Geophysical Research Abstracts
Vol. 19, EGU2017-5199, 2017
EGU General Assembly 2017

Towards a novel continuous sublimation extraction/laser spectroscopy method for greenhouse gas measurements in the oldest ice

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Ice cores are unique archives of ancient air providing the only direct record of past greenhouse gases – key in reconstructing the roles of greenhouse gases in past climate changes. The European Partnership in Ice Core Sciences (EuroPICS) plans to drill an ice core extending over 1.5 Ma, nearly doubling the time span of the existing greenhouse record and covering the time period of the Mid Pleistocene Transition. The ice covering the time interval from 1-1.5 Ma is expected to be close to the bedrock and, due to glacial flow, extremely thinned. A 10,000 yr glacial/interglacial transition can be compressed in 1 m of ice. The targeted 100 yr resolution therefore constrains the sample size to 15-30 g containing only 1-2ml STP air.
Within the deepSlice project we aim to unlock such atmospheric archives in extremely thinned ice by developing a novel coupled semi-continuous sublimation extraction/laser spectroscopy system. Vacuum sublimation, with an infrared source, has been chosen as extraction method as it allows 100% gas extraction of all gas species from ice without changing the isotopic composition of CO_2. In order to reduce ice waste and accelerate sample throughput, we are building a sublimation extraction system that is able to continuously sublimate an ice-core section and subsequently collect discrete full air samples. For the gas analytics, we develop a custom-made mid-infrared laser spectrometer allowing simultaneous measurement of the CO_2, CH4 and N2O concentrations as well as the isotopic composition of CO_2 on air samples of only 1-2 ml STP. The two systems will be coupled via cryo-trapping of the sample air in dip tubes, followed by expansion of the sample air into the laser spectrometer. Due to the nondestructive laser technique, the air sample can be recollected and reused for further analytics.