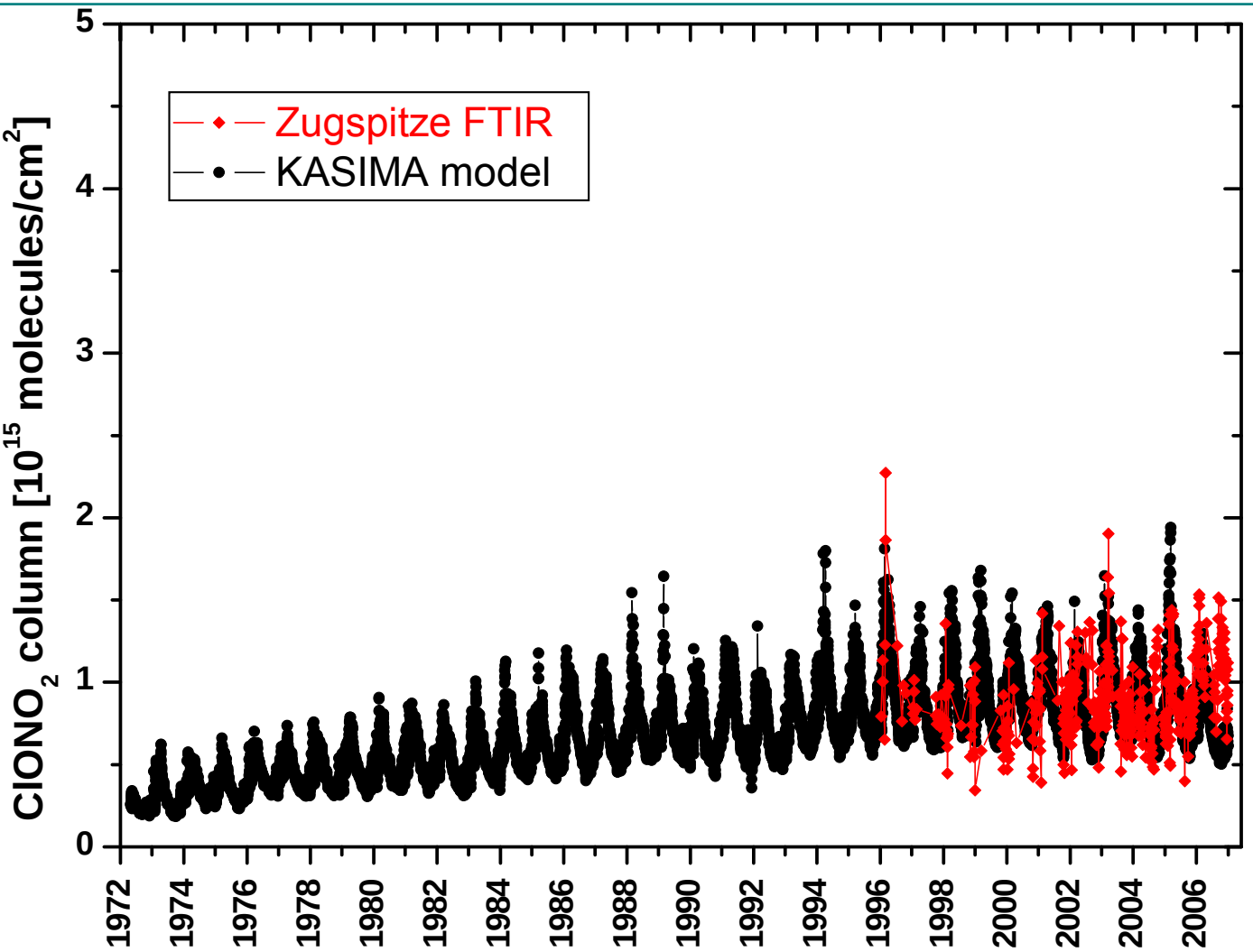
Montreal Protocol (stratospheric Cl_y): HCl at Zugspitze

KASIMA:
Ruhnke, Wiehle



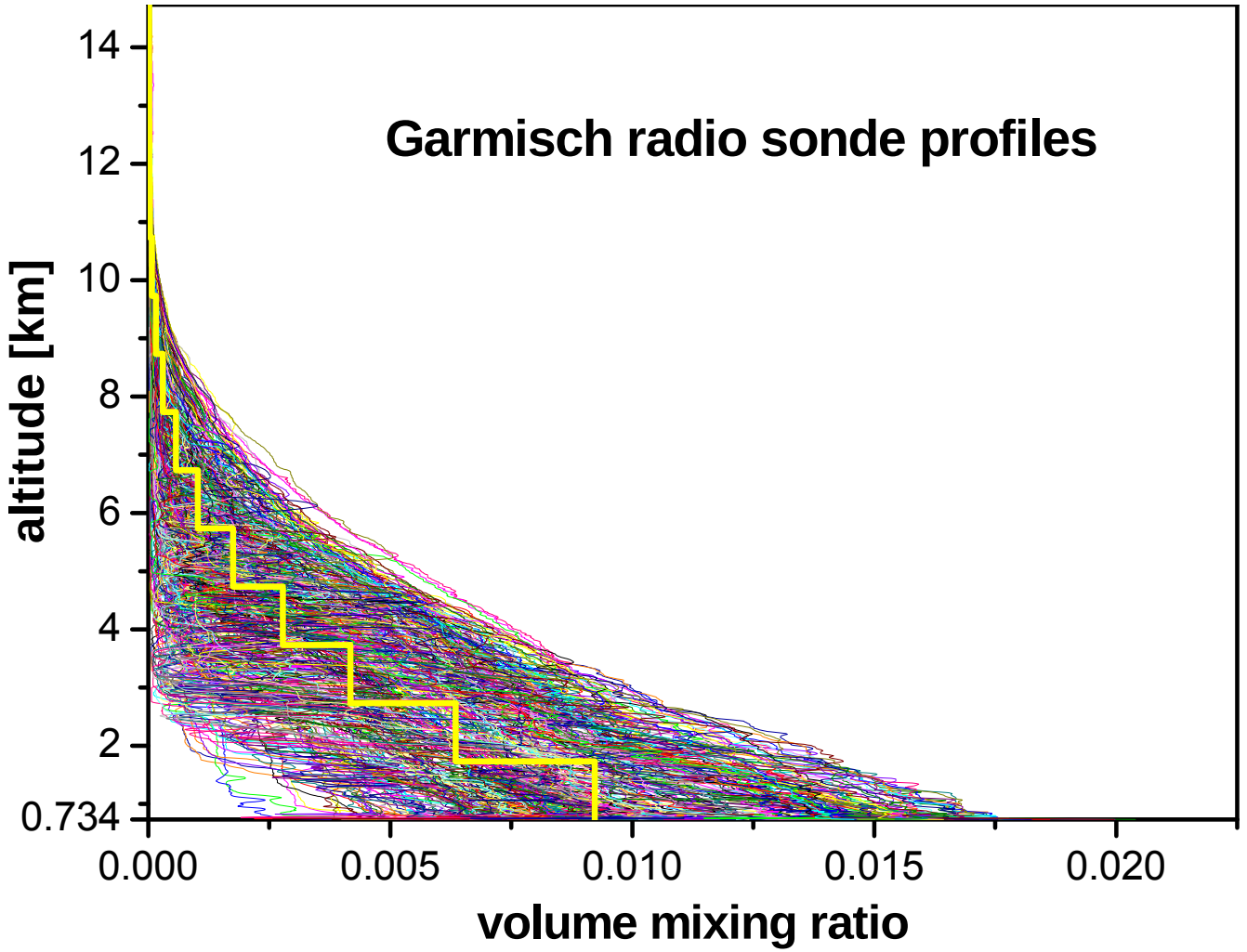
Montreal Protocol (stratospheric Cl_y): $ClONO_2$ at Zugspitze

KASIMA:
Ruhnke, Wiehle



Contribution to NDACC ad hoc group on water vapor (Bern 2006)

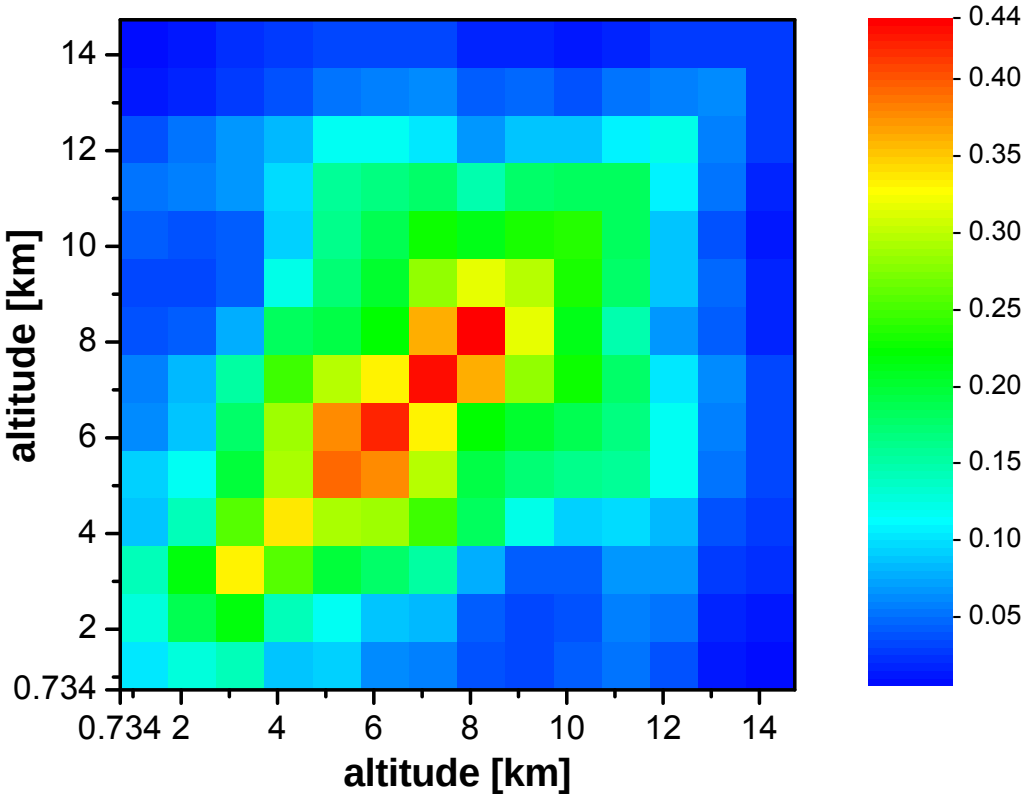
Water vapor profiles with Zugspitze FTIR: A priori information used (I)



Contribution to NDACC ad hoc group on water vapor (Bern 2006)

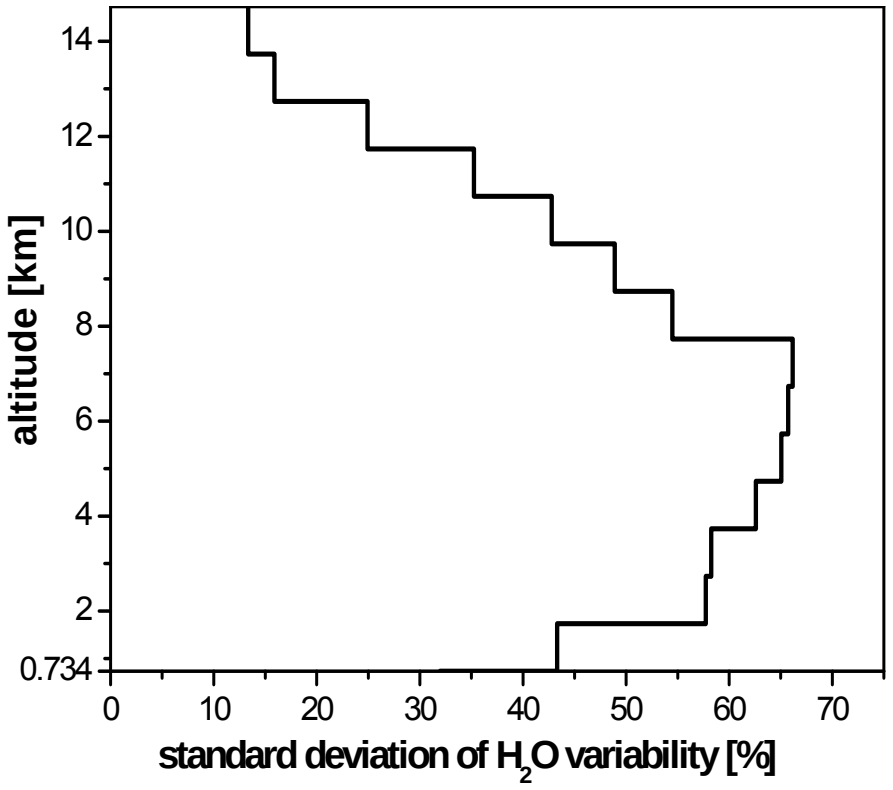
Water vapor profiles with Zugspitze FTIR: A priori information used (II)

water vapor covariance



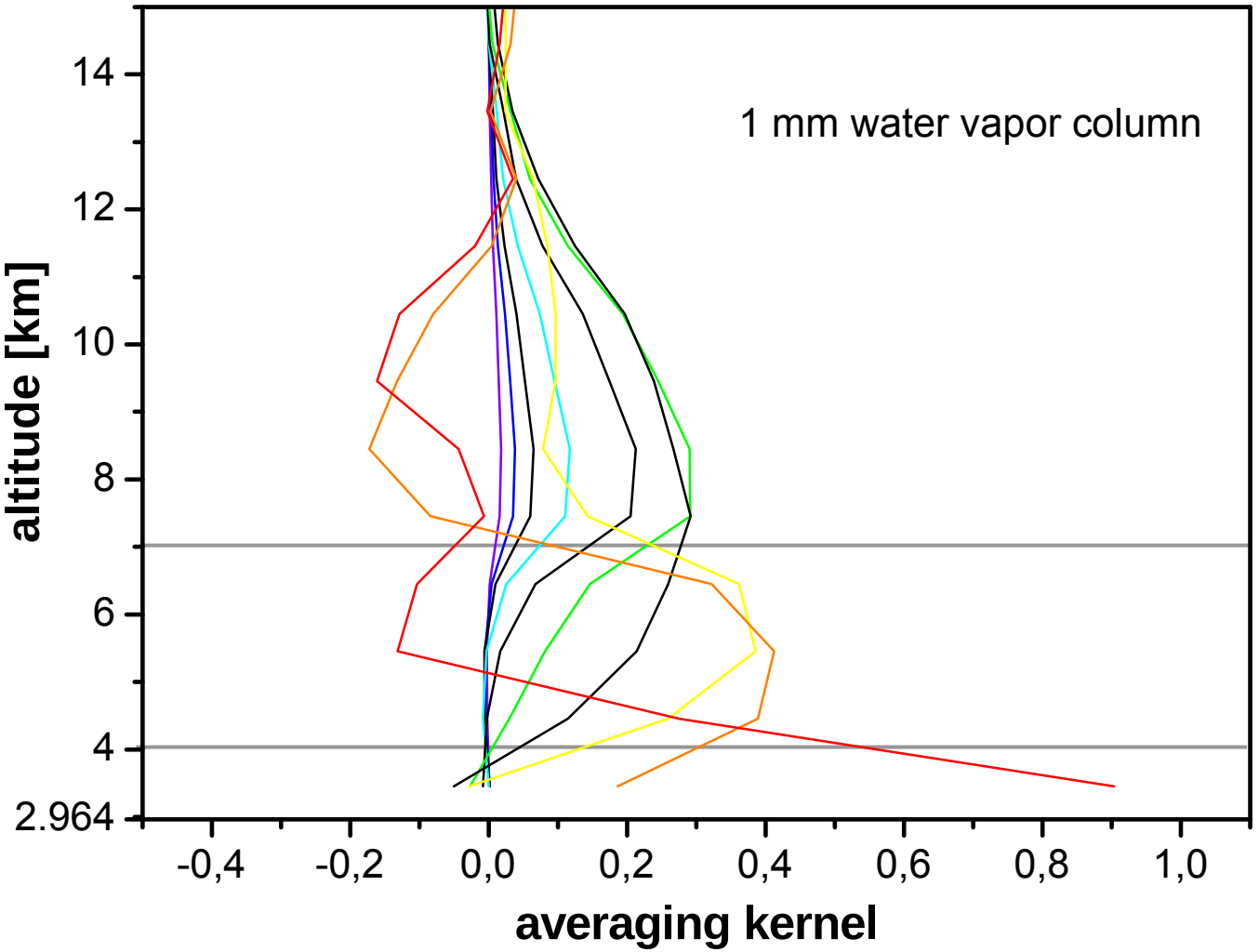
Unit: covariances of VMR-layer scaling factors

water vapor variability (stdv)



VMR

Water vapor profiles with Zugspitze FTIR: Averaging kernels

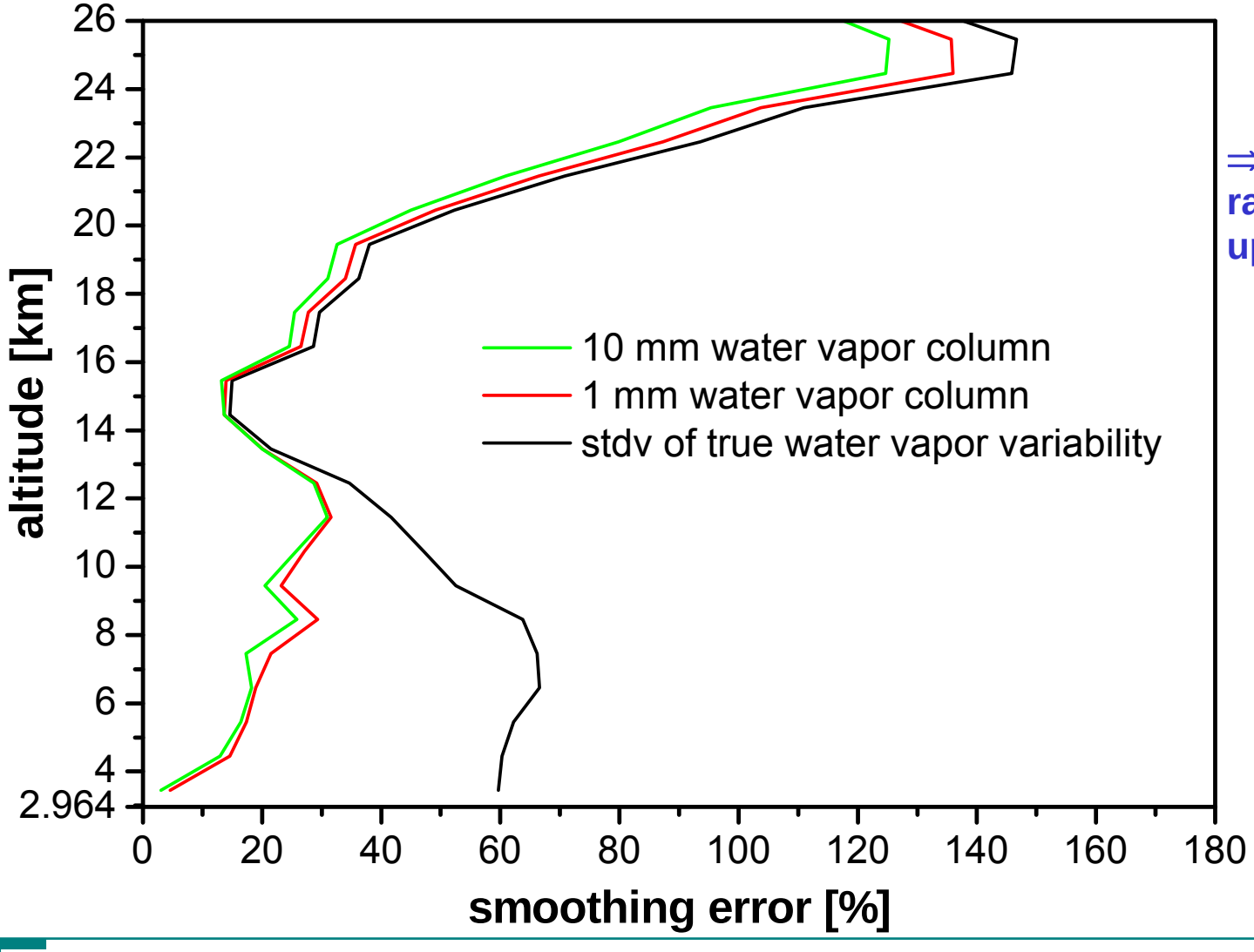


dofs ≈ 3 (snr ≈100)

dofs-1-layers:

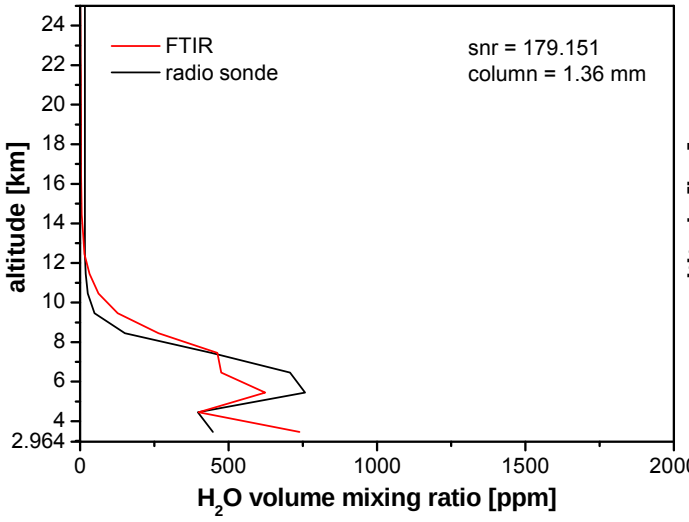
3 - 4 km
4 - 7 km
7 – 15 km

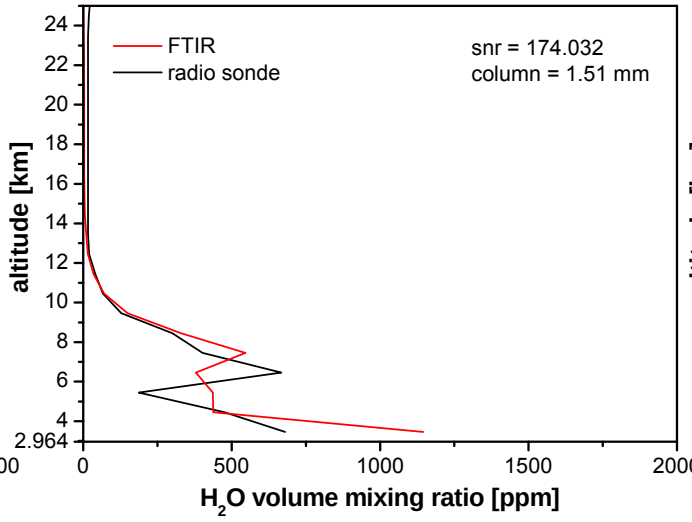
Water vapor profiles with Zugspitze FTIR: Smoothing error

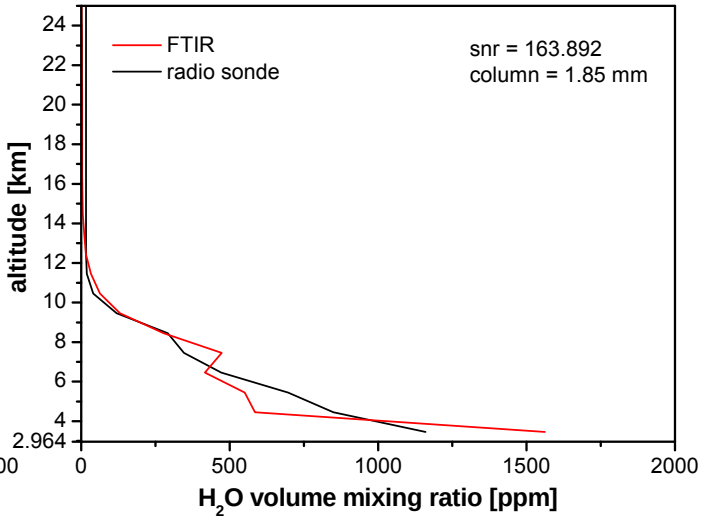


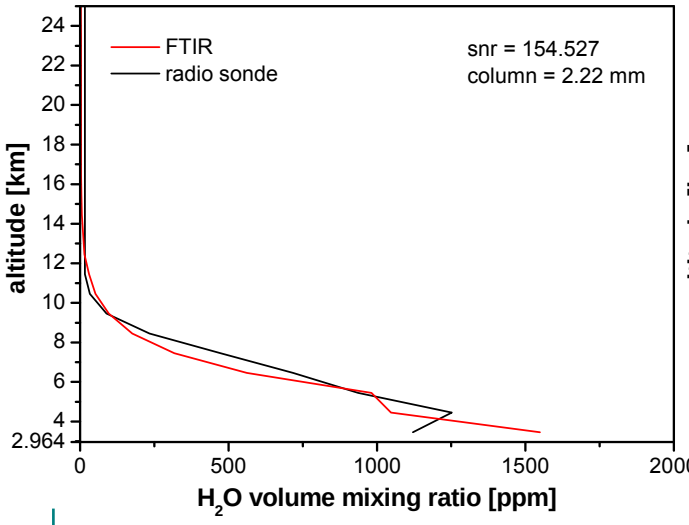
⇒ **Smoothing error / altitude range does not depend upon absolute column level**

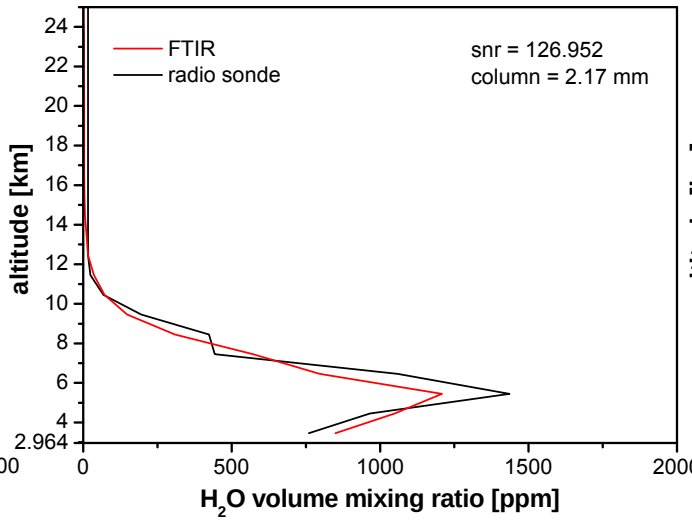
Water vapor profiles with Zugspitze FTIR: Retrieved profile versus sonde

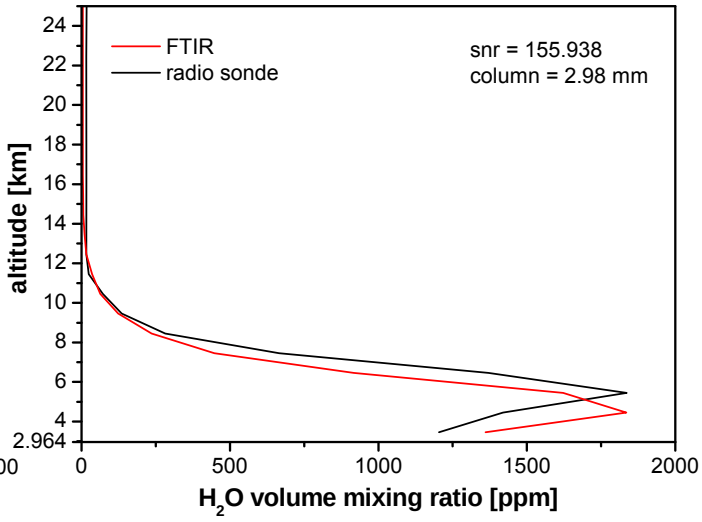








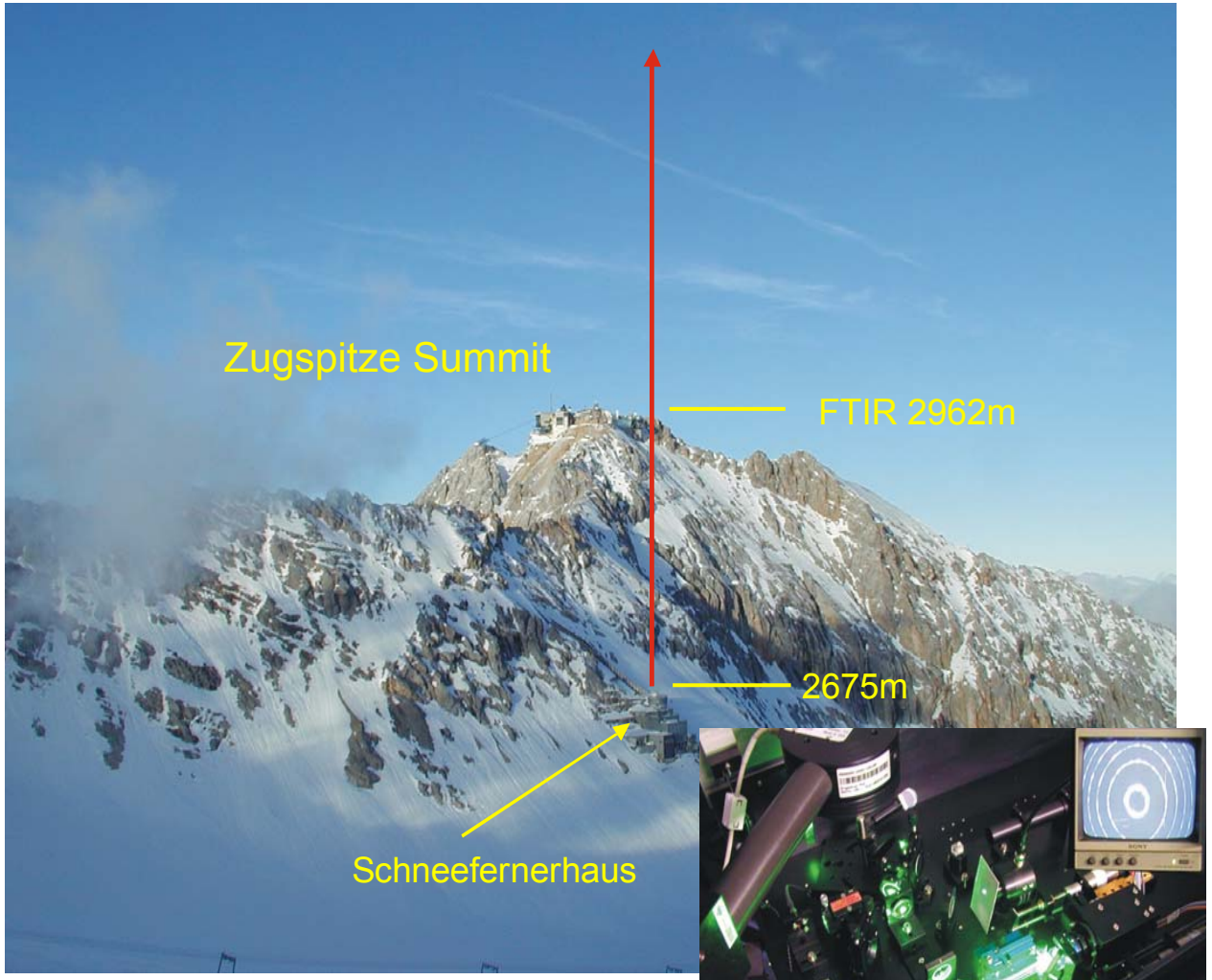




Research Center Karlsruhe **Ralf Sussmann**

IMK-IFU Garmisch-Partenkirchen **Zugspitze Primary Site Report**

Water vapor profiles with Zugspitze FTIR: Synergistic combination with H_2O lidar



Water vapor lidar Zugspitze:
H. Vogelmann, T. Trickl, IMK-IFU

Requirements:
- Range 12km asl. (Tropopause)
- Relative errors less than ca. 5%
- Vertical resolution ca. 50m to 300m
- Measurements at all daytimes

Method:
- Differential absorption LIDAR (DIAL)

Advantages versus Raman-Lidar:
- Daylight capability

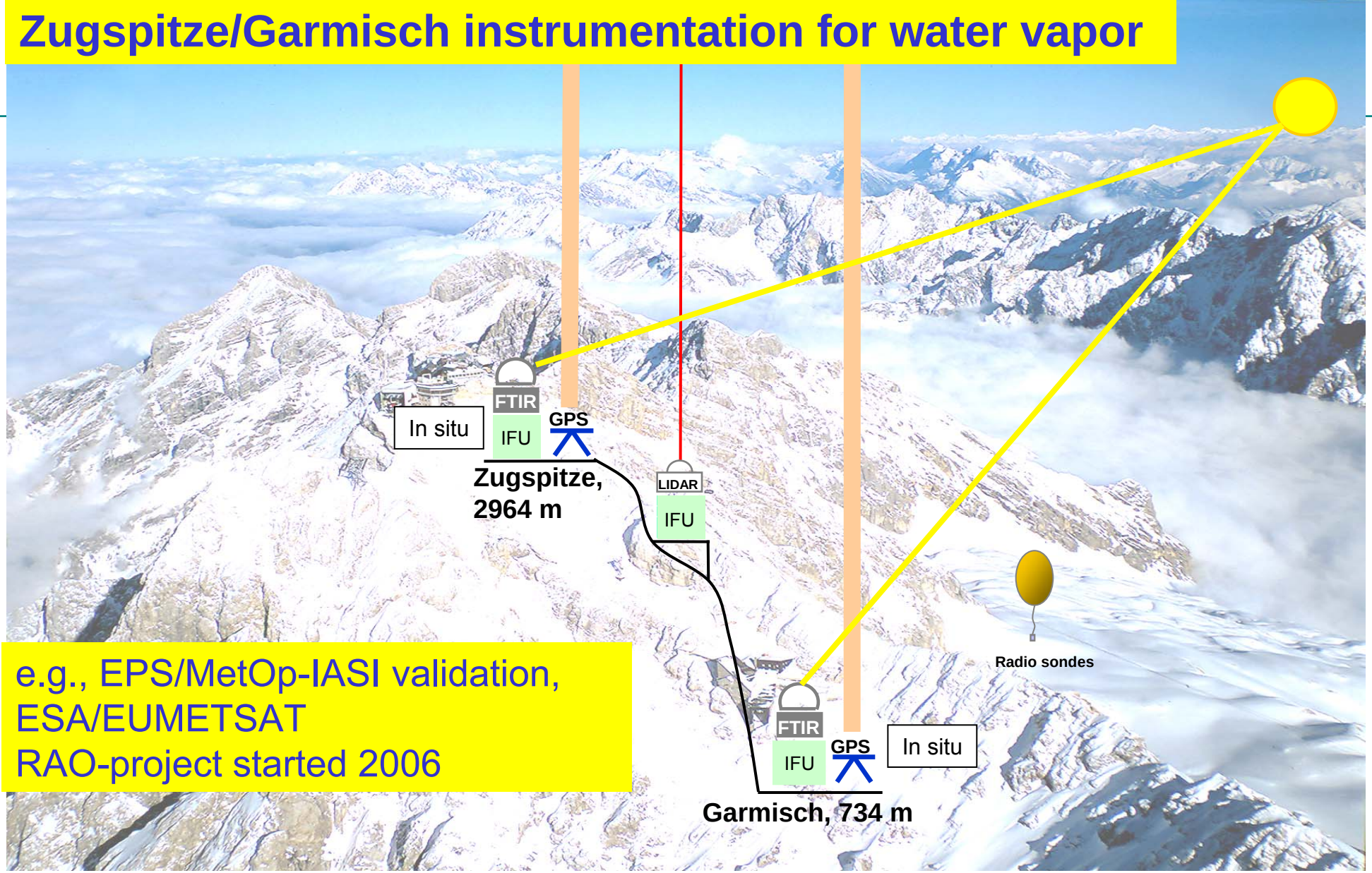
⇒ capture intrusion events without daytime interruptions!

- Selfcalibrating technique

⇒ pre-requisite for trend measurements!

Major challenge:
-High power widely tunable narrow-band laser system had to be developed

Zugspitze/Garmisch instrumentation for water vapor



e.g., EPS/MetOp-IASI validation,
ESA/EUMETSAT
RAO-project started 2006

Primary Site Report: Zugspitze FTIR

Matter(s) that need to be discussed during SC meeting: -

List of publications that appeared during the reporting period:

Dils, B., De Mazière, M., Blumenstock, T., Buchwitz, M., de Beek, R., Demoulin, P., Duchatelet, P., Fast, H., Frankenberg, C., Gloudemans, A., Griffith, D., Jones, N., Kerzenmacher, T., Kramer, I., Mahieu, E., Mellqvist, J., Mittermeier, R.L., Notholt, J., Rinsland, C.P., Schrijver, H., Smale, D., Strandberg, A., Straume, A.G., Stremme, W., Strong, K., Sussmann, R., Taylor, J., van den Broek, M., Wagner, T., Warneke, T., Wiacek, A., Wood, S.: Comparisons between SCIAMACHY and ground-based FTIR data for total columns of CO, CH_4, CO_2 and N_2O, Atmos. Chem. Phys., 6, 1953-1963, 2006.

Sussmann, R. and Borsdorff, T.: Interference errors in infrared remote sounding of the atmosphere, Atmos. Chem. Phys. Discuss., 6, 13027-13073, 2006.

Primary Site Report: Zugspitze FTIR

Funding status (instrument and facility): good

- Permanent 80 % basic funding by Helmholtz Society of German Research Centers
- plus several projects:

1. EC-HYMN (CH_4, N_2O, new 2006)
2. EC-GEOMON (Cl_y, F_y, new 2006)
3. Pole - Equator - Pole (PEP), Variability of atmospheric trace constituents along a North-South Transect (German Helmholtz Society 'Impuls und Vernetzungsfond' for the creation of a virtual institute, ongoing)
4. TASTE (ENVISAT long-term validation, ESA-funded, new 2006)
5. ESA/EUMETSAT project EPS/MetOp-IASI and -GOMEII validation, new, unfunded

Summary – Zugspitze FTIR Primary Site Report

- 141 measurements days/yr, archiving nearly up to date, well funded, 2 papers
- transferred SFIT2-batches to Linux Parallel Processing
- contributed to NDAC ad hoc working group on water vapor (Bern 2006)
- very recently updated Zugspitze CO, O_3, HF, COF_2, HCl, $ClONO_2$ series
- KASIMA model comparison (Cl_y, F_y, O_3) looks fine