Network for the Detection of Atmospheric Composition Change (NDACC)
Primary Site 47 °N, 11 °E, 2964 m a.s.l.
Zugspitze: NDACC
operational since 1995
141 meas. days during last 12 months
O₃, ClONO₂, HCl, HF, COF₂, HNO₃, NO₂,
CO, CH₄, N₂O, C₂H₆, CFC-22, H₂O

Garmisch: TCCON
2004: 94 meas. days
2005: 147 meas. days
2006: 136 meas. days
2007: 42 meas. days
CH₄/O₂, CO₂/O₂
“Differential FTIR” with Zugspitze:
O₃, CO, CH₄, N₂O, C₂H₆, CFC-22, H₂O

Zugspitze 2964 m
Garmisch 734 m
Zugspitze retrievals: SFIT2.39, batches transferred to Linux Parallel Processing

IMK-IFU Linux-Cluster

<table>
<thead>
<tr>
<th>Prozessortyp</th>
<th>knots</th>
<th>communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMD Athlon MP 2200+</td>
<td>24</td>
<td>Myrinet 2000</td>
</tr>
<tr>
<td>Intel Xeon 3 GHz</td>
<td>96</td>
<td>Gigabit Ethernet</td>
</tr>
<tr>
<td>Intel XeonEMT64 3.2 GHz</td>
<td>94</td>
<td>Gigabit Ethernet</td>
</tr>
</tbody>
</table>

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 aircraft profiles

CO a priori covariance

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IMK-IFU Garmisch-Partenkirchen

Ralf Sussmann
Zugspitze Primary Site Report
CO profiles from Zugspitze FTIR: Characterization

Zugspitze a priori ensemble (aircraft) and retrieved ensemble (Zugspitze FTIR)

CO volume mixing ratio [ppbv] vs. altitude [km]

Averaging kernel and area
Zugspitze Total CO Anomaly

(reference period Mar 2000-Feb 2002)

monthly means
### Period(s) covered in data archiving at NDACC DHF: 1995-2005

<table>
<thead>
<tr>
<th>Compound</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF</td>
<td>03/1995</td>
<td>08/2005</td>
</tr>
<tr>
<td>HCl</td>
<td>06/1995</td>
<td>11/2001</td>
</tr>
<tr>
<td>ClONO$_2$</td>
<td>07/1996</td>
<td>11/2001</td>
</tr>
<tr>
<td>O$_3$</td>
<td>07/1995</td>
<td>09/2004</td>
</tr>
<tr>
<td>N$_2$O</td>
<td>07/1995</td>
<td>09/2004</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>03/1995</td>
<td>09/2004</td>
</tr>
<tr>
<td>CO</td>
<td>06/1995</td>
<td>08/2005</td>
</tr>
<tr>
<td>C$_2$H$_6$</td>
<td>06/1995</td>
<td>09/2004</td>
</tr>
</tbody>
</table>
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$_2$O, CO, CH$_4$, NO$_2$, O$_3$ to coincident Jungfraujoch data. E.g., N$_2$O 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$_2$O 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

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Zugspitze Primary Site Report
Montreal Protocol (stratospheric F$_y$): HF at Zugspitze

KASIMA:
Ruhnke, Wiehle

Research Center Karlsruhe Ralf Sussmann
IMK-IFU Garmisch-Partenkirchen Zugspitze Primary Site Report
Montreal Protocol (stratospheric $F_y$): $\text{COF}_2$ at Zugspitze

KASIMA:
Ruhnke, Wiehle

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Montreal Protocol (stratospheric Cl<sub>y</sub>): HCl at Zugspitze

KASIMA: Ruhnke, Wiehle

HCl column [10<sup>15</sup> molecules/cm<sup>2</sup>]


Zugspitze FTIR
KASIMA model
Montreal Protocol (stratospheric Cl\textsubscript{y}): ClONO\textsubscript{2} at Zugspitze

KASIMA: Ruhnke, Wiehle
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)

Unit: covariances of VMR-layer scaling factors

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Zugspitze Primary Site Report
Water vapor profiles with Zugspitze FTIR: Averaging kernels

1 mm water vapor column

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

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Zugspitze Primary Site Report
Water vapor profiles with Zugspitze FTIR: Retrieved profile versus sonde

*Graphs showing water vapor profiles with Zugspitze FTIR.*

- **FTIR** vs **radio sonde**
- **snr** values: 179.151, 174.032, 126.952, 179.151, 154.527, 126.952, 163.892, 155.938
- **Column** values: 1.36 mm, 1.51 mm, 2.17 mm, 1.36 mm, 2.22 mm, 2.17 mm, 1.85 mm, 2.98 mm

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**IMK-IFU Garmisch-Partenkirchen**

**Ralf Sussmann**
**Zugspitze Primary Site Report**
Water vapor profiles with Zugspitze FTIR: Synergistic combination with $\text{H}_2\text{O}$ 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

<table>
<thead>
<tr>
<th>Matter(s) that need to be discussed during SC meeting:</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of publications that appeared during the reporting period:</td>
<td></td>
</tr>
</tbody>
</table>


Funding status (instrument and facility):  good
- Permanent 80% basic funding by Helmholtz Society of German Research Centers
- plus several projects:
  1. EC-HYMN (CH₄, N₂O, new 2006)
  2. EC-GEOMON (Clᵧ, Fᵧ, 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
• 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, O₃, HF, COF₂, HCl, ClONO₂ series
• KASIMA model comparison (Clₓ, Fₓ, O₃) looks fine