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Supplement of

The impact of ship emissions on air quality and human health in the Gothenburg area – Part II: Scenarios for 2040

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Supplement 1 – emission factors for 2040

Table S1: Emission factors to derive 2040 emissions (CLE2040) from 2012 emissions from the Greenhouse Gas - Air Pollution Interactions and Synergies (GAINS) model using the emission scenario ECLIPSE_V5a_CLE_base.

Emission sectors	**SO_2**	**NO_x**	**PM_{10}**	**NMVOC**
Energy Industries	0.662978	0.854049997	\	0.889792231
Fuel combustion within industry for energy use	1.196401	0.846780766	1.657303371	1.448372093
Diffuse emissions from fuel management	0.843987	0.808	11.10621762	0.736323394
Refineries	0.558219	0.917042889	11.51612903	0.958333333
Boilers	\	\	0.075342466	3.432692308
Residential heating	0.575404	0.731368781	0.216500766	0.410687481
Mineral industry	\	\	1.857886905	\
Chemical industry	1.183701	1.18066561	3.930084746	0.988788041
Metal industry	1.179078	\	0.133764833	\
Pulp and paper industry	1.138498	1.138363893	2.289488477	\
Other industry	\	\	0.520822622	1.007579302
Non-road mobile machinery	0.454545	0.118023075	3.801980198	0.435876623
Solvents (use of chemical products in households and operations)	\	\	0.075296108	0.984338488
Agriculture	1	1	24.1754386	1

Supplement 2 – Seasonal BAU2040 results

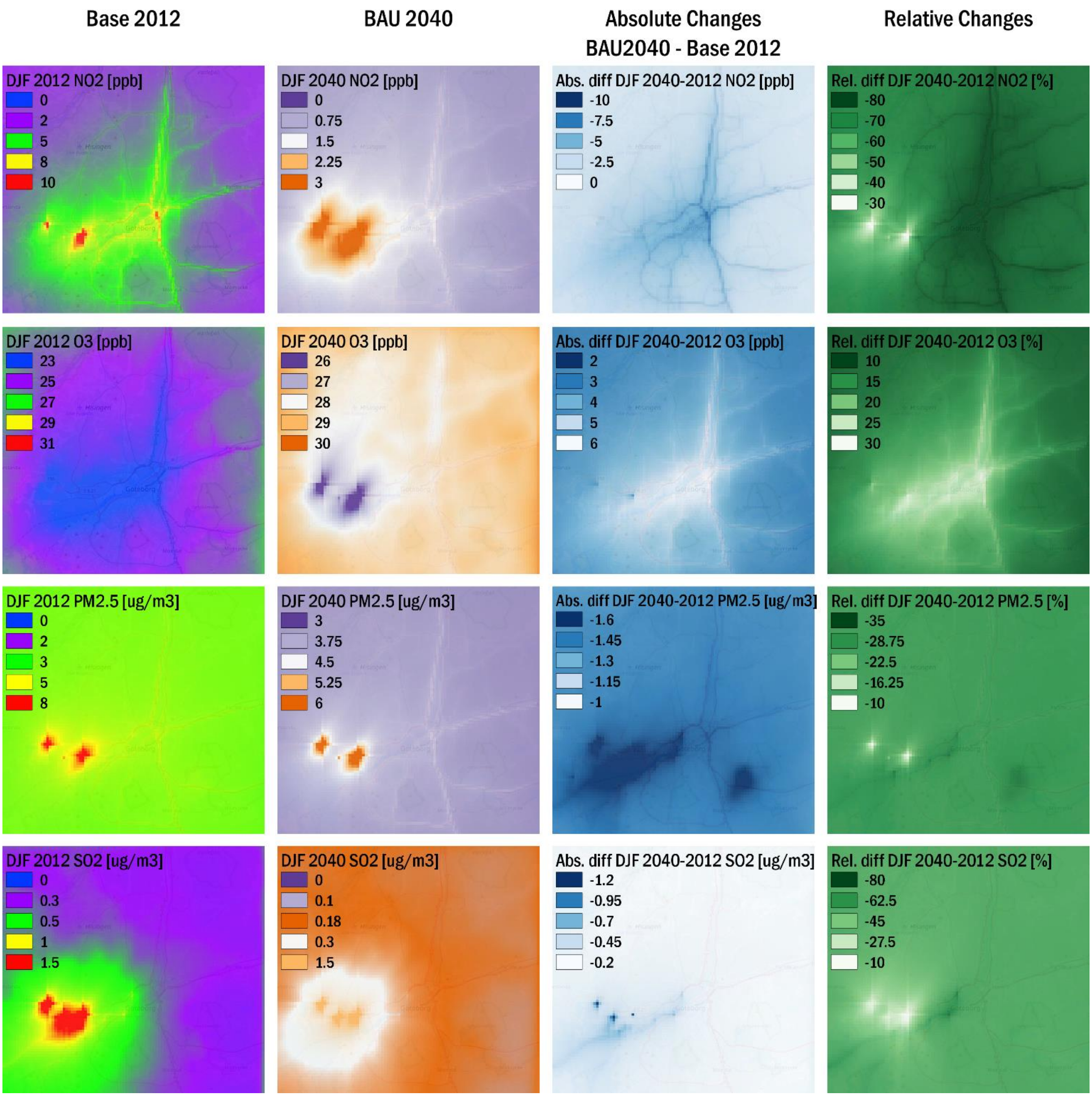

Figure S1: The total modeled present day winter (December, January, February) concentration for NO_2, O_3, $PM_{2.5}$ and SO_2 (column 1) as well as the concentration in BAU2040 (column 2) and the difference between the present day and BAU2040 in absolute (column 3) and relative (column 4) values. © OpenStreetMap contributors 2019. Distributed under a Creative Commons BY-SA License.

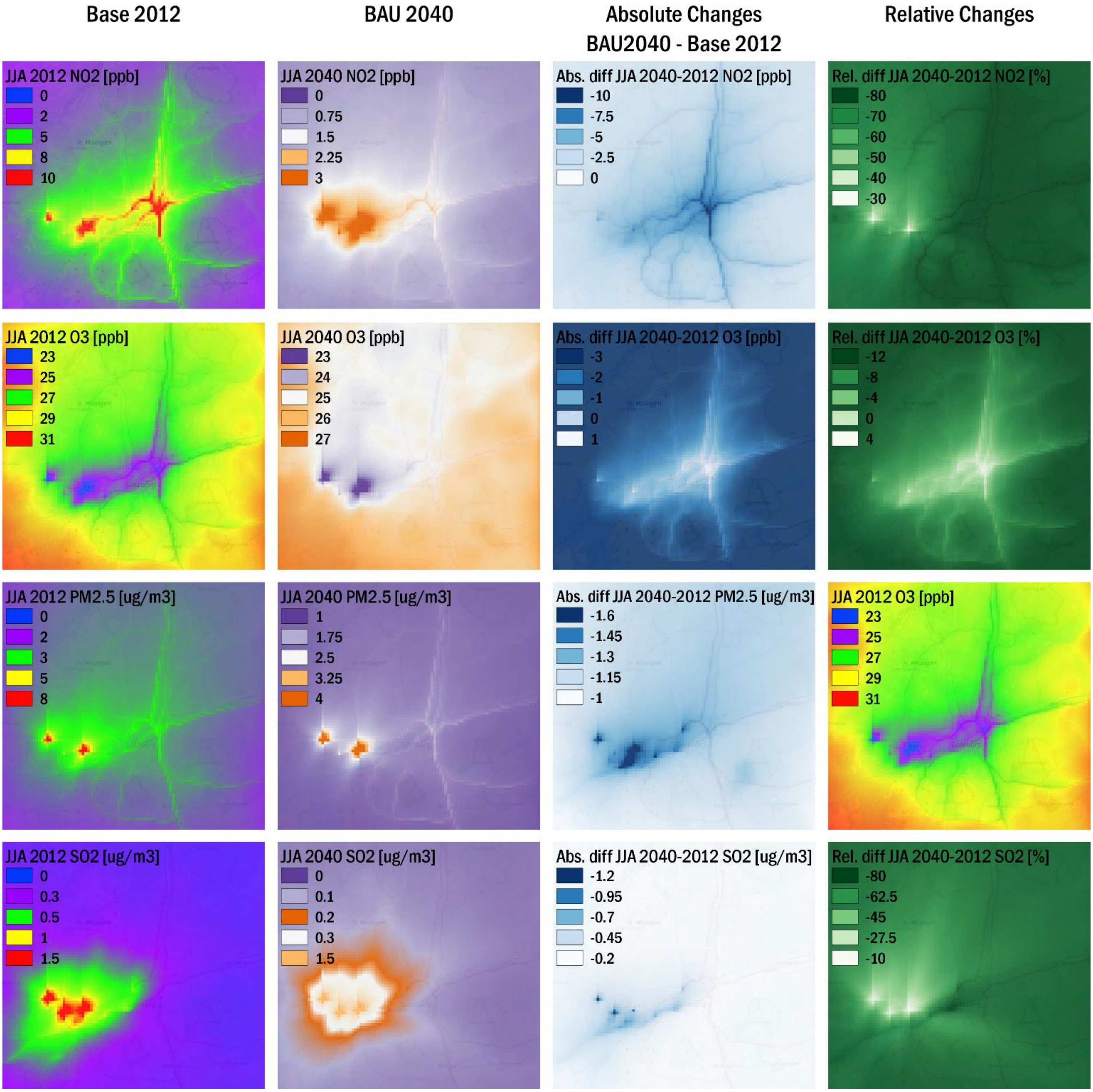

Figure S2: The total modeled present day summer (June, July, August) concentration for NO_2, O_3, $PM_{2.5}$ and SO_2 (column 1) as well as the concentration in BAU2040 (column 2) and the difference between the present day and BAU2040 in absolute (column 3) and relative (column 4) values. © OpenStreetMap contributors 2019. Distributed under a Creative Commons BY-SA License.

Supplement 3 – EEDI2040 results

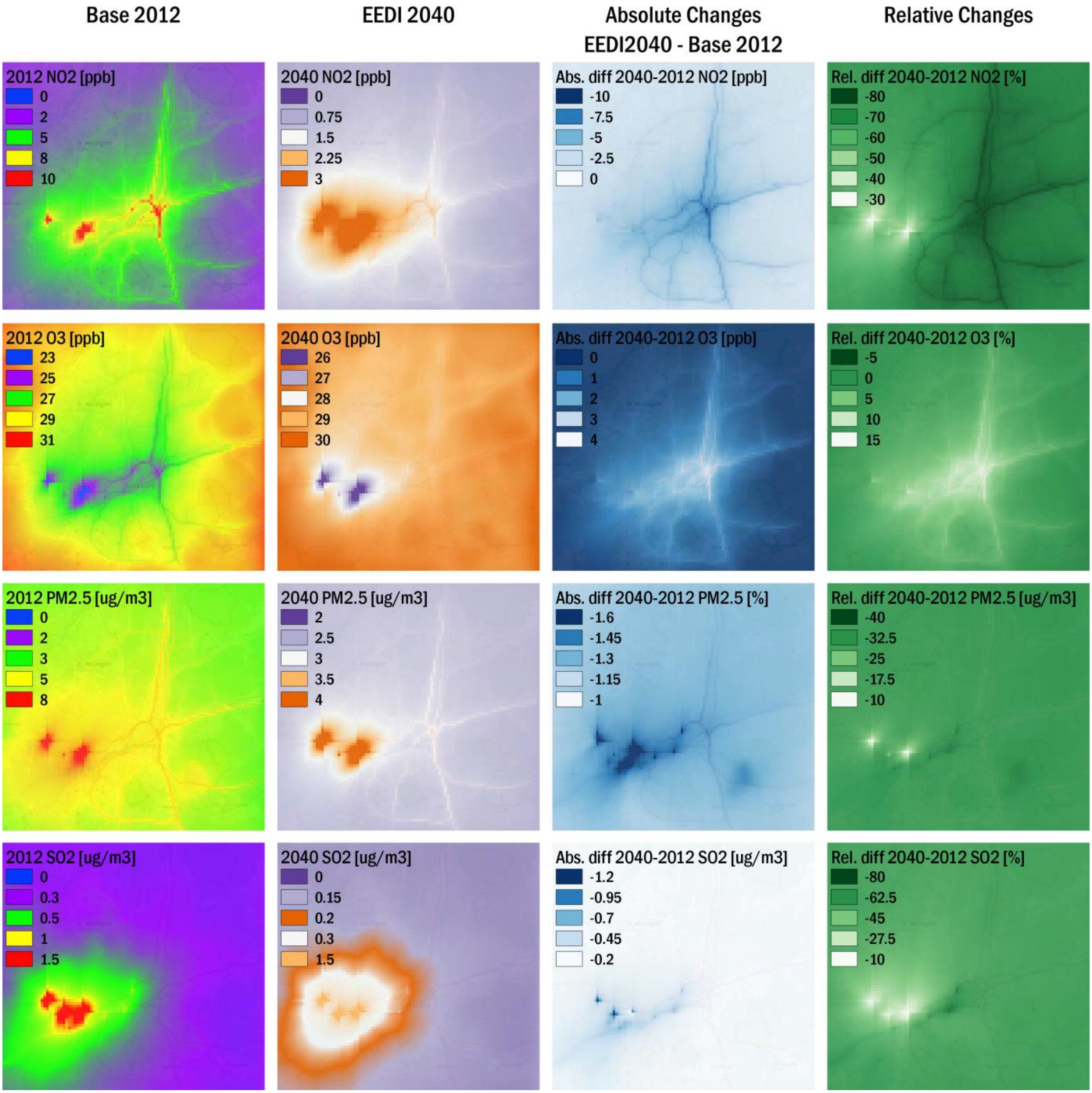

Figure S3: The total modeled present day concentration for NO_2, O_3, $PM_{2.5}$ and SO_2 (column 1), as well as the concentration in EEDI2040 (column 2) and the difference between the present day and EEDI2040 in absolute (column 3) and relative (column 4) values. © OpenStreetMap contributors 2019. Distributed under a Creative Commons BY-SA License.

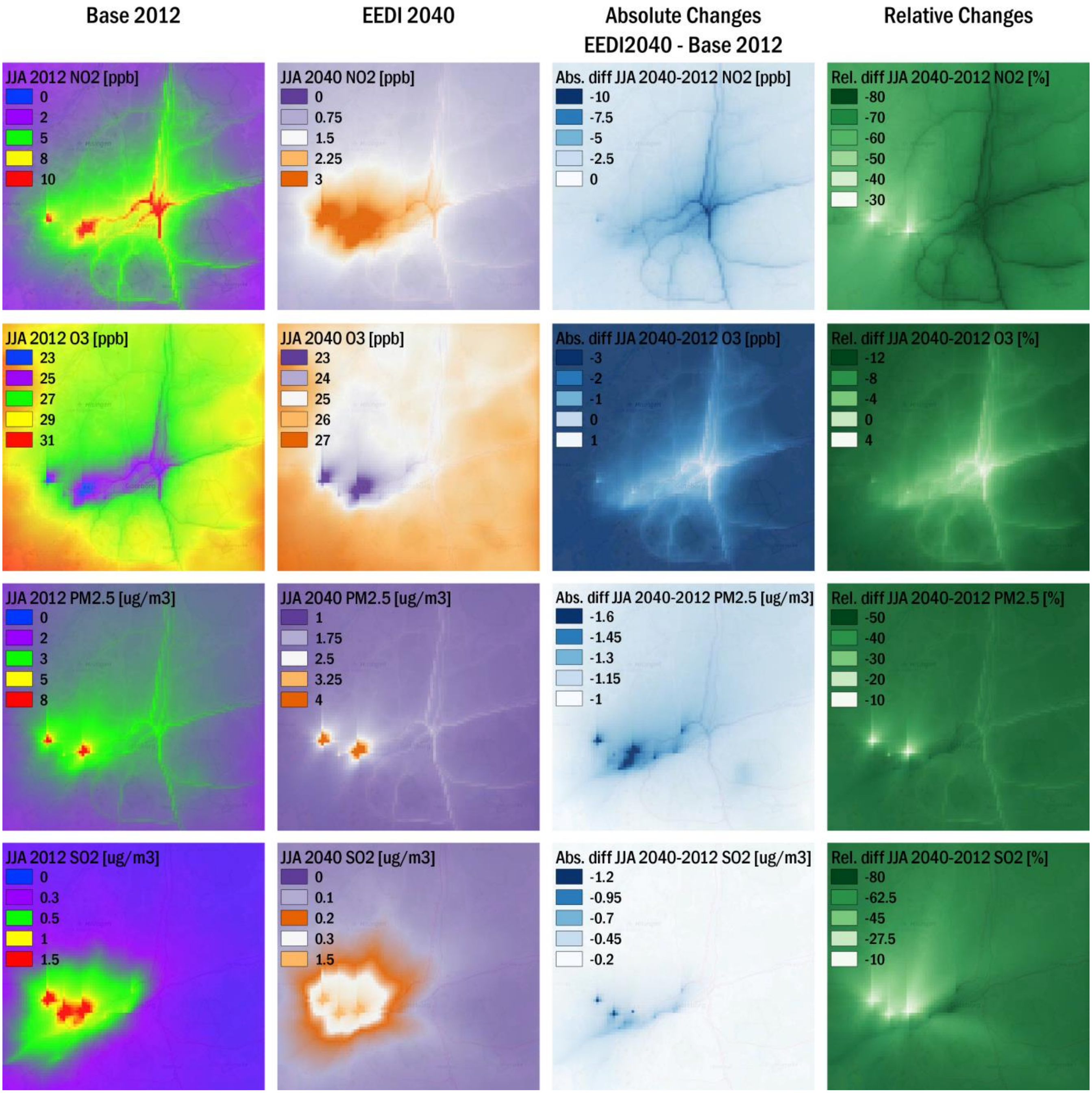

Figure S4: The total modeled present day summer (June, July, August) concentration for NO_2, O_3, $PM_{2.5}$ and SO_2 (column 1) as well as the concentration in EEDI2040 (column 2) and the difference between the present day and EEDI2040 in absolute (column 3) and relative (column 4) values. © OpenStreetMap contributors 2019. Distributed under a Creative Commons BY-SA License.

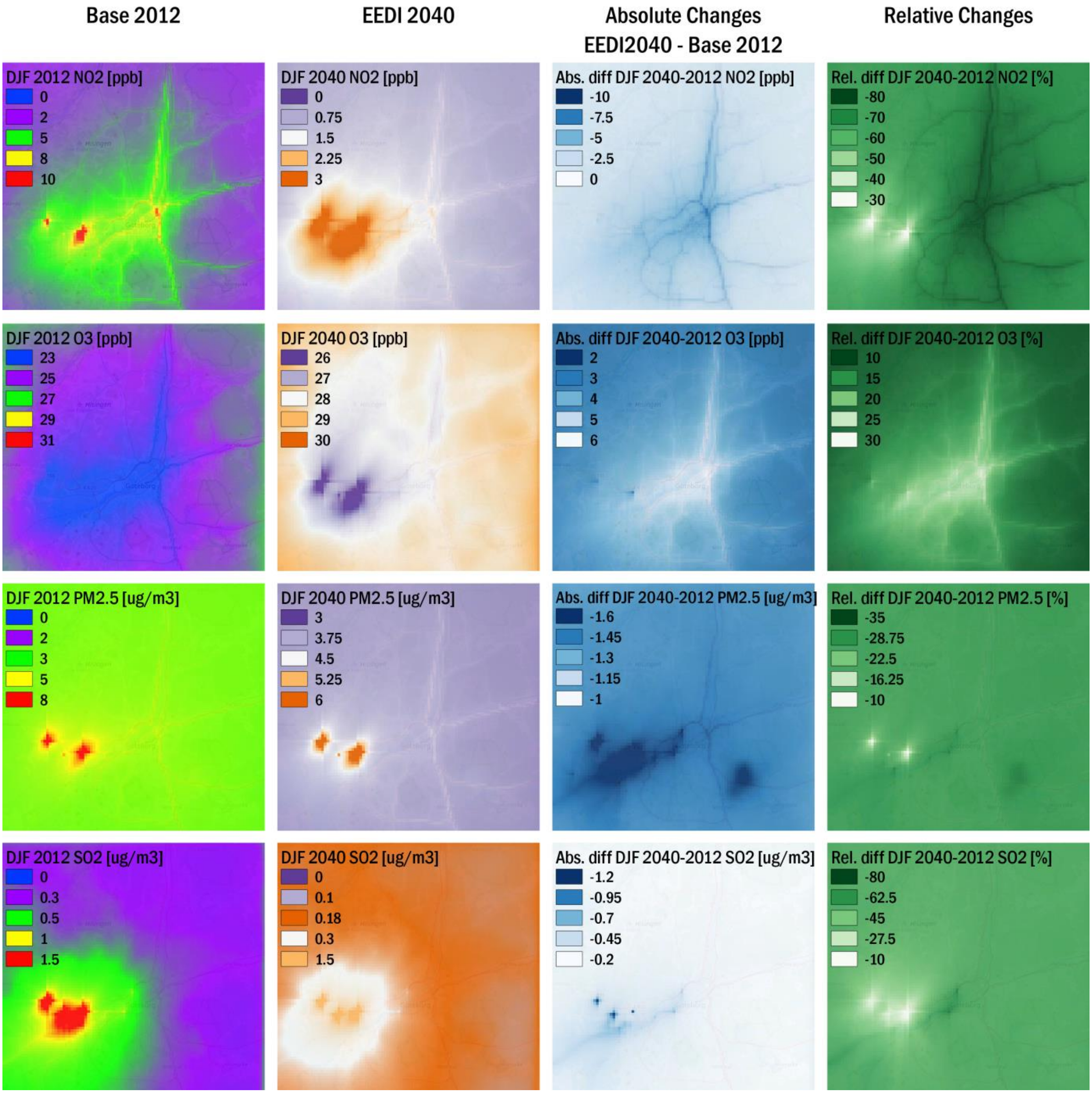

Figure S5: The total modeled present day winter (December, January, February) concentration for NO_2, O_3, $PM_{2.5}$ and SO_2 (column 1) as well as the concentration in EEDI2040 (column 2) and the difference between the present day and EEDI2040 in absolute (column 3) and relative (column 4) values. © OpenStreetMap contributors 2019. Distributed under a Creative Commons BY-SA License.

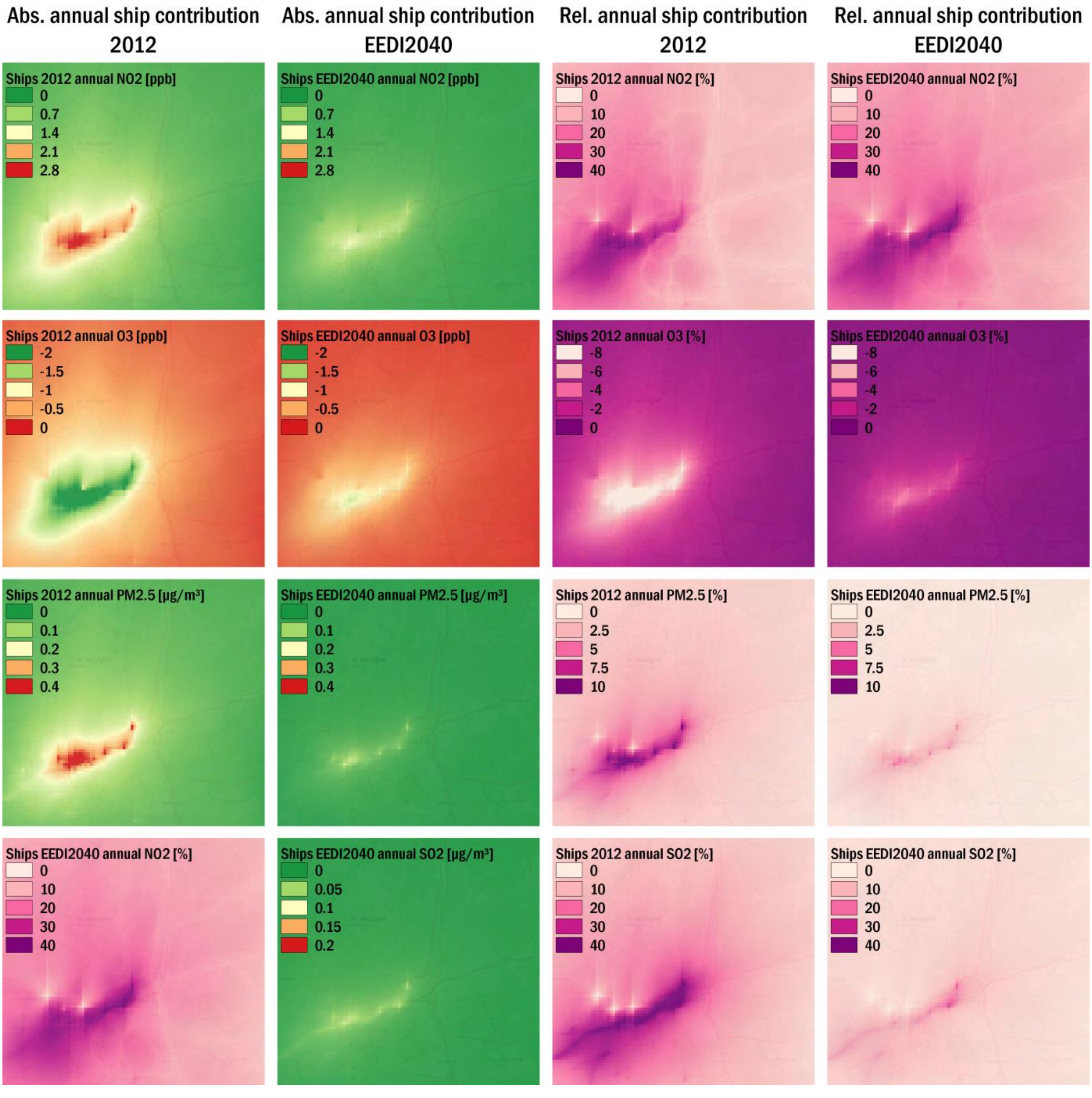

Figure S6: Absolute contributions of local ship emissions to annual mean concentration levels in Gothenburg in 2012 (column 1) and EEDI2040 (column 2), as well as the relative contributions (columns 3 and 4). © OpenStreetMap contributors 2019. Distributed under a Creative Commons BY-SA License.

EEDI2040 –

EEDI2040LP

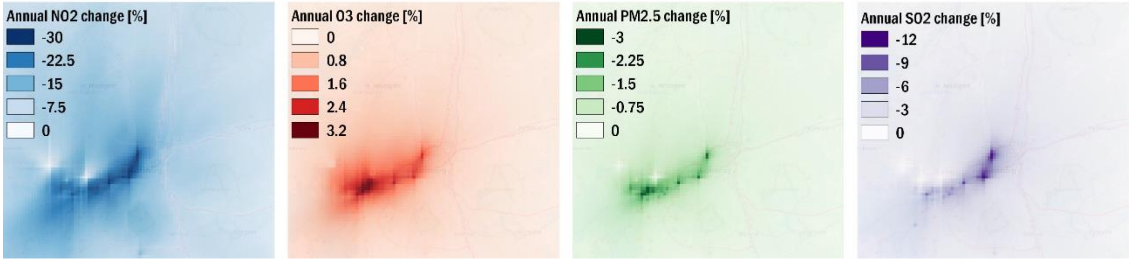

Figure S7: Relative changes in annual mean NO_2, $PM_{2.5}$ and O_3 concentrations for EEDI2040LP compare to EEDI2040 scenario. © OpenStreetMap contributors 2019. Distributed under a Creative Commons BY-SA License.

Supplement 4 – Model setup

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Table S4-1: City-scale model setup.

	Domain	Spatial resolutions	Model / Database
Meteorology 2012	30 km × 30 km	500 m	ECMWF ERA5 0.3˚ × 0.3˚, 21 layers
Background concentrations	160 km × 96 km	4 km × 4 km	CMAQ
Local shipping emissions 2012	30 km × 30 km	250 m × 250 m	STEAM2
Local traffic emissions 2012	30 km × 30 km	meters (line sources)	Miljöförvaltningen and HBEFA v. 3.2
Local industrial, machines, wood burning and aviation etc. 2012	30 km × 30 km	1 km × 1 km	SMED

The period of the simulation is the year 2012 (introduced in the manuscript) and due to the rather fast chemistry on urban-scales, there is no model spin-up necessary. Tests with and without a model spin-up time of one week have shown differences in results below 0.1% for the first hours of simulated concentrations in the simulation period.”

Supplement 5 – Spatial distribution of emissions Gothenburg

Maps of shipping emissions as given in part 1:

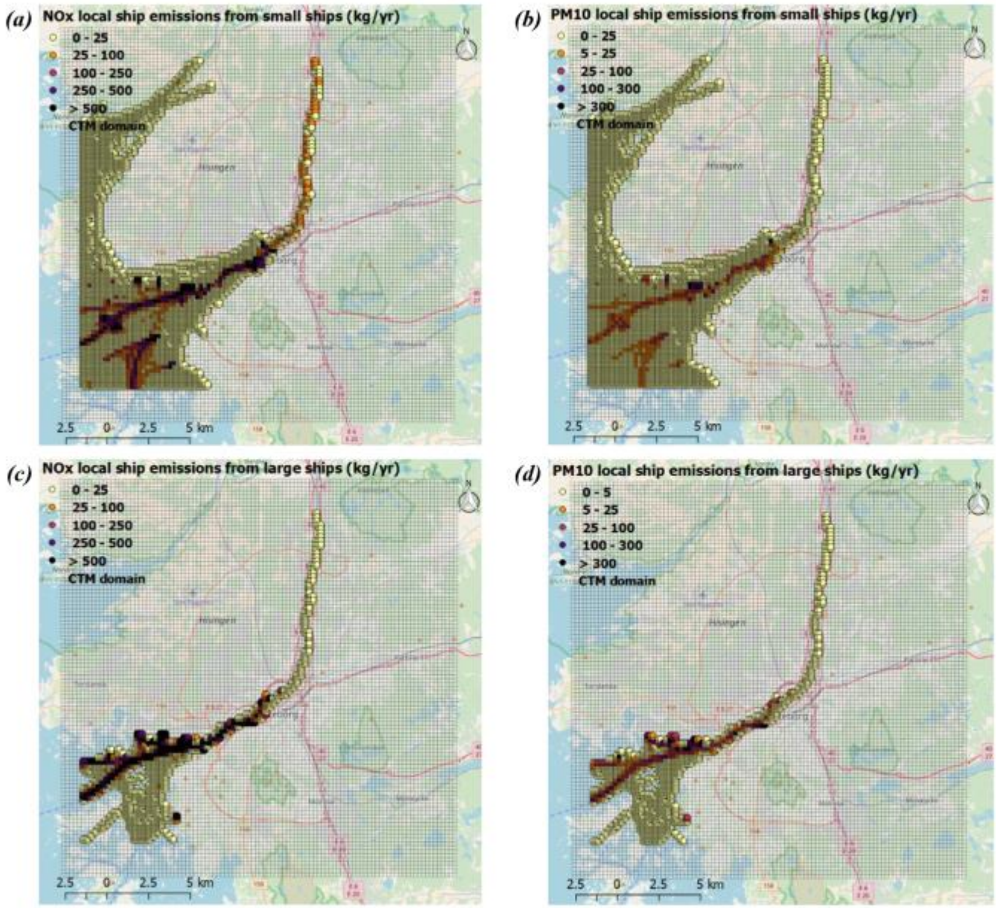

Figure 2. Annual local shipping emissions of **(a)** NO_x and **(b)** PM_{10} (equal to $PM_{2.5}$) from small vessels with a stack height below 36 m (assumed 15 m) and **(c)** NO_x and **(d)** PM_{10} from large vessels with high stack height above 36 m (assumed 36 m) in the Gothenburg area. Base map credits: © OpenStreetMap contributors 2020. Distributed under a Creative Commons BY-SA License.

Map of spatial distribution of local emissions from road traffic and industrial point sources. In addition, other emissions such as domestic heating, working and off-road machinery etc. expressed as grid sources in the model.

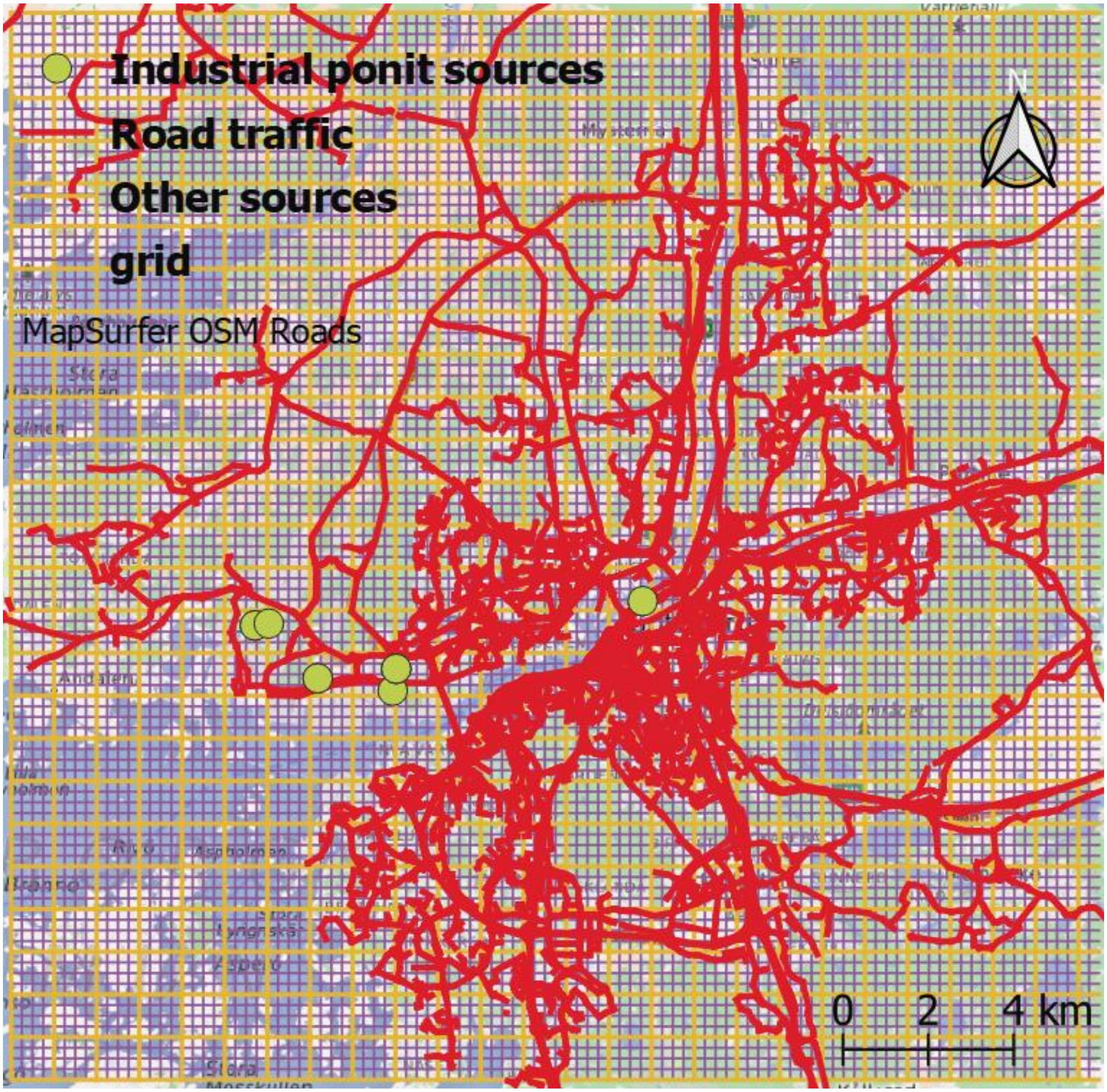

Figure x. The spatial distribution of local emissions from road traffic (red lines), industrial point sources (green circles), and other sources (yellow lines).