Anthropogenic, biogenic and pollen emission modules for PALM

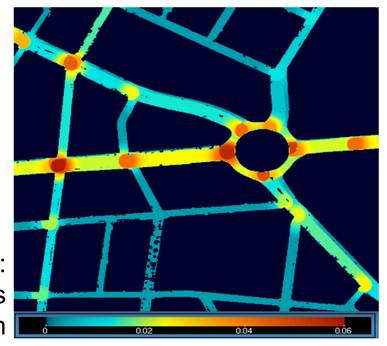
Edward C. Chan[1/2], Basit Khan[3], Ilona Jäkel[1], Sabine Banzhaf[1], Renate Forkel[3], Martijn Schaap[1/4] and Matthias Mauder[3/5]
[1]Freie Universität Berlin, [2]RIFS Potsdam, [3]Karlsruher Institut für Technologie, [4]TNO, [5]Technische Universität Dresden

Set-up and features of the PALM emission module

There are two implementations for emission input:

1. Emission input as **volume sources**
   - **LOD 0** - Emissions from point sources, domestic heating, BVOCs or pollen emissions via namelist input
   - **LOD 2** - Gridded, temporally disaggregated emission values for volume sources via netCDF file
2. Emission input as **surface fluxes**
   - **LOD 0** - Traffic emissions via namelist input
   - **LOD 1** - Gridded, annual emissions via netCDF file
   - **LOD 2** - Gridded, temporally disaggregated emission values for surface fluxes via netCDF file

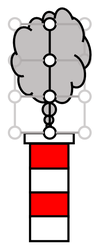
➢ All combinations of the above, also of emissions as volume sources and surface fluxes, are possible!



LOD 2 **surface fluxes**:
NO [g/m²/h] traffic emissions
January 17th 2017, 7:00am

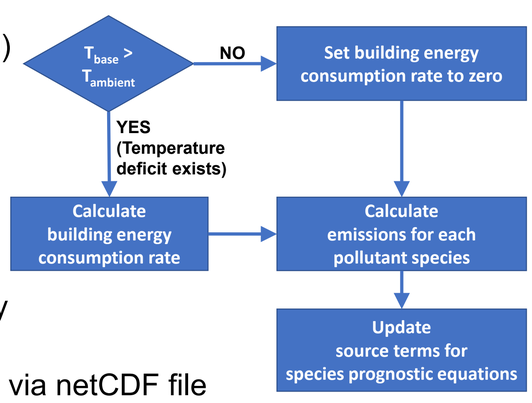
Anthropogenic emissions implemented as **volume sources**

LOD 0 - Emissions from point sources and domestic heating via namelist input



Point sources
- Implemented for emissions from e.g. Power Plants as included in E-PRTR or GRETA database
- Up to 200 point sources possible
- Annual emission per point source and per species
- Weighted distribution over vertical cells is available

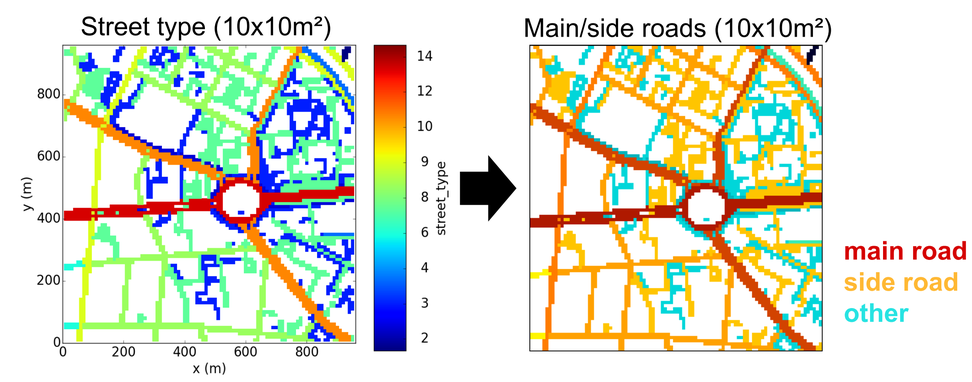
Domestic heating (Based on Struschka and Li, 2019)
- Tabulated emission factors for NOx, PM, etc.
- Calculate rate of energy consumption
- Building type classification/characteristics
  - ➢ Construction year
  - ➢ Zoning (residential / commercial)
  - ➢ Fuel and technology (oil / gas / wood)
- Stack (chimney) locations generated automatically



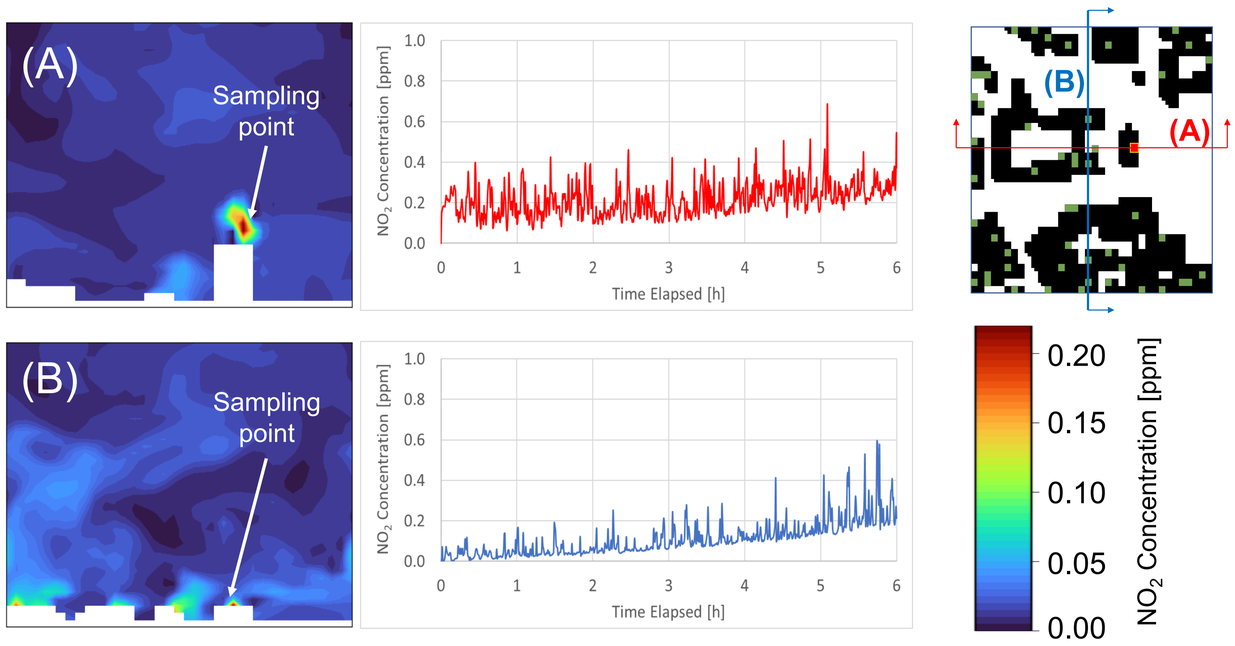
LOD 2 - Spatially distributed emission data provided via netCDF file
- Pre-processed emission values on grid per chemical species
- (Splitted) Annual or temporally disaggregated (with flexible temporal resolution)
  - ➢ Traffic & Domestic heating sector
  - ➢ Generic mode for any other selected sector

Anthropogenic emissions implemented as **surface fluxes**

LOD 0
- So far only implemented for the traffic sector
- Classification of streets, following the Open Street Map classification: street_type
- Flexible split into MAIN and SIDE roads and corresponding emission scaling
- Emission values in µmol/(m²d) (gas) or kg/(m²d) (PM)
- Standard week-day inner city time profile used to temporally disaggregate daily emissions to hourly values



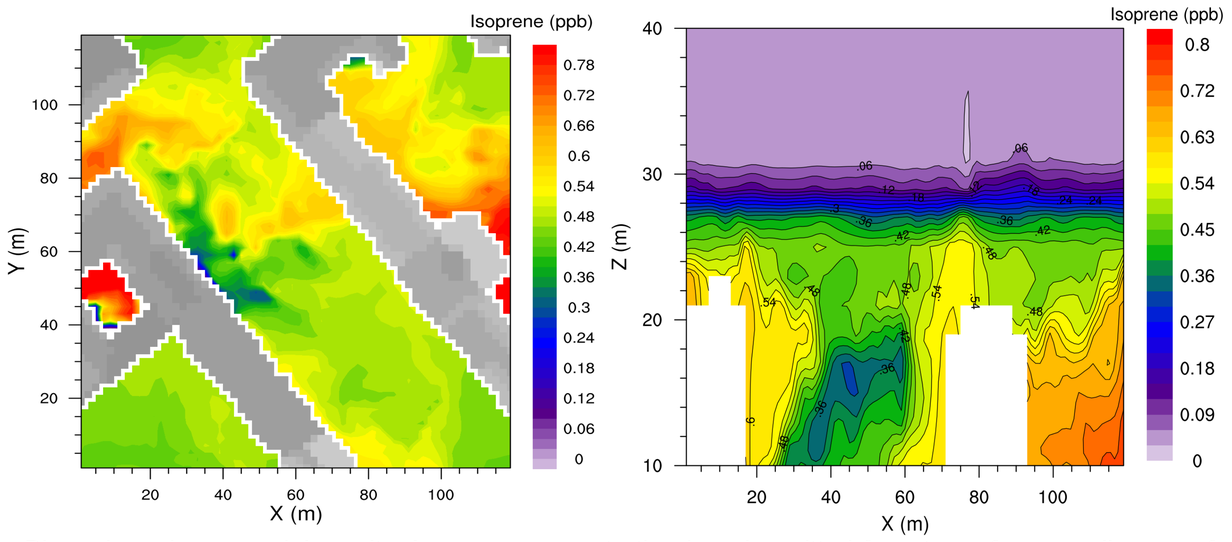
LOD 1 and LOD 2
- Spatially distributed emission data provided via netCDF input file
  - ➢ Pre-processed emission values on grid per chemical species
  - ➢ (Splitted) Annual or temporally disaggregated (with flexible temporal resolution)



Urban case set up with LOD 0 volume sources: Domain setup (36×36×80, Δx=10m) with one point source and emissions from domestic heating (red dot and green dots in the upper right figure, respectively). The green stack locations are generated automatically.

BVOCs emissions

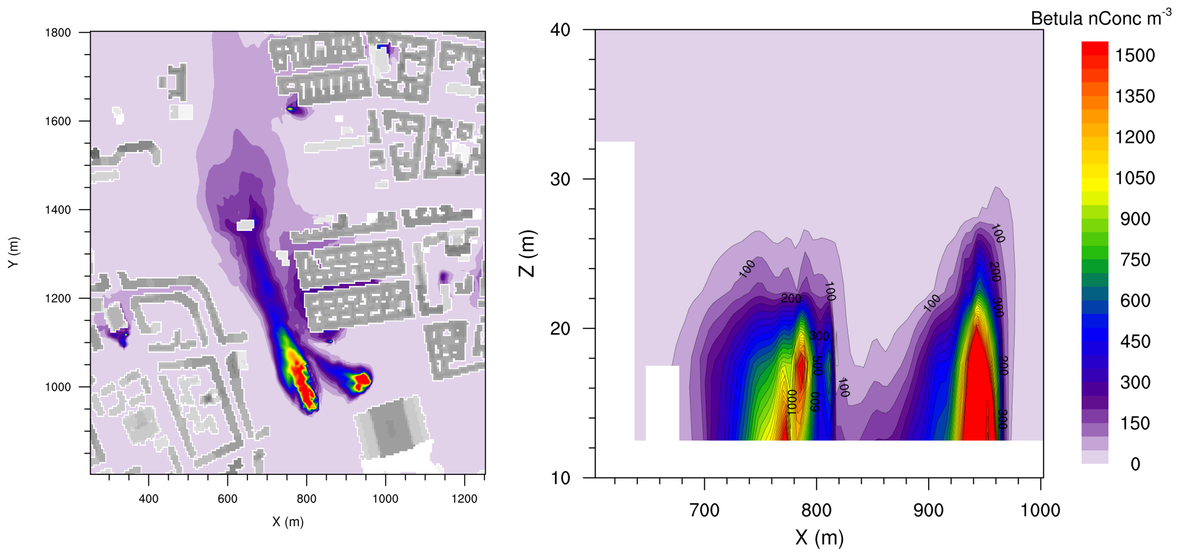
Emissions of Biogenic Volatile Organic Compound (BVOC) implemented as LOD 0 - volume sources
- Based on emission algorithms from Guenther et al. (1991, 1993, 2012).
- The BVOC model is able to compute the net primary emissions of up to 30 biogenic VOCs grouped in five classes, namely isoprene, monoterpenes, sesquiterpenes, reactive oxygenated VOCs (XVOC) and other VOCs (OVOC).
- Only resolved vegetation included, meaning emissions by 2D unresolved vegetation are not considered.



Biogenic emisson model results: Isoprene concentration in ppb emitted from trees for a small area of 120x120 m² centering over a street canyon with a tree line in Berlin. The right panel shows the horizonal and the left panel shows vertical distribution of isoprene simulated by the model.

Pollen Emissions and Transport

PALM-4U Pollen model adopted from EMPOL1.0 (Zink et al., 2013)
- Pollen model implemented as LOD 0 - volume sources
- Parameterization is based on physical and biological processes
- Pollen emission process: a) Pollen presentation (temperature and relative humidity)
  b) Pollen entrainment (TKE)
- Pollen release functions are plant dependent
- Pollen model Includes 4 plant species (Betula, Alder, Grasses and Ambrosia)



Pollen model results for 2x2 km² area in Berlin (Mauer Park). The two panels show Birch pollen dispersion in horizontal (left panel) and vertical (right panel) with buildings (white bars) to the right.

References:

Guenther, A. B., Monson, R. K., & Fall, R. (1991). *Isoprene and monoterpene emission rate variability: observations with eucalyptus and emission rate algorithm development*. Journal of Geophysical Research: Atmospheres, 96(D6), 10799-10808

Guenther, A. B., Zimmerman, P. R., Harley, P. C., Monson, R. K., & Fall, R. (1993). *Isoprene and monoterpene emission rate variability: model evaluations and sensitivity analyses*. Journal of Geophysical Research: Atmospheres, 98(D7), 12609-12617.

Guenther, A. B., Jiang, X., Heald, C. L., Sakulyanontvittaya, T., Duhl, T., Emmons, L. K., & Wang, X. (2012). *The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2. 1): an extended and updated framework for modeling biogenic emissions.* Geoscientific Model Development, 5(6), 1471-1492.

Khan, B. A., Banzhaf, S., Chan, E. C., Forkel, R., Kanani-Sühring, F., Ketelsen, K., Kurppa, M., Maronga, B., Mauder, M., Raasch, S., Russo, E., Schaap, M., and Sühring, M. (2021). *Development of an atmospheric chemistry model coupled to the PALM model system 6.0: impelementation and first applications, Geoscientific Model Development, 14, 1171–1193.*

Zink, K., Pauling, A., Rotach, M. W., Vogel, H., Kaufmann, P., & Clot, B. (2013). *EMPOL 1.0: a new parameterization of pollen emission in numerical weather prediction models.* Geoscientific Model Development, 6(6), 1961-1975.

Struschka and Li (2019). *Temperaturabhängige zeitliche Disaggregation von Emissionen aus Feuerungsanlagen der Haushalte und Industrie für Berlin im Rahmen des MOSAIK-Projektes*. Tech. rep., Universität Stuttgart.

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
[UC]² Urban Climate Under Change Stadtklima im Wandel
MOSAIK