International Journal of Wildland Fire 26(4), 317–330
doi: 10.1071/WF16142_AC

Supplementary material

The contribution of turbulent plume dynamics to long-range spotting

William Thurston[A,B,C], *Jeffrey D. Kepert*[A,B], *Kevin J. Tory*[A,B] *and Robert J. B. Fawcett*[A]

[A]The Bureau of Meteorology, GPO Box 1289, Melbourne, Vic. 3001, Australia.

[B]Bushfire and Natural Hazards Cooperative Research Centre, Albert Street, East Melbourne, Vic. 3002, Australia.

[C]Corresponding author. Email: W.Thurston@bom.gov.au

Section S1. Lagrangian transport model sensitivity testing

We conducted sensitivity testing to explore the robustness of the results of the Lagrangian transport model to (i) the output frequency of the LEM velocity fields used to drive the and (ii) the time step used in the transport model.

The largest source of error encountered by driving the Lagrangian transport model with velocity fields from too-infrequent LEM model dumps was not adequately capturing the temporal variability, e.g. puffing, of the plumes. This was particularly evident with the strong-wind plume, as it was more turbulent. In Fig. S1 (a) we illustrate this with a timeseries of the in-plume vertical velocity in the region of highest variability of the strong-wind plume. Spectral analysis of this timeseries, Fig. S1 (b), reveals the dominant frequency to be about 1/30 s^{-1}, and therefore by using a 5-s LEM output interval to drive the Lagrangian transport model we are able to capture this variability satisfactorily.

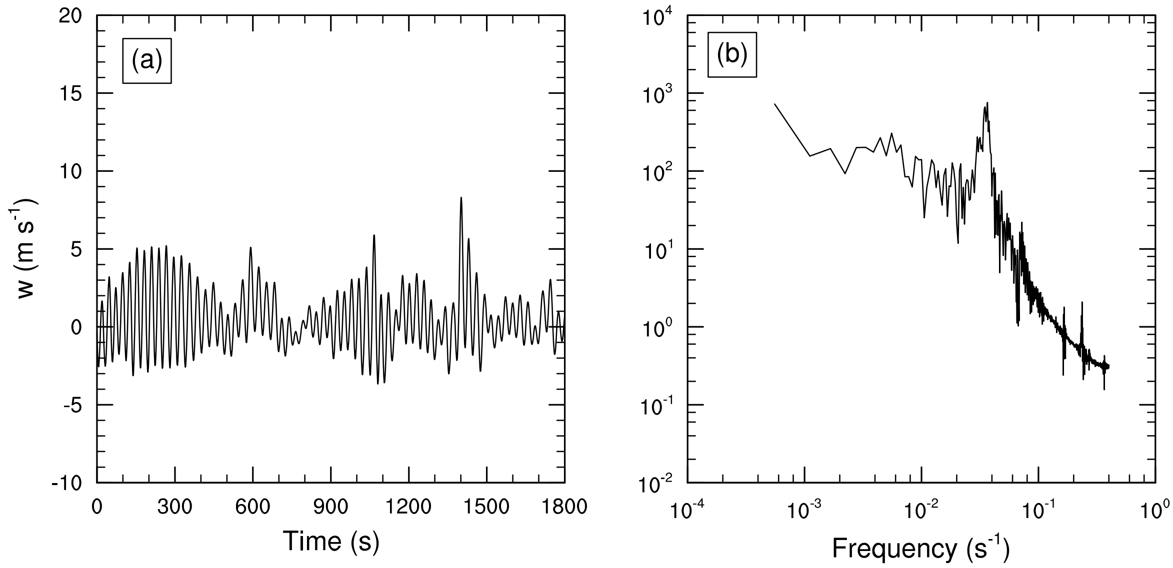

Fig. S1. (*a*) Timeseries of vertical velocity, w (m s−1), in the strong-wind plume at x = 2.25 km, z = 0.2 km. (*b*) Spectrum of the vertical velocity in (a). We ran the Lagrangian transport model with a number of different model time steps, from 0.01 s to 0.50 s, for both the weak-wind and strong-wind plumes in order to test the sensitivity of the results to the timestep. In Figs. S2/S4 we show the landing postions for all of the firebrands in each of these simulations and in Figs. S3/S5 we show the difference between the landing positions for a given timestep compared to the landing positions calculated with the shortest (0.01 s) timestep. Broadly speaking, the same overall pattern in landing position is evident, even up to the largest (0.50 s) timestep. Although at larger timesteps the mean the root-mean-square error in the firebrand landing position begins to approach 0.1 km. The trajectory calculations presented in the paper use a 0.05-s timestep, which can be seen here to have a small RMS position error and is also consistent with the _ 0.05-s timestep employed by the LEM.

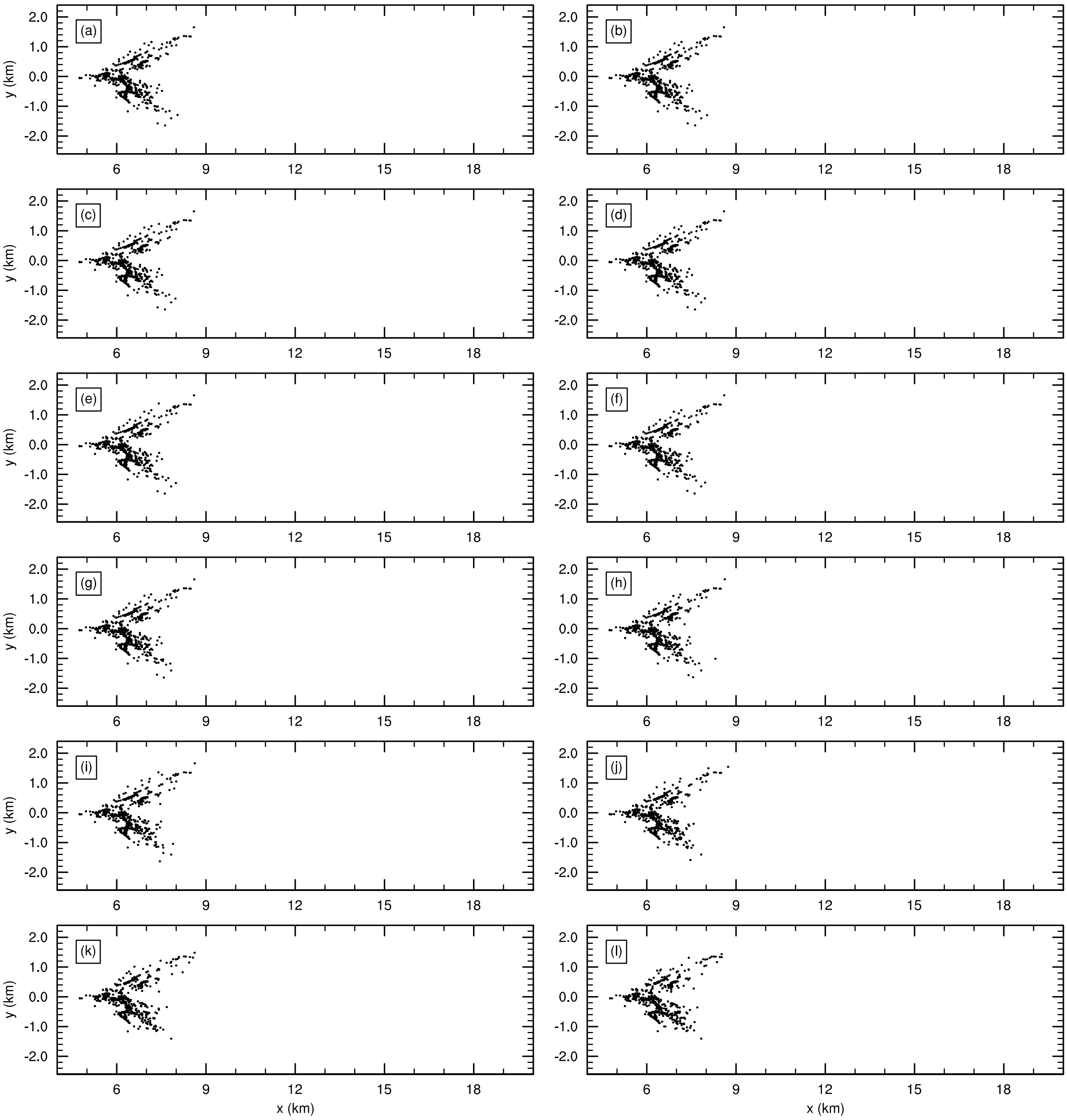

Fig. S2. Landing positions of individual firebrands lofted by the weak-wind plume calculated using the Lagrangian transport model with time steps of (*a*) 0.01 s, (*b*) 0.02 s, (*c*) 0.03 s, (*d*) 0.04 s, (*e*) 0.05 s, (*f*) 0.075 s, (*g*) 0.10 s, (*h*) 0.15 s, (*i*) 0.20 s, (*j*) 0.30 s, (*k*) 0.40 s and (*l*) 0.50 s.

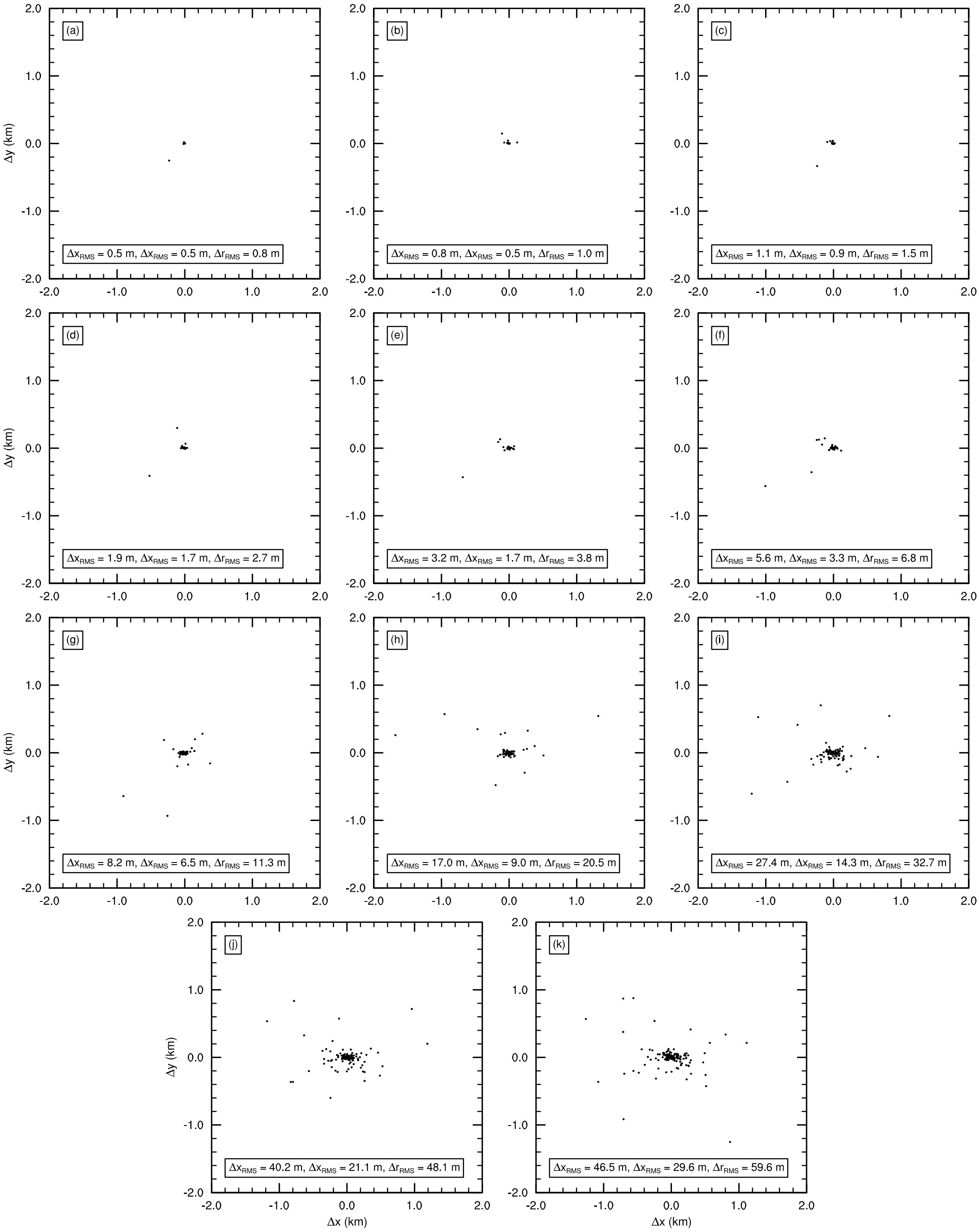

Fig. S3. Difference between landing positions of individual firebrands lofted by the weak-wind plume calculated using the Lagrangian transport model with a time step of 0.01 s and with time steps of (*a*) 0.02 s, (*b*) 0.03 s, (*c*) 0.04 s, (*d*) 0.05 s, (*e*) 0.075 s, (*f*) 0.10 s, (*g*) 0.15 s, (*h*) 0.20 s, (*i*) 0.30 s, (*j*) 0.40 s and (*k*) 0.50 s. The information box at the bottom of each panel displays the root-mean-square difference in landing position in both directions, (_x,_y) km, and the the root-mean-square difference in firebrand distance travelled, _r km.

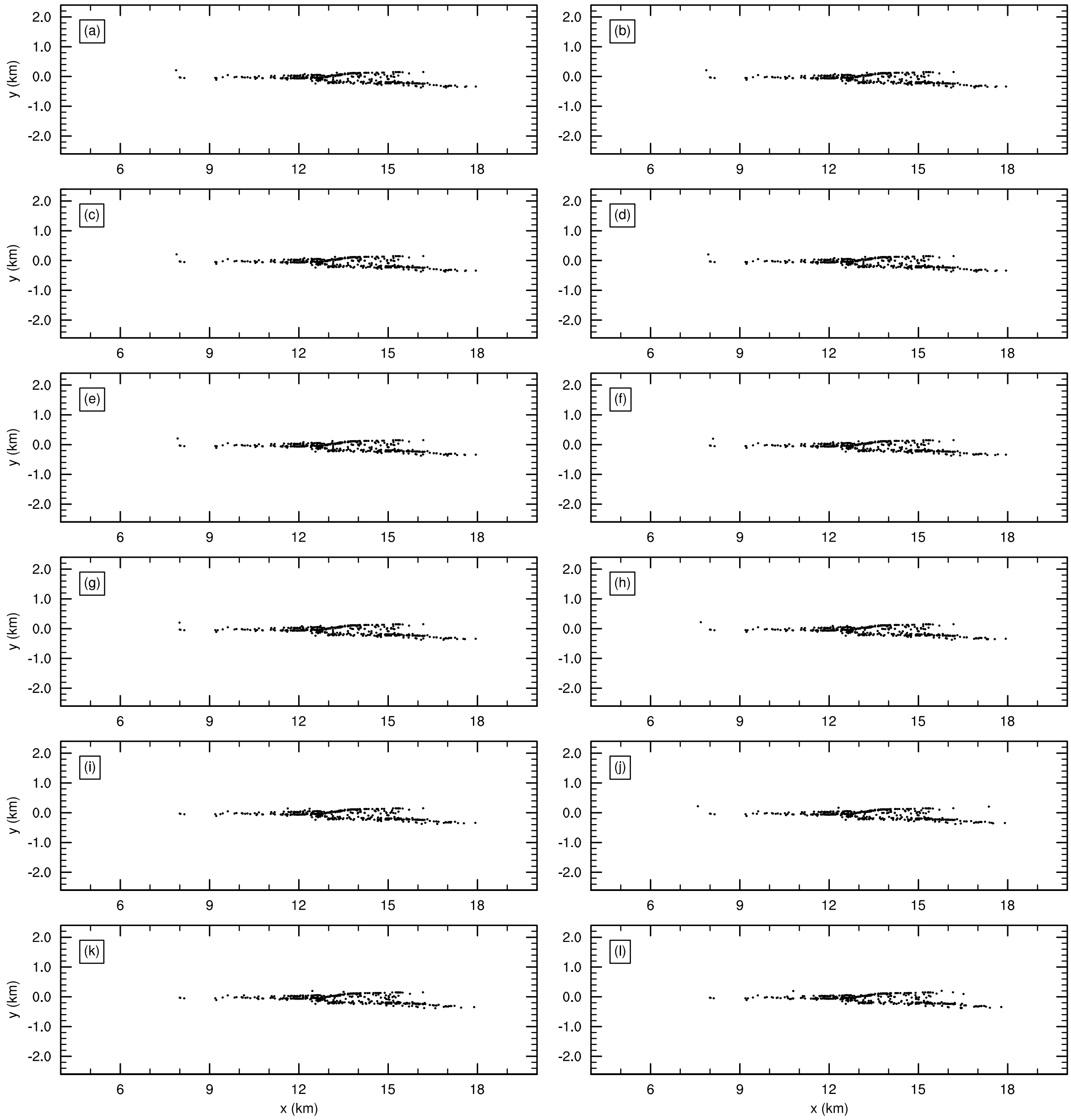

Fig. S4. As in Fig. S2, but for the strong-wind plume.

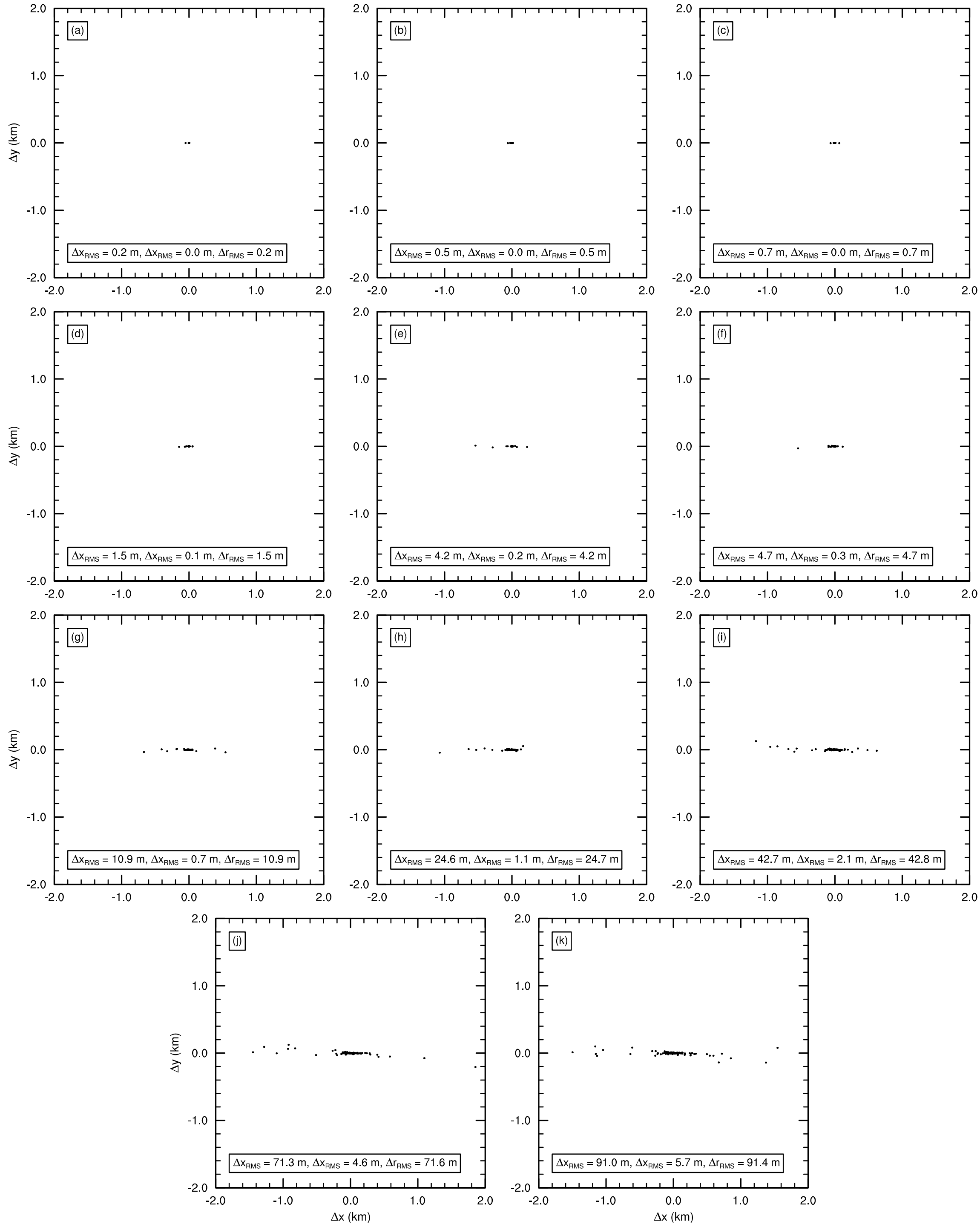

Fig. S5. As in Fig. S3, but for the strong-wind plume.

Section S2. Firebrand and plume animation

We present an animation of firebrand position and plume vertical velocity for the strong-wind plume in Movie S1, to further illustrate the controlling effect that the turbulent plume dyanmics has on firebrand transport.

Movie S1. Movie of (top) individual firebrand positions, projected onto the xz-plane and (bottom) plume vertical velocity, w (m s^{-1}), in the y = 0 plane. Individual frames are separated 5 s apart in model time, which with a frame rate of 8 fps results in a move than runs at 40× real speed. (For movie, see .mp4 file attached.)