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From fluxes to signals: A joint analysis of GHG and Air Quality over the Paris Megacity

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Given the steep trajectory of the global climate crisis, current emission allowances following the 2015 Paris Agreement require that national GHG budgets (sources/sinks) are quantified more accurately and more timely. Large cities also play a key role in achieving the national objectives of emission reduction as urbanization reaches unprecedented levels. Atmospheric inversion approaches have the potential to produce a semi-independent assessment of these fluxes by combining atmospheric data and high-resolution inventories. However, these approaches only provide an estimate of the total city flux, with no information on the per sector distribution, a major shortcoming for policy makers.

Multiple emission datasets have been developed worldwide at various spatial scales in order to provide a better understanding of the global carbon cycle, but also more locally for large cities and emission hot-spots. Due to the different methodologies and the quality of the surrogate data, large discrepancies are observed between these datasets, especially at the sectoral level. To allow for sectoral attribution in GHG inversions, we investigate Air Quality (AQ) data as additional information assimilated jointly with GHG's to attribute atmospheric information to specific sectors of activity.

We focus here on the Paris metropolitan area and analyze ground-based observations as well as high-resolution emission inventory estimates for both GHG's and other reactive pollutants. The observations were acquired by the ICOS GHG monitoring network and the Airparif AQMN. Bottom-up emission estimates were provided by three different emission products for CO_2, CO, NO_X.

We analyzed the atmospheric signals using a backward-in-time Lagrangian Particle Dispersion Model (LPDM) driven by meteorological variables from mesoscale simulations (WRF-FDDA) at 1-km resolution to represent the origin of the emissions (so-called tower footprints).

The modelled concentrations were compared to observations from March to June for the year 2019 to assess the validity of the temporal variations, for each emissions dataset and for both

weekly and diurnal cycles. Furthermore, we estimated a correction factor for the modelled NO_X, CO, and CO_2 concentrations using a Monte-Carlo approach that optimizes the three inter-species ratios (NO_X/CO, NO_X/CO_2, and CO/CO_2) to quantify the actual emissions for these three species. We further look into the first Covid-19 lockdown period of 2020 to evaluate the applicability of the method, a first step toward providing process-based information from atmospheric observations, and determine the sectoral contributions to observed emissions changes.