Long-range fire weather predictions for Australia

ERP14 Project – BoM, CFA, BNHCRC, DELWP (Safer Together program)

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Overview

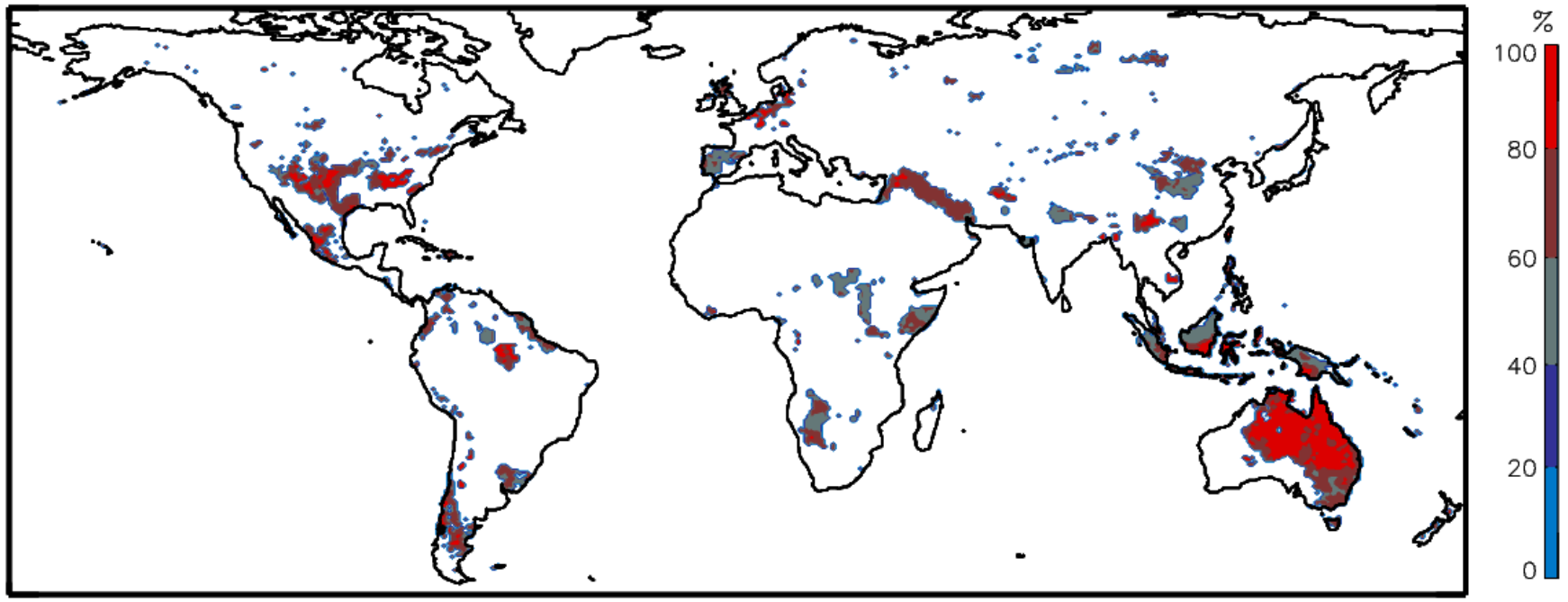
- New capability for Australia: predicting dangerous bushfire conditions more than one week ahead (weeks, months & seasons).
- Previously, long-range fire outlooks used temperature and rain individually: new modelling system combines humidity, wind, temperature and rain, with observations for fuel moisture.
- Long-range fire weather predictions are now being provided to fire agencies, including trialled over the past two summers.
- Component of broader development of 'seamless' predictions over different time scales, for various hazards (e.g., thunderstorms, dry lightning).

Motivation

Initial research showed high percentage of correct predictions 3 months ahead

(based on predictions of Fire Weather Index values above median)

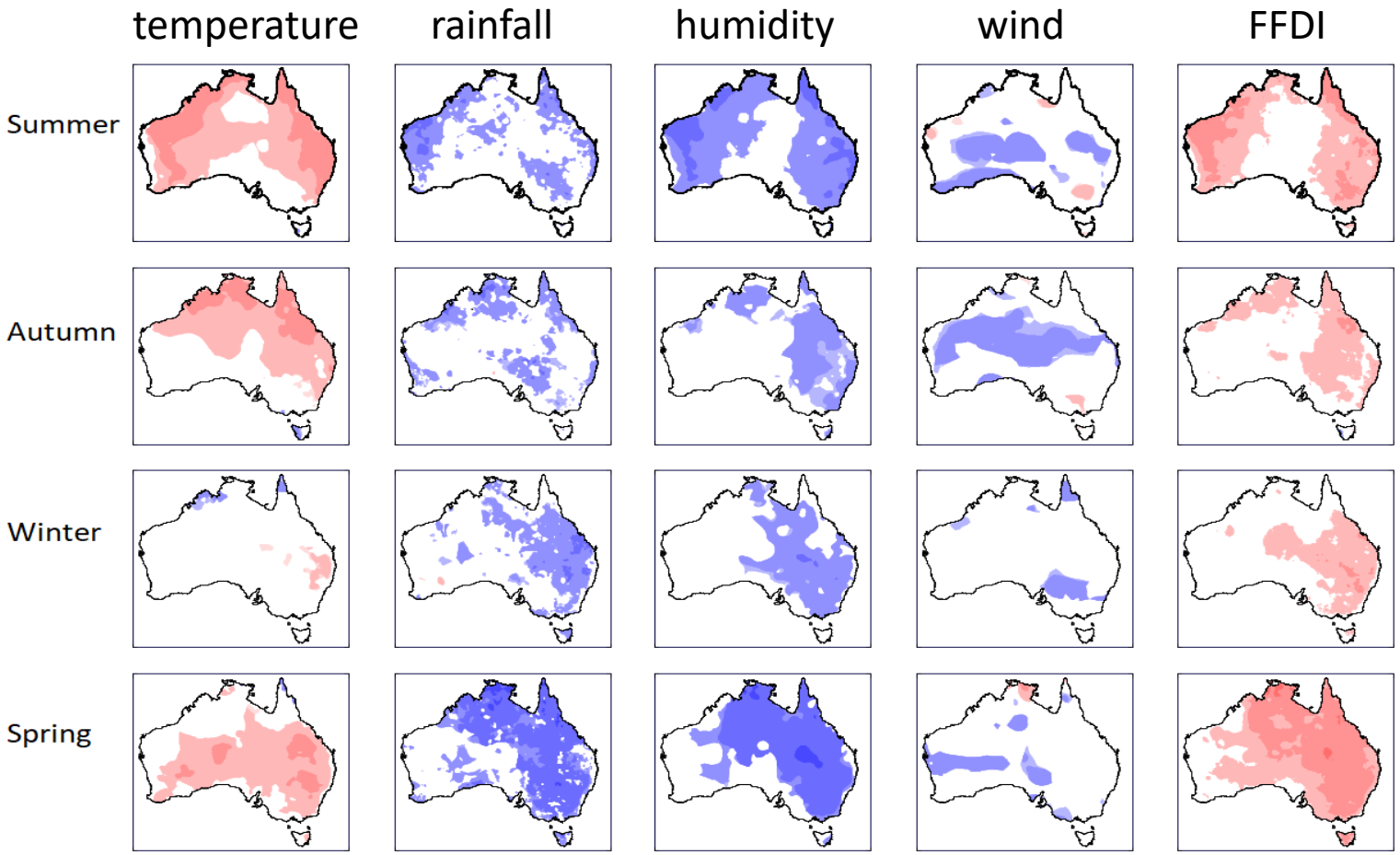
Accuracy of seasonal prediction of fire weather, for the months September-November.



Reference: ntrs.nasa.gov/citations/20170003345

Why are long-range fire predictions skilful in Australia?

Large-scale atmospheric and oceanic modes of variability (El Niño/Southern Oscillation, Indian Ocean Dipole, etc.)



El Niño Southern Oscillation example (based on the correlation with NINO34 index):

Red = positive correlation (lower values in La Niña and higher values in El Niño)

Blue = negative correlation (higher values in La Niña and lower values in El Niño

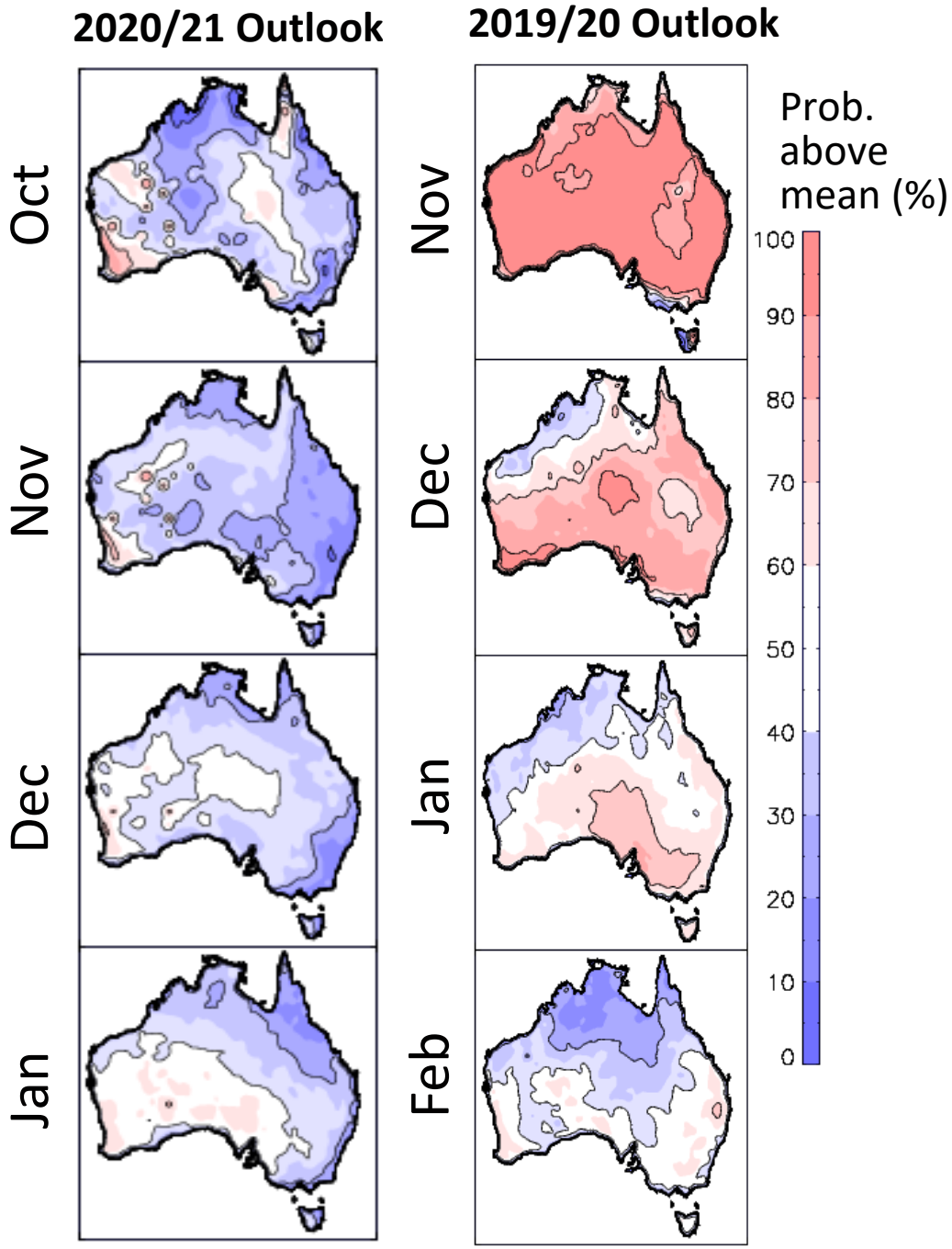
Indices such as Forest Fire Danger Index (FFDI) combine these factors

Outlooks delivered to fire agencies prior to recent summers

- **Probability of FFDI being higher than average.**
- **Red is above average, Blue is below average**

Method details:

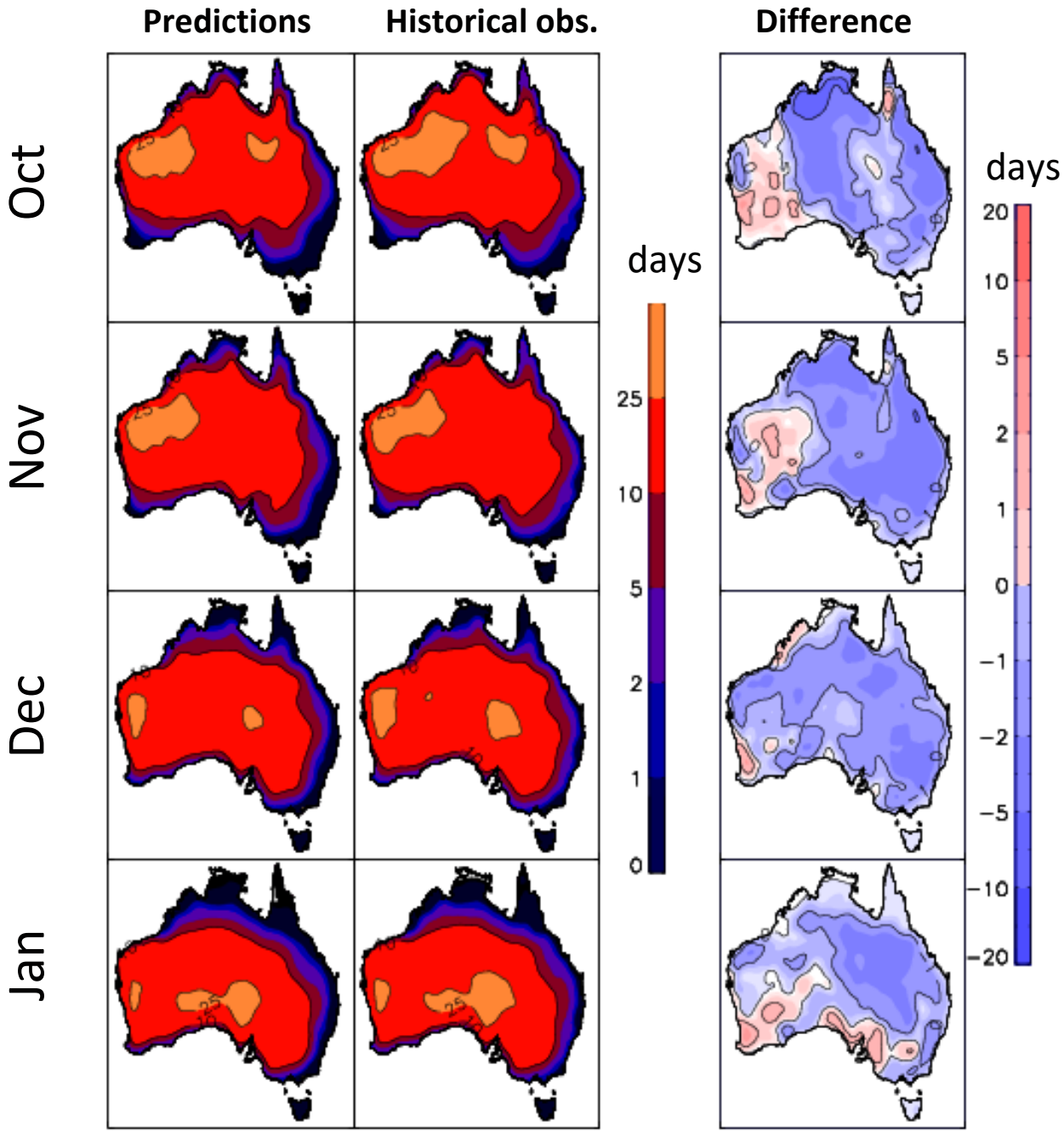
- Based on daily 5-km grids from ACCESS-S model (from 1 Oct. 2020, with 99-member ensemble) and fuel moisture initialised from observations (with Drought Factor based on Keetch-Byram Drought Index: KBDI).
- Probability based on percentage of model ensemble members that exceed the mean for 1990-2012 based on observations.
- Consistent 'seamless' predictions (calibrated to observations).
- Intended to be interpreted regionally, with FFDI as a generalised way to combine humidity, wind, rain and temperature.



Number of Very High fire danger days (FFDI > 25)

Predictions for last summer, compared to historical observations for those months:

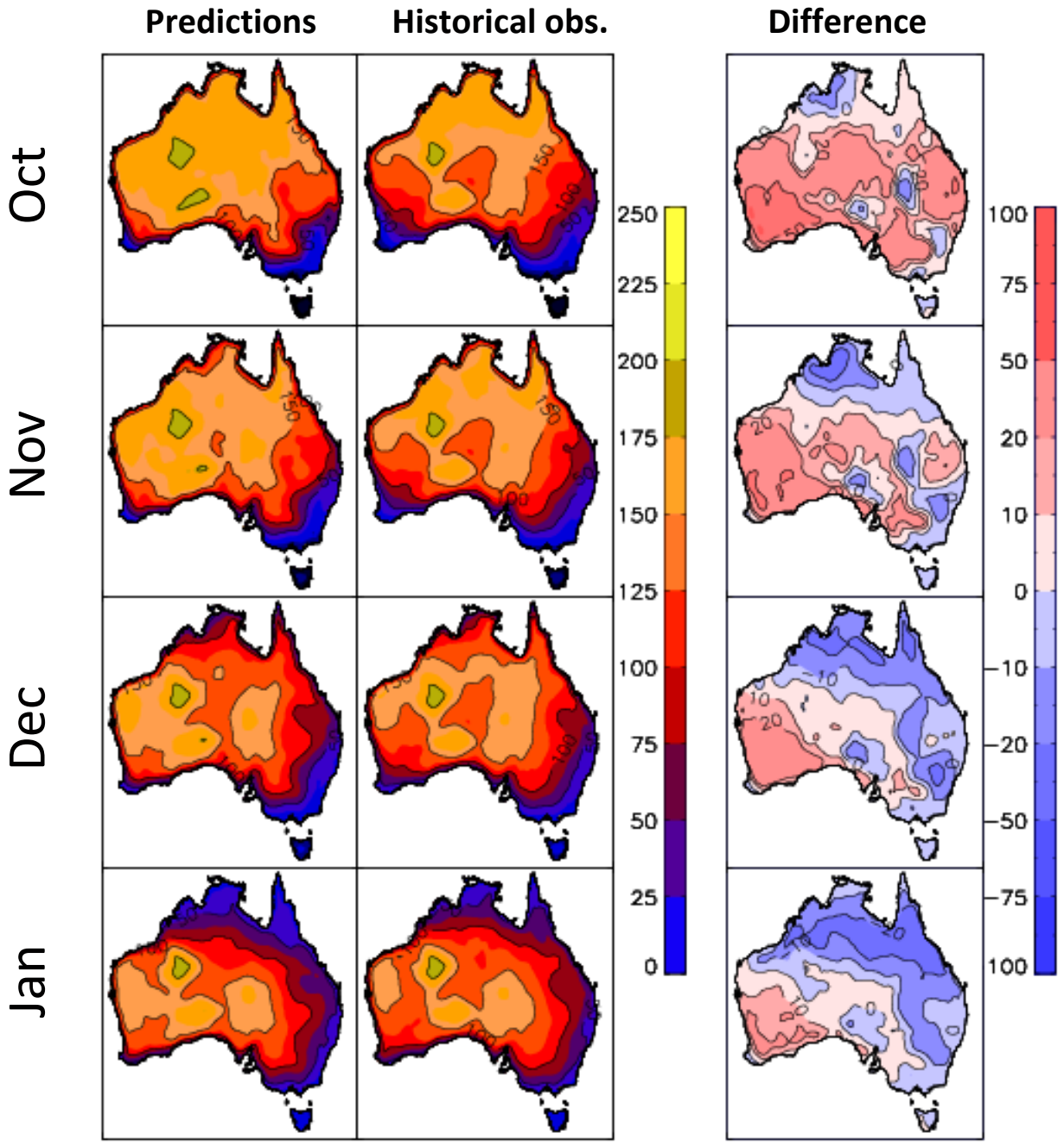
- Model correctly simulates the general spatial features and how these vary for different months.
- Fewer days with FFDI > 25 (based on comparison to historical observations for these months).



Soil moisture (for fuel moisture)

KBDI used as input to Drought Factor

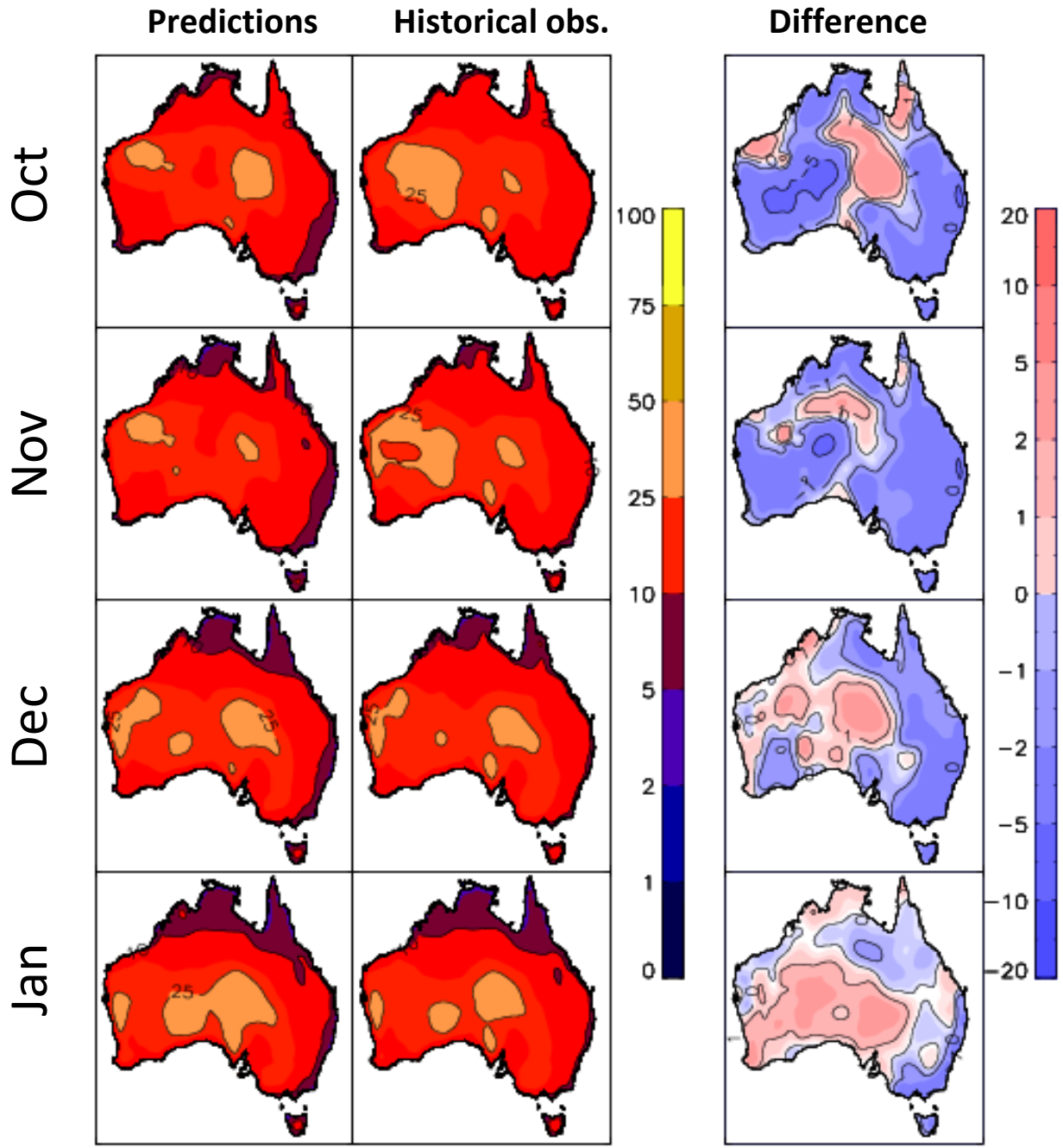
(as part of FFDI formulation)



Grassland Fire Danger Index (GFDI)

- Shown here for 100% curing and fuel load of 4.5 t/ha

- Also calculated for variations (e.g., 75% curing)

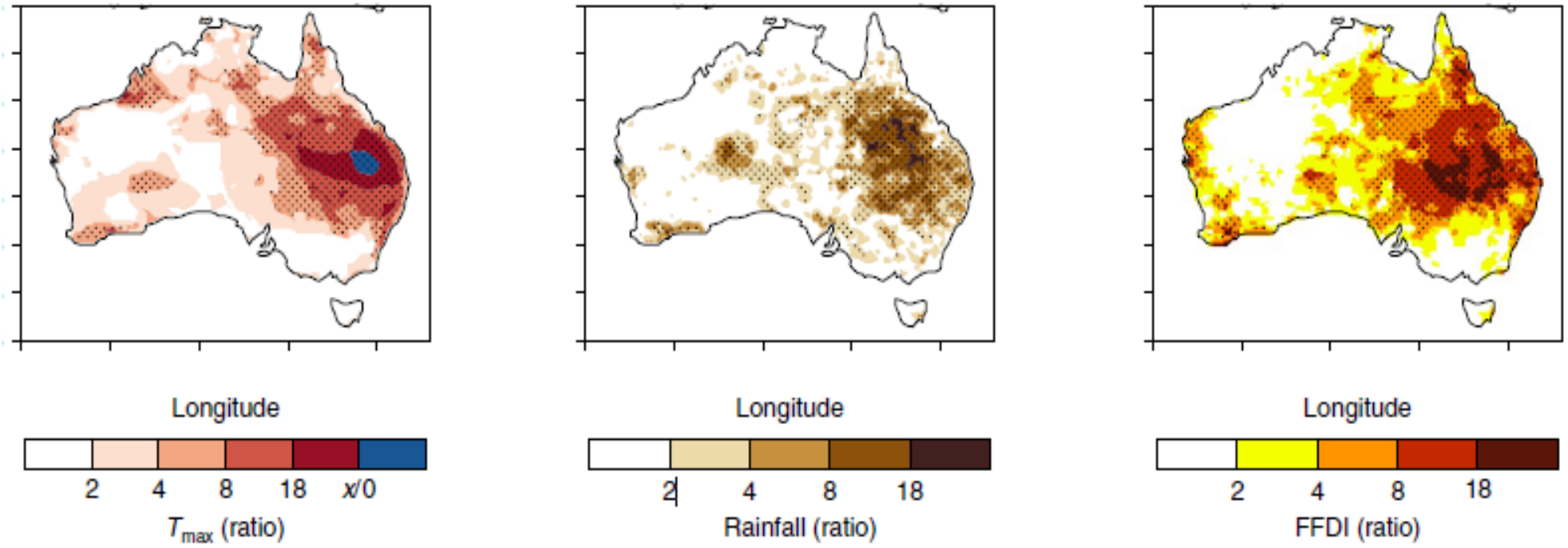


Why was the Black Summer predicted to be so severe?

Stratospheric polar vortex was one factor:

- Major contributor to severity of Black Summer fire conditions, together with the long-term drought, positive Indian Ocean Dipole (IOD) and climate change.
- The conditions might have been worse if a strong El Nino event had also occurred.

Changes in the likelihood of extreme high T_{max}, low rainfall and high wildfire danger during polar vortex weakening years

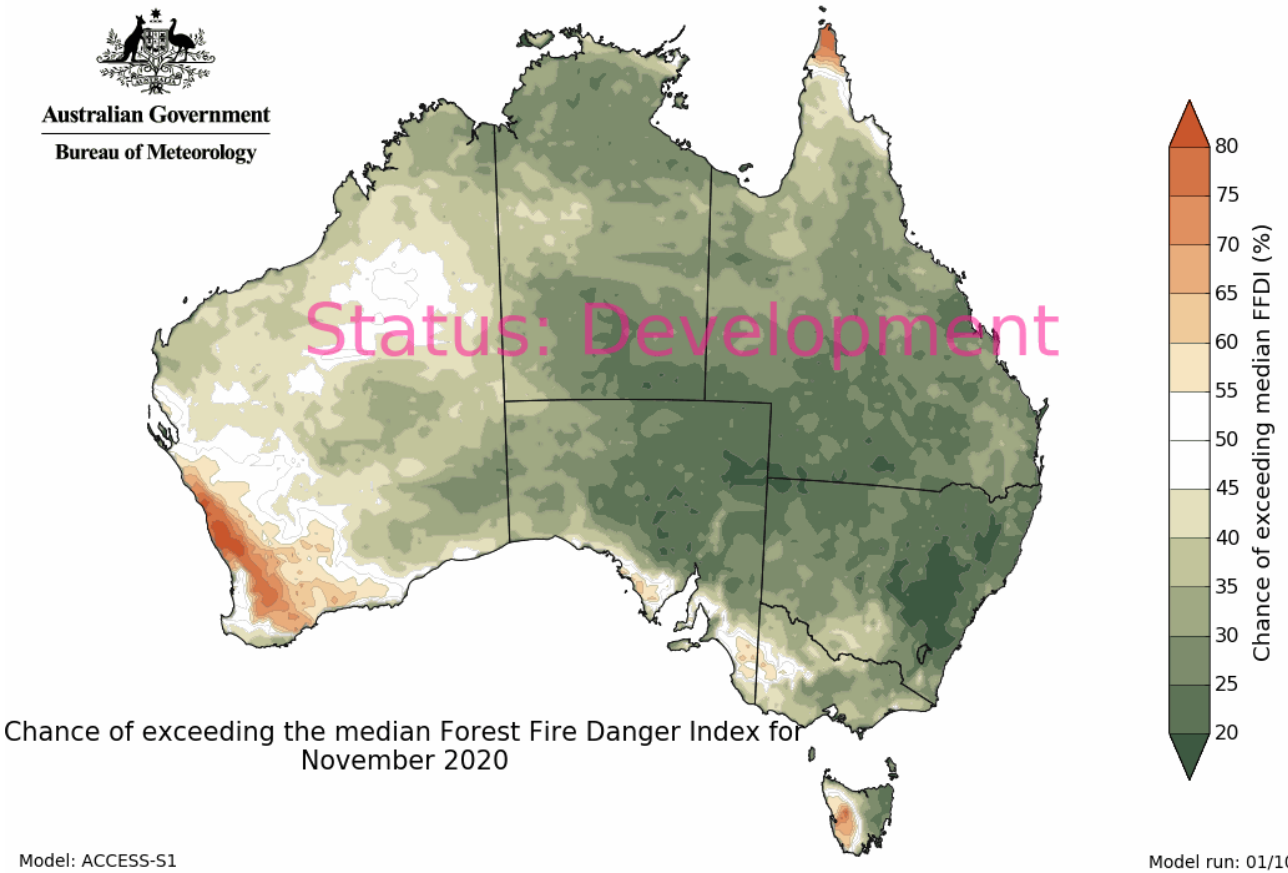


Reference: Lim et al. 2019 *Nature Geoscience*.

Automated products - and development of presentation styles

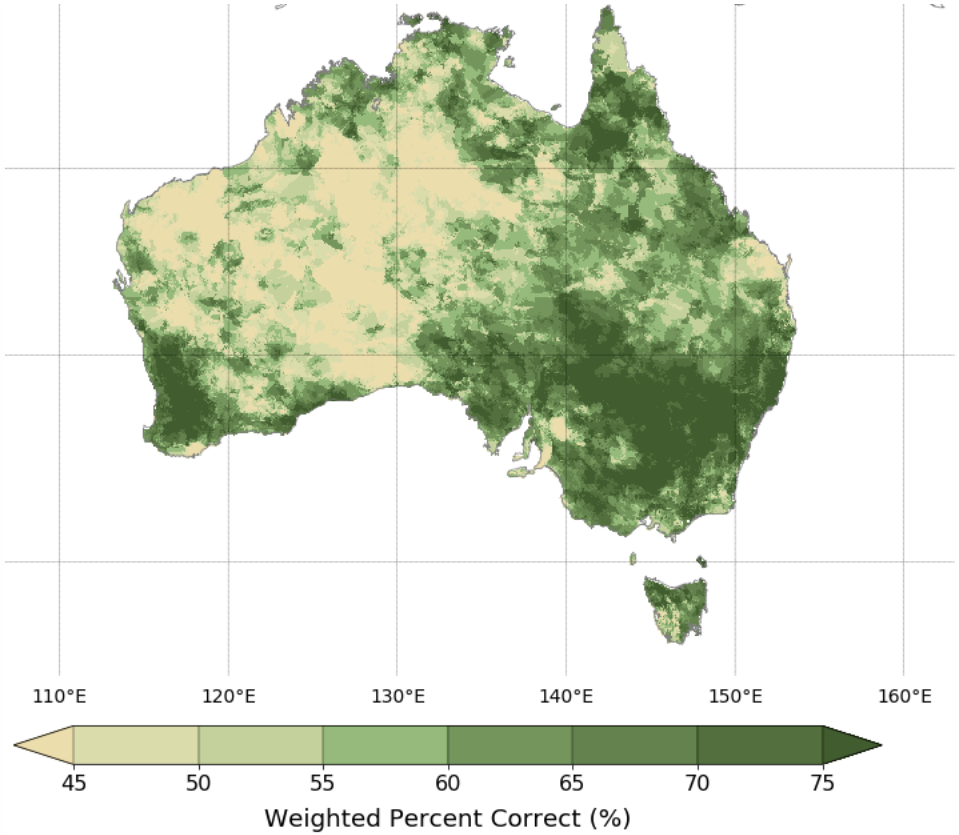
Real time

November 2020 Outlook
(based on model run 1 October 2020)



Hindcasts

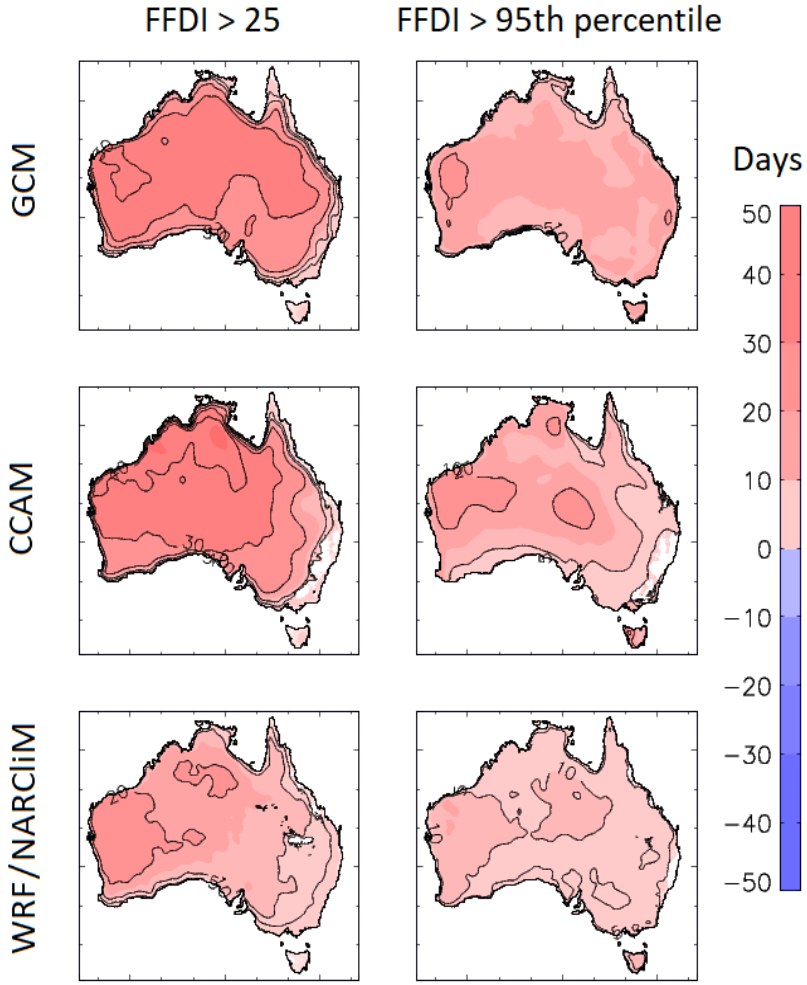
Predictive skill for November
(based on 1 October model runs 1990-2012)



Broader capability: predicting hazards over different time scales

Fire weather data available for each day (5 km grid)

- back to 1950 based on observations (www.bom.gov.au/jsp/ncc/climate_averages/ffdi)
- multi-week to seasonal predictions (from this project)
- climate change projections throughout this century (see Figure)



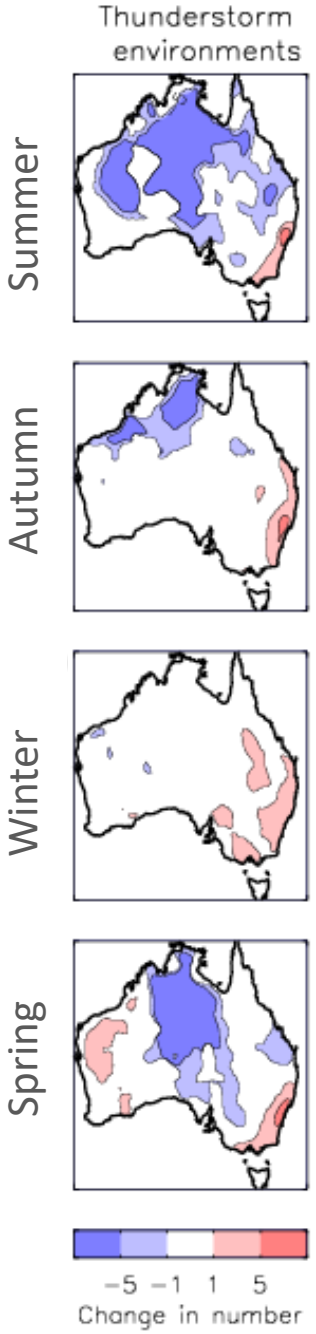
Future change in the number of days with dangerous conditions (2060:2079 - 1990:2009, for high emissions)

Projections for three different ensembles (using different downscaling approaches) and two measures of severity.

Reference: https://www.nature.com/articles/s41598-019-46362-x

Thunderstorms

- Unlike fire weather, climate drivers (e.g., El Nino/Southern Oscillation and Indian Ocean Dipole) have little influence on thunderstorms and lighting in Australia
  (e.g., https://www.nature.com/articles/srep20874).
- Long-range prediction not possible at the moment for Australia.
- Influence of climate change on lightning largely uncertain.
- Some evidence for long-term change in number of dry lightning days, including increases in parts of southeast Australia
  (reference https://doi.org/10.1007/s00382-020-05167-9).



Climate hazards – from research to outcomes

Climate research on fires, TCs, ECLs, thunderstorms and associated extremes (wind, heat, rainfall) used in many ways:

- For AFAC's Discussion Paper on climate hazards, leading to changes in practises (enhanced decision making and adaptation).
- Used for Royal Commission, State of the Climate, IPCC and sectors such as energy (ElectraNet, AEMO), environment (GBRMPA, World Heritage), state/federal gov. (PM briefings, Senate Estimates, QoN), health sector (fire/smoke, lightning, asthma), finance sector, planning (Standards Australia), …
- Series of summary brochures distributed to wide range of user groups including fire agencies: http://nespclimate.com.au/new-information-on-extreme-weather-and-natural-hazards-in-our-changing-climate/

Summary

- **New capability developed of long-range fire weather prediction in Australia.**
- **Contributes to broader set of seamless hazard services:**
  - Multi-week to seasonal predictions consistent with observations, as well as with climate change projections.
- **Seasonal predictions from this project are being delivered to fire agencies.**
- **The project results are also being built on through ACS and AFDRS projects for operationalisation in next steps.**