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# Numerical modeling of smoke plume dynamics in the wildland–urban interface

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**Abstract:** Smoke generated by fires can pose serious health risks to people living in wildland-urban interface (WUI) areas. It contains various toxic gases that can not only irritate the eyes and lungs but also lead to a reduction in visibility and cognitive function. These hazardous effects can hamper the ability of residents in WUI areas to escape during emergencies.

This study focuses on examining the spread of smoke in WUI environments, utilizing the powerful open-source computational fluid dynamics (CFD) software, OpenFOAM (Jasak et al., 2007). This free CFD toolbox comes with a variety of built-in features and capabilities, making it an excellent choice for this type of analysis. Specifically, we employed the ScalarTransportFoam solver within OpenFOAM, which is designed for simulating smoke dispersion in compressible flows using a realistic turbulence model. By solving convection-diffusion scalar transport equations for passive scalars with user-defined boundary conditions and velocity field, the ScalarTransportFoam solver enabled us to accurately model smoke propagation in the WUI environment. In the simulation, distinct terrains with varying roughness were accommodated by defining and implementing custom boundary conditions.

The study also defined two passive species to differentiate between the sources of smoke and clean air concentration. A domain size of 40m × 20m × 10m was considered and a high-quality grid through successive zonal refinement was generated. In order to precisely capture the intricate vortical flow structures generated, a subdomain encompassing a volume of 20 × 10 × 7m was delineated surrounding the smoke source. Moreover, the entire domain underwent spanwise refinement to produce a finely detailed mesh in the vicinity of the floor. In addition, we embedded an Atmospheric Boundary Layer (ABL) consisting of a pre-defined logarithmic velocity profile in the solution. This velocity profile has a value of zero on the ground and gradually increased with the height of the domain.

The study's results revealed that higher reference wind velocities can lead to the generation of stronger vortices due to the wind's influence, which can help transport smoke away from the fire source. However, the impact of the wind can also disrupt the pattern of smoke transport, potentially causing toxic gases to spread to neighbouring urban areas, depending on the intensity of the wind and proximity of the source. This underscores the critical need for effective measures to control and mitigate the dispersion of harmful pollutants from fire incidents, especially in areas with high population density. Implementing efficient and robust strategies for managing fire-related pollutants can help reduce the risk of health hazards associated with smoke inhalation and minimize the overall environmental impact of fires.

## REFERENCES

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