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Estimation of background CO_2 concentrations at the high alpine station Schneefernerhaus by atmospheric observations and inverse modelling

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In order to estimate the influence of Central European CO_2 emissions, a new method to retrieve background concentrations based on statistics of radon-222 and backward trajectories is developed and applied to the CO_2 observations at the alpine high-altitude research station Schneefernerhaus (2670 m a.s.l.). The reliable identification of baseline conditions is important for perceiving changes in time as well as in the sources and sinks of greenhouse gases and thereby assessing the efficiency of existing mitigation strategies. In the particular case of Central Europe, the analysis of background concentrations could add further insights on the question why background CO_2 concentrations increased in the last few decades, despite a significant decrease in the reported emissions.

Ongoing effort to define the baseline conditions has led to a variety of data selection techniques. In this diversity of data filtering concepts, a relatively recent data selection method effectively appropriates observations of radon-222 to reliably and unambiguously identify baseline air masses. Owing to its relatively constant emission rate from the ice-free land surface and its half-life of 3.8 days that is solely achieved through radioactive decay, the tropospheric background concentration of the inert radioactive gas is low and temporal variations caused by changes in atmospheric transport are precisely detectable. For defining the baseline air masses reaching the high alpine research station Schneefernerhaus, an objective analysis approach is applied to the two-hourly radon records. The CO_2 values of days by the radon method associated with prevailing atmospheric background conditions result in the CO_2 concentrations representing the least land influenced air masses.

Additionally, three-dimensional back-trajectories were retrieved using the Lagrangian Particle Dispersion Model (LPDM) FLEXPART driven by analysis fields of the Global Forecast System (GFS) produced by the National Centers for Environmental Prediction (NCEP). For the past five years, every two hours a total of 10.000 particles was released and followed backward in time for ten days. The trajectory position was stored with a time step of two hours. Based on the thereby calculated residence time each trajectory spent in the European planetary boundary layer (PBL), a validation of the baseline values derived from the radon statistics is received. Only terms where back trajectories and radon agree in the baseline detection are selected as unpolluted.

The ability to eliminate air masses contaminated by European pollution via combining these two filtering techniques permits to analyze the influence of different large-scale source regions to the receptor point Schneefernerhaus. In order to identify the different source regions, cluster analysis with the COST733 classification software is applied to the normalized position coordinates of each selected trajectory. This accounts for the variations in transport speed and direction in both horizontal and vertical directions simultaneously, yielding clusters of trajectories as homogeneous and as distinctly different from each other as possible. This methodology relates the variability in trace gas measurements to variations in synoptic-scale circulation facing a challenging task in the currently changing atmosphere.