Title: A first estimate of CO_2 emissions from the Paris city using an array of atmospheric CO_2 measurement sensors

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Abstract:

A pilot network of five CO_2 mole fraction atmospheric measurements sensors was established around the Paris city since 2010, and operated on a discontinuous basis until 2015 as part of research and innovation projects CO2-megaparis and Carbocount-City. Hourly time series of atmospheric CO_2 mole fraction measurements are used to adjust daily to monthly fossil fuel CO2 emissions of the Paris urban area, using a Bayesian inversion with priors. The ingredients of the inversion are 1) a first guess map of CO_2 anthropogenic emissions established from the emission inventory of the Airparif air quality agency with an a priori error estimate, and a first guess map of the biogenic flux of CO_2 exchanged between vegetated areas and the atmosphere, which can be a source or a sink of CO_2 with respect to the atmosphere, 2) observed CO_2 mole fraction atmospheric measurements and their uncertainties, arising from various sources, and 3) a 2-km horizontal resolution atmospheric tracer transport model over the Paris area that converts the signal of emissions into simulated mole fractions, this mesoscale model being nested into a global coarser grid transport model to obtain CO_2 atmospheric boundary conditions from outside the Paris area. The inversion adjusts CO_2 fluxes (anthropogenic and biogenic) with a temporal resolution of 6 hours, assuming temporal correlation of emissions uncertainties within the daily cycle, and from day to day, while keeping the a priori spatial distribution from the first guess emission inventory. The inversion significantly improves the agreement between measured and modelled concentrations. However, the residual misfits between the measurements and the model are sometimes large compared to the measured CO_2 gradients between the sites that are used to estimate the fluxes, in particular for the CO_2 sensor located on top of the Eiffel tower station. These results suggest that the inversion has better performances when we use the measured upwind-downwind CO_2 gradients rather than the individual mole fraction measurements at each station. With such setup, realistic emissions are retrieved for a one year period. The uncertainty reduction on emissions obtained by the inversion will be discussed, together with the different uncertainty terms entering in the error budget of the approach, separating random errors and systematic errors that lead to biased emission estimates.