Subseasonal-to-Seasonal Prediction of Heat Waves: Definitions and Dynamics

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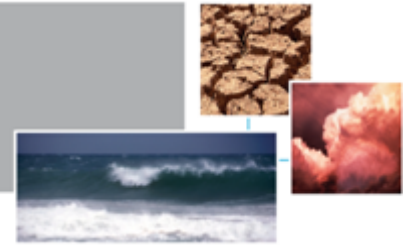
David Jones, Andrew Watkins, Michael Pook, James Risbey

Australian Government
Bureau of Meteorology

CSIRO

Increasing demand



Improving subseasonal predictions (Oct 2009-Sept 2012)

Subseasonal prediction of heat extremes (Jan 2012-Dec 2014)

CliMag

Edition 18 December 2009

Multi-week forecasts will help bridge the gap

When it comes to weather and climate forecasts, farmers will take all the information they can get.

Forecasts currently available to farmers tell them about the specific weather in the week ahead, or the expected climate for the full 3-month season ahead. But more detail about expected variations in weather in the fortnight or month ahead would help farmers make better farm management decisions.

Susan Carn and her husband manage a dryland merino sheep farm with occasional wheat and barley crops in Quorn in South Australia's Flinders Ranges. Being totally reliant on rainfall, every decision they make hedges on predicting how much rain will fall, and when.

Susan Carn, Quorn, South Australia

'We're pretty cautious. I start looking at the long-range forecast in March, three months ahead, to see how the season looks like panning out', says Susan. 'We need to decide how much stock to keep or, if it looks promising, we might buy more stock. With crops, if it looks good on the long-range forecast we'll plant some crop and spend money on fertiliser. If it's not looking good, we won't sow much, if any; we're in marginal country, so we have to be conservative.'

There are two main limitations with the traditional suite of forecasts currently available to farmers like Susan Carn:

- The gap between the 7-day weather forecast and the 3-month seasonal forecast limits the planning decisions farmers need to make on a fortnightly or monthly basis.
- Seasonal forecasts are based on historical records, using statistics about past weather patterns to predict what will happen this season. As a result, statistical models do not perform as well when faced with rare or unprecedented conditions, a situation we are increasingly seeing with climate change.

A new forecasting tool in its early stages of development by the Bureau of Meteorology will help overcome these two limitations. Rather than relying on historical weather statistics, the Predictive Ocean Atmosphere Model for Australia (POAMA) uses global circulation models to predict the weather and climate for the coming months.

Forecasters enter information about the current state of the oceans and the atmosphere into the model which then forecasts the probabilities of the weather and climate being different from typical conditions. For example, the model can calculate the chances of the total rainfall for a forecast period being above or below the historical average.

The advantage of using a global circulation model is that it naturally takes into account changes in the climate because the forecast is based on today's observations of the atmosphere and the ocean', explains Dr Harry Hendon, one of the developers of POAMA.

[continued on page 2]

In this issue

MANAGING CLIMATE VARIABILITY R&D PROGRAM

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GRDC Grains Research & Development Corporation

mla MEAT & LIVESTOCK AUSTRALIA

Australian Government

Department of Agriculture, Fisheries and Forestry

Rural Industries Research and Development Corporation

Sugar Research and Development Corporation

MANAGING CLIMATE VARIABILITY

MULTI-WEEK FORECASTS MAY BE APPROPRIATE IN CERTAIN REGIONS AT CERTAIN TIMES OF THE YEAR.

Multi-week forecasts to fill the gap

The first science-based multi-week forecasting service for Australia is in development

TO FILL THE gap between seven-day weather forecasts and three-month seasonal outlooks, the Bureau of Meteorology (BoM) and CSIRO are developing multi-week rainfall and temperature forecast products. These products, designed for farmers, will be based on forecasts from Australia's coupled ocean/atmosphere seasonal forecast model – POAMA (see breakout).

Current investments as part of Managing Climate Variability will: assess POAMA's performance in predicting rainfall and temperature two to four weeks in advance; investigate factors that influence the predictability of these forecasts; and identify and develop products to a demonstration stage.

Further investment will be required to make products fully operational and available on the BoM Water and the Land (WATL) website (www.bom.gov.au/watl).

Historically, seasonal forecast models have used fairly simple statistical relationships between rainfall and climate indicators. With climate change, it is unclear how representative these past relationships will be for the future. However, forecasts based on coupled ocean/atmosphere general circulation models, such as POAMA, represent the future of climate forecasting. This is because these models are purely driven by the physics of the atmosphere and ocean, not what happened in the past. As a result, these models are able to represent the full complexity of climate drivers, including the effects of climate change.

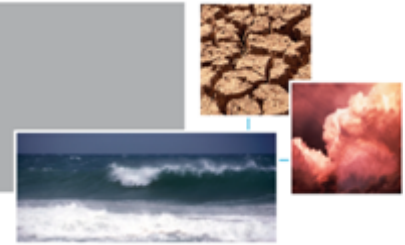
Preliminary analysis of the current operational version of POAMA (version 1.5) has shown that its multi-week forecasts may have substantial skill in certain regions and at certain times of the year, even though POAMA was not specifically designed for this short timescale.

For example, research by Dr Seithuli Asseng, from the CSIRO Climate Adaptation Flagship, has shown that wheat farmers in south-west Western Australia could benefit from using growing-season rainfall forecasts generated by POAMA.

This work showed that when farmers were provided with POAMA forecasts they could make better decisions about when to apply nitrogen fertilisers. For the farmer in WA's southern wheatbelt this resulted in potential returns increasing by more than $50 per hectare a year, when farmers reduced their fertiliser in forecasted below-average years and increased it in above-average years.

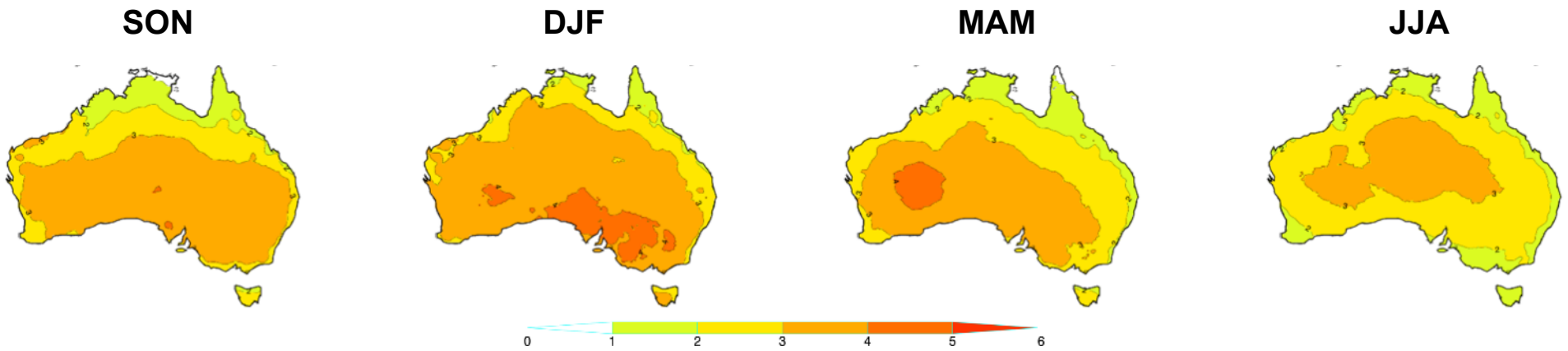
As part of the project led by Dr Debbie Hudson

Two Definitions

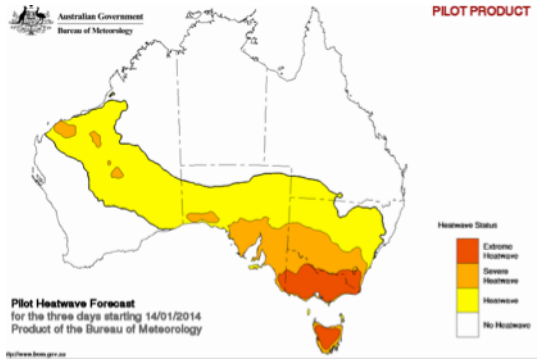


1. Weekly-mean temperature anomalies in highest decile (above the 90th percentile; highest 10% of climatology)

Upper decile thresholds for calculating probability composites (AWAP)



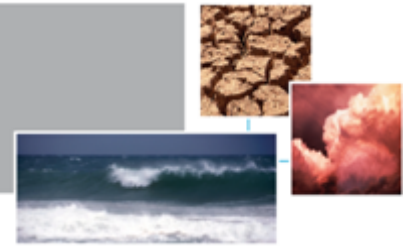
2. Excess Heat Factor (EHF) (Bureau Pilot Heatwave Program since January 2014; Nairn and Fawcett 2013)

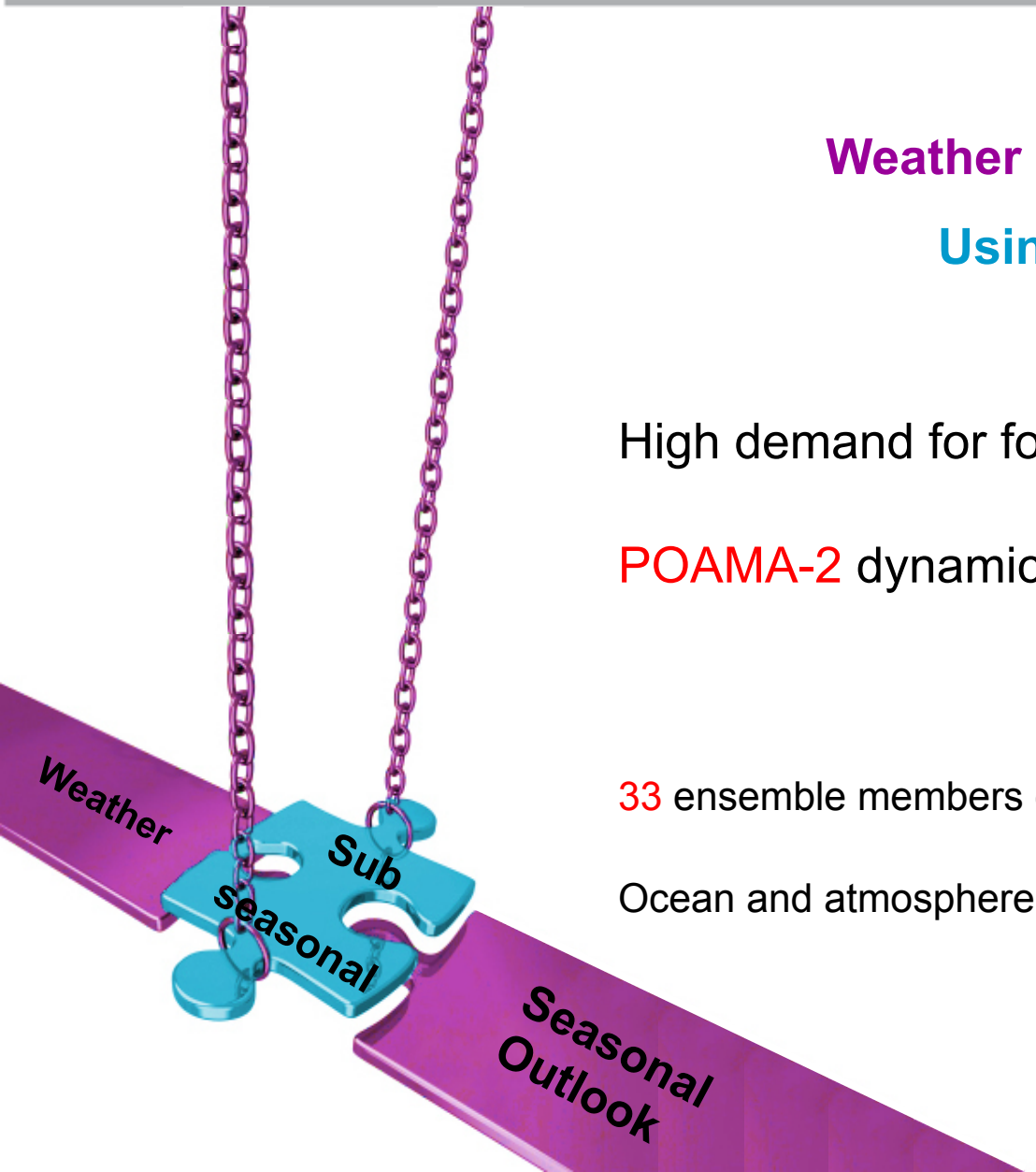


Three days or more of high maximum and minimum temperatures that are unusual for that location.

This includes the degree of acclimatisation over the last 30 days.

Prediction





Weather and climate forecasts for risk management

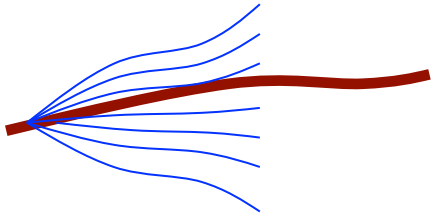
Using POAMA/ACCESS to help fill the gap

High demand for forecast guidance on this timescale (e.g. agriculture)

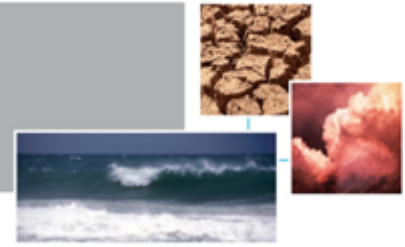
POAMA-2 dynamical subseasonal-to-seasonal prediction

33 ensemble members on 1st, 6th, 11th 16th, 21st & 26th of month (multi-model), 1981-2010

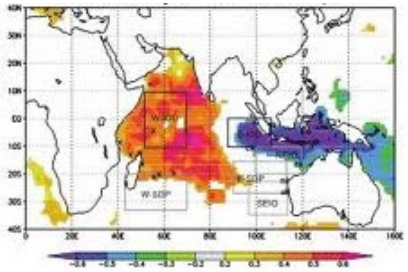
Ocean and atmosphere perturbations from Coupled Ensemble Initialisation Scheme (breeding)



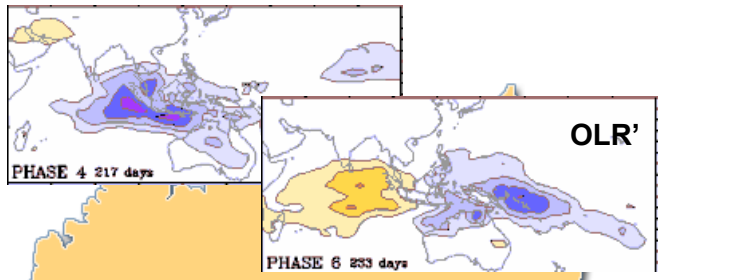
Drivers



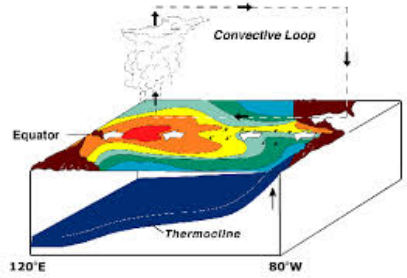
IOD



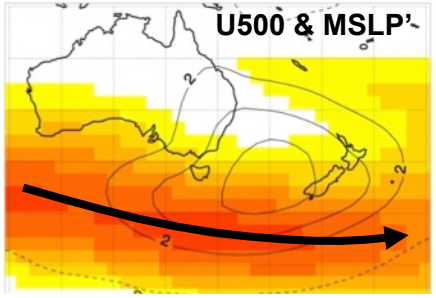
MJO



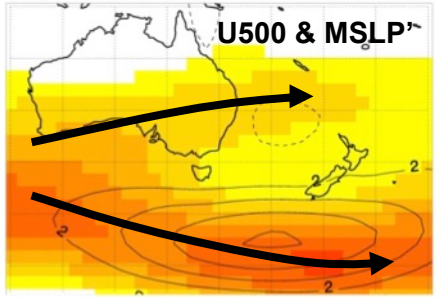
ENSO



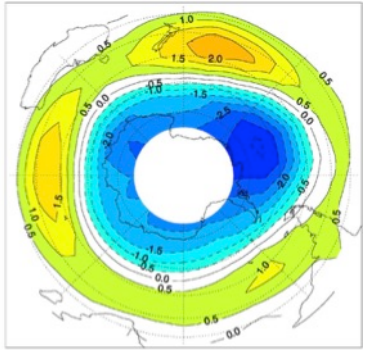
STR high
H
(Tasman)



Split-flow
H
blocking

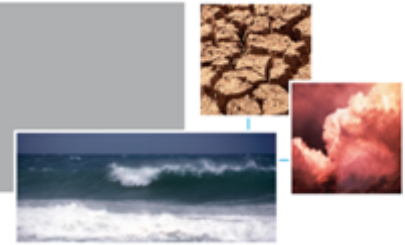


MSLP EOF1



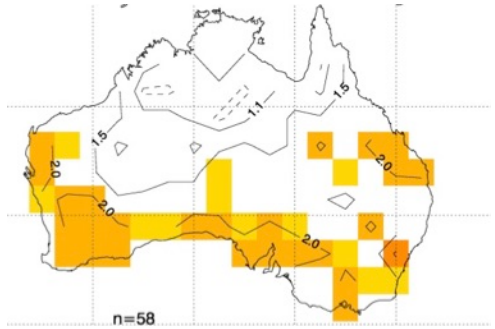
SAM

Capturing the links: e.g. SAM, MJO, STRH

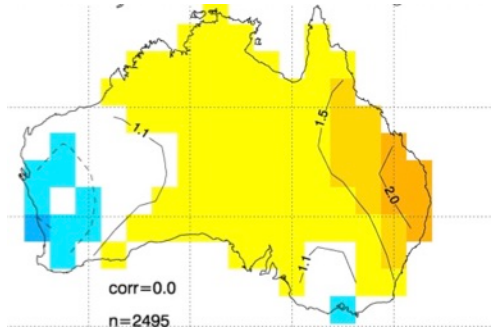


Negative SAM phase (SON)

OBS

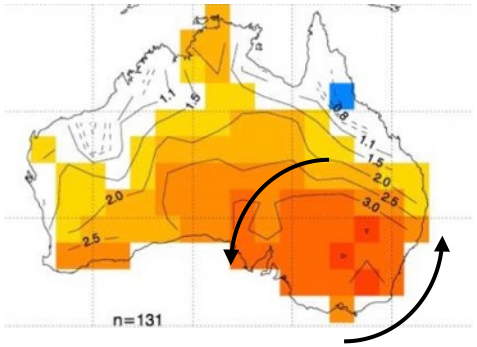


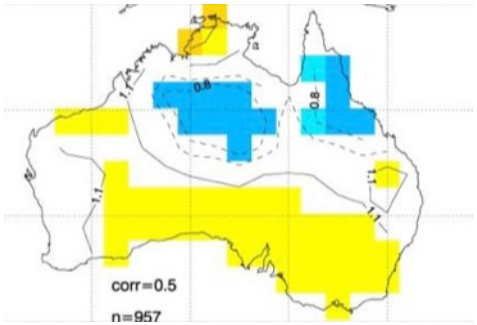
POAMA-2



- Equatorward shift of the midlatitude westerly wind belt
- Reduced mean rainfall and cloud, enhanced daytime warming

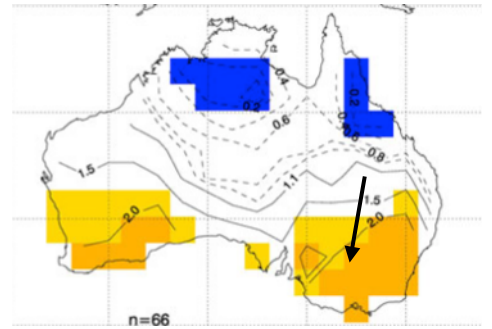
MJO phase 3 (SON)

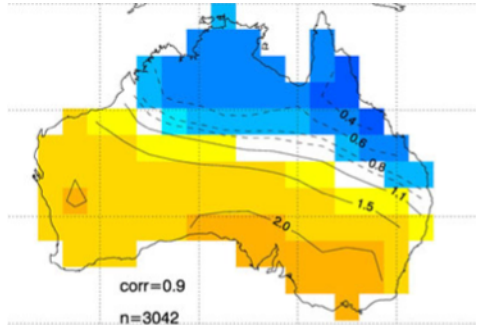




- Remote teleconnection to easterly tropical anomalies - strong anticyclone over SE Aus
- Reduced rainfall, increased temp

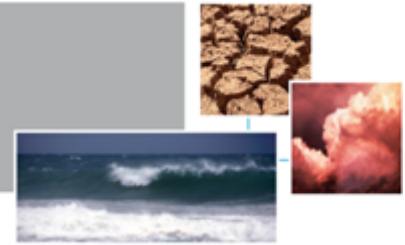
Persistent STR Tasman High (JJA)





- Anticyclone to the east provides northerly anomalous flow to south-eastern Australia

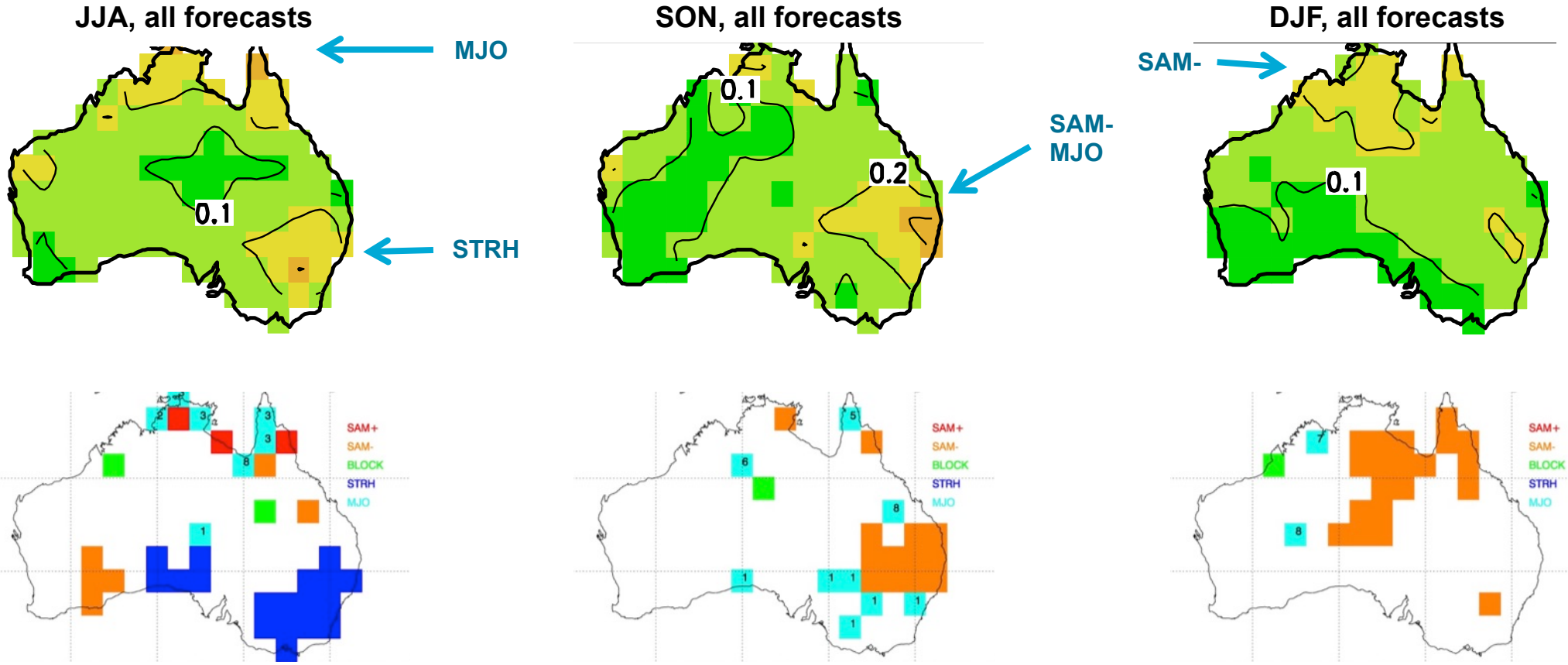
Prediction



The Symmetric Extremal Dependence Index (SEDI; Ferro and Stephenson, 2011) – non-degenerate

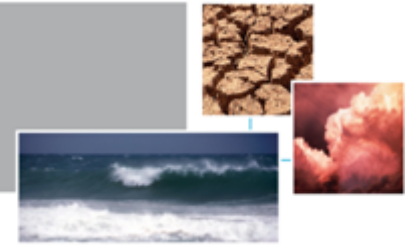
Overall skill

Driver with highest skill



Windows of forecast opportunity: **Drivers providing subseasonal predictability for extreme heat over regions where the likelihood of an extreme heat event is high**

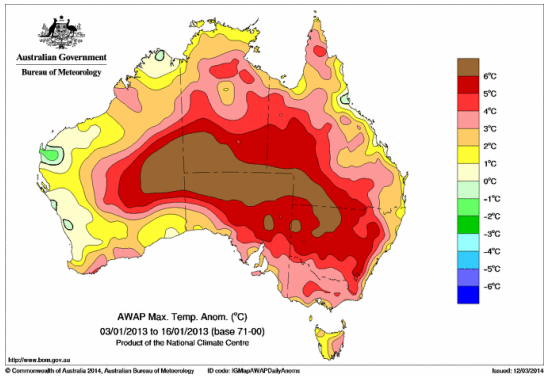
Experimental forecast products poama.bom.gov.au, e.g. January 2013



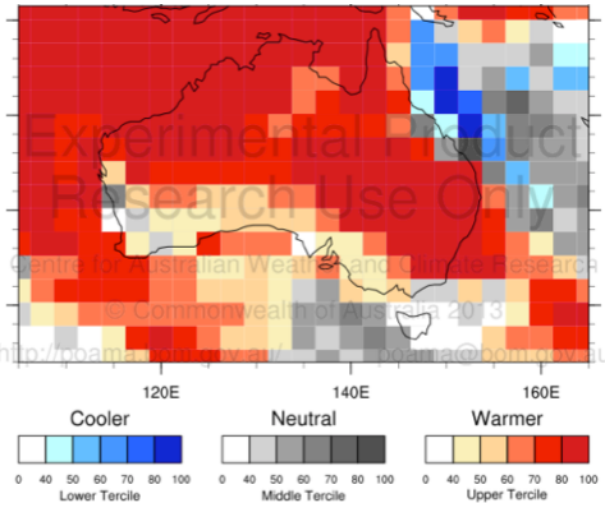
POAMA Tmax probability forecasts for the fortnight 3-16 January 2013

Weeks 2 and 3 (Initialised 27 December 2012)

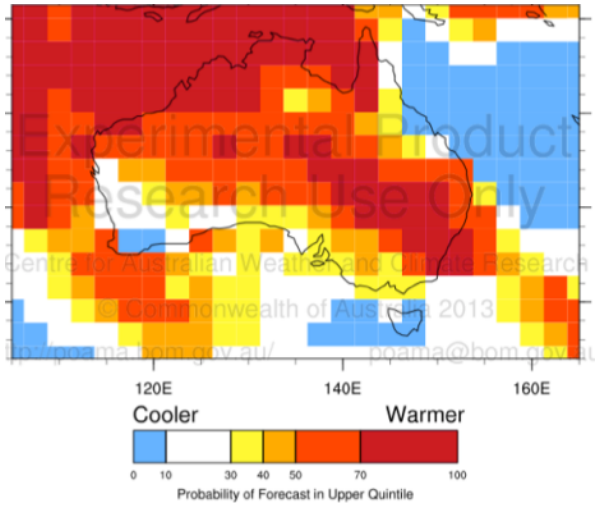
OBSERVED (AWAP)



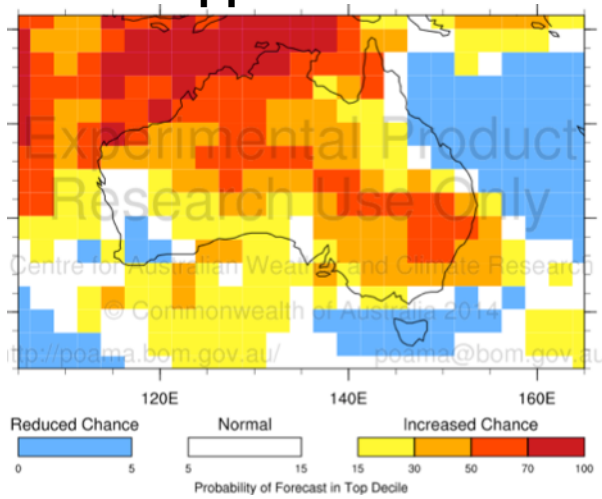
Tercile



Upper Quintile

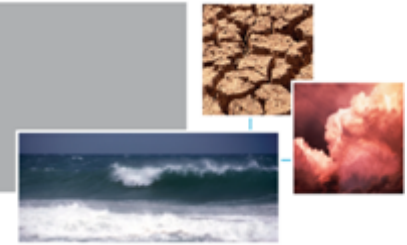


Upper Decile



Products available for Weeks (1, 2), Fortnights (1, 1.5, 2), Months (1, 2, 3) and Seasons (1, 2, 3)

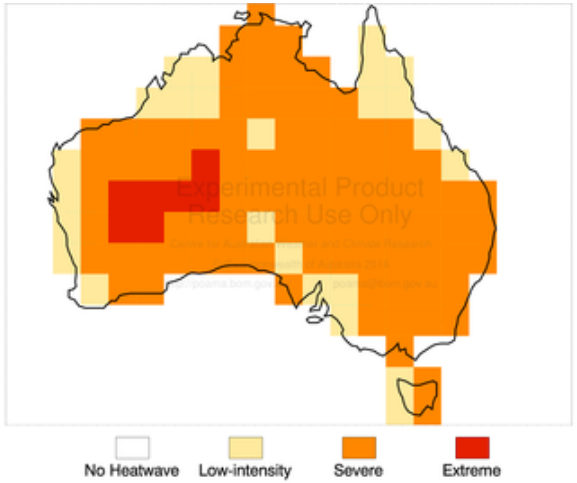
Experimental forecast products poama.bom.gov.au, e.g. January 2013



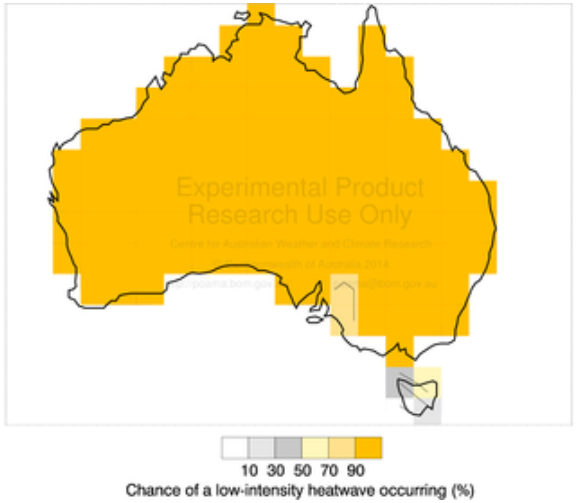
POAMA EHF heatwave probability forecast for January 2013

Month 1 (Initialised 27 December 2012)

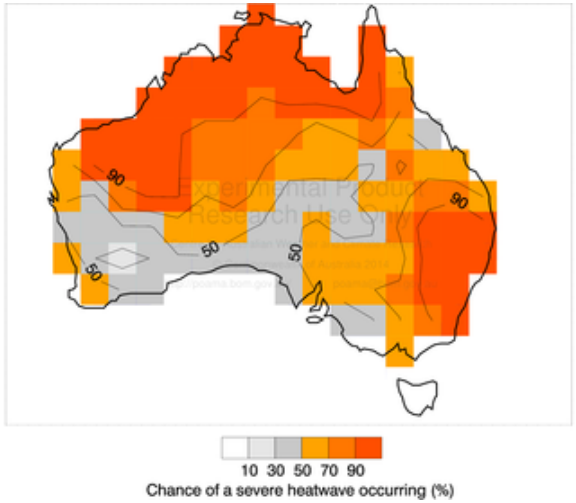
OBSERVED (AWAP)



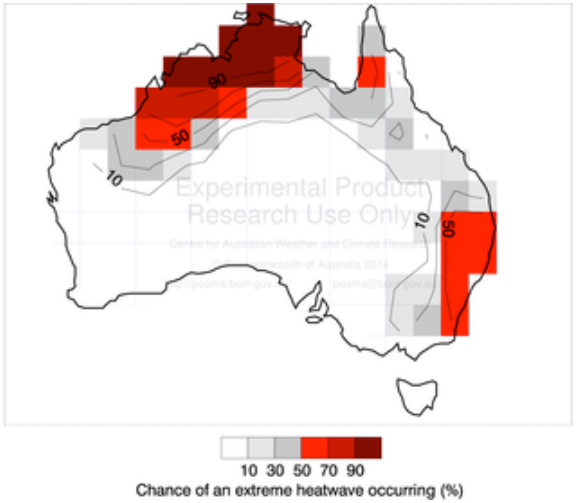
Low-intensity



Severe

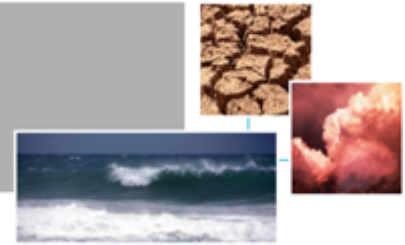


Extreme



Product also available for Weeks (2,3), Fortnights (1, 1.5, 2) and Month 1

Summary: our approach



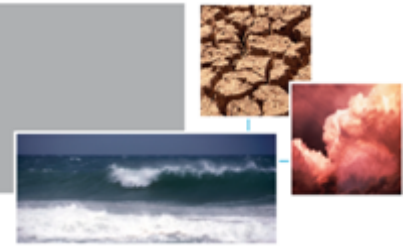
1. Understand the large-scale climatic processes (e.g. state of the SAM) that lead to episodes of extreme heat over Australia

2. Examine the model's ability to simulate the teleconnection and predict these large-scale processes

3. Explore and define model skill for making predictions of heat extremes, including identifying windows of forecast opportunity

4. Trial different heat extreme index definitions for forecast products

Conclusions



POAMA generally reproduces well the extreme heat response to each driver, windows of forecast opportunity where each driver provides subseasonal prediction skill

Significant potential to extend traditional weather forecasts and warnings for extreme events to include subseasonal-to-seasonal probabilistic guidance, experimental products

Thank you

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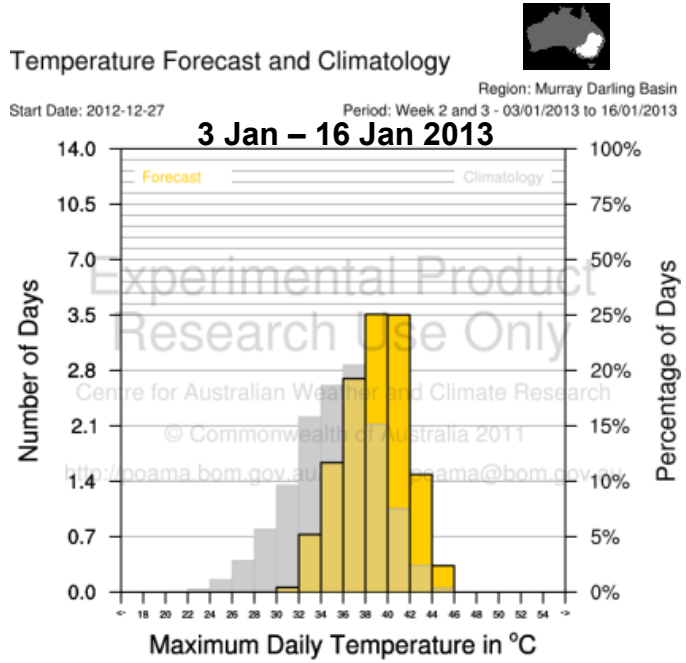

Predicted Tmax distribution (yellow) is shifted about +4°C, relative to climatology (grey)