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Spatiotemporal dynamics of CO_2 flux in Basel city centre

Stavros Stagakis[1], Christian Feigenwinter[1], Etienne Zurbriggen[1], Andrea Pitacco[2], and Roland Vogt[1]

[1]Department of Environmental Sciences, University of Basel, Basel, Switzerland (stavros.stagakis@unibas.ch)
[2]Department of Agronomy, Food, Natural resources, Animals and Environment, University of Padova, Legnaro, Italy (andrea.pitacco@unipd.it)

Independent, timely and accurate monitoring of urban CO_2 emissions is important to assess the progress towards the Paris Agreement goals, evaluate the mitigation potential of the implemented actions and support urban planning, policy- and decision-making processes. However, there are several challenges towards achieving comprehensive urban emission monitoring at the required scales, which are mainly related to the complexities in the urban form, the urban function and their interactions with the atmosphere. Cities are highly heterogeneous mosaics of CO_2 sources and sinks. Typically, the main emission sources in an urban neighbourhood are vehicles and buildings, while the contribution of human, plant and soil respiration can be also significant depending on population density and green area fraction. At the same time, urban vegetation acts as carbon sink, mitigating urban emissions locally. This study attempts to unravel the complex urban CO_2 flux dynamics by modelling each component separately (i.e. building emissions, traffic emissions, human metabolism, photosynthetic uptake, plant respiration, soil respiration) based on high resolution geospatial, meteorological and population activity datasets. The case study is the city centre of Basel, Switzerland. The models are calibrated and evaluated using Eddy Covariance measurements of CO_2 flux from two permanent tower sites in the city centre, covering a significant part of the study area. Moreover, an extended field campaign for the measurement of the biogenic components (i.e. photosynthetic uptake, plant respiration, soil respiration) has been active since the summer of 2020, involving regular chamber flux measurements and soil stations across the study area. The study reveals the spatial and temporal complexity of the urban CO_2 flux dynamics both diurnally and seasonally. The relative contribution of each flux component to the seasonal cycle is presented, while the mitigation potential of urban vegetation is evaluated. Cross-comparison between model outputs and Eddy Covariance measurements are discussed in respect to source area variability, airflow complexity in the urban canopy layer and irregular unrecognized emission sources.