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Isotopic characterization of coal mine methane in the Upper Silesian Coal Basin, Poland

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Emissions from fossil fuels are one of the primary sources of atmospheric methane (CH_4) growth. However, estimates of anthropogenic CH_4 emissions still show large uncertainties on global and regional scales. Differences in CH_4 isotopic source signatures $\delta^{13}C$ and δD can help to constrain different source contributions (e.g. fossil, thermogenic, or biogenic).

The Upper Silesian Coal Basin (USCB) represents one of the largest European CH_4 emission source regions, with more than 500 Gg CH_4 yr^{-1} released by more than 50 coal mine ventilation shafts. During the CoMet (Carbon Dioxide and Methane Mission) campaign in June 2018 methane observations were conducted from a variety of platforms including aircraft and cars. Beside the continuous sampling of atmospheric methane concentration, numerous air samples were taken from inside the ventilation shafts, around the ventilation shafts (1–2 km distance) and aboard the DLR Cessna Caravan aircraft and analyzed in the laboratory for the isotopic composition of CH_4.

The ground-based samples allowed determining the source signatures of individual ventilation shafts. These signatures displayed a considerable range between different shafts and also varied from day to day. The airborne samples contained a mixture of methane emissions from several mines and thus enabled accurately determining the signature of the entire region. The mean isotopic signature of methane emissions over the USCB derived from the aircraft samples was -51.9 ± 0.5 ‰ for $\delta^{13}C$ and -233 ± 6 ‰ for δD. This is in between the range of other microbial and thermogenic coal reservoirs, but more depleted in δD than previous USCB studies reported based on samples taken within the mines. Signatures of methane enhancements sampled upwind of the mines and in the free troposphere clearly showed the presence of methane of biogenic origin (e.g. wetlands, waste, ruminants).

Furthermore, we simulated the methane isotopologues using the on-line three-times nested

global regional chemistry climate model MECO(n). We implemented a submodel extension, which includes the kinetic fractionation and uses the isotopic source signatures determined by the ground-based observations. We compare the regional simulations to flask samples taken during CoMet.