3D RAY TRACING FOR MODELLING BUSHFIRE HOUSE EXPOSURE

Fire Impact & Risk Evaluation from case studies- FIRE-DST

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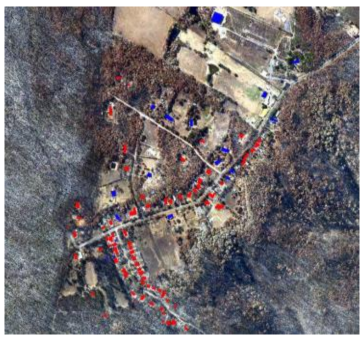
Objectives

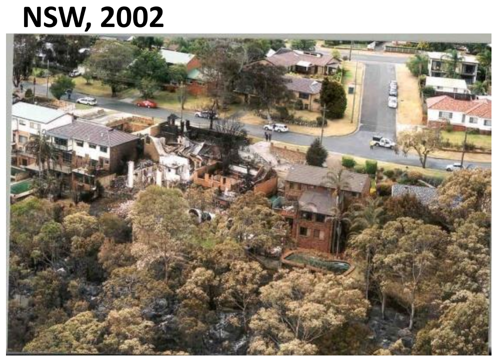
The objective of this project is to assess the vulnerability of homes to bushfire on the basis of potential radiant heat flux. The potential maximum radiant heat flux is modelled using a combination of information derived from remote sensing datasets and a three dimensional ray tracing approach. The methods have been validated using historical house lass from fires in three case studies.

Pine Ridge Road Kinglake, VIC, 2009



Eyre Peninsula, North Shields, SA, 2005

Engadine, Thurlgona Road NSW, 2002



Model Inputs

Fuel and topography

Modelling of radiant heat flux for individual homes requires knowledge of fuel load, fuel structure and topography present in the vicinity of the home. For case study 1 (Pine Ridge Road) this information was derived from airborne lidar. For case study 2 and 3, no lidar data is available and this information is derived from aerial photography.

Develop flame front simulation

The direction from which the historical fires impacted homes was derived from the Phoenix RapidFire fire spread model (Tolhurst 2008). Fire rate of spread and flame characteristics were determined using the remote sensing based fuel load, topography, known weather conditions and the equations used by McArthur (1967), and described by Noble (1980).

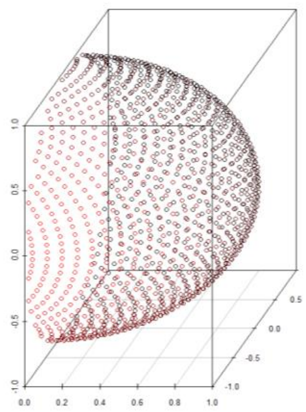
Flame mapping

Fire line intensity was mapped at a scale of 2m pixel resolution across the pilot study region. For each house, fuel and topography within a 250m radius were considered for incident radiant heat flux calculations.

Vulnerability analysis

Incident Radiant Heat Flux (RHF)

The RHF calculation is based on the Stephan-Boltzman law, which includes a view factor, the emissivity for vegetation fuel (assumed 0.95), Stephan Bolztman constant (5.67×10^{-8} $W.m^{-2}.K^{-4}$), temperature of the flame (1200K). Historically, view factor has ignored occlusion due to topography and objects (including potential fuels) which exist between the flame front and the house. Both of these were included in the current study.

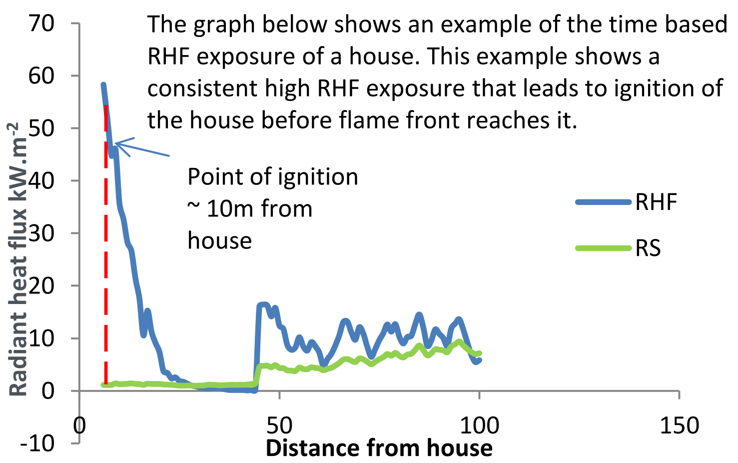


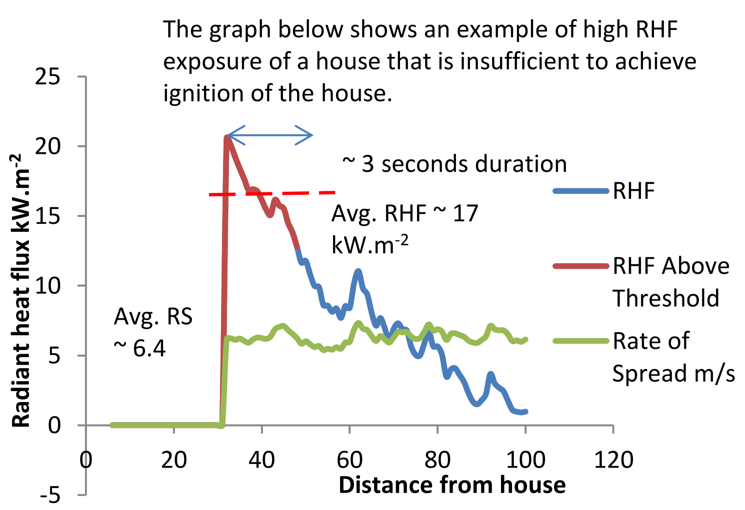
View factor calculation: using equal solid angle ray distribution

House Ignition Criteria

Flame fronts are modelled at every metre step towards the house, giving a view factor for the approaching flame, and an instantaneous rate of spread (RS) of the fire front – this generates the time a house was exposed to that level of RHF. A linear function was derived from Tran (1992) to determine if the accumulated RHF was enough to lead to an exceedance of the unpiloted ignition temperature.

Outcomes : radiant heat flux analysis (examples at house level)





Conclusion

The radiant heat calculations used in this study build on previous approaches by incorporating attenuation by topography and vegetation. An assessment of this modelling approach explained 13% of the houses burnt in the Pine Ridge Rd region during the Black Saturday fires. We propose that many of the homes not predicted to have burnt due to RHF were in fact destroyed by direct and indirect ember attack. This theory will be further tested in final analysis of the pilot studies.

McArthur, A. G. (1967). Fire behaviour in eucalypt forests. Leaflet No. 107., Comm. of Australia For. & Timber Bur.
Noble, I. R., G. A. V. Bary, et al. (1980). "Mcarthur Fire-Danger Meters Expressed as Equations." Australian Journal of Ecology **5**(2): 201-203.
Tolhurst, K., B. Shields, et al. (2008). "Phoenix: development and application of a bushfire risk management tool." The Australian Journal of Emergency Management **23**(4): 47.
Tran, H. C., J. D. Cohen, et al. (1992). Modeling ignition of structures in wildland/urban interface fires. Proceedings of the 1st international fire and materials conference, Arlington, VA, Inter Science Communications Limited.