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Analysis of transport and source contributions to alpine CO_2 concentrations based on back trajectories

Esther Giemsa (1), Jucundus Jacobeit (1), Ludwig Ries (2), and Stephan Hachinger (3)

(1) Institute of Geography at the University of Augsburg (IGUA), Physical Geography and Quantitative Methods, Augsburg, Germany (esther.giemsa@geo.uni-augsburg.de), (2) German Environment Agency (UBA), Environment Research Station Schneefernerhaus, (3) Alpine Environmental Data Analysis Centre (AlpEnDAC), Leibniz-Rechenzentrum (LRZ)

The main purpose of our study consists in contributing to the improvement of the present knowledge concerning regional carbon dioxide (CO_2) exchange as an essential step towards reducing the uncertainties along with bottom-up estimations of the carbon budget by identifying the characteristic spatial and temporal scales of the regional CO_2 fluxes. To this end, we propose a stepwise statistical top-down methodology for examining the relationship between synoptic-scale atmospheric transport patterns and CO_2 mole fractions to finally receive a characterization of the European Alps with regard to the key processes driving CO_2 concentration levels measured there. The Alps are considered as a perfect place for investigating the comprehensive influence of regional emissions, since the high representativity together with the absence of dominant local interferences constitute ideal high-altitude conditions to study source-receptor relationships for greenhouse gases.
For the traceability of the impact from sources and sinks through atmospheric transport and mixing conditions, a large ensemble of four-dimensional (three space dimensions plus time) ten-day back trajectories every two hours from four high-alpine sites (Schneefernerhaus (Germany), Jungfraujoch (Switzerland), Sonnblick (Austria) and Plateau Rosa (Italy)) over the entire study period 2011 – 2015 is calculated with the Lagrangian Particle and Dispersion Model (LPDM) FLEXPART (Stohl et al. 2005) driven by the ERA-Interim analysis fields of the European Centre for Medium-Range Weather Forecasts (ECMWF) with 0.2° resolution*. To reduce intrinsic model uncertainties, the backward FLEXPART simulations of the particle dispersions are aggregated to their centroid tracks.
The centroid pathways are further subjected to the receptor modelling approach of Concentration Weighted Trajectory (CWT) fields (Seibert et al. 1994) that proceeds from concentrations at the receptor sites backward to responsible emission sources and sinks by relating the on-site arriving paths of air masses to the contemporaneously measured short-term fluctuations in the CO_2 concentrations. The CWT approach founded on the basic assumption that air parcel back trajectories crossing a grid cell where a source or sink is located, transport the entailed alterations of the atmospheric trace gas concentration effectively to the receptor. The grid cells indicate their probability to act as emission sources or sinks and, taken in their entirety, constitute a complete map. These maps distinguish between moderate sources/sinks and intense ones thereby representing the relevant areas affecting the CO_2 concentrations measured at the Alpine receptor sites.

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