Referee Comment on gmd-2023-70 ”Modelling concentration heterogeneities in streets using the street-network model MUNICH” by Thibaud Sarica et al.

General Comment

A new version of the street-network model MUNICH is presented that introduces a vertical discretization of street canyons in three layers and the horizontal discretization of the street canyon in two zones (recirculation and ventilation) based on well-evaluated parameterizations of the OSPM model. The manuscript is well organized although more discussion of pertinent issues such as the influence of the vehicle wake and atmospheric stability on the vertical pollutant distribution in street canyons would give the paper more credibility. The new version, termed MUNICH-hete is applied to two street canyons and districts in Copenhagen and to one district in Greater Paris and compared to the homogeneous version of the model and OSPM results for two street-level receptors as well as street-level measurements. Further, a sensitivity study of the influence of the street network on the concentrations in the streets with MUNICH-hete was performed concluding that intersections with neighboring streets underline the need for simulating a street network rather than a single street.

MUNICH-hete predicts that concentrations of compounds emitted by traffic are higher at the bottom of the street than at the top. However, the vertical distribution of pollutants in the three-layer street canyon is not compared to measurements. For wide streets and avenues with dense traffic, the concentrations in the first level (MUNICH-hete-11) are generally higher than in the homogenous version of the model. A systematic analysis of the influence of the aspect ratio on the concentration differences between MUNICH-hete-11 and the homogenous version has unfortunately not been performed.

Specific Comments:

1.) P2, line 35-36: EPISODE-CityChem (Karl et al., 2019) that uses a simplified OSPM and CALIOPE-Urban (Benavides et al., 2019), which applies a downscaling depending on atmospheric stability and building density, should be mentioned here.

2.) P2, line 42: Was the SSH-aerosol model used in this study? It would be interesting to see the effect of detailed VOC chemistry on SOA concentrations along street canyons.

3.) P3, line 60: “The new version of MUNICH” should be given a version number. Is it based on MUNICH v2.0 in all other aspects than the vertical discretization or is it a different development branch?

4.) Resuspension of road dust can be an important of the non-exhaust particulate matter emissions from vehicles and its relevance will increase in the future due to transition to electric

mobility. Here it is stated that resuspension is a minor process compared to transport and chemistry, however that only applies to vehicular exhaust emissions. The consequence would be to restrict the application of MUNICH-hete to vehicular exhaust emissions of gaseous pollutants.

5.) How is the influence of atmospheric stability on vertical mixing within a street canyon taken into account in MUNICH? Some dispersion models like SIRANE account for this.

6.) Vertical distribution of pollutants in the street canyons of this study with MUNICH-hete should be shown, and compared to observation in different heights of the street canyons. There is some debate about the shape of the vertical profile in street canyons. Zoumakis et al. (1995) based on analysis of measurements report that the average vehicular pollutant concentration profile follows the general exponential form rather than the simple exponential function or Gaussian distribution. Kumar et al. (2009) report that concentrations of particle numbers increase from road level up to 2 m height, this increase is reproduced by a CFD model.

7.) This also concerns the question whether three levels are sufficient to represent the pollutant distribution in a street canyon. As I understand it, the height of the first level defines the volume in which traffic emissions are injected and diluted. The height of the first layer should be evaluated with a model that can resolve the flow and dispersion in the vehicle wake (Kumar et al., 2011). A sensitivity study on the height of the munich-11 level should be carried out.

8.) How is traffic-induced turbulence considered in the vertical turbulence flux sigma_w of Equation 12? The influence of the traffic-induced turbulence should then only be considered in the first level.

9.) P7, line 173: Explain no-slip condition at the ground.

10.) Is it planned to use 3-D building heights to inform the model on the real street canyon geometries?

Technical Corrections:

P 1, line 10: “Results show an improvement”. In the abstract, give quantitative information on the improvement and state compared to which model the improvement was achieved.

P9, line 226: “when NO2 concentrations are underestimated” – does this refer to measured NO2?

Figure 3: Annotations on x-axis and y-axis are incomplete.

Figure 5: Same as for Figure 3. In Figure 5a the line for the CO observations is missing.

Figure 7: Same as for Figure 3.

References:

Benavides, J., Snyder, M., Guevara, M., Soret, A., Pérez García-Pando, C., Amato, F., Querol, X., and Jorba, O.: CALIOPE-Urban v1.0: coupling R-LINE with a mesoscale air quality modelling system for urban air quality forecasts over Barcelona city (Spain), Geosci. Model Dev., 12, 2811–2835, https://doi.org/10.5194/gmd-12-2811-2019, 2019.

Karl, M., Walker, S.-E., Solberg, S., and Ramacher, M. O. P.: The Eulerian urban dispersion model EPISODE – Part 2: Extensions to the source dispersion and photochemistry for EPISODE–CityChem v1.2 and its application to the city of Hamburg, Geosci. Model Dev., 12, 3357–3399, https://doi.org/10.5194/gmd-12-3357-2019, 2019.

Kumar, P., Garmory, A., Ketzel, M., Berkowicz, R., and Britter, R.: Comparative study of measured and modelled number concentrations of nanoparticles in an urban street canyon, Atmos. Environ., 43, 949–958, doi:10.1016/j.atmosenv.2008.10.025, 2009.

Kumar, P., Ketzel, M., Vardoulakis, S., Pirjola, L., and Britter, R.: Dynamics and dispersion modelling of nanoparticles from road traffic in the urban atmospheric environment – A review, J. Aerosol Sci., 42, 580–605, doi:10.1016/j.jaerosci.2011.06.001, 2011.

Zoumakis, N. M.: A note on average vertical profiles of vehicular pollutant concentrations in urban street canyons, Atmos. Environ., 29(25), 3719–3725, doi:10.1016/1352-2310(95)00105-8, 1995.