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Carbon dioxide emissions variability monitoring, based on four years of Eddy Covariance measurements in a typical Mediterranean city

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Urban areas around the globe are growing rapidly and as a consequence the anthropogenic effects on the environment are ever-increasing. Understanding the dynamics, procedures and mechanics behind urban greenhouse gas emissions is a challenge for the scientific community. This study investigates the variability of urban CO₂ emissions in the city centre of Heraklion, a typical Mediterranean city in Greece, during a four-year period with gradual changes in the traffic regulations and changes in traffic patterns due to the recent restriction measures imposed to limit the spread of the COVID-19 pandemic. The CO₂ flux (Fc) was measured using the Eddy Covariance (EC) method with a single tower-based system, permanently installed in the centre of the city. Fc was calculated at a 30-min time step and the time-series were quality-controlled and gap-filled using a moving look-up table (mLUT) technique. Fc time series were then aggregated to monthly and yearly emissions totals. Annual flux source area was estimated with the Flux Footprint Prediction (FFP) model, parameterized using measured atmospheric parameters and urban morphological parameters extracted from a Digital Surface Model. The source area was characterized by complex urban morphology and land use types. Specifically, at North of the tower a commercial zone is located, where significantly higher Fc patterns were detected, compared to South, where a residential area dominates. A gradual reduction to CO₂ emissions has been observed since 2016, due to urban planning interventions related to pedestalization of extended areas in the city centre and traffic regulation. During the COVID-19 lockdown period in the Spring of 2020, the diurnal Fc patterns and the monthly aggregated Fc showed significant reductions in the order of 70 % compared to the previous years. Fc values returned to the previous years' levels with the end of the lock-down in the summer 2020, as it was expected. Finally, during the second lock-down, started in Greece in November 2020, the CO₂ emissions were higher compared to the first lock-down, reflecting a higher level of mobility in Heraklion centre.