



2025-2026 EOAS Colloquium Series

Billow-like vortices within the smoke plume of wildland fires: Observations, numerical simulations, and implications for ember transport

In this study, we combine radar observations of wildland fire plumes with large-eddy simulations (LES) using the Cloud Model 1 (CM1) to investigate the eddy dynamics in the smoke plumes. The numerical simulation successfully reproduces the observed spatiotemporal evolution of the plume, including its characteristic bent-over structure and the presence of well-organized billow-like large eddies at the plume head. When coupled with a newly developed ember transport module, the simulations also capture the observed spatial distributions and temporal evolution of embers within the plume, demonstrating strong consistency between observations and numerical results.

Our analysis indicates that billow-like large eddies play a central role in plume bending and episodic ember transport, offering a plausible mechanism for intense spotting during the early stages of a fire or following rapid increases in fire intensity. Sensitivity simulations further reveal that the height and spatial scale of the billow-like vortex are jointly controlled by fire heat release, atmospheric stratification, and vertical shear of the background crossflow. We extend classical scaling analyses of plume height in vertically sheared crossflow to establish predictive relationships between vortex characteristics and environmental conditions and demonstrate the importance of coherent plume-scale eddies in long-distance ember transport and spotting-driven fire spread.

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Location: EOA 1044

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