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The COCCON city campaigns: Monitoring greenhouse gas emissions of Paris and Madrid

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Greenhouse gases (GHGs) are the main driver of the anthropogenic excess radiative forcing and thereby largely contribute to the current increase of global mean temperature. Out of the GHGs, carbon dioxide (CO_2) and methane (CH_4) are the most important species with respect to radiative forcing. The importance of reducing GHGs has been acknowledged by international parties, leading to the Kyoto protocol and subsequent PARIS COP21 agreement.

For the successful implementation of the mitigation goals cities are of special importance. Currently, over 50 % of the human population lives in urban areas and the population growth is predicted to occur predominantly in urban centers. At present, cities are estimated to be responsible for 53 % - 87 % of fossil fuel CO_2 emissions and are predicted to further increase. While emissions of CO_2 can be estimated rather precisely on the national scale, higher uncertainties are reported for urban GHG emissions, especially CH_4. The large uncertainty of the global contribution of urban areas to GHG emissions is why a new generation of city-scale observing and modelling systems is needed.

Here, newly developed, mobile, solar absorption Fourier Transform spectrometers (EM27/SUN) measuring column-averaged dry air mole fractions of trace gases (X_{gas}) are utilized to quantify city scale emissions of CO_2 and CH_4. This novel technique was successfully tested by KIT and partners during several campaigns for detecting emissions from various sources. We present results from two campaigns carried out in April – May 2015 in Paris and in September – October 2018 in Madrid. Five EM27/SUN spectrometers were operated on the outer perimeter of the cities along the prevailing wind axis upwind and downwind of the city source.

For Paris, we focus on CO_2 and present a comprehensive study comparing measured XCO_2 and CHIMERE-CAMS atmospheric transport modelling results. We find that the model correctly predicts the impact of meteorological parameters on the concentration gradients between the different stations. The modelling framework indicates that the local XCO_2 gradients detected between the sites are dominated by fossil fuel CO_2 emissions. For the eastern part of Paris, the modelled gradients are significantly smaller than the observed gradients, likely due to suboptimal emission estimates in the modelling framework. This highlights the usefulness of XCO_2 observations for the optimization of urban GHG emission inventories.

For Madrid, we analyze XCO_2, XCH_4 and XCO and present preliminary campaign results. Similarly to Paris, fossil fuel emissions are mainly responsible for CO_2 emissions, while CH_4 enhancements are strongly linked to waste treatment. Due to the proximity of a waste disposal site to the Madrid Metropolitan area, very large XCH_4 enhancements up to 140 ppbv were observed during the campaign.