LARGE EDDY SIMULATION OF ATYPICAL WILDLAND FIRE SPREAD ON LEEWARD SLOPES

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Background

Fire channelling is a fire spread phenomenon in which a wildland fire can spread laterally across a steep leeward facing slope under appropriate weather, terrain and fire conditions. This atypical fire spread is driven by an interaction between the wind, the terrain and the fire.

Research Objectives

Two and three-dimensional large eddy simulations, performed using the WRF-LES model, were used to investigate the atmospheric flow features in the lee of a mountain of height 1 km.

Three-dimensional coupled atmosphere-fire simulations, performed using the WRF-Fire model, were used to investigate the physical mechanisms driving the lateral fire spread seen in fire channelling.

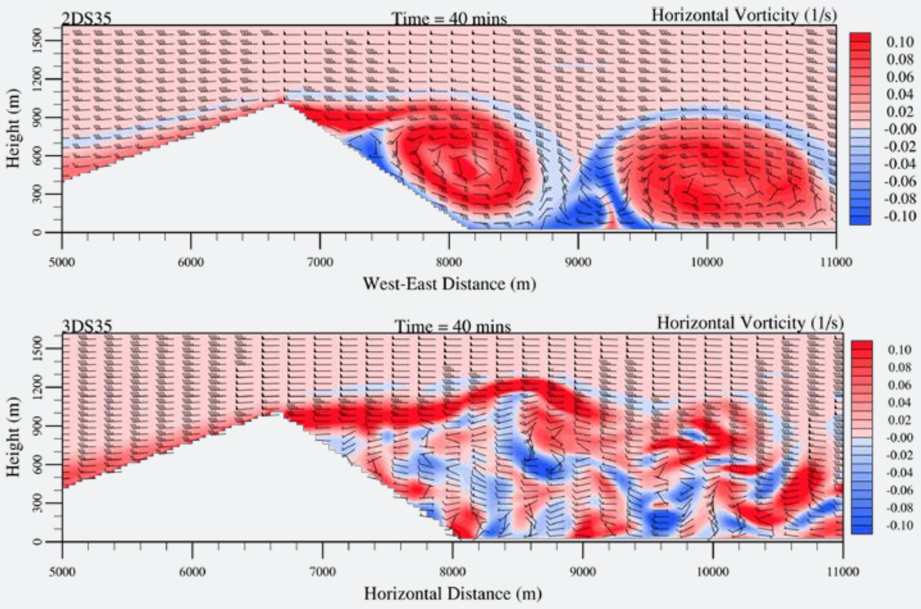


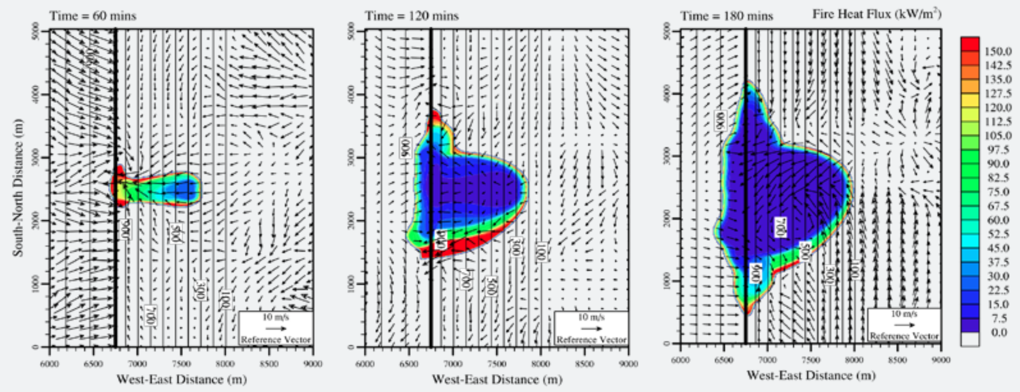
Figure 1: Horizontal vorticity for the 2D and 3D atmospheric simulations. Red indicates positive vorticity, blue negative.

Large Eddy Simulations - Results

Two-dimensional simulations: periodic formation of large-scale positive vorticity rotors, which detach from the leeward slope and then propagate downstream. Rotors form independently of mountain wave activity and result in time-averaged leeward flow separation.

Three-dimensional simulations: absence of large-scale features such as rotors. Instead, turbulence is dominated by chaotic fine-scale features. Time-averaged flow reveals leeward flow separation and mountain wave activity, similar to that observed in 2D.

Three stability profiles and three leeward slope angles were considered. It was found that for the conditions tested, the leeward slope angle had a greater impact on the turbulence than the atmospheric stability.



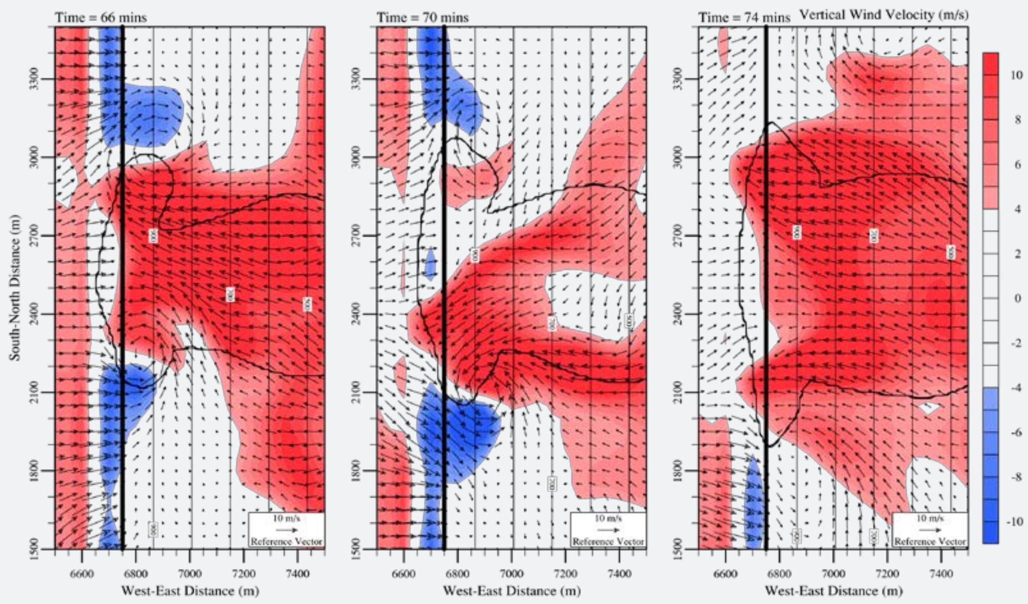


Figure 2 (top): Lateral fire spread on mountain leeward slope.
Figure 3 (bottom): Updrafts (red) and downdrafts (blue) driving the lateral fire spread.

Coupled Atmosphere-Fire Simulations - Results

Modelled fire spread for a parameterized heavy logging slash fuel type resembles that seen during fire channelling events i.e. lateral fire spread close to the ridge line on a leeward slope. It was discovered that the lateral fire spread is driven primarily by the movement of updraft/downdraft interfaces across the fire perimeter. These interfaces result in strongly circulating surface winds which drive the fire. These updrafts and downdrafts are believed to result from the interaction between strong pyro-convection and terrain-modified winds.

Summary

This research makes use of coupled atmosphere-fire modelling to investigate the physical processes responsible for the lateral fire spread observed on leeward slopes during fire channelling events. This new discovery has important implications for firefighting strategy and safety procedures for wildland fires in complex terrain.

Reference

Simpson et al. (2012) "Large eddy simulation of atypical wildland fire spread on leeward slopes", *International Journal of Wildland Fire* (under review)

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