Faculty of Engineering, Computer and Mathematical Sciences
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Coupled fire-atmosphere simulations of three Australian fires where unusual fire behaviour occurred

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Contents

Abstract

Predicting where and how a fire will burn is critical information for mitigating the impacts of bushfires and minimising risk at fuel reduction burns. Firefighter entrapments and fatalities occur mostly at fires that display rapid changes or fluctuations in fire activity. In this thesis, I explore several of the factors that lead to rapid changes in fire behaviour. Understanding these factors is necessary in order to produce accurate fire predictions, which are critical for fire-fighter safety and effective operations.

Weather is a primary driver of fire activity; consequently, meteorological information is a key input for anticipating fire behaviour. At present, weather forecasts focus on near-surface conditions; but fires and the atmosphere are three dimensional, and dynamical interactions occur that can have a dramatic influence on fire behaviour. However, these fire-atmosphere interactions are poorly understood due to their complex nature and the difficulty of collecting observational data from a bushfire.

In order to further understanding of dynamical interactions between a fire and the surrounding atmosphere, we have simulated three Australian fires where unexpected fire activity occurred, using the coupled fire-atmosphere model WRF and SFIRE. The coupled simulations have been run in feedback on and feedback off mode in order to assess the impact that the fires have on their surrounding atmosphere. The results show significant changes to the mesoscale atmospheric structure as result of the energy released by the fire.

Computational fire behaviour models are being used by fire managers in real time and this use will grow in the future. The question is, given we know that fires affect the surrounding atmospheric flow; what weather inputs should the fire models of the future use? The Australian fire science community is currently presented with the opportunity and the challenge to design, develop, and implement fire behaviour simulation models that contain appropriate and comprehensive meteorological inputs. The results presented in this thesis are thought provoking for the current approach to fire weather forecasts and for the use and development of computational fire simulations in the future.

Signed Statement

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This thesis has my name on the title page, but it is the result of a project owned by many people.

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And, to my family for everything.

Dedication

For the firefighters.

Thesis Structure

This thesis has been prepared as a series of publications. Each of chapters two to five are presented as a separate work, with self contained literature reviews, figures and references.

The research was conducted in two stages, and this is reflected in the composition of the chapters. The initial stage involved meteorological case studies of three events where unexpected fire behaviour was observed. Subsequently, the events were simulated with WRF and SFIRE.

The Technical Report on the Kangaroo Island fires contains detail of the D'Estrees and Rocky River fires and is included as Appendix B. Chapters two and three are the WRF and SFIRE simulations of D'Estrees and Rocky River respectively. The Layman meteorological case study is chapter four, preceding the Layman simulations at chapter five. The WRF and SFIRE chapters are presented in the order in which the simulations were done.

The notation WRF and SFIRE (as opposed to WRF-fire) is used in accordance with the stated preference of the developers.

Thank you for taking the time to read this work.

Presentation List

This research has been presented at a number of forums:

International Congress on Modelling and Simulation
MODSIM conference, Adelaide, SA (2013)
MODSIM conference, Perth, WA (2011) - Student Presentation Award

Australasian Fire and Emergency Services Authorities Council
AFAC Conference, Melbourne, VIC (2013)
AFAC Conference Perth, WA (2012) - Best Oral Presentation Award

Science Communication
FameLab State Finalist (2014)
CRC Association Early Career Researcher Showcase Finalist (2013)

American Meteorological Society
Fire and Forest Meteorology Symposium, Bowling Green, Kentucky, USA (2013)
Fire and Forest Meteorology Symposium, Palm Springs, California, USA (2011)

Fire Weather Workshop
Fire Weather Workshop, Busselton, WA (2013)
Fire Weather Workshop, Bowral, NSW (2011)

Bureau of Meteorology
Science for Services Workshop, Melbourne, VIC (2013)
Advanced Forecasters Course, Melbourne, VIC (2013)

Project Stakeholders
Dept. Environment Water and Natural Resources, Kangaroo Island, SA (2012)
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