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Bottom-up estimation of traffic emissions in Munich based on macroscopic traffic simulation and counting data

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FRAME OF THE PROJECT

We present a **spatially and temporally explicit bottom-up traffic emission inventory** (TUM Inventory) for the city area of Munich. It accounts for greenhouse gases (CO_2, CH_4) and air pollutants (CO, NO_x and PM). It has a temporal resolution of one hour and is compiled for the years of 2019 to 2022.

The inventory was developed within the frame of **ICOS Cities**, a project that aims to develop a systematic greenhouse gas measurement system for urban areas [1].

- Emission inventories are required as prior input for inverse modelling of emissions.
- The presented inventory is based on the city's official macroscopic traffic model.
- Temporal scaling was conducted with data from more than hundred permanent traffic counting stations on different road types.

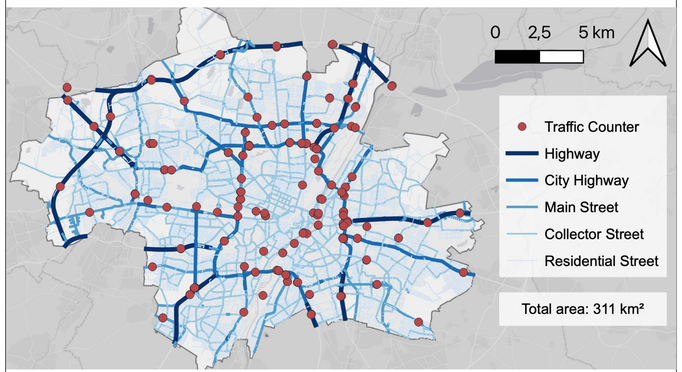
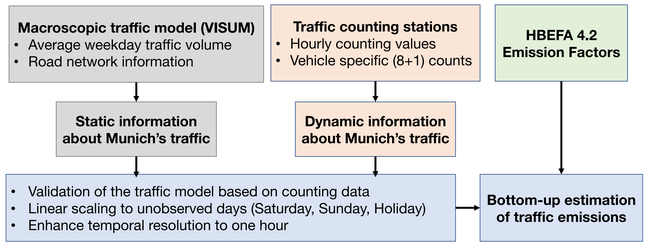


Figure 1: Overview of Munich showing different road categories of the traffic model and locations of the available traffic counting stations in Munich.

METHOD



VISUM model gives **average daily traffic on a weekday outside vacation time**
→ Needs to be **scaled to unobserved days** using traffic counting data
→ Specific scaling for different **road types, day types** and **vehicle classes**

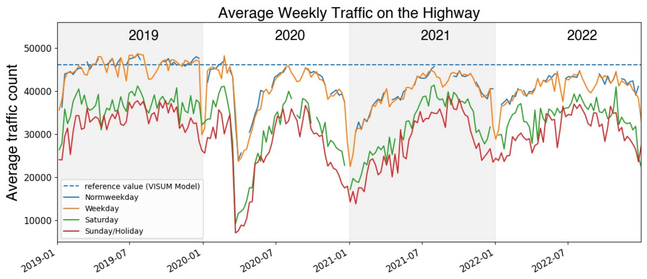


Figure 2: Dynamic information about Munich's traffic: Average traffic count on the highway for different day types from 2019 to 2022. The data clearly incorporates the expected changes of the traffic behaviour during COVID lockdowns.

RESULTS & COMPARISON

RESULTS

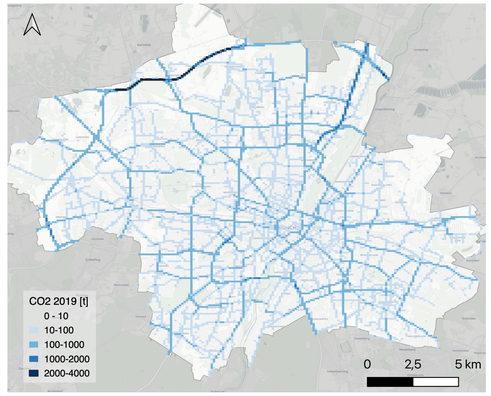


Figure 3: 100x100m spatial representation of the annual CO_2 emissions of 2019, temporal profiles and vehicle shares.

Table 1: Annual total values for different emission components

Year	$CO_{2\ ff}$ [kt]	$CO_{2\ ff+bf}$ [kt]	CH_4 [t]	NO_x [t]	CO [t]	PM [t]	Difference $CO_{2\ ff\ +\ bf}$
2019	1139	1198	47	3142	2389	46	
2020	945	1009	44	2302	1919	37	-15.7 %
2021	907	969	41	2027	1777	30	-19.1 %
2022	899	962	38	1800	1633	27	-19.7 %

COMPARISON WITH OTHER INVENTORIES IN MUNICH

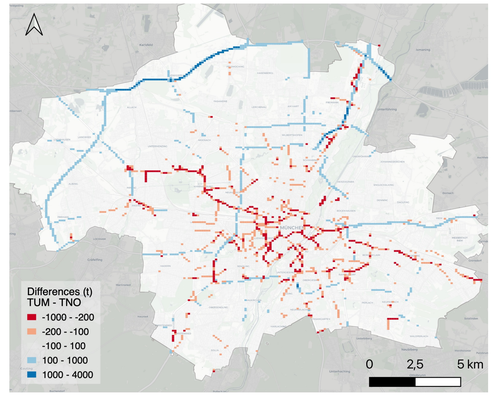


Figure 4: Spatial CO_2 differences in comparison with downscaled 100x100m TNO GHGco HighRes v1.1 inventory. The red areas indicate higher values in the TNO inventory, the blue areas higher values for the TUM inventory

Table 2: Comparison of the annual totals from different inventories

Inventory	Year	Sum [kt]	Difference
TUM Inventory	2019	1198 CO_2	-
UBA IIR [2]	2020	1159 CO_2	- 3.2 %
TNO GHGco HighRes v.1.1 [3]	2018	927 CO_2	- 22.6 %
LHM – GHG Monitoring [4]	2019	1592 CO_{2e}[1]	+ 32.8 %[1]

[1] Corrected by 241 kt CO_{2e} imputed by public and railroad transport.

CONCLUSION

- The annual total of the TUM inventory is well in line with the UBA inventory for the Munich region.
- Overestimation by the City of Munich due to simplified temporal scaling (unobserved-days are scaled with a constant factor of 0.9).
- Underestimation by TNO was also found in other pilot cities of the ICOS Cities project (Zurich, Paris).
- Road length is an insufficient proxy to downscale national inventories to street-level resolution.
- Implementing the traffic volume is indispensable for spatially explicit inventories with a regional focus.

FUTURE WORK

- Use inventory for air pollutant modeling (GRAMM/GRAL) and compare results with actual measurements.
- Implement updated VISUM model which will be provided by the City of Munich and is available from July 23'.
- Update methodology: Implement road gradients, include cold start emissions, include Munich-specific temperature profiles.
- Calculate uncertainties and further investigate differences between different inventories.

[1] https://www.icos-cp.eu/projects/icos-cities-project
[2] Antoon Visschedijk, Hugo Denier van der Gon, Stijn Dellaert, Ingrid Super; High-resolution scenarios of co2 and co emissions, 2019
[3] Patrick Gniffke, Michael Kotzulla, Michael Strogies, Christian Boettcher. German Informative Inventory Report, 2020.
[4] Klimaschutzplaner - Ergebnisbericht Landeshauptstadt München. Website, 2019. Accessed: 19.04.2022.

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Sharing is encouraged