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Lagrangian stochastic modeling of pollutant dispersion in the turbulent atmospheric boundary layer – application to an urban area over complex terrain

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The modeling of pollutant dispersion in the atmospheric boundary layer depends on an adequate description of the turbulent processes. Since turbulence is a multi-scale phenomenon characterized by a high degree of disorder, a statistical approach is needed. Among the statistical approaches, Lagrangian stochastic particle models provide a well established theoretical framework for the description of pollutant dispersion in different atmospheric boundary layer scenarios. Usually turbulent structure in the surface layer is described in terms of Monin-Obukhov similarity theory (MOST) using universal relationships between scaling parameters. These relationships have been shown to be valid in the case of horizontal homogeneity for stationary turbulence. The description of the turbulent processes above rough surfaces, such as over canopies, is a more complex case. For the urban canopy it was found that under developed stationary turbulence conditions MOST relations are approximately valid (in some cases, with extensions). An even more complex case is that of rough surfaces over topography, as no similarity theory has been established to properly describe the turbulence exchange over heterogeneous surfaces in complex terrain.

We show Lagrangian stochastic model simulations based on MOST against measurements in urban canopy over complex terrain. Comparison gives good agreement with direct tracer measurements, in cases of neutral and convective stratifications. It is shown that in conditions of developed stationary turbulence, at most areas, there is in an agreement with MOST predictions. However, in very low wind conditions the turbulent nocturnal boundary layer is not necessarily stationary and is spatially non-homogeneous. This results in larger horizontal velocity standard deviation than expected in regular stable regime, as manifested in the pollutant pattern.