ESR20-030 - Vienna Urban Carbon Laboratory (VUCL)

Abstract

Urban climate change mitigation will be critical to bringing about the necessary greenhouse gas (GHG) emission reductions required to limit global warming. Many capitals and large cities around the world, including Vienna, have announced ambitious net-zero targets. However, implementing effective urban climate action may be hampered by uncertainties in city-scale emission inventories. The Vienna Urban Carbon Laboratory investigated and compared novel methods to quantify urban GHG emissions using local atmospheric measurements of carbon dioxide (CO2) and methane (CH4). On top of the A1 Arsenal radio tower at 144 m above the city, a research station has been established to continuously observe fluxes and concentrations of CO2 and CH4, as well as stable carbon isotopes. Additionally, measurement campaigns have been conducted involving stationary, ground-based remote sensing of CO2 and CH4 as well as mobile, in situ measurements of street-level CO2. Collectively, the methods were shown to provide independent, spatially-explicit and temporally-resolved estimates of total and sector-level emissions. The tall-tower CO2 flux measurements were shown to deliver plausible direct estimates of local CO2 emissions at various temporal scales, documenting the post-pandemic reductions in annual emissions compared to the pre-pandemic years, as well as the drastic weekly decreases in emissions during the COVID lock-down periods. The same tall-tower flux system, together with the ground-based spectrometer measurements of total column concentrations, have furthermore shown that post-meter gas leaks and releases are a significant urban source of CH4 in Vienna, verifying the recent addition of this source to the local and national GHG inventory. Moreover, the tall tower observations of CO2 concentrations and stable C isotopes were analyzed with respect to regional background observations from the ICOS network to derive isotopic signatures of local emissions. Encouragingly, the derived mean annual isotopic signature converged with the theoretical value derived from the inventory estimates of emissions from natural gas and liquid fuel combustion and biogenic sources. Finally, mobile measurements of ground-level CO2 were combined with the simultaneous tall□tower observations via a gradient approach to map afternoon street-level emissions. Beyond the scientific investigation of the trialed methods, the project has engaged with stakeholders to demonstrate potential applications and discuss how these observations could complement and inform local emissions monitoring. The project concludes having made a substantial scientific contribution to urban emissions research and lays an important foundation for further impact through the WWTF ESR 2024 project Constraining Vienna's Carbon Footprint.

Scientific disciplines:
Environmental physics (50%) | Atmospheric chemistry (40%) | Sustainable urban development (10%)

Keywords:
Urban greenhouse gas emissions, flux measurements, stable isotopes, total column mixing ratios, carbon dioxide, methane, climate change mitigation, inverse modeling and mass balance approaches

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Status: Completed (01.02.2021 – 31.07.2025)

GrantID: 10.47379/ESR20030

Further links to the persons involved and to the project can be found under
https://wwtf.at/funding/programmes/esr/ESR20-030/