Modelling wind profiles in heterogeneous urban environments using fractional derivatives

Omduth Coceal
Department of Meteorology, University of Reading

Modelling wind profiles in heterogeneous environments requires the solution of PDEs or the solution of an ODE with position-dependent coefficients. The former is subject to complicated boundary conditions and requires sophisticated numerical methods. The latter gives rise to a whole panoply of ODE types, requiring different solution methods, and then only once appropriate closure models have been formulated and tested. A novel solution is to put the position dependence not in the coefficients, but in the index of fractional-order derivatives. In this way the character of the differential equation does not vary spatially and the same solution method can be applied in different flow regimes. This provides a unified and economical treatment of the problem. We develop analytical and numerical solutions for the resulting fractional differential equation and test them against DNS and LES data for different urban setups.