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Improved Evaluation of Atmospheric Flow and Transport over Complex Terrain at Multiple-Scales with Uncertainty

The simulation of atmospheric plumes requires a holistic multi-scale modeling approach accounting for uncertainty. Such an approach is needed for close-range monitoring and for simulating time-varying releases over complex topography. Our approach will accommodate variable source terms and the resolution of surface meteorological complexities through the development of advanced large-eddy simulation and immersed boundary methods for the Weather Research and Forecasting model. Predicted plume trajectories over complex terrain can diverge as temporal and spatial details are unresolved, particularly in the near-field. Our improved model facilitates better numerical representations of flow over complex terrain, capable of capturing diurnal up-slope and down-slope flow and representing a quantifiable improvement to predictions of plumes from a time-varying source in complex terrain. Uncertainty is quantified using an ensemble-based Bayesian methodology incorporating data and model perturbation. The utility of the Bayesian approach is described in detail for one multi-scale approach through a numerical weather and transport study of a tracer release experiment at a nuclear power plant in California. Here we describe our technique and how it quantifies the contribution of individual source and meteorological parameters to overall model-data variance. This work was performed under the auspices of the US DOE by LLNL under contract DE-AC52-07NA27344.

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