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Surprisingly low frequency attenuation effects in long tubes when measuring turbulent fluxes at tall towers

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The eddy covariance technique relies on the fast and accurate measurement of gas concentration fluctuations. While for some gasses robust and compact sensors are available, measurement of, e.g., non CO_2 greenhouse gas fluxes is often performed with sensitive equipment that cannot be run on a tower without massively disturbing the wind field. To measure CO and N2O fluxes, we installed an eddy covariance system at a 125 m mast, where the gas analyser was kept in a laboratory close to the tower and the sampling was performed using a 150 m long tube with a gas intake at 96 m height.
We investigated the frequency attenuation and the time lag of the N2O and CO concentration measurements with a concentration step experiment. The results showed surprisingly high cut-off frequencies (close to 2 Hz) and small low-pass filter induced time lags (< 0.3 s), which were similar for CO and N2O. The results indicate that the concentration signal was hardly biased during the ca 10 s travel through the tube. Due to the larger turbulence time scales at large measurement heights the low-pass correction was for the majority of the measurements < 5%. For water vapour the tube attenuation was massive, which had, however, a positive effect by reducing both the water vapour dilution correction and the cross sensitivity effects on the N2O and CO flux measurements.
Here we present the set-up of the concentration step change experiment and its results and compare them with recently developed theories for the behaviour of gases in turbulent tube flows.