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# Numerical simulation of the Lagrangian transport of aerosols of various genesis in urban conditions

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# Lagrangian model physics

Newton's second law + Medium resistance force + Buoyancy force

## Equations of motion

$$\frac{\mathrm{d}\boldsymbol{u_p}}{\mathrm{d}t} = \frac{\boldsymbol{g}(\rho_p - \rho)}{\rho_p} + F_D(\boldsymbol{u} - \boldsymbol{u_p})$$

$$\frac{\mathrm{d}\boldsymbol{x_p}}{\mathrm{d}t} = \boldsymbol{u_p}$$

- $\rho_p$ – particle density
- $d_p$ – particle diameter
- $\boldsymbol{u_p}$ – particle velocity
- $\boldsymbol{g}$ – gravitational acceleration
- $\rho$ – air density
- $\boldsymbol{u}$ – wind velocity

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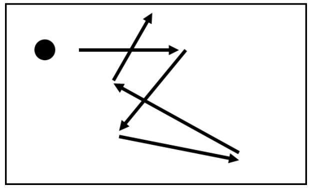
## Turbulence parameterizations

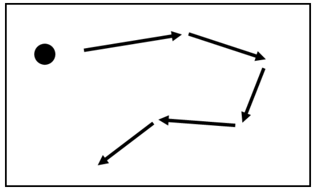
Random displacement model

$0^{th}$ **order** stochastic model



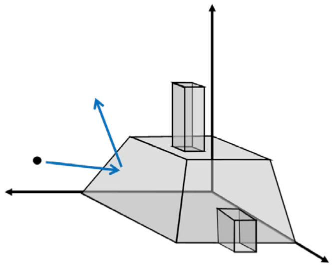
Langevin model

$1^{st}$ **order** stochastic model

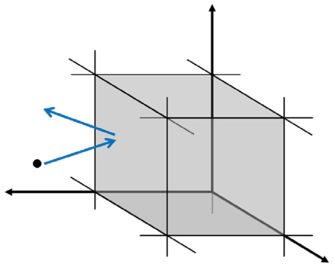


## Interaction with surfaces

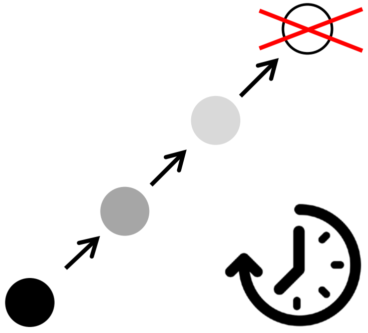
Complex geometry mode



Simple geometry mode (cubic)



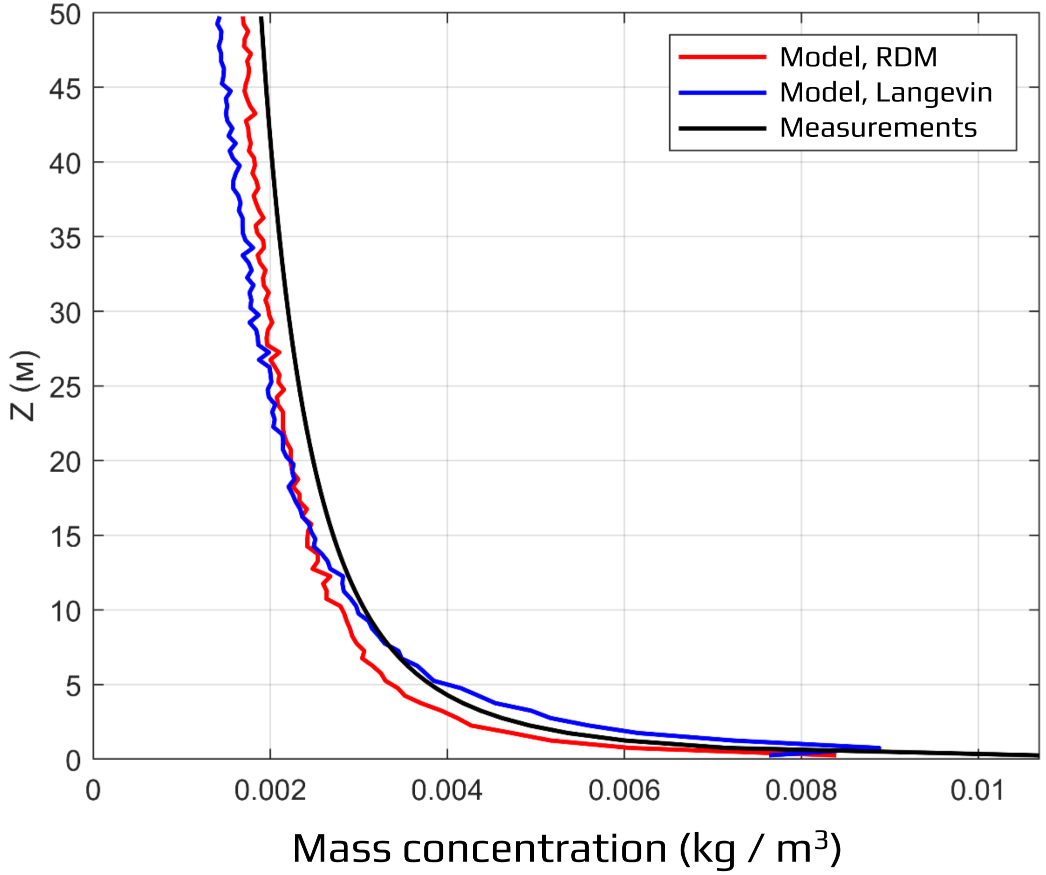
## Particle decay



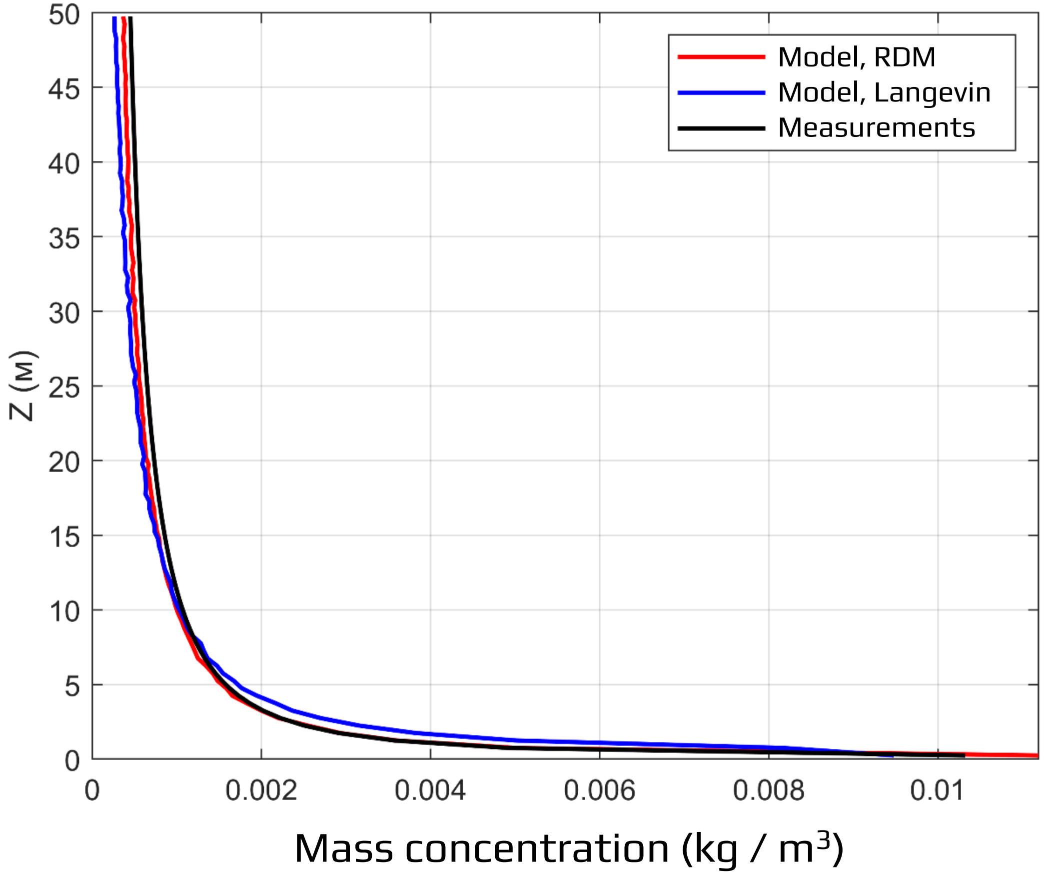
# Model verification

**Data:** measurements of vertical profiles of particle concentrations during dust and sand storms in Central Asia

Dust storm, $d_p$ = 35 μm

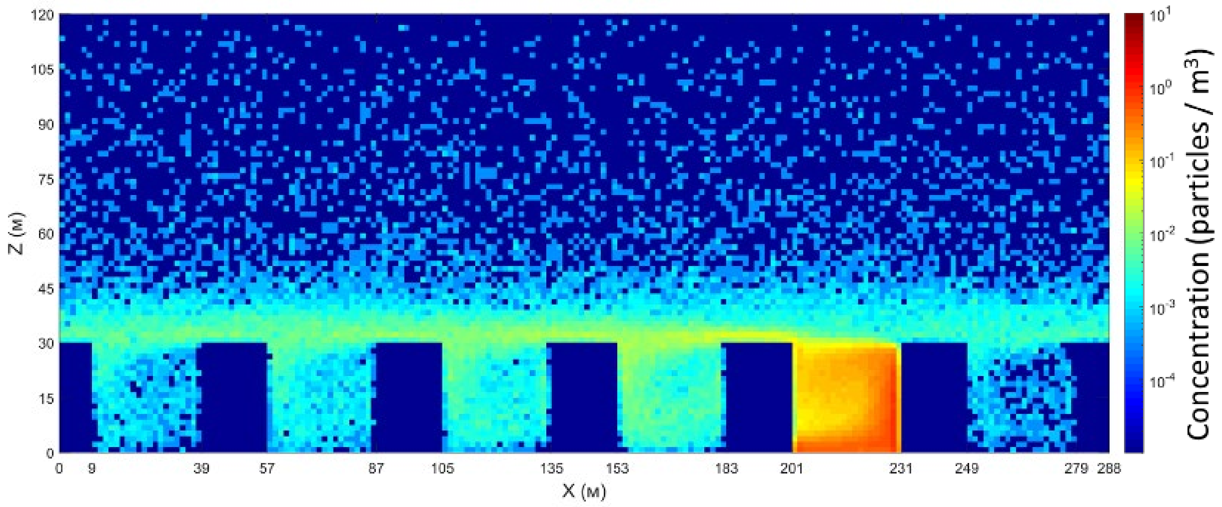



Sand storm, $d_p$ = 50 μm

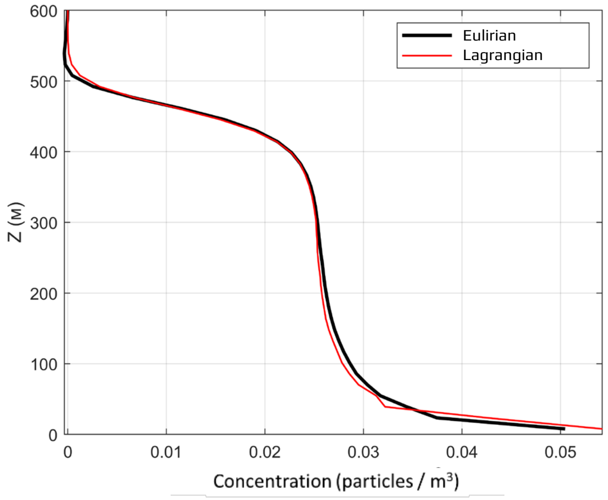


# Simulations: particle transport in urban conditions

## Bioaerosols (SARS-CoV-2) in a series of urban canyons

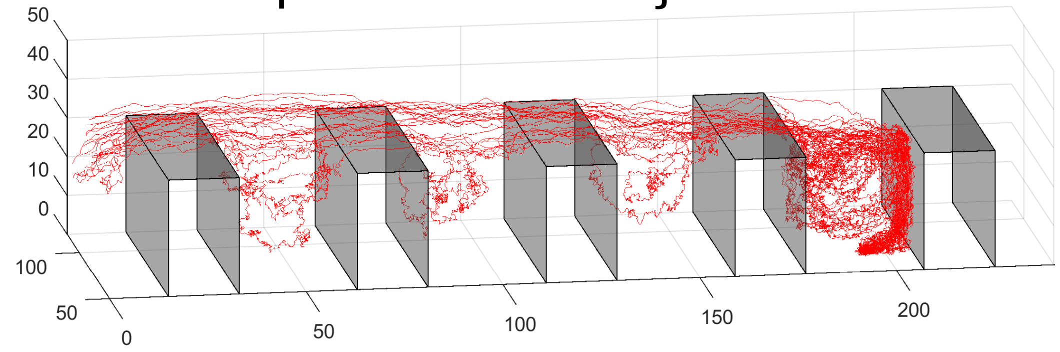



## Perspectives

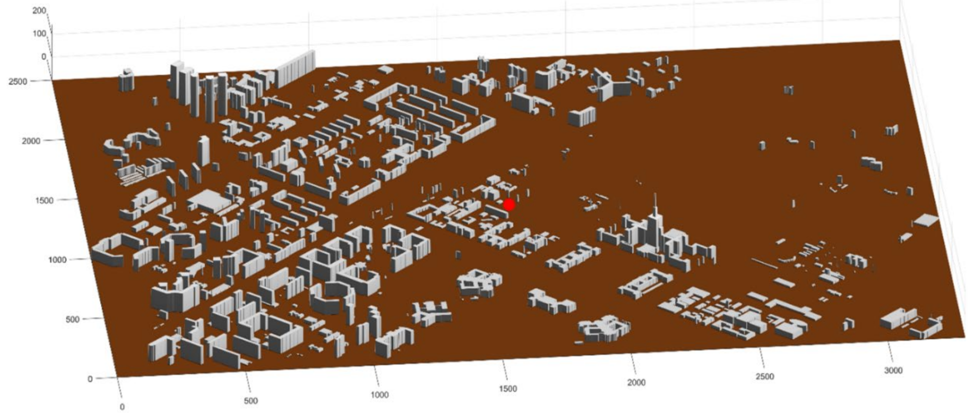



Implementation in the LES model as an external module in parallel to Eulirian approach

## Representative trajectories




## Calculations with realistic building geometries



# Results

The results of the development of a numerical model of the Lagrangian transport of particles are presented:

- The model implements stochastic parametrizations of the 0th and 1st orders, which allows to choose between them depending on the task and input data
- The model has been verified on analytical solutions for both light and heavy particles, including taking into account the influence of particles on atmospheric stratification
- The model is verified on field measurements of dust and sand particles concentrations data
- Experimental calculations have been successfully carried out for idealized types of urban geometry with different atmospheric conditions
- The Lagrangian particle transport module was developed and implemented in the hydrodynamic RANS/LES/DNS model, successful test calculations were carried out

Publications on the previous results of the work:
https://doi.org/10.1088/1755-1315/386/1/012045
https://doi.org/10.1088/1755-1315/611/1/012017