uDALES: applications overview & development plan

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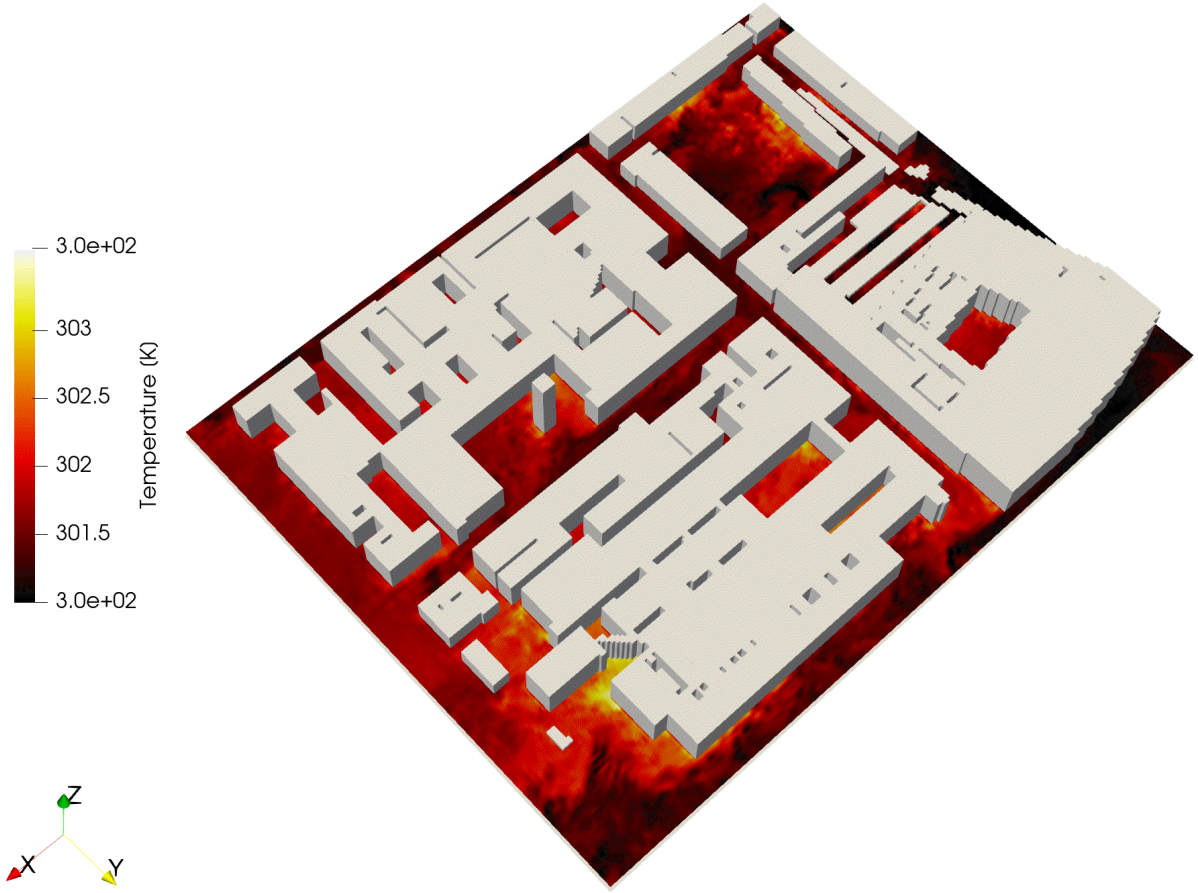
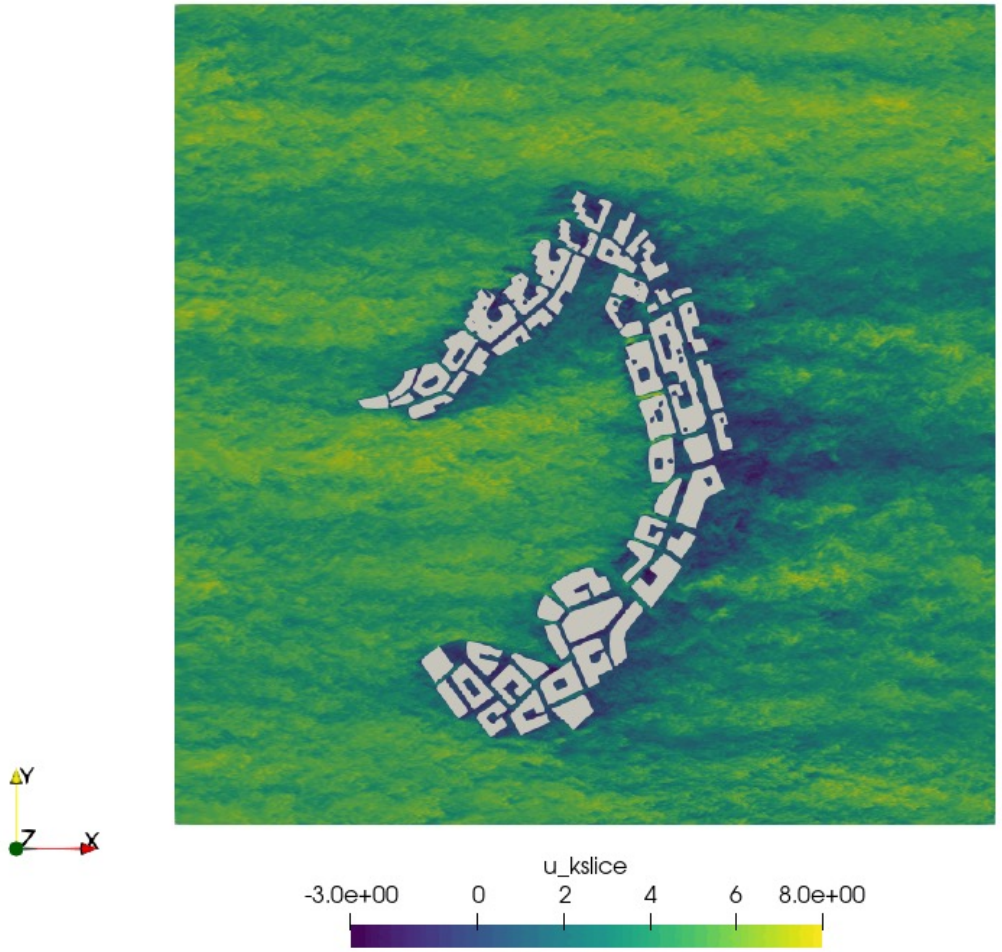
Introduction

- uDALES: a large-eddy simulation framework for urban environments.
- Surface energy balance model for man-made & vegetative facets.
- Pollutant chemistry & dispersion.
- Minimal tree model.
- Used for microclimate studies, wind & thermal comfort, air quality, surface parametrisation.
- Aim: increase performance and enable more realistic geometries.



Wind comfort

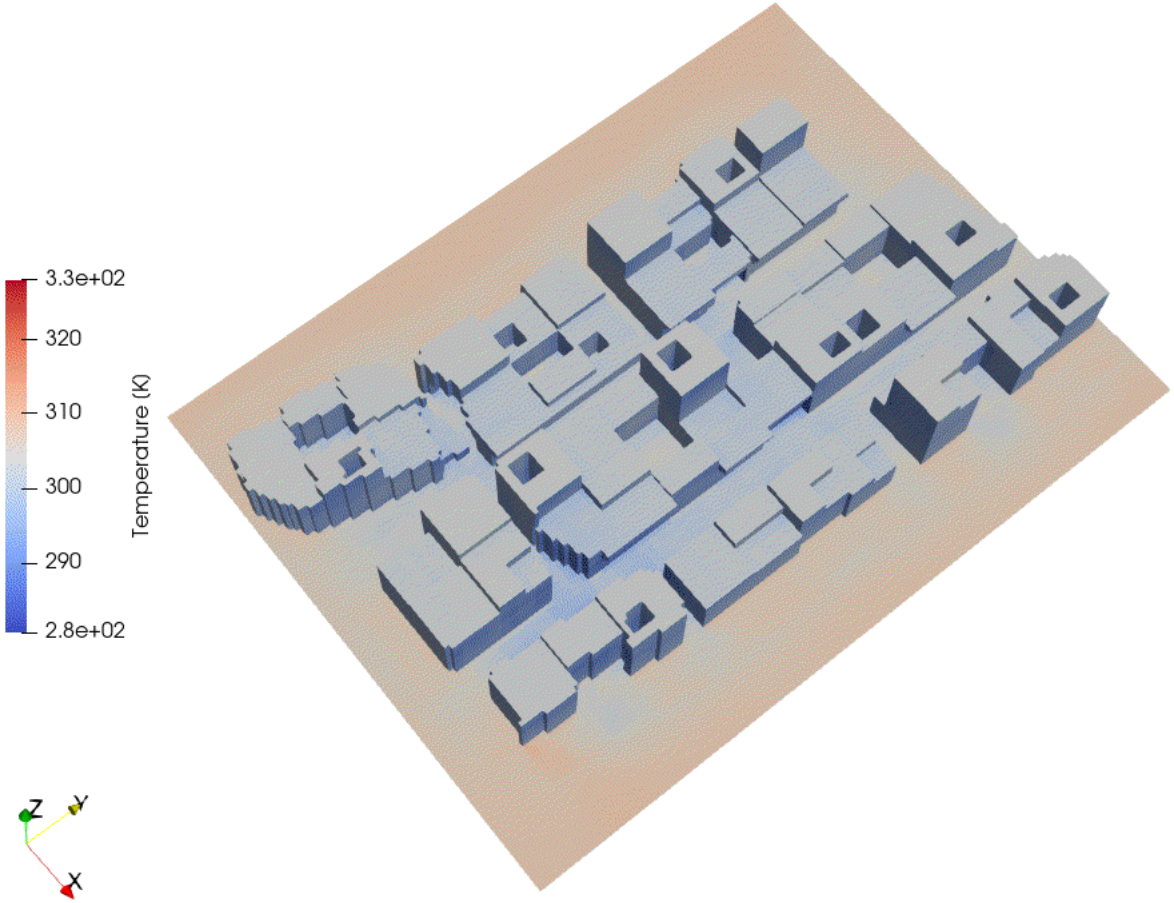
Instantaneous streamwise velocity



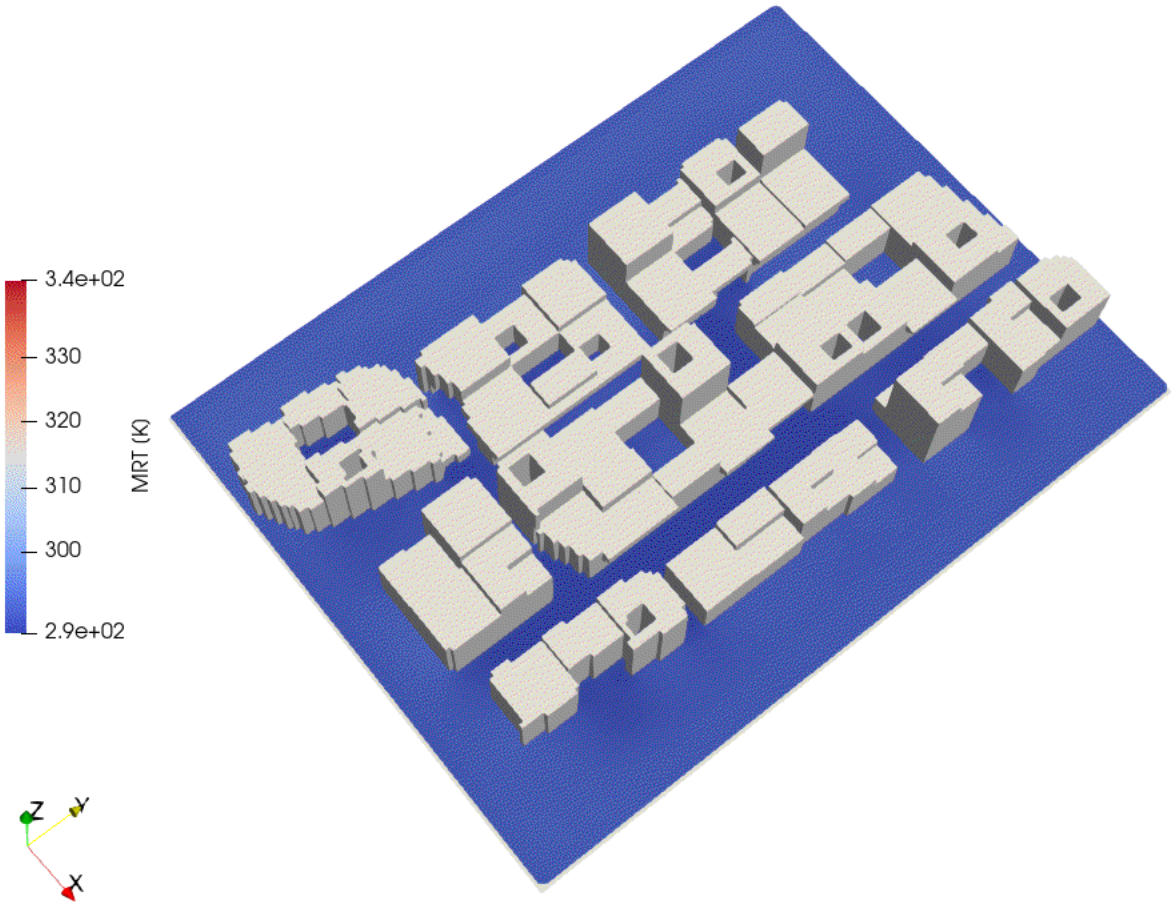
Time-averaged streamwise velocity

Thermal comfort

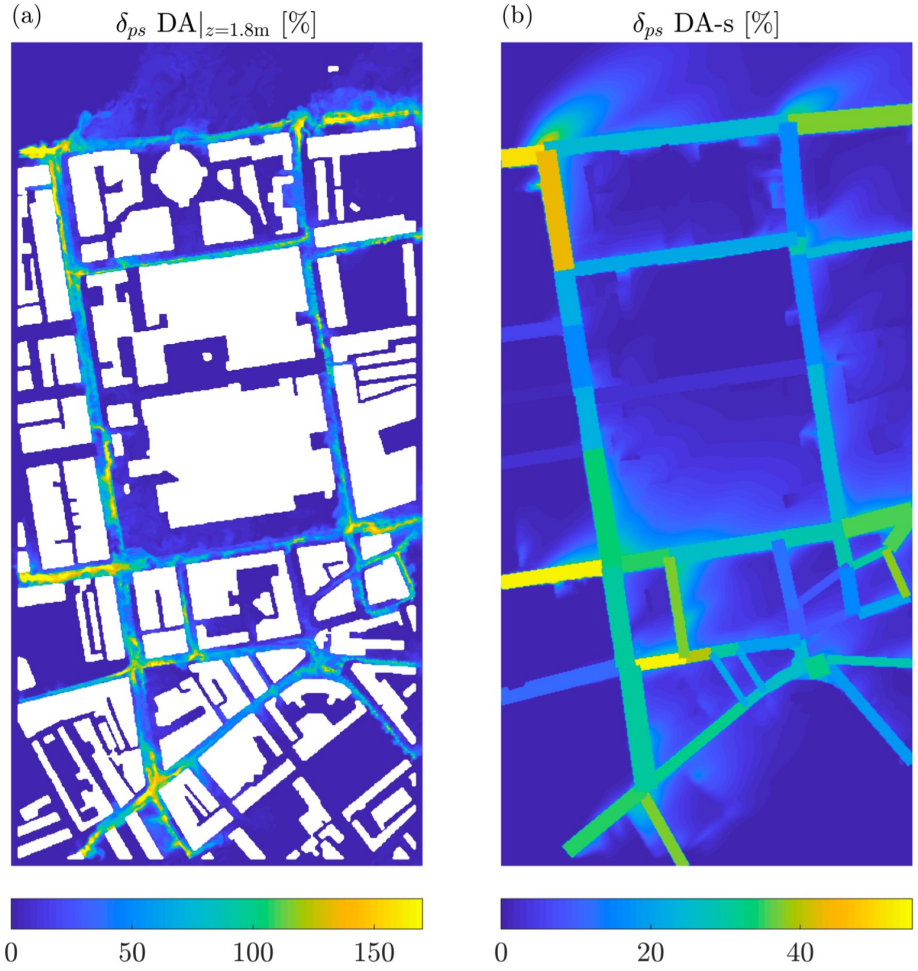
Surface temperature

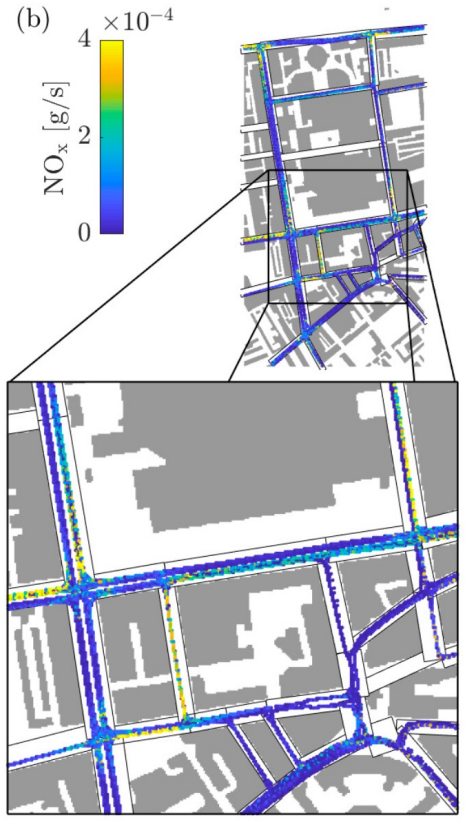


Mean radiant temperature

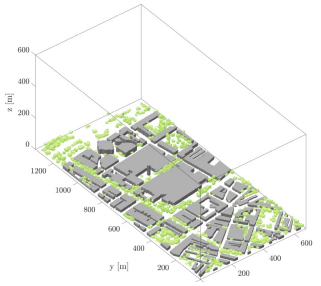


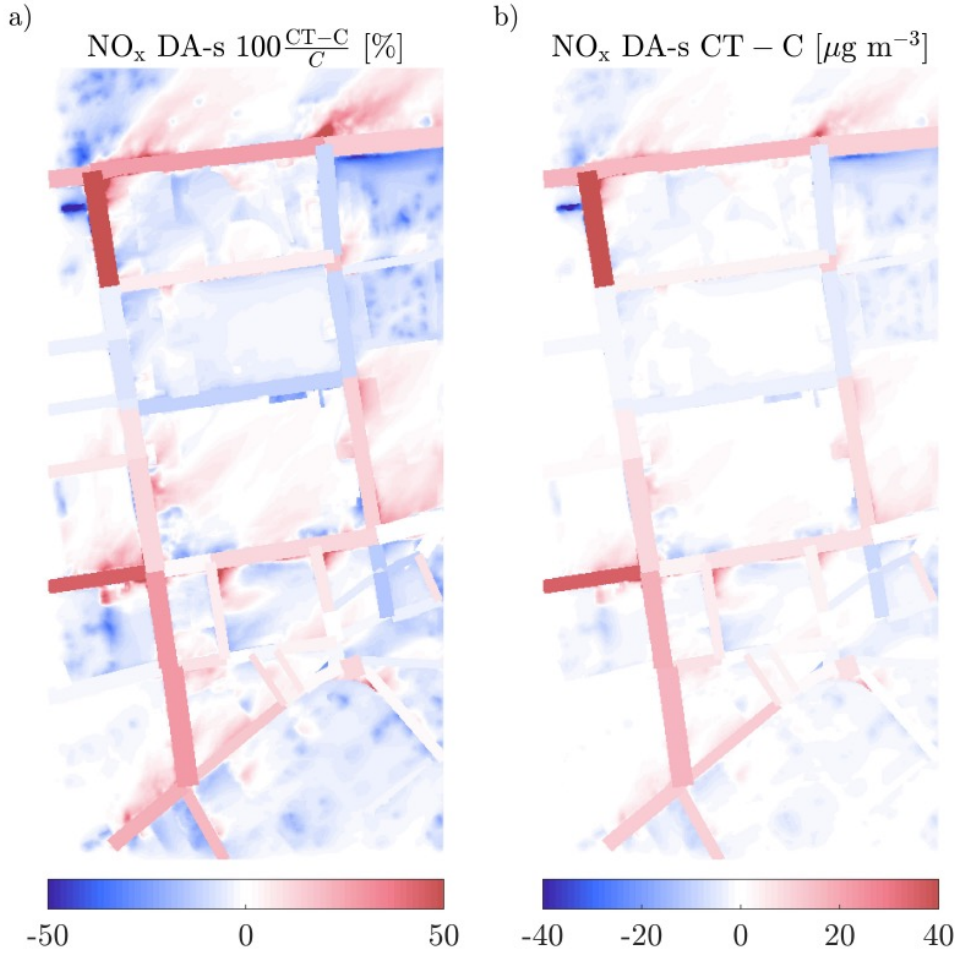
Air quality





+ trees





Grylls, T. et al. Evaluation of an operational air quality model using large-eddy simulation. *Atmos. Env*. (2019)
Grylls, T. & van Reeuwijk, M. How trees affect urban air quality: It depends on the source. *Atmos. Env*. (under review)

Urban surface parametrisation

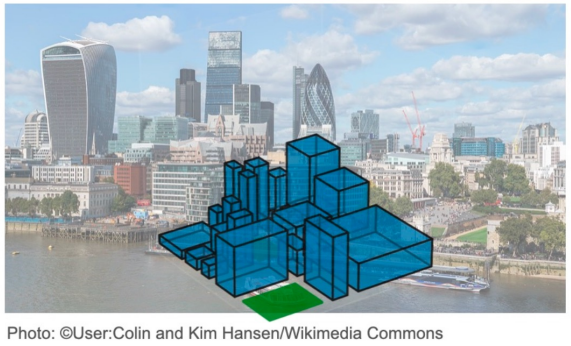
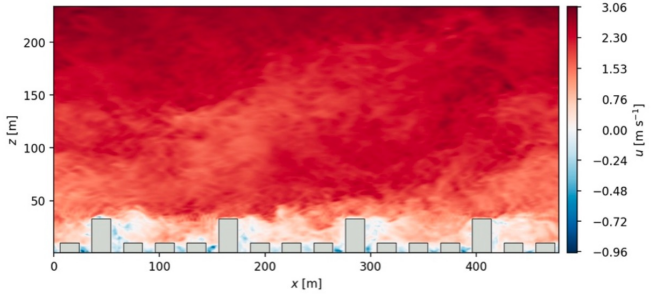


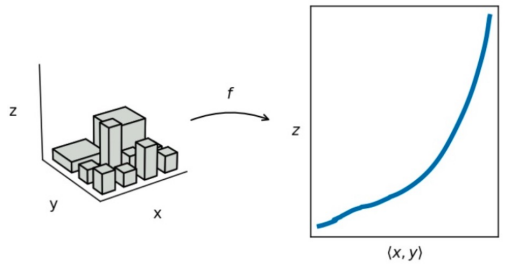
Photo: ©User:Colin and Kim Hansen/Wikimedia Commons

Urban Landscape Generator

uDALES building-resolving model



Urban drag parameterization



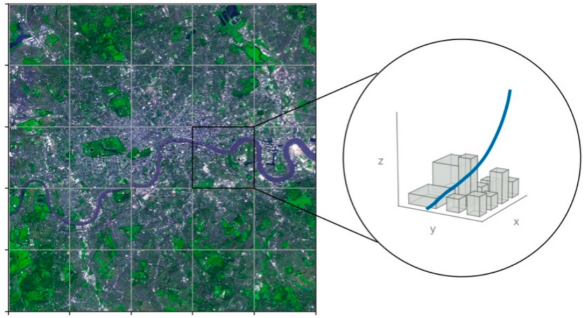
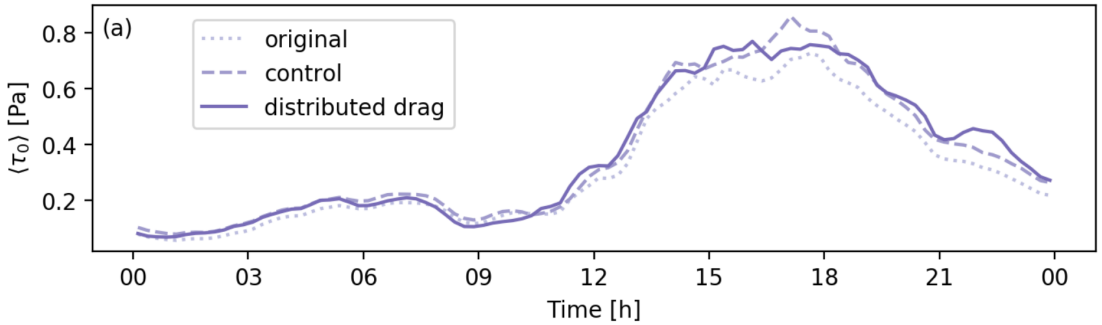
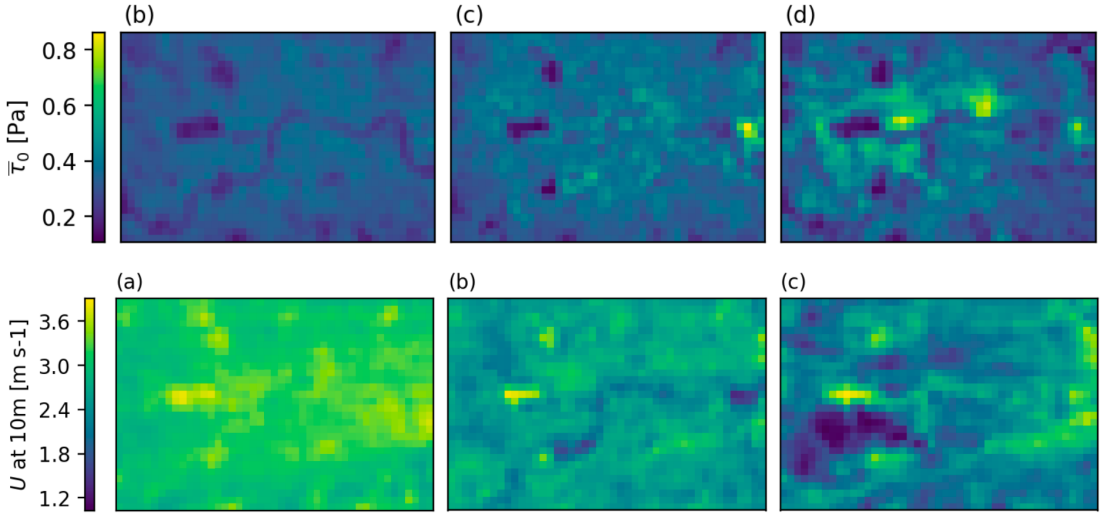


Photo: ©NASA

Urban numerical weather-prediction model

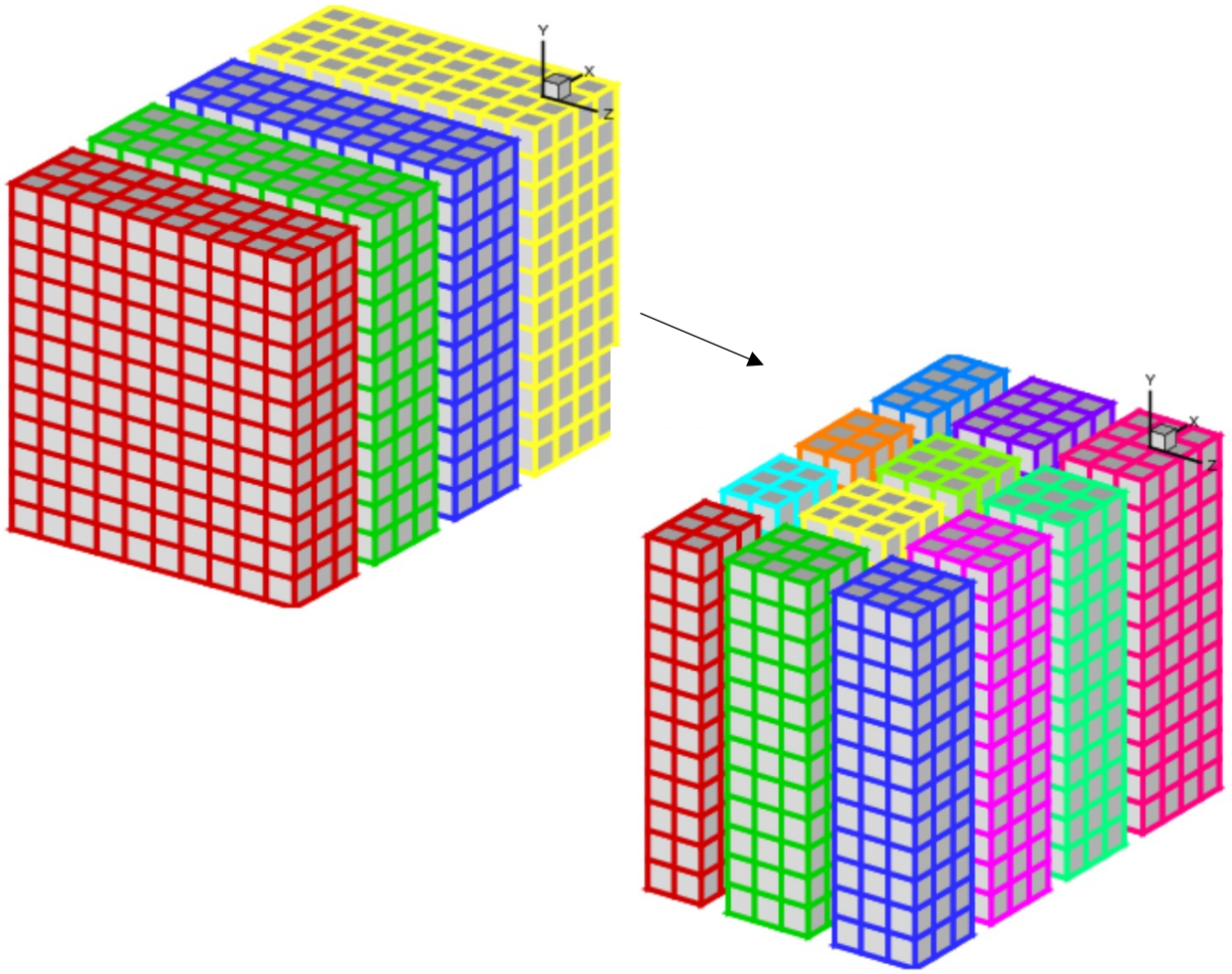




Sützl, B. et al. Drag distribution in idealized heterogeneous urban environments. *Bound.-Layer Meteorol*. (2021)
Sützl, B. et al. Distributed urban drag parametrization for sub-kilometre scale numerical weather prediction. *Q. J. R. Meteorol. Soc.* (2021)
Sützl, B. Rising from the ground: Distributed drag parameterization of urban environments for numerical weather prediction. *PhD thesis*. (2021)

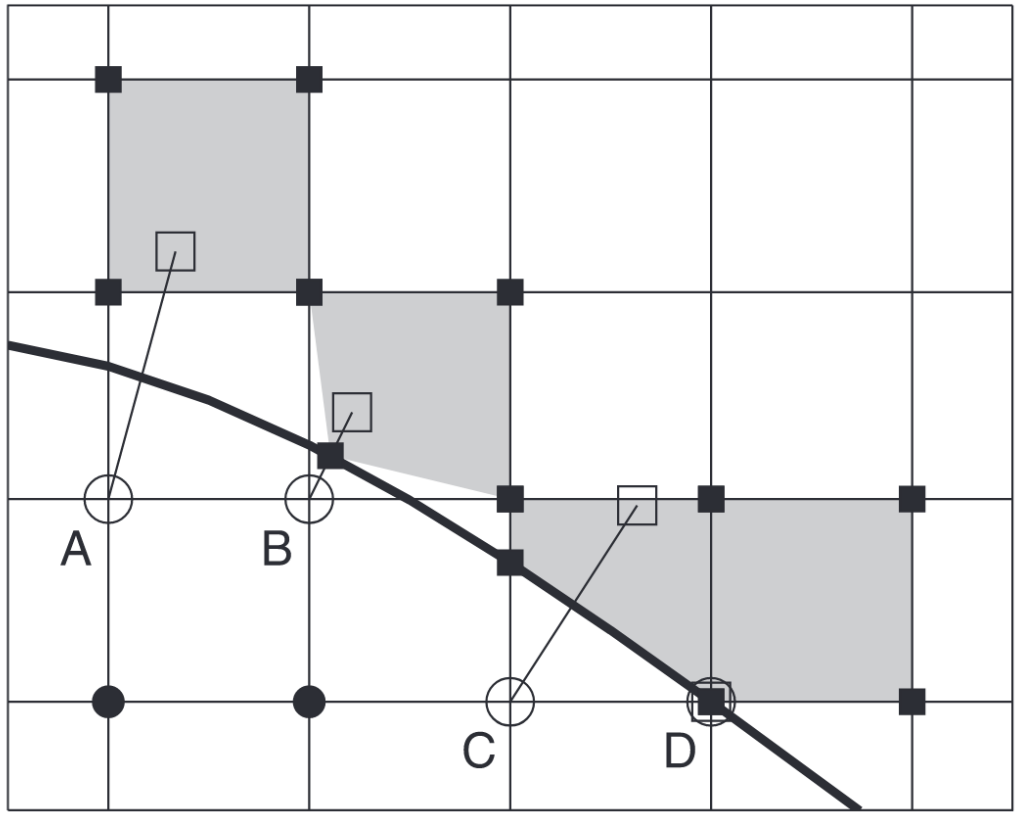
Development plan – 2DECOMP&FFT

- 2D domain decomposition (done).
- Halo cells (done).
- Transposition routines in pressure solver (done).
- Cosine transforms for Neumann pressure BCs (done) – modify 2DECOMP's FFT routines?
- Test cases such as Taylor-Green vortex, shear layer, developing boundary layer.



Development plan – IBM

- First implement grid-aligned IBM – existing approach assumes 1D domain decomposition.
- Test with flow past cubes.
- Then use ghost-cell methodology to permit non-aligned cases.
- Test with flow past cylinder.



Lundquist, K. A., Chow, F. K., & Lundquist, J. K. An immersed boundary method for the weather research and forecasting model. *Monthly Weather Review*, *138*(3), 796-817. (2010).

Development impact

- Faster diurnal cycle simulations.
- Larger domains.
- Increase feasibility of architectural design process workflow.
- Realistic geometries.
- More efficient parameter space investigations for NWP models, e.g. effect of vegetation and heterogeneity on urban surface processes.