Idealised numerical modelling of bushfire plumes and their potential for firebrand lofting

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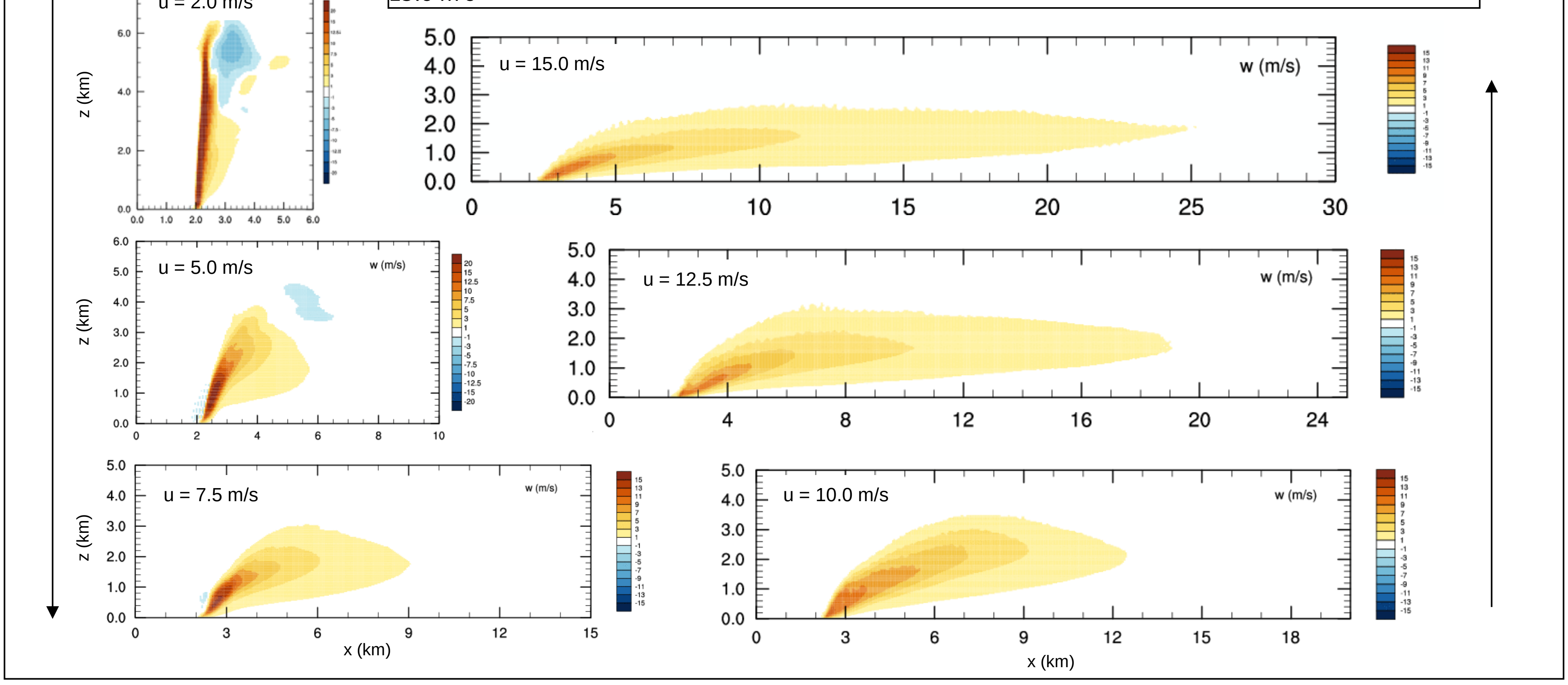
1. The lofting of firebrands from bushfires into a background flow leads to spotting downwind of the fire front. Firebrands can travel a considerable distance under suitable conditions, so lofting and spotting make a significant contribution to the spread of fires. To further our knowledge of plume behaviour and its potential for firebrand lofting and spotting, we perform idealised large-eddy simulations of bushfire plumes under a range of background wind speeds.

2. The modelling configuration used in this study is described in the accompanying poster "*Large-eddy simulations of bushfire plumes in the turbulent atmospheric boundary layer*". We simulate idealised bushfire plumes over a range of background wind speeds, from 2 to 15 m s^{-1}, using the UK Met Office Large-Eddy Model (LEM). Once each plume has reached a quasi-steady state, we calculate the time-averaged properties of the plume over one further hour of simulation time.

Fig. 1. Mean plume centreline updraft position for backgrounds winds of 2.0, 5.0, 7.5, 10.0, 12.5 and 15.0 m s^{-1}



3. Cross-sections of the time-averaged plume centreline updraft over the range of background wind speeds are presented in Figure 1. Under the strongest background winds, plumes have a horizontal extent of more than 20 km downwind from the fire. Under the weakest winds, plumes reach a height in excess of 6 km. A continuum of behaviour from intense, narrow, upright plumes to weak, broad, bent-over plumes is seen over the range of background wind speeds.

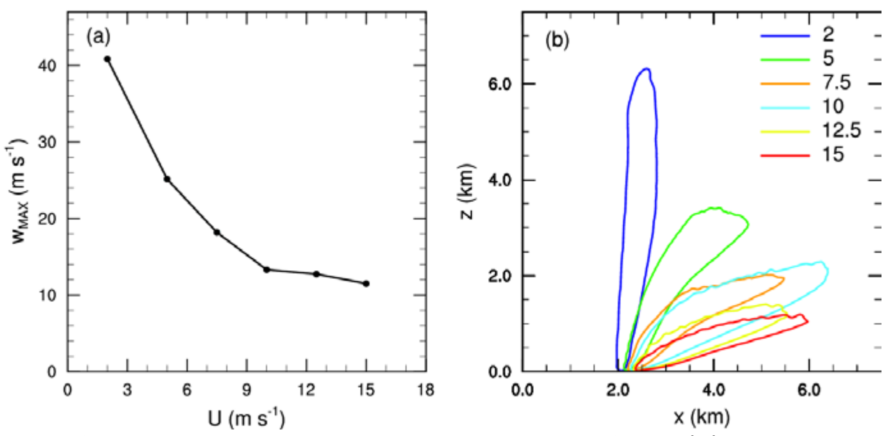


Fig. 2. Plume properties time-averaged over one hour. (a) Maximum updraft (m s^{-1}) as a function of background wind speed and (b) location of the 6 m s^{-1} updraft contour, for each of the six background wind speeds.

4. The variation of maximum updraft with horizontal wind speed is shown in Figure 2 (a). As seen in the cross-sections, there is a continuum of behaviour, signified by the smooth decrease in maximum updraft with increasing wind speed. Note that even the weakest plumes have a maximum updraft in excess of 10 m s^{-1}. In order to quantify each plume's potential for firebrand lofting and transport, we present contours of the 6 m s^{-1} updraft for each plume in Figure 2 (b). This value is chosen as it is representative of the fall speed of a typical firebrand. We can see that although the maximum updraft in the weakest-wind simulation is about four times larger than in the strongest-wind simulation, the cross-sectional area of each plume that contains an updraft strong enough to support a firebrand is actually quite similar.

Summary: We have performed high-resolution simulations of idealised bushfire plumes over a range of background wind speeds, using the UK Met Office LEM. Our results reveal a continuum of plume behaviour over the entire range of wind speeds. Although the maximum updrafts in the 2 m s^{-1} background wind cases are about four times more intense than in the 15 m s^{-1} background wind cases, all plumes have a comparable areas that are capable of supporting a firebrand. Future work will use Lagrangian particle tracking in order to more accurately quantify the spotting potential of each plume.

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