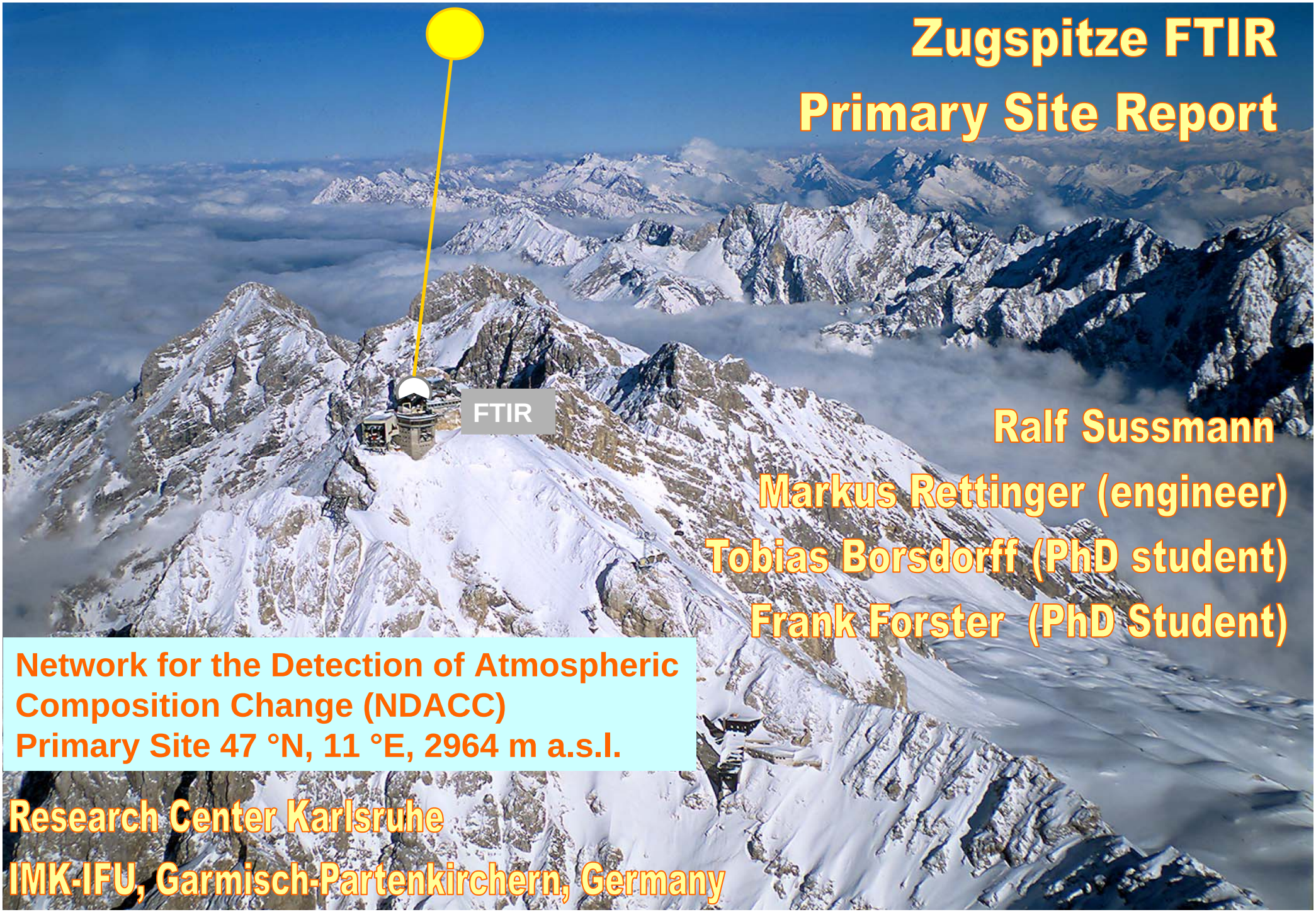


Zugspitze FTIR
Primary Site Report

Ralf Sussmann
Markus Rettinger (engineer)
Tobias Borsdorff (PhD student)
Frank Forster (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
138 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: 140 meas. days
2008: 45 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

Research Center Karlsruhe **Ralf Sussmann**

Rettinger bitte eintragen

IMK-IFU Garmisch-Partenkirchen **Zugspitze Prin**

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

Will archive our updates as soon as new data base format will have been fixed:

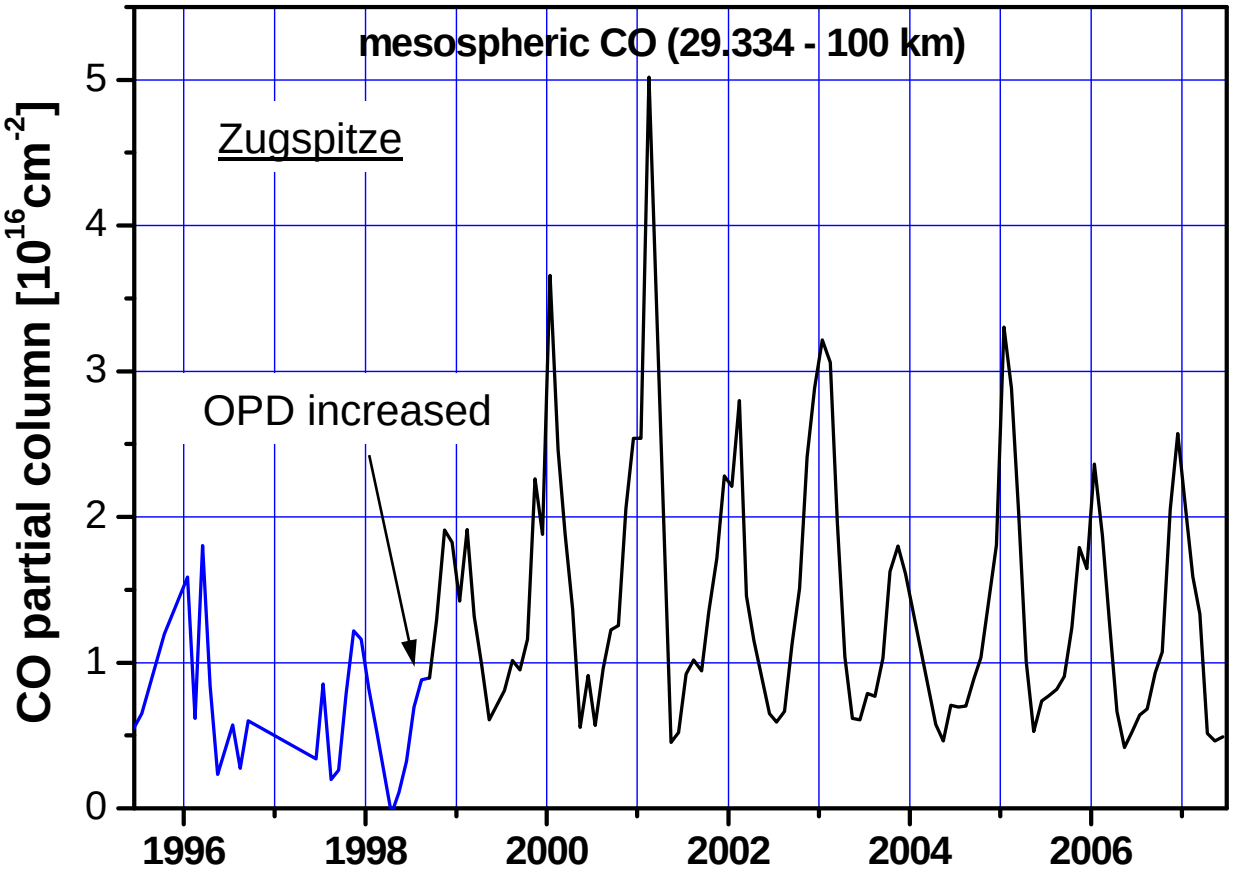
very recently updated Zugspitze CO, O3, HF, COF2, HCl, ClONO2, and CH_4 series

Research Center Karlsruhe **Ralf Sussmann**

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

Mesospheric CO at Zugspitze: For the first time observed above mid latitudes

Mesosph. CO-annual cycle - Velazco et al., ACP 2007: „We showed in this study that this feature is generally not observed in mid-latitude stations.“



Meso-CO detectability is a question of spectral resolution and regularization setting ($R=S_a^{-1}$)

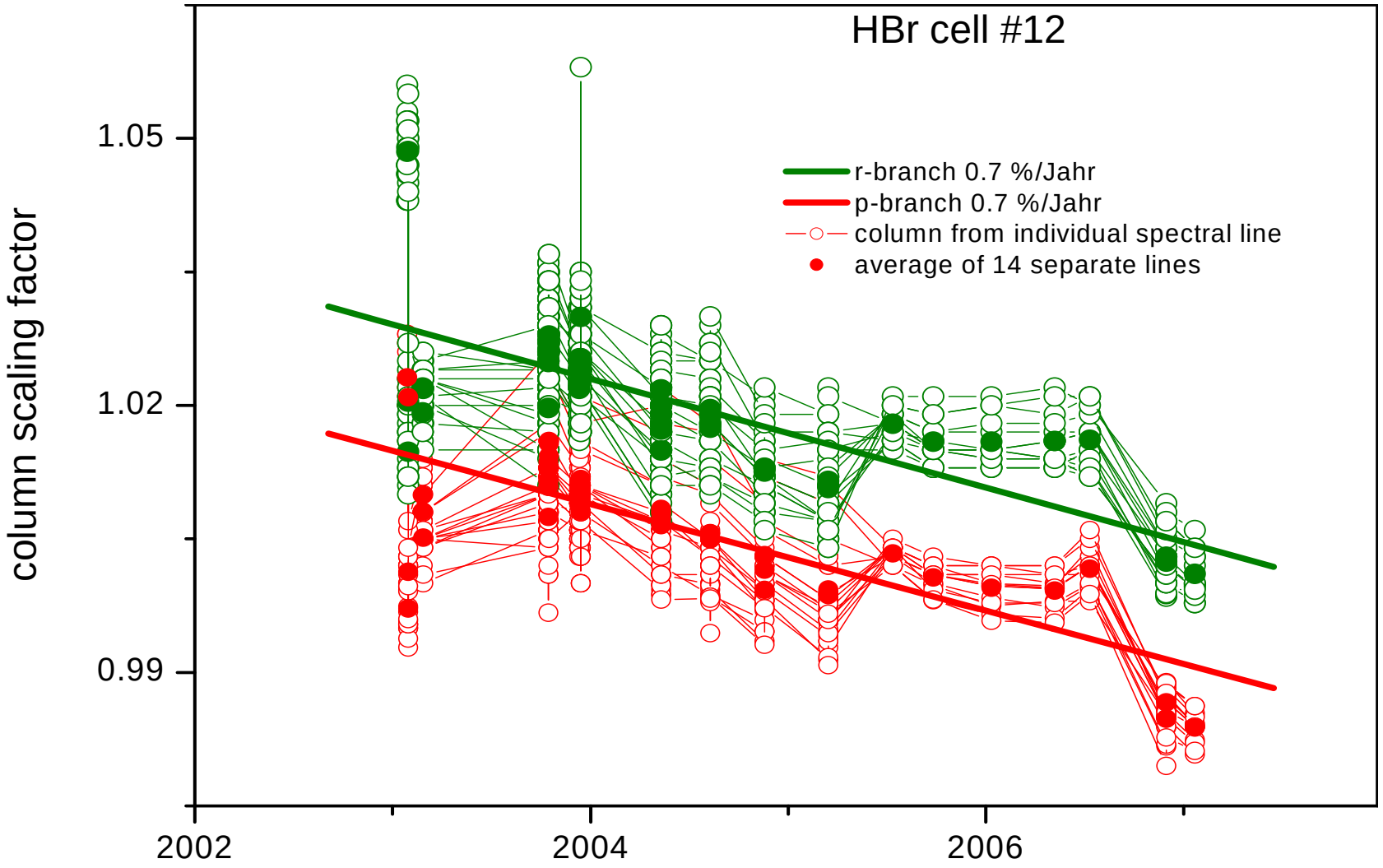
Borsdorff, Sussmann, to be published

Primary Site Report: Zugspitze FTIR

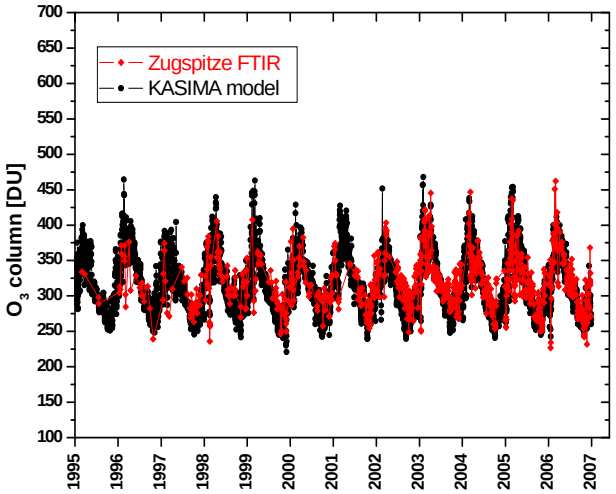
Name, date, and location of last intercomparison and/or validation:

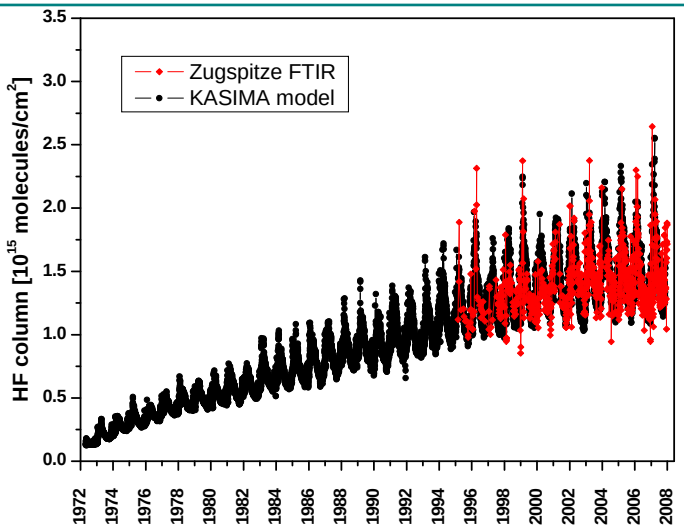
- 1996 intercomparison with Jungfraujoch: coincident measurements and blind independent analyses of HF, HCl. Agreement within 2 per cent
- In 2001 evaluation of the Zugspitze time series since 1995 of HCl and $ClONO_2$, and comparison to the Jungfraujoch series; showed very good overall agreement!
- 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
- Initial SCIAMACHY validation: learned much about precision of CO, CH_4, NO_2 measured by FTIR
- Comparison of Zugspitze HF, COF_2, HCl and $ClONO_2$ to KASIMA model (issue of fall FTIR-ClONO2 enhancements)
- Validation of maturated SCIA CH_4 data: precision of MIR retrievals (prior impact, annual cycle issue)
- Comparing Zugspitze CH_4 to Jungfraujoch: Pefect agreement of annual cycle and day-to-day variability

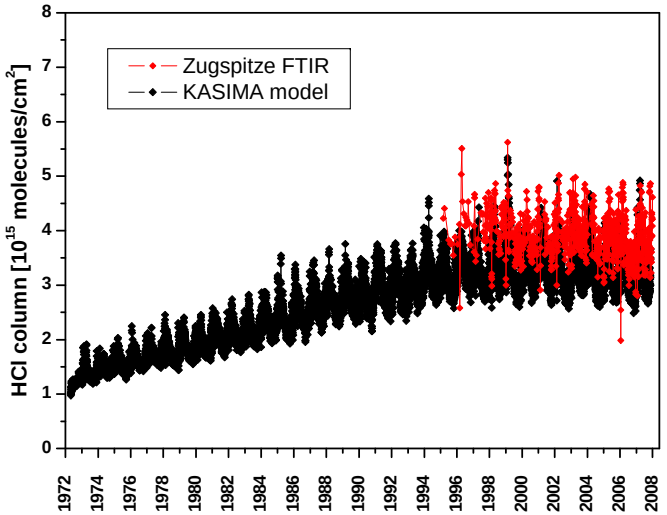
Special for Mike ☺

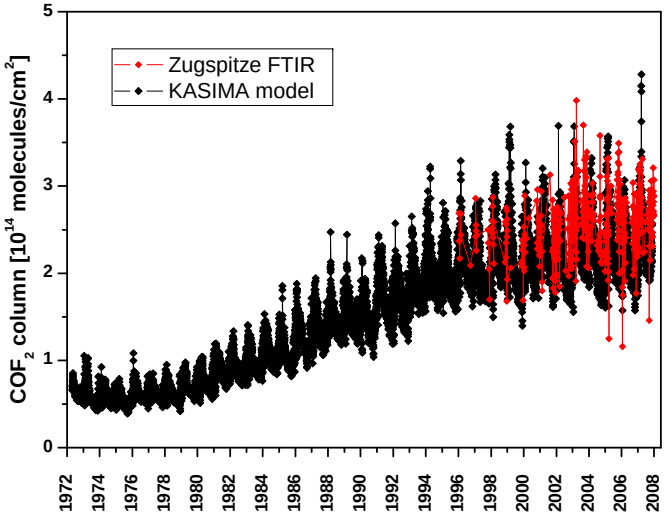


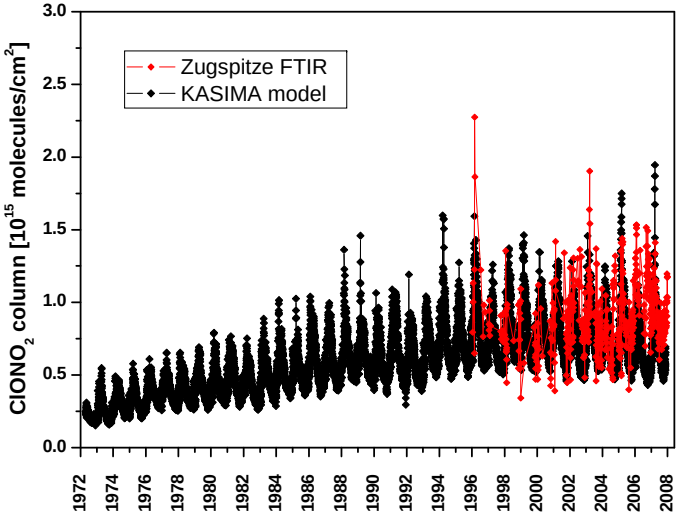
Montreal Protocol: Total O_3, Cl_y and F_y at Zugspitze versus KASIMA model











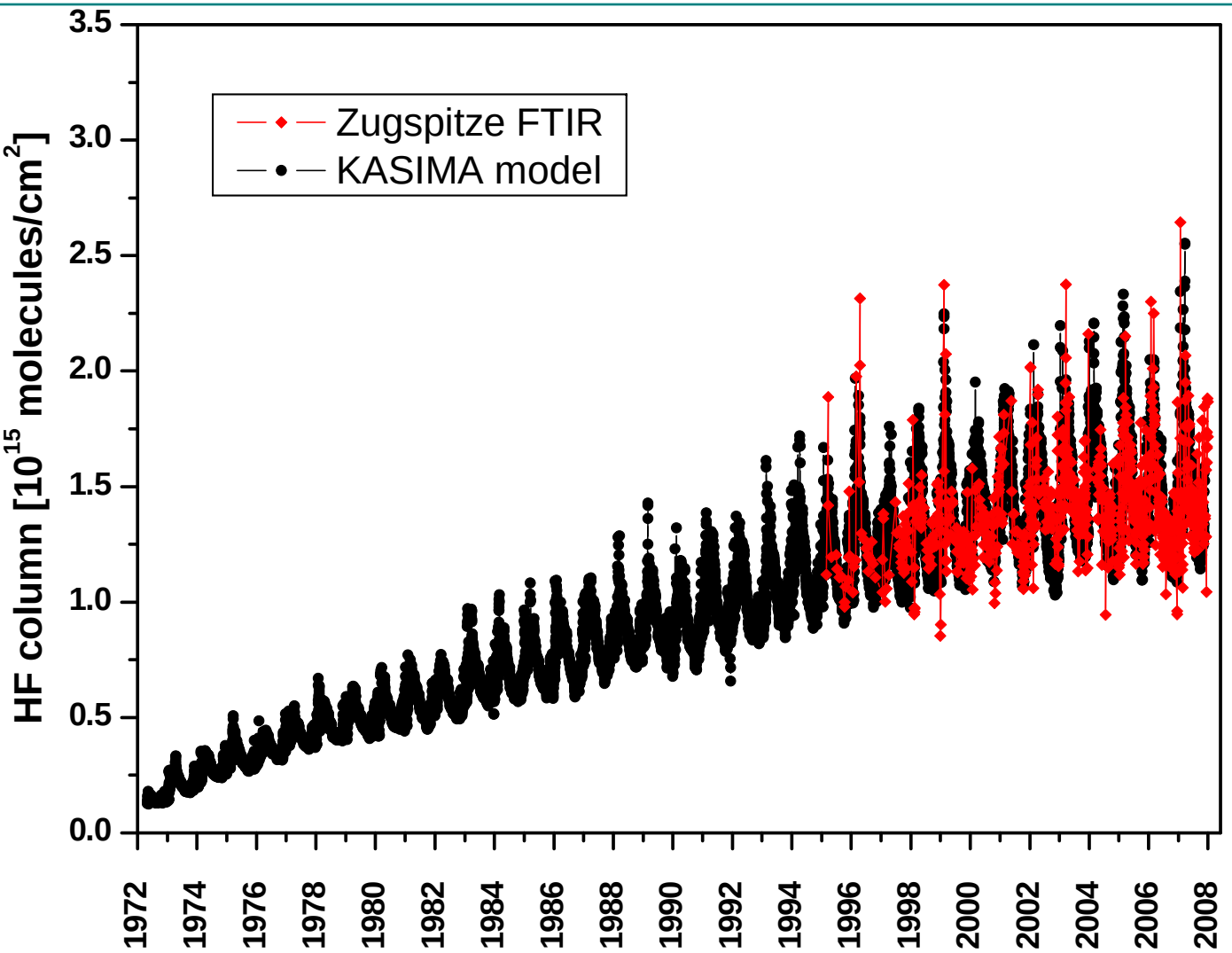
EC-GEOMON project

Research Center Karlsruhe **Ralf Sussmann**

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

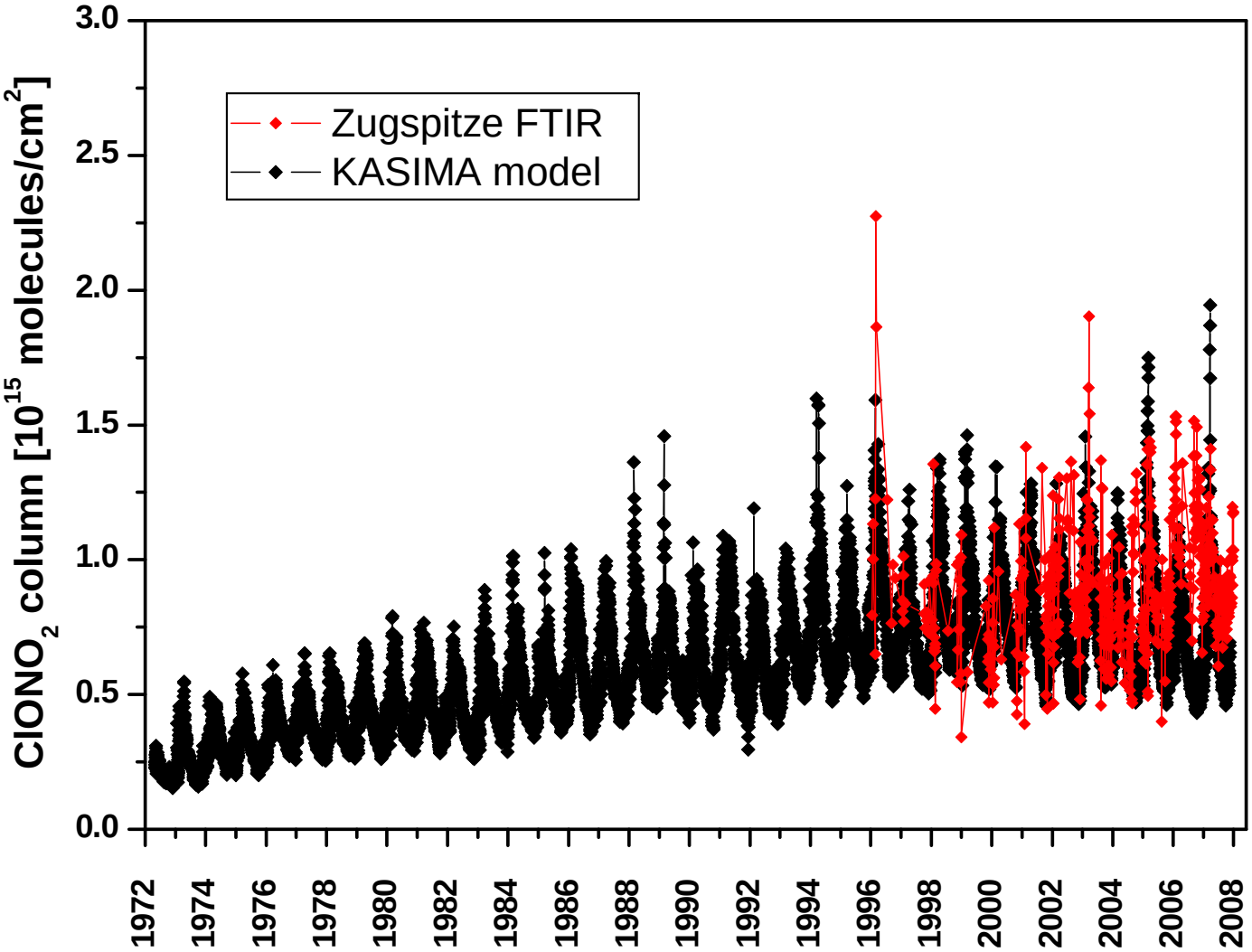
Montreal Protocol (stratospheric F_y): HF at Zugspitze

KASIMA:
Ruhnke



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

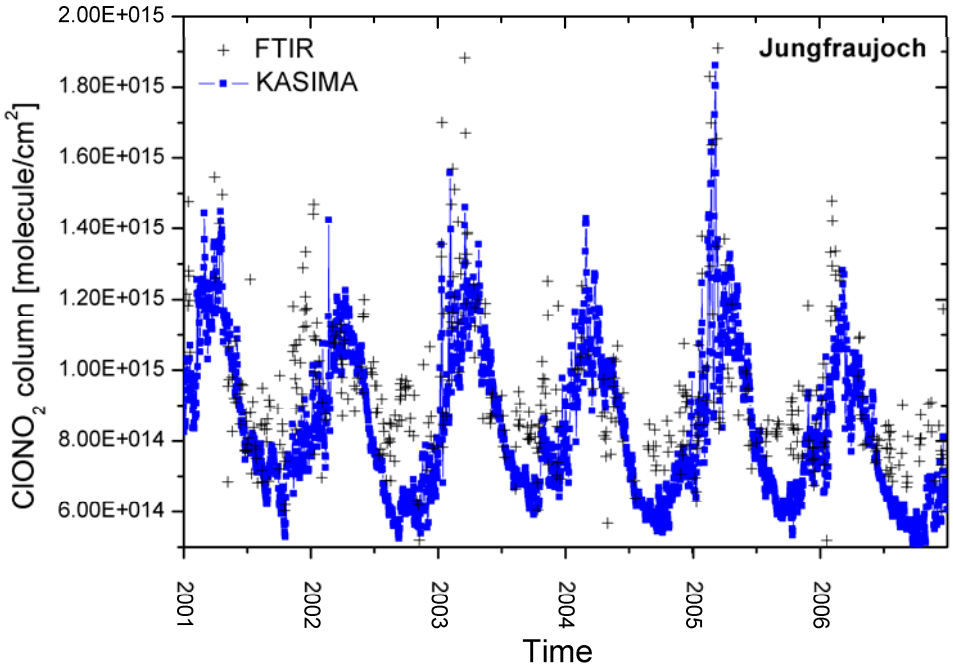
KASIMA:
Ruhnke

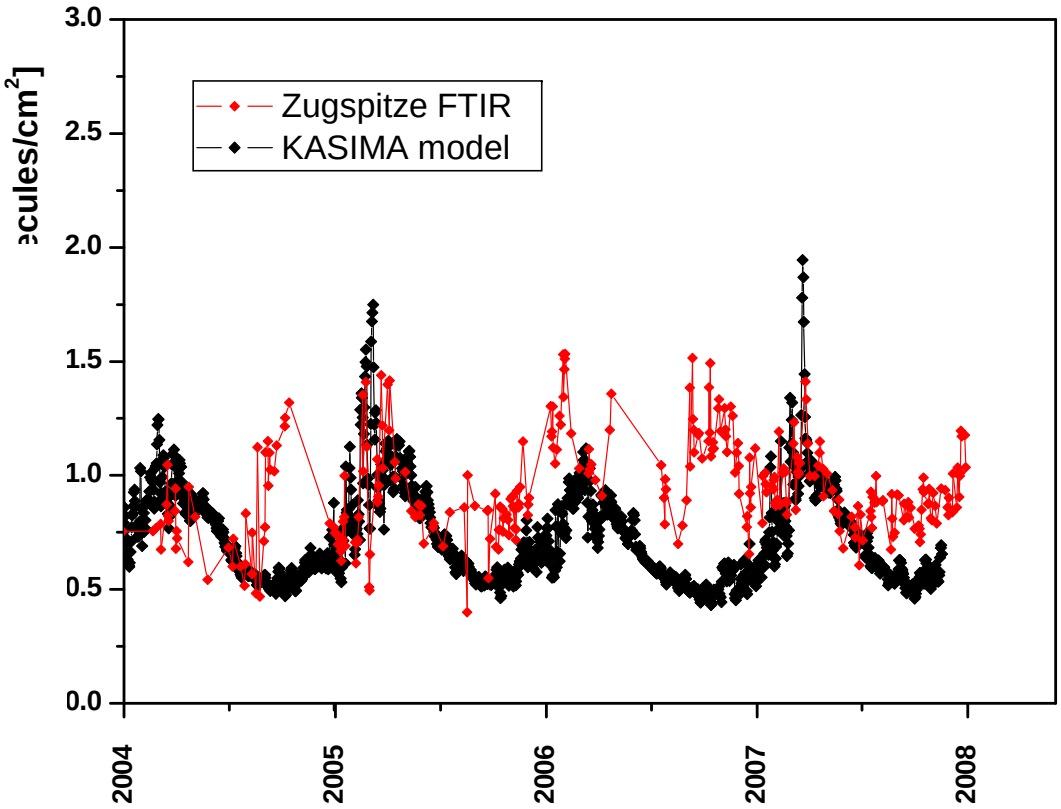


Montreal Protocol: $ClONO_2$ summer/fall enhancements

FTIR in summer/fall:
- no obvious lineshape problem from the nearby O3 and CO2 lines
- no significant zero line distortion

KASIMA (R. Ruhnke): „Kasima underestimates in general summertime ClONO2 at mid latitudes“





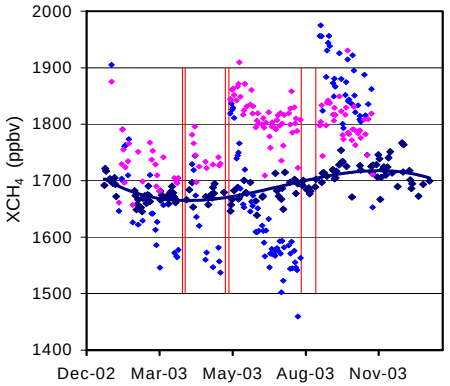
Ralf Sussmann

Zugspitze Primary Site Report

Methane retrieval optimization, SCIAMACHY validation, riddle of annual cycle

ENVISAT/SCIAMACHY CH_4 measurements were showing time-dependent drifts up to ≈20 % from channel 8 detector icing.

Sussmann, R., Stremme, W. Buchwitz, M., and de Beek, R.: Validation of ENVISAT/SCIAMACHY columnar methane by solar FTIR spectrometry at the Ground-Truthing Station Zugspitze, Atmos. Chem. Phys., 5, 2419–2429, 2005.



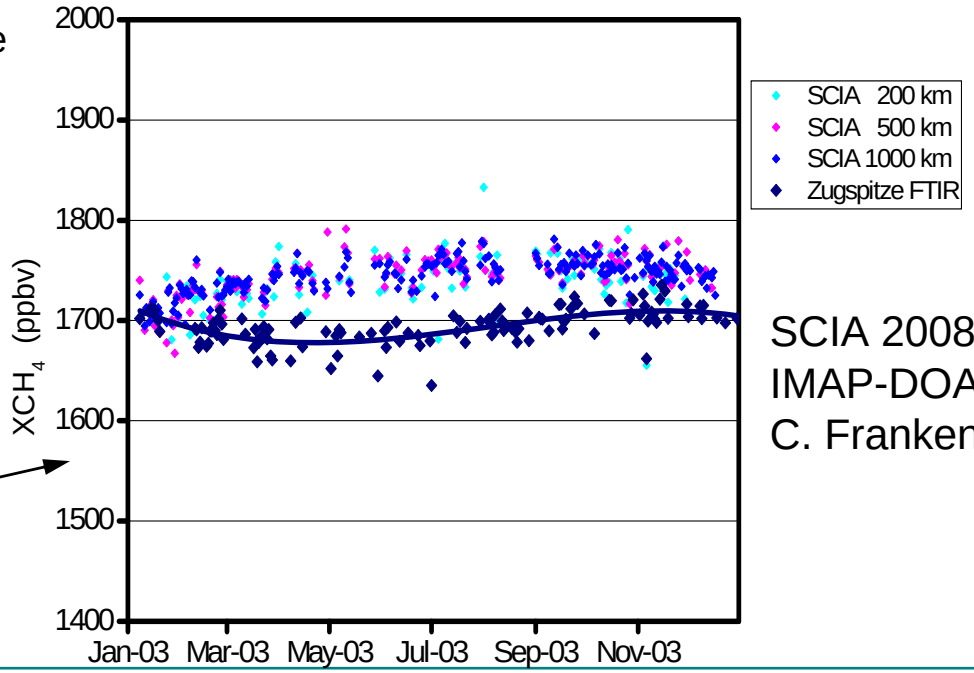
- **Zugspitze-FTIR**
- **SCIA ver0.4**
- **SCIA ver0.41**

Decontamination

SCIA 2005:
WFM-DOAS
M. Buchwitz

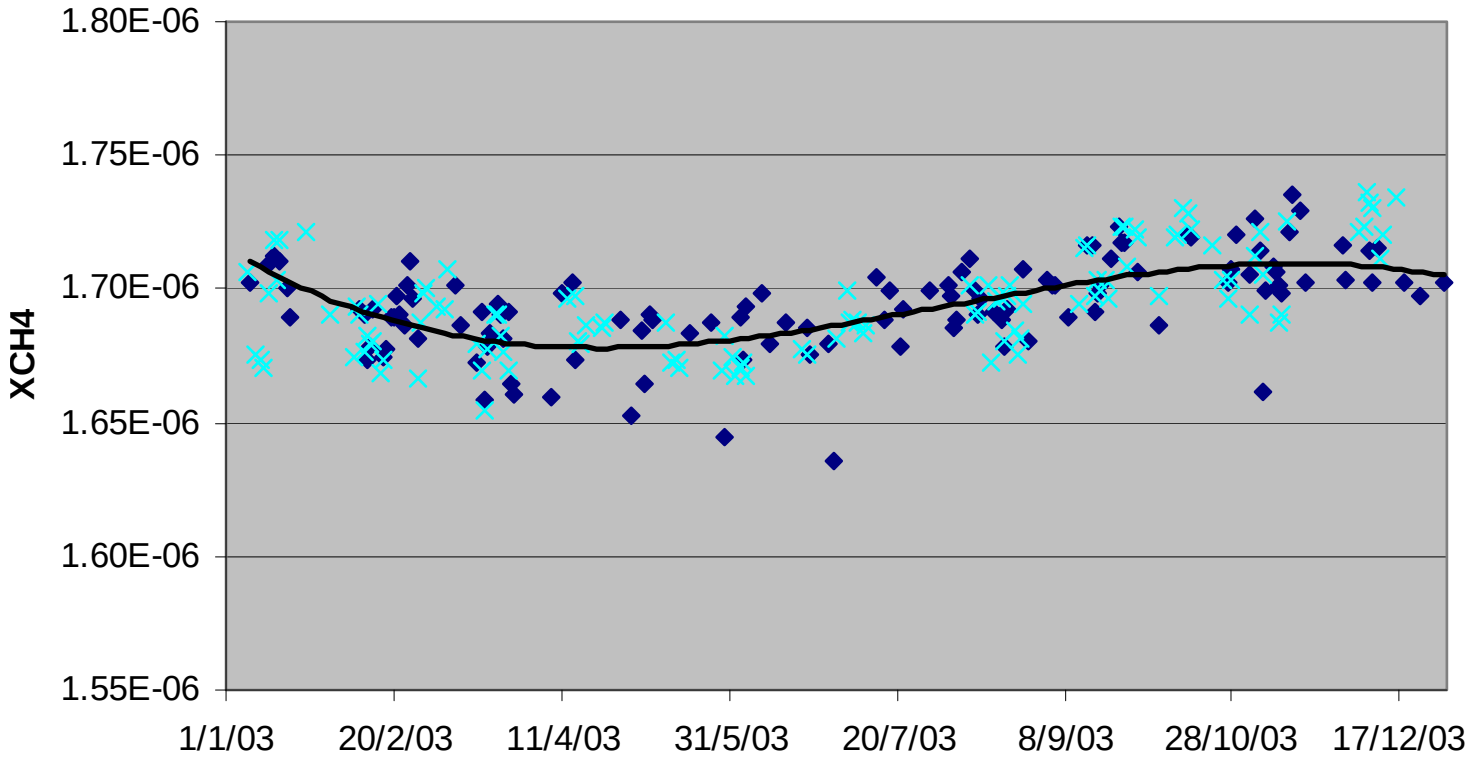
Thereafter the SCIA retrieval was successfully re-implemented to SCIAMACHY *channel 6* which is not impacted from icing.

2008 SCIA validation paper in prep. with the EC-HYMN+ consortium
focus: CH_4 precision/ variability



SCIA 2008:
IMAP-DOAS v.48
C. Frankenberg

methane annual cycle: Zugspitze FTIR compared to Jungfraujoch FTIR



Zugspitze and ISSJ annual cycles agree
BUT: Simple column model taking pT-variability and tropopause variability into account give a different annual cycle comparable to SCIA -> see separate talk on methane precision

Primary Site Report: Zugspitze FTIR

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

List of publications that appeared during the reporting period:

Sussmann, R. and Borsdorff, T.: Technical note: Interference errors in infrared remote sounding of the atmosphere, Atmos. Chem. Phys., 7, 3537-3557, 2007.

Gardiner, T., Forbes, A., Woods, P., de Maziere, M., Vigouroux, C., Mahieu, E., Demoulin, P., Velazco, V., Notholt, J., Blumenstock, T., Hase, F., Kramer, I., Sussmann, R., Stremme, W., Mellqvist, J., Strandberg, A., Ellingsen, K., and Gauss, M.: Method for evaluating trends in greenhouse gases from ground-based remote FTIR measurements over Europe, Atmos. Chem. Phys. Discuss., 7, 15781–15803, 2007.

Clerbaux, C., George, M., Turquety, S., Walker, K. A., Barret, B., Bernath, P., Boone, C., Borsdorff, T., Cammas, J. P., Catoire, V., Coffey, M., Coheur, P.-F., Deeter, M., De Mazière, M., Drummond, J., Duchatelet, P., Dupuy, E., de Zafra, R., Eddounia, F., Edwards, D. P., Emmons, L., Funke, B., Gille, J., Griffith, D. W. T., Hannigan, J., Hase, F., Höpfner, M., Jones, N., Kagawa, A., Kasai, Y., Kramer, I., Le Flochmoën, E., Livesey, N. J., López-Puertas, M., Luo, M., Mahieu, E., Murtagh, D., Nédélec, Ph., Pazmino, A., Pumphrey, H., Ricaud, P., Rinsland, C. P., Robert, C., Schneider, M., Senten, C., Stiller, G., Strandberg, A., Strong, K., Sussmann, R., Thouret, V., Urban, J., and Wiacek, A.: CO measurements from the ACE-FTS satellite instrument: data analysis and validation using ground-based, airborne and spaceborne observations, Atmos. Chem. Phys. Discuss., 7, 15277-15340, 2007.

Primary Site Report: Zugspitze FTIR

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

List of publications that appeared during the reporting period:

E. Dupuy, K. A. Walker, J. Kar, C. D. Boone, C. T. McElroy, P. F. Bernath, J. R. Drummond, R. Skelton, S. D. McLeod, R. C. Hughes, C. R. Nowlan, D. G. Dufour, J. Zou, F. Nichitiu, K. Strong, P. Baron, R. M. Bevilacqua, T. Blumenstock, G. E. Bodeker, T. Borsdorff, A. E. Bourassa, H. Bovensmann, I. S. Boyd, A. Bracher, C. Brogniez, J. P. Burrows, V. Catoire, S. Ceccherini, S. Chabrillat, T. Christensen, M. T. Coffey, U. Cortesi, J. Davies, C. De Clercq, D. A. Degenstein, M. De Mazière, P. Demoulin, J. Dodion, B. Firanski, H. Fischer, G. Forbes, L. Froidevaux, D. Fussen, P. Gerard, S. Godin-Beekman, F. Goutail, J. Granville, D. Griffith, C. S. Haley, J. W. Hannigan, M. Höpfner, J. J. Jin, A. Jones, N. B. Jones, K. Jucks, A. Kagawa, Y. Kasai, T. E. Kerzenmacher, A. Kleinböhl, A. R. Klekociuk, I. Kramer, H. Küllmann, J. Kuttippurath, E. Kyrölä, J.-C. Lambert, N. J. Livesey, E. J. Llewellyn, N. D. Lloyd, E. Mahieu, G. L. Manney, B. T. Marshall, J. C. McConnell, M. P. McCormick, I. S. McDermid, M. McHugh, C. A. McLinden, J. Mellqvist, K. Mizutani, Y. Murayama, D. P. Murtagh, H. Oelhaf, A. Parrish, S. V. Petelina, C. Piccolo, J.-P. Pommereau, C. E. Randall, C. Robert, C. Roth, M. Schneider, C. Senten, T. Steck, A. Strandberg, K. B. Strawbridge, R. Sussmann, D. P. J. Swart, D. W. Tarasick, J. R. Taylor, C. Tétard, L. W. Thomason, A. M. Thompson, M. B. Tully, J. Urban, F. Vanhellemont, T. von Clarmann, P. von der Gathen, C. von Savigny, J. W. Waters, J. C. Witte, M. Wolff, and J. M. Zawodny: Validation of ozone measurements from the Atmospheric Chemistry Experiment (ACE), Atmos. Chem. Phys. Discuss., 8, 2513-2656, 2008.

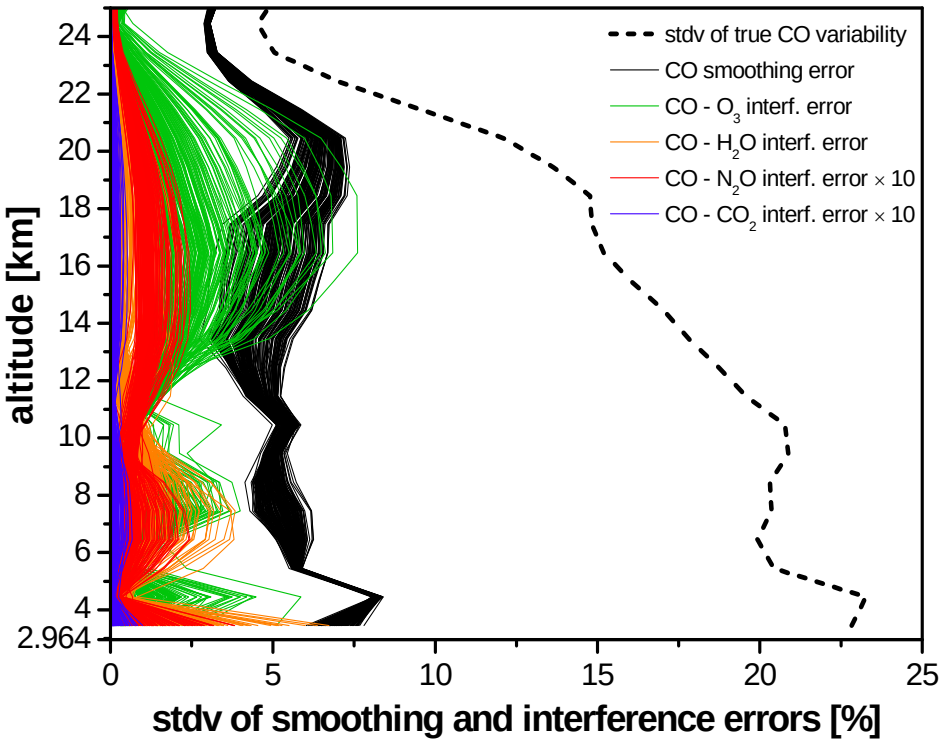
Research Center Karlsruhe **Ralf Sussmann**

IMK-IFU Garmisch-Partenkirchen

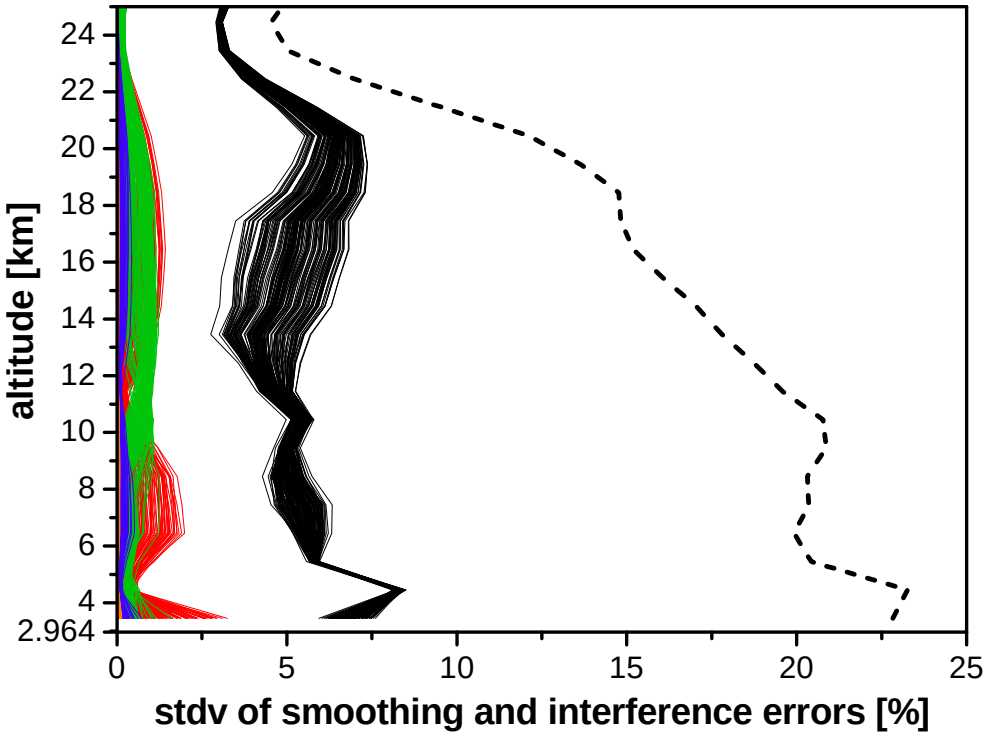
Zugspitze Primary Site Report

Interference errors on CO profiles: Interference error minimization

Standard Rinsland (2000) retrieval strategy



Optimum strategy for retrieving interfering species



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, ongoing)
2. EC-GEOMON (Cl_y, F_y, new 2006, ongoing)
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, end 2008)
4. TASTE (ENVISAT long-term validation, ESA-funded, end 2008)
5. SATVAL-A (German Space Agency, new 2007 - SCIA Validation: CH4)

Summary – Zugspitze FTIR Primary Site Report

- 138 measurements days/yr, well funded
- paper on interference errors $\Rightarrow$ separate talk
- very recently updated Zugspitze CO, O3, HF, COF_2, HCl, $ClONO_2$, and CH_4 series
- KASIMA model comparison (Cl_y, F_y, O_3) looks fine with exception of $ClONO_2$ summer/fall enhancements
- go into detail of CH_4 variability/precision from MIR-FTS (SCIA validation, Jungfraujoch intercomparison; annual cycle issue) $\Rightarrow$ separate talk
  (SCIA prec. val. paper within EC-HYMN+ consortium with common optimized retrieval strategy currently prepared – non-EU: write me an email if you want contribute)