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Domain nesting for multi-scale large eddy simulation

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The need to simulate city scale areas (O(10 km)) with high resolution within street canyons in certain areas of interests necessitates different grid resolutions in different part of the simulated area. General purpose computational fluid dynamics codes typically employ unstructured refined grids while mesoscale meteorological models more often employ nesting of computational domains.

ELMM is a large eddy simulation model for the atmospheric boundary layer. It employs orthogonal uniform grids and for this reason domain nesting was chosen as the approach for simulations in multiple scales. Domains are implemented as sets of MPI processes which communicate with each other as in a normal non-nested run, but also with processes from another (outer/inner) domain.

It should stressed that the duration of solution of time-steps in the outer and in the inner domain must be synchronized, so that the processes do not have to wait for the completion of their boundary conditions. This can achieved by assigning an appropriate number of CPUs to each domain, and to gain high efficiency.

When nesting is applied for large eddy simulation, the inner domain receives inflow boundary conditions which lack turbulent motions not represented by the outer grid. ELMM remedies this by optional adding of turbulent fluctuations to the inflow using the efficient method of Xie and Castro (2008). The spatial scale of these fluctuations is in the subgrid-scale of the outer grid and their intensity will be estimated from the subgrid turbulent kinetic energy in the outer grid.