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Long open path Fourier transform spectroscopy measurements of greenhouse gases in the near infrared

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Atmospheric composition measurements are an important tool to quantify local and regional emissions and sinks of greenhouse gases. But how representative are in situ measurements at one point in an inhomogeneous environment? Open path Fourier Transform Spectroscopy (FTS) measurements potentially offer spatial averaging and continuous measurements of several trace gases (including CO_2, CH4, CO and N2O) simultaneously in the same airmass. Spatial averaging over kilometre scales is a better fit to the finest scale atmospheric models becoming available, and helps bridge the gap between models and in situ measurements. With what precision, accuracy and reliability can such measurements be made?

Building on our pooled experience in ground-level open path Fourier transform spectroscopy and TCCON solar FTS in the infrared (Wollongong) and long path DOAS techniques in the UV-visible (Heidelberg), we set up a new type of open path measurement system across a 1.5 km one-way path in urban Heidelberg, Germany, using FTS in the near infrared. Direct open-atmosphere measurements of trace gases CO_2, CH4, CO and N2O as well as O_2 were retrieved from several absorption bands between 4000 and 8000 cm-1 (2.5 – 1.25 micron). At one end of the path an in situ FTIR analyser simultaneously collected well calibrated measurements of the same species for comparison with the open path-integrated measurements. The measurements ran continuously from June – November 2014.

We introduce the open path FTS measurement system and present an analysis of the results, including assessment of precision, accuracy relative to co-incident in situ measurements, reliability, and avenues for further improvements and extensions. Short term precision of the open path measurement of CO_2 was better than 1 ppm for 5 minute averages and thus sufficient for studies in urban and other non-background environments. Measurement bias relative to calibrated in situ measurements was stable across the measurement period. The system operated reliably with data losses mainly due only to weather events such as rain and fog preventing transmission of the IR beam. In principle the system can be improved to provide longer pathlengths and higher precision.