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2.7μm TDL-spectrometer for Open-path $H_2{}^{18}O$/$H_2{}^{16}O$ isotope measurements in ice clouds

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Isotopic tracers are widely used to investigate environmental processes related to climate change, e.g. measurements of water isotopes in precipitated snow have long been used in climate studies. IRMS (Isotopic resolved mass spectrometry) is the most frequently used isotope selective technique, but the required gas sampling causes inherent difficulties and may be critically influenced by the strong H_2O adsorption, causing a large risk for changes in the water phase equilibrium and thus the isotopic signature. Water isotope measurements are quite interesting for cloud microphysics but have not been applied so far. TDLAS (tunable diode laser absorption spectroscopy) offers promising possibilities for isotope selective studies, but is only applied in extractive sensors which require gas sampling [1]. Yet TDLAS also offers a non-invasive, fast, in situ diagnostic method that allows highly sensitive, sampling free, open path detection of small molecules like water, which has been successfully applied to in-cloud studies [2, 3]. TDLAS could therefore offer interesting possibilities for isotope-selective open-path detection.

We report here on instrument developments as part of the ISOCLOUD project, funded by NSF and DFG, to use water vapor isotopes for the study of the formation and growth of cold cirrus clouds. We build here on previous work that realized highly sensitive open path TDLAS instruments [4] on $H_2{}^{16}O$ absorption lines for rapid in-cloud water vapor detection [5] and report on the development, setup, principles and spectroscopic characterization of one of the new ISOCLOUD instruments, a 2.7 μm open path TDL spectrometer configured for measurement of $H_2{}^{18}O$ and $H_2{}^{16}O$ over water concentrations ranges from 1 to 100 ppm. We report on its application for ice cloud studies in the AIDA cloud chamber, and show open path measurements of $H_2{}^{18}O$ and $H_2{}^{16}O$ water isotopes during cloud formation. With the use of special background subtraction techniques, the preliminary results show with a time resolution of 0.1 s and an absorption path of 280 m through the cloud an absolute detection limit of 0.2 ppb for $H_2{}^{18}O$ and 80.6 ppb for $H_2{}^{16}O$. We discuss the capabilities for resolving changes in the $H_2{}^{18}O$/$H_2{}^{16}O$ isotopic ratio and potential technical improvements.

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