TRANSPORT OF FIREBRAND PARTICLES IN THE TURBULENT ATMOSPHERIC BOUNDARY LAYER

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Abstract

Wildfires are among the most devastating events in nature and have profound environmental and socioeconomical impacts around the world. A particularly important mechanism of wildfire spread refers to the transport and eventual deposition of burning debris known as firebrands. Under favorable conditions, firebrands can travel several kilometers downwind, igniting new fires upon landing. The erratic nature of firebrand transport makes spotting challenging to predict and control. Firebrand ignition is an important pathway of fire spread into communities, straining fire suppression resources and posing considerable risk to lives and property. Despite the extensive literature, many aspects of spotting behavior remain understudied. Particularly, no previous study has provided an in-depth, fundamental insight on the role of turbulence structures on firebrand transport and spotting behavior in complex environments. This lack of understanding compromises our capability in accurately predicting firebrand transport, therefore hindering risk mitigation and management efforts. This research aims to advance our understanding of the spotting phenomenon through a computational study of particle-turbulence interactions that govern firebrand behavior during flight and after landing. The present research involves a Lagrangian particle tracking model, capable of simulating thousands of firebrands with varying mass, size, and temperature. This model was employed in combination with large-eddy simulations to examine how topography-driven turbulence influences the flight and post-landing dynamics of firebrands across different particle sizes. Additionally, this research investigates how different turbulence scales, including small-scale motions comparable to firebrand sizes, influence the large-scale transport of inertial and settling particles in boundary layer flows, with applications to improving models of particle transport in the atmospheric boundary layer. Collectively, the insights of this research contribute towards advancing our understanding of firebrand spotting, therefore improving strategies for fire-risk mitigation around the world.