Hands-on session for MUNICH

Youngseob Kim, Lya Lugon, Karine Sartelet, Yelva Roustan

CEREA (ENPC – EDF R&D)

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http://cerea.enpc.fr/munich
https://gitlab.enpc.fr/cerea/munich

Plan

Introduction

- MUNICH: Model of Urban Network of Intersecting Canyons and Highways [Kim et al., 2018]
- Simulation of sub-grid concentrations in the urban canopy represented by the street network
- Calculation of pollutant concentrations for each street segment (segment length < 100 m)
- Gas-phase concentrations using a comprehensive CB05 chemical kinetic mechanism [Yarwood et al., 2005]
- Aerosol model is implemented and testing is ongoing (ssh-aerosol)

Install

Instruction for required libraries and building: MUNICH User's Guide

Source code

- Gitlab: `https://gitlab.enpc.fr/cerea/munich`
- tar archive: `http://cerea.enpc.fr/munich/src/munich-1.1.tar.bz2`

User's guide: `http://cerea.enpc.fr/munich/doc/munich-guide.pdf`

Hands-on session

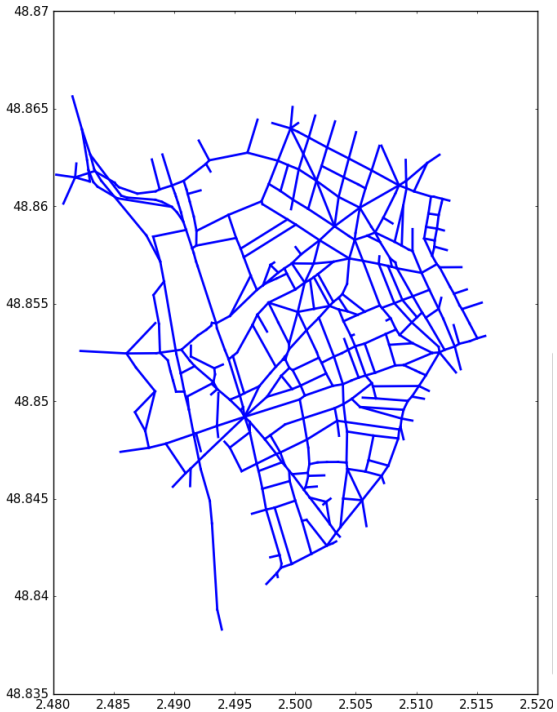
- Data and configuration files: `https://cloud.enpc.fr/remote.php/webdav/data-munich.tar.bz2`
- Document `http://cerea.enpc.fr/munich/doc/munich-training-doc.pdf`

Studied area for hands-on session: Trafipollu project

- Le Perreux-sur-Marne

  (suburb , 13 km east of Paris)
- Street network : 577 street segments and 433 intersections
- Simulation period :

  16 to 18 March 2014
- Gas-phase pollutants including NO_x, and O_3



Download the configuration files and input data

You need to download and extract the archive `munich-training.tar.bz2` in your working directory.

```
> tar -xjvf munich-training.tar.bz2
```

Please check if you have the following sub-folders in `munich-training`:

- `data`: all input data for Trafipollu project including raw data for emission, meteorology, background concentrations.
- `postprocessing`: python scripts for visualization.
- `preprocessing`: python scripts to convert raw data for MUNICH simulation.
- `processing`: configuration files for MUNICH simulation.

Preprocessing

Python script `sing_preproc.py` can be used and run with a configuration file `sing_preproc.cfg`.

```
> cd munich-training/preprocessing
> python sing_preproc.py sing_preproc.cfg
```

- `input/background_concentration.dat`: background concentrations data
- `input/meteo`: meteorological data from a WRF model simulation
- `input/street-geog-info.dat`: geographical data including street id, street width, average building height.
- `input/traffic`: hourly traffic emission data

Preprocessing output files

Input data for MUNICH are generated in the folder indicated as `Output_dir` in the configuration file `sing_preproc.cfg`.

```
[output]

Output_dir: output/
```

Please check the generated data

```
> ls -l munich-training/preprocessing/output/

-rw-r--r-- 1 kimy air 276768 Feb 21 10:18 CH4.bin
-rw-r--r-- 1 kimy air 276768 Feb 21 10:18 CO.bin
-rw-r--r-- 1 kimy air 276768 Feb 21 10:18 NMHC.bin
-rw-r--r-- 1 kimy air 276768 Feb 21 10:18 NO.bin
-rw-r--r-- 1 kimy air 276768 Feb 21 10:18 NO2.bin
-rw-r--r-- 1 kimy air 276768 Feb 21 10:18 NOx.bin
drwxr-xr-x 2 kimy air   4096 Feb 21 10:18 background
drwxr-xr-x 2 kimy air   4096 Feb 21 10:18 emission
drwxr-xr-x 2 kimy air   4096 Feb 21 10:18 meteo
drwxr-xr-x 2 kimy air   4096 Feb 21 10:18 textfile
```

Binary files in `output` are not used for MUNICH. They are generated only for a simulation Street-in-Grid coupled with Polair3D model.

- `background`: hourly background concentrations for each street segment.
- `emission`: hourly traffic emission data for each street segment.
- `meteo`: hourly meteorological data for each street segment.
- `textfile`

Size of the files in `background`, `emission` and `meteo` folders is equal to N_t x N_{street} x size of float (72 x 577 x 4) in bytes.

Speciation of NMHC

The script speciation_aggregation.py is used to split organic matter emissions from NMHC → CB05 chemical kinetic mechanism species.

```
> cd munich-training/preprocessing/utils/speciation
> python speciation_aggregation.py
```

Please make sure you have additional files in the emission folder :

```
> ls -l munich-training/preprocessing/output/emission/
```

```
-rw-r--r-- 1 kimy air 166176 Feb 21 10:44 ALD2.bin
-rw-r--r-- 1 kimy air 166176 Feb 21 10:44 ALDX.bin
-rw-r--r-- 1 kimy air 166176 Feb 21 10:44 API.bin
-rw-r--r-- 1 kimy air 166176 Feb 21 10:44 CH4.bin
-rw-r--r-- 1 kimy air 166176 Feb 21 10:18 CO.bin
...
...
-rw-r--r-- 1 kimy air 166176 Feb 21 10:44 XYL.bin
```

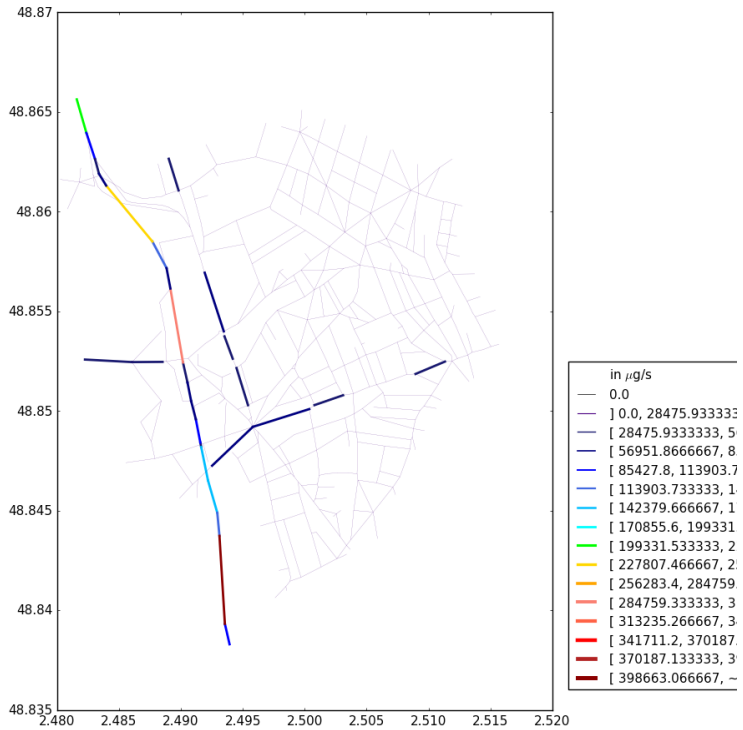
Preprocessing outputs vizualization

`display_emission.py` allows to check the generated emission data.

```
> cd munich-training/preprocessing/utils
> python display_emission.py
```

To specify the file name and the species name, please modify the following lines in `display_emission.py`

```
date = "20140316-16"
# available species: NO, ...
species_name = "NOx"
```



Files in the folder `output/textfile` are used for this script.

```
-rw-r--r-- 1 kimy air 49011 Feb 21 11:29 emission-trafipollu-eff.20140316-00.txt
-rw-r--r-- 1 kimy air 48373 Feb 21 11:30 emission-trafipollu-eff.20140316-01.txt
```

Processing

Download the program

The program is available at `https://gitlab.enpc.fr/cerea/munich`. Please clone by `git` or download an archive.

Compile

The program needs to be compiled with Scons. Please make sur that Scons has already been installed in your system `https://www.scons.org`. Then type `scons` as follows:

```
> cd munich-v1.1/processing/photochemistry
> ./scons
```

To ease the next step, please make a symbolic link to the compiled program into your working directory as follows:

```
> cd munich-training/processing
> ln -s munich-v1.1/processing/photochemistry/munich .
```

Prepare the configuration files

Three configuration files

- `munich.cfg`: main configuration file (informations on the options of the simulation
- `munich-data.cfg`: configuration file to describe input data files
- `munich-saver.cfg`: parameters to save output results

Three input data files

- `street.dat`: list of street segments
- `intersection.dat`: list of intersections
- `species-cb05.dat`: list of chemical species

Launch your first run

Please make sure that all paths in the configuration files are correct. In particular, `Directory` in `munich-data.cfg` should point to the generated binary files.

```
Directory: ../preprocessing/output/
```

And `Output_dir` in `munich-saver.cfg` should be checked. Default folder is `results`.

```
Output_dir: results/
```

`street.dat` and `intersection.dat` are obtained by the preprocessing script `sing_preproc.py`. They should be found in `preprocessing/output/textfile`. However, they are copied into `processing` for this hands-on session. You are ready to launch :

```
> ./munich munich.cfg
```

Visualization

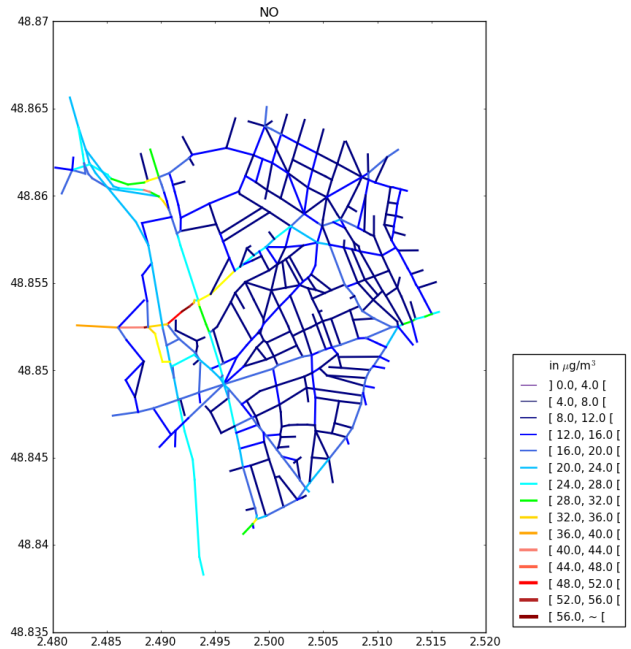
This script `disp_concentrations.py` visualizes concentrations of a species on the domain map.

```
> cd postprocessing
> python disp_concentrations.py disp_concentrations.cfg
```

Species name and directory for the results can be changed by editing `disp_concentrations.cfg`

```
[input]

Species: NO
Directory: ../processing/results/
```



Without steady-state assumption

1) Modify munich.cfg

```
[street]

...

# If stationary hypothesis are used to compute ...
With_stationary_hypothesis: no
```

2) Change the directory for output files in munich-saver.cfg.

```
Output_dir: results-sim2/
```

3) Run again the program

```
> ./munich munich.cfg
```

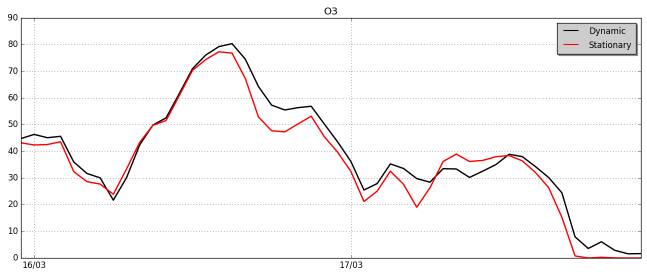
Visualization

The script `disp_temporal.py` visualizes temporal variations of concentrations in a street segment. Modify species name in `disp_temporal.cfg`

```
Species: O3
```

Modify directories for the simulation results in `disp_temporal.py`

```
# Simulation 1
directory = "../processing/results-sim2/"
# Simulation 2
directory = "../processing/results-sim/"
python disp_temporal.py disp_temporal.cfg
```



References I

Kim, Y., Wu, Y., Seigneur, C., and Roustan, Y. (2018).
Multi-scale modeling of urban air pollution: development and application of a Street-in-Grid model (v1.0) by coupling MUNICH (v1.0) and Polair3D (v1.8.1).
Geosci. Model Dev., 11:611–629.

Yarwood, G., Rao, S., Yocke, M., and Whitten, G. (2005).
Updates to the carbon bond chemical mechanism: CB05. rep. RT-0400675.
page 246pp.
available at `http://www.camx.com/files/cb05_final_report_120805.aspx`, last access 27 March 2017.