LONG-RANGE SPOTTING BY BUSHFIRE PLUMES: THE EFFECTS OF IN-PLUME TURBULENCE ON FIREBRAND TRAJECTORY

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LARGE-EDDY SIMULATIONS OF BUSHFIRE PLUMES ARE COMBINED WITH FIREBRAND TRAJECTORY CALCULATIONS TO ESTIMATE THE EFFECTS OF IN-PLUME TURBULENCE ON FIREBRAND TRANSPORT. IN-PLUME TURBULENCE SUBSTANTIALLY LENGTHENS THE MAXIMUM SPOTTING DISTANCE AND INCREASES THE LATERAL AND LONGITUDINAL SPREAD OF FIREBRAND LANDING POSITIONS

METHODOLOGY

- Bushfire plumes are simulated for different wind speeds using the UK Met Office Large-Eddy Model (LEM).
- Particle-transport calculations are performed for firebrands with a 6 m s^{-1} fall speed, driven by the time-varying velocity fields output by the LEM.
- The particle-transport calculations are repeated using a quasi steady-state plume, calculated from the 1-h mean of the time-varying plume.

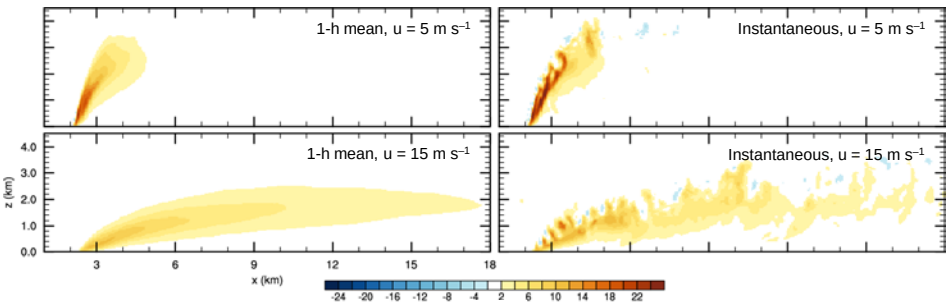

Figure 1 Vertical cross-sections of the mean (left) and instantaneous (right) vertical velocity, m s^{-1}, through the plume centre line, for background wind speeds of 5 (top) and 15 (bottom) m s^{-1}.

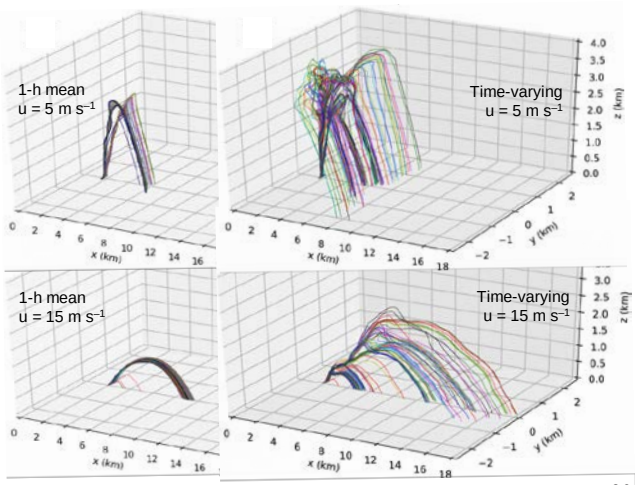

Figure 2 Trajectories of 100 randomly chosen firebrands lofted by the mean (left) and time-varying (right) plumes under background wind speeds of 5 (top) and 15 (bottom) m s^{-1}.

RESULTS

- The 15 m s^{-1} background wind speed plume has a ***weaker updraft***, is more ***bent over*** and more ***turbulent*** than the 5 m s^{-1} background wind speed plume (Figure 1).
- Trajectories of firebrands lofted by the time-varying ***5 m s^{-1}*** background wind speed plume have ***a lot of lateral spread*** and ***moderate longitudinal spread*** (Figure 2).
- Trajectories of firebrands lofted by the time-varying ***15 m s^{-1}*** background wind speed plume have ***very little lateral spread*** and ***large longitudinal spread*** (Figure 2).
- Trajectories of firebrands lofted by the ***1-h mean plumes*** exhibit the same general pattern as their turbulent counterparts, but with ***much less lateral and longitudinal spread***, and with a ***greatly-reduced maximum spotting distance*** (Figure 3).

DISCUSSION

- In-plume turbulence substantially ***lengthens the maximum spotting distance*** and ***increases the lateral and longitudinal spread*** of firebrand landing positions.
- Systematic studies such as this will eventually form the basis of computationally inexpensive, physically sound spotting parameterizations in firespread models.
- Accurate calculation of ember landing distribution will need to account for turbulence in the plume.

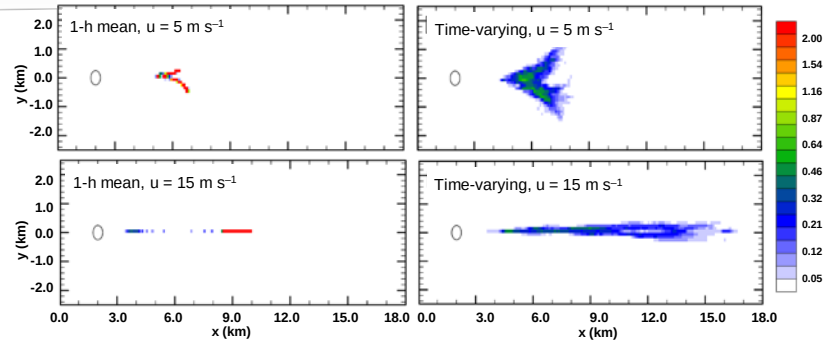

Figure 3 Spatial distributions of firebrand landing position (percent of particles launched per km^2) for the mean (left) and time-varying (right) plumes under background wind speeds of 5 (top) and 15 (bottom) m s^{-1}.

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