A greenhouse gas monitoring and modelling system for Switzerland: The CarboCount CH project

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CarboCount CH is a collaborative project of six research institutes in Switzerland. It investigates human-related emissions and natural exchange between the atmosphere and the biosphere of the two most important long-lived greenhouse gases carbon dioxide (CO_2) and methane (CH_4) at the regional scale with a special focus on Switzerland. For this purpose, four new measurement sites have been established including a 210 m tall tower at Beromünster, a water reservoir tower in flat terrain at Gimmiz, and two mountain sites at Lägern (856 m a.s.l.) and Früebüel (977 m a.s.l.). All sites were equipped with high-precision instruments for continuous measurements of CO_2, CH_4, and partially CO. The continuous CO measurements as well as bi-weekly $^{14}CO_2$ samples at the tall tower site help to distinguish between anthropogenic and biogenic contributions to the observed CO_2 concentrations. All data are transferred to the central processing facility at Empa where the calibrated data are uploaded to a database and made remotely accessible to all partners. The network is complemented by flux measurements of the Swiss Fluxnet network and other existing sites with CO_2 and/or CH_4 measurements including the high altitude GAW site Jungfraujoch. The four CarboCount CH sites have been operating reliably and almost continuously for more than one year now.

For data interpretation and top-down flux estimation, two separate atmospheric transport and inverse modeling systems are being developed within the project. The first one uses the new tracer transport module of the regional numerical weather prediction model COSMO together with an Ensemble Kalman filter scheme. The second framework is based on backward simulations with the Lagrangian transport model FLEXPART-COSMO. Anthropogenic a priori emissions are obtained from newly developed high-resolution (500 m x 500 m) inventories of diurnally and seasonally varying CO_2 and CH_4 emissions in Switzerland, merged with European and global emission inventories. Atmosphere-biosphere exchange fluxes of CO_2 are simulated with the coupled system COSMO-CLM^2, i.e. COSMO coupled to the Community Land Model, a state-of-the-art land processes and biogeochemistry model.

Here we present a general outline of the project, the setup of the measurement network and of the different modeling components and inverse methods. We have performed transport simulations for the first year of observations and calculated the contributions from anthropogenic and biogenic sources/sinks upstream of the measurement sites. The generally good agreement between simulated and measured concentrations underlines the high quality of the transport simulations, but occasional deviations are pointing towards weaknesses in both the emission inventories and in the simulated meteorology. The CarboCount CH project provides an ideal test bed for future carbon monitoring systems, to test the suitability of different types of monitoring stations, to analyze the challenges of a heterogeneous landscape, and to identify critical modelling components.