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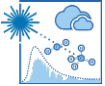Technical University of Munich

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The semi-operational Multi-scale Modelling Infrastructure for Munich

Xinxu Zhao, **Jia Chen**, Julia Marshall, Michal Galkowski, Christoph Gerbig,

Stephan Hachinger, Florian Dietrich, Lijuan Lan, Christoph Knote, and Hugo Denier van der Gon

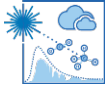Technical University of Munich, Environmental Sensing and Modeling, Munich, Germany

Correspondence: Xinxu Zhao (*xinxu.zhao@tum.de*) and Jia Chen (*jia.chen@tum.de*)

Max Planck Institute
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TNO innovation for life

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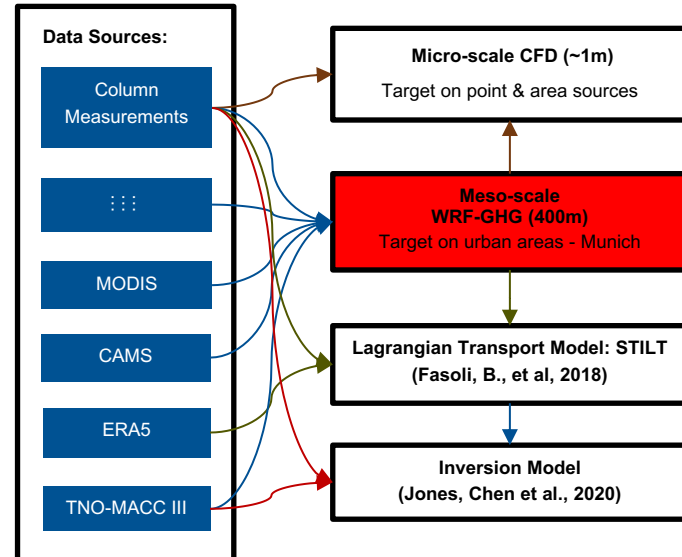culture of
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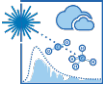# Objectives:

This **urban-scale modeling infrastructure:**

➢ **A semi-operational multi-scale modeling framework** for Munich

➢ Combined with **Greenhouse Gas Network Measurement in Munich (details in Slide 7th)** and **satellites** (OCO-2 is targeting Munich);

➢ Provides quantitative understanding of the carbon cycle in cities;

➢ Near-real-time modeling will provide guidance for local emission reductions.

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Details on the Modeling Infrastructure:

➢ Four separated model modules are designed in our modeling infrastructure;

➢ Various data sources are used as the inputs of these models;

➢ The meteorological outputs from WRF-GHG supposed to be the inputs of STILT and CFD;

➢ In the current stage, we focus on building the meso-scale WRF-GHG;

➢ Near-real-time simulations for emission estimates;

Data Sources:

- Column Measurements
- ⋮⋮⋮
- MODIS
- CAMS
- ERA5
- TNO-MACC III

Micro-scale CFD (~1m)
Target on point & area sources

Meso-scale WRF-GHG (400m)
Target on urban areas - Munich

Lagrangian Transport Model: STILT
(Fasoli, B., et al, 2018)

Inversion Model
(Jones, Chen et al., 2020)

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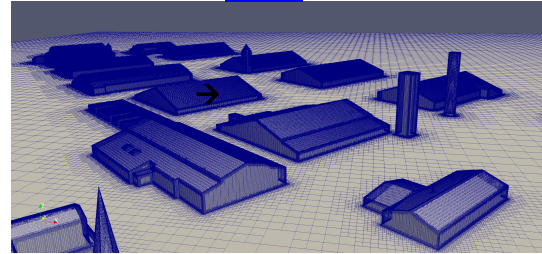# Details on the Modeling Infrastructure:

Micro-scale: CFD (~1m) Target on point and area sources

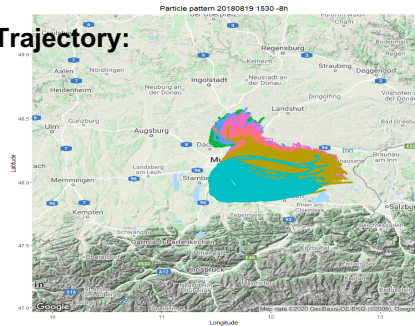Munich South Power Plant (Toja-Silva, Chen et al. 2017)
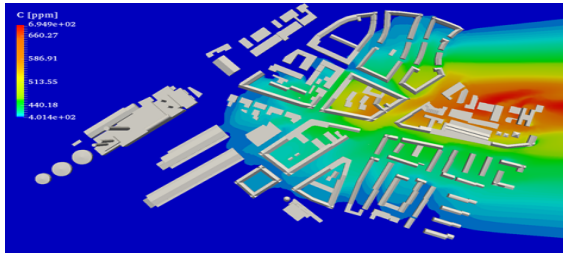
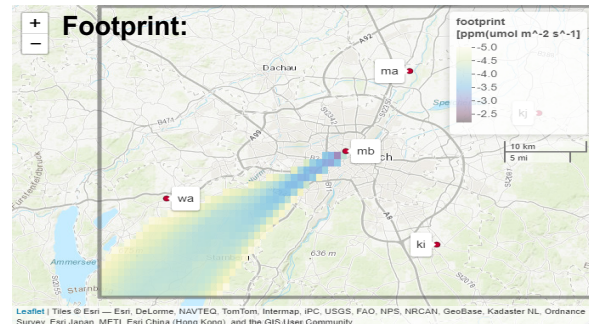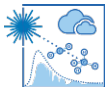Oktoberfest 2019 (Chen, J. et al. 2020)

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STILT: Provide footprints as the inputs of the inversion model

Trajectory:
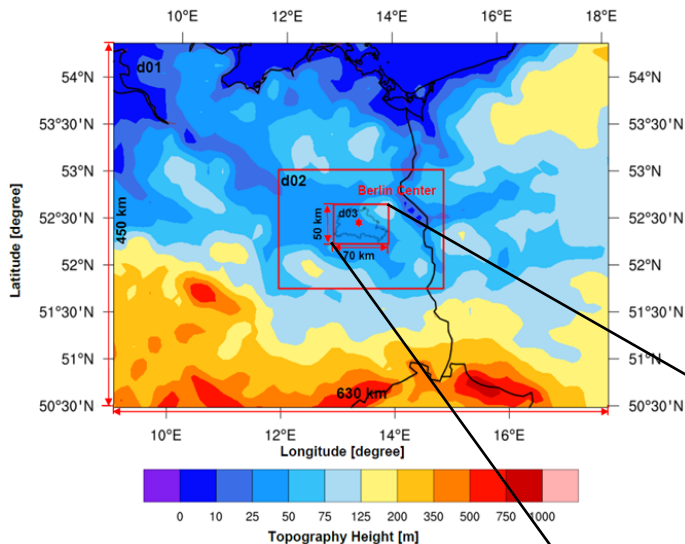
Footprint:

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WRF-GHG model for city Berlin (Zhao, X. et al. 2019)

Model Details:

- ➢ 3 domains with spatial resolutions of 9 km, 3 km & 1 km

- ➢ 26 Vertical layers, up to 50 hPa, 14 of which are in the lowest 2 km of the atmosphere

- ➢ Tracers: Anthropogenic (EDGAR V.4.1), soil uptake, VPRM and etc.

- ➢ Meteorological fields: GFS
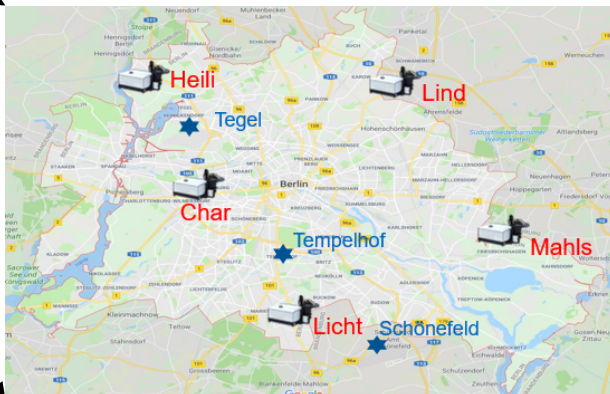
- ➢ The initial and boundary conditions: CAMS
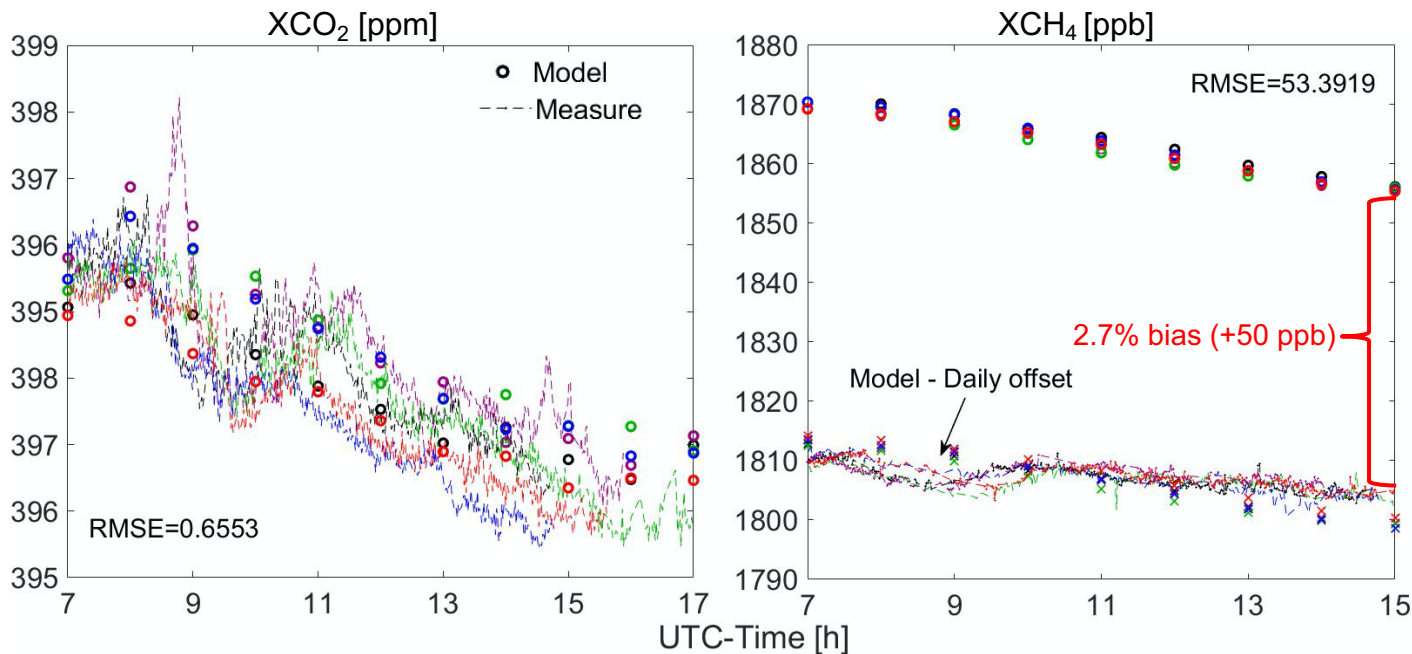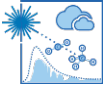

Measurement Details:

- Measuring CO_2 and CH_4 column concentrations

- 5 Ground-based remote sensing EM27/SUNs were deployed

- Performed in July 2014 in Berlin (Hase et al. 2015)

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Comparison of XCO$_2$ & XCH$_4$ (models & measurements)

XCO$_2$ [ppm]

XCH$_4$ [ppb]

RMSE=0.6553

RMSE=53.3919

2.7% bias (+50 ppb)

Model – Daily offset

o Model
--- Measure

UTC-Time [h]

- Modeled XCO$_2$ fits well with measurements
- Modeled XCH$_4$ has a bias compared with measurements

Conclusion: WRF-GHG is a suitable tool for GHG transport analysis in urban area
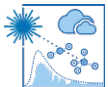
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Greenhouse Gas Network Measurement in Munich

(EGU 2020 Session: ITS5.2/AS3.17/BG2.14/CL3.8/ERE1.7)

• A permanent fully-automated column network for CO_2, CH_4, CO, NO_2, O_3

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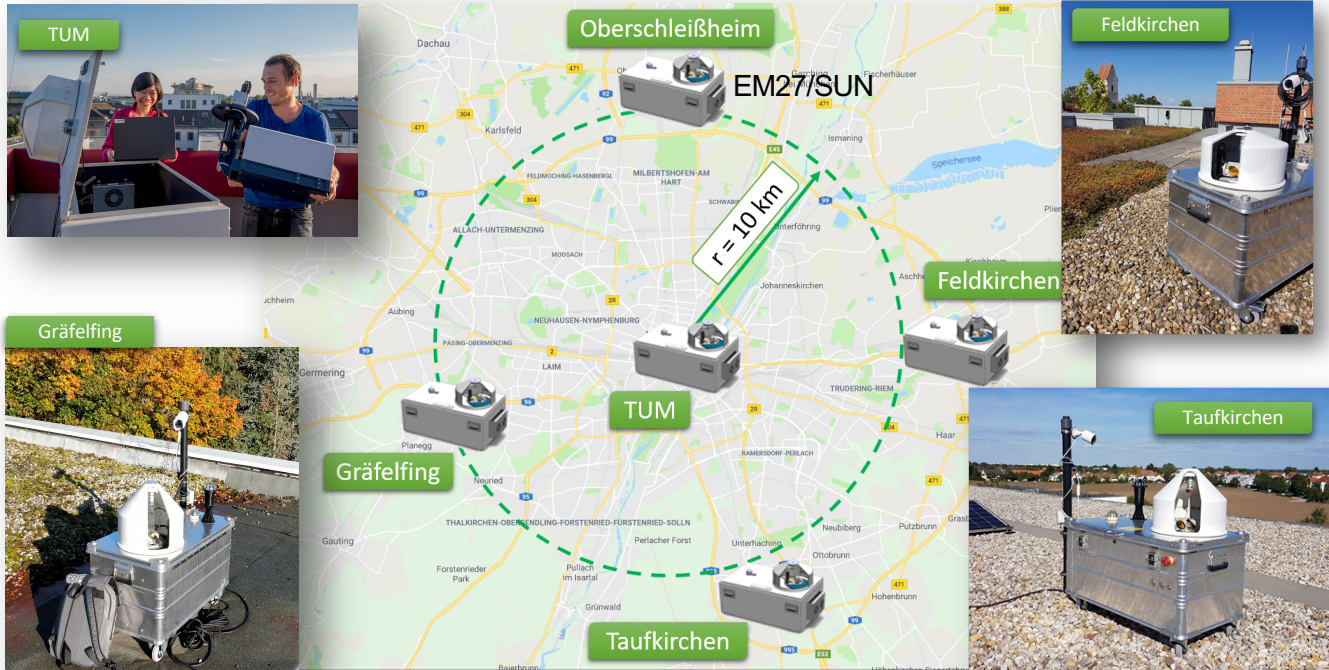
Model Configurations for Munich:

- ➢ 3 domains

- ➢ Spatial resolutions: 10 km, 2 km & 0.4 km

- ➢ 53 Vertical layers, up to 50 hPa, 20 of which in the lowest 5 km of the atmosphere

- ➢ Meteorological conditions: ERA5

- ➢ Tracers: Anthropogenic (TNO-MACCIII&TNO-MACCco), VPRM, wetland (Kaplan model)
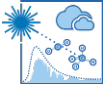
- ➢ Background conditions: CAMS
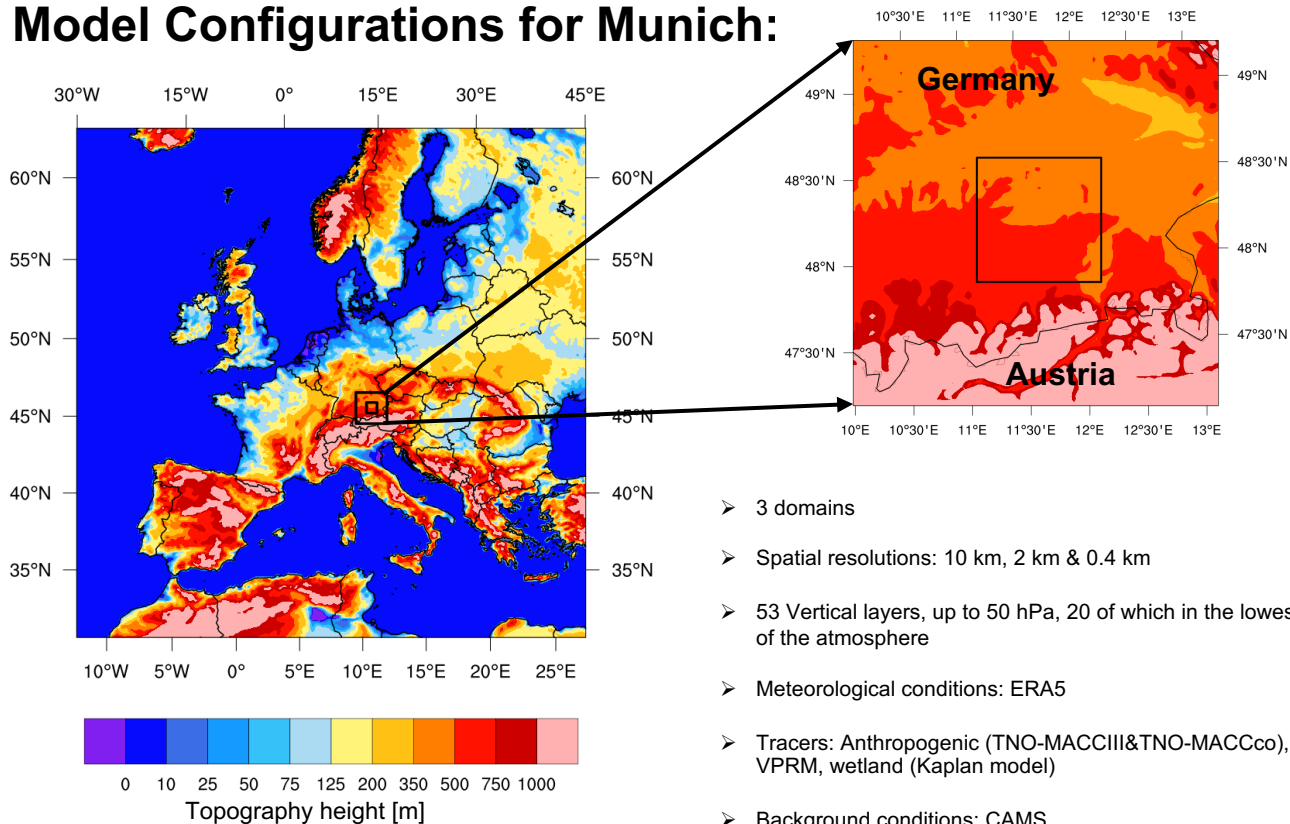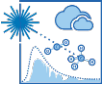
Conclusions and Outlooks:

- The meso-scale WRF-GHG model for Munich is on progress;

→ The precision of our modeling framework is assessed through comparing with surface and column measurements;

→ The WRF-GHG mesoscale simulation framework can be combined with microscale atmospheric transport models (CFD) for obtaining crucial details of transport patterns.

→ We target on providing near-real-time concentration/emission maps for Munich and this application will be tested for other cities (e.g., Hamburg).

Suggestions on our modeling infrastructure welcome!

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