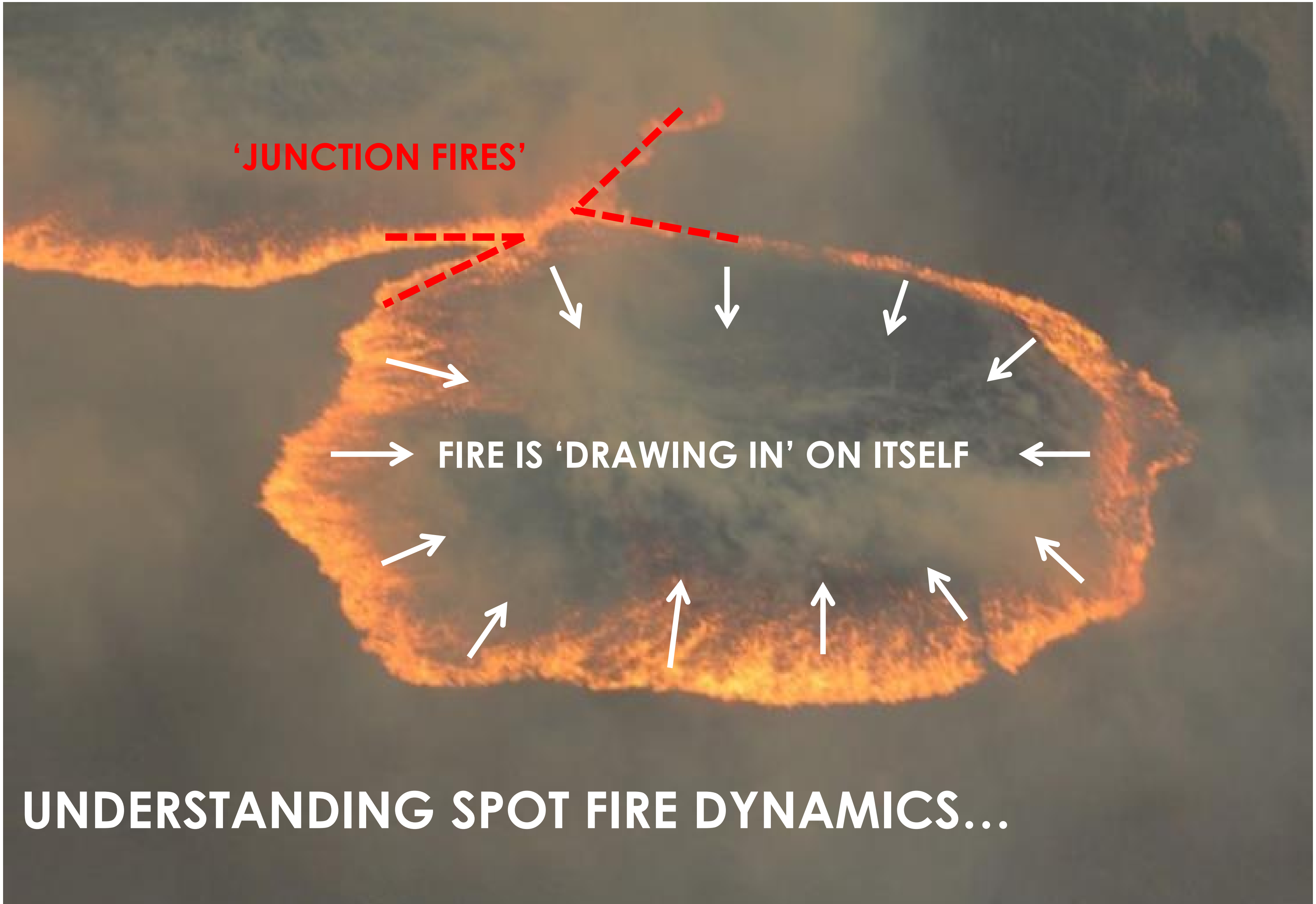
FIRE COALESCENCE AND MASS SPOT FIRE DYNAMICS

Experimentation, modelling and simulation

Jason Sharples[1], James Hilton[2], Andrew Sullivan[3]

1. Computational Science Initiative,
   School of Physical, Environmental and Mathematical Sciences, UNSW Canberra
2. CSIRO Data 61
3. CSIRO Land and Water

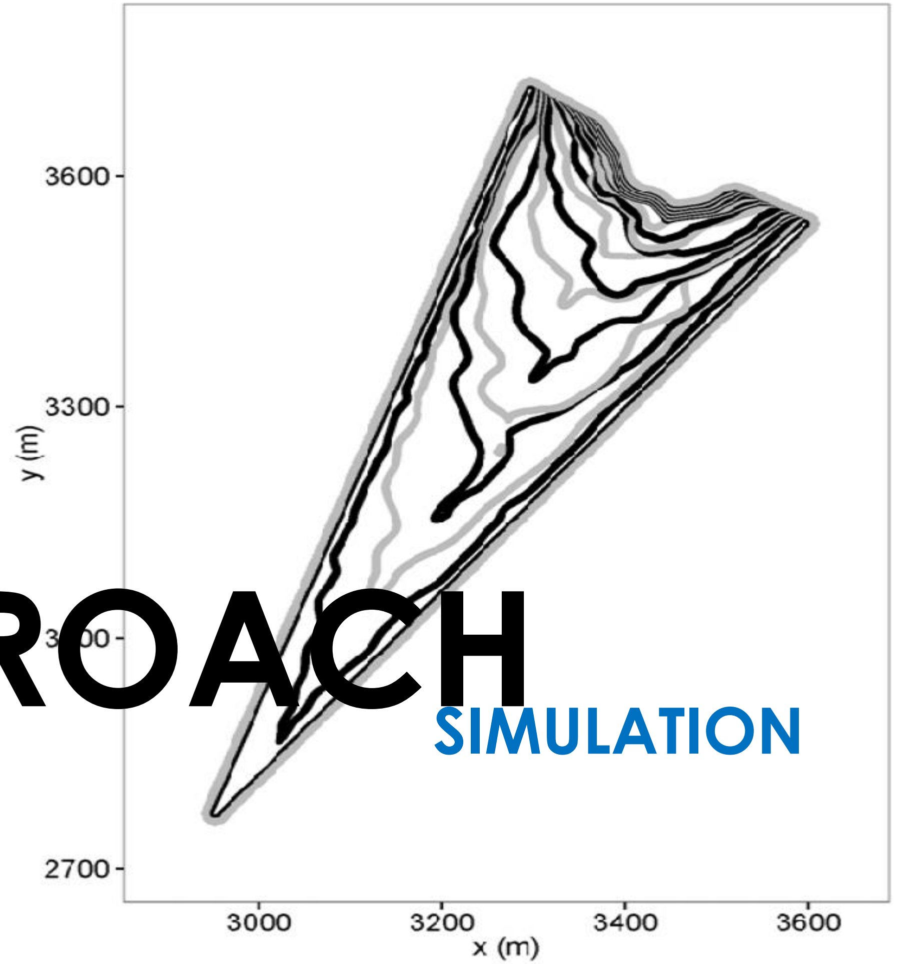
Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme
UNSW Australia Canberra
DATA 61
CSIRO
SPOTFIRE PROJECT



UNDERSTANDING SPOT FIRE DYNAMICS…

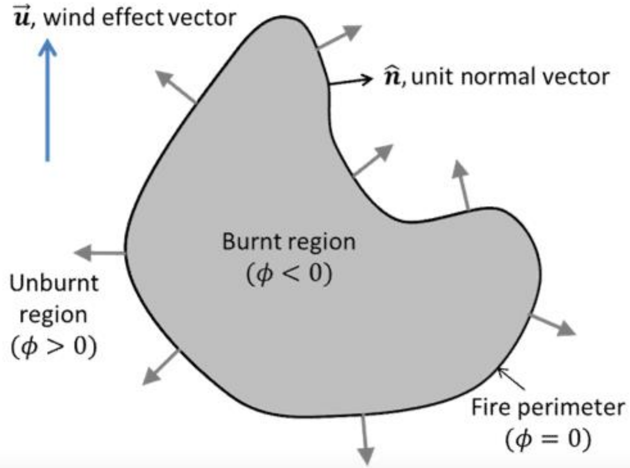
OUR APPROACH

EXPERIMENTATION



MATHEMATICAL MODELLING

SIMULATION

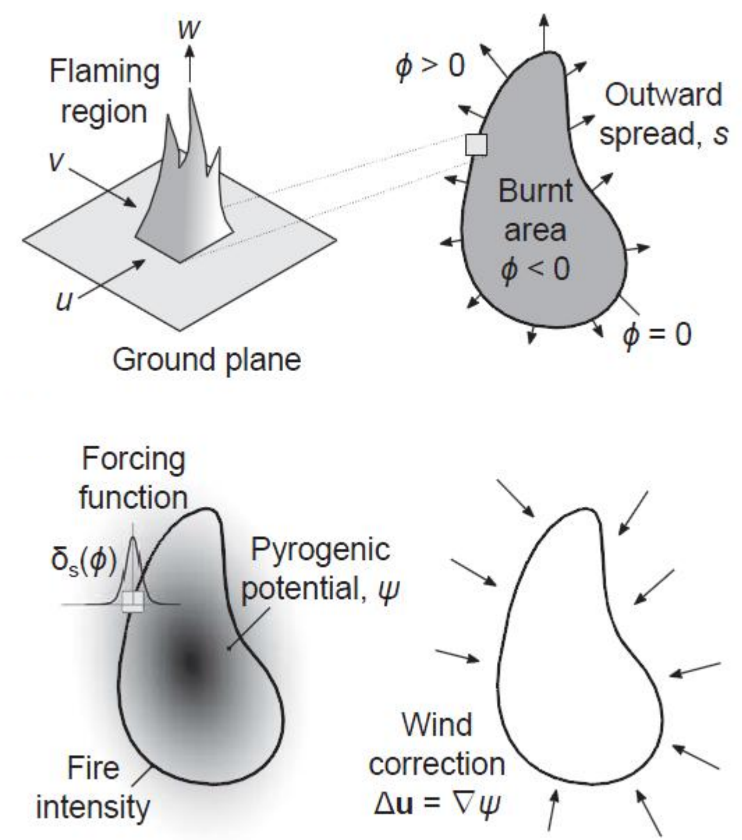


$$\frac{\partial ¤}{\partial t} + \quad \left\| \nabla ¤ \right\| + \left(\mathbf{u}_a (¥) + \nabla \cdot \quad \right) \cdot \nabla ¤ = 0$$

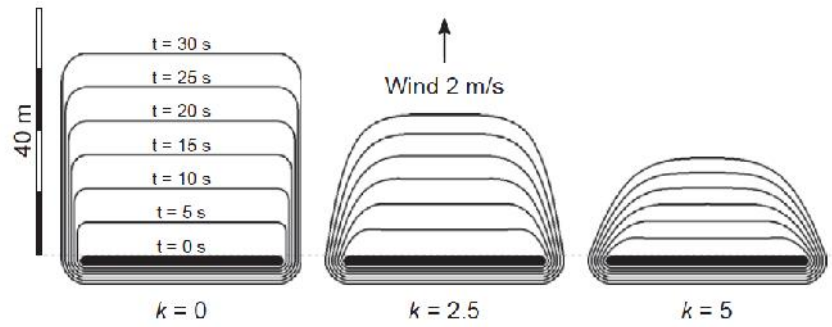
$$\nabla^2 \cdot \quad = {}^{\circ} \int ¢ \left(\mathbf{x} - \mathbf{x}_\Omega \right) d\mathbf{x} = \begin{cases} {}^{\circ} & \mathbf{x} \in \Omega \\ 0 & \mathbf{x} \notin \Omega \end{cases}$$

RECENT PROGRESS

GEOMETRIC MODELS WITH PYROGENIC POTENTIAL



Simulation of a wind-driven line ignition with different pyroconvective strengths

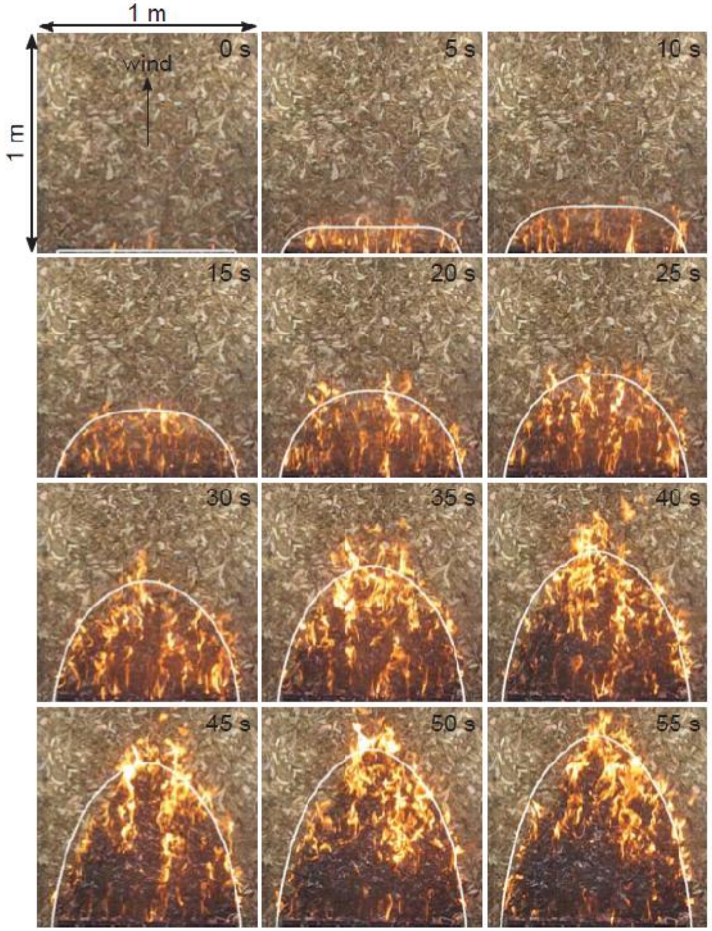


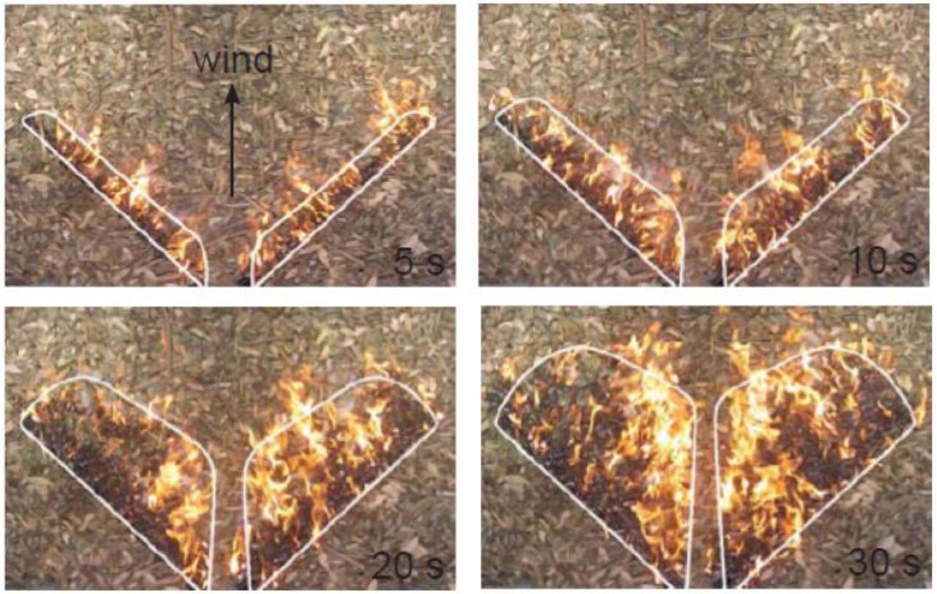
Plus strong potential for a physically based model for slope effect on fire spread...!

w/ XFireNZ, Missoula Fire Lab.

RECENT PROGRESS

GEOMETRIC MODELS WITH PYROGENIC POTENTIAL

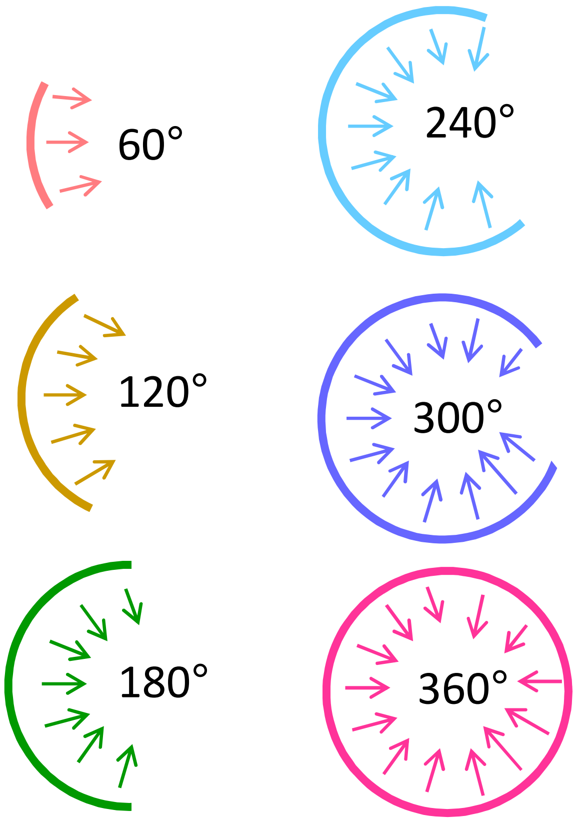




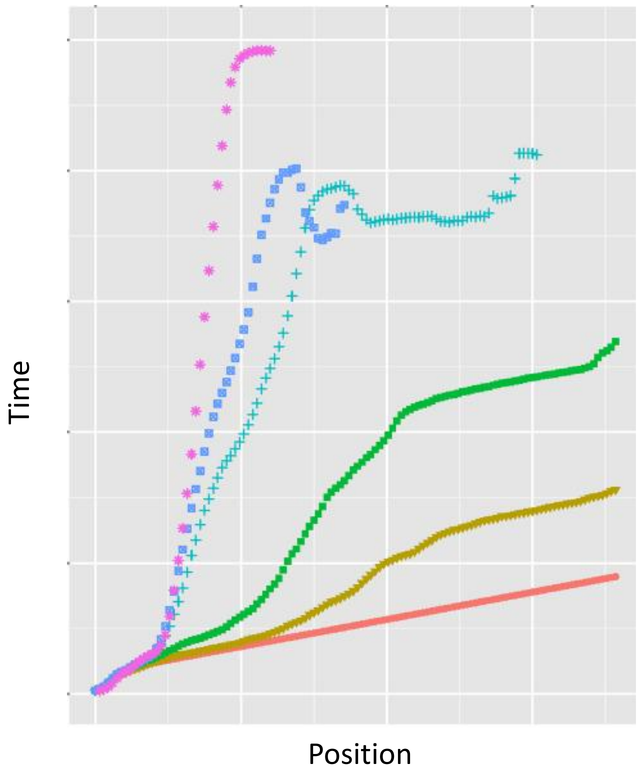
Separated V fire experiment and simulated fire propagation.

RECENT PROGRESS

UNDERSTANDING ARC FIRES



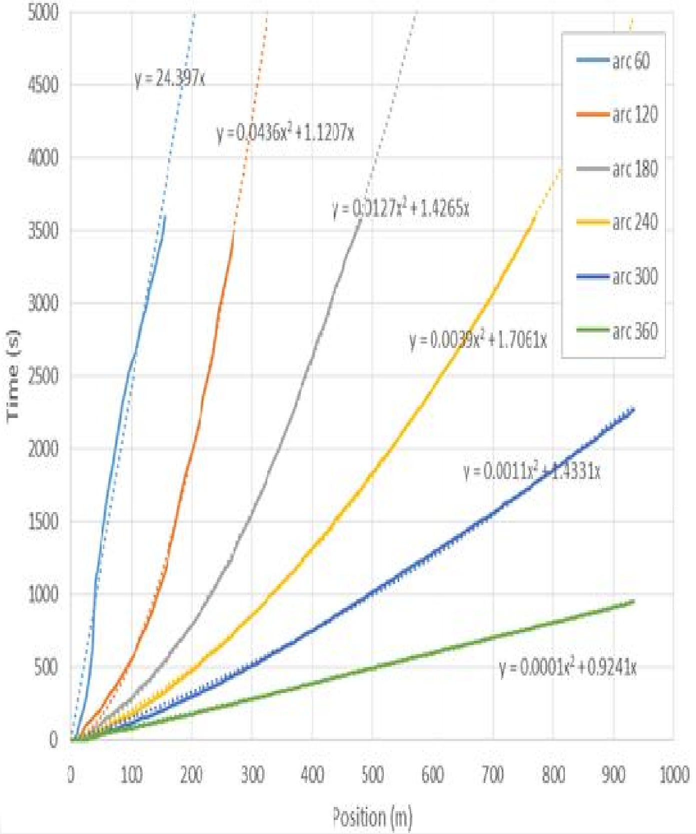
Fully coupled three-dimensional fire atmosphere model



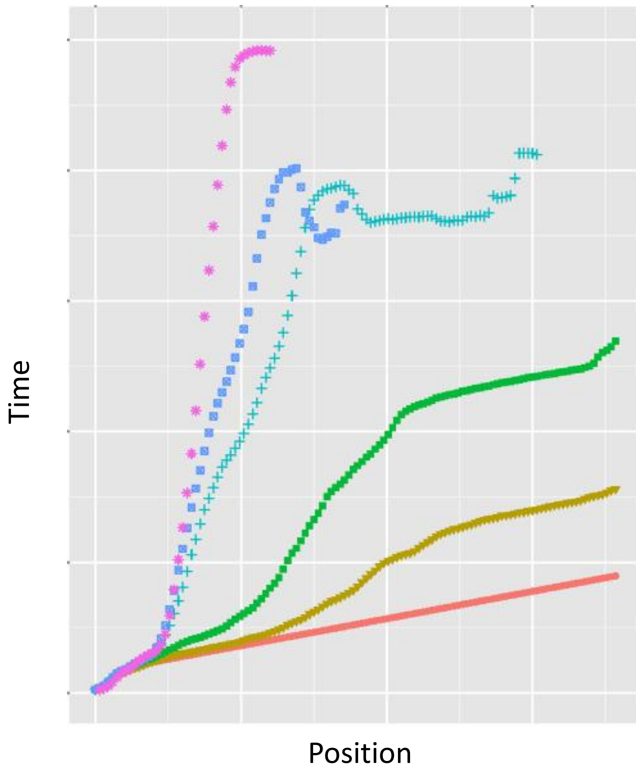
RECENT PROGRESS

UNDERSTANDING ARC FIRES

Two-dimensional simulator with pyrogenic potential

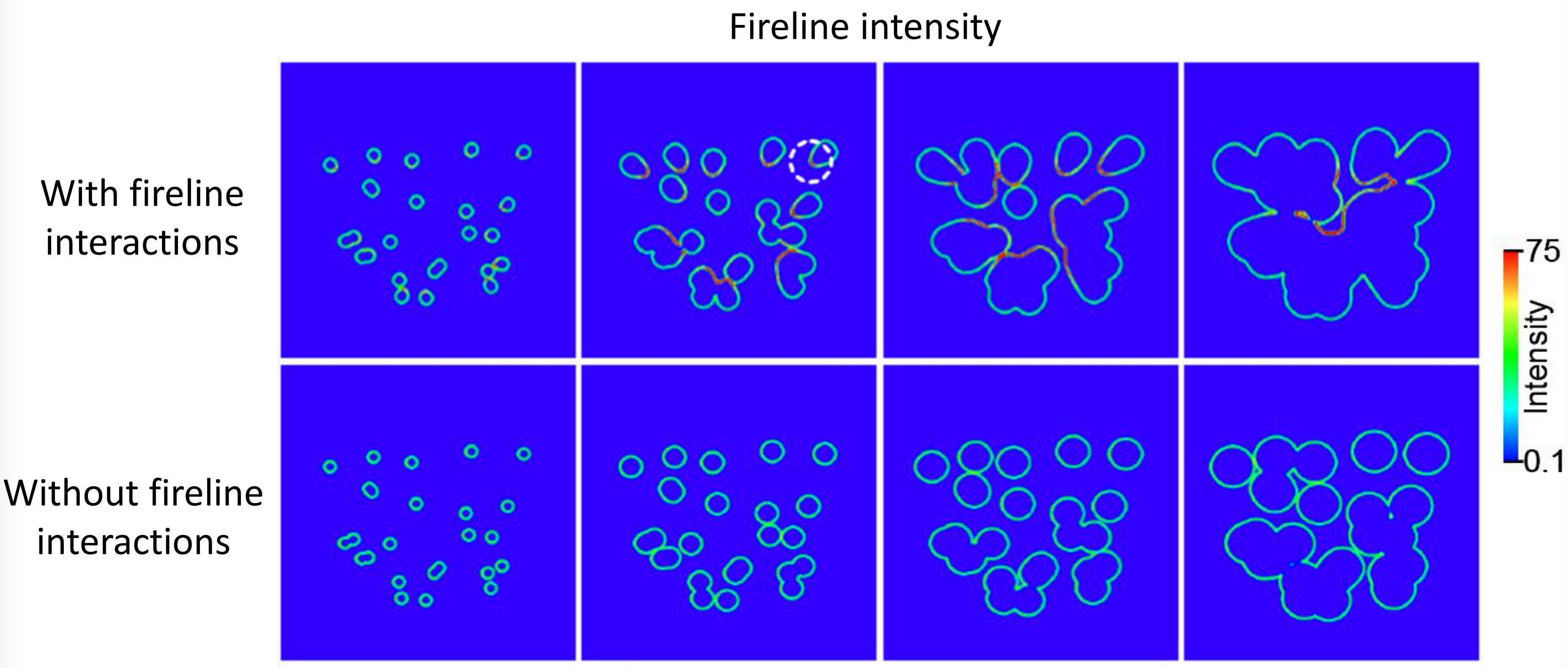


Fully coupled three-dimensional fire atmosphere model



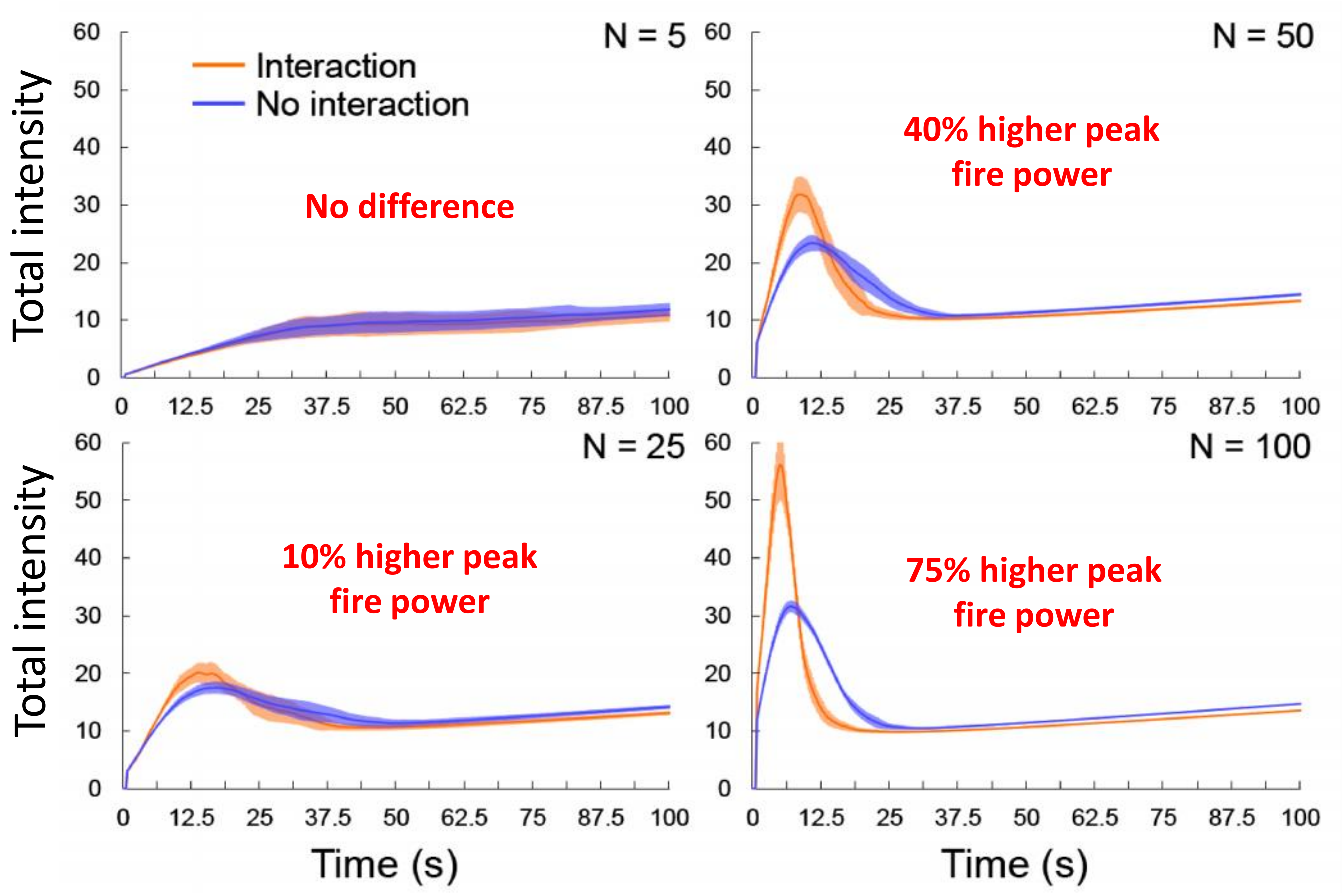
RECENT PROGRESS

EFFECT OF SPOT FIRE DENSITY ON PEAK FIRE POWER



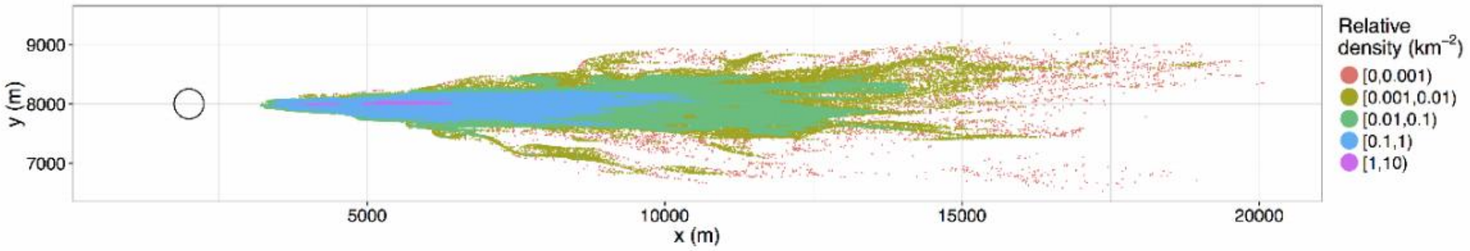
RECENT PROGRESS

EFFECT OF SPOT FIRE DENSITY ON PEAK FIRE POWER

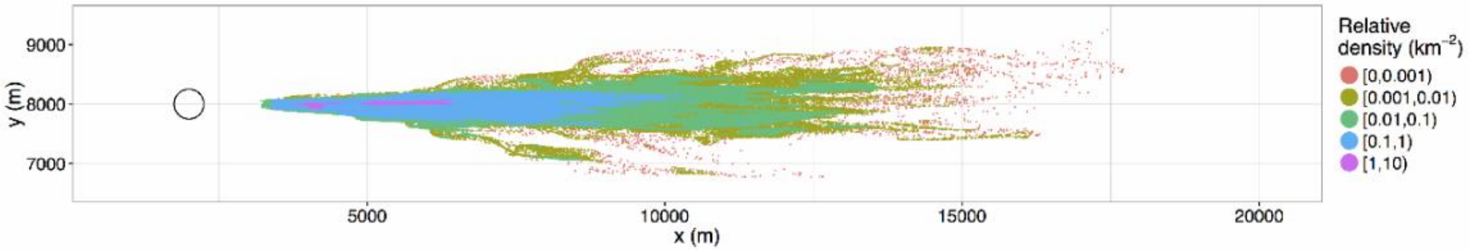


RECENT PROGRESS

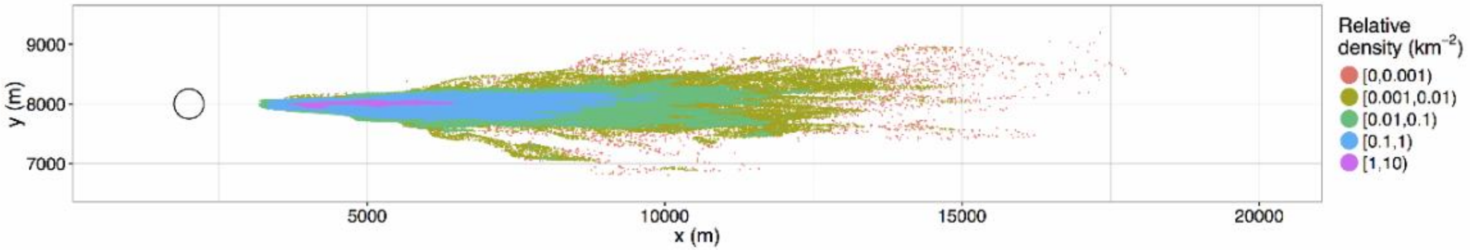
EFFECT OF TERMINAL VELOCITY DYNAMICS ON LONG-RANGE EMBER DISPERSAL



(a) Constant-terminal-velocity assumption



(b) Variable-terminal-velocity assumption



(c) No terminal-velocity assumption

UTILISATION PLANS

The immediate avenue for utilisation of this research will be scoping enhanced frameworks for firefighter and Fire Behaviour Analyst training.

PEER-REVIEWED PUBLICATIONS

1. Sullivan, A.L., Swedosh, W., Hurley, R.J., Sharples, J.J., Hilton, J.E. (2017) Investigation of the effects of interactions of intersecting oblique fire lines, with and without wind. In preparation.
2. Hilton, J.E., Sullivan, A.L., Swedosh, W., Sharples, J.J., Thomas, C.M. (2017) Incorporating convective feedback in wildfire simulations using pyrogenic potential. *Environmental Modelling and Software*, Under review.
3. Thomas, C.M., Sharples, J.J., Evans, J.P. (2017) Modelling the dynamic behaviour of junction fires with a coupled atmosphere–fire model. *International Journal of Wildland Fire*, 26(4), 331-344.
4. Hilton, J.E., Miller, C., Sharples, J.J., Sullivan, A.L. (2017) Curvature effects in the dynamic propagation of wildfires. *International Journal of Wildland Fire*, 25(12), 1238-1251.
5. Sharples, J.J., Hilton, J.E. (2017) Modelling the dynamic behaviour of small scale junction fires using curvature flows. *Proceedings of the 22nd International Congress on Modelling and Simulation*.
6. Hilton, J.E., Sharples, J.J., Sullivan, A.L., Swedosh, W. (2017) Spot fire coalescence with dynamic feedback. *Proceedings of the 22nd International Congress on Modelling and Simulation*.
7. Thomas, C.M., Sharples, J.J., Evans, J.P. (2017) Modelling firebrand transport: comparison of two methodologies. *Proceedings of the 22nd International Congress on Modelling and Simulation*.
8. Thomas, C.M., Sharples, J.J., Evans, J.P. (2017) Rate of spread and fireline curvature in a coupled atmosphere–fire model. *Proceedings of the 22nd International Congress on Modelling and Simulation*.
9. Roberts, M.E., Sharples, J.J., Rawlinson, A.A. (2017) Incorporating ember attack in bushfire risk assessment: a case study of the Ginninderry region. *Proceedings of the 22nd International Congress on Modelling and Simulation*.
10. Thomas, C.M., Sharples, J.J., Evans, J.P. (2015) Pyroconvective interaction of two merged fire lines: curvature effects and dynamic fire spread. *Proceedings of the 21st International Congress on Modelling and Simulation*.