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Intercomparison of atmospheric water-vapor soundings from the differential absorption lidar (DIAL) and the solar FTIR system on Mt. Zugspitze

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Abstract: Water vapor is a key component for the development of the climate and related atmospheric physics. It is a big challenge to determine how the water-vapor distribution develops, especially in the upper troposphere and lower stratosphere. Therefore, sensitive and accurate measurement techniques with measurement errors smaller than 5% are urgently needed. The differential absorption lidar (DIAL) on Mt. Zugspitze (Schneefernerhaus research station, 2675 m a.s.l.) was designed to provide this high accuracy, a vertical range covering the free troposphere, high resolution in time and altitude, and full day-time capability (Vogelmann and Trickl 2008). At the same time, the adjacent Fourier-transform infrared spectrometer (FTIR) at the Zugspitze summit (2964 m a.s.l.) provides highly accurate total columns of water vapor. These may serve as well calibrated reference for validating the integrated water-vapor profiles from the DIAL. The FTIR instrument is exactly located at the altitude, where the vertical range of the DIAL starts (300 m above the instrument). This outstanding combination allows the direct intercomparison of these two very different measurement methods. Firstly we report a side-by-side lidar-FTIR comparison for integrated water vapor. We follow and extend the intercomparison strategy recently described by Sussmann et. al. (2009) for the case of two collocated FTIR instruments. Our effort covers the measurements during the time span 2007-2009. From the scatterplot of the DIAL and FTIR data (time difference $\leq$ 20 min.) we derive an almost ideal slope of 0.994 and an intercept of 0.0103 mm. This verifies the high accuracy of the data from both sounding systems, which are based on the use of spectroscopic parameters in two entirely different spectral regions. The results reflect the influence of spatial mismatch, daytime, season, as well as of the variability and inhomogeneity of water vapor. This is caused by atmospheric processes such as dry intrusions or orographic winds. Finally, we investigate the dependency of the standard deviation of the differences of both data sets on different time scales (daytime, season). Therefrom we conclude that the deviation of water-vapor columns from both systems is strongly influenced by the volume matching.

References:

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