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Technical Note: Harmonized retrieval of column-integrated atmospheric water vapor from the FTIR network – first examples for long-term records and station trends

R. Sussmann[1], T. Borsdorff[1], M. Rettinger[1], C. Camy-Peyret[2], P. Demoulin[3], P. Duchatelet[3], E. Mahieu[3], and C. Servais[3]
[1]Karlsruhe Institute of Technology, IMK-IFU, Garmisch-Partenkirchen, Germany
[2]Laboratoire de Physique Moléculaire pour l'Atmosphère et l'Astrophysique (LPMAA), CNRS/UPMC/IPSL, Paris, France
[3]Institute of Astrophysics and Geophysics, University of Liège, Liège, Belgium

Abstract. We present a method for harmonized retrieval of integrated water vapor (IWV) from existing, long-term, measurement records at the ground-based mid-infrared solar FTIR spectrometry stations of the Network for the Detection of Atmospheric Composition Change (NDACC). Correlation of IWV from FTIR with radiosondes shows an ideal slope of 1.00(3). This optimum matching is achieved via tuning one FTIR retrieval parameter, i.e., the strength of a Tikhonov regularization constraining the derivative (with respect to height) of retrieved water profiles given in per cent difference relative to an a priori profile. All other FTIR-sonde correlation parameters (intercept=0.02(12) mm, bias=0.02(5) mm, standard deviation of coincident IWV differences (stdv)=0.27 mm, R=0.99) are comparable to or better than results for all other ground-based IWV sounding techniques given in the literature. An FTIR-FTIR side-by-side intercomparison reveals a strong exponential increase in stdv as a function of increasing temporal mismatch starting at $\Delta t \approx 1$ min. This is due to atmospheric water vapor variability. Based on this result we derive an upper limit for the precision of the FTIR IWV retrieval for the smallest Δt(=3.75 min) still giving a statistically sufficient sample (32 coincidences), i.e., precision(IWV_{FTIR})<0.05 mm (or 2.2% of the mean IWV). The bias of the IWV retrievals from the two different FTIR instruments is nearly negligible (0.02(1) mm). The optimized FTIR IWV retrieval is set up in the standard NDACC algorithm SFIT 2 without changes to the code. A concept for harmonized transfer of the retrieval between different stations deals with all relevant control parameters; it includes correction for differing spectral point spacings (via regularization strength), and final quality selection of the retrievals (excluding the highest residuals (measurement minus model), 5% of the total).

As first application examples long-term IWV data sets are retrieved from the FTIR records of the Zugspitze (47.4° N, 11.0° E, 2964 m a.s.l.) and Jungfraujoch (46.5° N, 8.0° E, 3580 m a.s.l.) NDACC sites. Station-trend analysis comprises a linear fit after subtracting an intra-annual model (3 Fourier components) and constructing an uncertainty interval [95% confidence] via bootstrap resampling. For the Zugspitze a significant trend

of 0.79 [0.65, 0.92] mm/decade is found for the time interval [1996–2008], whereas for the Jungfraujoch no significant trend is found. This confirms recent findings that strong variations of IWV trends do occur above land on the local to regional scale (≈250 km) in spite of homogeneous surface temperature trends. This paper provides a basis for future exploitation of more than a dozen existing, multi-decadal FTIR measurement records around the globe for climate studies.

Final Revised Paper (PDF, 730 KB) Discussion Paper (ACPD)

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