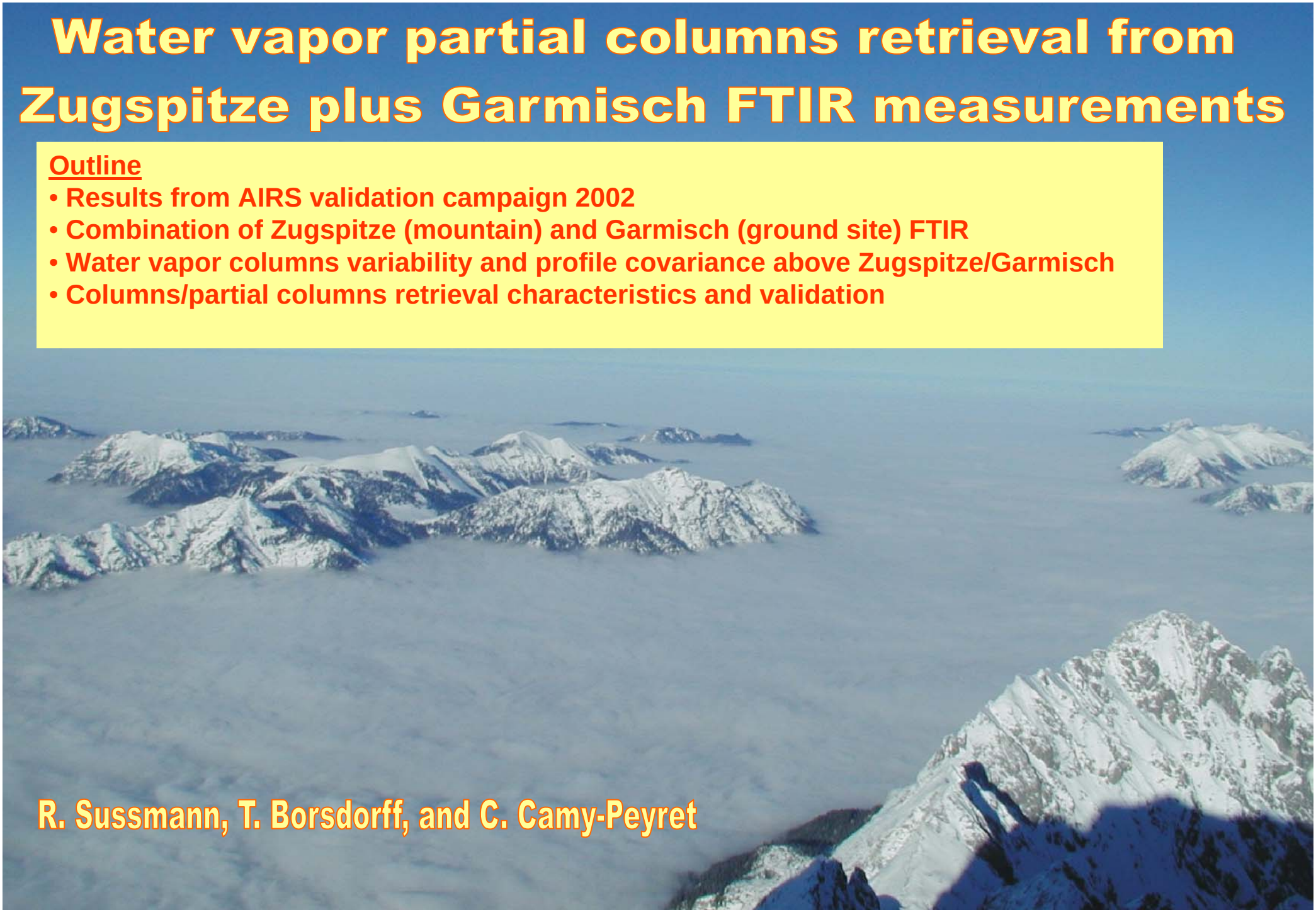
Water vapor partial columns retrieval from Zugspitze plus Garmisch FTIR measurements

Outline

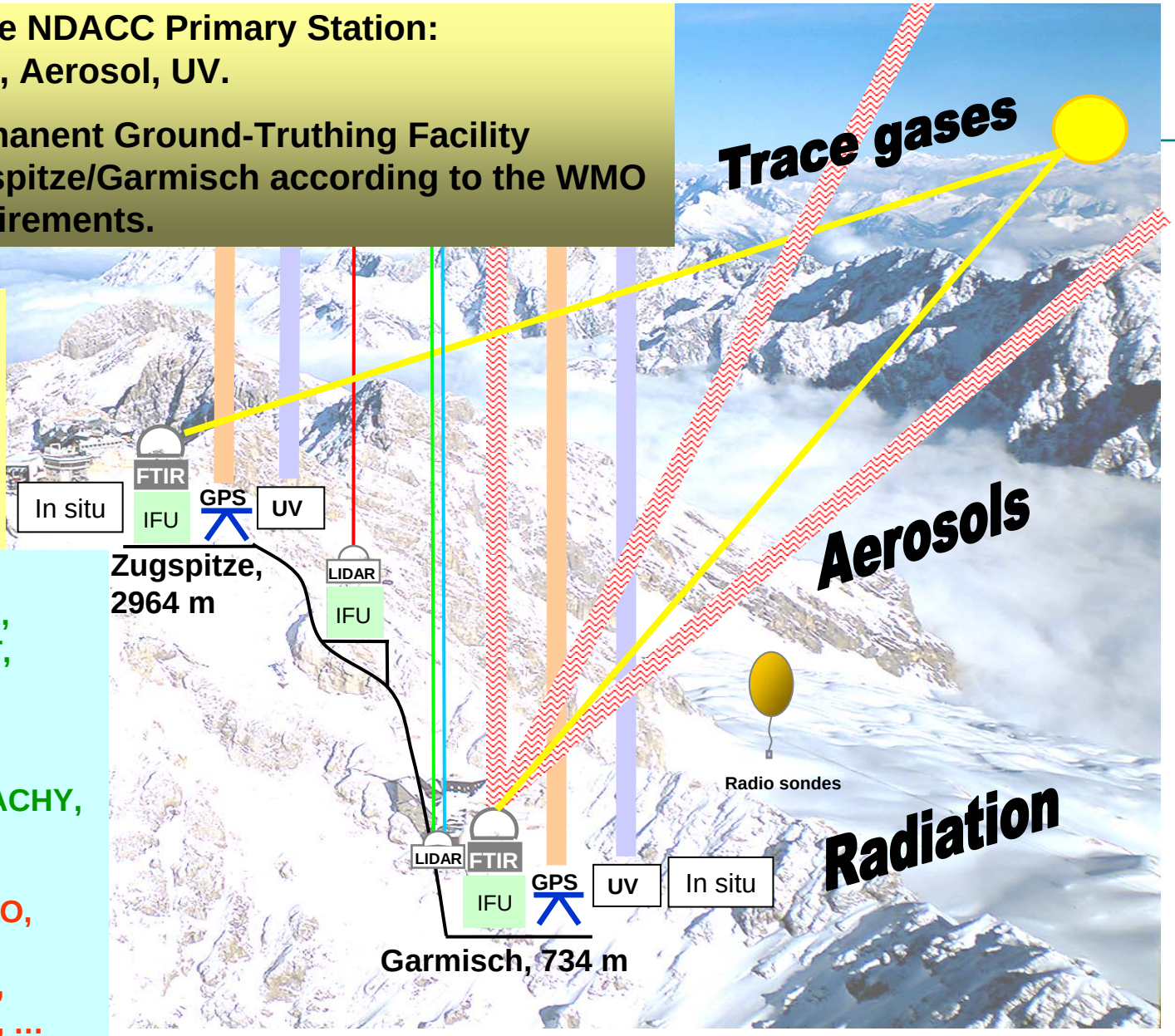
- Results from AIRS validation campaign 2002
- Combination of Zugspitze (mountain) and Garmisch (ground site) FTIR
- Water vapor columns variability and profile covariance above Zugspitze/Garmisch
- Columns/partial columns retrieval characteristics and validation



R. Sussmann, T. Borsdorff, and C. Camy-Peyret

Triple NDACC Primary Station:
FTIR, Aerosol, UV.

Permanent Ground-Truthing Facility Zugspitze/Garmisch according to the WMO requirements.



IMK-IFU Working Group „Variability and Trends“

Scientists
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- H.E. Scheel
- T. Trickl
- H. Vogelmann
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- M. Rettinger
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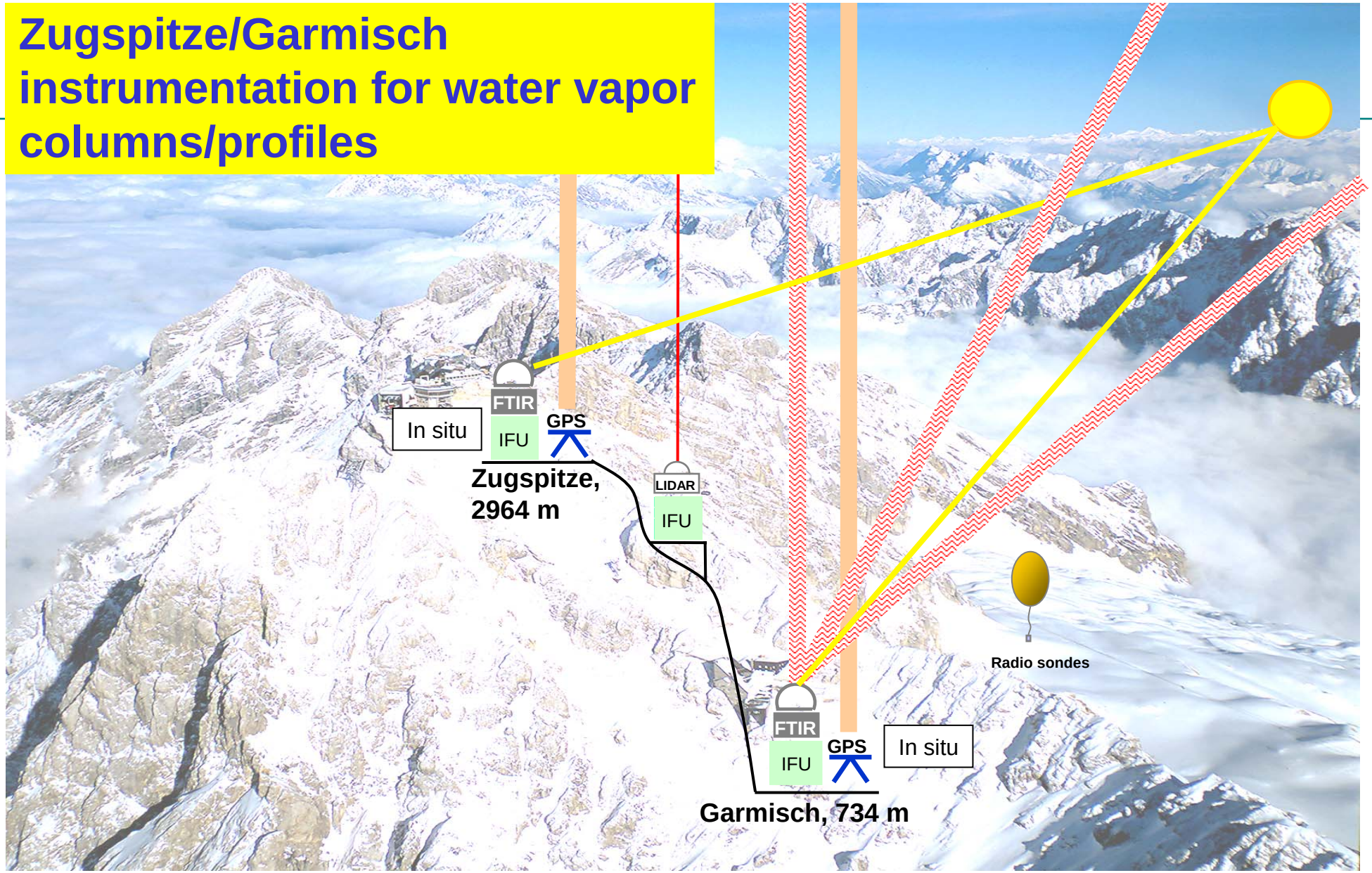
- W. Stremme
- T. Borsdorff

MAPS, CRISTA, MOPITT, SAGE, GOME, AIRS, SCIAMACHY, ACE, IASI, CALIPSO, OCO, TCCON, GOSAT, ...

Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Zugspitze/Garmisch instrumentation for water vapor columns/profiles



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Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

2002 AIRS validation campaign at Zugspitze/Garmisch: Schedule

Campaign duration:
3 Months (19 Aug 2002 - 17 Nov 2002)

Data delivery: within 12 h for both day- and night-overpasses

Validation measurements:
7 days a week,
2-hours-period around each overpass delivered,
for 2 EOS-Aqua overpasses per day

- Zugspitze FTIR: clear sky operation, typically, 20-min-integration intervals
- Radio Sondes (Garmisch): 4 sondes a day (two per overpass)
- GPS Garmisch+ Zugspitze, permanent operation, half hourly mean values
- In-Situ Met Data (Garmisch + Zugspitze): 1-min-values
- Cloud/weather information (Zugspitze: hourly; Garmisch: 1 fish eye image per overpass)

2002 AIRS validation campaign at Zugspitze/Garmisch: Radio Sounding

Sonde 1 launched 1h before overpass
Sonde 2 launched 5 min before overpass

Vaisala RS 80-30 G sondes
TOTEX-800-g balloons
2 x Digicora III (Marvin 21, SPS220G)

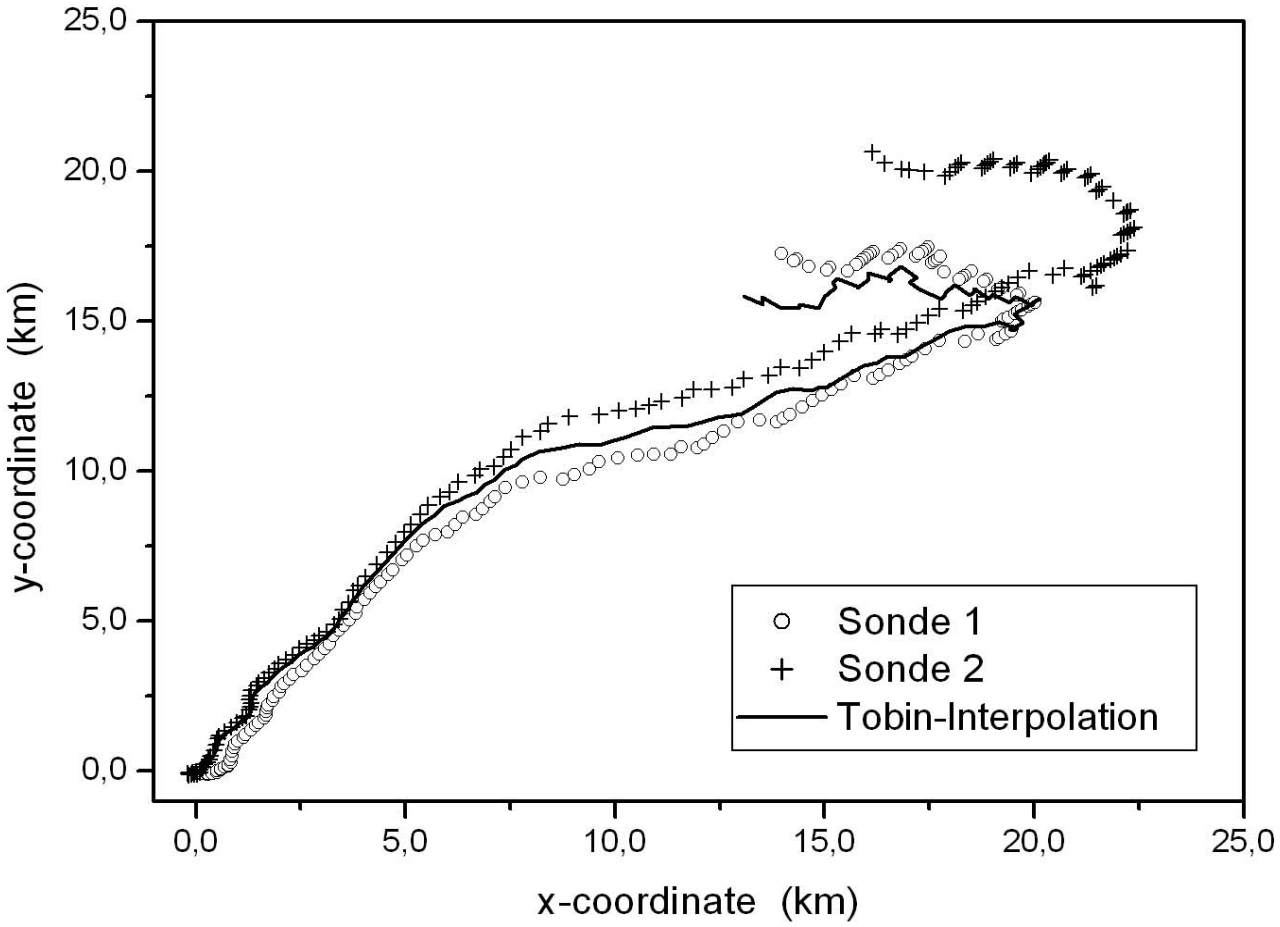
TOBIN-Inter-/Extrapolation between both soundings:

$$q_{Tobin}(z, t_{op}) = q_{sonde}(z, t_0) + (dq(z)/dt)\,(t_{op} - t_0)$$

Tobin, D., W. Feltz, B. Knuteson, H. Revercomb, *"ARM T/q Best Estimate Profiles for AIRS validation"*, 1 March 2000

Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

2002 AIRS validation campaign at Zugspitze/Garmisch: Radio Sounding



delivered within 12 hours

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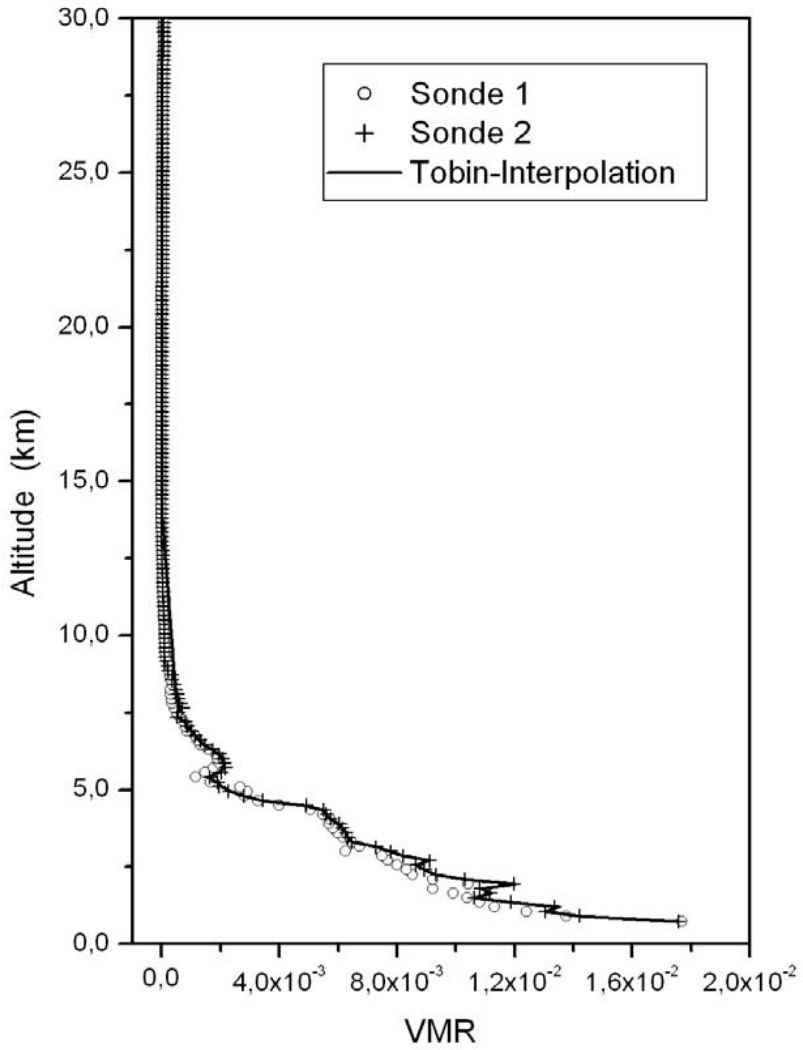
Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

2002 AIRS validation campaign at Zugspitze/Garmisch: Radio Sounding



delivered within
12 hours

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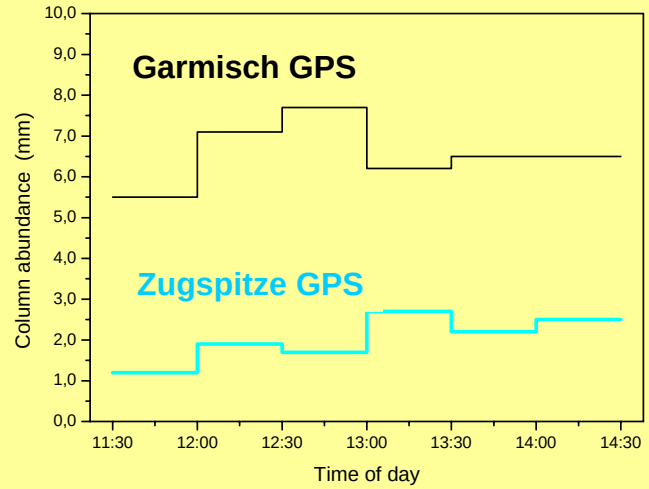
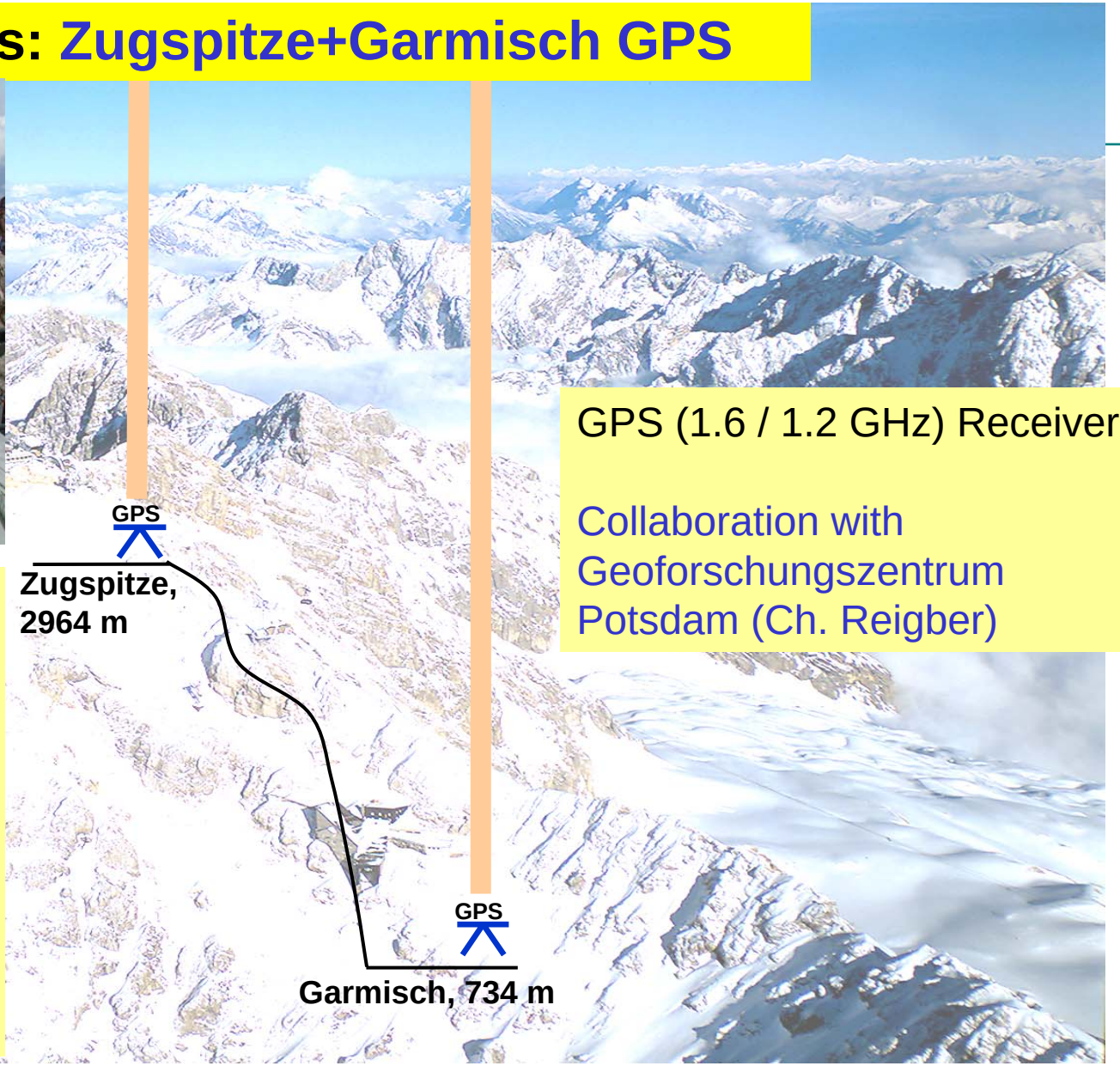
Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Water vapor columns: Zugspitze+Garmisch GPS





GPS (1.6 / 1.2 GHz) Receivers

Collaboration with
Geoforschungszentrum
Potsdam (Ch. Reigber)

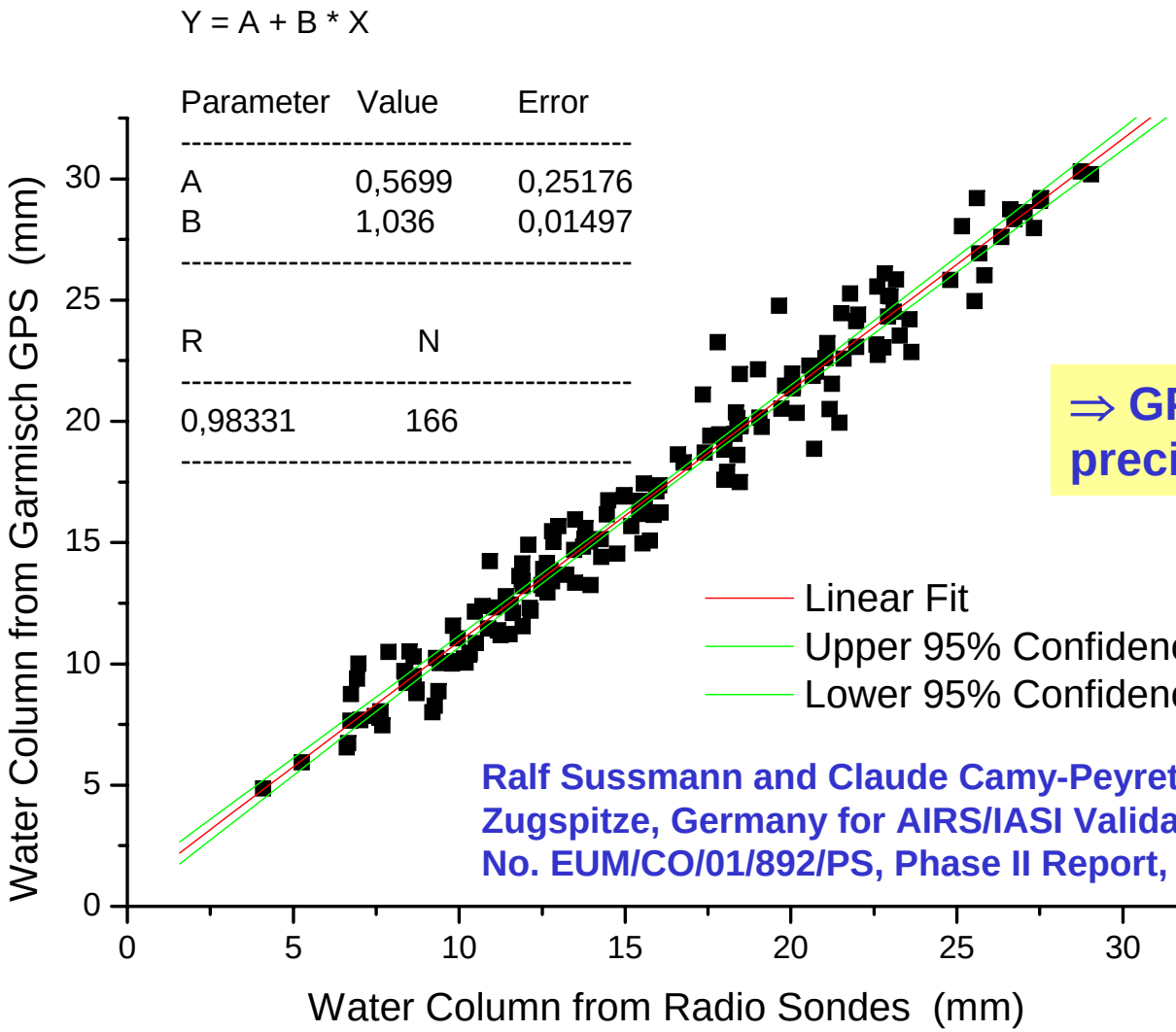
IMK-IFU, Research Center Karlsruhe, Garmisch-Partenkirchen, Ralf Sussmann

Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Water vapor columns: Validation of Garmisch GPS with radio sondes

Columns above Garmisch, 734 m

2-h-mean values



⇒ GPS bias 1-2 mm, precision 1 mm

Ralf Sussmann and Claude Camy-Peyret, Ground-Truthing Center Zugspitze, Germany for AIRS/IASI Validation, EUMETSAT Contract No. EUM/CO/01/892/PS, Phase II Report, 28 March 2003

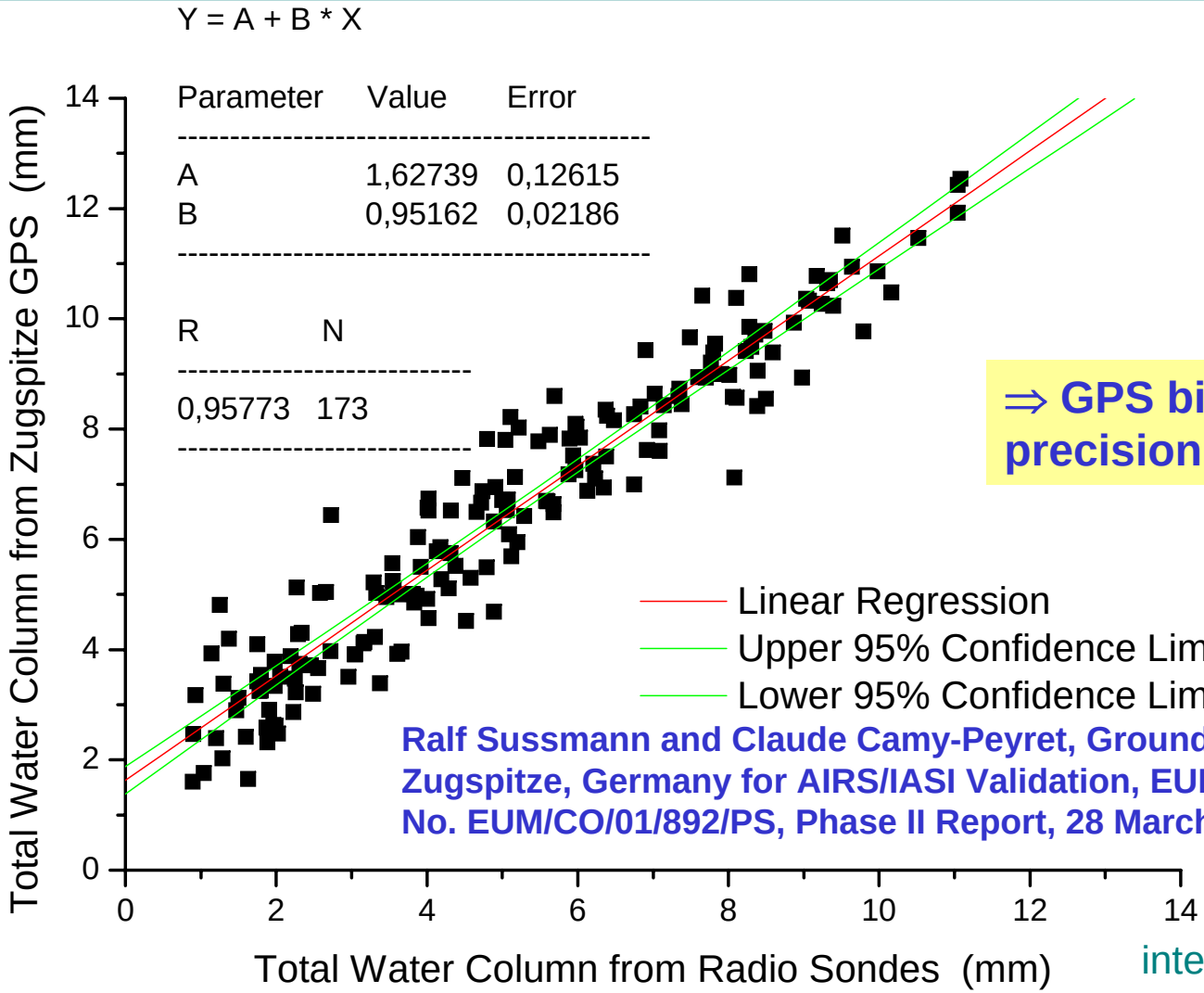
integrated Tobin-profiles

Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Water vapor columns: Validation of Zugspitze GPS with radio sondes

Columns above Zugspitze, 2964 m

2-h-mean values



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integrated Tobin-profiles

Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Zugspitze operational since 1995
typ. 130 measurement days per year

H_2O columns and profiles

FTIR
IFU

Zugspitze 2964 m

Garmisch operational since 2004
94 measurement days in 2004
147 measurement days in 2005

"Differential FTIR" with Zugspitze: H_2O columns and profiles

FTIR
IFU

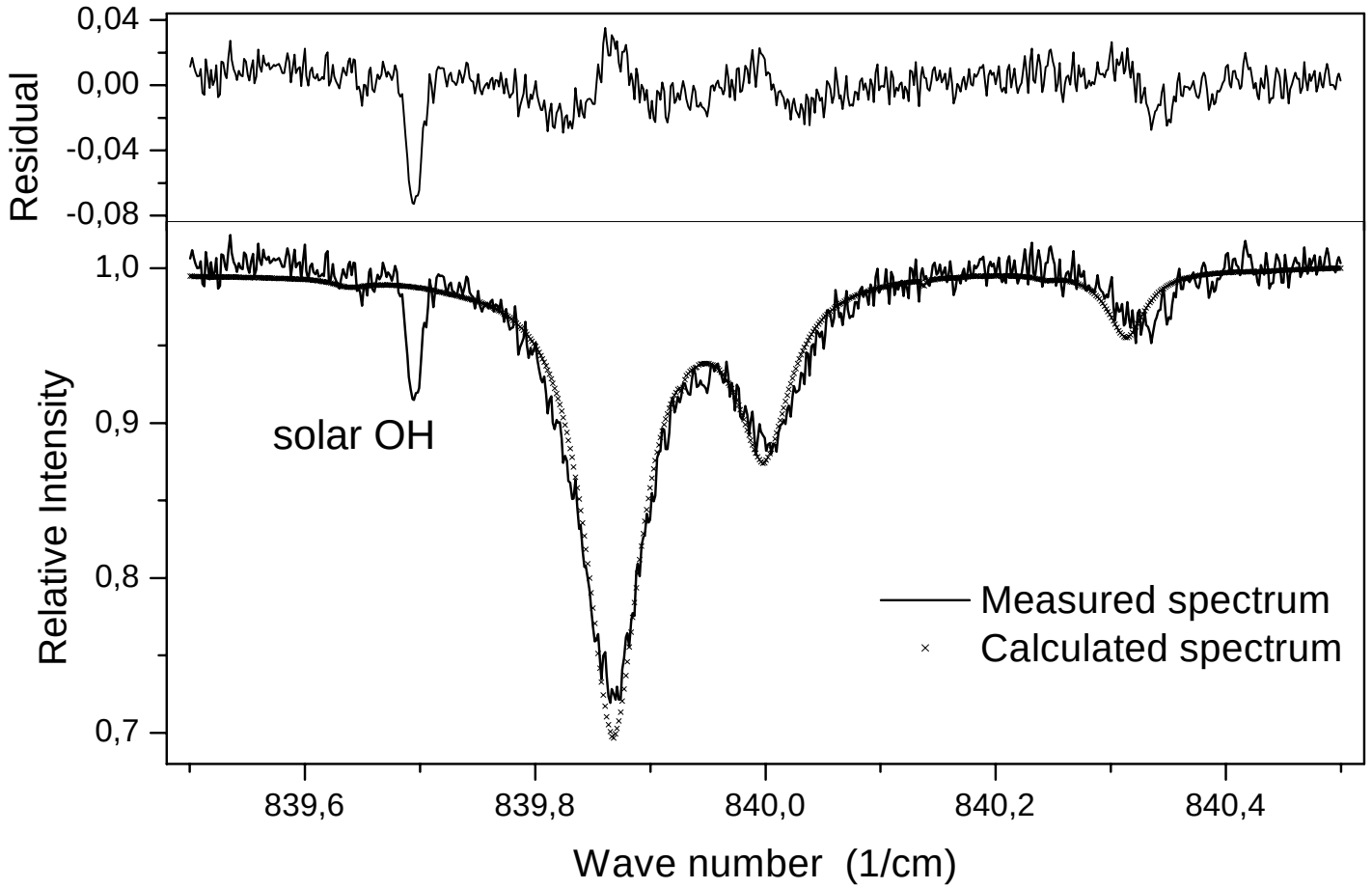
Garmisch 734 m

IMK-IFU, Research Center Karlsruhe, Garmisch-Partenkirc

Partial columns retrieval from Zugspitze and Garmis

Zugspitze solar FTIR retrieval: Micro windows

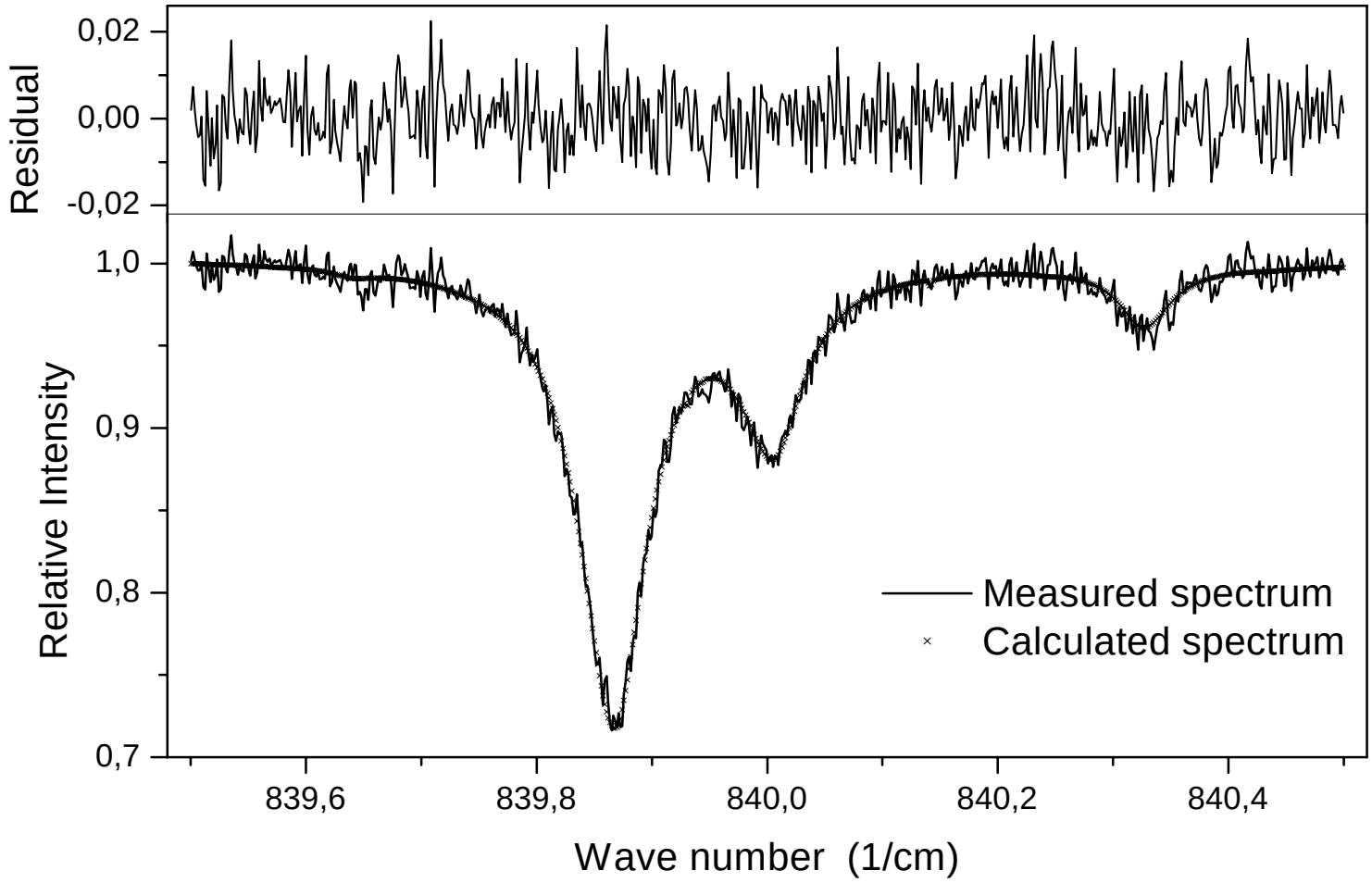
HITRAN96



010-010
R10, R14
water lines

Zugspitze solar FTIR retrieval: Micro windows

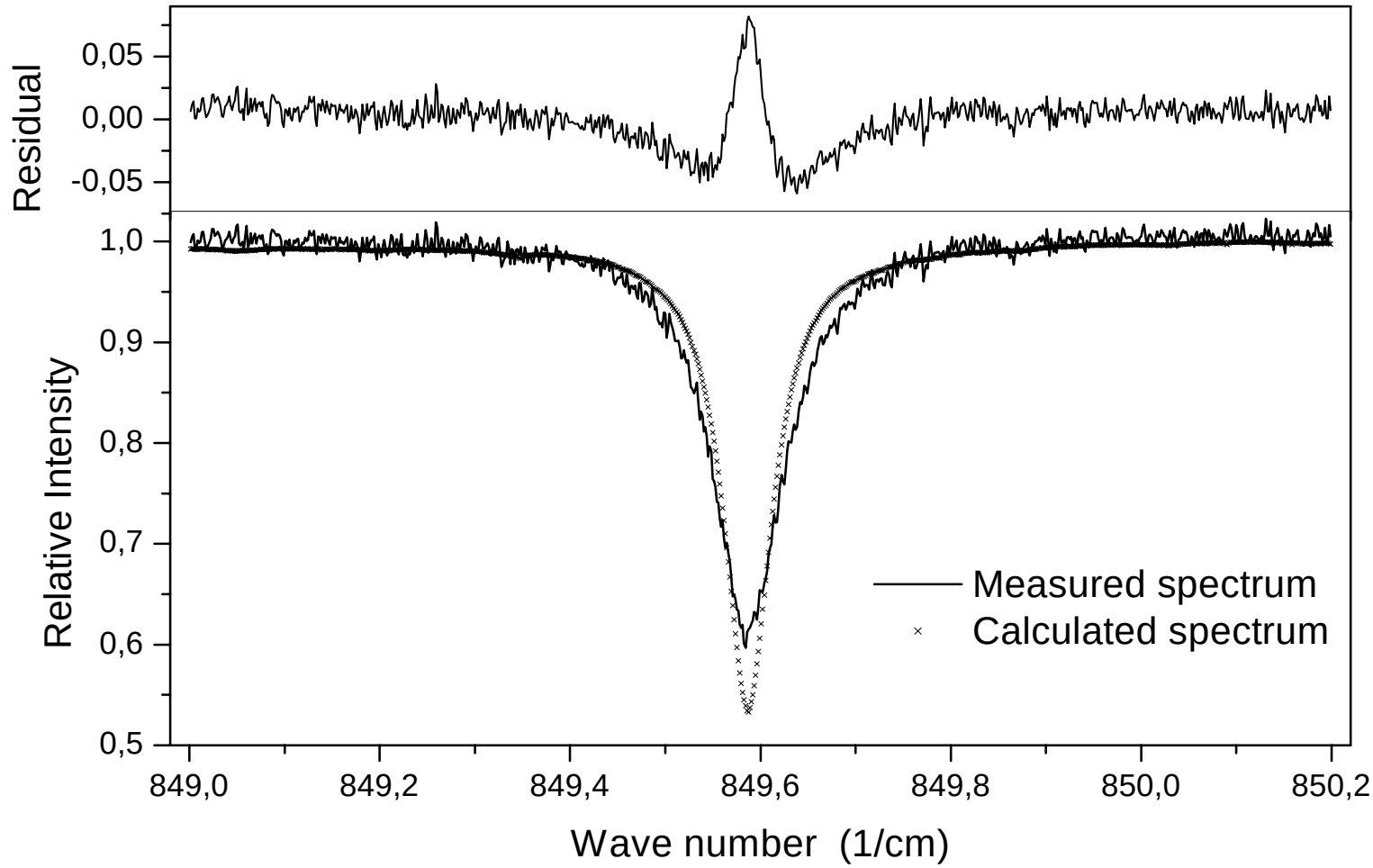
HITRAN2000, solar OH removed



010-010
R10, R14
water lines

Zugspitze solar FTIR retrieval: Micro windows

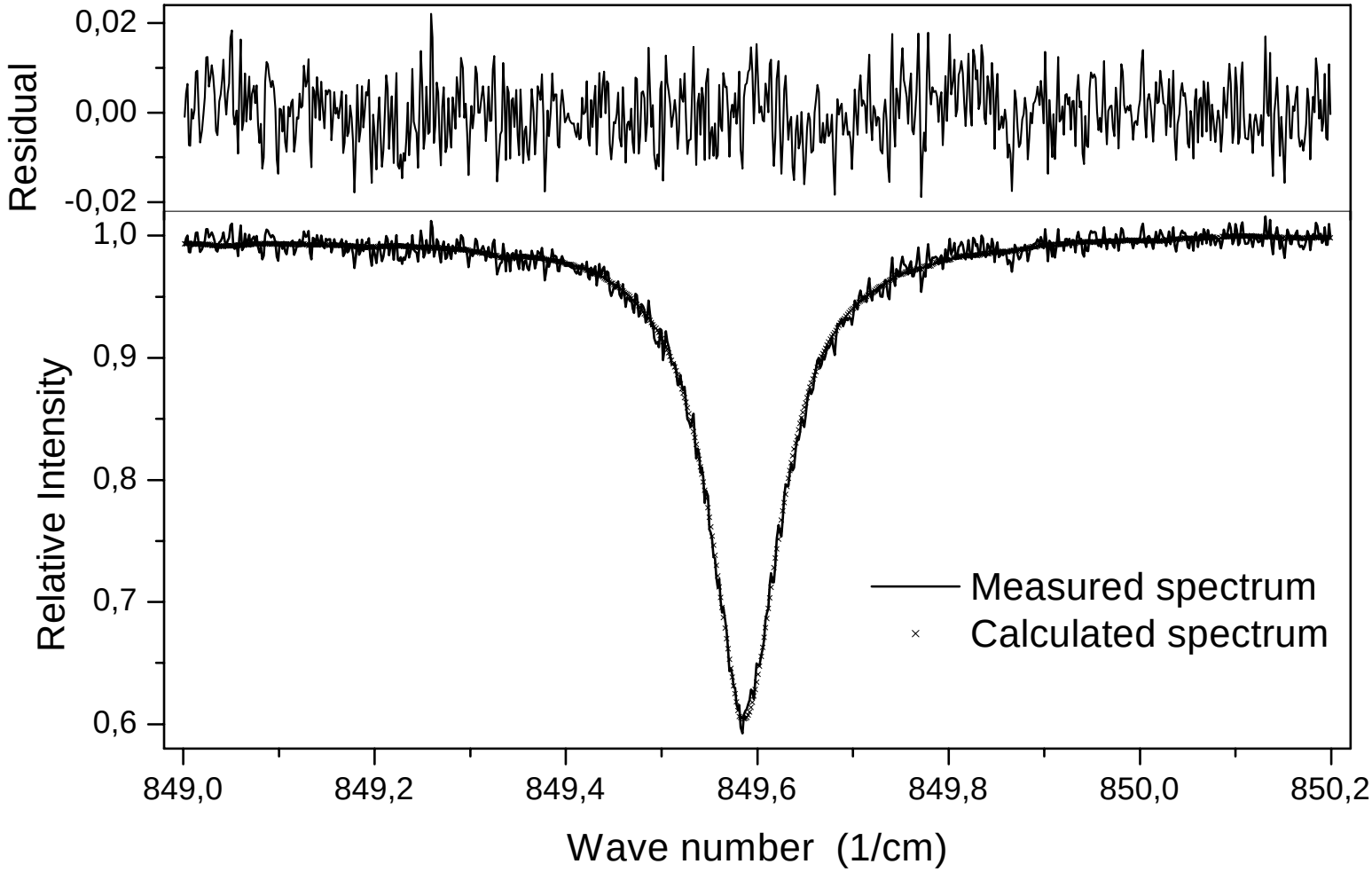
HITRAN96



010-010
R11
water line

Zugspitze solar FTIR retrieval: Micro windows

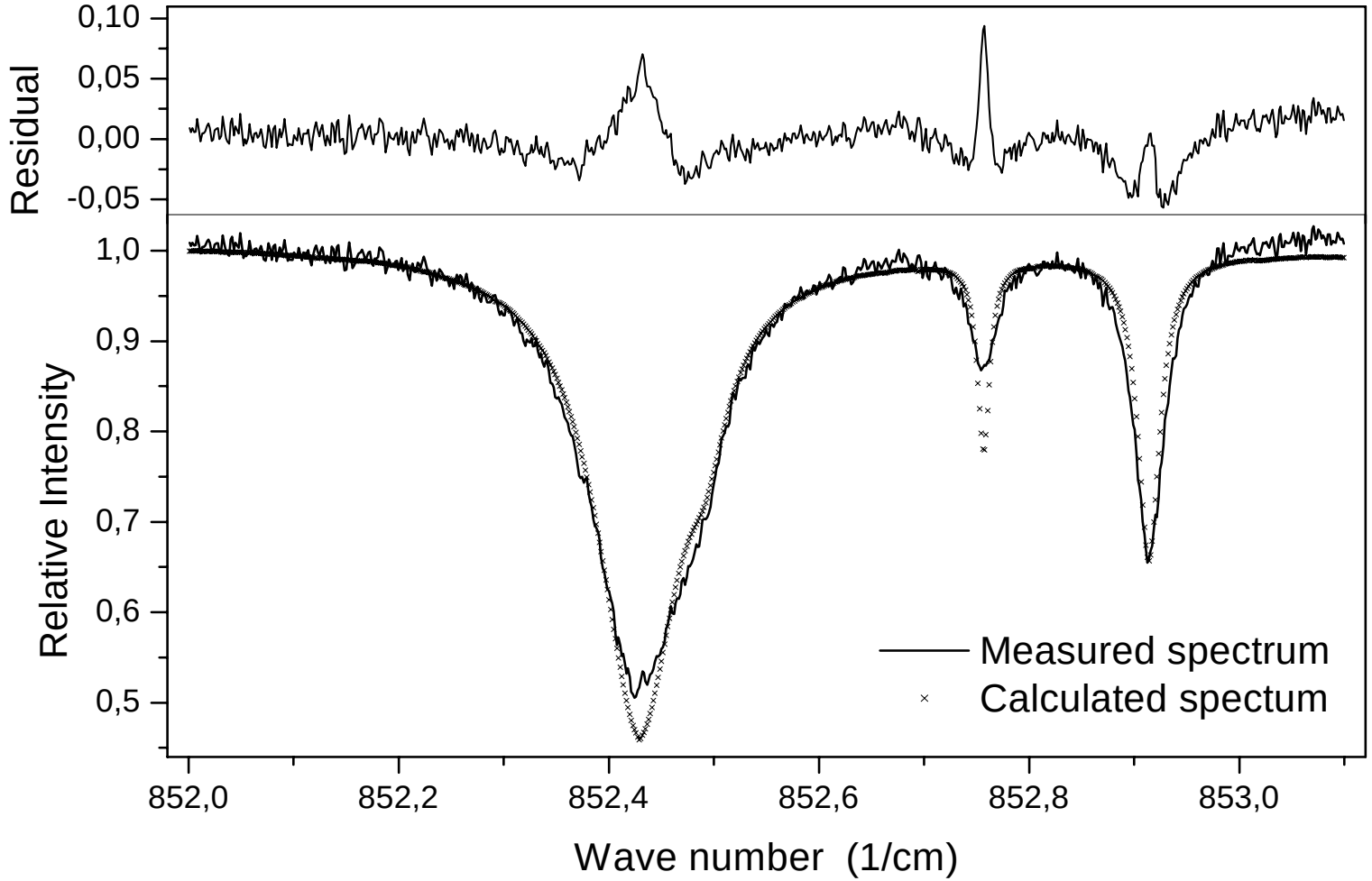
HITRAN2000



010-010
R11
water line

Zugspitze solar FTIR retrieval: Micro windows

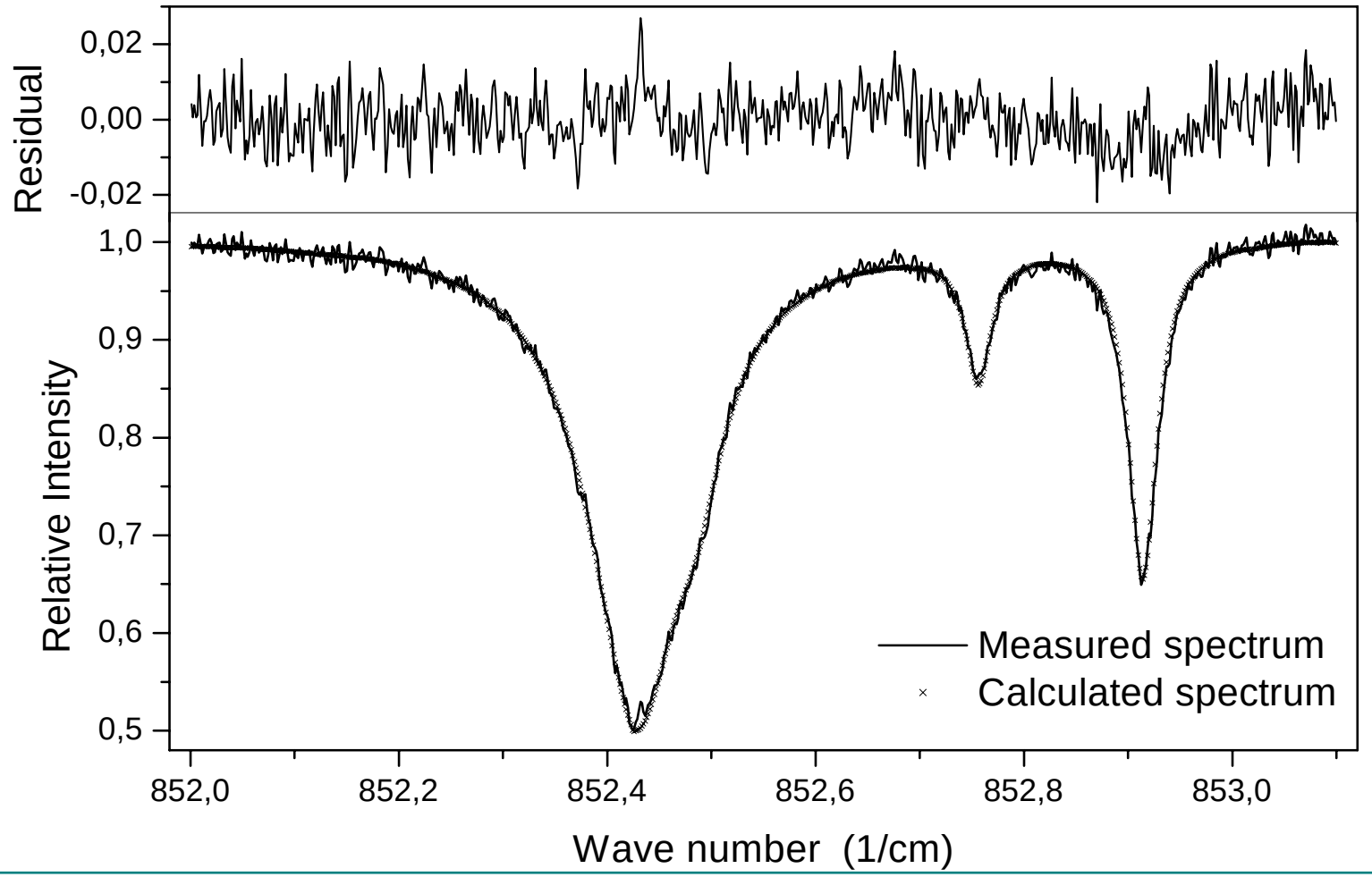
HITRAN96



010-010
R10, R13, R16
water lines

Zugspitze solar FTIR retrieval: Micro windows

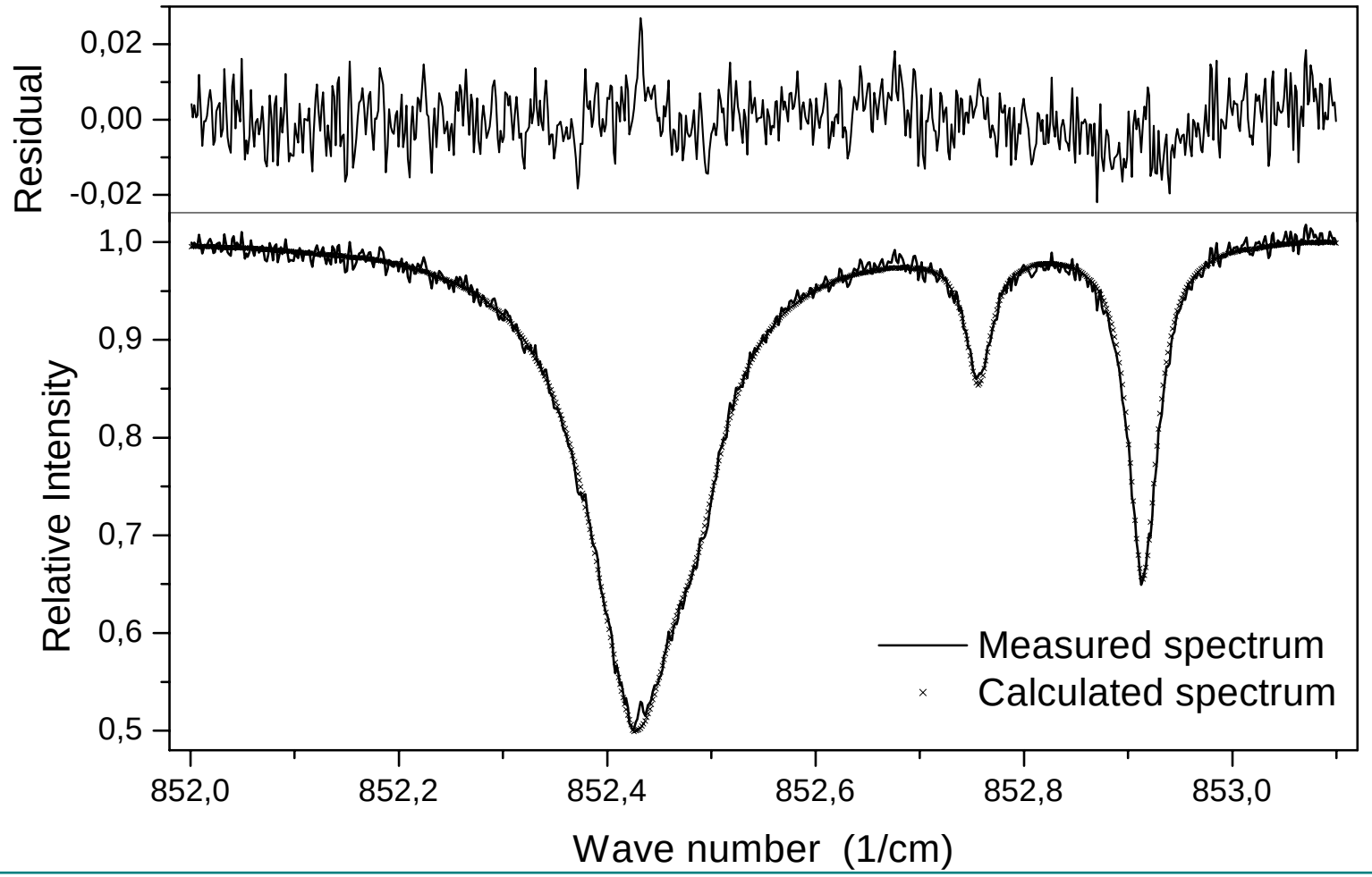
HITRAN2000



010-010
R10, R13, R16
water lines

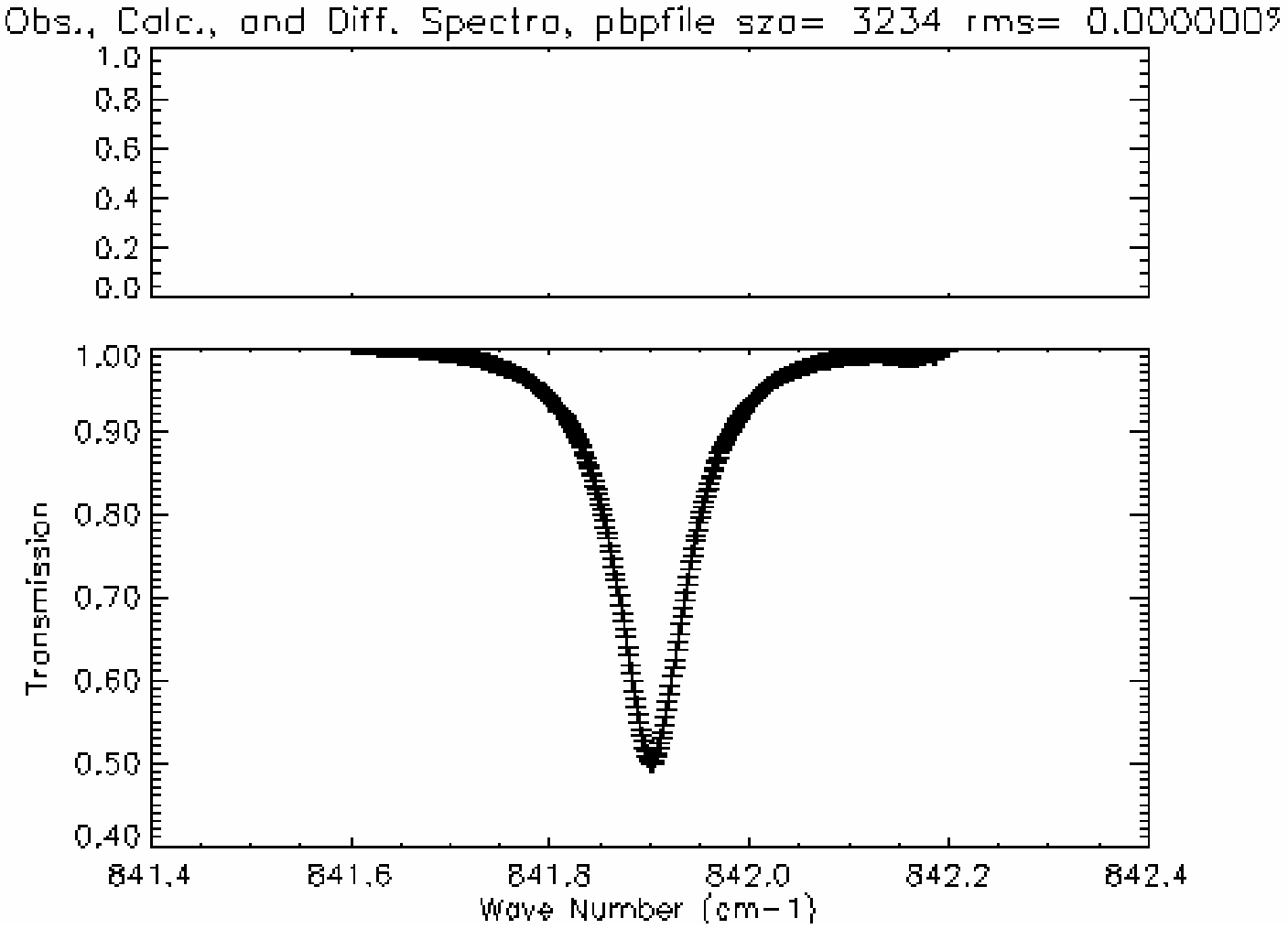
Zugspitze solar FTIR retrieval: Micro windows

HITRAN2000



010-010
R10, R13, R16
water lines

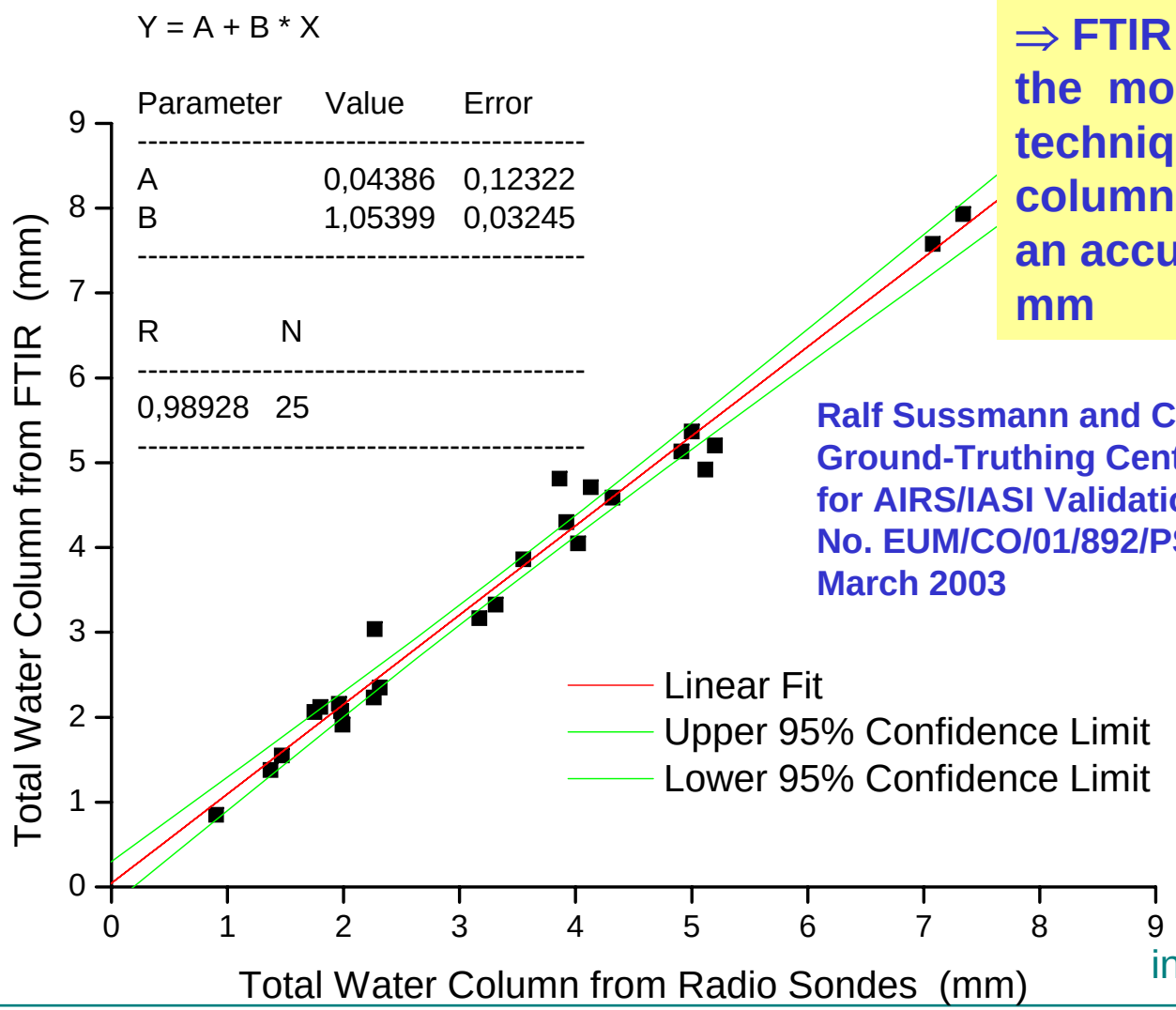
Zugspitze solar FTIR retrieval: Micro windows



Water vapor columns Zugspitze/Garmisch: Validation of solar FTIR with sondes

Columns above Zugspitze, 2964 m

2-h-mean values

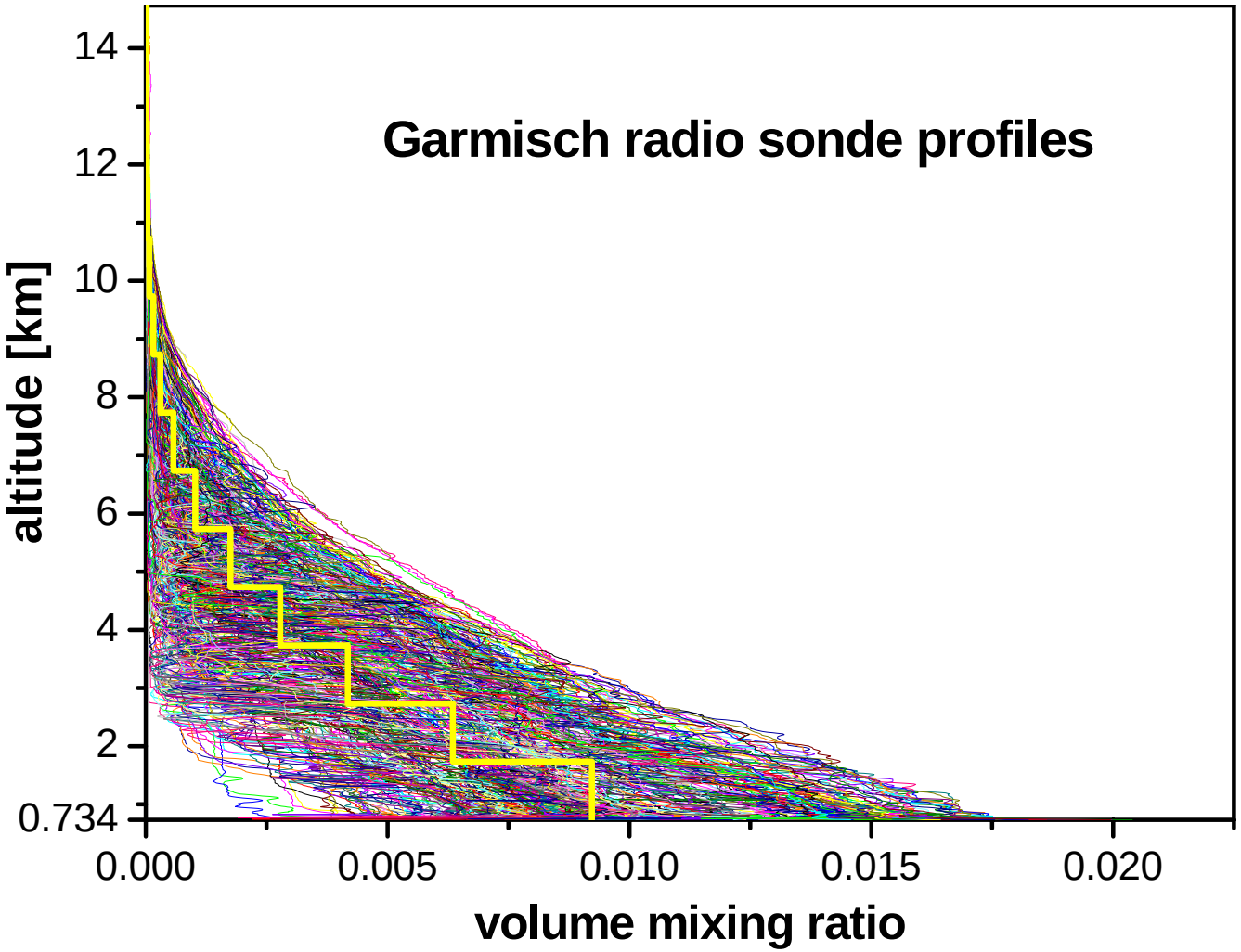


integrated Tobin-profiles

⇒ FTIR is probably one of the most accurate techniques to quantify columnar water vapor, with an accuracy around 0.1 mm

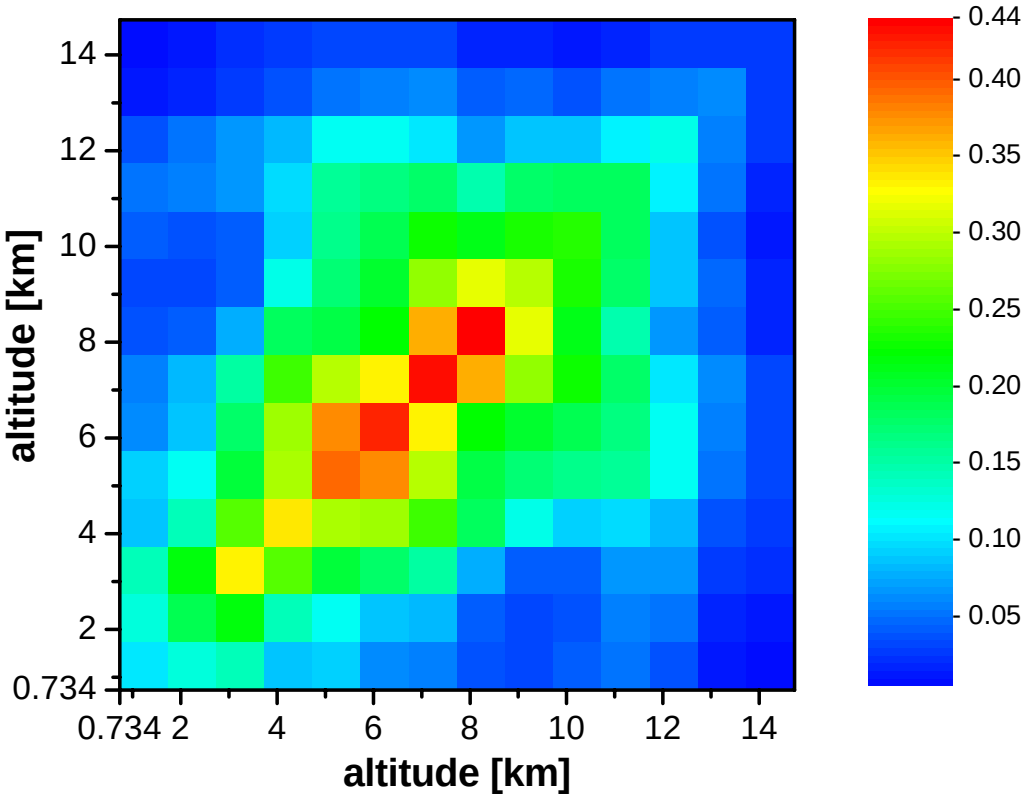
Ralf Sussmann and Claude Camy-Peyret, Ground-Truthing Center Zugspitze, Germany for AIRS/IASI Validation, EUMETSAT Contract No. EUM/CO/01/892/PS, Phase II Report, 28 March 2003

Zugspitze/Garmisch FTIR profile retrieval: A priori information used (I)



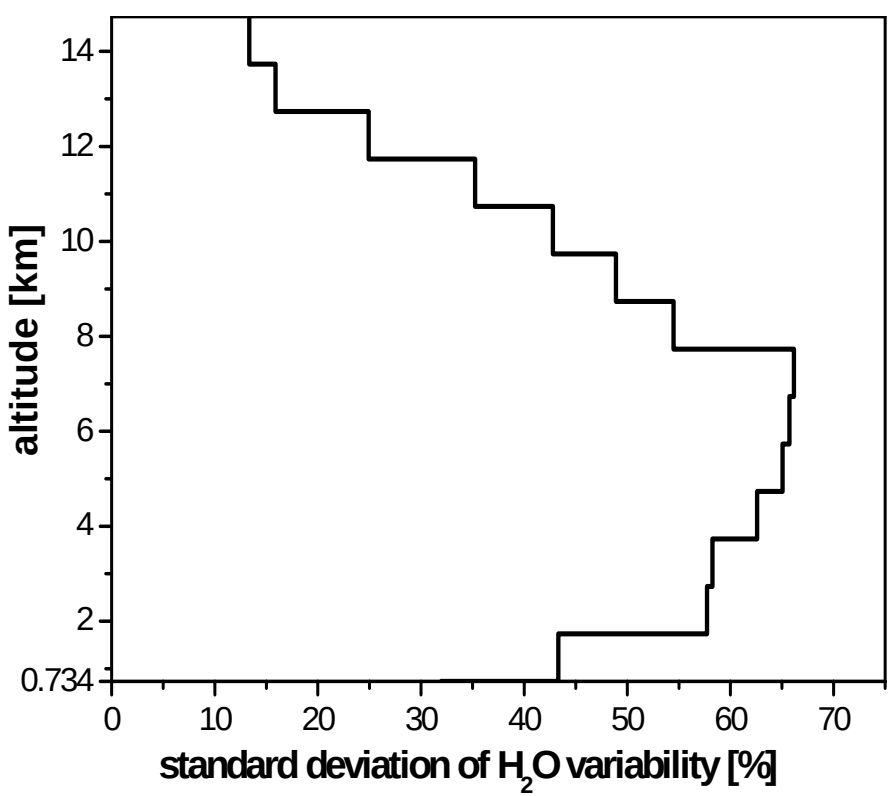
Zugspitze/Garmisch FTIR profile retrieval: A priori information used (II)

water vapor covariance



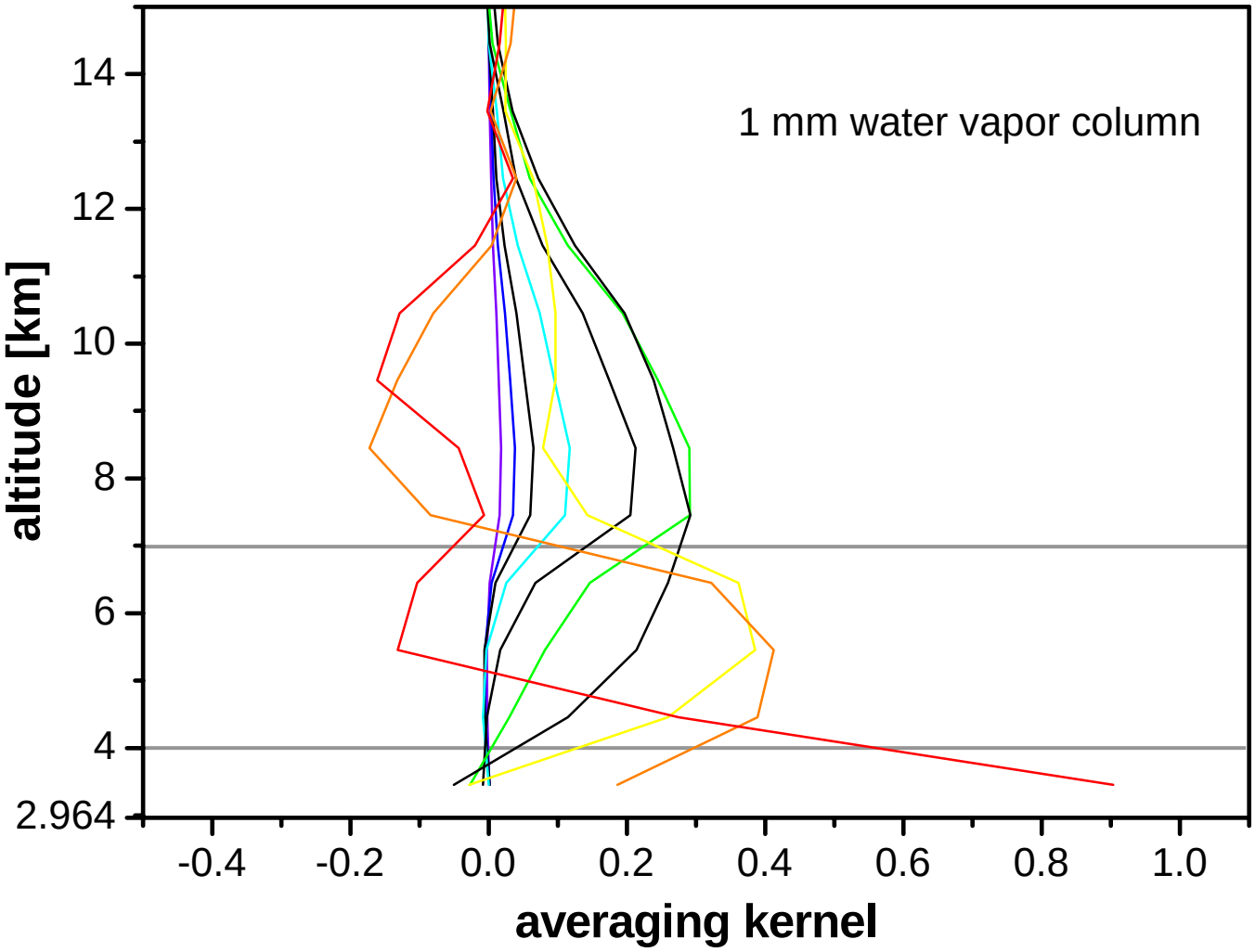
Unit: covariances of VMR-layer scaling factors

water vapor variability (stdv)



VMR

Zugspitze/Garmisch FTIR profile retrieval: Averaging kernels

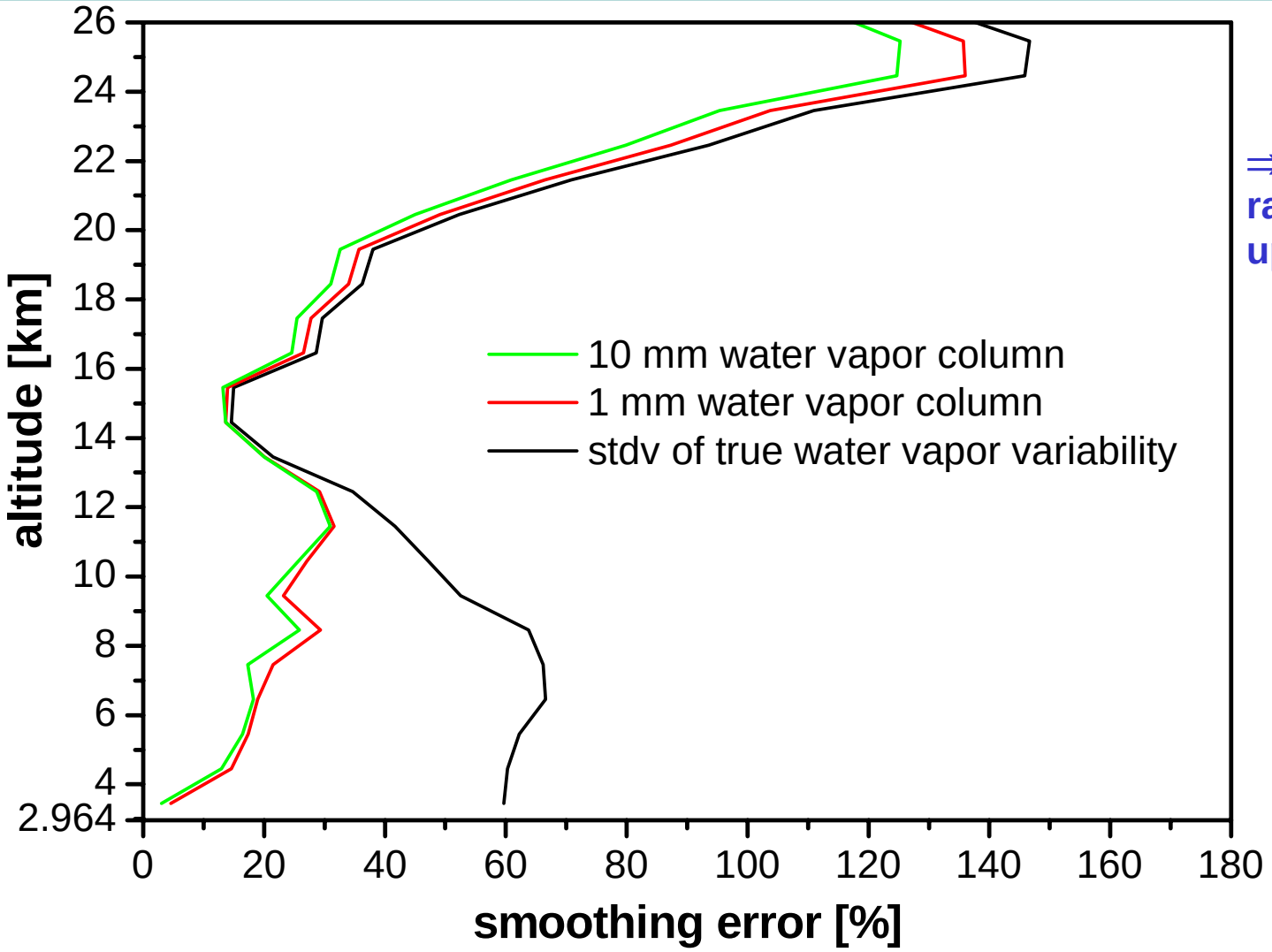


dofs ≈ 3 (snr ≈100)

dofs-1-layers:

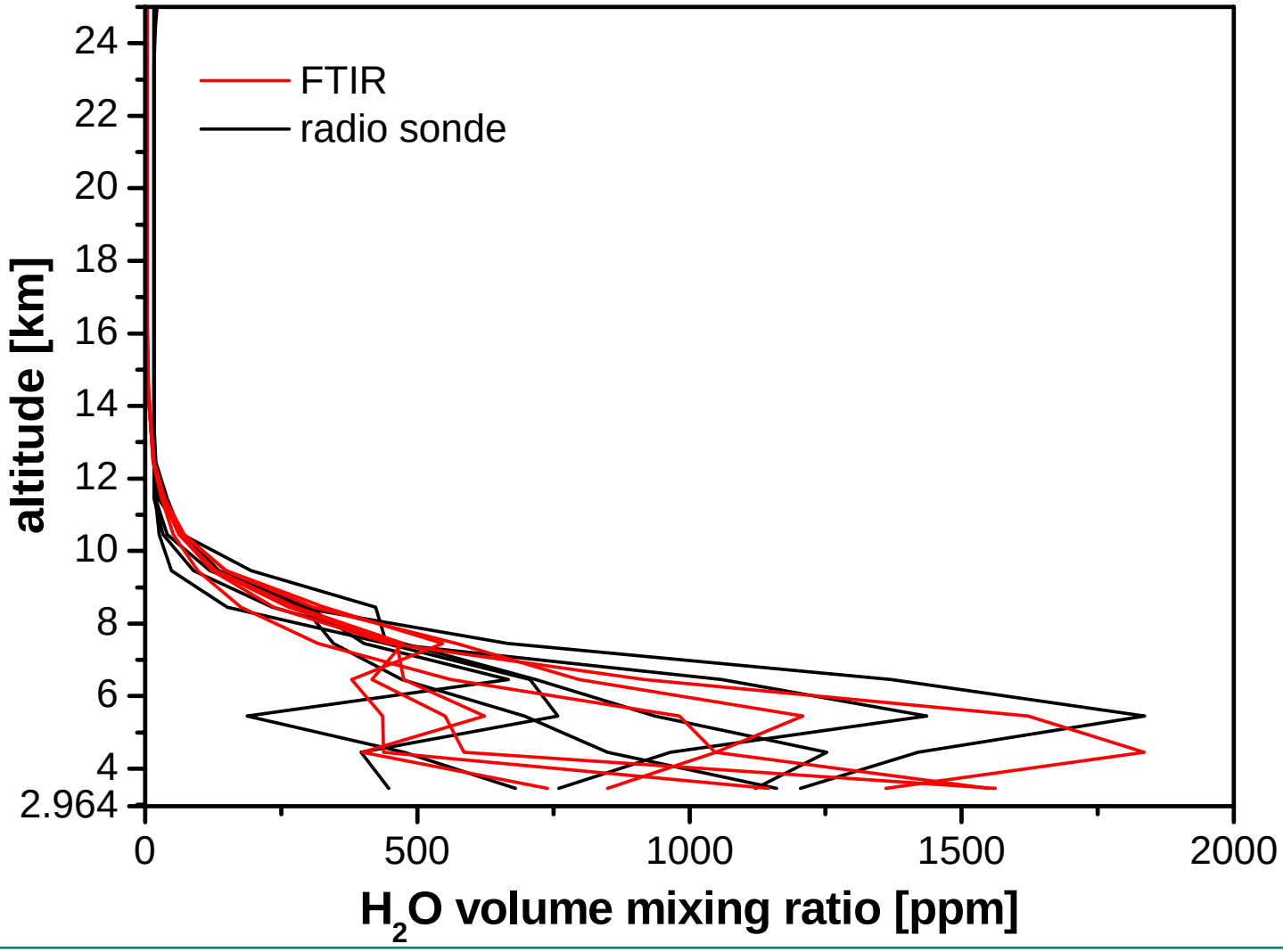
3 - 4 km
4 - 7 km
7 – 15 km

Zugspitze/Garmisch FTIR profile retrieval: Smoothing error



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

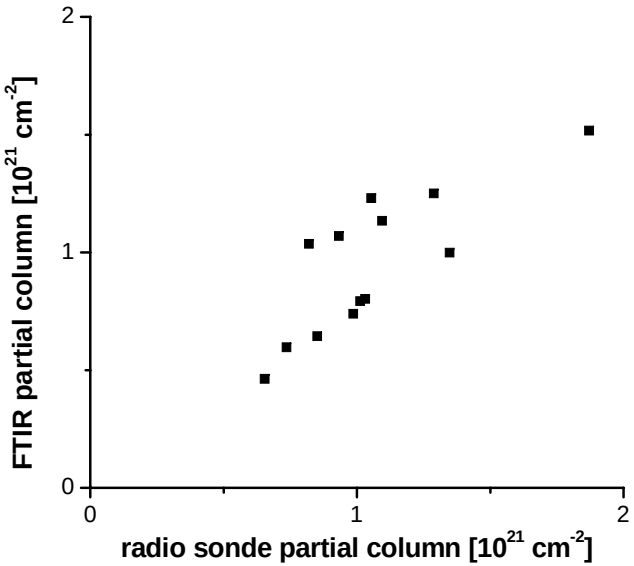
Zugspitze FTIR profile retrieval: Retrieved profiles versus sondes



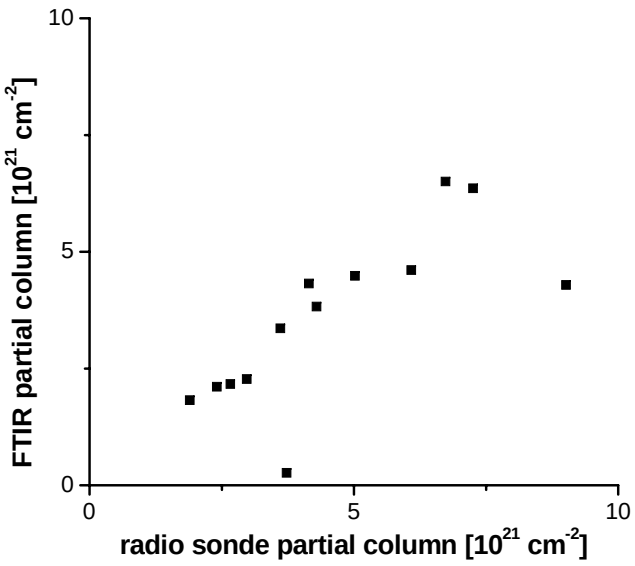
Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Zugspitze FTIR profile retrieval: Retrieved profiles versus sondes

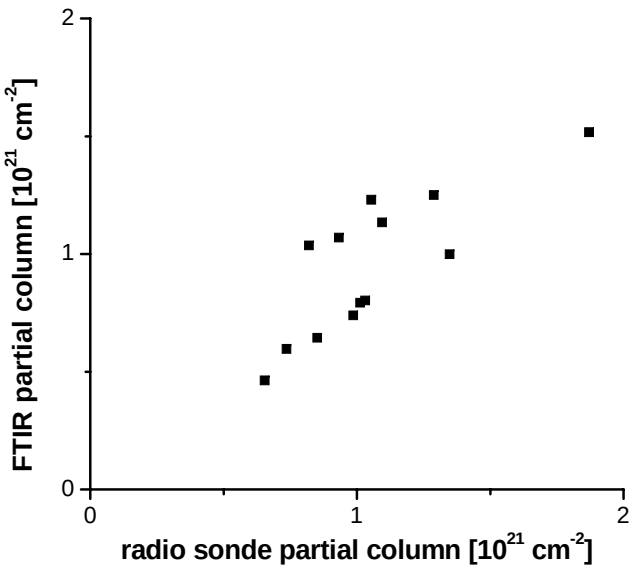
partial column 3 - 4 km



partial column 4 - 7 km

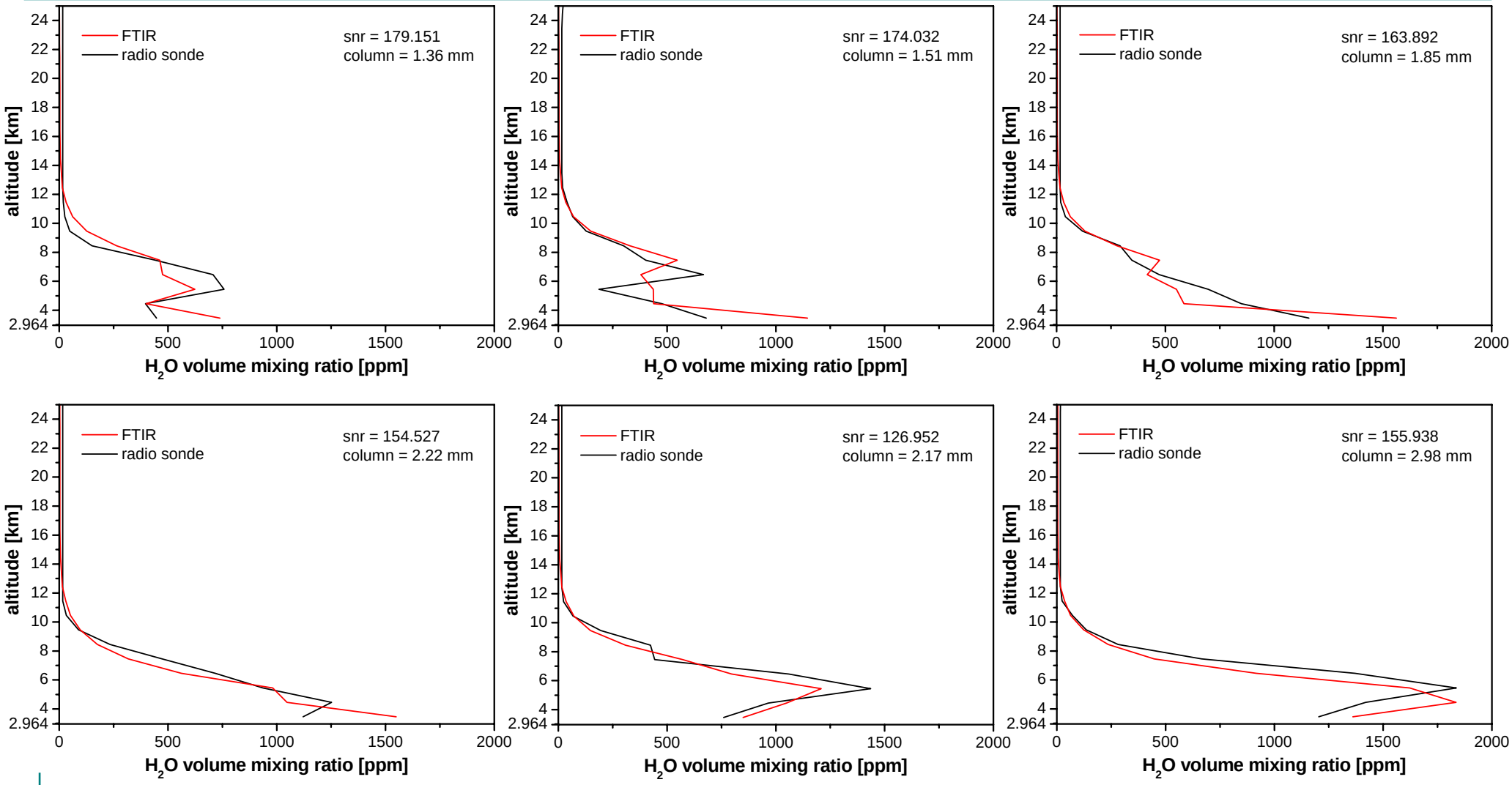


partial column 7 - 15 km



Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Zugspitze FTIR profile retrieval: Retrieved profile versus sonde



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Partial columns retrieval from Zugspitze and Garmisch FTIR measurements

Summary/Outlook: FTIR water vapor retrievals at Zugspitze + Garmisch

Summary

- found interference-free micro-window set
- FTIR yields very very high accuracy total columns
- Zugspitze – Garmisch „differential FTIR“
- OE with climatological a priori covariance from sondes works fine
- dofs ≈ 3, i.e., layers 3 - 4 km, 4 - 7 km, 7 – 15 km
- smooting error/altitude range does not significantly depend on absolute water column level
- validation against sondes good, given high quality spectra (snr > 120)

Outlook

- synergistic combination with Zugspitze water lidar measurements
- Zugspitze/Garmisch EPS-MetOp IASI validation campaign in 2007