High-resolution numerical models for smoke transport in plumes from wildland fires

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Predicting the impacts on air quality due to the smoke from prescribed fires and wildfires represents a central problem in smoke management, particularly for many locations in the Eastern United States where wildfire-prone regions are located near populated areas. A variety of models and tools are available for the purpose of modeling smoke impacts, and in many cases these models are appropriate and provide valuable information. Nevertheless, the majority of these models are based on simplifications to the governing equations, and few if any of them are able to represent accurately the three-dimensional dynamics of the plume and its interaction with the ambient atmosphere. It is of particular interest, then, to explore the fundamental dynamics of buoyant plumes (e.g., plume trajectory, lateral and vertical spread, etc.) to assess the utility and accuracy of the models currently in use for air quality assessment.

Using a high-resolution numerical model we have performed simulations of the detailed three-dimensional structure and evolution of buoyant plumes arising from heat sources representative of wildland fires in the presence of different ambient atmospheric conditions. The results of these simulations suggest that even for simple configurations plume behavior is highly complex and dominated by a variety of coherent vortex structures that may have a significant impact on smoke transport. Nevertheless, some of the predictions of the simplified models are indeed evident in the simulations.

In this talk we will describe the salient results from the numerical simulations, and we will discuss which aspects of these results are captured by the simplified models and which are not. We will also discuss ways in which the results from the high-resolution model simulations may be employed to improve existing models.