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Supplement of

Decoupling of urban CO_2 and air pollutant emission reductions during the European SARS-CoV-2 lockdown

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Supplementary Information:

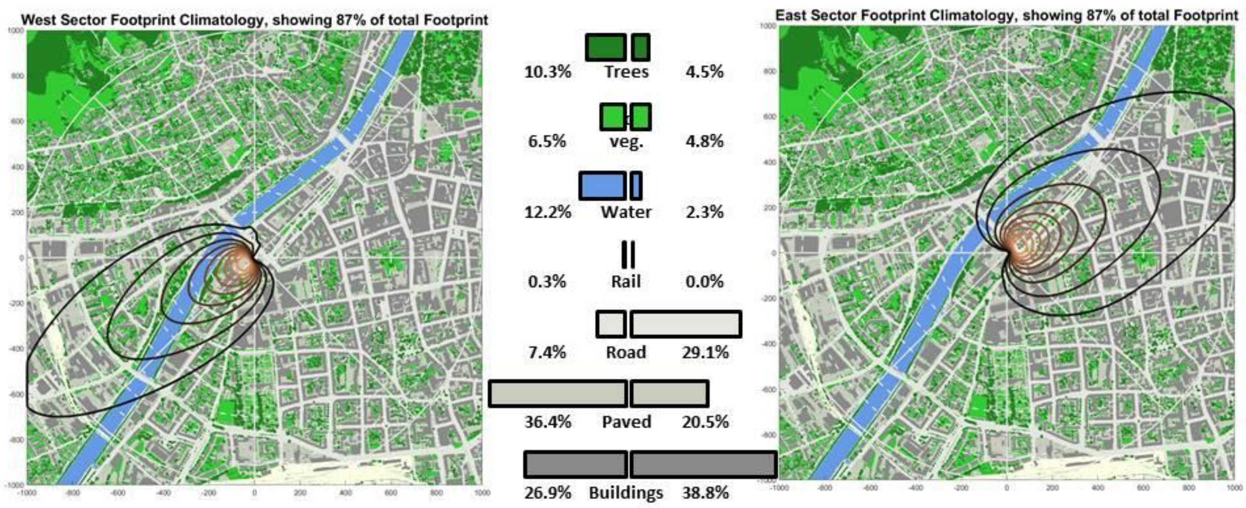

Fig. S1: Sectoral analysis of the IAO footprint. (data source: © OpenStreetMap contributors 2020. Distributed under a Creative Commons BY-SA License)

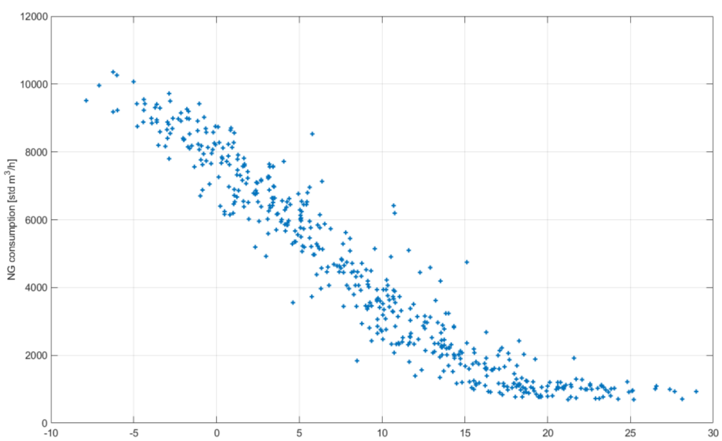

Fig. S2: Degree heating days vs natural gas consumption from 01/01/2019 to 01/05/2020 (data source: TIGAS, Tirol, www.tigas.at)

Boosted regression tree model:

Three methods are used to validate the regression model. The first approach (method 1: pre-lockdown) is based on long-term measurements of NO_2/NO, NO_x, CO_2 and traffic data, where the model is trained up to Feb. 29th 2020, and the prediction is then tested for the first two weeks in March 2020 before SARS-CoV2 lockdown measures were implemented. The second approach (method 2: bootstrapping) includes all chemical species. Here, the regression model is trained with 2019 data, when an air quality campaign was conducted during a similar timeframe (March-April 2019) as the SARS-CoV2 lock-down period in 2020. The regression model is then tested using bootstrapping based on 1000 randomized samples. The third approach (method 3: cross validation) is a variation where the model is trained on a subset of the 2019 period (March-April 2019), and tested against data that were not used to train the model. Table S1 summarizes respective model verification and initiation dates. Table S2 captures statistical parameters of the model output verification. Importance values of individual predictors of the regression model for key chemical species are shown in Fig. S3. The most important predictors are wind direction, time of day, radiation and temperature.

Table S1: Regression model setup

Species	Model training	Model verification	Model run initiated
NO_x, CO_2	1.9.2018 – 29.2.2020	1.3.2020-13.3.2020	13/3/2020
NO_x, CO_2	11.3.2019 – 9.4.2019	11.3.2019 – 9.4.2019	13/3/2020
NMVOC	11.3.2019 – 9.4.2019	11.3.2019 – 9.4.2019	13/3/2020
Traffic	1.9.2018 – 29.2.2020	1.3.2020-13.3.2020	13/3/2020

Uncertainty Analysis:

Regression model:

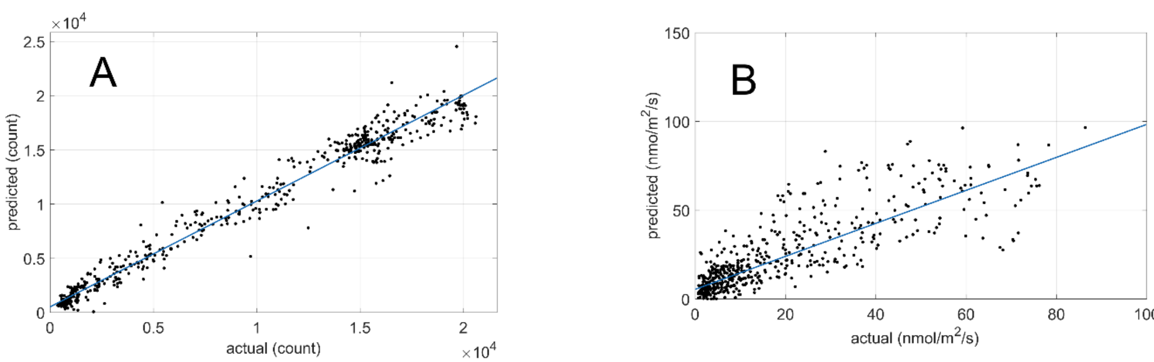

Fig. S3: (A) Regression model prediction for traffic during pre-lockdown (method 1). (B) Regression model prediction for NO_x during pre-lockdown. The regression slopes are represented by the blue lines and are used to calculate the average bias of the fit (see Table S2)

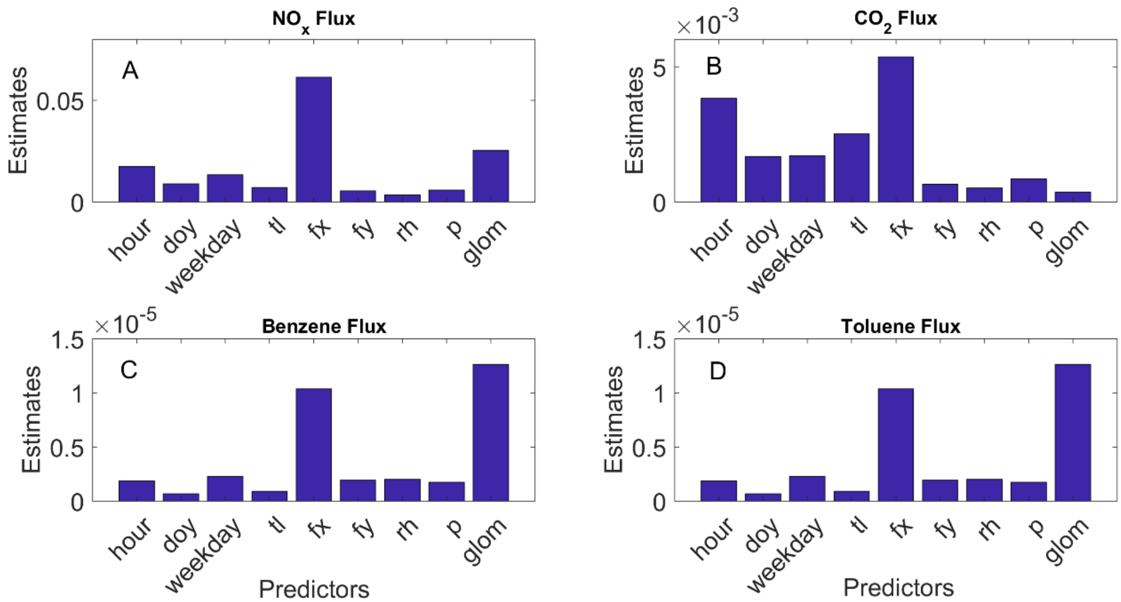

Fig. S4: Importance of individual predictors from the boosted regression tree model. (A) NO_x flux, (B) CO_2 flux, (C) benzene flux, and (D) toluene flux. Predictors are hour of the day (hour), day of year (doy), day of the week (weekday), ambient temperature (tl), longitudinal wind speed (fx), latitudinal windspeed (fy), relative humidity (rh), pressure (p), and global radiation (glom).

Table S2: Statistical results (bias, standard error and R^2) of the model verification methods for individual quantities.

Species	**Bias**	**SE**	**R2**	**Verification method**
NOx	-7%	0.04	0.80	Pre-lockdown
CO2	-25%	0.05	0.62	Pre-lockdown
traffic	-2%	0.01	0.97	Pre-lockdown
NOx	-2%	0.03	0.79	Bootstrapping
CO2	-1%	0.03	0.75	Bootstrapping
traffic	-1%	0.001	0.97	Bootstrapping
NOx	-6%	0.02	0.93	Cross-validation
CO2	-6%	0.01	0.86	Cross-validation
traffic	-1%	0.004	0.99	Cross-validation
Benzene	-1%	0.01	0.86	Bootstrapping
Toluene	-1%	0.01	0.83	Bootstrapping
Benzene	-13%	0.03	0.87	Cross-validation
Toluene	-21%	0.02	0.92	Cross-validation

Two end member pollutant model – uncertainty estimation:

Errors for coefficients a_s and b_s (eq 4.) can be calculated based on error propagation, where by definition $\Delta a_s = \Delta b_s$. Lets define $b_s := b$, $\frac{\delta T}{T} := t$, $\frac{\delta R}{R} := r$, and $\frac{\delta F}{F} := f$, then

$\Delta b = \frac{\partial b}{\partial f}\Delta f + \frac{\partial b}{\partial t}\Delta t + \frac{\partial b}{\partial r}\Delta r$, and $b = \frac{f-t}{r-t}$ (Seq. 2a, b)

Uncertainties of relative flux, traffic and RCP activity variations are taken as $\Delta f = 7\%$, $\Delta t = 2\%$, and $\Delta r = 50\%$. This leads to a combined uncertainty of $\Delta a = \Delta b = 0.11$. Δf represents the average bias obtained from the boosted tree regression model verification analysis. Δt is based on counting statistics of traffic observations. Δr is the least certain and estimated based on the constraints estimated for the RCP sector.