*APR.Intern Final Report Template*

*To be completed by the Intern, submitted to APR.Intern, and Reviewed by the Industry Partner*

This template is intended as a guide for the Final Report required by APR.Intern at the end of the internship project. It is not mandatory to use this format. The minimum standard for the Final Report is a generic overview of the research purpose, objectives, methodology and outcomes. The report may require disclosure of any IP developed from the research.

The purpose of the Final Report is to assess whether the objectives were met, outline the impact of the work for the Industry Partner and ensure sufficient recording of the research project is made available to the Industry Partner. The Final Report required for APR.Intern is 5-10 pages long. The Industry Partner may require additional documentation separate to this to finalise the internship.

**Please note:** The Final Report is protected under the Confidential Information Clause of the agreement. APR.Intern will request a copy for reporting purposes. The Industry Partner may request the removal of any IP or confidential information prior to submission to the APR.Intern Business Development contact and [contact@aprintern.org.au](mailto:contact@aprintern.org.au)

1. **Summary of Project**

In about 200-300 words, please provide a description of the purpose, objectives and expected outcome of the research project.

Energy released by fires can drastically change the nearby atmosphere and lead to unexpected fire spread and hazardous spotting, understanding of which requires both atmospheric and fire spread modelling. The project aims to determine whether the research version of the operational numerical weather prediction model ACCESS, coupled to an empirical fire model can aid in the diagnosis and prediction of fires in a-typical topological or meteorological scenarios.

Fire releases energy into the surrounding atmosphere, changing wind fields and local meteorology. This in turn influences the spread of the fire. Climate change along with increasing urban-rural fringe populations means large bushfires are both more frequent and have bigger impacts. The coupled-fire atmosphere model enables an enhanced scientific understanding of the dynamic interactions between the two systems, assisting with the development of tools and methods that can predict fire behaviour and impacts.

By examining two case studies through simulation and analysis, the project will determine if the ACCESS-Fire model can be used to reasonably simulate complex fire scenarios, and further to help explain the underlying causes of unexpectedly bad fires. These case studies will be used in both conference presentations and eventually two publications. There is potential for the modelling work to help inform the fire danger index, as it may help diagnose dangerous conditions not currently understood.

1. **Summary of Interns Work**

In 3-4 pages, describe the project, methodology and results using the headings below as a guide.

***Project Background***

The project uses Australia’s premier research and operational numerical weather prediction model ACCESS, coupled to an empirical fire model to run case studies of extreme fire events and examine the interactions between the fire and surrounding atmosphere. The project is supported by the Bushfire and Natural Hazards CRC and the project team is a small group of three in the Bureau of Meteorology’s Science to Services section. The project works closely with external stakeholders in fire and land management agencies. The work is of international interest due to climate change and increasing populations on the urban-rural fringe driving increased frequency and impacts of large bushfires, as well as a requirement for enhanced risk management during prescribed burns. The coupled-fire atmosphere model captures feedbacks between the fire and atmosphere, and examining the output enhances scientific understanding of the dynamical interactions and assists in development of tools and methods to predict fire behaviour and impacts.

ACCESS-Fire will be run on two case studies; the Waroona and Sir Ivan fires. It is expected that the model runs and write-up will mostly be performed by other team members (however the intern may be involved). The intern will assist with managing the large datasets (on NCI) and plotting and analysing the output, including multiple fields, derived parameters, spatial and temporal plots, cross sections and animations. Plots will be required in a format suitable for journal publication.

***Research Method***

The intern will develop familiarity with the output of the ACCESS NWP system and run and modify available conversion scripts to reformat ACCESS output files (to .nc or equivalent). Output will be visualised with Python and Matplotlib using various methods, including time series, multiple parameters, temporal and spatial scales, vertical levels (pressure, height, sigma) and cross sections.

The intern will work closely with the other members of the project team to decide on optimal approaches to data analyses and must be flexible with exploring different display approaches and testing and refining analysis tools. Manipulation and display of observational data, including displaying combinations of spatial datasets from different platforms, will also be used in the analysis of model output.

The intern will learn elements of the fundamental sciences of meteorology and fire behaviour, with a focus on boundary layer and mesoscale meteorology, fire prediction systems and extreme fire behaviour. The intern will be expected to contribute to regular team meetings, and there is the opportunity to attend seminars at the Bureau of Meteorology. The intern will also be exposed to Australia's leading numerical weather prediction system and may have the opportunity to learn how to run simulations.

***Intern’s Contribution***

The intern's job has revolved around large sets of modelled output. The tasks initially revolved around managing and formatting the output and its storage, before turning to visualisation, and preliminary analysis. This required advanced understanding of the national computational infrastructure provided by ANU, along with large scale data processing and visualisation techniques. Further learning of fire spread and meteorological parameters has been necessary along with advanced mapping procedures to enable detailed visualisations of 3D+time model output.

A suite of python scripts has been created to help analyse model output from the broad to the fine scale. These scripts show topographical overlays and interpolated transects of various meteorological metrics allowing an understanding of the simulated system. This includes collaborative work with Dr. Kevin Tory, on pyrocumulonimbus (pyroCB) fire power threshold (pyroCB) calculation.

A framework of python scripts, with documentation including examples has also been created. The programs have all been streamlined to work with minimal friction on the NCI infrastructure – to allow easy analysis of future model output and provide an intuitive code base for future enhancements.

In addition to analysis of broader modelled weather, the scripts show an examination of several features of interest such as pyroCB formation, downslope winds, and firefront driven updrafts. Some of these features have been presented directly to BNHCRC clients (oral presentation), CSIRO fire modelling groups (formal discussions), and at the ACCOMC conference (as a poster).

***Research Results and Outcomes***

The key deliverables on the project are case studies of two significant bushfires using the coupled fire-atmosphere model. Model visualisations have successfully been used to find and help explain simulated pyroCB formation. Model visualisation has also contributed to model design, as large sets of gridded output require exploration and analysis in order to determine how reasonably the model behaves. Newly developed model iterations have been validated and undergone preliminary analysis, with a focus on production and causes of PCB. Observed anomalous fire spread that occurred due to topographical features also appears to be captured by model output. This may help explain the driving meteorological causes and eventually be used to enhance the fire danger index and inform fire risk management.

Interest in the project is very high in land management and fire agencies and our external partners are very keen for us to share the simulation results. Therefore, it is expected that the graphics produced by the intern will be shared broadly across a range of forums in Australian fire and emergency management, including conference presentations, online webinars and training material as well as being a key component of the required publications. The findings from the project will inform decisions pertinent to safety of life and property during bushfires.

***Future Research***

Modelled meteorological fields along the fire front appear to support the idea that ACCESS-fire is capable of reproducing conditions conducive to ember storms. This is one term for when burning debris is lofted by winds and deposited downwind while still burning – spreading fire across regions even without connected fuel sources. This aspect of the meteorological modelling requires more work to assess whether the conditions are actually capable of lofting debris. Assessment will be performed using a particle dispersion model (most likely the UK Met Office's Numerical Atmospheric-dispersion Modelling Environment) that can use ACCESS wind fields and can then track simulated debris.

Further analysis and validation of PCB through detailed analysis of model output is desirable. Fire power output largely flows into fire plumes, which can lead to PCB, but what portion of the energy is transported this way and what portion is lost in other ways?

*APR.Intern Executive Summary Template*

*To be completed by the Intern, submitted to APR.Intern, and Reviewed by the Industry Partner*

The Executive Summary is a mandatory component of the APR.Intern program and is to illustrate the educational outcomes of the internship for the Intern. The Intern Executive Summary is to be completed in a manner that is suitable for publication and as such does not require the disclosure of any IP developed from the research.

The Intern Executive Summary may be disclosed to the student’s institution upon request.

The Executive Summary will require review and approval by the Industry Partner to ensure no confidential information is disclosed.

Please note: The report requires review by the Academic Mentor and approval by the Industry Partner prior to submission to ensure no confidential information is disclosed. Please submit in PDF format to your APR.Intern Business Development contact and [contact@aprintern.org.au](mailto:contact@aprintern.org.au)

1. **Summary of Research Project Background & Objectives**

In about 100 words, please provide a description of the purpose and expected outcome of the project that is suitable for media or other publicity material.

The project uses Australia’s premier research and operational numerical weather prediction model ACCESS, coupled to an empirical fire model to run case studies of extreme fire events and examine the interactions between the fire and surrounding atmosphere. The energy released by the simulated fire into the surrounding atmosphere, changes the surrounding wind fields and influences how the fire behaves. The project is supported by the Bushfire and Natural Hazards CRC and the project team is a small group of three in the Bureau of Meteorology’s Science to Services section. The work is of international interest due to climate change and increasing populations on the urban-rural fringe driving increased frequency and impacts of large bushfires, as well as a requirement for enhanced risk management during prescribed burns. Examining the coupled-fire atmosphere model output enhances scientific understanding of the dynamical interactions and assists in development of tools and methods to predict fire behaviour and impacts

1. **Summary of Research Undertaken**

In about 300 words, please provide a description of the research undertaken, in terms of methodology and your contribution to the research as an intern.

A suite of python scripts has been created to help analyse model output from the broad to the fine scale. These scripts show topographical overlays and interpolated transects of various meteorological metrics allowing an understanding of the simulated system. This includes collaborative work with Dr. Kevin Tory, on pyrocumulonimbus (PCB) fire power threshold calculation.

Model visualisations have successfully been used to find and help explain simulated PCB formation. Model visualisation has also contributed to model design, as large sets of gridded output require exploration and analysis in order to determine how reasonably the model behaves. Newly developed model iterations have been validated and undergone preliminary analysis, with focus on production and causes of PCB. Observed anomalous fire spread that occurred due to topographical features also appears to be captured by model output.

In addition to analysis of broader modelled weather, the scripts show -several features of interest such as PCB formation, downslope winds, and firefront driven updrafts. Some of these features have been presented directly to CRC clients (oral presentation), CSIRO fire modelling groups (formal discussions), and at the ACCOMC conference (as a poster).

1. **Summary of the Educational Outcomes**

In about 100 words, in plain language, summarise how the internship contributed to your professional development as a researcher. Discuss any challenges translation of research, research environment etc. that occurred during the internship?

I have attended regular internal science seminars on a range of meteorological, climate and modelling topics as well as attend the week-long annual research seminar series, and the Australian Climate and Water Summer Institute. Together these experiences have greatly broadened my knowledge and experience in the meteorological data analytics space.

Analysing fire driven weather systems has really enhanced my knowledge of meteorology, and the experienced programmers and scientists here have really improved my understanding of data management within the NCI framework. It's exciting to work for passionate people who can explain to me what I'm visualising before I've even figured out what colour scale to use. Building up a complete overview of large sets of 3d gridded information really helps me appreciate the underlying physics, and keeps me interested in learning how to efficiently and effectively represent the output with python.

1. **Intern Impact Statement**

In about 75 words, please outline the impact that the internship has had on you in terms of work-readiness and competitiveness for future employment.

The internship has provided training and supervision by the Intern supervisor and other members of the team regarding fire spread and meteorological modelling. It has also helped develop soft-skills such as team working, presentation and communication. As a result of this placement, the intern is industry ready.

1. **Final Comments**

Insert any additional comments if applicable

It has been a real pleasure to work with the exceptional Mika, Harvey, Jeff, and Kevin, who have all shown real passion and verve.

*APR.Intern Industry Impact Statement Template*

*To be completed by the Industry Partner*

This template is intended as a guide for the Industry Impact Statement required by APR.Intern at the end of the internship project. The Industry Impact Statement is in to be completed by all Industry Partners as agreed to in Clause 4.1 of the APR.Intern Agreement and may be used for publicity and marketing purposes. The impact statement does not require disclosure of any IP developed from the research.

1. **Impact Statement for the Industry Partner**

In 250-300 words, please outline the research project outcomes and relevance/impact that the research will have on the organisation.

A suite of python scripts has been created to help analyse model output from the broad to the fine scale. The programs have all been streamlined to work with minimal friction on the NCI infrastructure – to allow easy analysis of future model output and provide an intuitive code base for future enhancements. These scripts show topographical overlays and interpolated transects of various meteorological metrics allowing an understanding of the simulated system. This includes collaborative work with Dr. Kevin Tory, on pyrocumulonimbus (PCB) fire power threshold calculation.

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