A fast, physically based scheme for predicting long-range spotting potential

Jeff Kepert[1,2], Serena Schroeter[2,4], Kevin Tory[1,2] and Will Thurston[3]

[1] Bureau of Meteorology. [2] Bushfire and Natural Hazards CRC. [3] UK Met Office. [4] Busy mother of twins.

In extreme cases, embers transported in a bushfire plume have started new fires over thirty kilometres away. Even in less extreme situations, new ignitions a kilometre away can complicate fire management and threaten safety. The ability to forecast spotting due to ember transport in fire plumes would assist fire management and improve fire models.

EMBER TRANSPORT IN TURBULENT PLUMES

Bushfire plumes are buoyant and turbulent, with strong updrafts. Because they are turbulent, these updrafts are patchy and episodic (Fig. 1). In previous work (Thurston et al 2017), we used a large-eddy model (LEM), running on a 50-m grid, to simulate ember transport (Fig. 2). For intense fires and strong winds, we found transport distances comparable to observations.

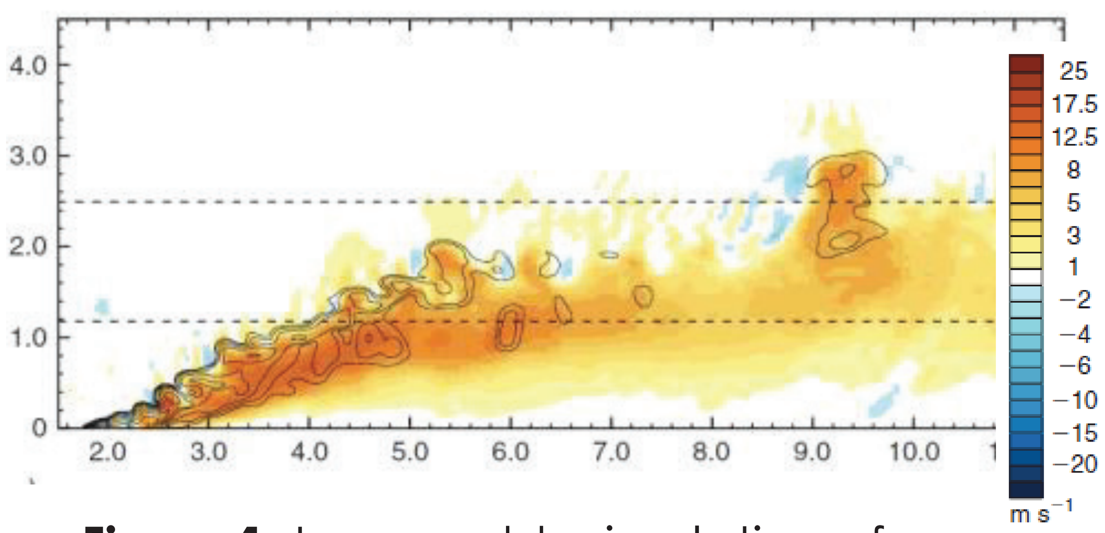

Figure 1: Large-eddy simulation of a turbulent bushfire plume. Shading shows the vertical velocity and contours the temperature perturbation.

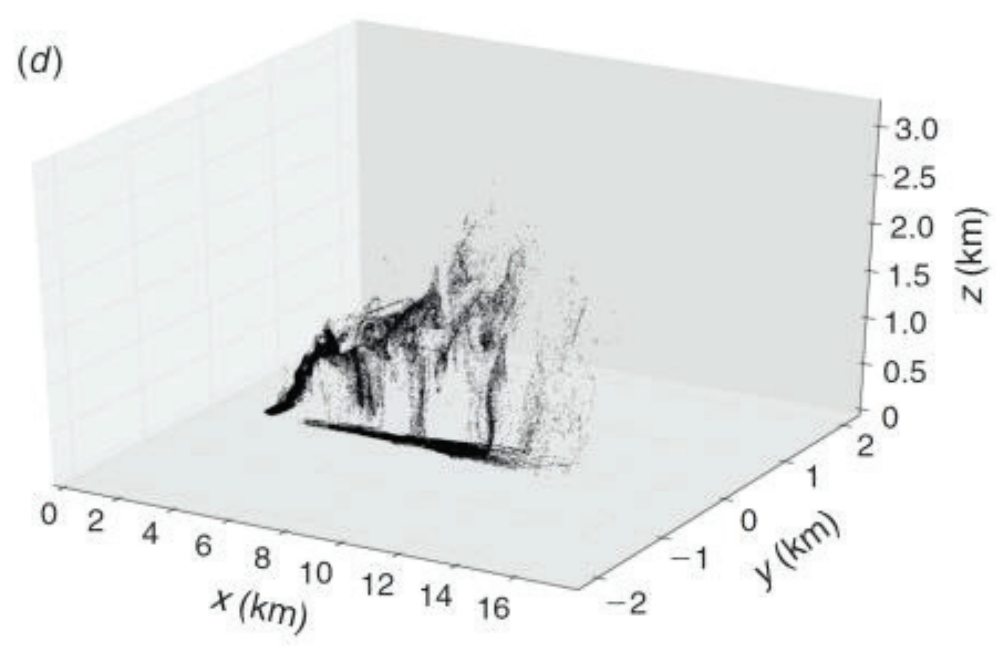

Figure 2: Snapshot of ember transport in the turbulent plume in Figure 1. The embers fall out in clumps as they experience weaker updrafts in the plume.

"BULK" PLUME MODELS

Large-eddy model simulations require much time on large supercomputers, so cannot be used for real-time forecasting. Simpler plume models exist, that just aim to predict the average (or bulk) properties of the plume. They trade off some accuracy and the ability to represent the turbulence against computational cost. Figure 3 shows a bulk model simulation, which can be compared to the time-mean LEM data in Fig. 4.

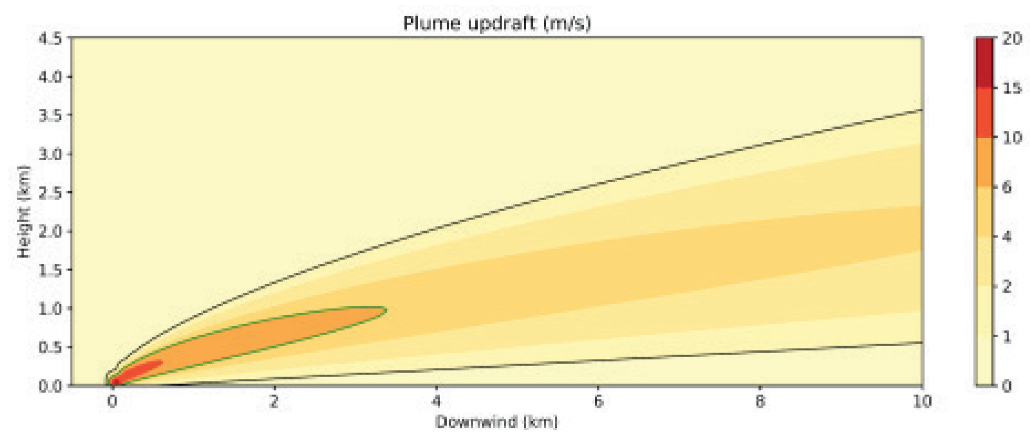

Figure 3: Simulated updraft from a bulk plume model. The green contour is 6 m/s updraft and indicates that part of the mean plume that can loft typical firebrands.

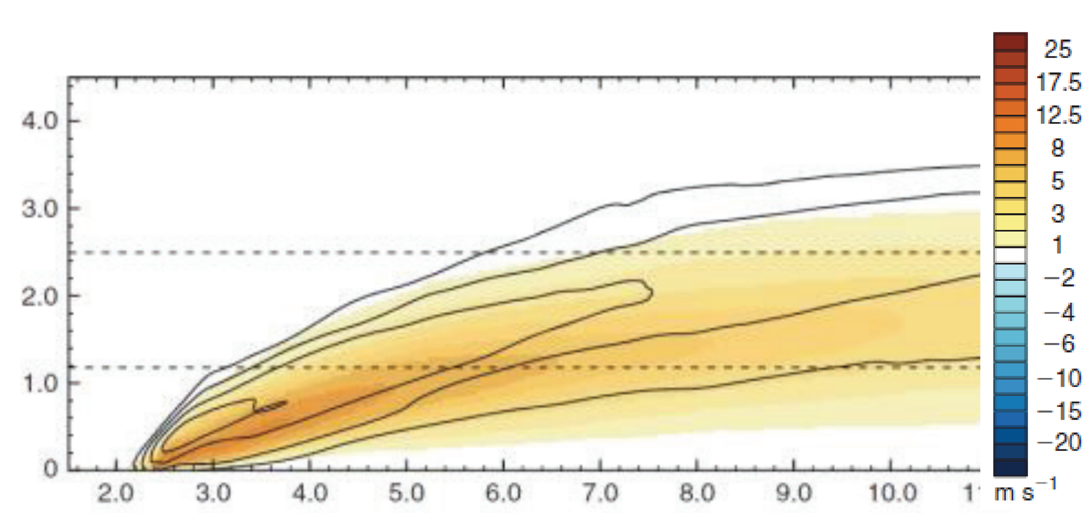

Figure 4: Mean plume updraft (colour) and turbulence intensity (contours, logarithmic scale) from the large-eddy model simulation.

Reference:

Thurston, W., Kepert, J. D., Tory, K. J. and Fawcett, R. J. B., 2017: The contribution of turbulent plume dynamics to long-range spotting. *Int. J. Wildland Fire*, **26**, 317–330.

ADDING TURBULENCE TO A BULK PLUME MODEL

Turbulence matters to ember transport. We found that the maximum transport distance was about doubled when we included turbulence.

We need to add turbulence to the bulk plume model. The turbulence intensity depends on plume buoyancy and wind shear and is being fine-tuned using the large eddy model results (Fig. 4).

EMBER TRANSPORT IN THE BULK MODEL

At any slice across the plume, embers will experience a range of updrafts. The mean and standard deviation of the updraft distribution will determine what percentage of embers fall out (Fig. 5). By calculating this fraction along the plume and with due consideration of along-plume correlation of the turbulence, we can find the distribution of landing points.

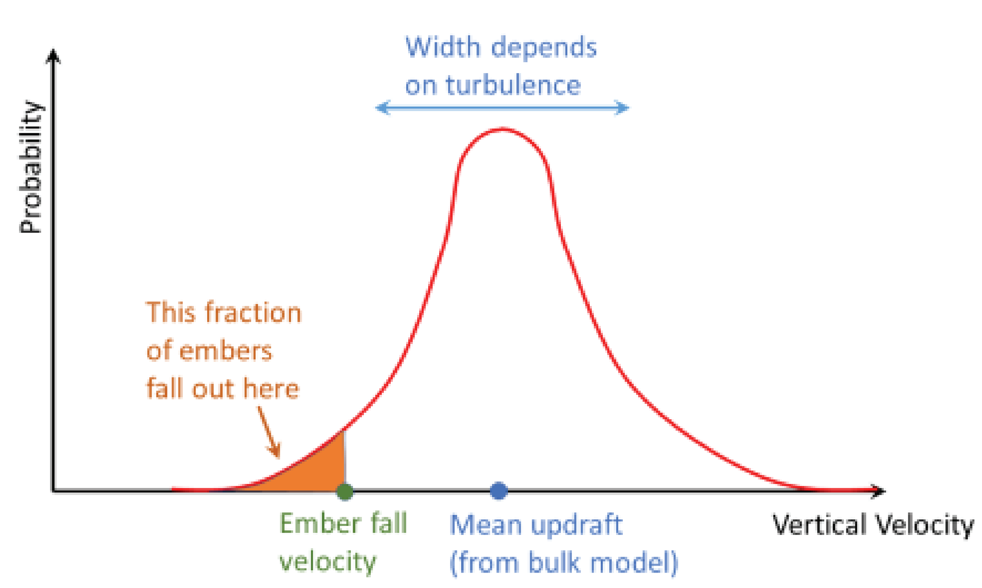

Figure 5: At each point along the plume, there is a probability distribution of updrafts. The width and mean of the distribution varies along the plume. The fraction of embers that fall out depends on probability (updraft < fall velocity).

End result: Bulk simulations similar to LES, but at a tiny fraction of the computational cost.

Australian Government Department of Industry, Innovation and Science | Business Cooperative Research Centres Programme

Australian Government Bureau of Meteorology