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Fire Risk to Australian Plantations Under Changed Climate

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Forest&Wood Products Australia
Knowledge for a sustainable Australia

Introduction

- Various fire risks
  - Here consider primarily biophysical aspects
- Past work has looked at changing climate and fire using
  - Weather based fire danger indices
  - Change surfaces for community extent
- Changing climate also expected to change fuels
- Examine effect of climate change on:
  - Fuel load using process-based forest growth model
  - Fire behaviour using simple model
- Other research:
  - Human caused ignitions
  - Lightning

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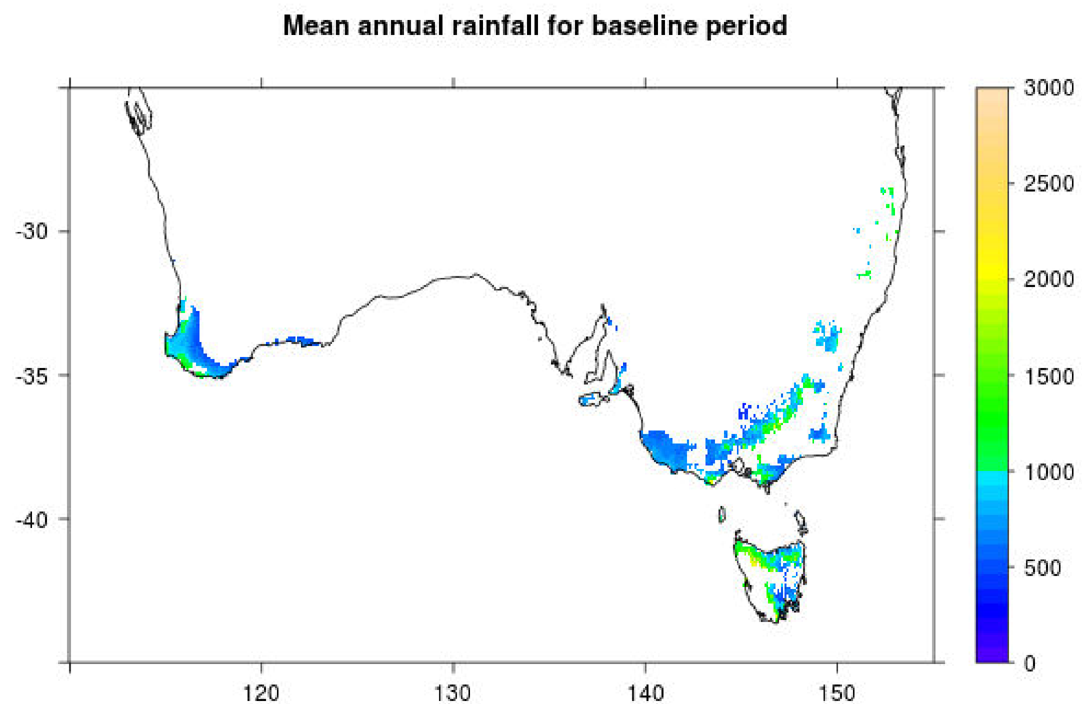
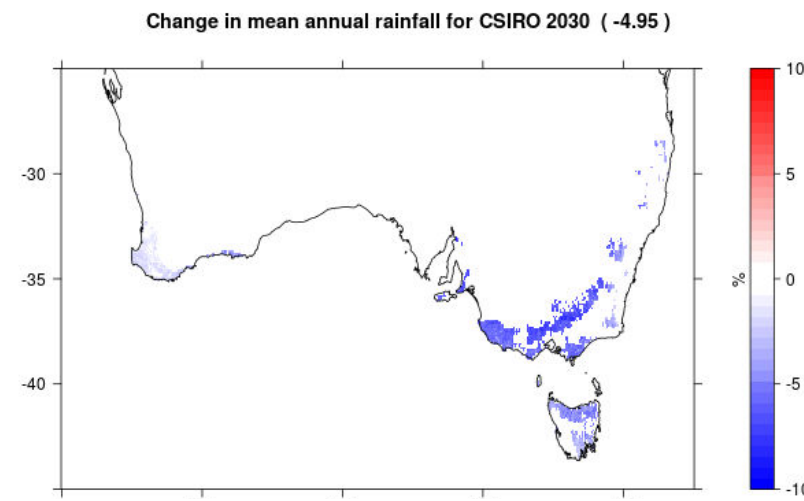
Baseline weather data

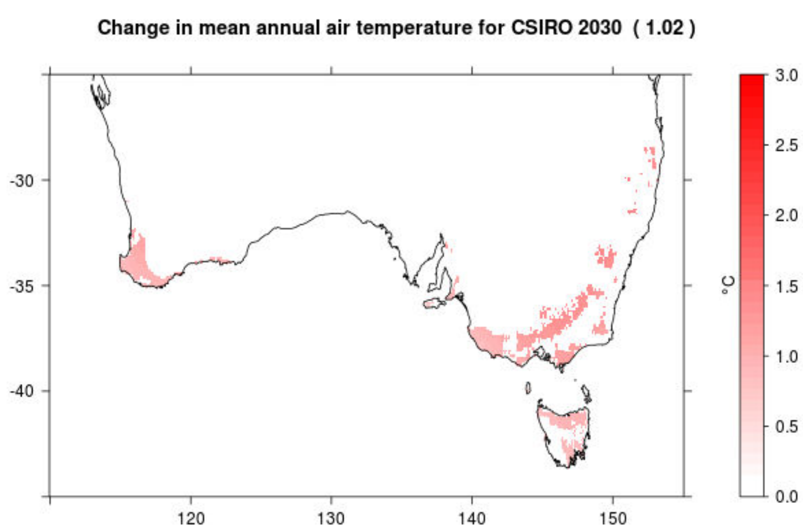
- Project required gridded predictions for plantation estate at 10 km resolution
- “SILO” daily grids of temperature, humidity, rainfall
- McVicar (2008) daily 2m wind run grid

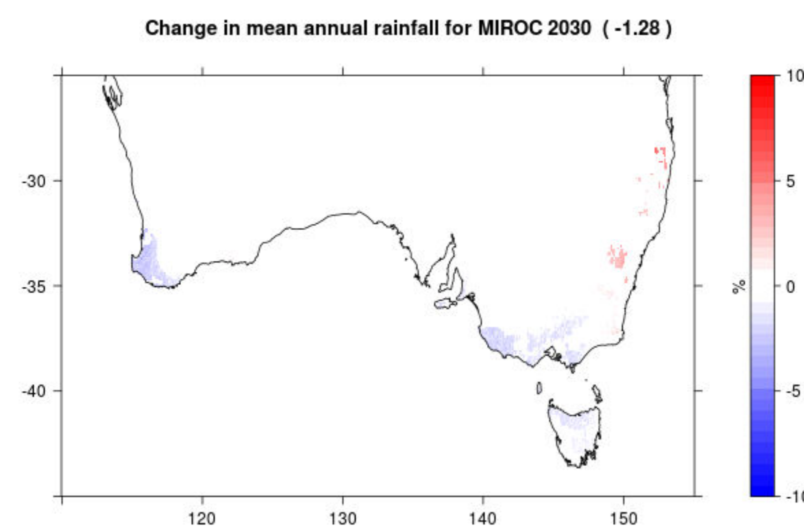


Climate change scenarios

- 2 models
- A1F1 (high) emissions scenario
- Model used to perturb gridded obs
- Increase temperature (moderate)
- Differing rainfall response







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Fire behaviour

- Fire danger index: $$F = 2De^{-0.45-0.0345H+0.0338T}e^{0.0234U}$$
- Rate of spread: $$R = 0.0012wF$$
- Intensity: $$I = HwR$$

Process-based model

- Cabala forest growth model
- Simulates plantation growth based on
  - Weather
  - Soil
  - Species specific plant physiology
  - CO_2
- Outputs
  - Stand volume and structure
  - Above and below ground biomass
  - Nutrient pools
  - Litter input and balance

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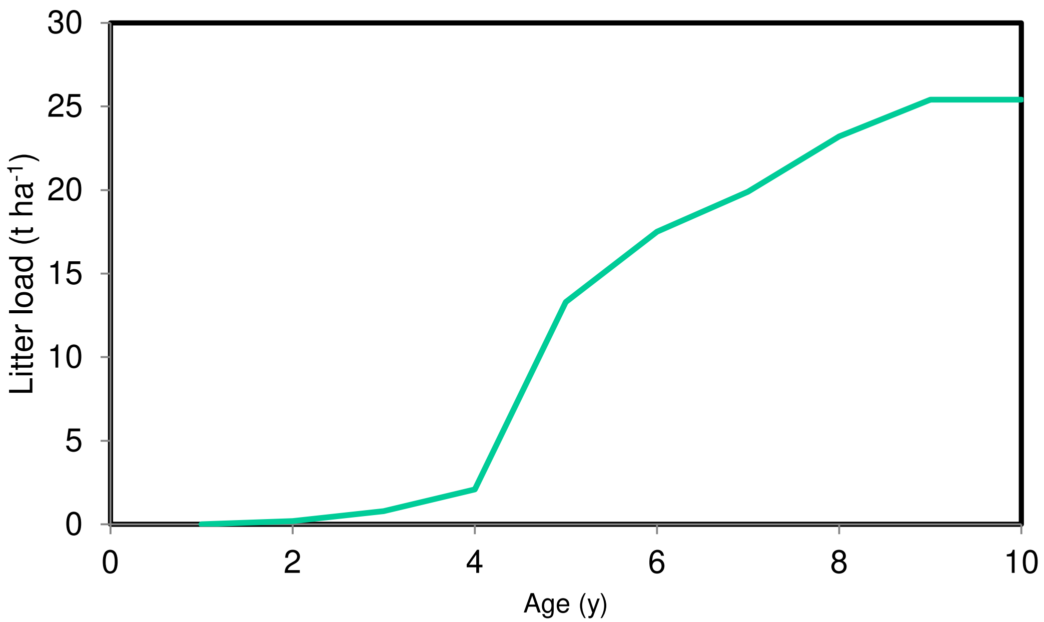
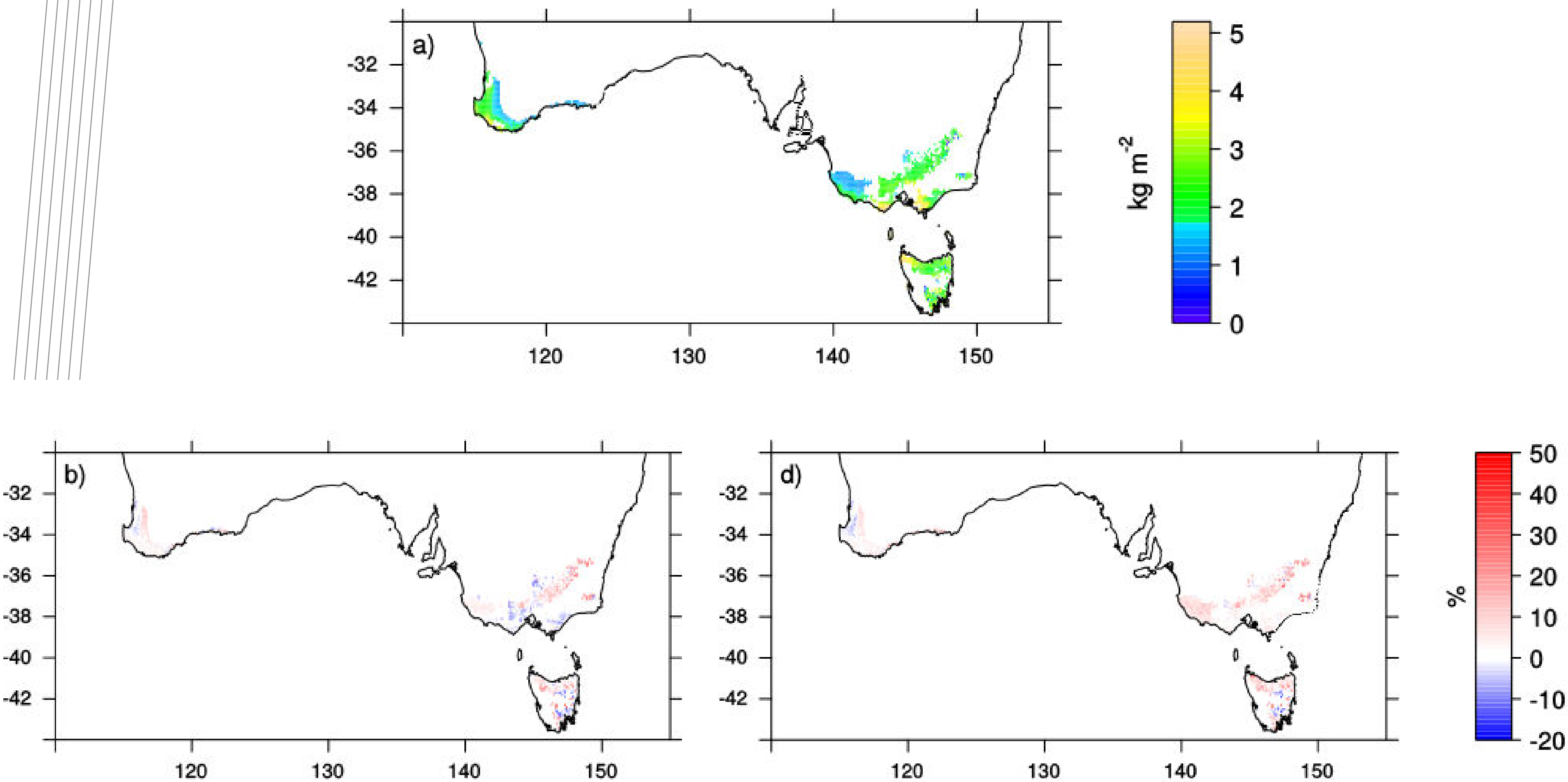
Plantation litter load

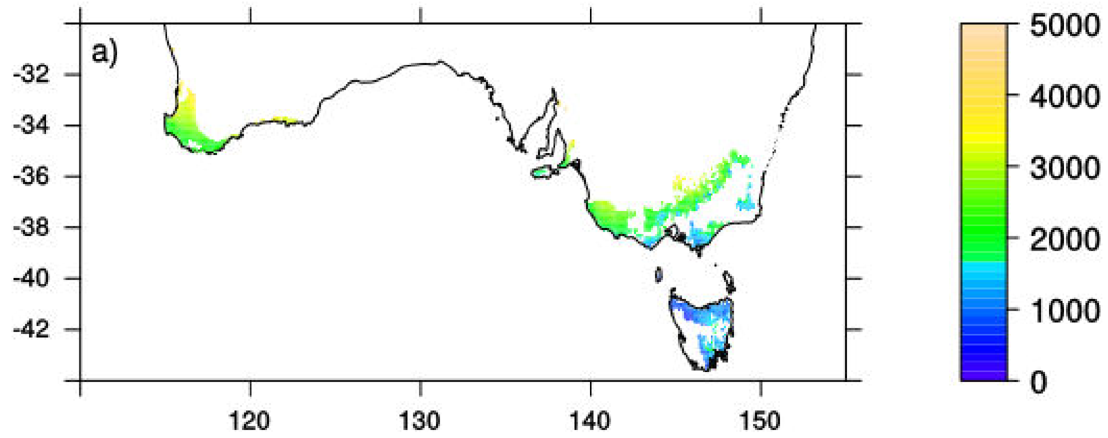
- 20 rotations simulated, each 10 years long
- No management actions (fertiliser or thinning)
- Litter accumulates during years 6 - 10
- Fuel load taken from final year

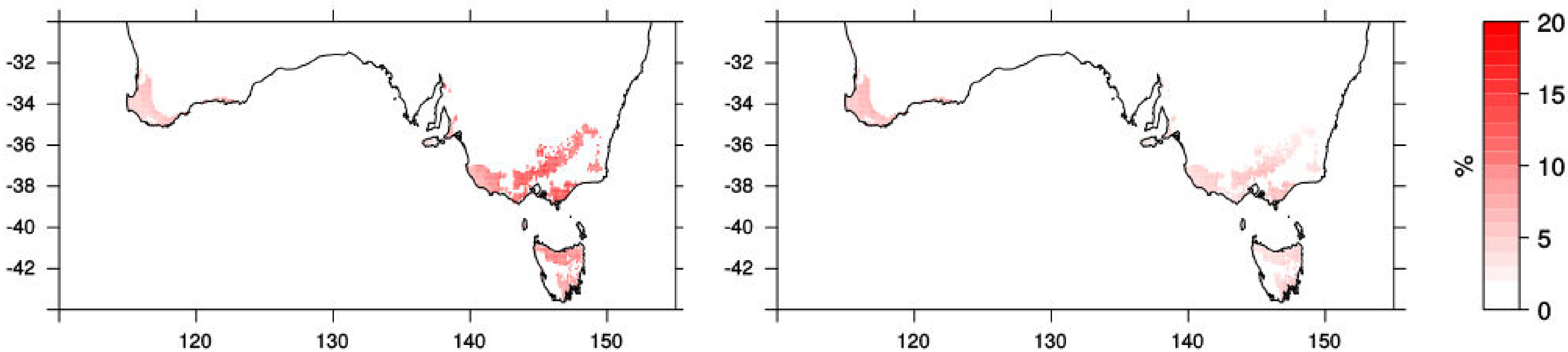


Plantation litter load

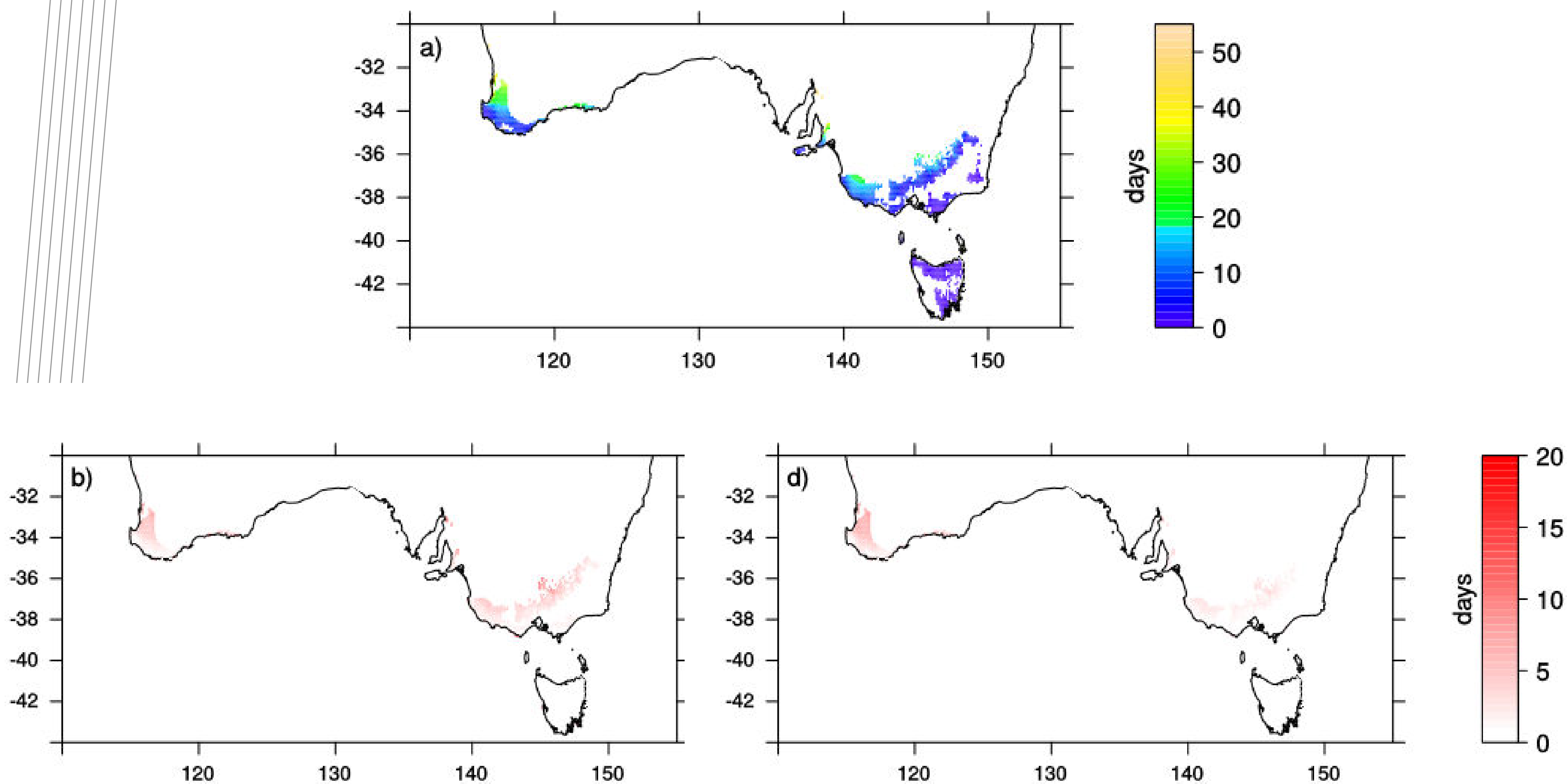


Results - Fire danger index

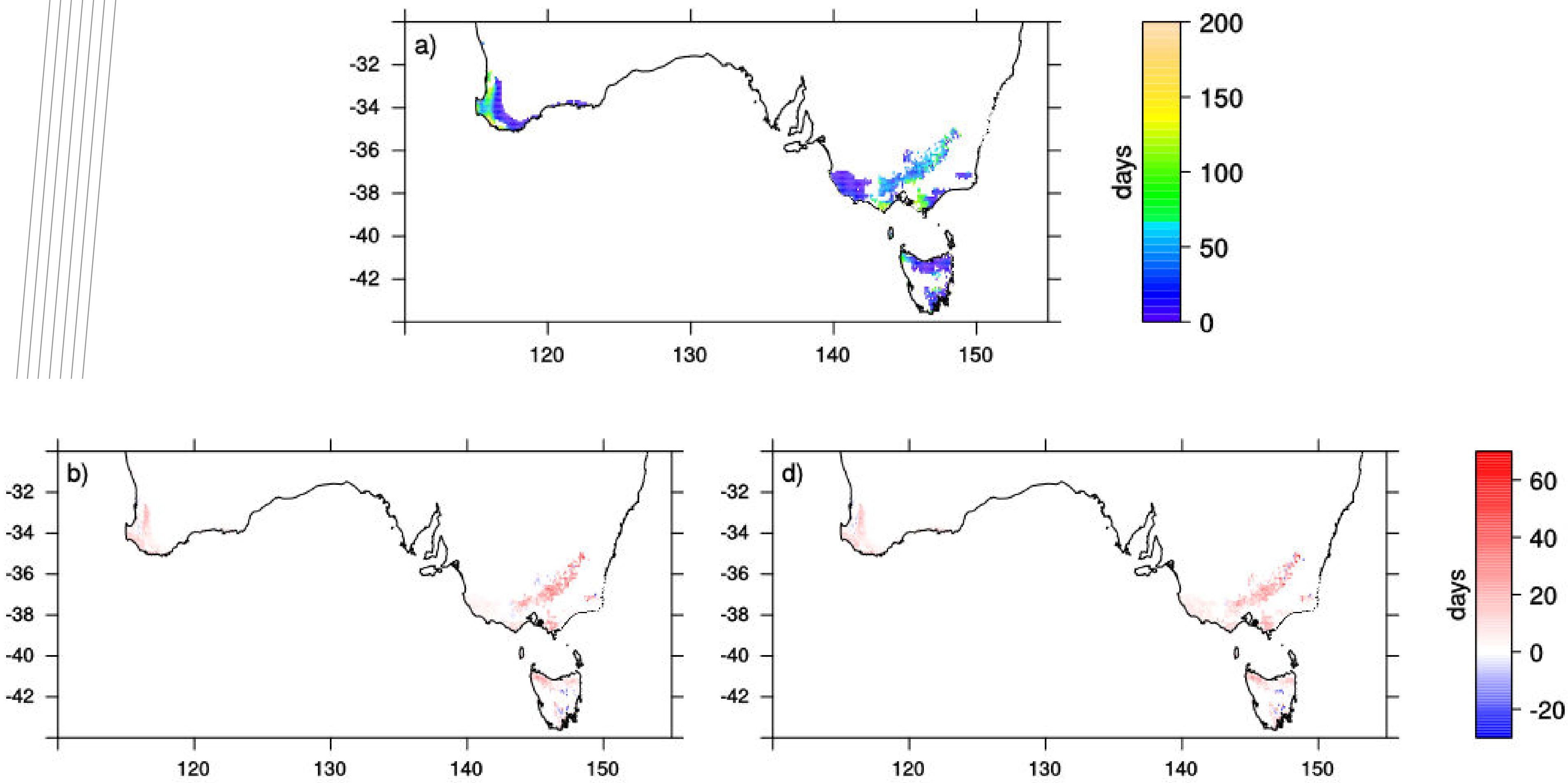




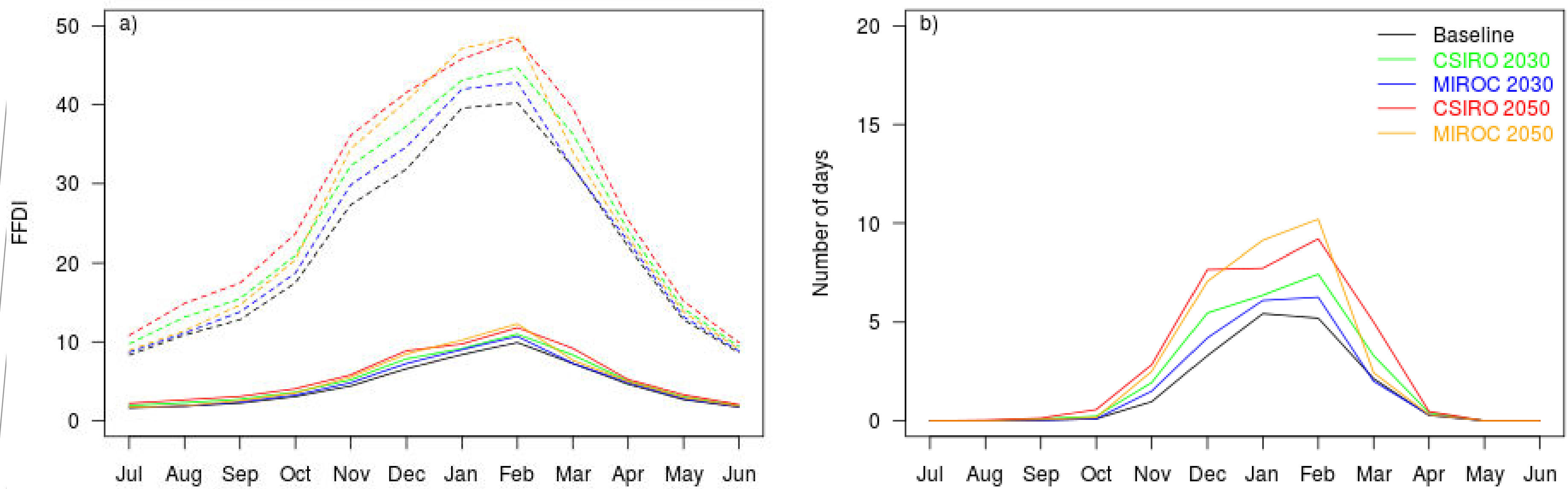
Days with FFDI > 25



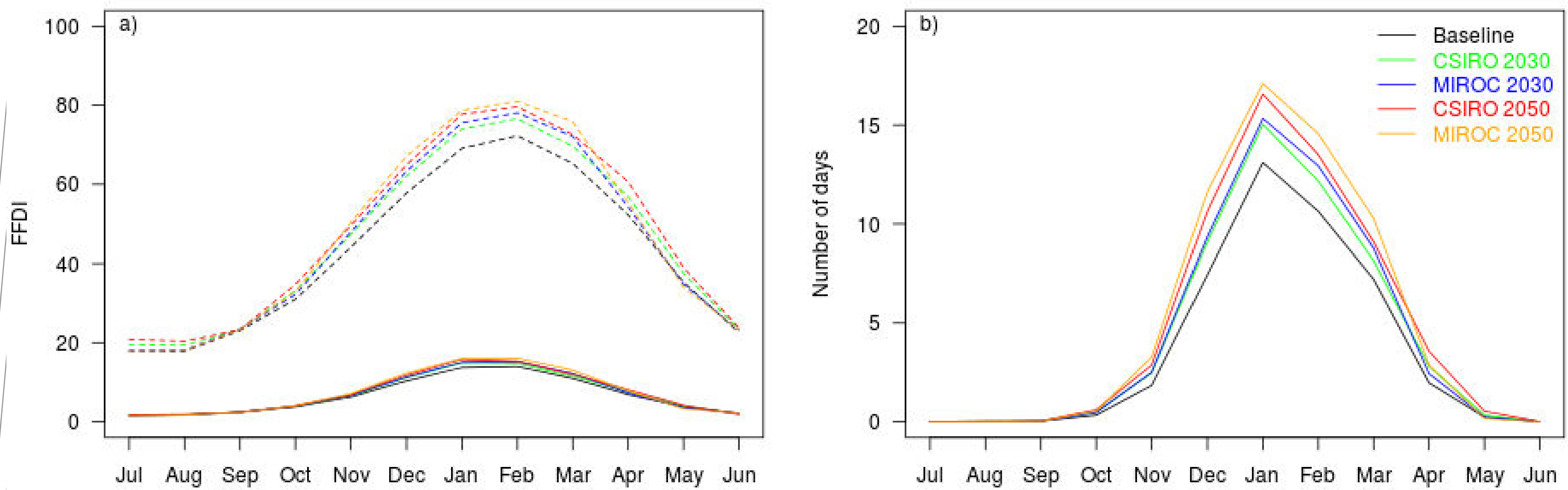
Days with I > 4000 kW/m



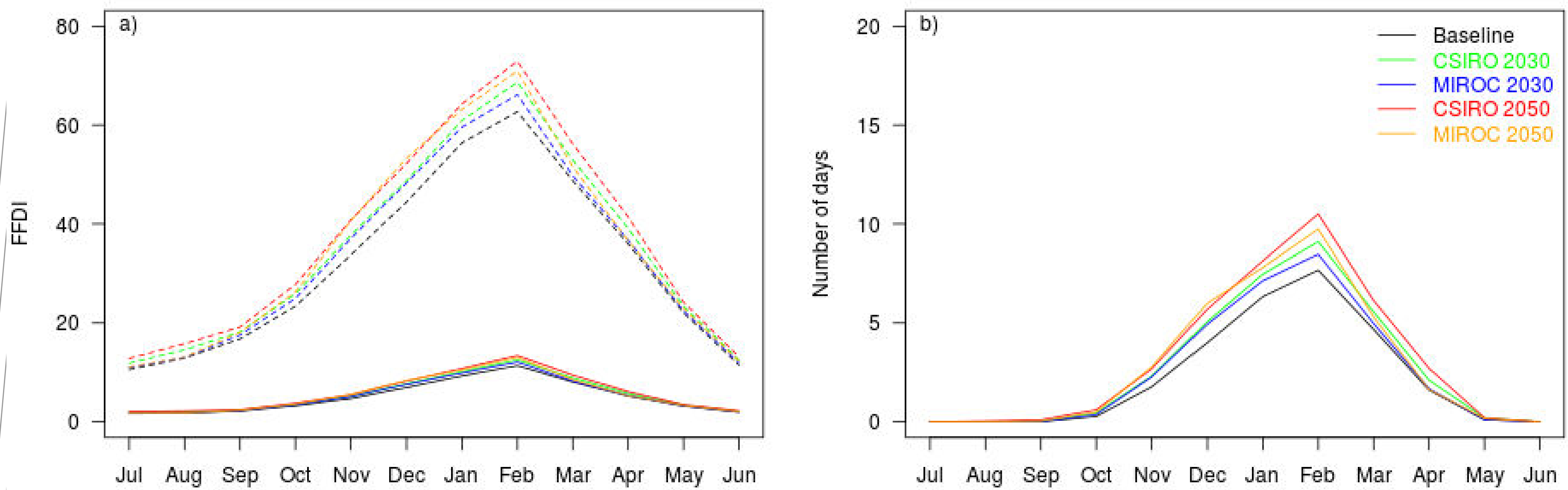
Regional averages – Victoria/NSW



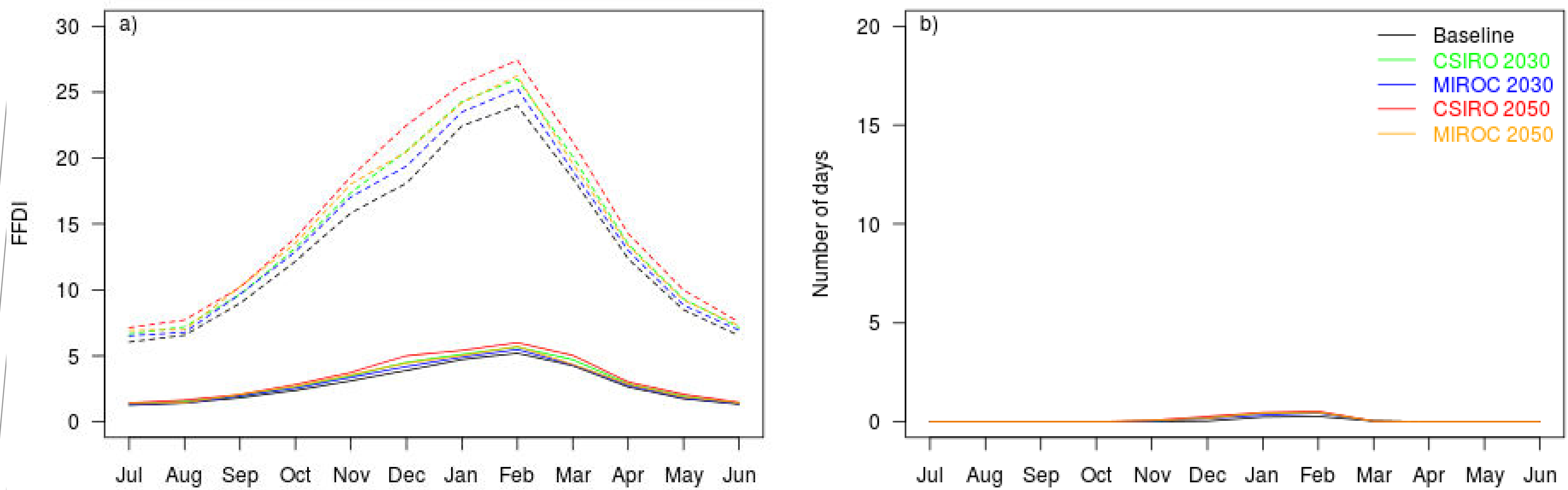
Regional averages – Western Australia



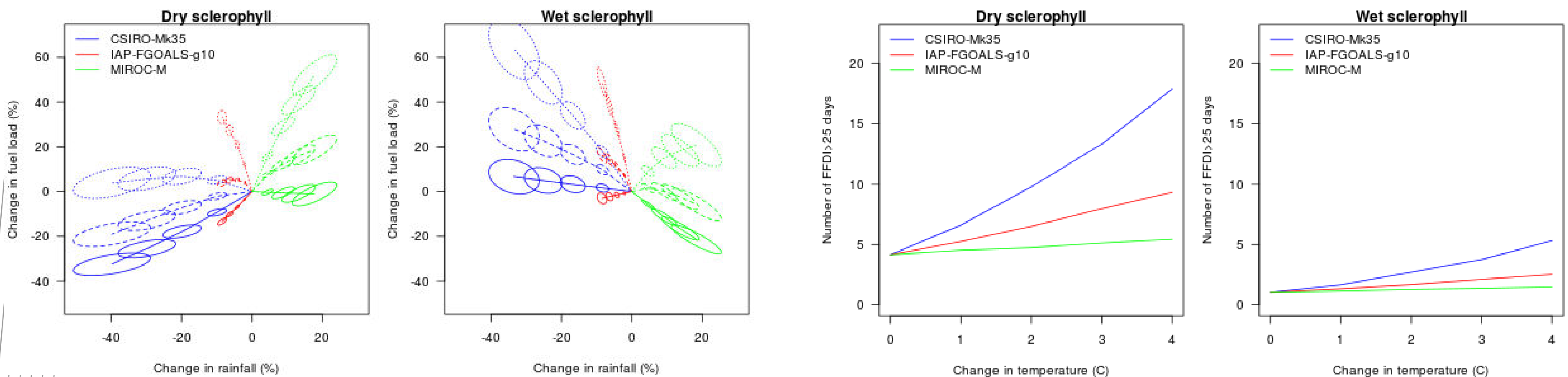
Regional averages – South Australia

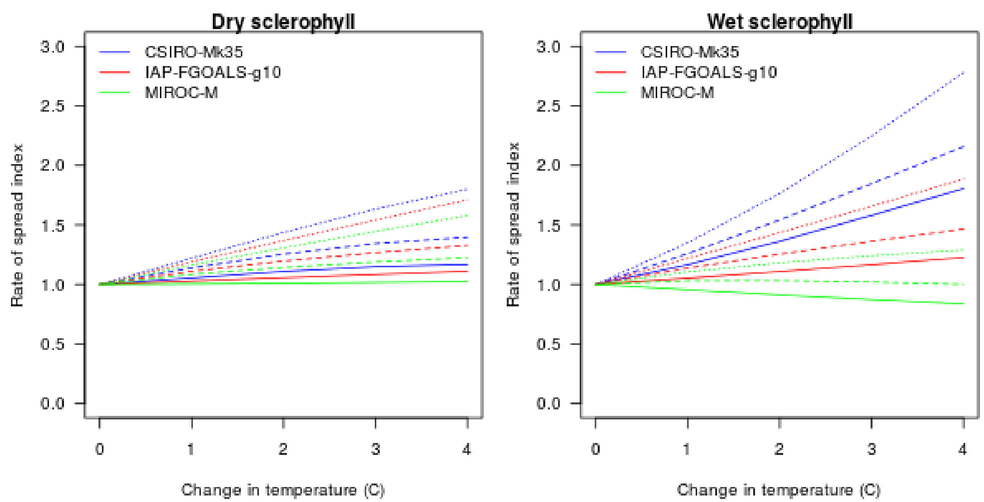


Regional averages – Tasmania



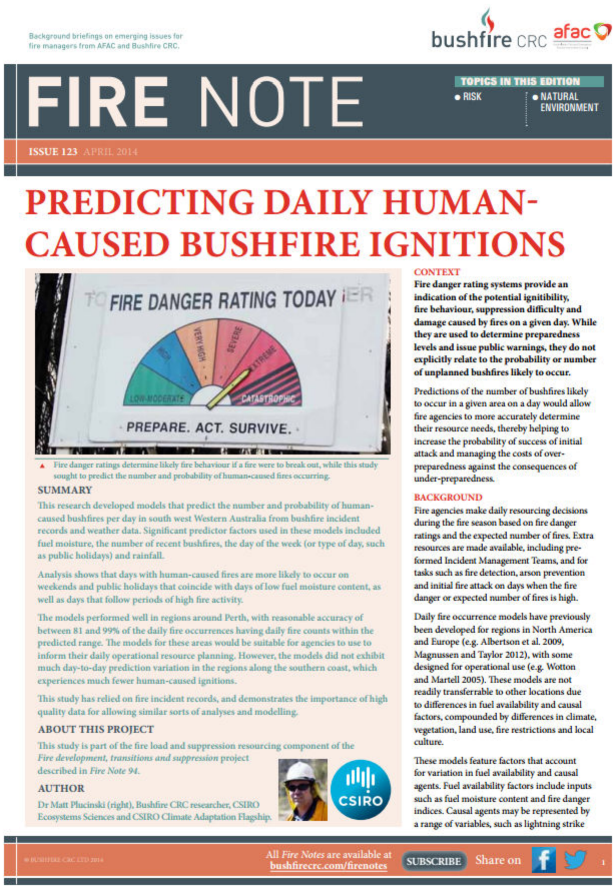
(Bonus) Native forests





Ignition modelling for human caused fires

- Plucinski (2014) for SW WA
- Main factors:
  - Fuel moisture
  - Recent fire activity
  - Weekends
  - Rain


Background briefings on emerging issues for fire managers from AFAC and Bushfire CRC.

bushfire CRC afac

FIRE NOTE

TOPICS IN THIS EDITION
- RISK
- NATURAL ENVIRONMENT

ISSUE 123 APRIL 2014

PREDICTING DAILY HUMAN-CAUSED BUSHFIRE IGNITIONS

▲ Fire danger ratings determine likely fire behaviour if a fire were to break out, while this study sought to predict the number and probability of human-caused fires occurring.

SUMMARY

This research developed models that predict the number and probability of human-caused bushfires per day in south west Western Australia from bushfire incident records and weather data. Significant predictor factors used in these models included fuel moisture, the number of recent bushfires, the day of the week (or type of day, such as public holidays) and rainfall.

Analysis shows that days with human-caused fires are more likely to occur on weekends and public holidays that coincide with days of low fuel moisture content, as well as days that follow periods of high fire activity.

The models performed well in regions around Perth, with reasonable accuracy of between 81 and 99% of the daily fire occurrences having daily fire counts within the predicted range. The models for these areas would be suitable for agencies to use to inform their daily operational resource planning. However, the models did not exhibit much day-to-day prediction variation in the regions along the southern coast, which experiences much fewer human-caused ignitions.

This study has relied on fire incident records, and demonstrates the importance of high quality data for allowing similar sorts of analyses and modelling.

ABOUT THIS PROJECT

This study is part of the fire load and suppression resourcing component of the *Fire development, transitions and suppression* project described in *Fire Note 94*.

AUTHOR

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CONTEXT

Fire danger rating systems provide an indication of the potential ignitibility, fire behaviour, suppression difficulty and damage caused by fires on a given day. While they are used to determine preparedness levels and issue public warnings, they do not explicitly relate to the probability or number of unplanned bushfires likely to occur.

Predictions of the number of bushfires likely to occur in a given area on a day would allow fire agencies to more accurately determine their resource needs, thereby helping to increase the probability of success of initial attack and managing the costs of over-preparedness against the consequences of under-preparedness.

BACKGROUND

Fire agencies make daily resourcing decisions during the fire season based on fire danger ratings and the expected number of fires. Extra resources are made available, including pre-formed Incident Management Teams, and for tasks such as fire detection, arson prevention and initial fire attack on days when the fire danger or expected number of fires is high.

Daily fire occurrence models have previously been developed for regions in North America and Europe (e.g. Albertson et al. 2009, Magnussen and Taylor 2012), with some designed for operational use (e.g. Wotton and Martell 2005). These models are not readily transferrable to other locations due to differences in fuel availability and causal factors, compounded by differences in climate, vegetation, land use, fire restrictions and local culture.

These models feature factors that account for variation in fuel availability and causal agents. Fuel availability factors include inputs such as fuel moisture content and fire danger indices. Causal agents may be represented by a range of variables, such as lightning strike

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Climate and lightning caused fires

- Dowdy et al. (2013)
- Satellite lightning records
  - 1995-2011
- Correlation to El Niño
- Future = ?
  - USA work suggests more

EXTENDED ABSTRACT ONLY

Modelling the impact of climate change on lightning ignition of bushfires

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Abstract: Fires ignited by lightning ('lightning-fires') typically burn a larger area of land than fires ignited by other sources, due to lightning often occurring in large temporal and spatial clusters in remote regions that are sparsely populated and difficult for response personnel to access. Lightning-fires can also have catastrophic impacts on densely populated regions, such as was the case for the January 2003 Canberra fires. However, few studies have attempted to model the occurrence of lightning-fires, particularly in Australia. Additionally, very little is known about the influence of climate change on lightning-fires. These knowledge gaps are currently being examined, with results presented here, by a project within the Australian Climate Change Science Program.

High-based thunderstorms with dry air at lower levels were previously found to provide a good indication of a high risk of lightning-fire occurrence in Victoria. Additionally, a variety of other potential factors were found to influence the temporal and spatial variability of the risk of lightning-fire occurrence, including the influence of atmospheric conditions (at the surface and above), fuel characteristics (moisture content, size/depth and type) and dry-lightning (lightning that occurs without significant rainfall).

Building on this previous research, subsequent investigations have recently been undertaken to model the risk of lightning-fire occurrence, for potential application to coarse resolution data (e.g. global climate models). Initial results from these investigations consider seasonal differences in Pearson correlation coefficients between monthly anomalies of lightning flash densities and the NINO3.4 index (as a measure of the El Niño/Southern Oscillation: ENSO). Lightning flash data were obtained from two NASA satellite sensors: the Lightning Imaging Sensor (LIS) and the Optical Transient Detector (OTD) based on a monthly gridded time series product (named "LISOTD_LRMTS") during the time period from 1995 to 2011. The spatial resolution of the lightning data is 2.5 degrees in both latitude and longitude, although prior to being released for public use the data are smoothed with a 7.5°×7.5° and 111-day boxcar moving average. The geographic study region used here covers all longitudes throughout Australia, and ranges in latitude from 38.75°S to 38.75°N due to the field of view of the LIS sensor. The NINO3.4 index data were obtained from the Climate Prediction Centre (CPC) of the National Oceanic and Atmospheric Administration (NOAA).

Significant relationships occur between lightning activity and the NINO3.4 index in each of the four seasons for different regions throughout Australia, with a significant correlation at the 95% level (corresponding to $|r| \geq 0.43$). Previous studies have examined the relationship between ENSO and lightning activity in various different regions throughout the world, although this is the first time that this relationship has been examined for four individual seasons throughout the year, including with a specific focus on the Australian region. We have shown here that large-scale phenomena, such as ENSO, can have a significant influence on the seasonal lightning climate of Australia. Information such as this (i.e. knowledge about the factors that influence the chance of lightning occurrence) could be combined with information relating to the chance of fire given the occurrence of lightning, to undertake climatological investigations of lightning-fire occurrence. An improved ability to model lightning-fires could be expected to produce benefits such as a reduction in the response time to these fires and thus a reduction in the damage that they cause. It is also expected to lead to an improved ability to model carbon budgets, given that lightning-fires are responsible for a large proportion of annual carbon dioxide emissions.

Keywords: *Fire, lightning, climate, extreme weather*

Adapting

Risk factor	Strategy	Comment
Fire weather	Regional response plans	Climate change is expected to change the frequency and intensity of fires but not the nature of fire
Fuel loads	Clean up debris Prune branches Weed control	May be a strategy for high risk areas
Fire spread	Landscape design to limit fire spread and aid suppression	Opportunities to avoid fire by relocating plantation estate were not identified

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