Simulations of aerosol filtration by vegetation: Validation of existing models with available lab data and application to near-roadway scenario

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Concentrations of ultrafine particles (UFP) are generally elevated in the near-roadway environment due to traffic-related pollution. Exposure to UFP has been linked to adverse health effects for communities living near major roadways. Strategies to mitigate near-roadway air pollution include vehicle emission regulations, as well as installation of physical barriers such as walls, tree stands, and shrubs. Numerical simulation tools can be very useful to investigate the effectiveness of these barriers in mitigating air pollution. In the present work, a Reynolds-Averaged Navier–Stokes (RANS) based computational fluid dynamics (CFD) solver is used to predict filtration of UFP by vegetation. The RANS equations for turbulent flow are combined with a dry deposition velocity model and three different wake turbulence models. Reasonably good predictions of pressure drop across the vegetation and particle penetration efficiency are obtained when compared with available wind tunnel experiments for high leaf area density (LAD) in the range 69–263 m2/m3. It is found that the model predictions are sensitive to the choice of wake turbulence model and certain model parameters. The model predictions also suggest that thin roadside vegetation with local LAD ≤ 5 m2/m3 is only partially effective in filtering UFP, especially when the vegetation thickness is less than 10 m along the direction of the wind.