COUPLED FIRE-ATMOSPHERE MODELLING PROJECT

Annual Project Report 2017

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EXECUTIVE SUMMARY

The goal of the project is to improve understanding of fire and atmosphere interactions and feedback processes by running a coupled fire-atmosphere simulation model. Planned outcomes of the project include: preparation of meteorological and simulation case studies of significant fire events, installation and testing of a coupled model on the national computing infrastructure and preparation of training material to support operational implementation of research findings.

Weather forecasting and fire prediction are similar in that skilled practitioners of both rely on a combination of detailed scientific knowledge and objective analysis, juxtaposed with pattern recognition that draws on past experience and a mental inventory of previous events. By preparing detailed case studies and coupled simulations of events where unexpected or unusual fire-atmosphere interactions occurred, we contribute to both the scientific understanding for fire–atmosphere interactions and the knowledge base of operational meteorologists and fire analysts.

The project started in March 2016, and work for the first year and a quarter has been on two main fronts; a case study of the Waroona fire and implementing the coupled fire-atmosphere model ACCESS-Fire.

The Waroona fire in Western Australia in January 2016 was selected as the first case study. It was a complex event, with significant impacts including the destruction of the town of Yarloop. A detailed paper on the Waroona fire has been prepared and the manuscript submitted to the Journal of Southern Hemisphere Earth Systems and Science (JSHESS). The paper is expected to be published by late 2017. The paper is the result of a collaborative effort between Department of Parks and Wildlife, WA and research and operational representatives from the Bureau of Meteorology. The work has been presented at a number of forums and has been accepted for oral presentation at two major conferences in late 2017.

Progress with the coupled model ACCESS-Fire (ACCESS is the Australian Community Climate and Earth-System Simulator) has been slower than anticipated, but significant headway has been made. ACCESS high resolution nested suites are now running on the project space on the National Computing Infrastructure. Importantly, the framework is more generic than the original code and can be easily re-configured to relocate and run for a new event anywhere in Australia. The nested suites are now running successfully in the advanced graphical user interface "Rose-Cylc" which will receive ongoing support and development from the UK Met Office. The fire code has been implemented on the JULES land-surface scheme and final testing is in progress.

END USER STATEMENT

Dr Lachlan McCaw
Department of Biodiversity, Conservation and Attractions, Western Australia

Fire behavior models currently used in Australia for operational predictions consider fire spread as a two dimensional process driven by surface-level inputs of weather, terrain and fuel. While these models perform well under a broad range of conditions, the current generation of models have been shown to be incapable of representing the complex fire behavior that can occur when large bushfires interact with the atmosphere. Fires of this type tend to be particularly dangerous and have resulted in extensive damage and loss of life. Having a sound understanding of factors that trigger coupling between a fire and the atmosphere, together with the ability to predict fire behavior in real time, would better place fire managers to respond to fires of this type and to minimise impacts on the community.

The Coupled Fire-Atmosphere project team have made good progress over the past year, completing an important case study of the 2016 Waroona bushfire in south-west Australia and steadily progressing the capability for modelling with ACCESS-Fire. These achievements are attracting international interest in the project, and favourably positioning the research of the Bushfire and Natural Hazards CRC. Members of the project team have engaged effectively with end-users from a range of organisations, and are well regarded for their efforts. Important developments and findings from the research have been communicated in a variety of ways, and to a broad range of audiences.
End users keenly await initial results from the modelling phase of the project.

END USER STATEMENT

INTRODUCTION

Large bushfires release substantial amounts of energy into the surrounding atmosphere. This energy release modifies the structure of the surrounding wind, temperature and moisture profiles in four dimensions. The changes driven by the fire can manifest as winds that are similar in speed but opposite in direction to the prevailing winds, pyrocumulus clouds and, in extreme cases, pyro-cumulonimbus clouds. The dynamic feedback loops produced by the fire-atmosphere coupling process can have a dramatic influence on how a fire evolves.

In current operational fire simulation models, simple meteorological inputs are inserted into an algorithm for fire spread to predict how a fire perimeter will evolve across a two-dimensional landscape. This approach does not incorporate any three dimensional interactions between the fire and atmosphere and, in many cases, will provide a limited depiction of how a fire may evolve, particularly in a dynamic environment in high terrain where risk is greater. This project explores the ability to examine fire-atmosphere interactions through use of a coupled model.

The project uses the premier operational Australian high-resolution weather prediction model ACCESS, coupled to a fire-spread model. The ACCESS model has been used to examine several high impact fire events and has provided detailed insights into the meteorological processes impacting the fire environment. Coupling ACCESS to a fire model builds on previous expertise and provides opportunity for future development of coupled modelling in Australia.

The coupled fire atmosphere model ACCESS-Fire has been installed on national Australian computing infrastructure for research application, with future capability for operational use. The model will be used to run a series of case studies. Detailed examination of high impact events and verification against available meteorological and fire behaviour data will highlight the importance of assessing and predicting the likelihood of fire-atmosphere interactions in anticipating fire evolution. The close links of the project team with operational and training groups in both meteorology and fire management provide a clear pathway for implementing research findings.

The Waroona fire in southwest WA in January 2016 is the first case study. Over a two-day period, there were four periods of extreme fire behaviour; two separate pyro-convective thunderstorm events and two evening ember storms. A detailed case study examining and linking the meteorology and fire behaviour has been submitted for publication. Coupled simulations will test hypotheses developed in the case study and further examine dynamical process during the event.

PROJECT BACKGROUND

The project examines case studies and uses high resolution coupled modelling to better understand and predict fire-atmosphere feedback processes. Fire-atmosphere feedback is important because it often reflects a transition from steady-state fire spread to non-linear fire activity, which is inherently more difficult to predict. Blow-up fires, extreme fire behaviour and dynamic fire behaviour are all terms that may be used to describe fire activity that is non-linear and potentially dangerous to fire fighters. Coupled modeling will assist in identifying and understanding the triggers and ingredients that lead to non-linear fire activity. This knowledge will enable risk mitigation activities to be undertaken, both at bushfires and fuel reduction burns.

Coupled models (e.g. WRF-Fire) have previously been used in Australia by several researchers to examine fire-atmosphere coupling processes. This project uses the ACCESS-Fire model, which links directly to high-level operational and research Australian meteorological computing capability. ACCESS-Fire represents an important opportunity for future development as well as potential to provide a fire prediction tool to other countries through the overarching Unified Model framework.

Coupled models provide a greater level of detail than uncoupled models, however they are computationally expensive and this (currently) makes them impractical for use as operational tools. One aim of this project in the latter stages is to explore the potential for intermediate complexity models, which would be better suited for operational application. These may be simplified or parameterized models or ingredients based tools.

The strong links between the project team and training and operational activities present a clear pathway to implement research findings and produce training materials from this and related projects. The project focusses on analysing real events, from which learnings can translate directly into operational practice.

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WHAT THE PROJECT HAS BEEN UP TO

The project commenced in March 2016. In consultation with stakeholders, the Waroona fire in Western Australia was selected as the first case study and a detailed manuscript has been prepared and submitted to JSHESS. The Sir Ivan fire (in NSW) has been selected as the second case study and initial data collection has been undertaken. Progress with ACCESS-Fire was initially constrained by implementation of a major change to the user interface of the model framework, however significant progress has been made in recent months. Contributions have been made to a range of other fire-meteorology related activities, as described below.

WAROONA CASE STUDY

The Waroona fire burnt south of Perth in January 2016. The case study focuses on the meteorology and fire behaviour during the first two days of the fire, 6th and 7th January. On these days the fire was burning through heavy fuels on the plateau, east of the towns of Waroona and Yarloop. Four separate episodes of extreme fire behaviour occurred and these have been documented in the prepared paper :

Meteorological drivers of extreme fire behaviour during the Waroona bushfire, Western Australia, January 2016. Peace, M., McCaw, L., Santos, B., Kepert, J.D., Burrows, N., and Fawcett, R.J.B. Submitted to JSHESS, 2017.

The study examines in detail a combination of video footage, radar and satellite data, AWS observations and fire spread data as well as high resolution simulations with ACCESS.

There were two separate pyro-cumulonimbus events, one in the evening on 6 January and one late morning on 7 January. On the evenings of 6 and 7 January respectively the fire produced destructive ember showers over the towns of Waroona and Yarloop respectively. Most of the buildings in Yarloop were destroyed and there were two fatalities.

A detailed summary of the study has not been included here, however we are very happy to provide a copy of the manuscript, please contact either mika.peace@bom.gov.au or jeff.kepert@bom.gov.au and we will provide the most up-to-date version.

SIR IVAN CASE STUDY

The Sir Ivan Fire has been selected as the second case study for the project. The analysis of the event will be prepared in collaboration with FBANs from NSW RFS and members of the NSW Bureau of Meteorology Severe Weather and Embedded Meteorologist teams. Initial data collection has occurred and negotiations with legal sections regarding data release are underway.

ACCESS-FIRE

Work on the ACCESS-Fire model has progressed on several fronts.

1. The initial fire model code provided by Monash University was "hard-wired" for the Black Saturday case. Considerable effort has been invested towards producing a nested suite framework which can be easily modified to run a simulation for any location in Australia. This framework can be used for both fire and other High Impact Weather cases.

2. The ACCESS model is underpinned by the UK Met Office Unified Model (UM). In the past year the UM has moved from a script-line to a graphical interface called Rose-Cylc. This change has necessitated significant re-building of the framework for running nested, high resolution simulations. A working suite in the new framework has been developed in collaboration with other UM and ACCESS users.

3. The fire code in ACCESS-Fire interacts with the atmospheric model through the land-surface scheme JULES. The original coding interface has changed in the new framework. In collaboration with other ACCESS users, modifications to the programming of the fire code have been made and the required changes are in the final stages as of July 2017.

4. The project team (Jeff) has visited the UK Met Office to discuss future use and application of ACCESS-Fire. The underpinning UM model is used on all continents and representatives from the UK and South Africa have indicated interest in being able to use the coupled fire model in future.

OTHER ACTIVITIES

Embedded Met

Mika has provided operational support to SA forecasting operations in a number of High Impact Weather events including the September 2016 SA 'State Blackout' storms. Also filled a period of 'Embedded Meteorologist' at SA CFS and SES during November and December 2016.

Working Groups

Contributions to the BoM Spot Fire Forecast Review, the (RFS) National Fire Danger Ratings project, the BoM Embedded Meteorologist group and the BoM Fire Weather Working group.

AFAC 2017

Waroona Case Study accepted for oral presentation.

ACCESS-Fire detailed description accepted for poster presentation

MODSIM 2017

Waroona Case Study and progress on ACCESS-Fire simulations accepted for oral presentation.

Media interviews

ABC Radio. Live interview at Writers Week, Adelaide for International Women's Day.

ABC Radio. Live interview at SA BoM for the first day of summer.

ABC radio. Live interview at ABC studios on the topics of general meteorology and fire research.

Workshop presentations

Presentation at the inaugural Extreme Weather Desk Workshop and the Weather and Environmental Prediction Workshop.

EWD trial collaboration

Collaboration on the planned 2017-2018 Extreme Weather Desk fire outlook trial (dry lightning, PyroCb potential, wind changes and entrainment potential).

DEWNR/CFS Seminar series

Talks to SA DEWNR and CFS on the Waroona fires (presented by Mika) and the "SA Blackout Storms", (presented by Jon Fisher) in December 2016.

AFAC Fire weather training chapter review

Major revisions of chapters for the AFAC Fire Weather Training Manual.

ICT mentoring program

Mika was selected for the ICT Coaching Circles Women in Leadership mentoring program and has been attending monthly professional development sessions in Canberra.

PUBLICATIONS LIST

JOURNAL PAPERS

Meteorological drivers of extreme fire behaviour during the Waroona bushfire, Western Australia, January 2016. Peace, M., McCaw, L., Santos, B., Kepert, J.D., Burrows, N., and Fawcett, R.J.B. Submitted to JSHESS, 2017.

BNHCRC EXTERNAL REPORTS

Tory, K. J., Peace, M. & Thurston, W. *Pyrocumulonimbus forecasting: needs and issues*. (Bushfire and Natural Hazards CRC, 2016).

CURRENT TEAM MEMBERS

Jeff Kepert. Project lead.

Mika Peace. Lead researcher.

Harvey Ye. IT support.