FTIR sites

Kiruna, Sweden, 1996
Izaña, Spain, 1999
Altzomoni, Mexico, 2012
Karlsruhe, Germany, 2009
Addis Ababa, Ethiopia, 2009
Annual Group Meeting of IRWG

• June 10-12 at Abashiri, Japan
  including visit to Rikubetsu station
• Joined with TCCON meeting, June 13-14
• Participants: ~ 60
• Science talks, site reports and posters
Canditate Stations

- Syowa Station, Antarctica (69.0°S, 39.6°E)
  - Instrument operable, intermittent observations
  - Hideaki Nakajima, NEIS

- Altzomoni, Mexico (19.11°N, 98.65°W, 4000m a.s.l.)
  - Instrument operable
  - Michel Grutter, UNAM
  - Certification in process, Referee: M. Coffey, NCAR
Stations Communicating with IRWG

• Anmyeondo, South Korea (69.0°S, 39.6°E)
  – Instrument operable (Bruker 125 HR)
  – Primary TCCON, possibly NDACC
• Kourovka, Russia (57.0°N, 59.6°, 295m a.s.l.)
  – New instrument: Bruker 125 M
  – Primary TCCON, possibly NDACC
• Tomsk, Russia (56.50°N, 84.97°E)
  – Instrument originally for lab work (Bruker 125 HR)
  – Solar tracker added recently
• St. Petersburg, Russia (59.55°N, 30.15°E)
  – Instrument operational (Bruker 120 HR)
  – Data analysis is ongoing
• Addis Ababa, Ethiopia (8°59′N, 38°48′E)
  – Instrument operable (Bruker 120 M)
  – PI (Dr. Gizaw Mengistu) is visiting KIT for 1 year
Science Highlights

• Stratospheric ozone trends

• Recent HCl increase!? 

• MUSICA: Tropospheric water vapor isotopologues at ten globally distributed NDACC sites: current FTIR dataset \( \approx 15000 \) observations, to be archived on NDACC data base

• Emission factors of biomass burning products
Ozone trends

Mid-latitude stations: all

- **Trends in %/decade**

<table>
<thead>
<tr>
<th>Station</th>
<th>Period</th>
<th>Total column</th>
<th>Lower strato.</th>
<th>Middle strato.</th>
<th>Upper strato.</th>
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<tbody>
<tr>
<td><strong>Jungfrau.</strong></td>
<td>1995-2012</td>
<td>-0.8±1.7</td>
<td>-1.5±3.8</td>
<td>-0.8±1.3</td>
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<td>QBOs, AO, EP</td>
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<td>QBOs, AO, EP</td>
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<td><strong>Lauder</strong></td>
<td>2001-2012</td>
<td>-0.8±2.0</td>
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</table>

- At the 3 stations, the total columns trends are non significant.
- The 1-2% positive trends in upper strato. is also seen in Lidar and satellite data in both Hemispheres (WMO 2010).
- The uncertainty of the total column trend at Lauder is very good for a short time-series.

*C. Vigouroux et al., NDACC-IRWG, 2013*
## Ozone trends

### North. high-latitude stations

#### Trends in %/decade

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<th>Station</th>
<th>Period</th>
<th>Total column</th>
<th>Lower strato.</th>
<th>Middle strato.</th>
<th>Upper strato.</th>
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<td>Ny-Alesund</td>
<td>1995-2012</td>
<td>-3.1±2.9</td>
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<td>QBO, EP</td>
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<td>Thule</td>
<td>1999-2012</td>
<td>-2.0±3.2</td>
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<td>0.8±5.9</td>
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<td>QBOs, EP</td>
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<td>Kiruna</td>
<td>1996-2012</td>
<td>-0.2±1.7</td>
<td>-2.6±3.0</td>
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<td>QBOs, TPs</td>
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<td>Harestua</td>
<td>1995-2012</td>
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<td>QBO, TP</td>
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- Significant positive trends in the upper strato. only for the period starting in 1995: **ozone recovery** or **unexplained ozone increase in the 1995-1999 period**? Kiruna 99-12: 2.7±4.9%/dec.
- Ny-Alesund total columns and middle strato. trends do not agree with other stations: due the **sampling** (March-Sept. Only; fewer data)?
- **Ozone-sondes** from R. Kivi show non significant trend in lower strato.

*C. Vigouroux et al., NDACC-IRWG, 2013*
Deseasonalized total columns at Kiruna

- Example of VPSC effect: Kiruna total columns
- Trend 96-2009:
  - Simple model: $-0.4 \pm 3.6\% / \text{dec}$.
  - only QBOs, TPs: $+0.3 \pm 2.3\% / \text{dec}$.
  - Plus VPSC: $-0.8 \pm 2.1\% / \text{dec}$.
- This inter-annual variability correlates with tropopause pressure and QBO variabilities.

C. Vigouroux et al., NDACC-IRWG, 2013
HCl stratospheric columns above Jungfraujoch

- Mean levels at the end of 2011 = those of early 2002
- But short time period of only 5 years...

P. Demoulin et al., NDACC-IRWG, 2013
MUSICA

NDACC / FTIR long-term data set

H₂O

δD

M. Schneider et al., AMT, 2012
MUSICA
Network-wide consistency

Satisfactory network-wide consistency

Validation campaign with airborne and g-b. in-situ meas. on Canary I. in August this year

MUSICA data → NDACC data archive !?
Simultaneous increase of CO, HCN and C$_2$H$_6$ in August 2010

HCN total columns are enhanced by more than 50% compared to the four-year (2008-2011) monthly mean for August measurements.
Wildfires reached around five million hectares by early August 2010.

Smoke extended over about 3,000 km (from east to west).

Sometimes reached altitudes of 12 km.

C. Viatte, NDACC-IRWG, 2013
Estimating emissions – case study

For all 2010

a) $\text{C}_2\text{H}_6$ vs. CO

For August 2010

b) $\text{C}_2\text{H}_6$ vs. CO

R = 0.94
$R^2 = 0.88$

$y = 0.0103x - 4.89E15$
N = 58

c) HCN vs. CO

d) HCN vs. CO

R = 0.85
$R^2 = 0.73$

$y = 0.0059x - 2.91E15$
N = 61

C. Viatte, NDACC-IRWG, 2013
<table>
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<tr>
<th>Platform</th>
<th>Vegetation type</th>
<th>EF(_{\text{CO}})</th>
<th>EF(_{\text{x}})</th>
<th>ER(_{\text{x}})</th>
<th>HCN</th>
<th>C(_2)H(_6)</th>
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<td>This study</td>
<td>ground-based</td>
<td>127 ± 45</td>
<td>107 ± 37</td>
<td>0.0108 ± 0.0036</td>
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<td>113 ± 72</td>
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<td>86 ± 17</td>
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<td>0.26 ± 0.11</td>
<td>0.43 ± 0.22</td>
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C. Viatte, NDACC-IRWG, 2013
Technical Highlights 1

• Improved CH4 spectroscopy being developed
• Improved ILS monitoring & offer to validate sealed HBr cells with refillable N2O cell (Hase, AMT, 2012)
• Ongoing MIR versus NIR comparison
  – CH4 : Sussmann et al 2012
  – CO : Christoff ___?? In process
  – CO2, N2O, HF ... ?
• Continued validation/satellite comparisons
• IRWG / NORS SFIT4 & Error Analysis workshop
Technical Highlights 2

- New instrumentation:
  - AERI emission low-resolution FTS
  - Compact Low-resolution FTIR for CO$_2$ & CH$_4$ total column
  - InSb / InGaAs High-resolution FTS


- Line Parameters- dynamic listing
  - Web-based wiki (bugzilla) for community updates
  - Linelist Meister – Geoff Toon / JPL
  - ~common linelist for mir/nir (IRWG/TCCON)
  - HITRAN 2012 testing in process
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Profile
Column
Typical Uncertainty
Column should be profile

(column)
IRWG/NORS Error Analysis & SFIT-4 Workshop 1

• 12 IRWG members / attendees
  – U. Wollongong, NEIS, BIRA, U Liege, U Toronto, KIT-Garmisch, U. Bremen, NCAR
  – Jan 28 – Feb 1 2012, Boulder, CO, USA

• Activities
  – Expand / generalize error sources into error budget
    • Enhance core data processing algorithm
    • Define error algorithm
  – Provide common data processing environment
    • Large dataset analysis codes
    • Core retrieval code
    • Error analysis code
    • HDF production
  – Improve cohesive operational expertise across network
  – Release preliminary versions
  – Expand documentation
IRWG/NORS Error Analysis & SFIT-4 Workshop 2

• Follow on meeting after IRWG, NEIS Jun2 17-19 2013
• 17 attendees
• Release beta versions
  • Core / error analysis / processing environment
• Create web interface / access
  • Sfit / Retrieval wiki
  • https://wiki.ucar.edu/display/sfit4/Infrared+Working+Group+Retrieval+Code,+SFIT
• Bug reporting (bugzilla)
• Version control (git)
Case Study 3: Ground-based CH₄

One of three mid-IR windows used to retrieve CH₄ from the ground. Large residuals seen at 2603.3 and 2603.4 cm⁻¹ under humid conditions. Residuals can reach 1.5% at low airmass and 10% at high airmass. Shape of residuals, and their variability suggest water vapor. Also, CH₄ line at 2601.93 cm⁻¹ has wrong shape (width problem?)
Adding extra HDO lines fixes the problem. Other large residuals due to D$_2$O, which are not a problem for atmospheric observations.

Residuals seen in fits of atmospheric spectra at 2603.3 and 2603.4 cm$^{-1}$ also seen in D-enriched lab spectra, implying that missing lines are HDO.

HITRAN 2008 + Toth’s D$_2$O

Toth 2003 + Toth’s D$_2$O + extra empirical HDO lines
Addition of missing HDO lines improves spectra fits by factor 2.5, under humid conditions & changes retrieved CH$_4$ by up to 3%. Since atmospheric HDO is highly variable, the missing lines make the retrieved CH$_4$ seem noisy.

Addition of the missing HDO lines completely fixes residuals in fits to atmospheric solar spectra.
Compact CO$_2$ Total Column

The players

- U. Bremen – Petri, Notholt
  - FTS, Bruker IFS 66 0.1 cm$^{-1}$ benchtop FTS
- KIT Karlsruhe (1) – Hase, Blumenstock, Gisi
  - FTS, 0.5 cm$^{-1}$ Bruker EM27, portable, cam tracker
- KIT Karlsruhe (2) – Butz. Hase et al.
  - Robust, small grating spectrometer
- UoW/Vipac – Jones, Griffith, O’Brien
  - FTS, 0.5 cm$^{-1}$ Bruker IR cube, fibre optic coupling to small tracker
  - Fibre Fabry-Perot Interferometer (FFPI) development
- Harvard U. – Chen
  - FTS (status unknown)
- Univ. Kyoto – Kawasaki, Inoue, Ibuki
  - Low res Optical Spectrum Analyser
  - FFPI
- UNSW – Bailey
  - FFPI
M. Gisi, F. Hase et al., AMT 2012: Modified EM27 Bruker®-spectrometer

- RockSolid™ pendulum FTIR-Spectrometer
- Resolution: 0.5 cm⁻¹ (single sided IFGs)
- RT-InGaAs-Detector
- ~3 mm beam diameter used (of available 40mm)
- 35 x 40 x 27 cm
- Weight: 25 kg incl. tracker
FTIR Karlsruhe: Measurements of CO$_2$ with a table-top FTIR: Modified Bruker EM27 compared with 125HR

Instrument commercially available since this year

M. Gisi, F. Hase et al., AMT 2012
Conclusion of low-resolution instrument

- Excellent agreement with TCCON *
  - Whole time series: 0.12% ± 0.08%
  - Mean daily scattering: 0.05%

*: EM27 spectra analysed with PROFFIT

- Our instrument suited for high precision CO₂ measurements (note: no scanner wear!)

Outlook:
- Well suited for areas with few infrastructure
- Measurement campaigns (sources of CO₂)
- Commercialization by Bruker in 2013

M. Gisi, F. Hase et al., AMT 2012
XCO2(O₂) for Okt. 15\textsuperscript{th} 2011

Difference of daily means = 0.13%

St.Dev. = 0.53 <> 0.86
UNDER DEVELOPMENT: robust grating spectrometer for campaign purposes and harsh environments

Breadbord model #1: conventional Czerny-Turner

Breadbord model #2: Si-immersed grating

F. Klappenbach, F. Hase, A. Butz – RemoteC @ KIT
UoW - FTS

- Bruker 0.5 cm\(^{-1}\) IRcube FTS
  - Quartz beamsplitter, InGaAs detector
  - Solar feed from TCCON tracker or 20m fibre

N. Jones et al.
## Publications Summary 2013

### Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Pubs</th>
<th>Sites or Group Included</th>
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### Retrieval Technique

- Solar Tracking
- Calibration

### Unique publications from Group 18
Actions, funding, summary

• Eureka – renewed funding

• Lauder / Arrival Heights:
  – 1 (maybe 2) new observation scientist positions at Lauder
  – Likely support for 125 HR at Arrival Heights

• Wollongong
• end
AERI deployed systems
Worldwide network

Canada
Eureka
U. of Toronto

Canada
U. of Manitoba

USA (2)
U. Of Wisconsin

USA
U. of Cal

USA (3)
SGP + AMF1
DOE/ARM

USA (2)
NASA Goddard
UMBC

USA (3)
U. of Miami

Antarctica
U. of Idaho

Germany (3)
IMK-IFU + U. of Köln

Italy
Basilicata U.

South Korea
KMA

Australia
Bureau of Metrology

Built by
ABB

1st & 2nd Generation

2nd Generation

3rd Generation

4th Generation

Image: ABB Bomem
HCl Total Columns above Thule (76°N)

- June, July & August column values only: Excluding highly variable year-to-year Arctic Spring measurements
  - 2001 – 2007: -0.9%/y
  - 2007 – 2011: +1.8%/y
## Trends in %/yr

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## Publications Summary 2012

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*Unique publications from Group ~26*
Fitted a KP lab H$_2$O spectrum measured in Jan1986 at 4 Torr and 24C. **Left panel** shows several lines missing from HITRAN 2008 in this region. **Right panel** shows fits using HDO linelist empirically adjusted/supplemented with several new lines. Note change in residual scale 12% $\rightarrow$ 6 % peak.