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Urban carbon dioxide flux monitoring using Eddy Covariance and Earth Observation: An introduction to diFUME project

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Monitoring CO₂ emissions originating from urban areas has become a necessity to support sustainable urban planning strategies and climate change mitigation efforts. Integrative decision support, where net effects of various emission/sink components are considered and compared, is now an increasingly relevant part of urban planning processes. The current emission inventories rely on indirect approaches that use fuel and electricity consumption statistics for determining CO₂ emissions. The consistency of such approaches is questionable and they usually neglect the contribution of the biogenic components of the urban carbon cycle (i.e. vegetation, soil). Moreover, their spatial and temporal scales are restricted because consumption statistics are often available in coarse spatial scales (national, provincial/state, municipal) and usually scaled down using proxy data (e.g. population density) to city-scale annual estimates. The diFUME project (<https://mcr.unibas.ch/difume/>) is developing a methodology for mapping and monitoring the actual urban CO₂ flux at optimum spatial and temporal scales, meaningful for urban design decisions. The goal is to develop, apply and evaluate independent models, capable to estimate all the different components of the urban carbon cycle (i.e. building emissions, traffic emissions, human metabolism, photosynthetic uptake, plant respiration, soil respiration), combining mainly Eddy Covariance (EC) with Earth Observation (EO) data. EC provides continuous in-situ measurements of CO₂ flux at the local scale. Processing, analysis and interpretation of urban EC measurements is challenging due to the inherent spatial complexity of CO₂ source and sink configurations of the urban structure. The diFUME methodology is using multiple EO datasets to achieve multi-scale monitoring of urban cover, morphology and vegetation phenology in order to characterize the urban source/sink configurations and parameterize turbulent flux source area models. Such combination of EC and EO provides enhanced interpretation of the measured CO₂ flux, analysis of its controlling factors and therefore the potential of fine scale mapping and monitoring. The diFUME methodology is being developed and applied in the city of Basel, exploiting the available long-term database (> 15 years) of urban EC measurements. The first results highlight the potential of EO-derived geospatial data to interpret the complexity of urban EC measurements. Seasonal and land cover related trends in the EC-measured CO₂ flux are recognized, while the use of environmental, census and mobility datasets are increasing the interpretation capabilities and the modelling potential of the urban CO₂ flux patterns.