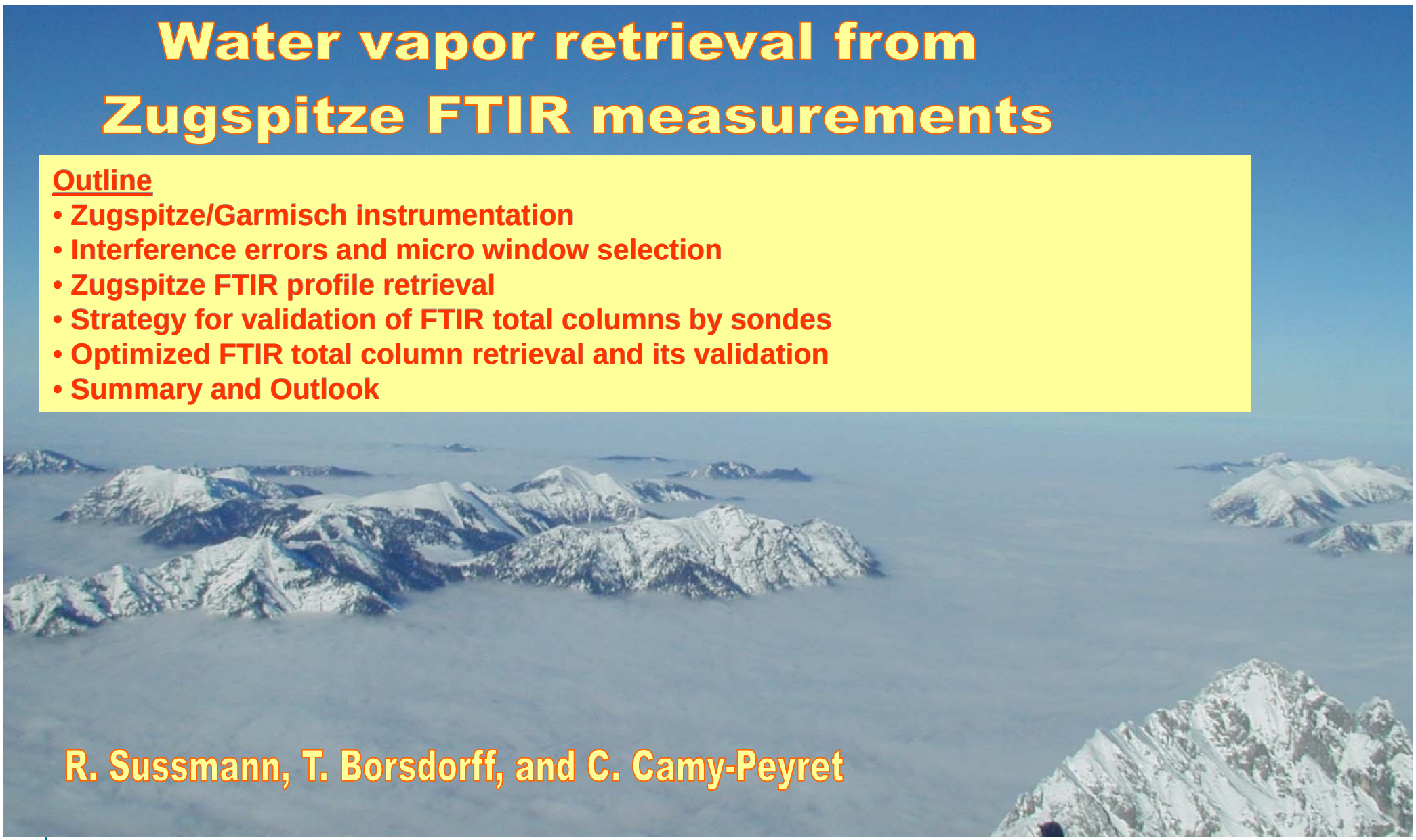
Water vapor retrieval from Zugspitze FTIR measurements

Outline

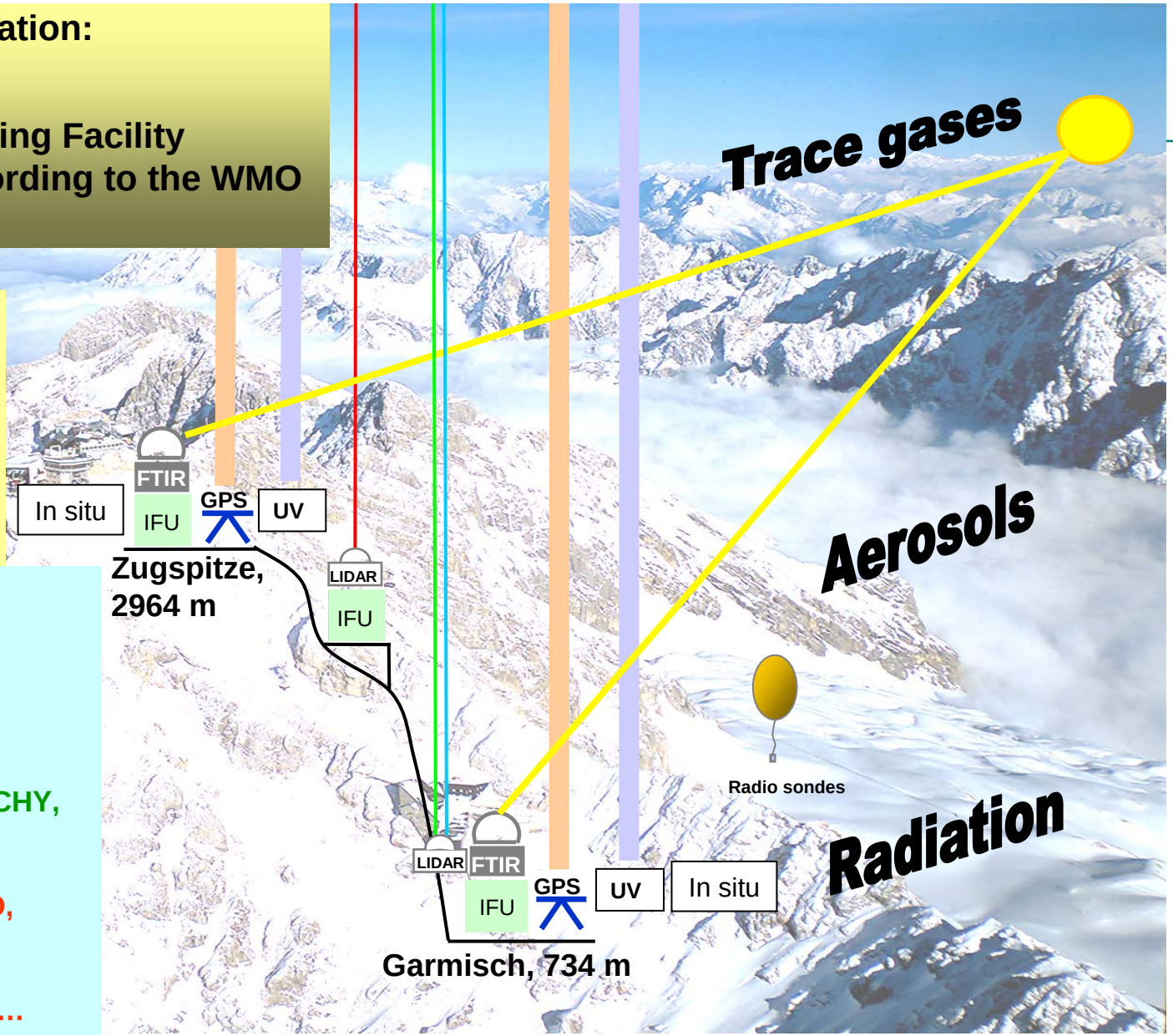
- Zugspitze/Garmisch instrumentation
- Interference errors and micro window selection
- Zugspitze FTIR profile retrieval
- Strategy for validation of FTIR total columns by sondes
- Optimized FTIR total column retrieval and its validation
- Summary and Outlook



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
- R. Sussmann
- H.E. Scheel
- T. Trickl
- H. Vogelmann

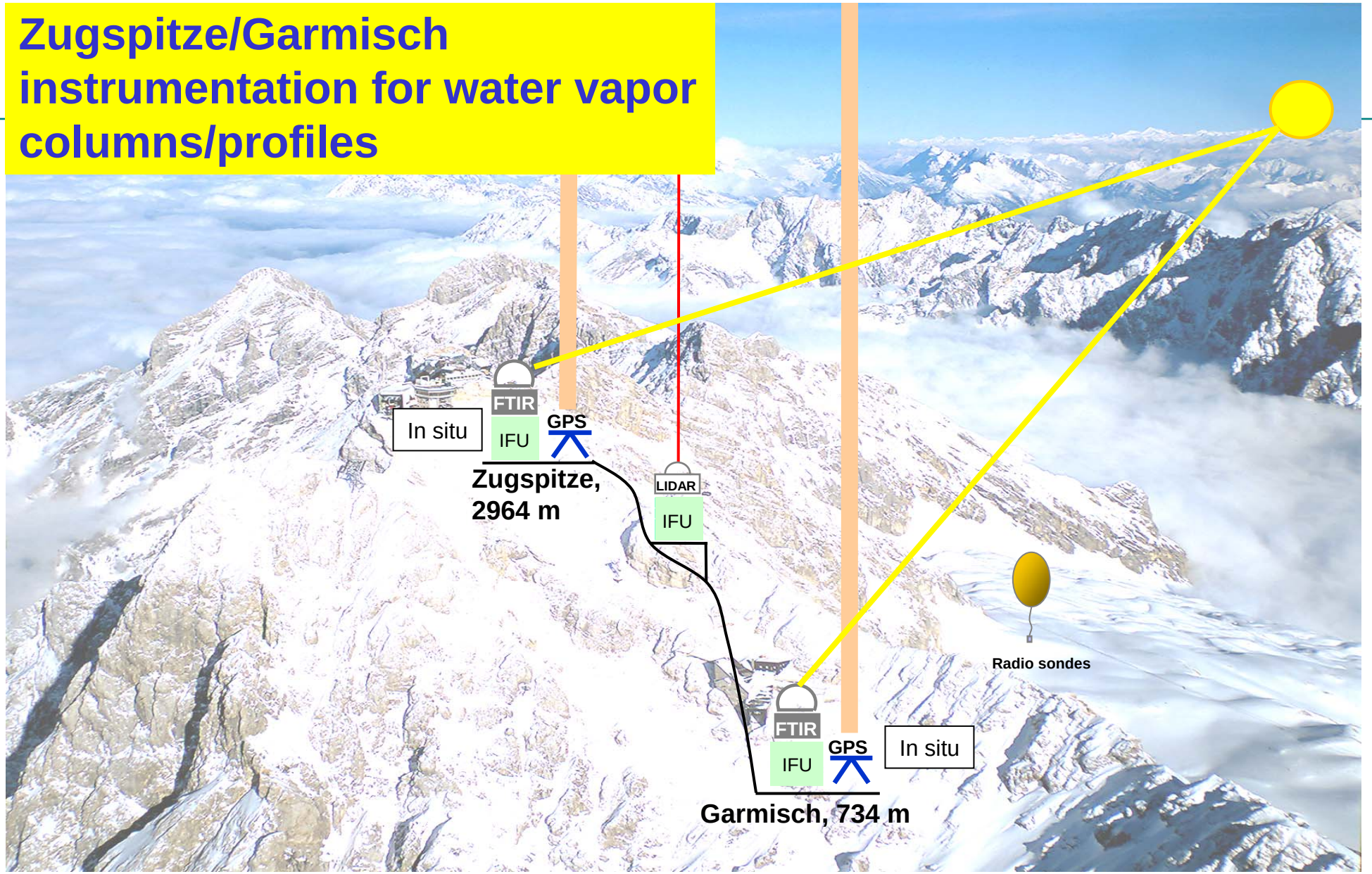
Engineers
- H. Giehl
- M. Rettinger

PhD students
- T. Borsdorff
- F. Forster

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

Water vapor retrieval from Zugspitze FTIR measurements

Zugspitze/Garmisch instrumentation for water vapor columns/profiles



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

Water vapor retrieval from Zugspitze FTIR measurements

Zugspitze operational since 1995
typ. 130-140 measurement days per year

H_2O columns and profiles

FTIR
IFU

Zugspitze 2964 m

Garmisch operational since 2004
typ. 130-140 measurement days per year

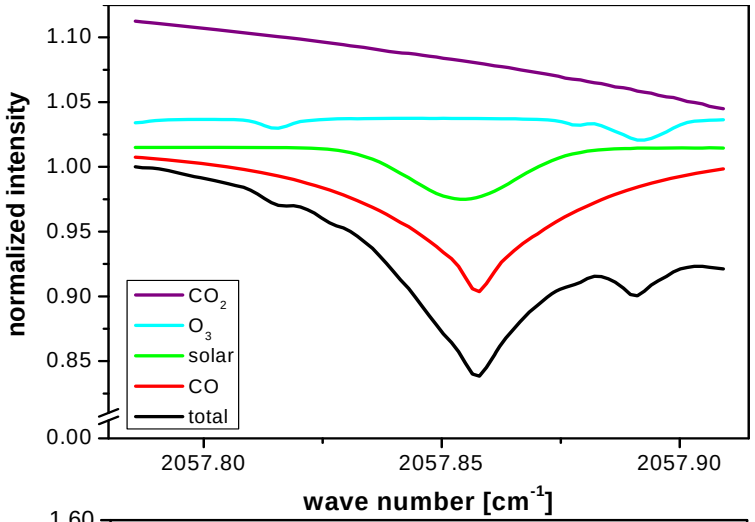
"Differential FTIR" with Zugspitze: H_2O columns and profiles

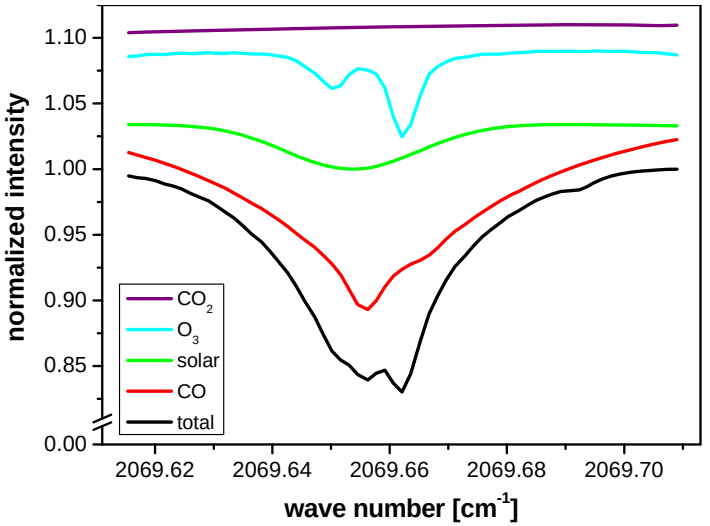
FTIR
IFU

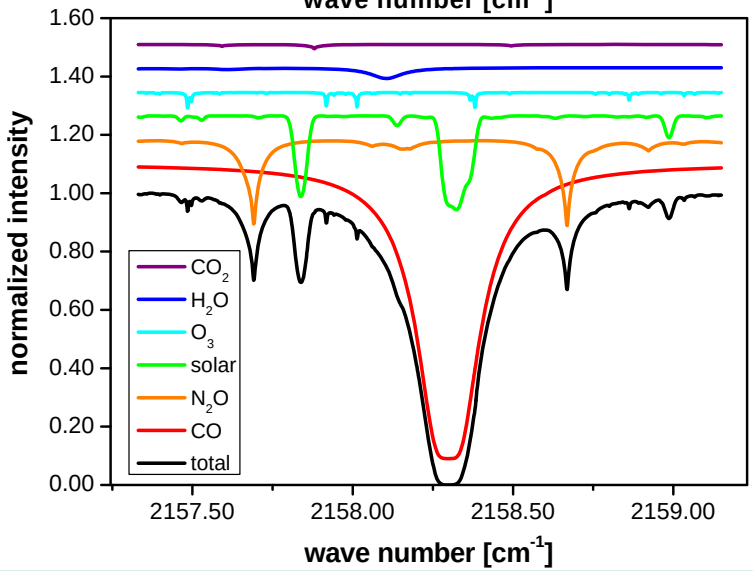
Garmisch 734 m

Water vapor retrieval from Zugspitze FTIR measur

Interference erros and micro window selection: Interference errors (I)

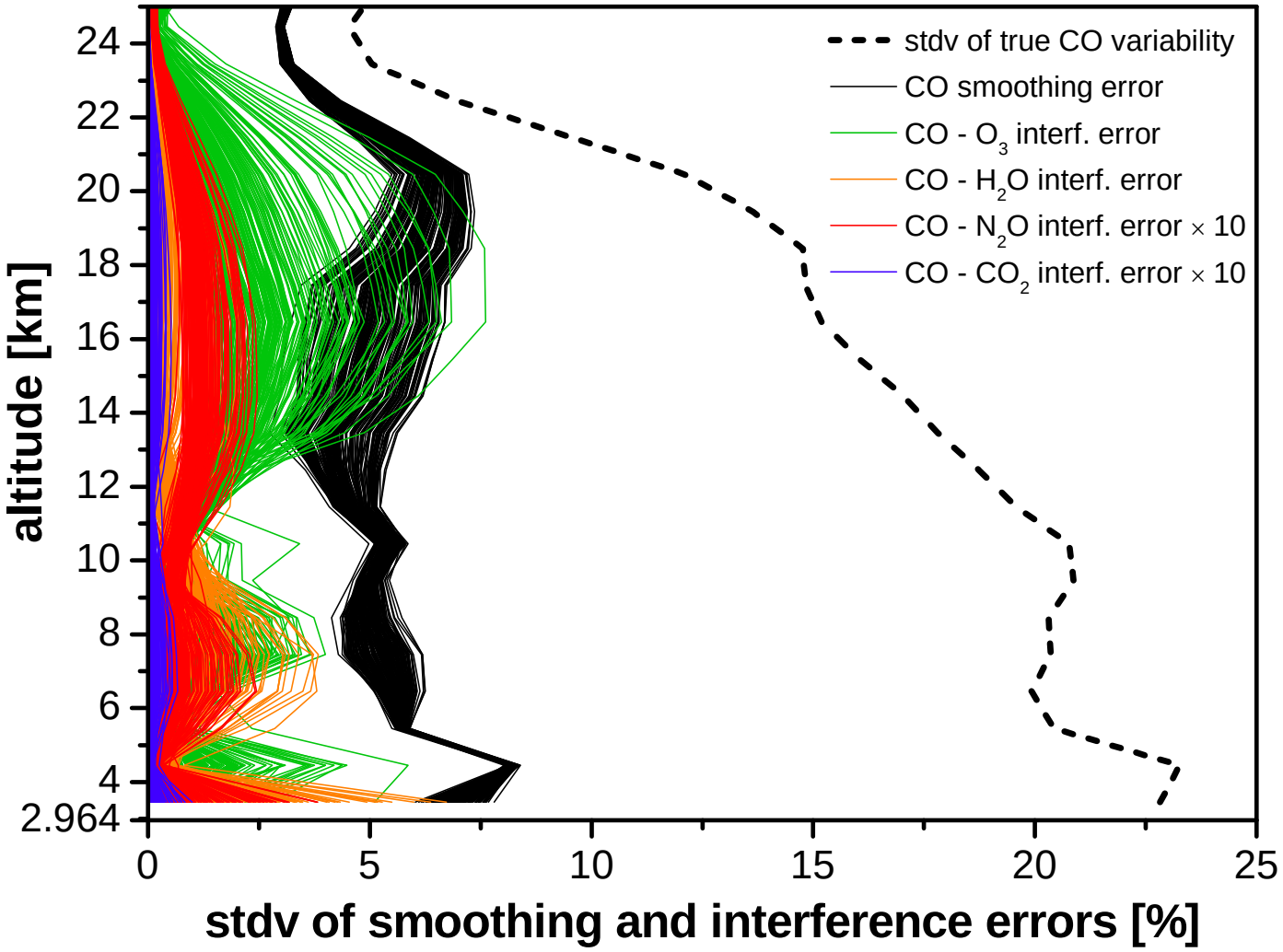






Example CO retrieval:
interfering species
O_3, N_2O, CO_2, H_2O

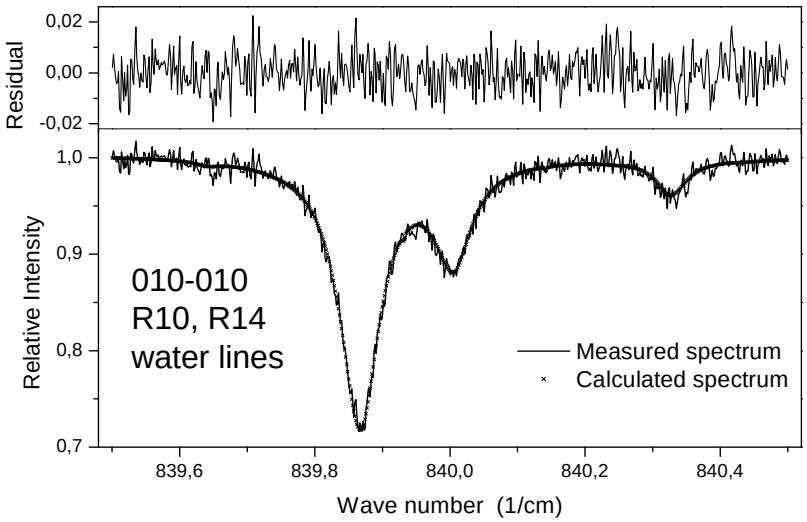
Interference erros and micro window selection: Interference errors (II)

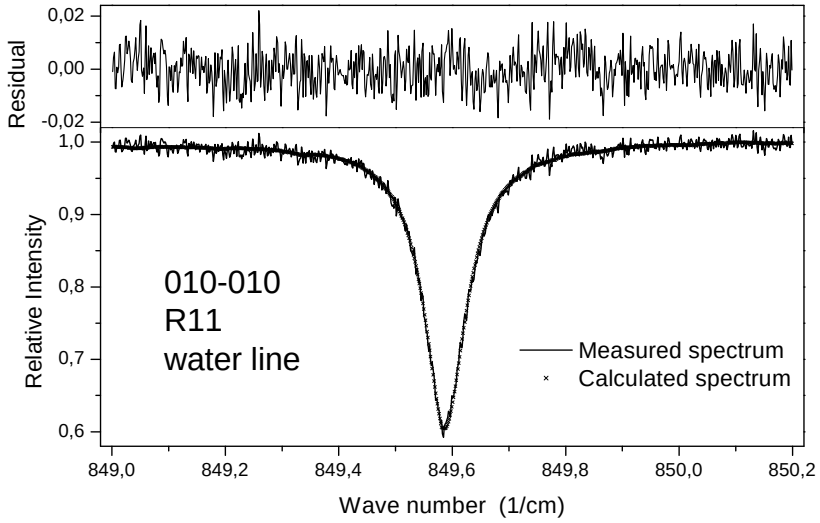


Example CO retrieval

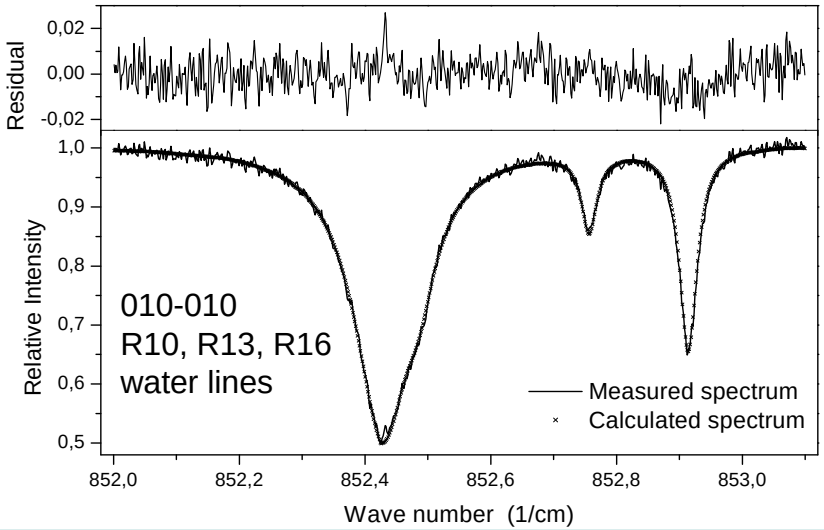
taken from:
Sussmann, R. and Borsdorff, T: Technical note: Interference errors in infrared remote sounding of the atmosphere,
Atmos. Chem. Phys., 7, 3537-3557, 2007.

Zugspitze FTIR water vapor profile retrieval: Interference-free micro windows

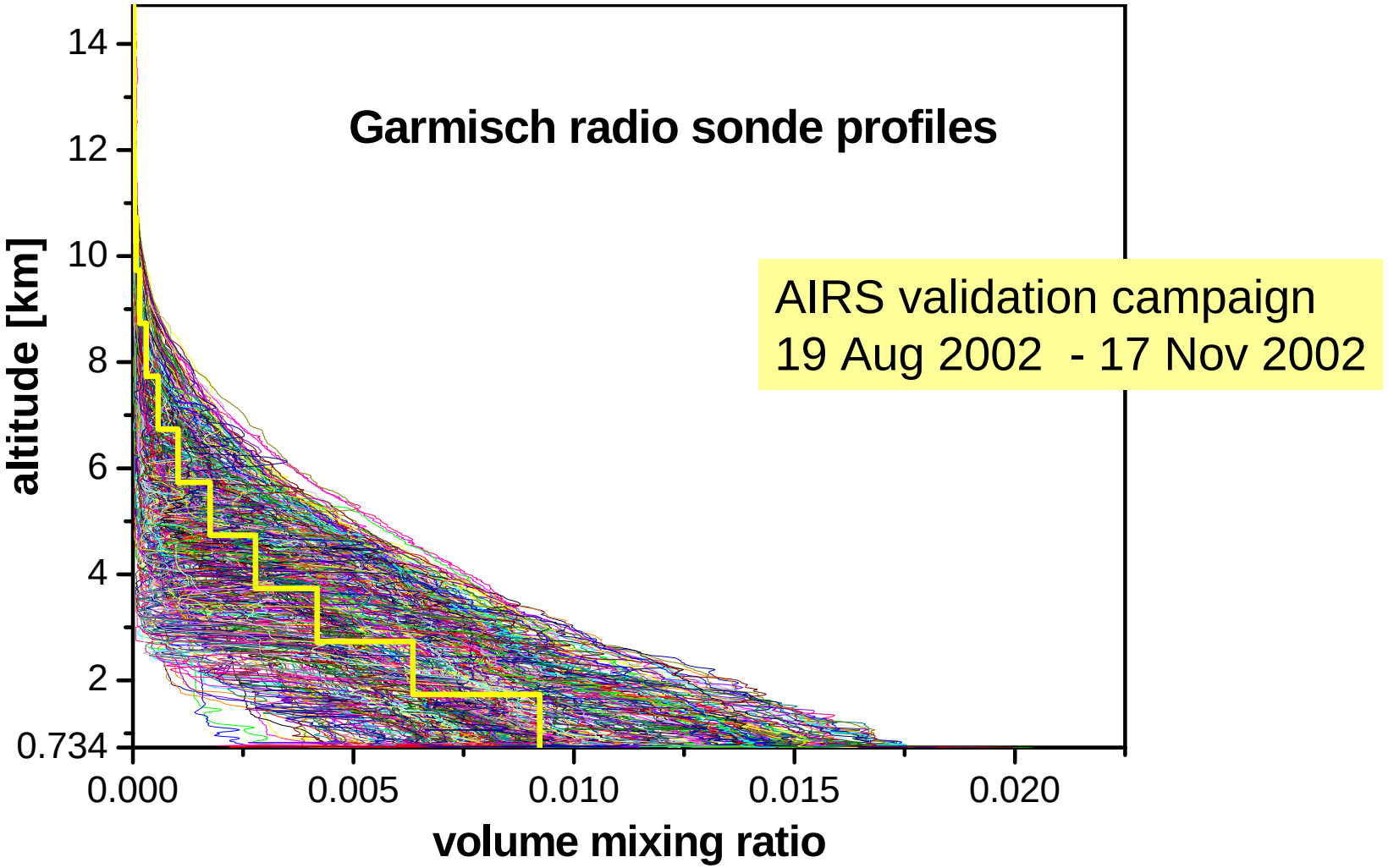




HITRAN2000

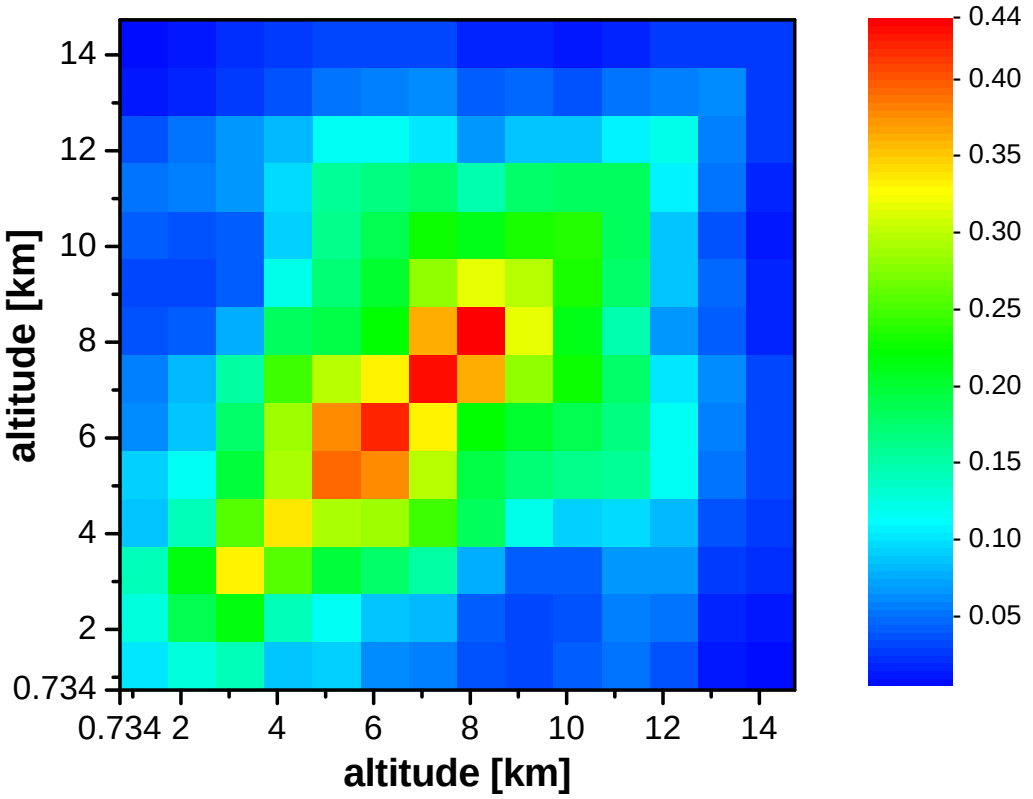


Zugspitze FTIR water vapor profile retrieval: A priori information used (I)



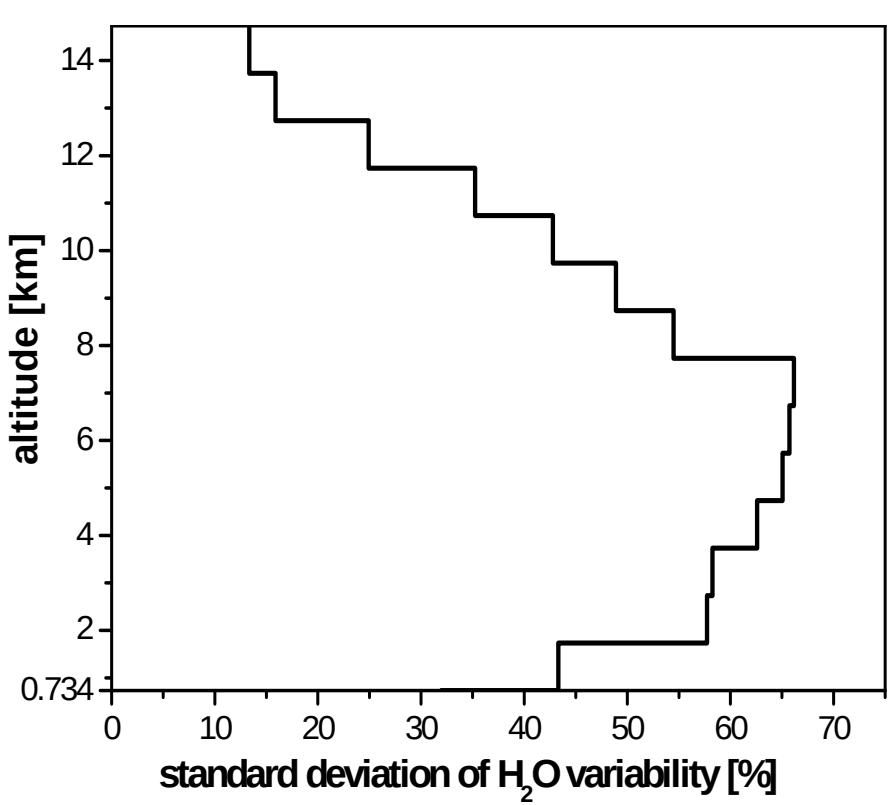
Zugspitze FTIR water vapor profile retrieval: A priori information used (II)

water vapor covariance



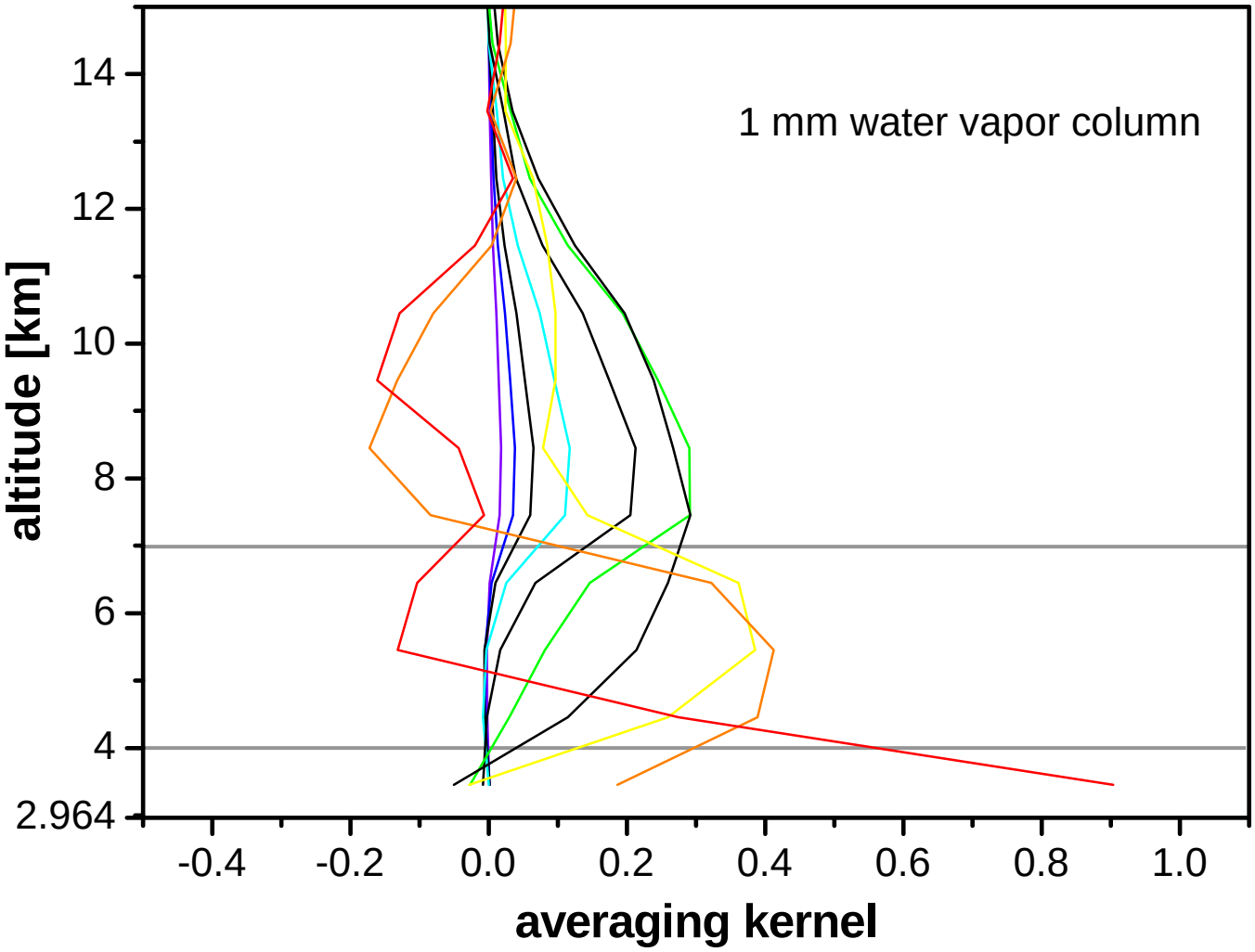
Unit: covariances of VMR-layer scaling factors

water vapor variability (stdv)



VMR

Zugspitze FTIR water vapor profile retrieval: Averaging kernels

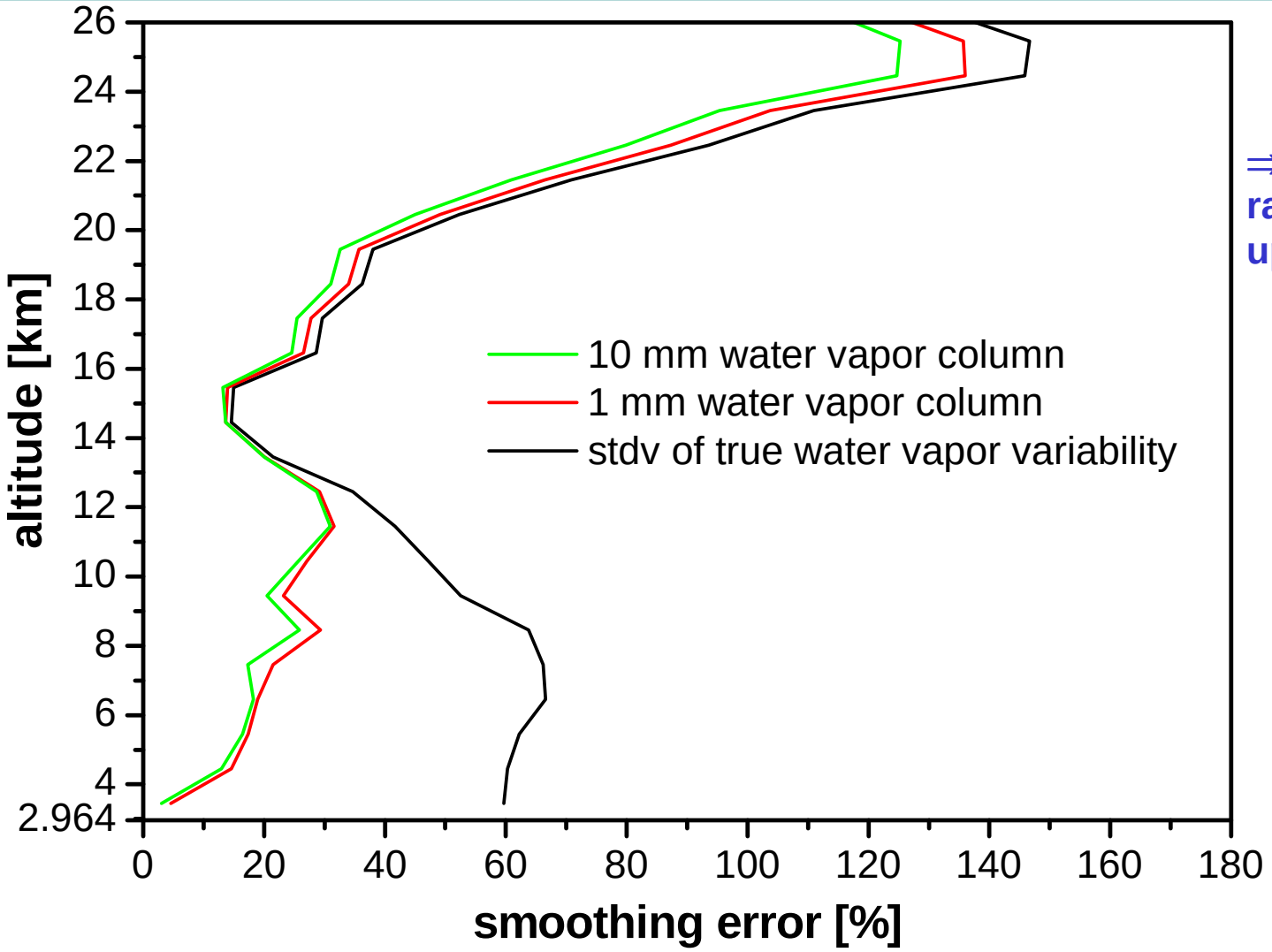


dofs ≈ 3 (snr ≈100)

dofs-1-layers:

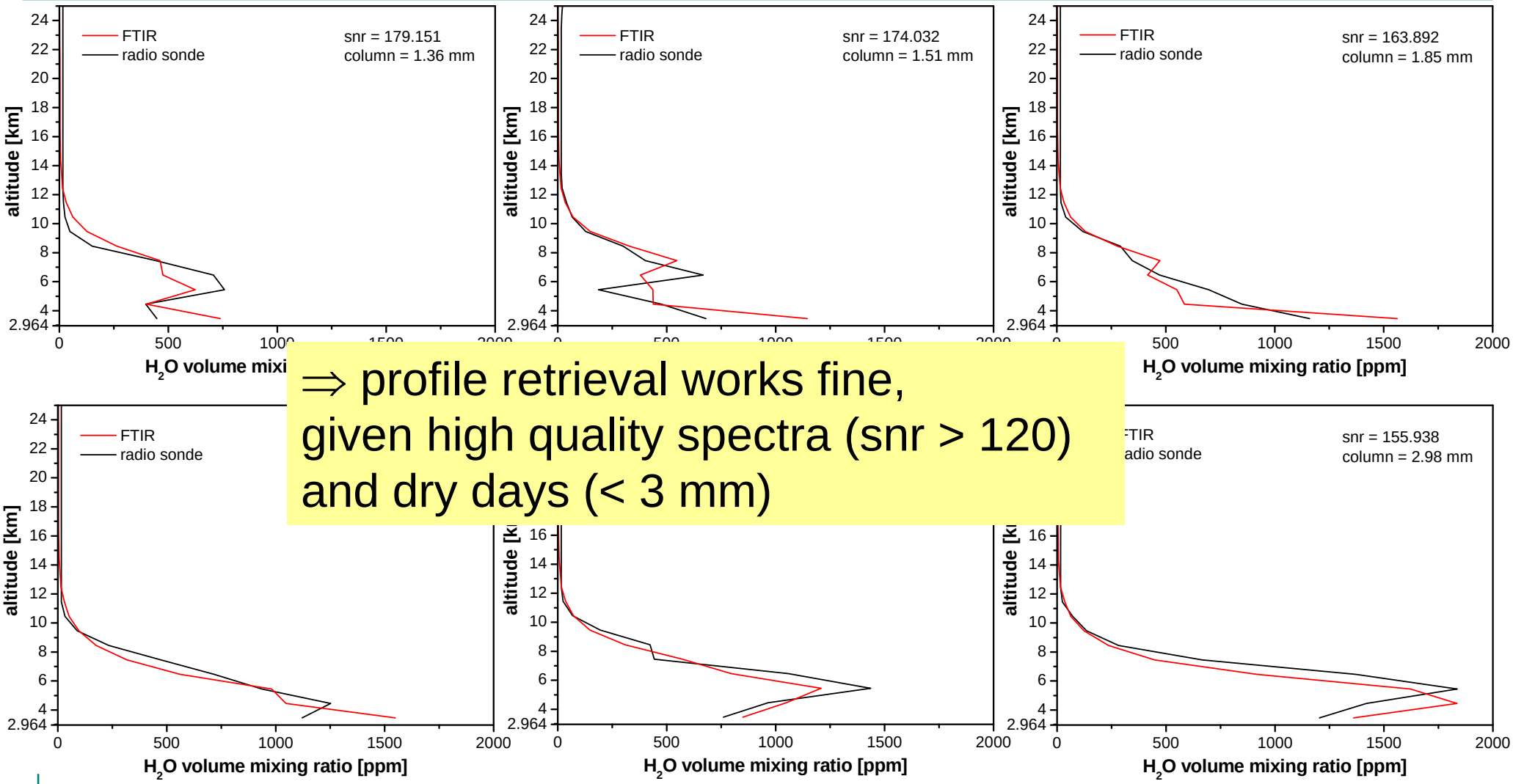
3 - 4 km
4 - 7 km
7 – 15 km

Zugspitze FTIR water vapor profile retrieval: Smoothing error



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

Zugspitze FTIR water vapor profile retrieval: Retrieved profile versus sonde



⇒ profile retrieval works fine,
given high quality spectra (snr > 120)
and dry days (< 3 mm)

Strategy for validation of FTIR total water vapor columns by sondes: Tobin-Sondes

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

AIRS validation campaign
19 Aug 2002 - 17 Nov 2002

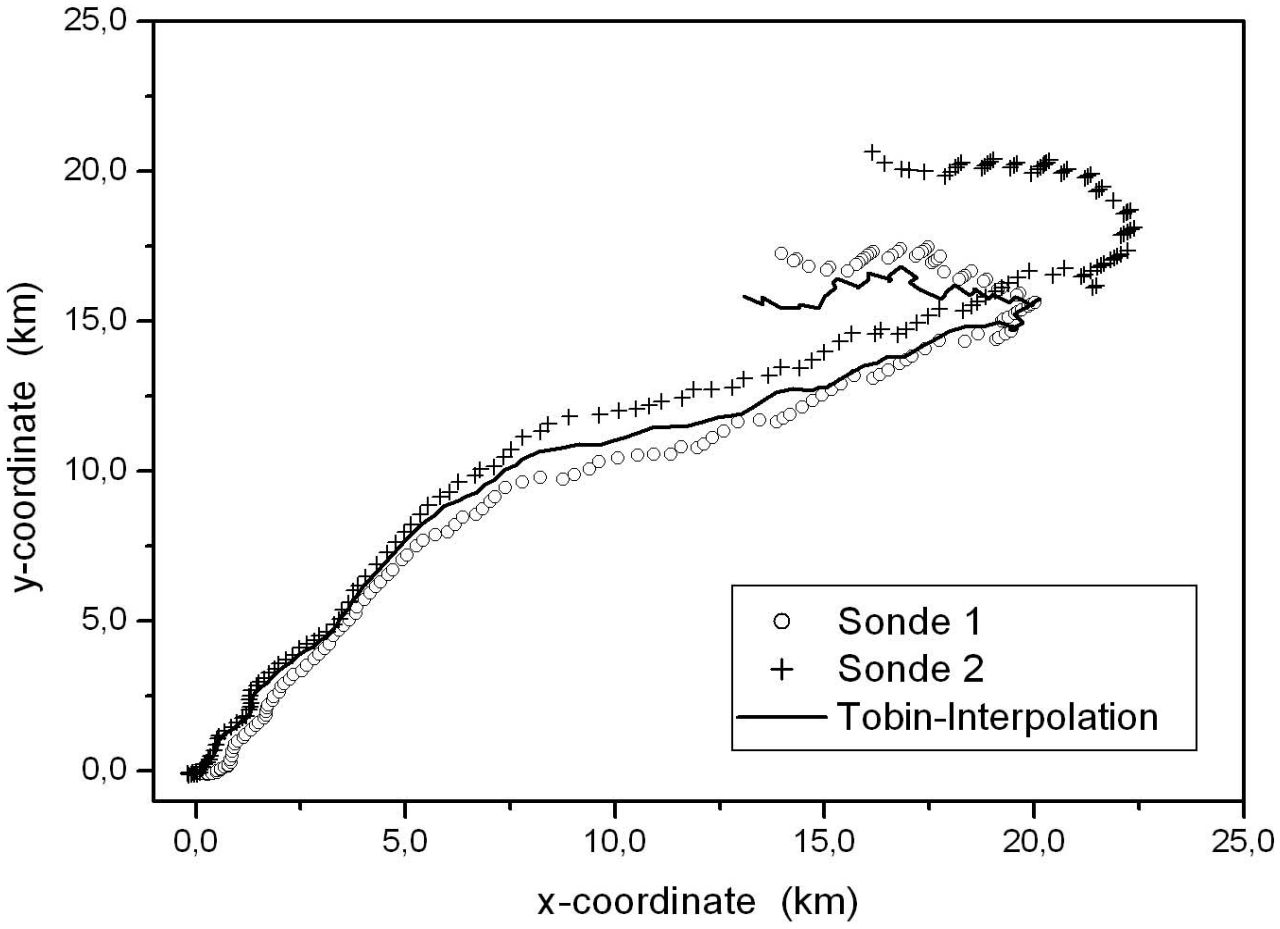
Vaisala RS 80-30 G sondes
TOTEX-800-g balloons
2 x Digicora III (Marvin 21, SPS220G)

TOBIN-Inter-/Extrapolation between both soundings:

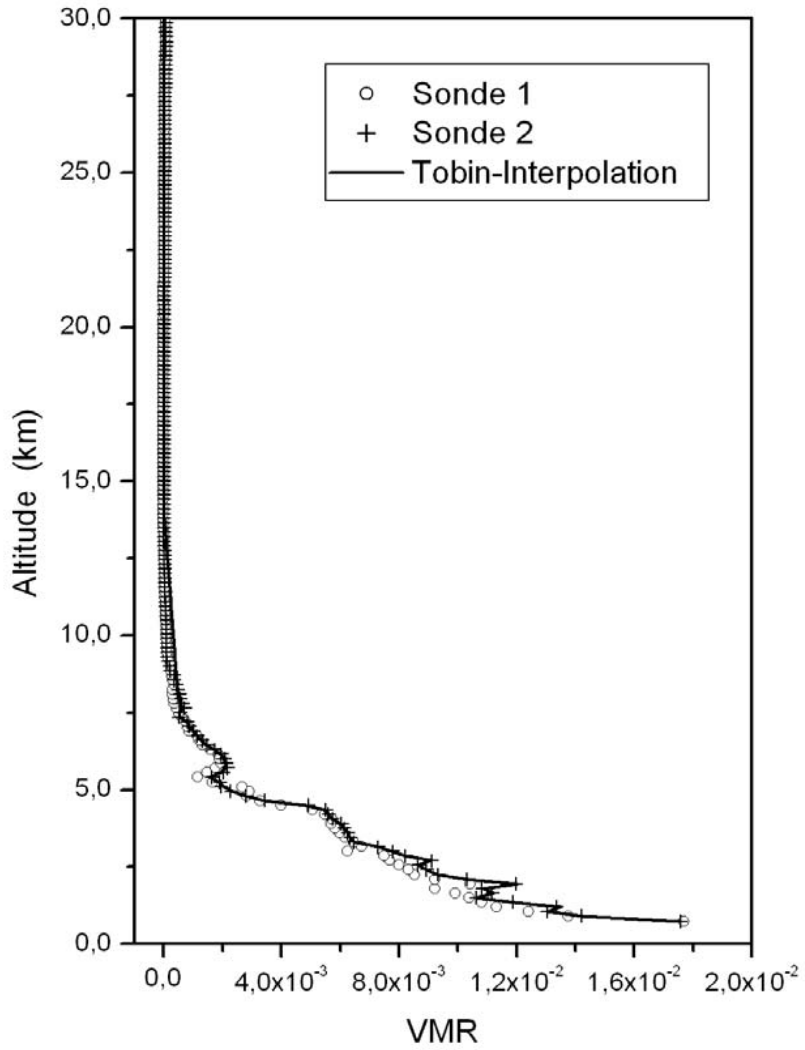
$$q_{Tobin}(z, t_{op}) = q_{sonde}(z, t_0) + (dq(z)/dt)\ (t_{op} - t_0)$$

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

Strategy for validation of FTIR total water vapor columns by sondes: Tobin-Sondes



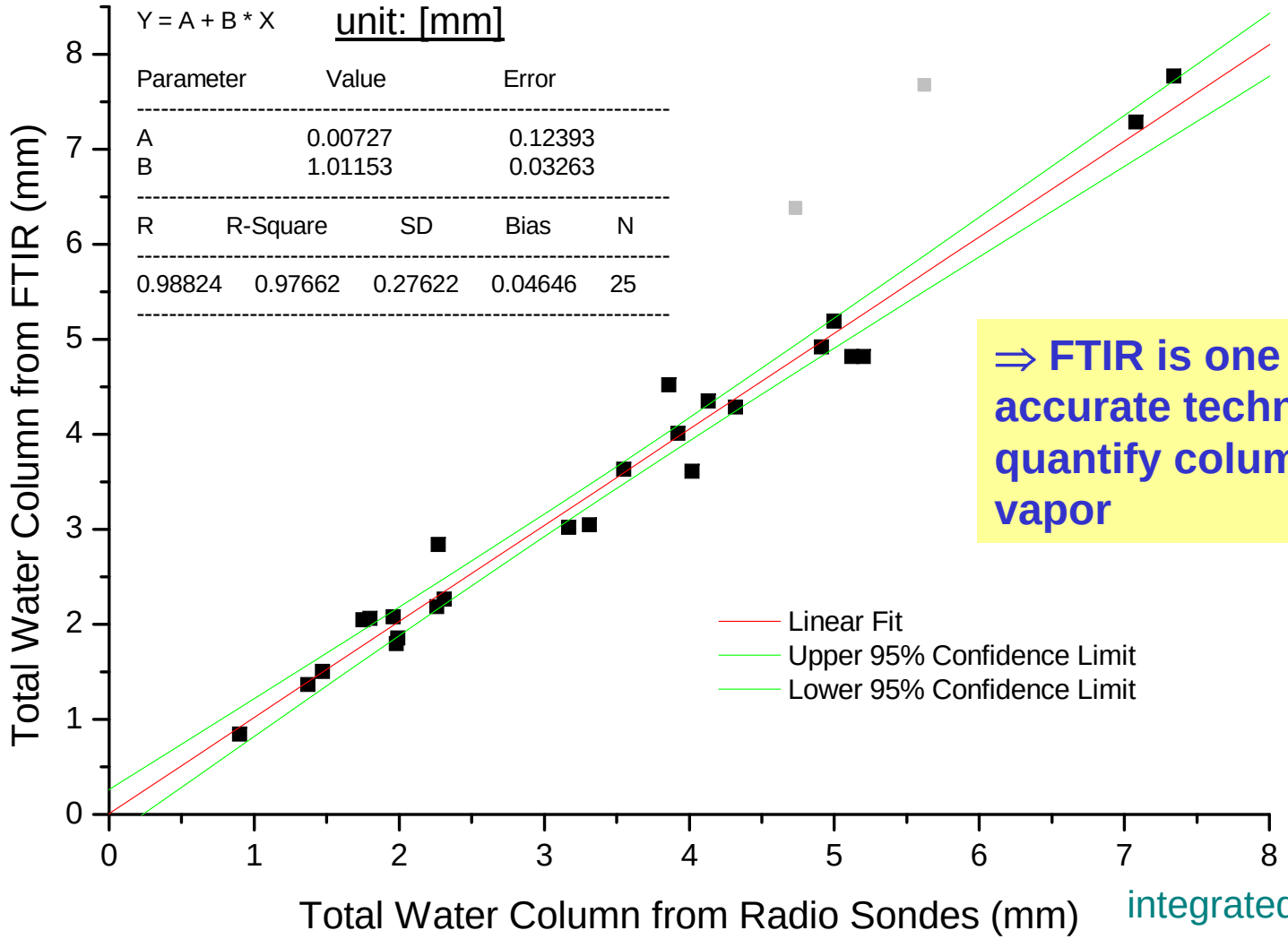
Strategy for validation of FTIR total water vapor columns by sondes: Tobin-Sondes



Optimized FTIR total water vapor column retrieval and its validation

Columns above Zugspitze, 2964 m

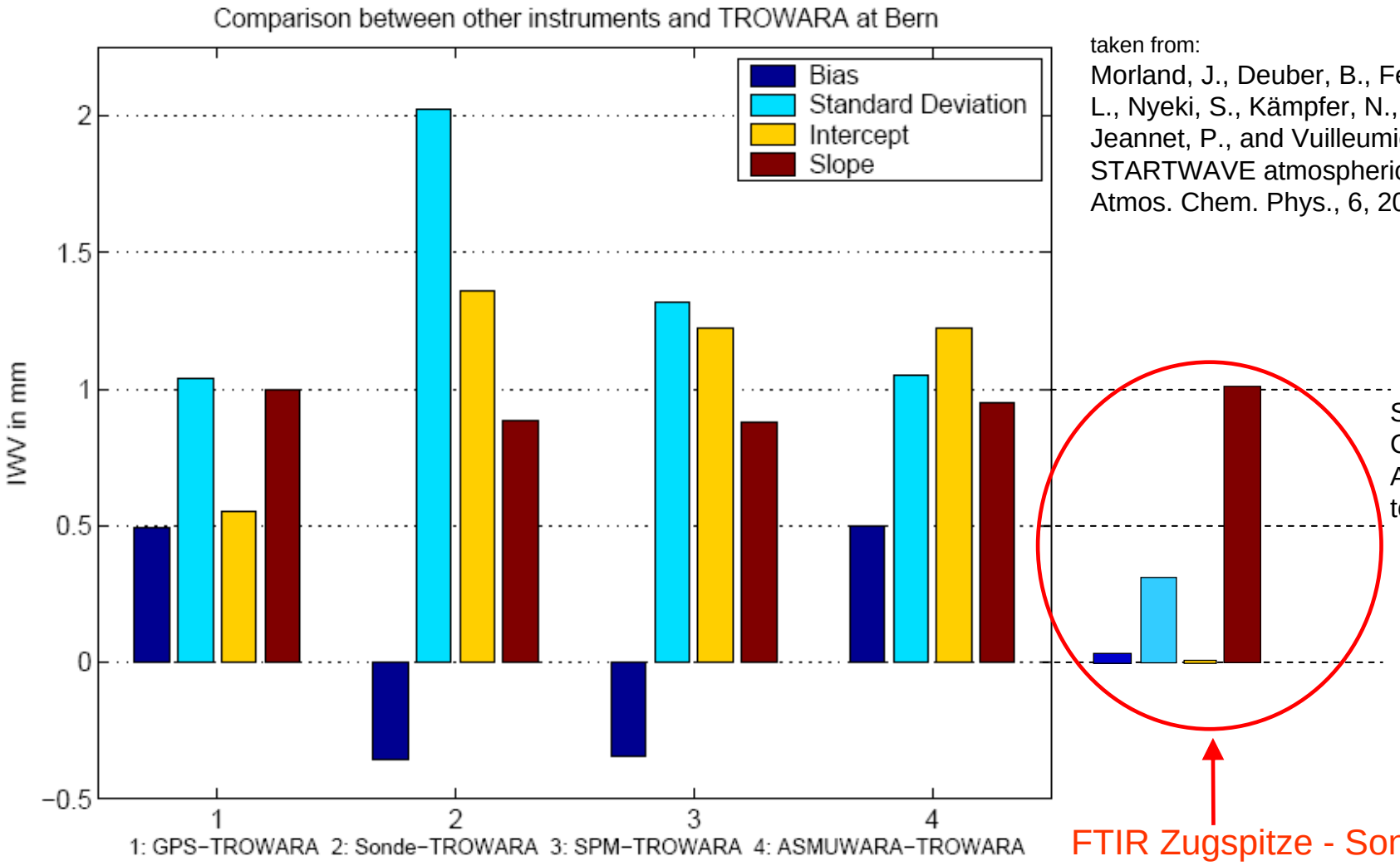
2-h-mean values



integrated Tobin-profiles

⇒ FTIR is one of the most accurate techniques to quantify columnar water vapor

Optimized FTIR total water vapor column retrieval and its validation



taken from:
Morland, J., Deuber, B., Feist, D. G., Martin, L., Nyeki, S., Kämpfer, N., Mätzler, C., Jeannet, P., and Vuilleumier, L.: The STARTWAVE atmospheric water database, Atmos. Chem. Phys., 6, 2039-2056, 2006.

Sussmann, Borsdorff, Camy-Peyret, Atmos. Chem. Phys., to be published

FTIR Zugspitze - Sonde

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

Water vapor retrieval from Zugspitze FTIR measurements

Summary

- found interference-free micro-window set
- profile retrieval
  - OE with climatological a priori covariance from sondes: dofs ≈ 3, i.e., layers 3 - 4 km, 4 - 7 km, 7 – 15 km
  - smooting error/altitude range does not depend on absolute water column
  - FTIR profiles reproduce sonde fine struture well, given high quality spectra (snr > 120) and dry days (< 3 mm)
- FTIR is the most accurate technique for total columns (?): validation against sondes (Tobin): R^2 = 0.98, slope = 1.01, stdv < 0.3 mm, intercept < 0.01 mm, bias < 0.05 mm

Outlook

- validation against lidar / synergetic combination with lidar
- investigate “differential FTIR“ (Garmisch – Zugspitze column)