NEXT GENERATION MODELS FOR PREDICTING THE BEHAVIOUR OF BUSHFIRES: CHALLENGES AND PROSPECTS

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BUSHFIRES OCCUR ON A SCALE THAT MAY BE MEASURED IN KILOMETERS. HOWEVER, A CHALLENGE FACED IN DEVELOPING NEXT GENERATION BUSHFIRE MODELS IS TO CAPTURE THE SIGNIFICANT CONTRIBUTIONS THAT SMALL SCALE PHENOMENA MAKE TO THE PROPAGATION OF BUSHFIRES. IN THIS WORK IT IS PROPOSED TO EXPLOIT METHODS OF SPATIAL AVERAGING TO ACCURATELY DESCRIBE THE INTERACTIONS BETWEEN THE WIND AND VEGETATIVE CANOPIES. AVERAGING METHODS WILL ALSO BE USED TO QUANTIFY THE RATE OF THERMAL RADIATION IN BUSHFIRES.

AN INTELLECTUAL FRAMEWORK

The idea of developing a next generation physics-based model of the propagation of bushfires implies charting a new course. This will entail drawing on the precepts of contemporary science and adapting them to describe phenomena specific to bushfires. Several promising approaches arise from the need to account for the very large range of length and time scales on which the governing phenomena occur. The length scales range from sub-millimeter on which turbulent kinetic energy is dissipated through to the scale of the landscape - a ratio of scales of 10^{10}.

This work points to some of the mathematical and computational tools that are available to span this range. The simulation of the propagation of bushfires must be run on computers that are available. Hence, the equations that govern the behaviour of the flow of the air and the transport of thermal energy and chemical species must be accurate on a length scale of about one metre. This implies some averaging of the small scale phenomena. It is proposed to invoke the methods of spatial averaging to elucidate the mechanisms that underpin the interaction of vegetation and the atmosphere. The geometry of the vegetation can be used to derive values of the extinction coefficient of thermal radiation, and large eddy simulation models the dissipation of turbulent kinetic energy.

Next generation models of bushfires will incorporate detailed description of the generation and spread of embers.

SPATIAL AVERAGING

Terrain over which a bushfire is likely to propagate shares some characteristics with rough surfaces. The individual vegetative elements represent asperities that penetrate the inertial sub-layer of the atmospheric flow close to the ground. As a result, the mean velocity profile exhibits an inflexion at the interface of the vegetative canopy and the clear atmosphere. This destabilizes the flow and generates large scale vortices that penetrate the plant canopy. The conservation of mass demands that penetrations are accompanied by eruptions from the canopy. The eddies that penetrate the canopy are likely to have a significant impact on the propagation of bushfires.

The plant canopy exhibits features of a porous medium. The leaves and twigs constitute a solid phase with a length scale on the order of centimetres. Small scale eddies are generated when the air flow interacts with the canopy, and the rate of turbulent energy dissipation is increased. It is quite infeasible to resolve the flow on the scales of the leaves and twigs. Hence, it is proposed to account for the presence of the solid phase by exploiting the volume averaging theorem (Whitaker, 1999). This approach offers, at least in principle, the possibility of using the geometry of the plant canopy to derive equations that govern the behaviour of quantities that vary on the scale of the order of one metre. Finnigan(2000) shows that a more immediately useful result of spatial averaging of two point turbulence equations in plant canopies is that it gives rise to terms that account for the generation of turbulence by air interacting with the canopy, and this turbulence is dispersed in part by spatial deviations generated by air flow through the canopy.

THERMAL RADIATION

Thermal radiation often plays a crucial role in propagating bushfires. We are again confronted by a need to reduce a multiphase system consisting of air, leaves, twigs and branches to one that can be described as a continuous, optically turbid model. Pimont (2008)has shown how the geometry of the needles and shoots of *Pinus halepensis* can be used to calculate a radiation extinction coefficient. It is quite likely that similar techniques will be used in the next generation of models of Australian bushfires.

IMPROVED COMPUTATIONAL METHODS

The next generation of bushfire models will exploit the latest developments in computing hardware and software. This is being achieved in the present project by exploring the use of massive parallelisation and improved algorithms.

REFERENCES

Finnigan, J. J. (2012). Turbulence in plant canopies. Annual Review of Fluid Mechanics. 32, pp 519-571.

Pimont, F. (2008) Modélisation physique de la propagation des feux de forêts: Effets des caractéristiques physiques du combustible et de son hétérogénéité, Docteur de l'Universiité, Aix-Marseille – II.

Whitaker, S. (1999) The method of volume averaging. Springer

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