"Climate variability: impacts & outlook for key global production/ consumption regions"

Roger Stone

Australian Centre for Sustainable Catchments

University of Southern Queensland

Toowoomba

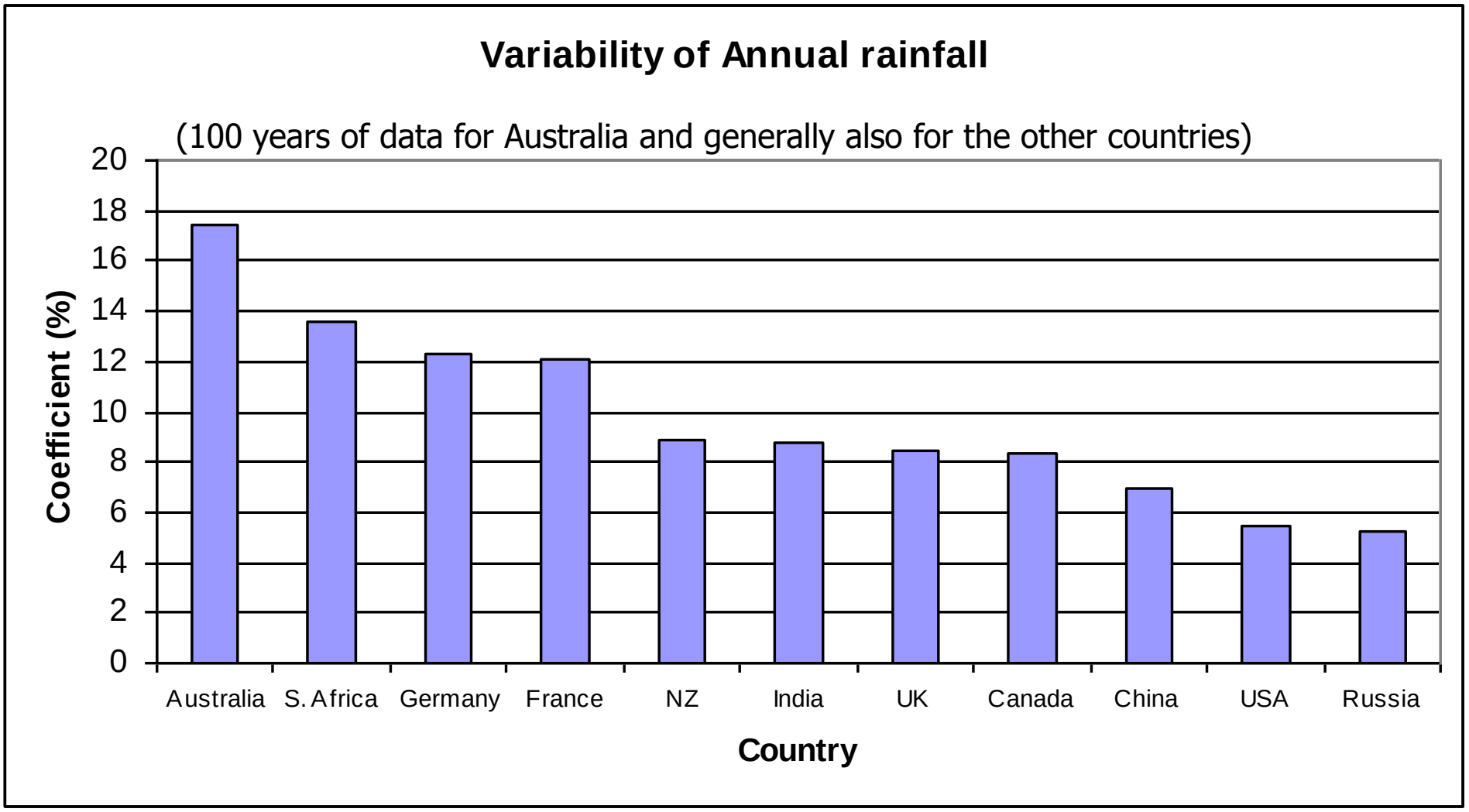
Australia

ECOM

Australian Government
Sugar Research and Development Corporation

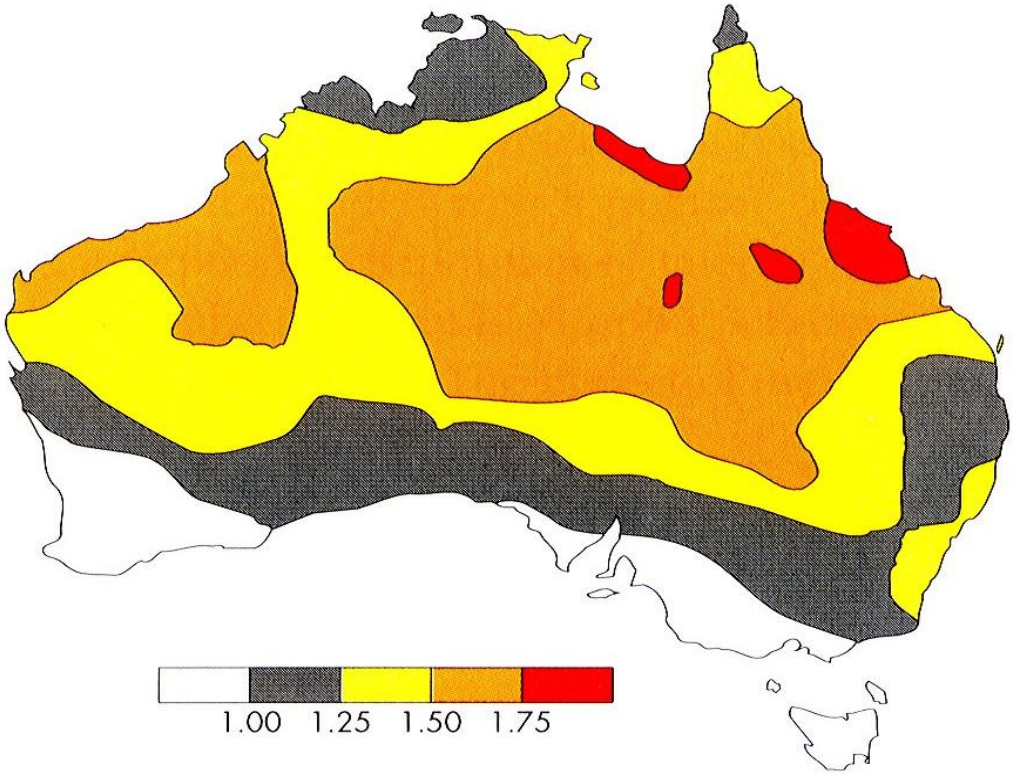
GRDC
Grains Research & Development Corporation
Your GRDC working with you

On the global scene, Australia has the world's highest levels of year-to-year rainfall variability



(Love, 2005)

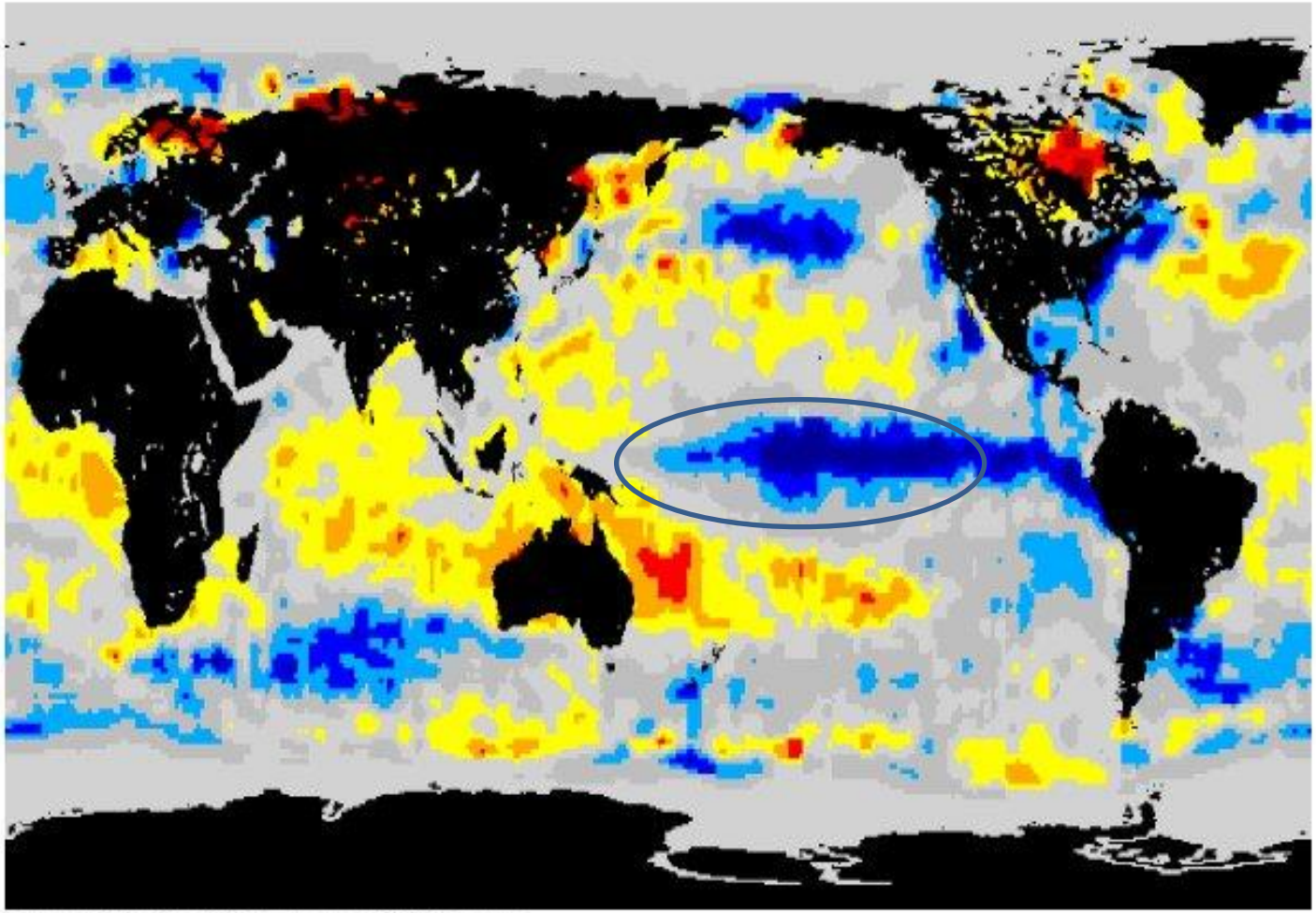
– especially in northern and eastern Australia…



Source: Nicholls, Drosdowsky and Lavery, Bureau of Meteorology Research Centre, from a paper 'Australian rainfall variability and change', yet to be published.

SST Anomaly (degrees C)

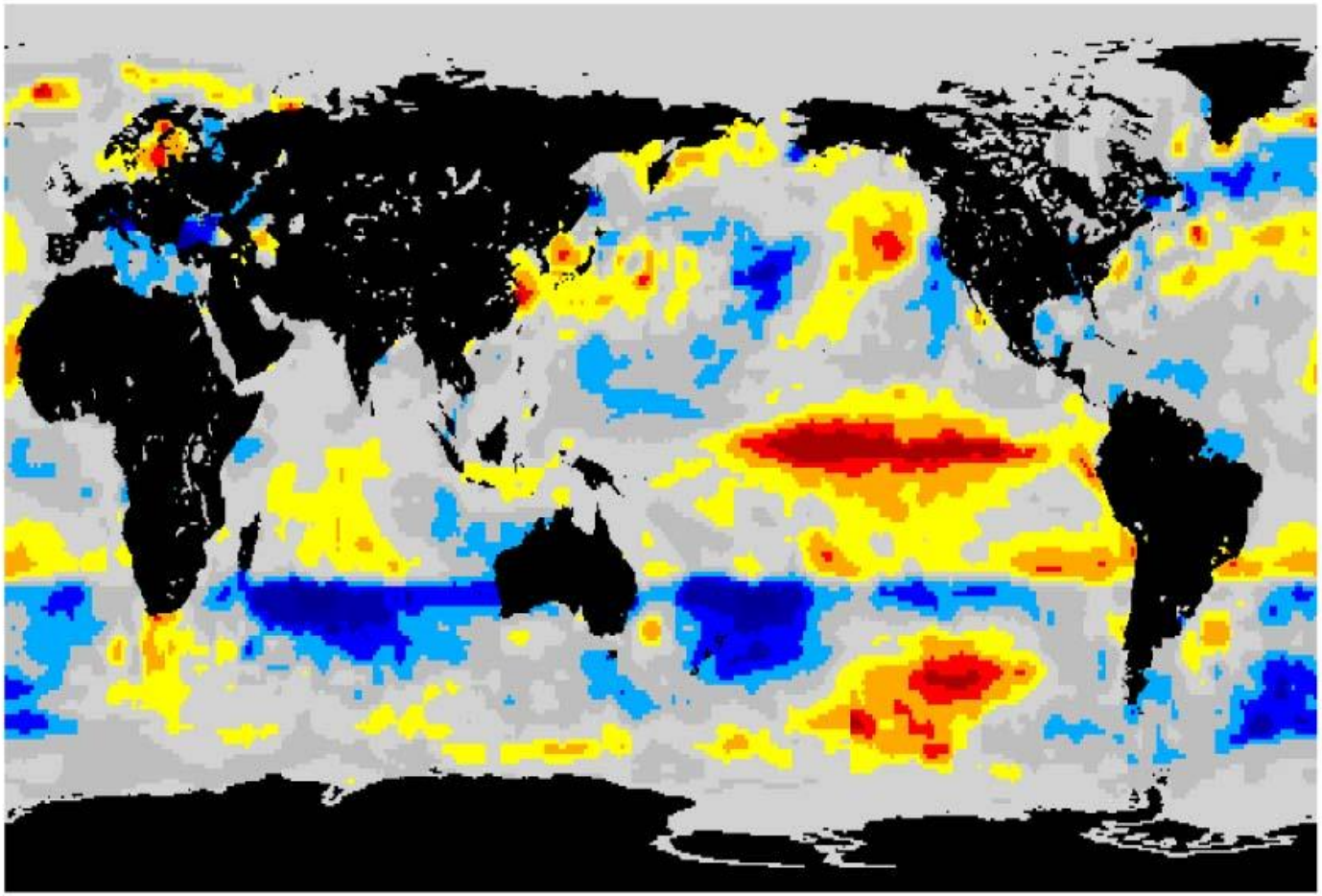
The main cause of the variability? Conditions in the Tropical Pacific Ocean – (example from October 1988 – La Nińa event)



Produced by Roger Stone & Torben Marcussen, QDPI, Toowoomba
Data courtesy of National Oceanographic and Atmospheric Administration, USA

SST Anomaly (degrees C)

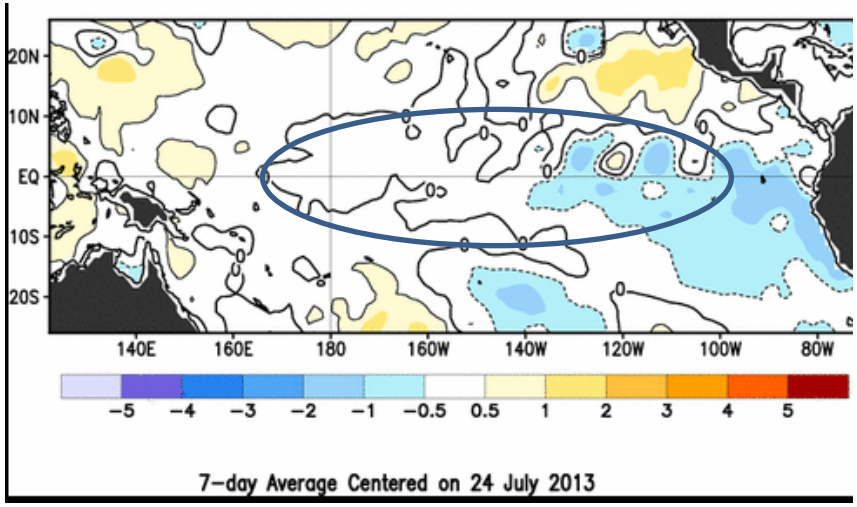
December 1991 – (El Niño event)…



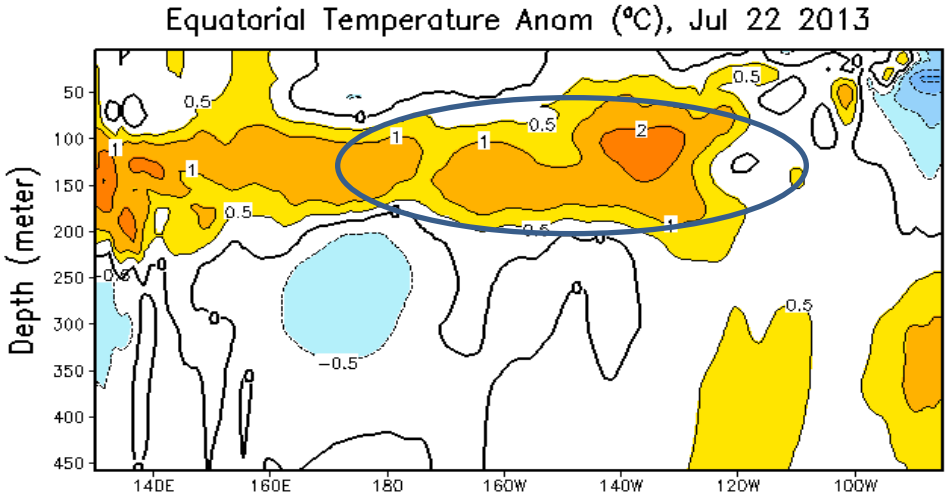
Produced by Queensland Center for Climate Applications, Toowoomba
Data courtesy of National Oceanographic and Atmospheric Administration, USA

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES RESOURCES Queensland Government

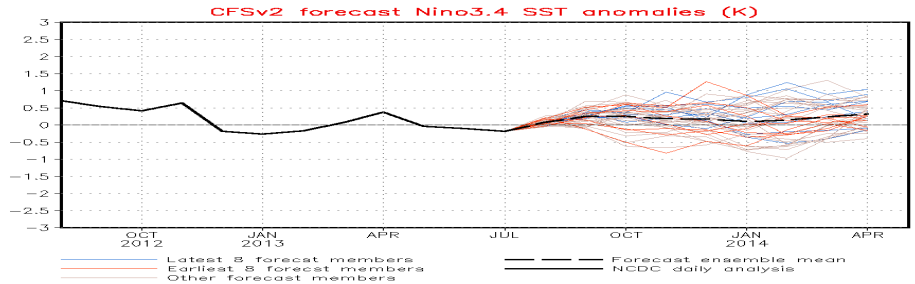
Latest sea-surface and sub-surface temperature anomalies (24 July, 2013) – courtesy CPC.



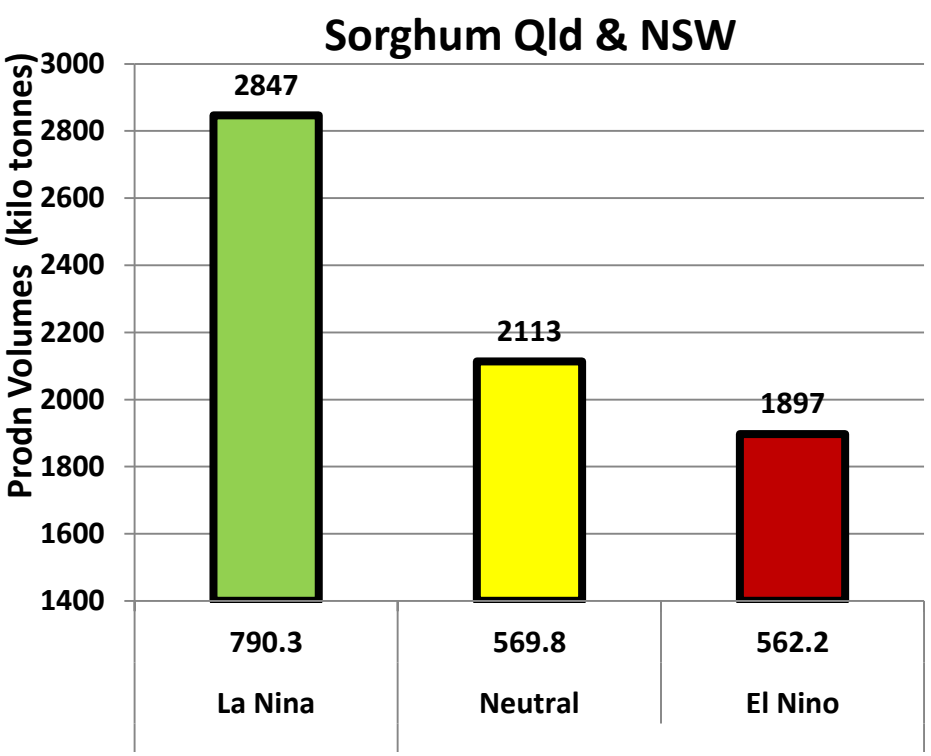
surface

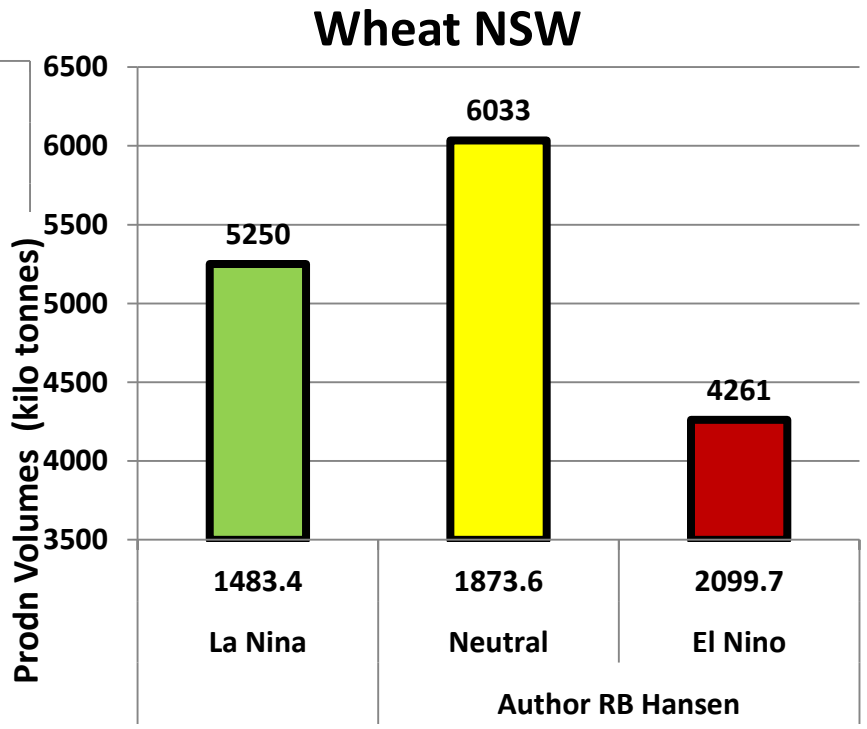


sub-surface



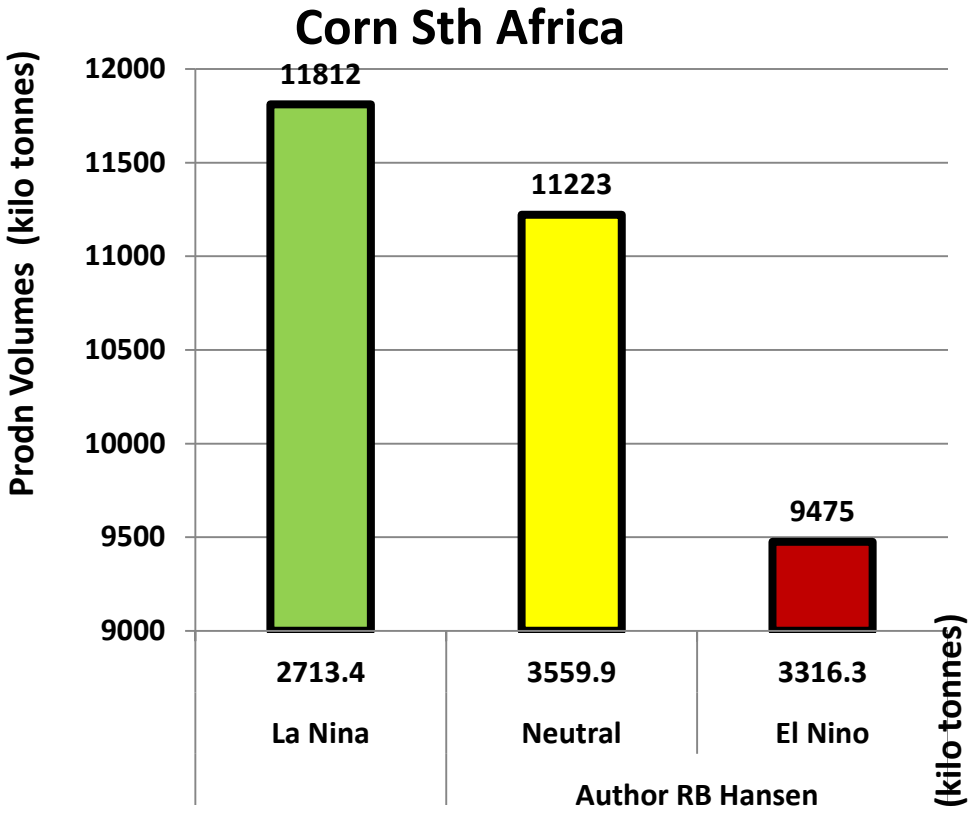
forecast

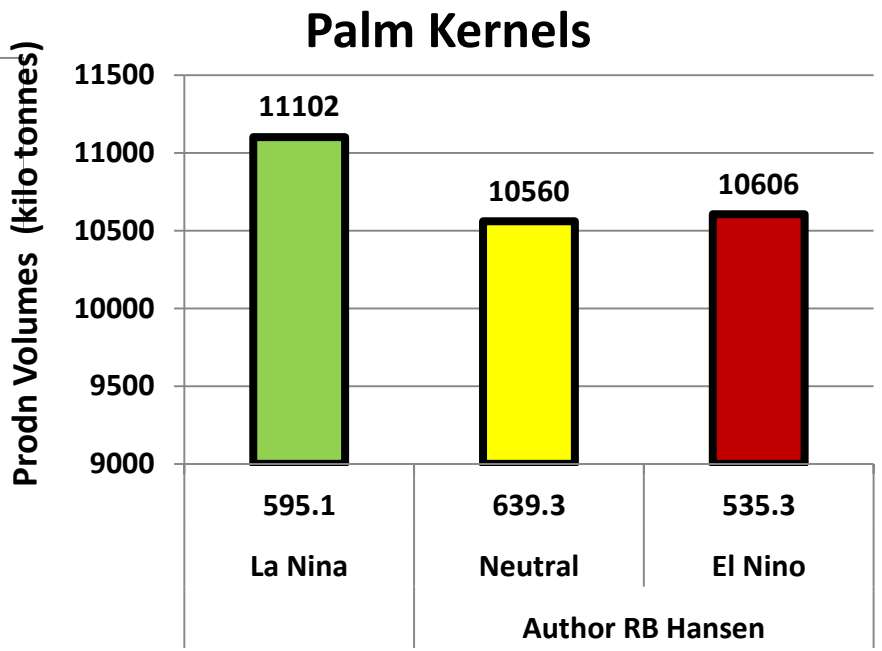




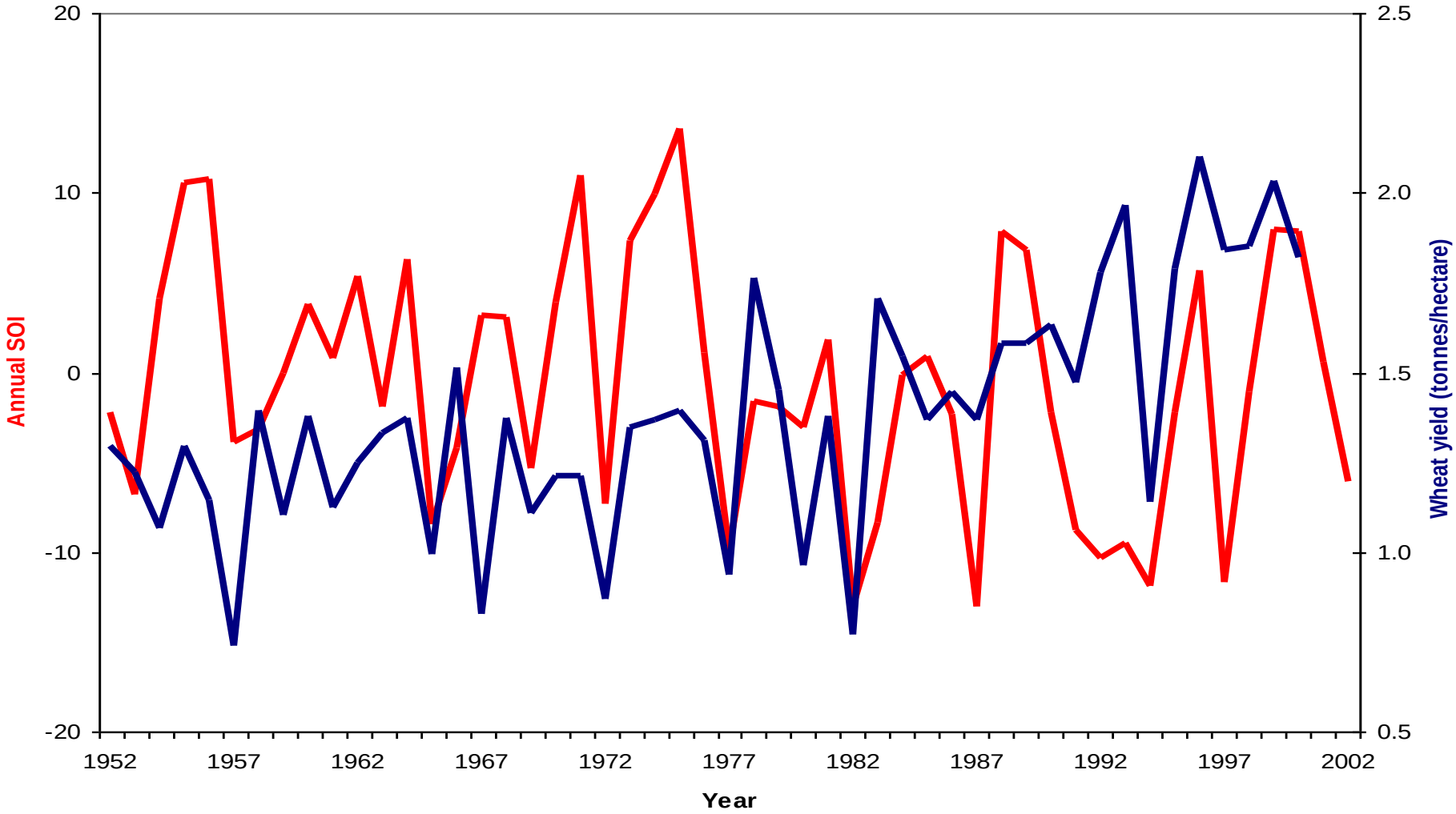
More detailed climate indicator/yield relationships:

Mean /std production levels associated with ENSO – example for sorghum and wheat /Australia (Hansen and Stone, 2012)

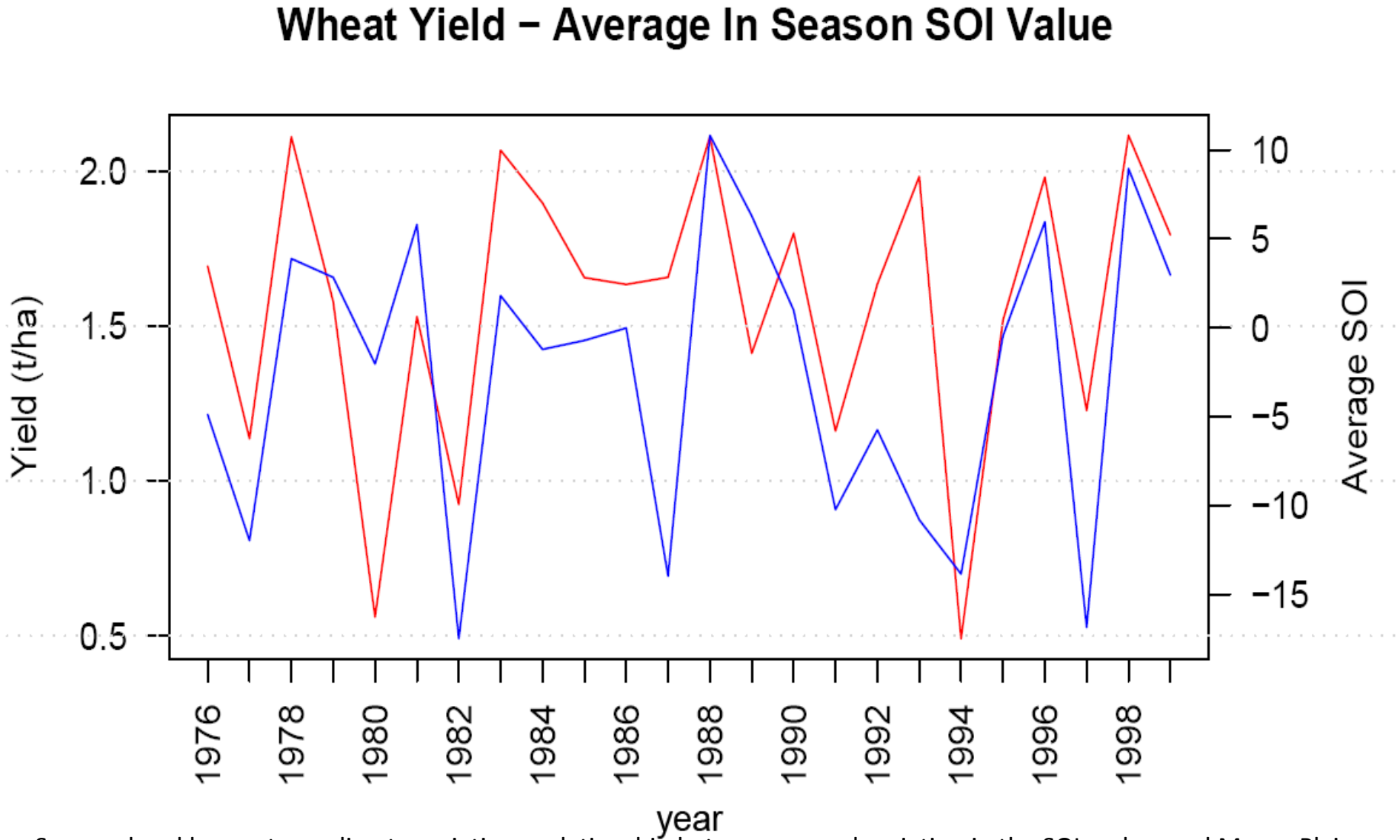




Mean/std Corn production RSA and Palm Kernels (global) associated with ENSO (Hansen and Stone, 2012)

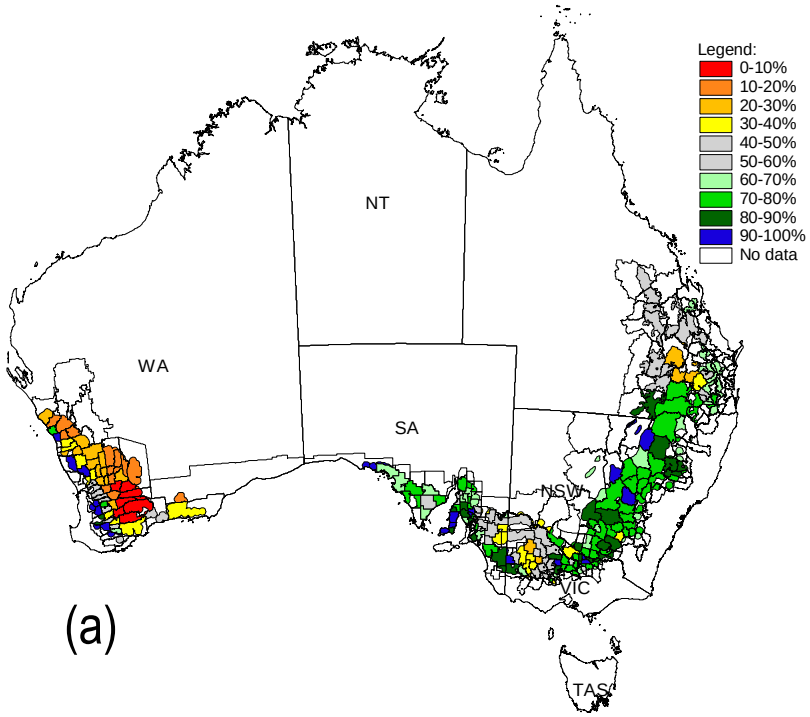


Climate variability impacts: relationship between annual variation in the SOI and annual Australian wheat yield (N Nicholls).



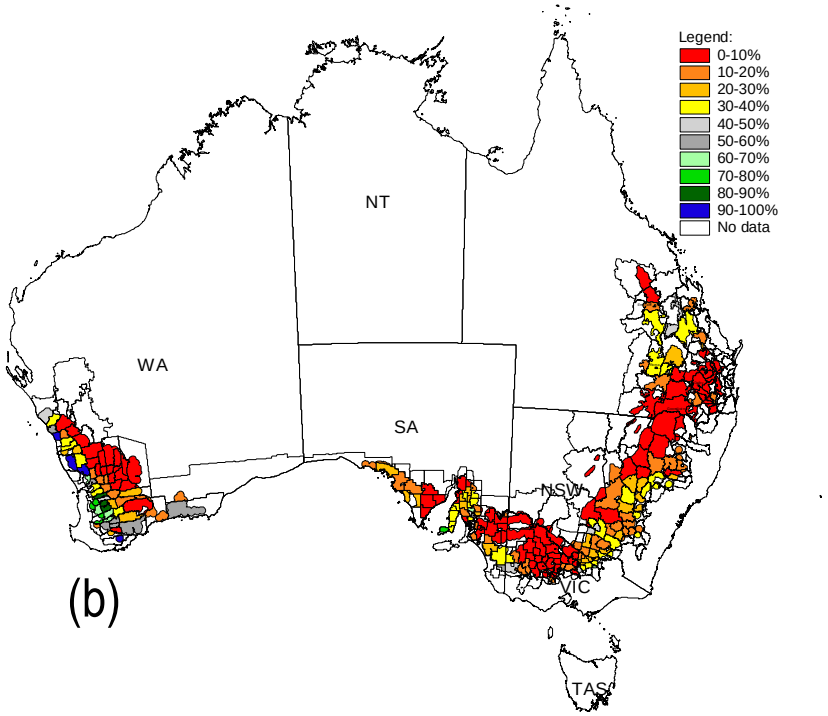
Seasonal and longer term climate variation - relationship between annual variation in the SOI and annual Moree Plains wheat yield (Stone and Donald, 2007).

July 2001



(a)

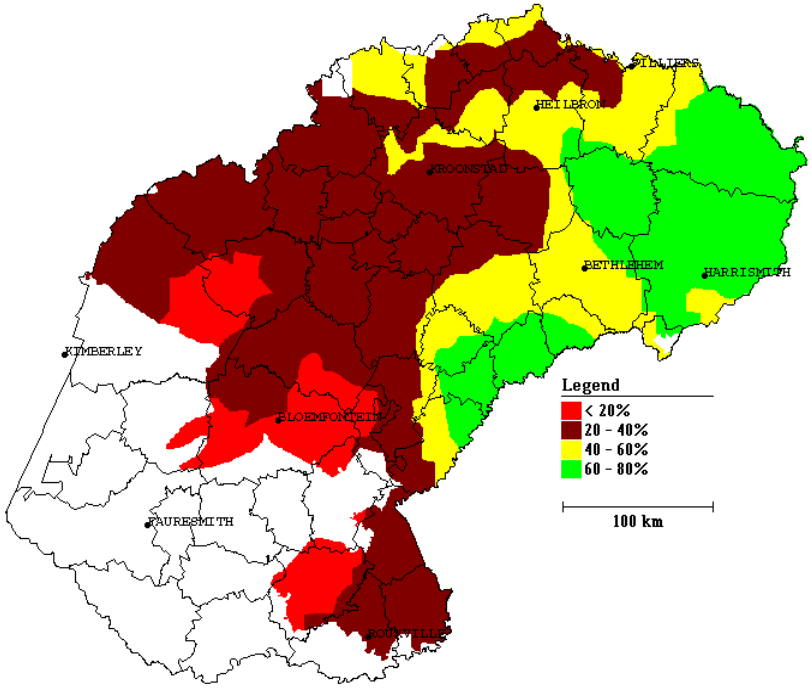
July 2002



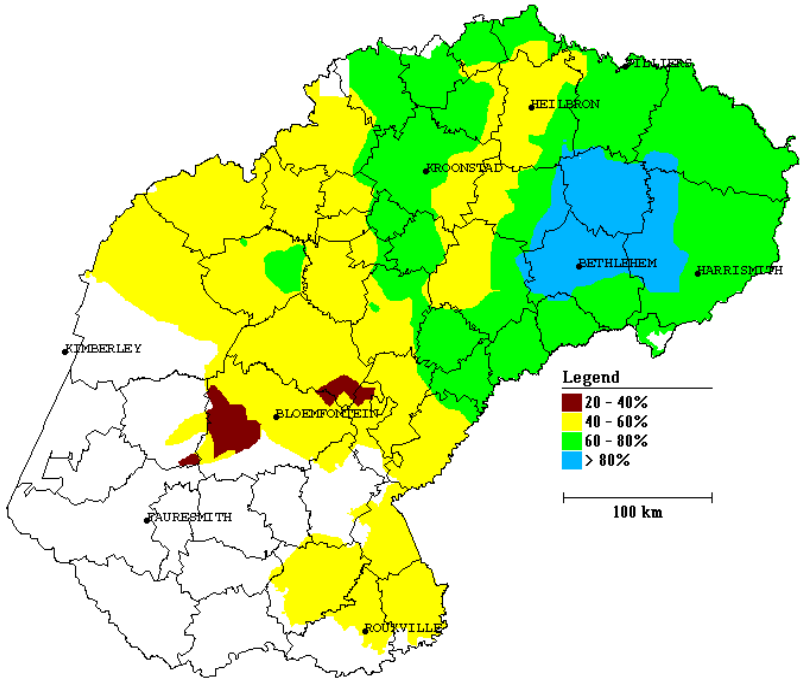
(b)

Two contrasting years - Probabilities of exceeding long-term median wheat yields for every wheat producing shire - example for Australia issued in July 2001 and July 2002, respectively (Potgieter, 2003).

Probabilities of exceeding long-term median maize yields for Free State, RSA, associated with a consistently negative SOI phase and a consistently positive SOI phase – output provides the probability (%) of exceeding maize yields of 2.5 t/ha (Potgieter, 2005).



Planting date: 1 November (Cons –ve SOI phase)



Planting date: 1 November (Cons +ve SOI phase)

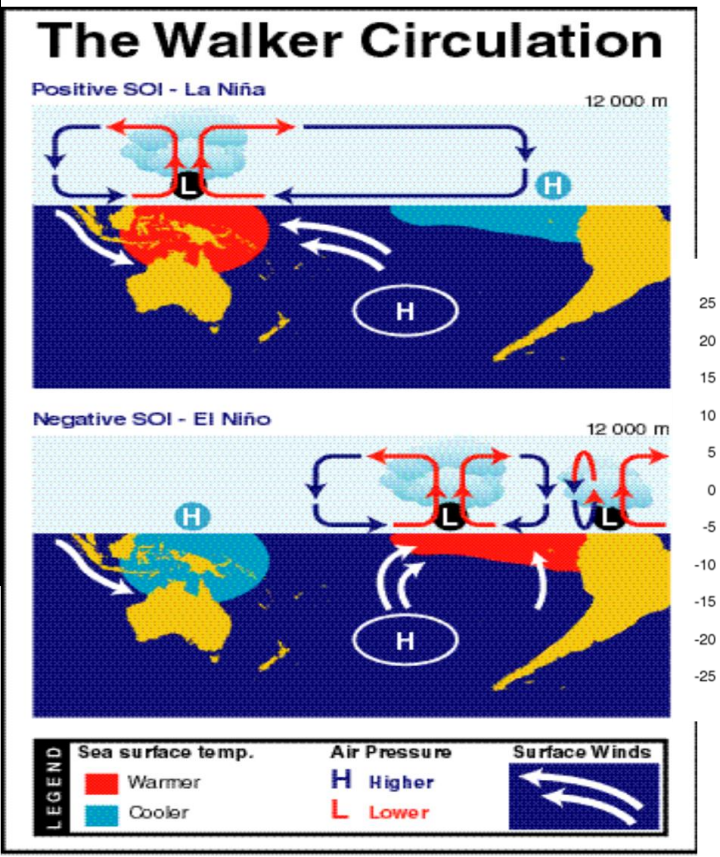
Agricultural/water resource systems operate on many time scales relevant to Australia = opportunities for preparedness

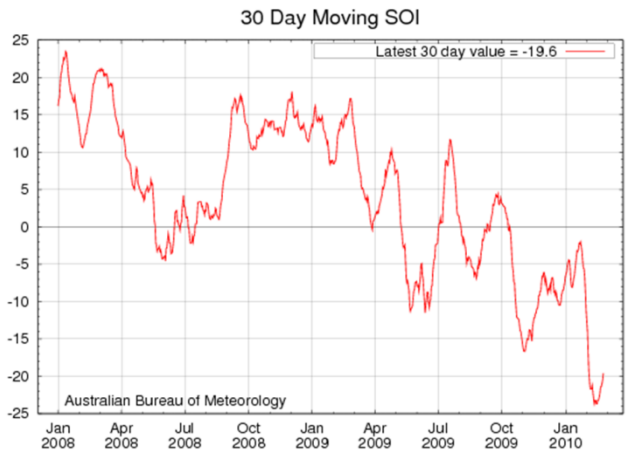
(Meinke and Stone, 2005).

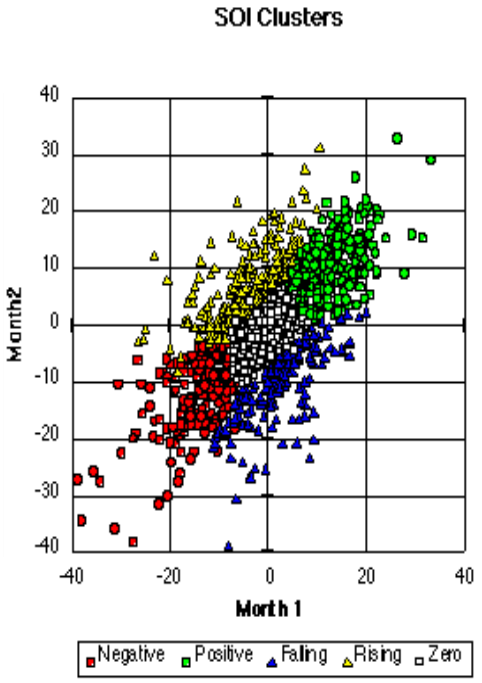
Decision type (eg. only)	Frequency (year)
Logistics (eg. scheduling of planting / harvest operations	Intraseasonal (>0.2)
Tactical crop management (eg. fertiliser/pesticide use)	Intraseasonal (0.2-0.5)
Crop type (eg. wheat or chickpeas); irrigation planning; irrigation scheduling	**Seasonal (0.5-1.0) (ENSO)**
Crop sequence (eg. long or short fallows)	Interannual (0.5-2.0)
Crop rotation (eg. winter or summer crop)	Annual/biennial (1-2)
Crop industry (eg. grain or cotton, phase farming)	Decadal (~10) includes latitude of the sub-tropical ridge
Agricultural industry (eg. crop or pasture)	Interdecadal (10-20)
Landuse (eg. Agriculture or natural system)	Multidecadal (20+)
Landuse and adaptation of current systems	Climate change

Core statistical seasonal climate forecasting method - 'SOI Phases'

SOI Phase classification - Tahiti minus Darwin Sea Level Pressure values – the phases are determined by conducting Principal Components and Cluster Analysis of patterns in the SOI (Stone et al, 1996)..5 patterns or 'phases' are the result..







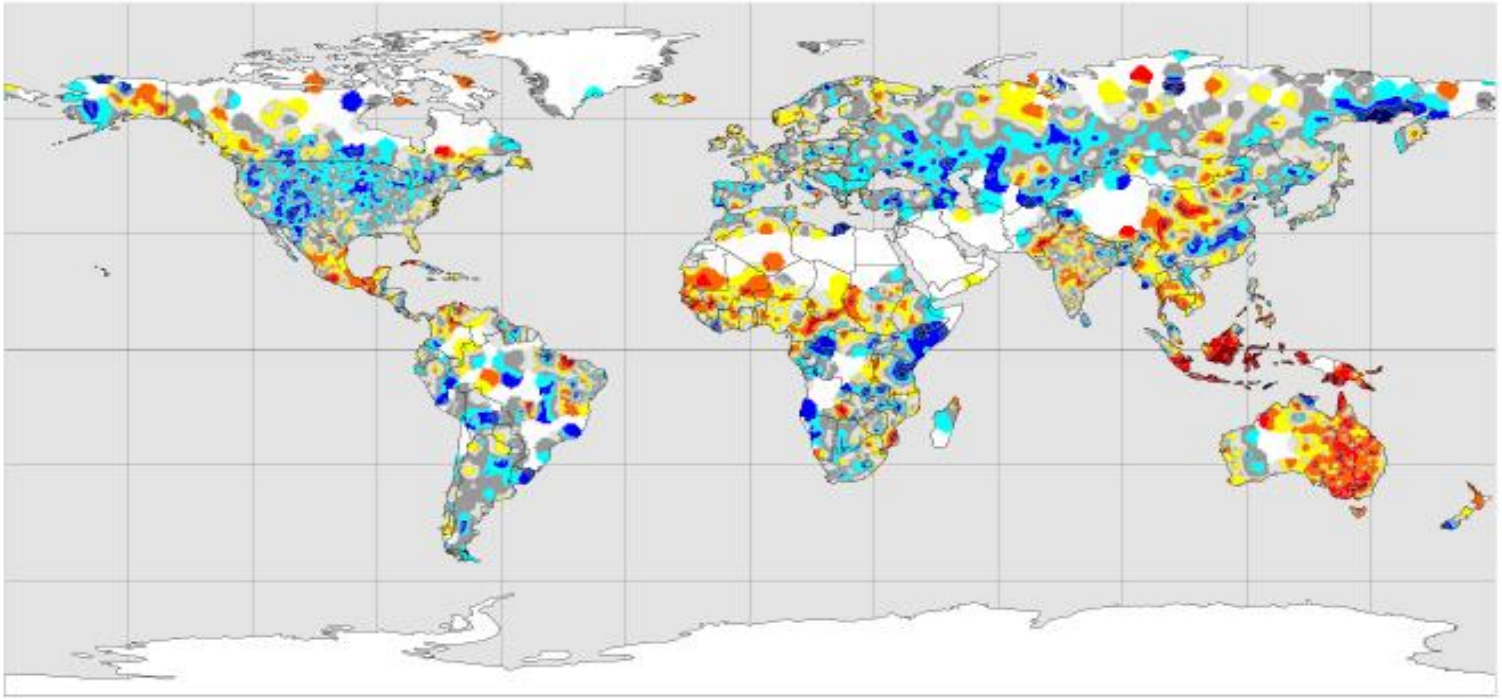
Probability of exceeding Median Rainfall

for August / October

based on consistently negative phase during June / July

"the world is often out of balance"

90 - 100%
80 - 90%
70 - 80%
60 - 70%
50 - 60%
40 - 50%
30 - 40%
20 - 30%
10 - 20%
0 - 10%
No nearby stations or seasonally dry



QCCA

Produced by Queensland Centre for Climate Applications, Toowoomba, 1999

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

NATURAL RESOURCES

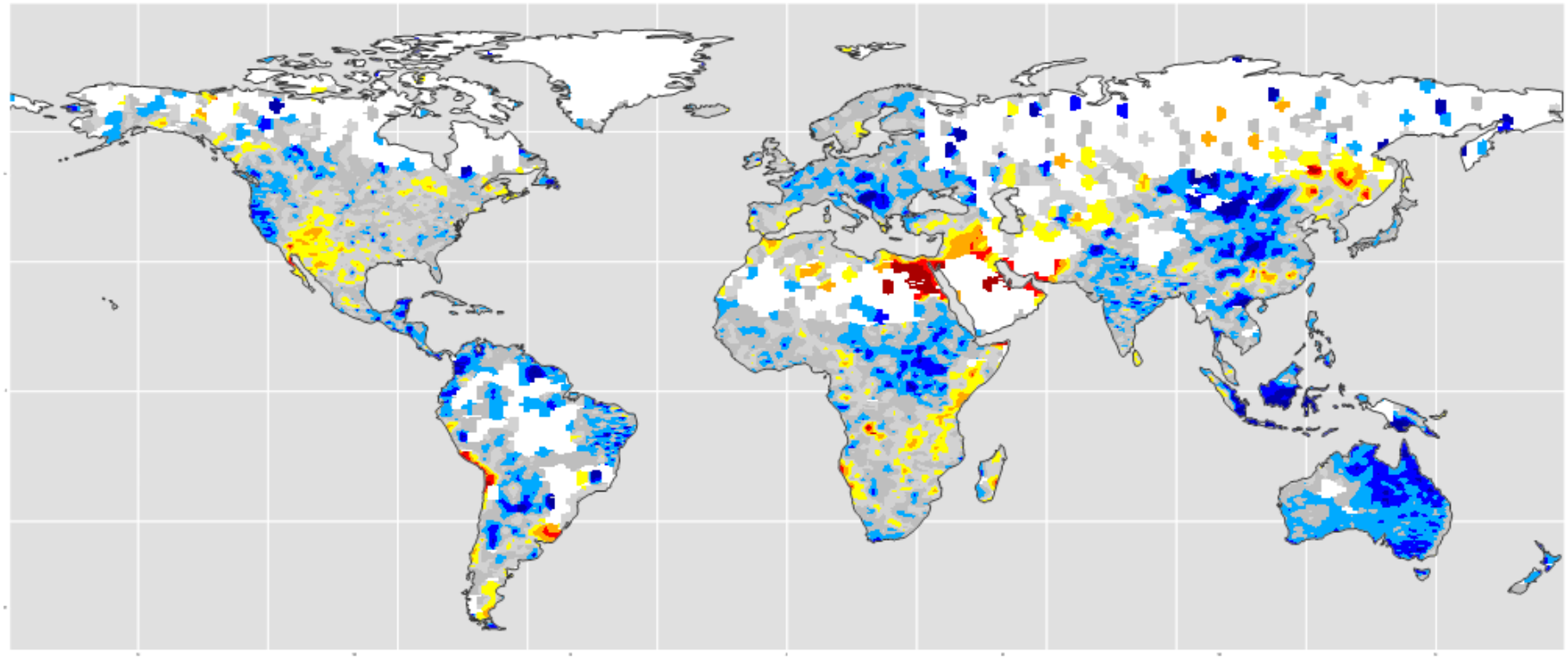
Global Forecast Example (during an El Niño event): capability to provide probabilistic information (across continents) based on core ENSO indicators (Stone et al., *Nature*, 1996)

Probability of Exceeding Median Rainfall

August / October

Based on Consistently Positive phase during June / July

Current statistically-based global seasonal climate forecast – for the August to October period, 2013



USQ AUSTRALIA

Australian Centre for Sustainable Catchments

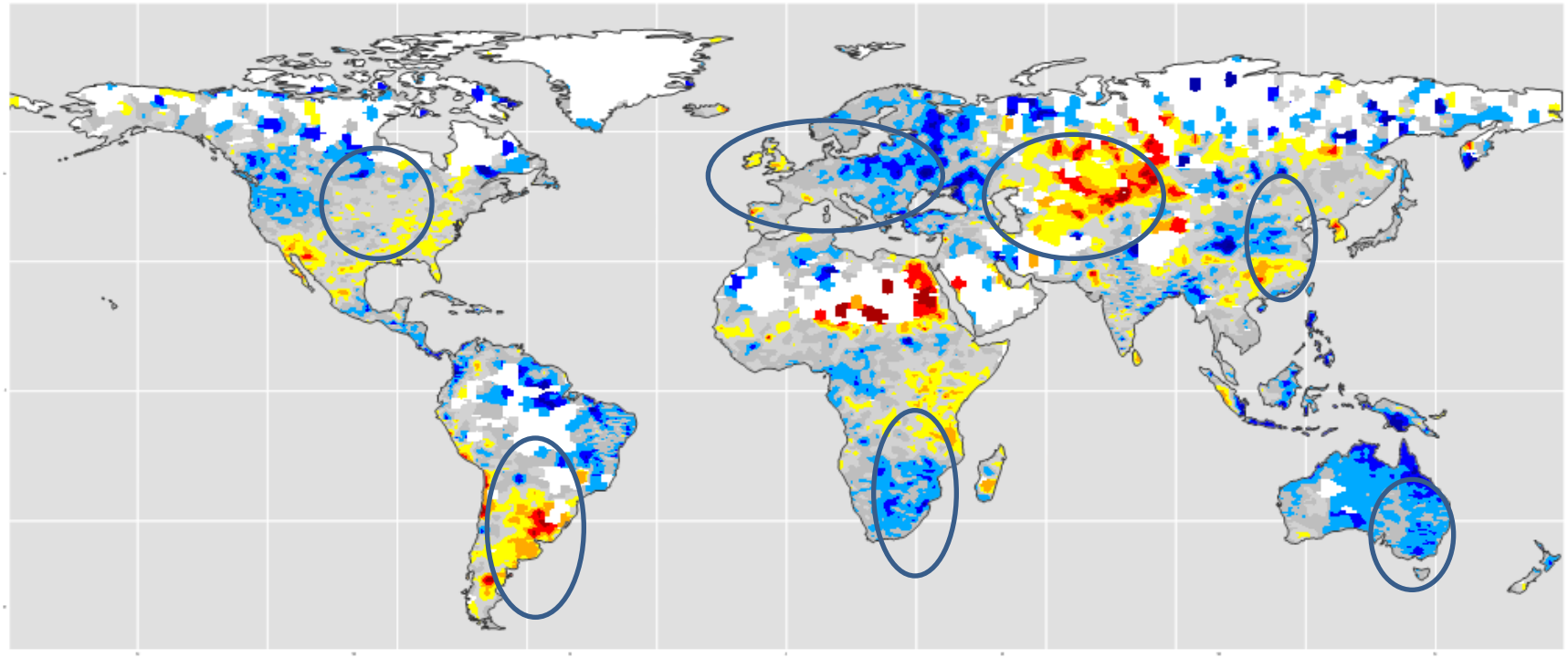
Stone, R.C., Hammer, G.L and Marcussen, T. (1996)
Prediction of global rainfall probabilities using phases of the Southern Oscillation Index.
Nature, 384, 252-255.

Probability of Exceeding Median Rainfall

October / December

Based on Consistently Positive phase during August / September

Likely pattern as the year progresses – but please update!



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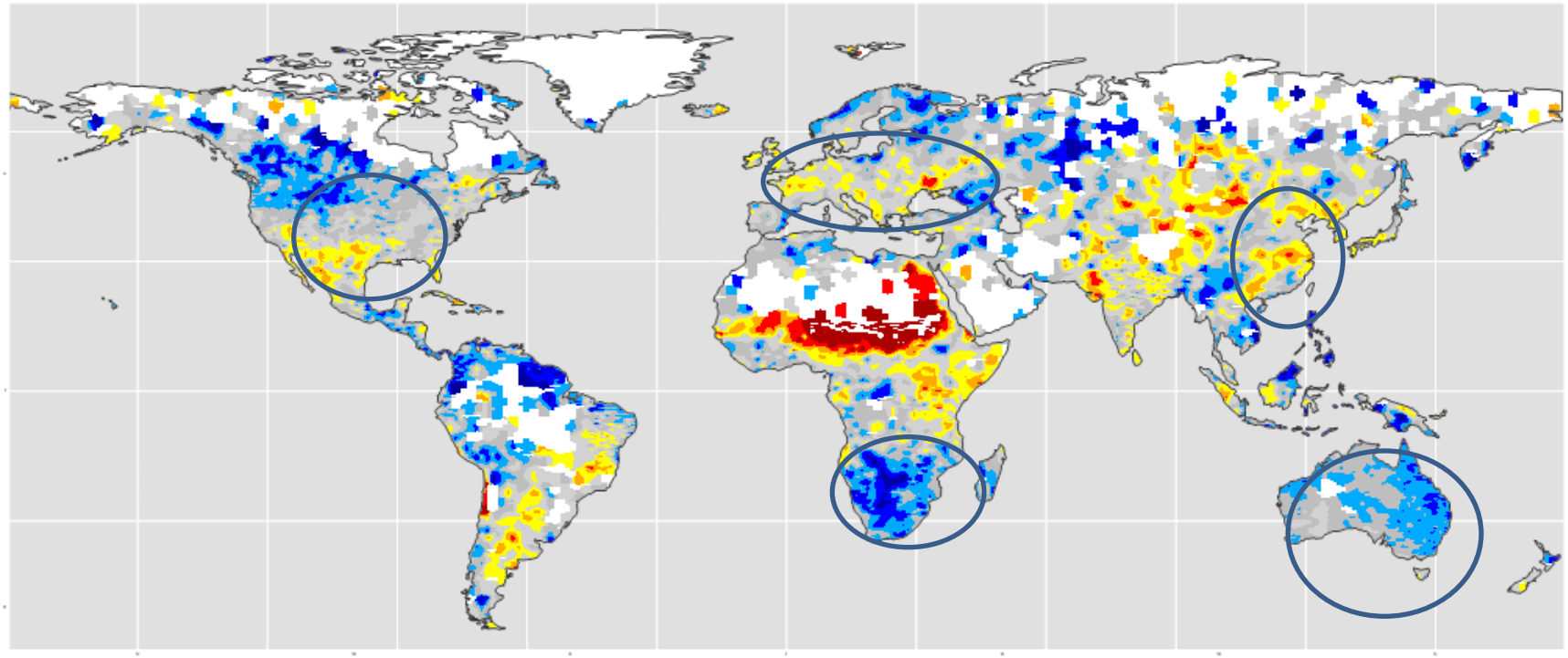
Probability of Exceeding Median Rainfall

November / January

Based on Consistently Positive phase during September / October

Assuming current pattern is maintained



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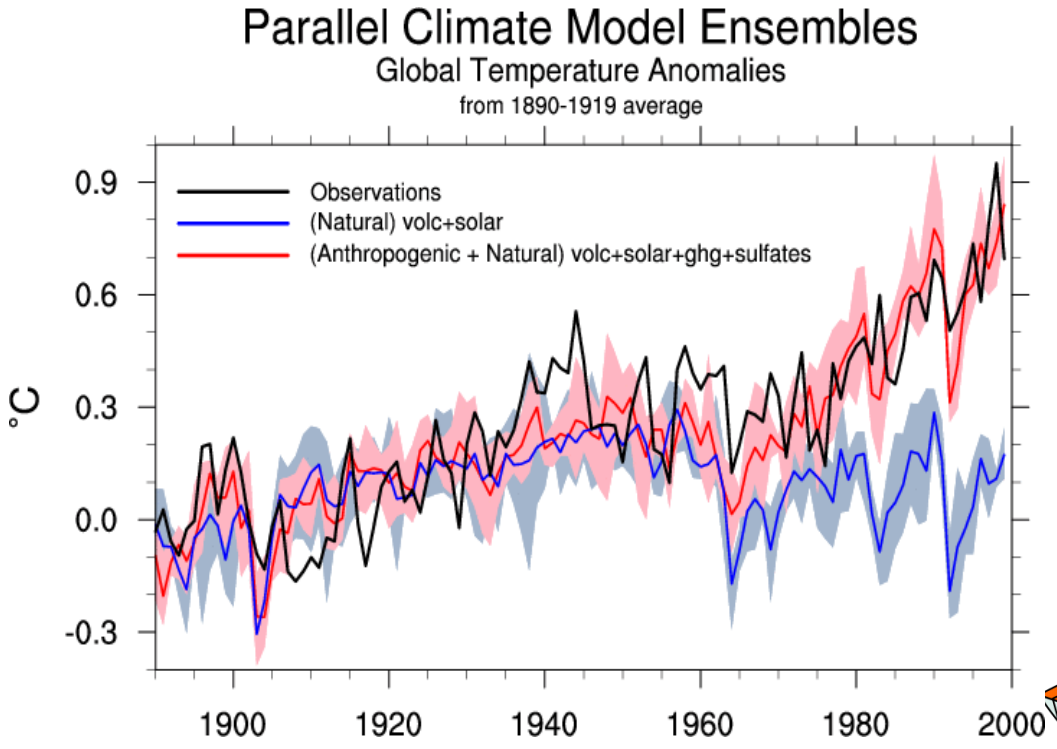
Nature, 384, 252-255.

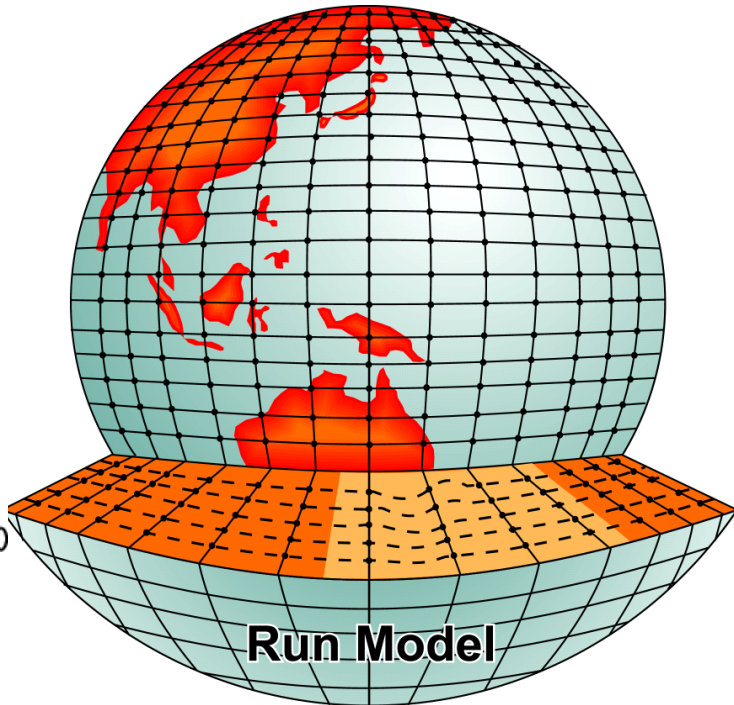
Dynamic models: General Circulation Model features

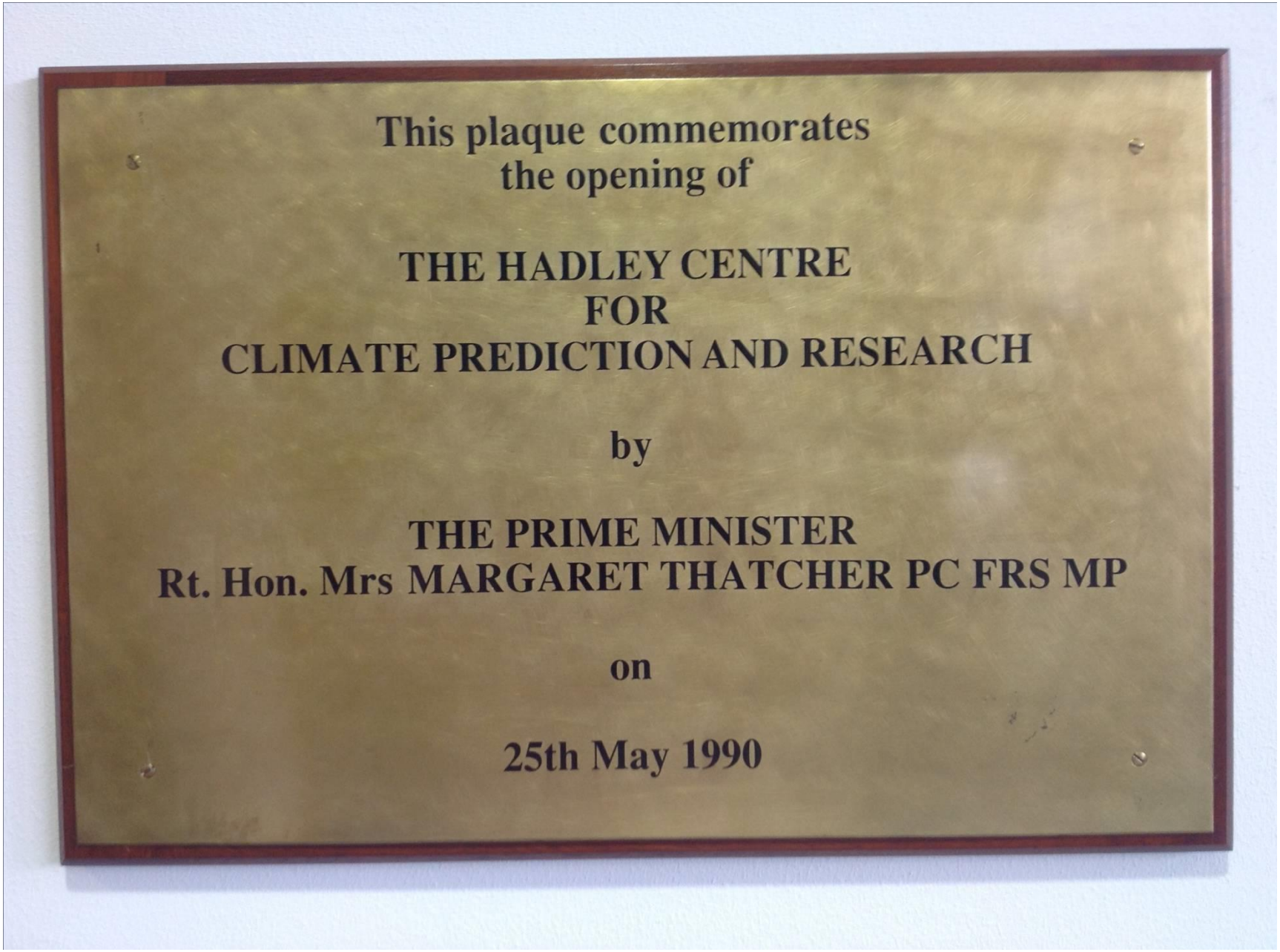
Four main components: the atmosphere, the land surface and biosphere, the oceans and polar ice

Data are computed in 30-minute time-steps over a global grid for a series of months or years

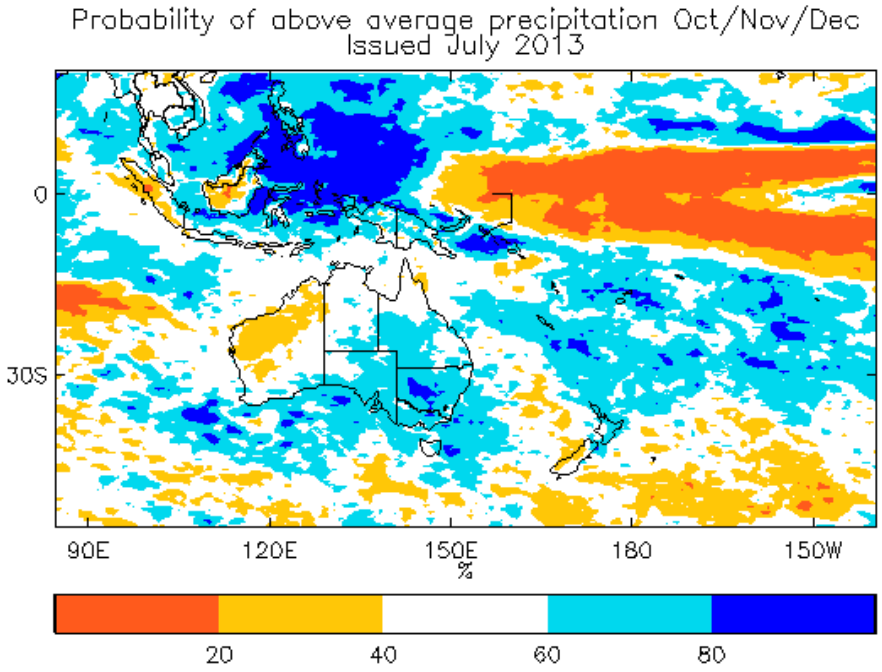
Models adequately simulate observed daily weather and average climate patterns





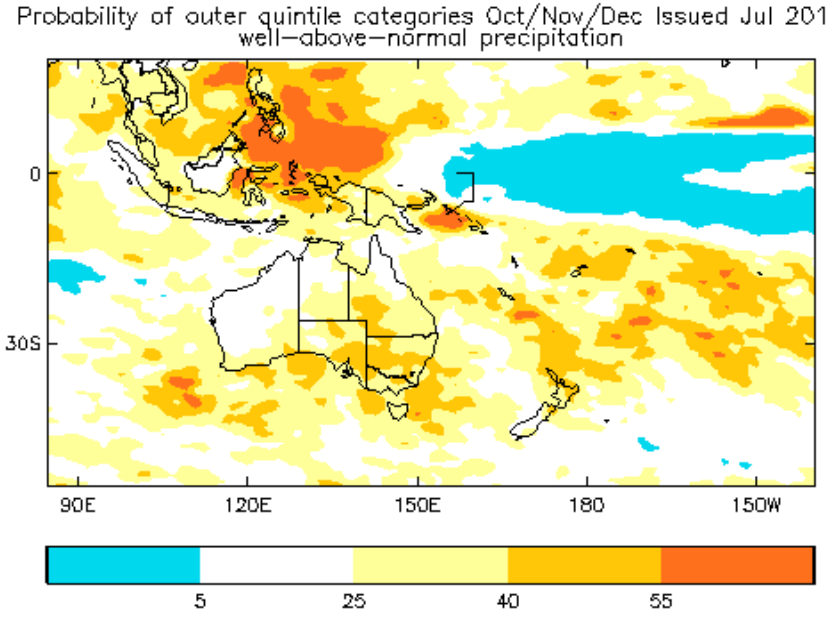

This plaque commemorates
the opening of
THE HADLEY CENTRE
FOR
CLIMATE PREDICTION AND RESEARCH
by
THE PRIME MINISTER
Rt. Hon. Mrs MARGARET THATCHER PC FRS MP
on
25th May 1990

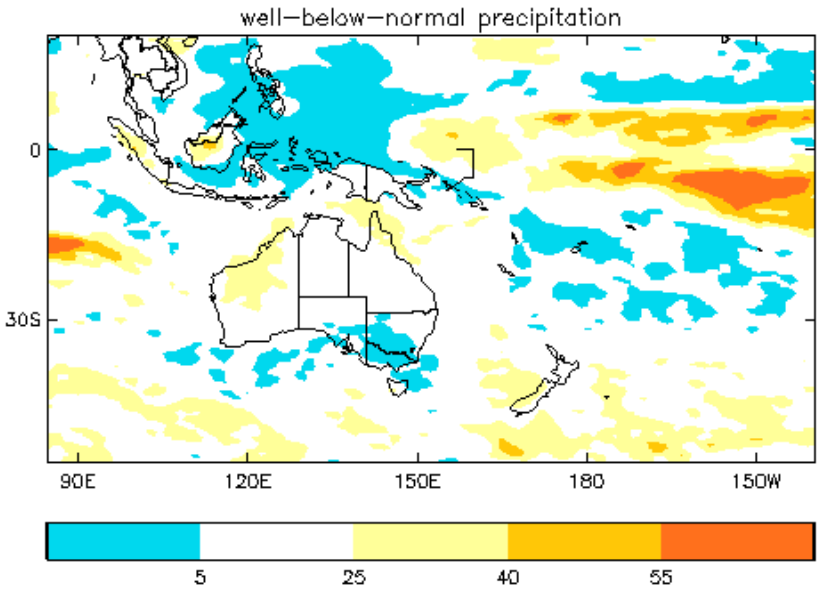
UKMO General Circulation Model output for Australia/NZ



UK MET OFFICE extended range climate forecast for Australia: October to December, 2013….

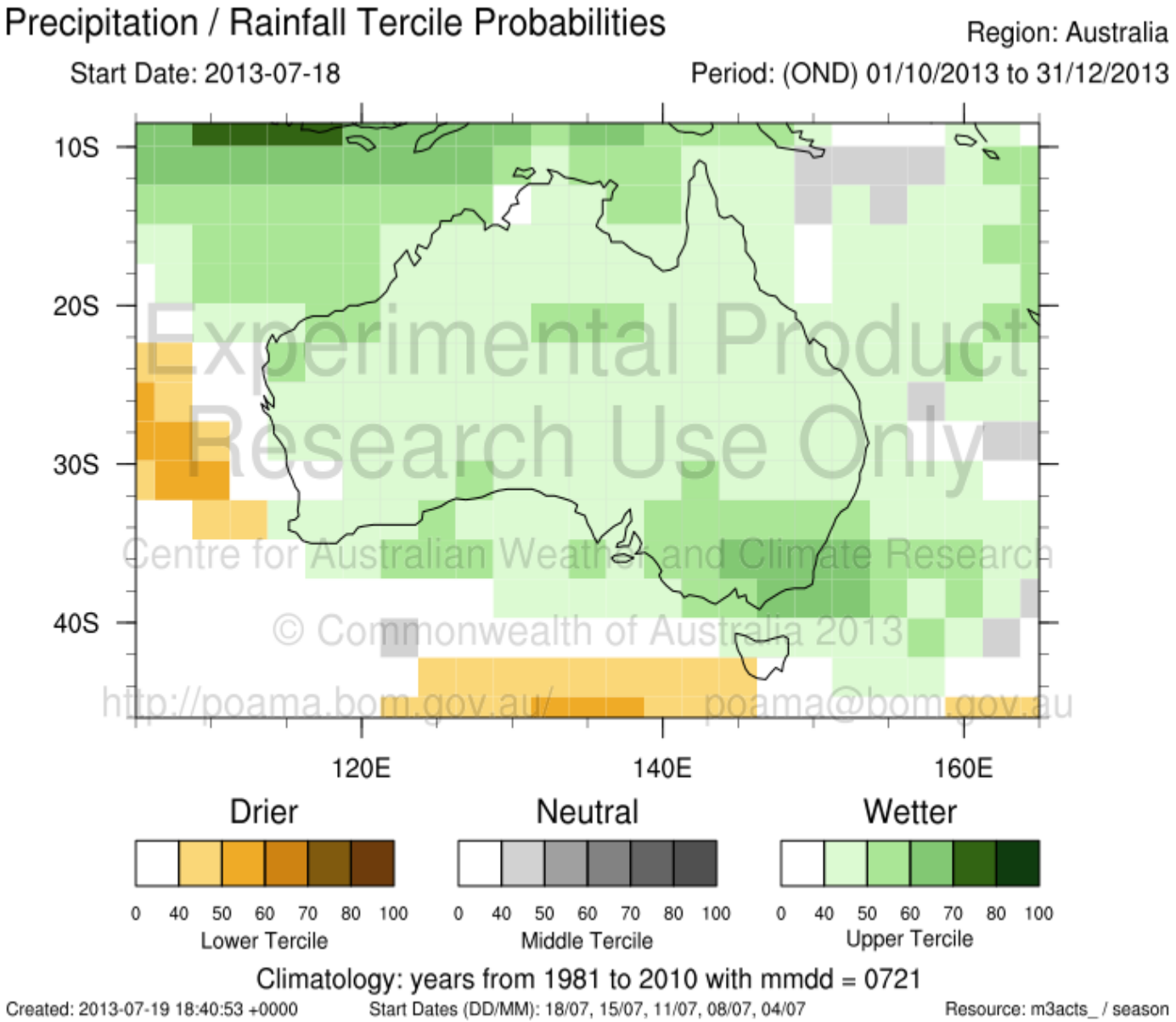
UK Met Office,
Exeter



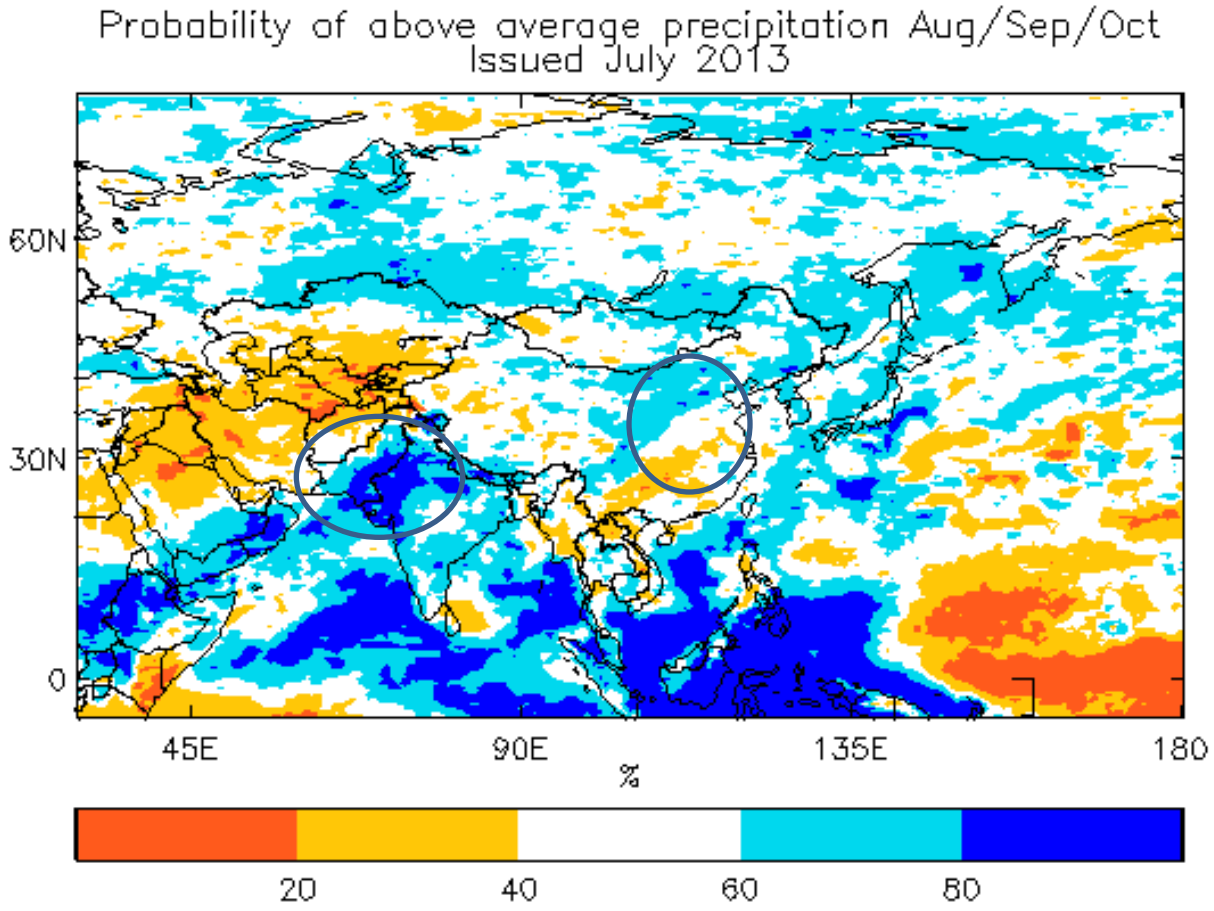


Forecasting extremes – top 20% or lowest 20% - all values relative to highest or lowest 20% of possible values.

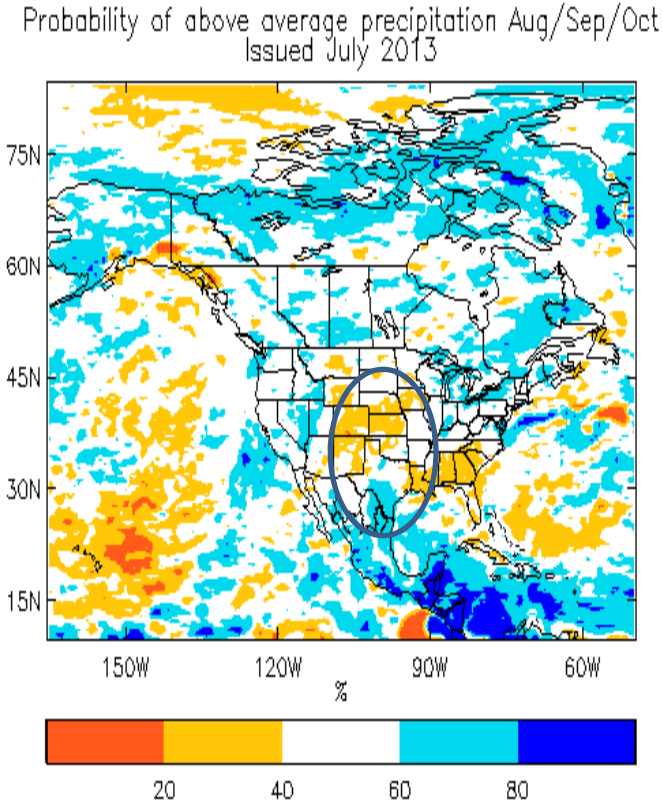
BoM:
POAMA2 output:
October to December, 2013

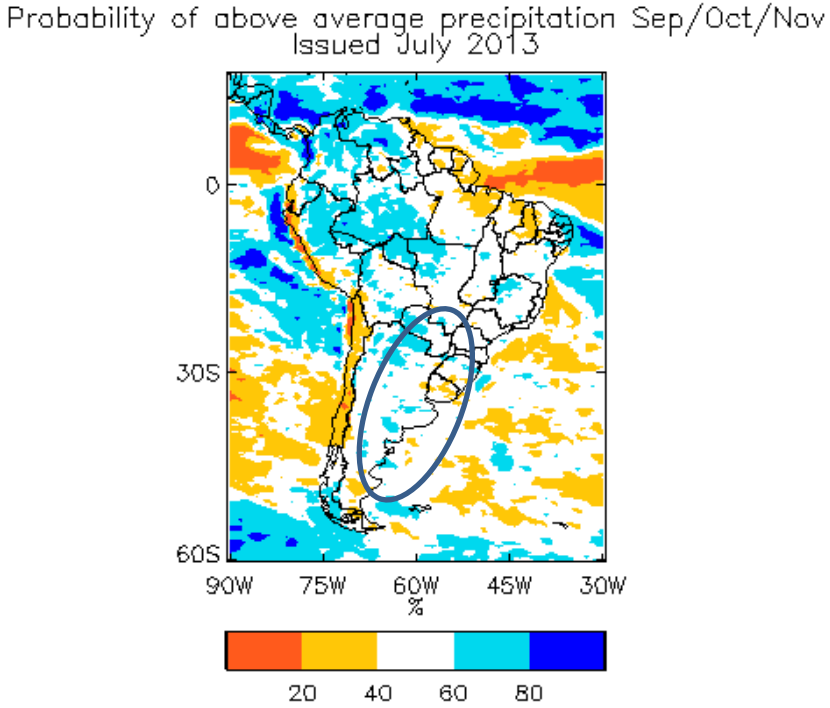


BoM Supercomputer



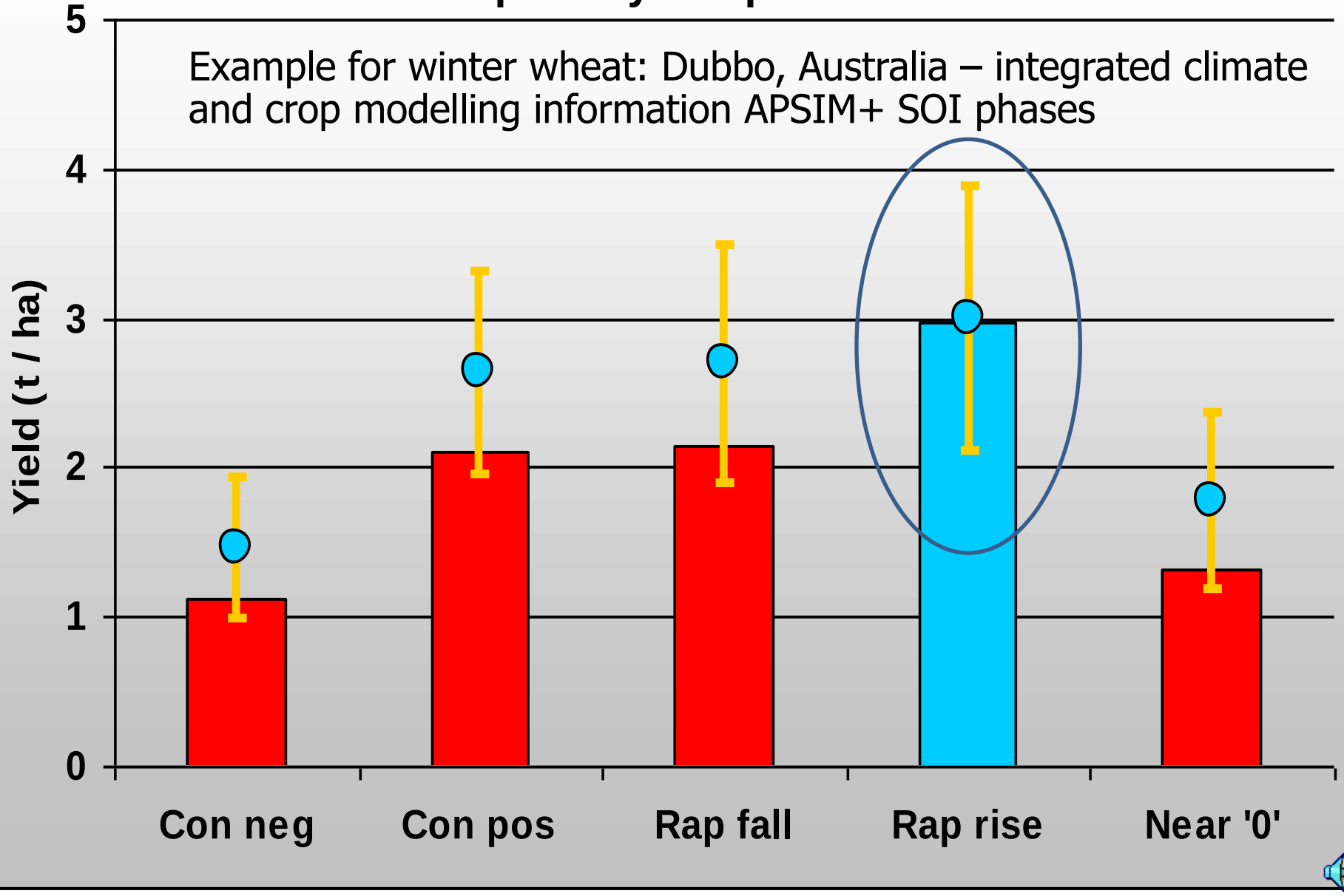
Other world regions: China, India, Pakistan – August to October period – courtesy UKMO

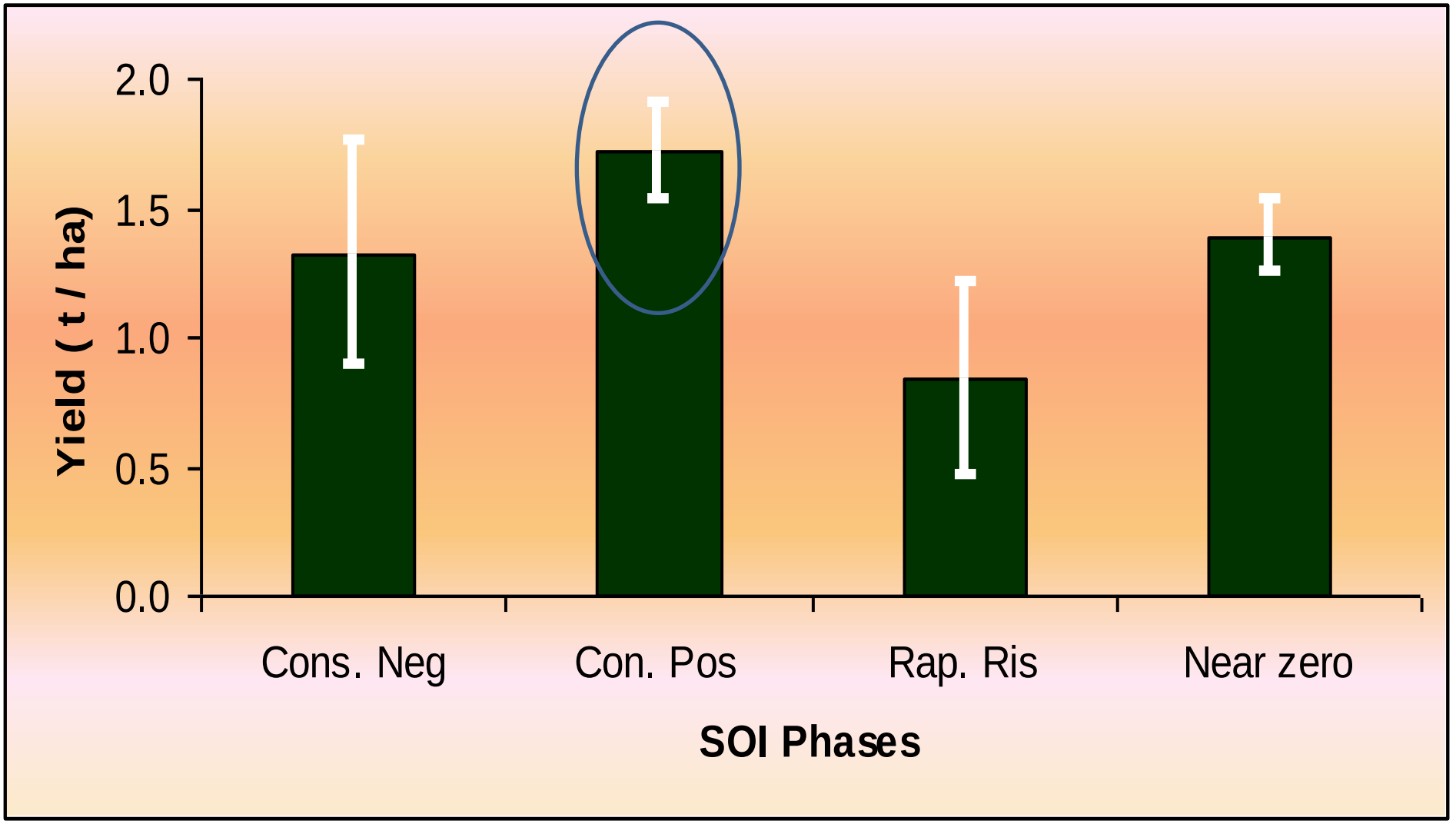




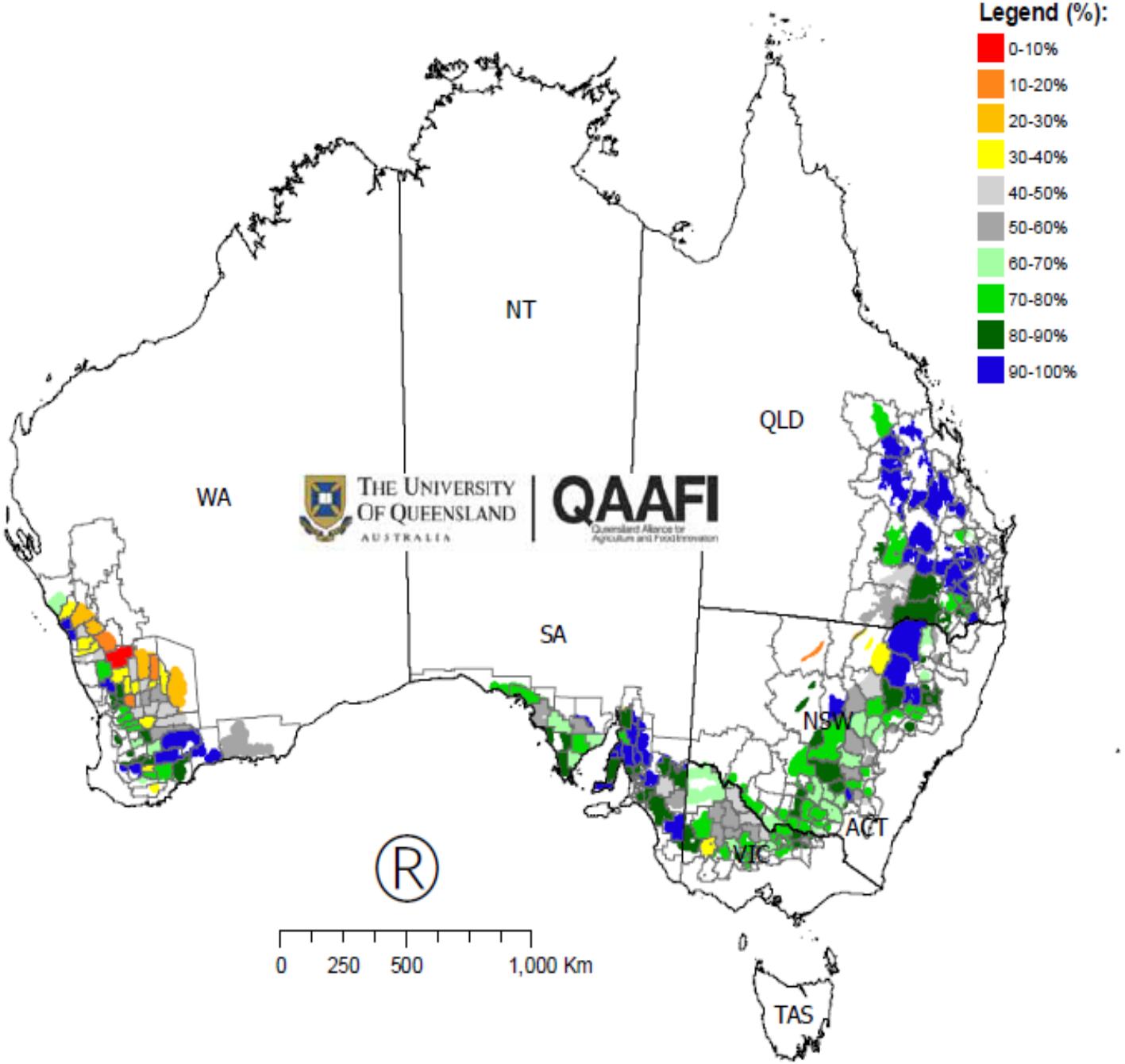
UKMO forecasts for Northern and Southern America/Argentina – Aug to Oct/Nov, 2013

Median wheat yields and standard deviations by April/May SOI phase





Utilising seasonal climate forecasts - forecasts of potential wheat yields associated with varying climate regimes (SOI patterns or phases): Example for a location in Pakistan – potential yields based on June/July SOI phase (APSIM output).



Probability of exceeding the long-term simulated median shire wheat yield (using OZ-Wheat), given the SOI phase was "consistently positive" during May-June

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA
QAAFI
Queensland Alliance for Agriculture and Food Innovation

Summary:

- Useful actual and forecast relationships between conditions in the Central Pacific Ocean (SSTAs) and both rainfall and grain yield values globally (AUS, parts of the US, Canada, Argentina, former USSR, Europe, China, Pakistan, India, RSA, Zimbabwe,).

- Integration of seasonal climate forecast models with crop simulation models provides useful predictive capability – relatively high yield values for much of eastern Australia and parts of SWWA (challenge to link new developments in GCMs with crop production modelling).

- Current 'trying to be a La Nina' pattern (but not quite getting there) suggests somewhat enhanced rainfall (+ shortened frost season in some areas) in Australia, RSA – but tending to the opposite rainfall pattern in central/SW USA, Argentina, Europe as the year progresses.

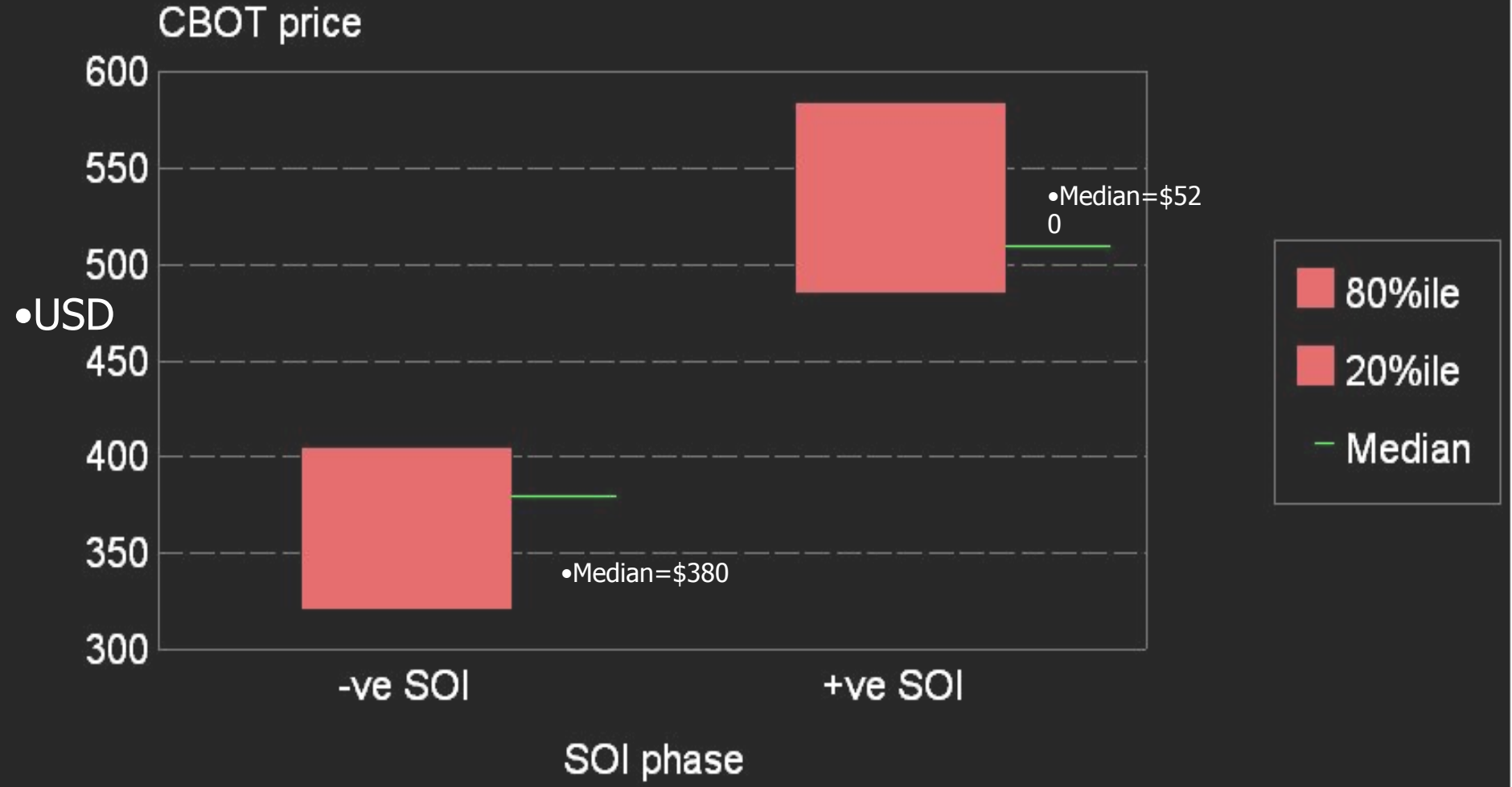
- Suggest update this type of info as often as possible.


THANK YOU!
Flávio Gasson

October price of the December contract

predicted in August

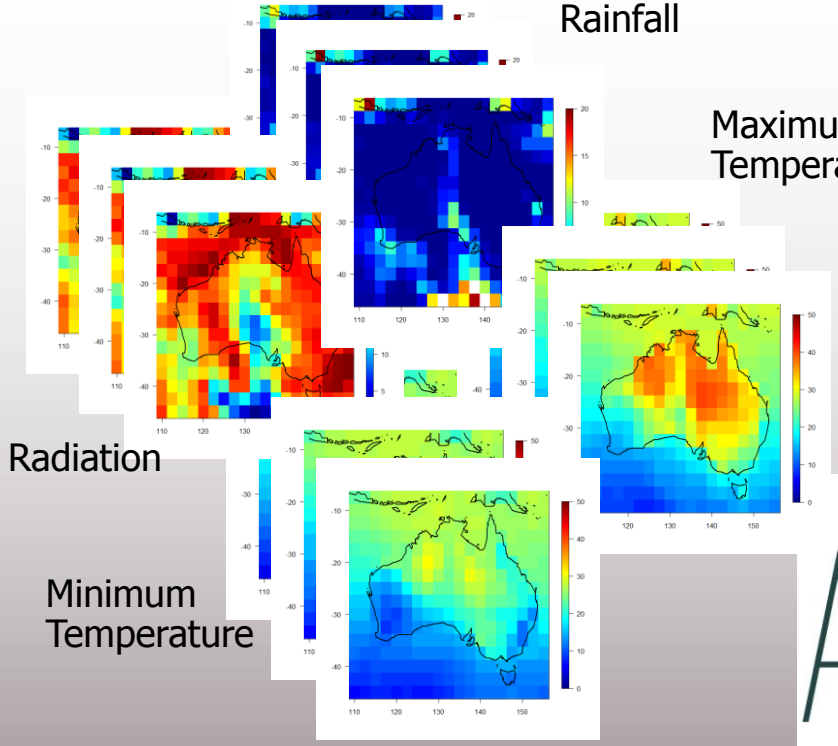
Predicting the October price of the December Chicago wheat futures price using phases of the SOI in the Pacific Ocean - in August (Stone et al, 1997)

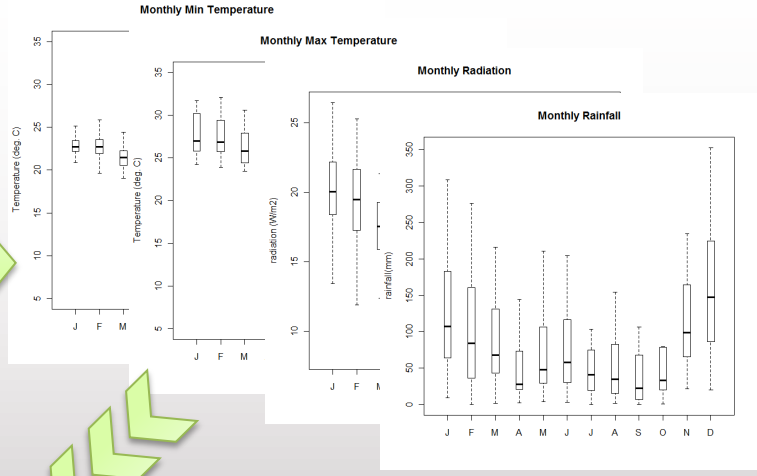


- -ve SOI=cons negative SOI phase in August
- +ve SOI=cons positive SOI phase in August

Multiple Gridded ECMWF/POAMA Realizations

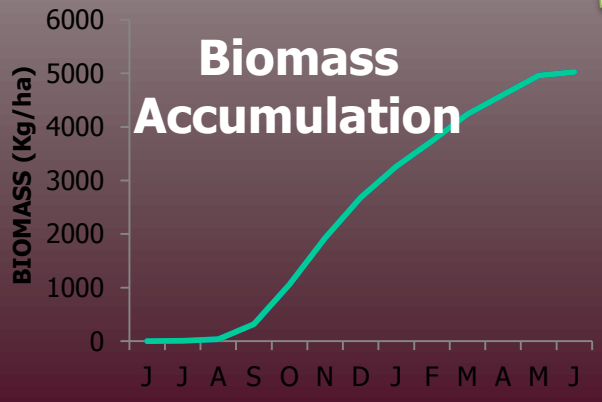
Distributions of Station Climate Data

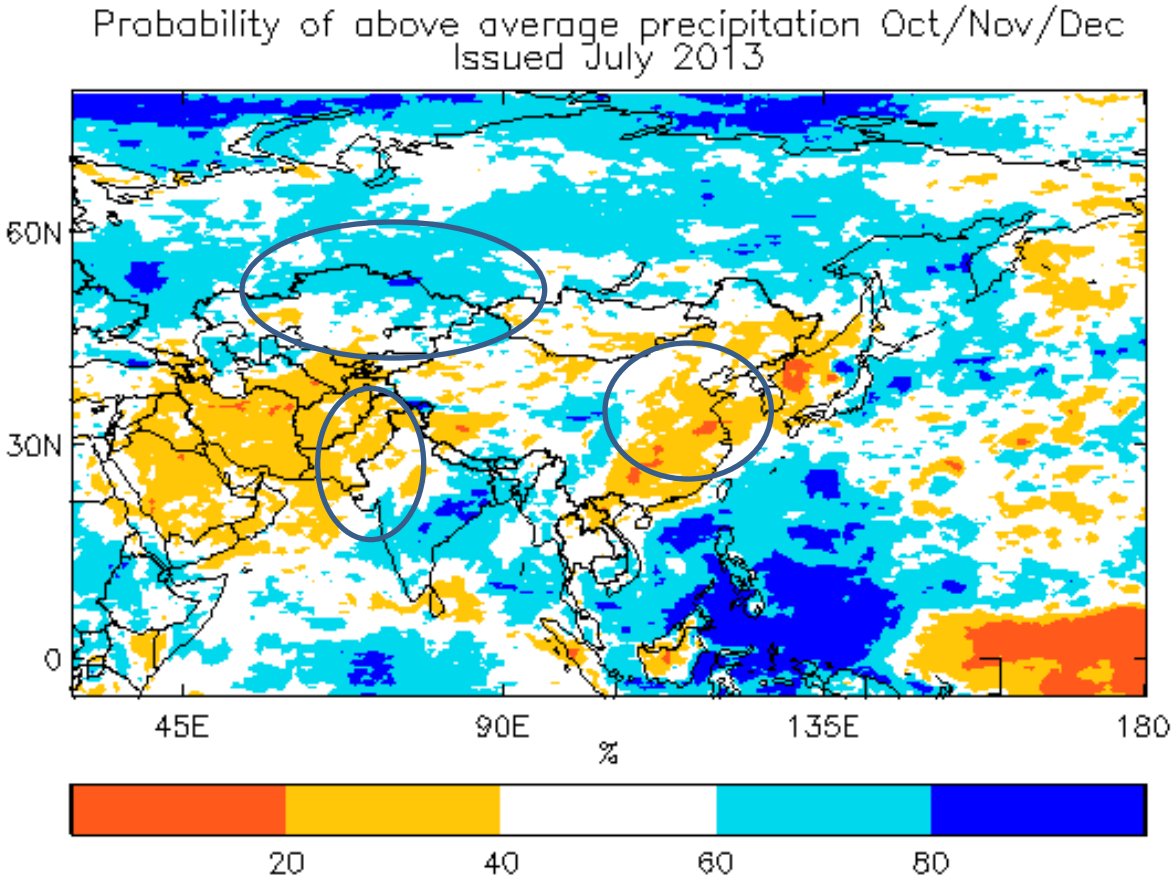




APSIM

AGRICULTURAL PRODUCTION SYSTEMS SIMULATOR



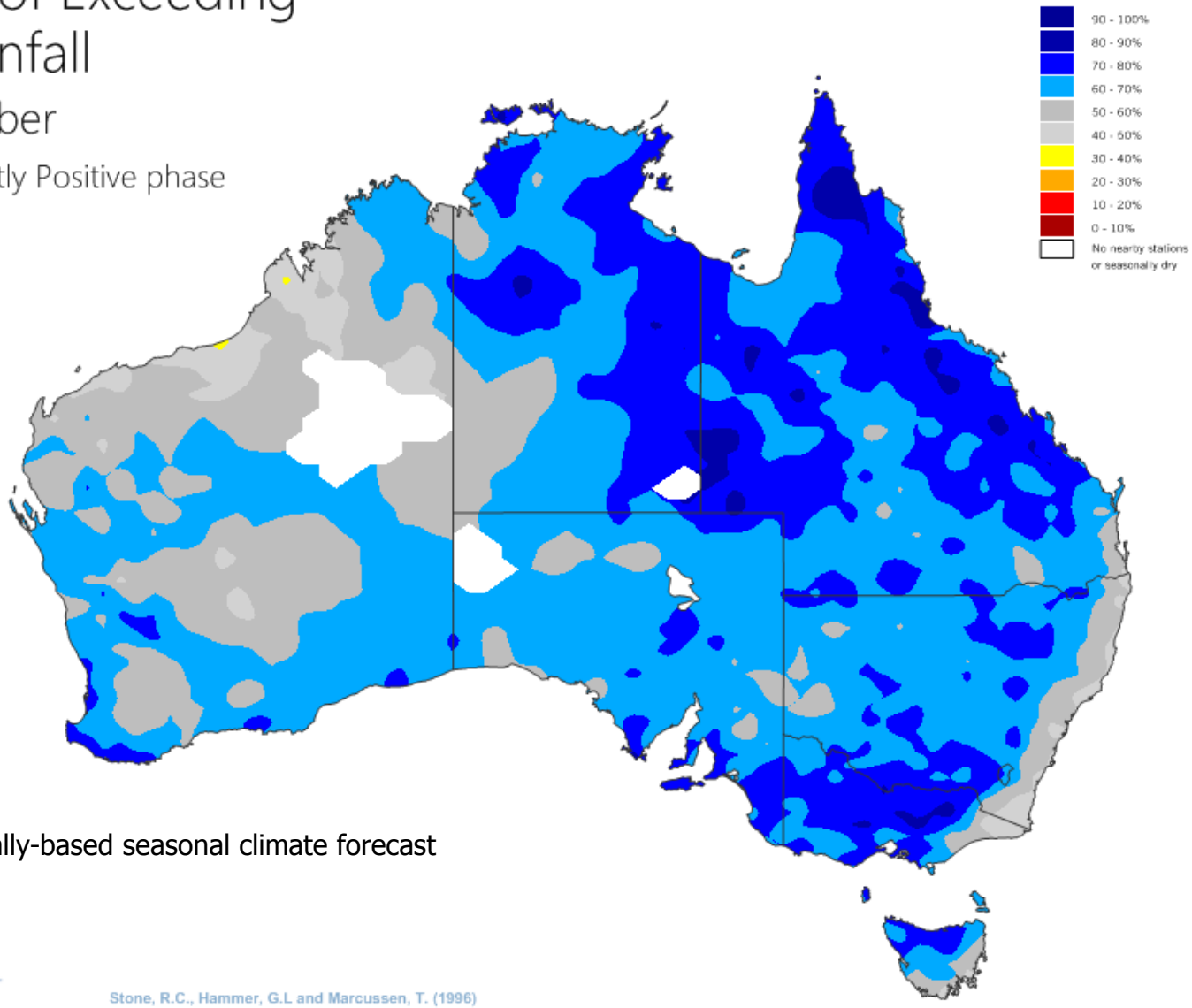


October to December this year – courtesy UKMO

Probability of Exceeding Median Rainfall

August / October

Based on Consistently Positive phase during June / July



A current statistically-based seasonal climate forecast product/output

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Stone, R.C., Hammer, G.L and Marcussen, T. (1996)
Prediction of global rainfall probabilities using phases of the Southern Oscillation Index.
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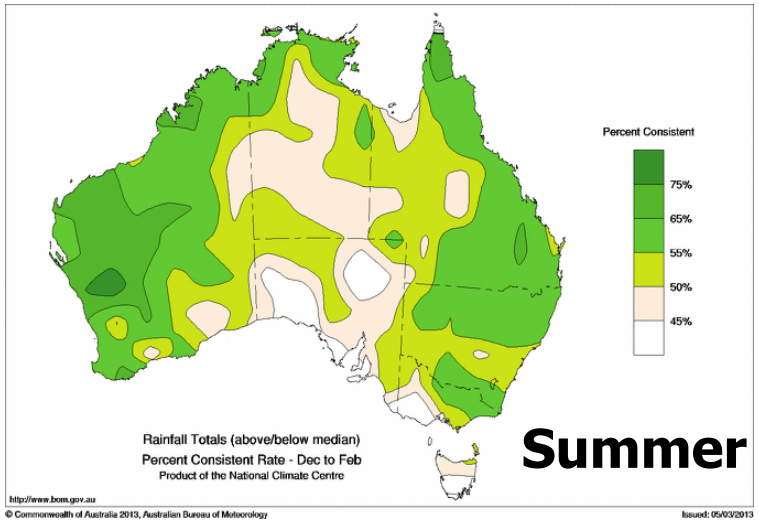
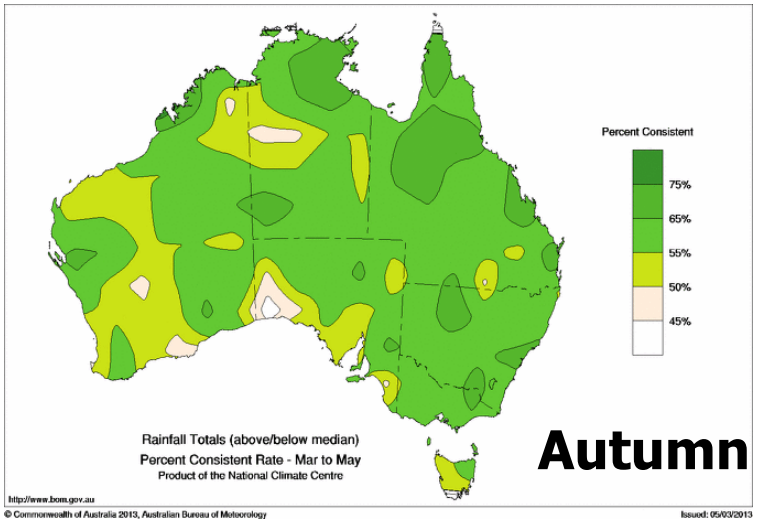
To assist in the decision process? the linking role of modelling in the application of climate information for agricultural production - the key role is to simulate management scenarios and evaluate outcomes and risks relevant to decisions

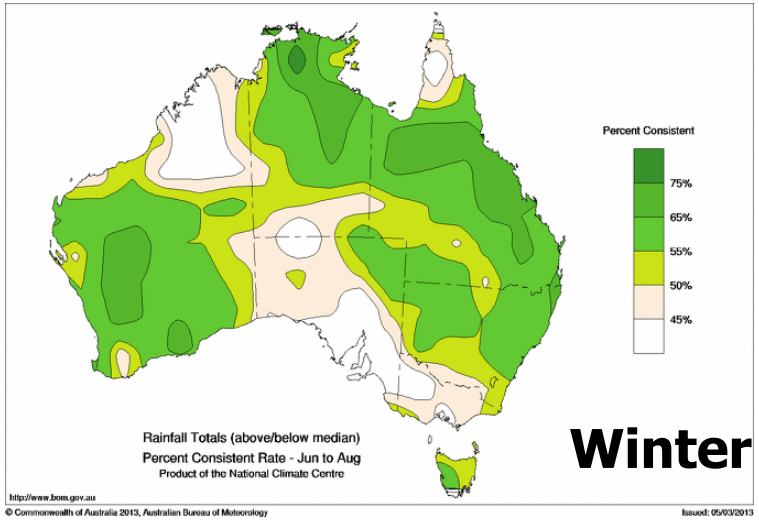
- Simulate management scenarios
- **Evaluate outcomes/risks relevant to decisions**
- Agricultural Production Systems Simulator (APSIM) simulates

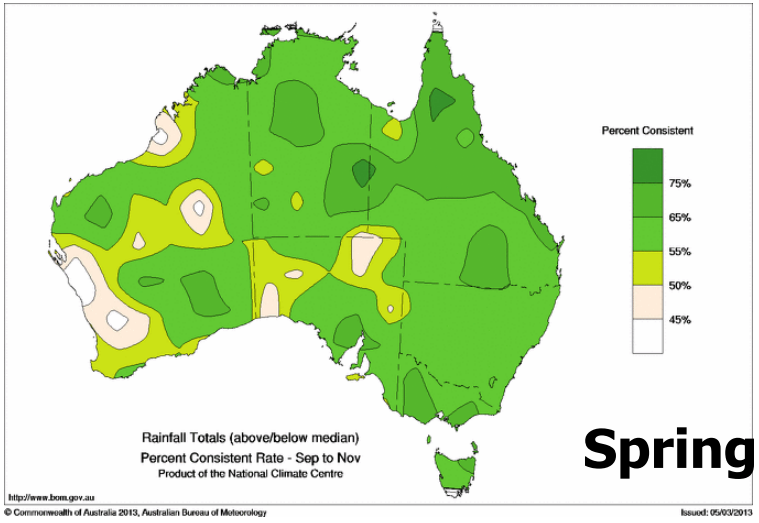
- yield of crops and pastures
- key soil processes (water, N, carbon)
- surface residue dynamics & erosion
- range of management options
- crop rotations + fallowing
- short or long term effects

New BoM Season Climate Outlook Model (POAMA) - Rainfall

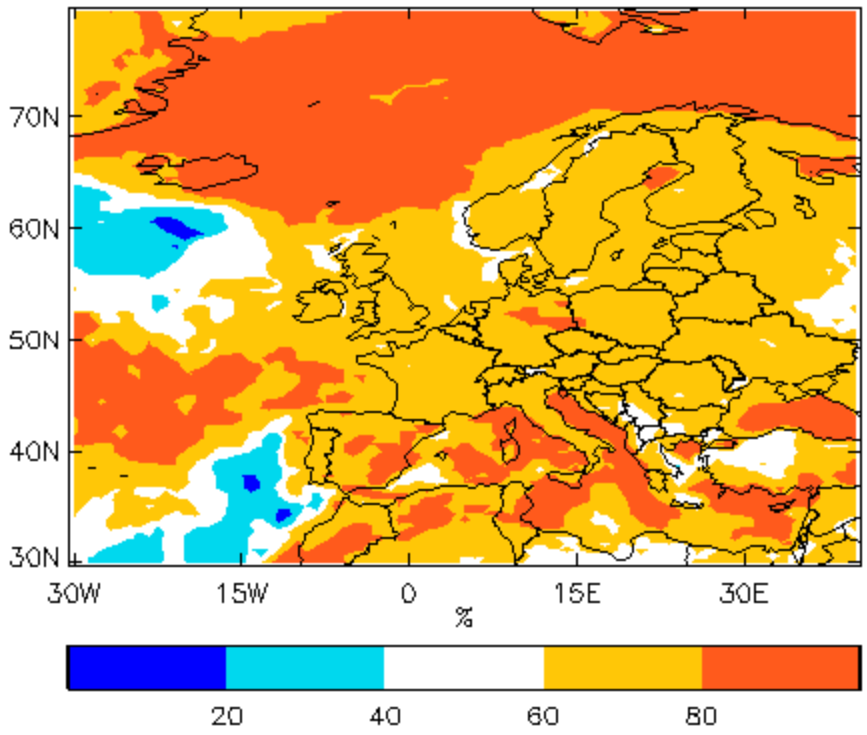




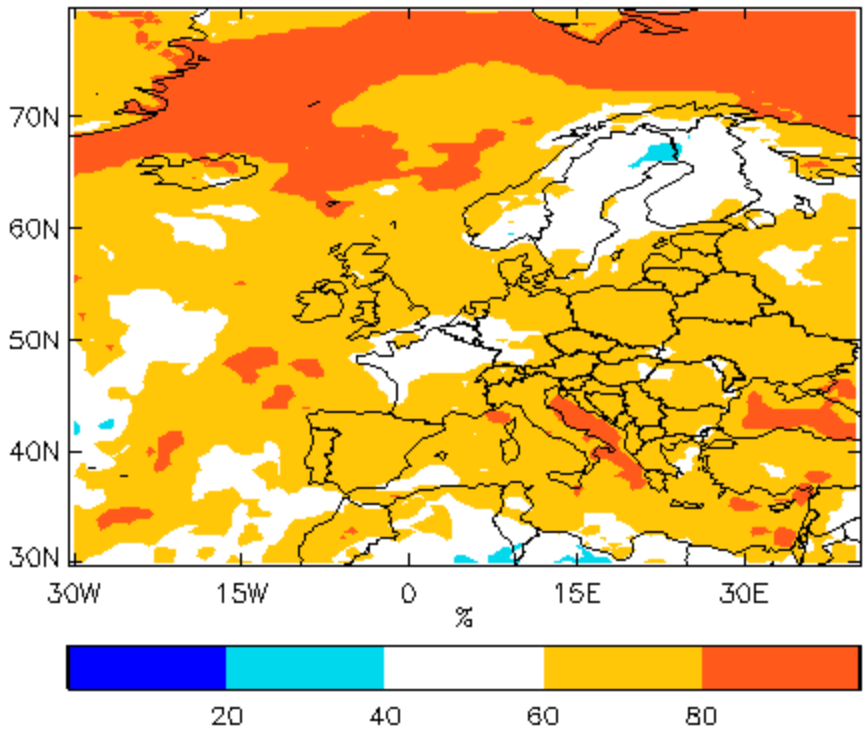


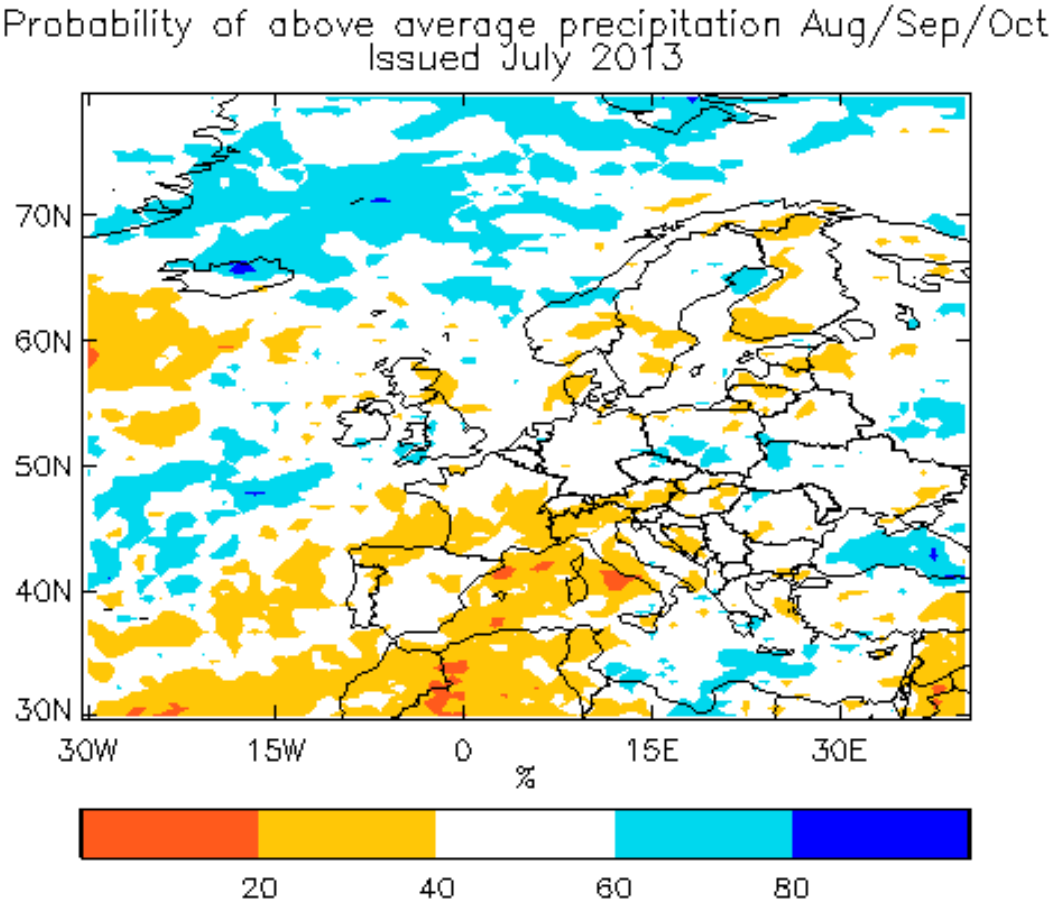


Probability of above average 2m temperature Aug/Sep/Oct
Issued July 2013



Probability of above average 2m temperature Oct/Nov/Dec
Issued July 2013





UKMO GCM FORECSTS FOR EUROPE: AUG-OCT 2013

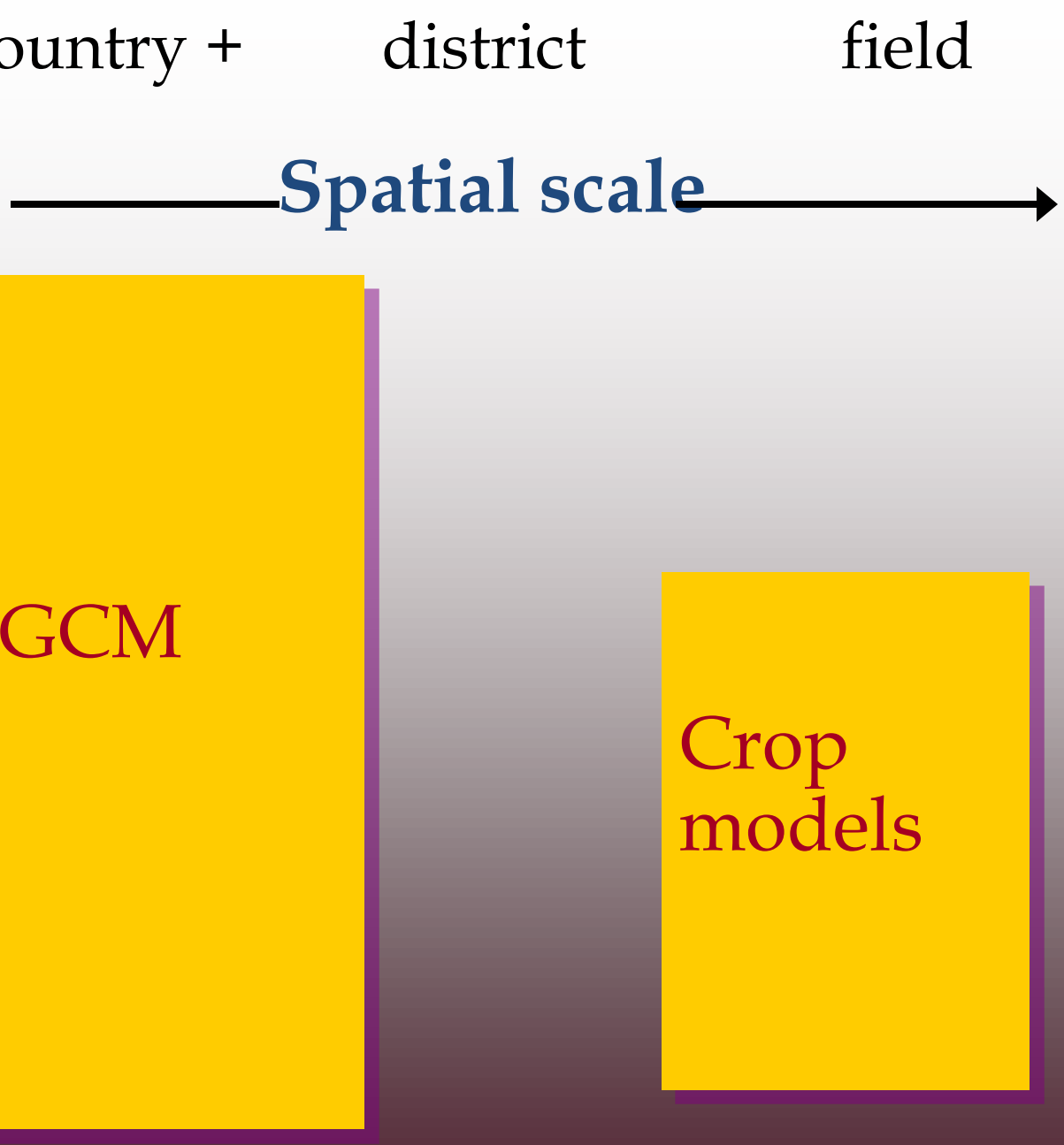
Climate forecast information has no value unless it changes a management decision - Utilising climate forecasts in decision making .

How much Nitrogen to apply given current low soil moisture levels and low probability of sufficient in-crop rainfall?”

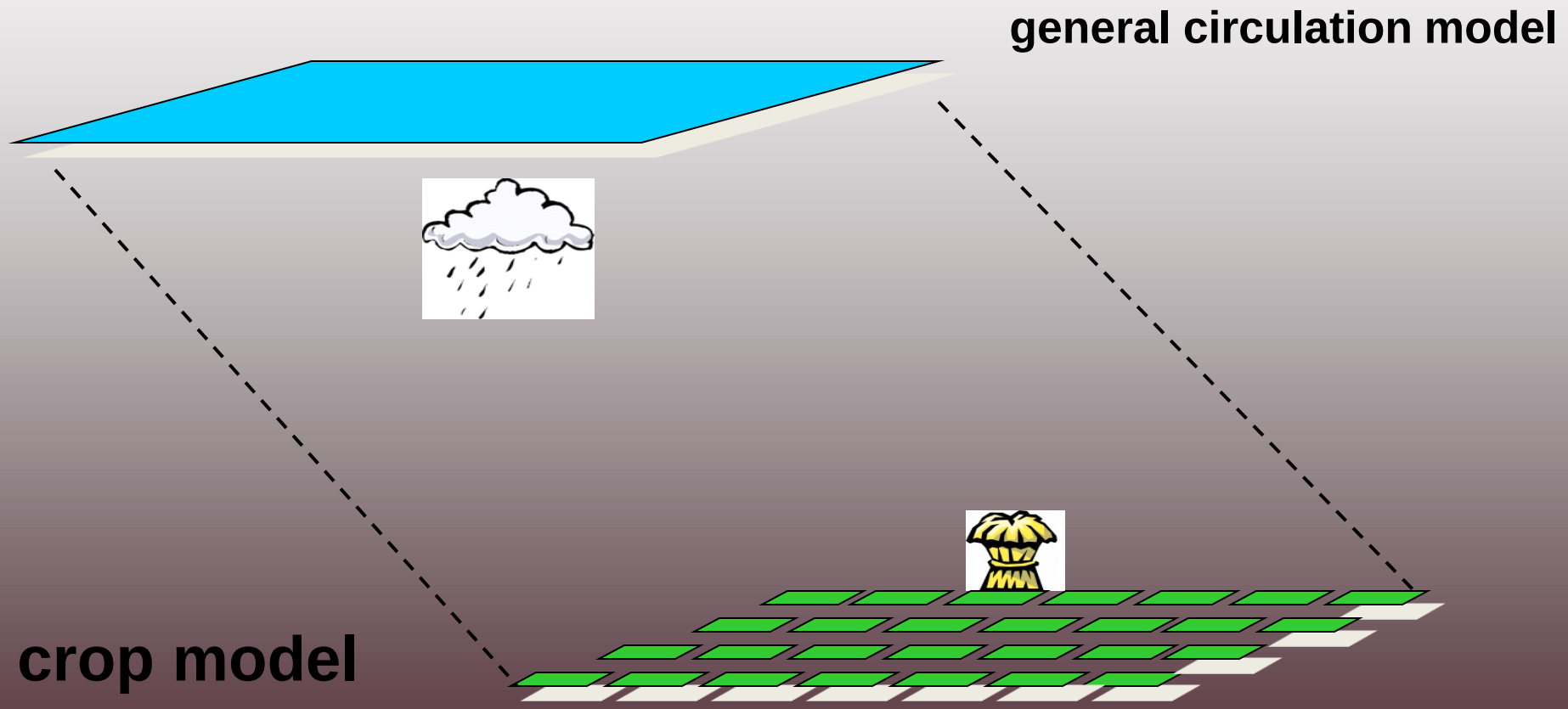
Deciding, which variety to plant given low rainfall probability values and high risk of damaging frost and anthesis?”

A core challenge

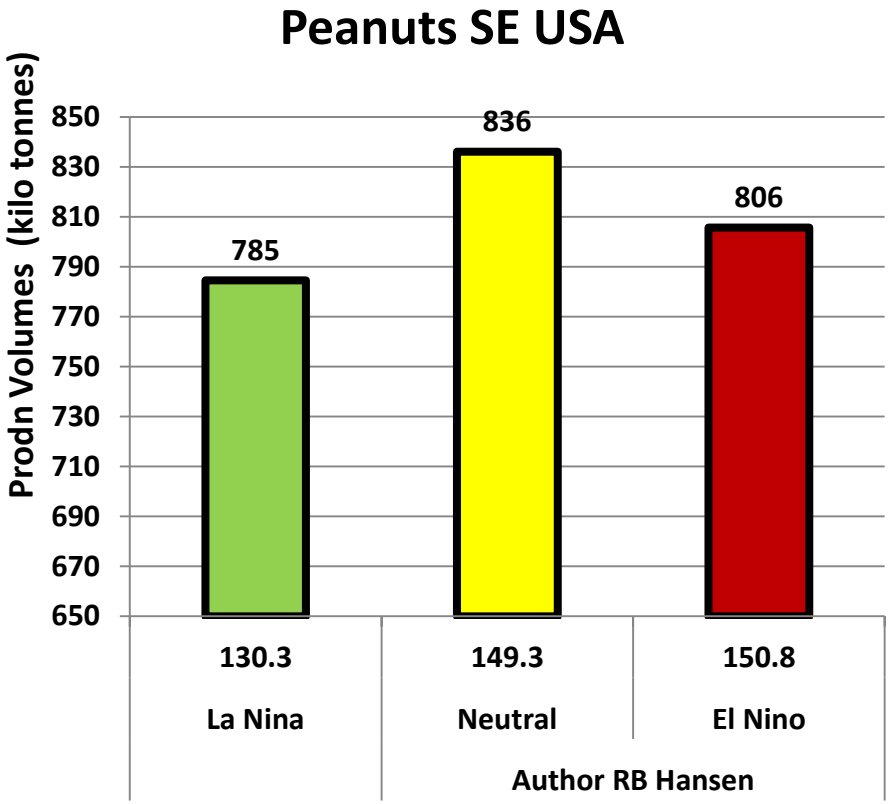
Challinor et al 2003

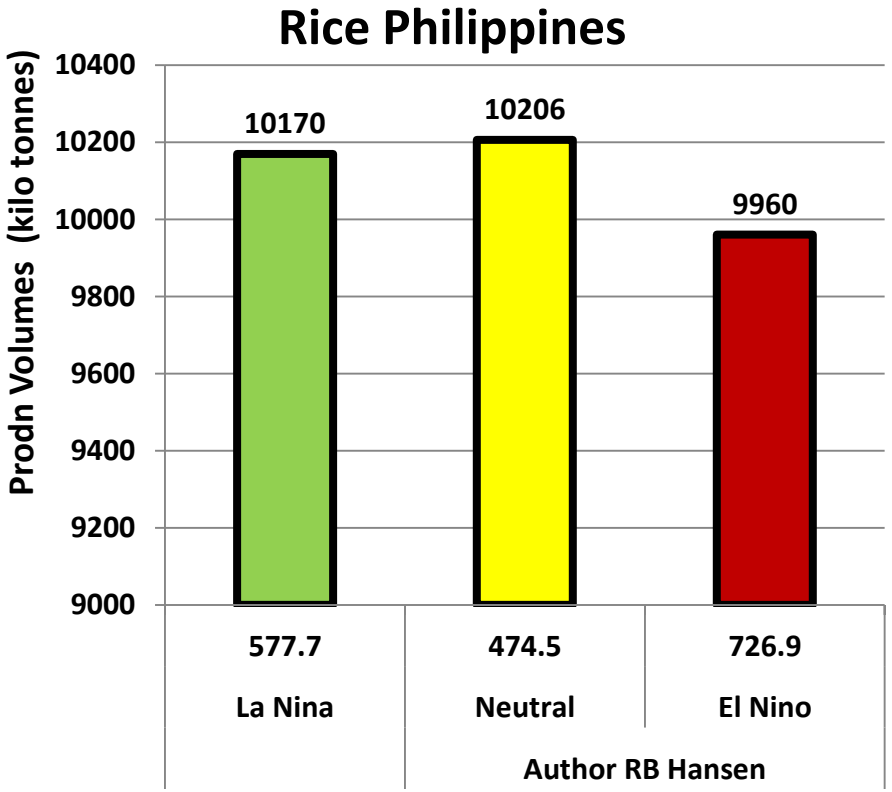


Key – to effectively link the new generation of general circulation models in climate prediction to agricultural models (Challinor et al)

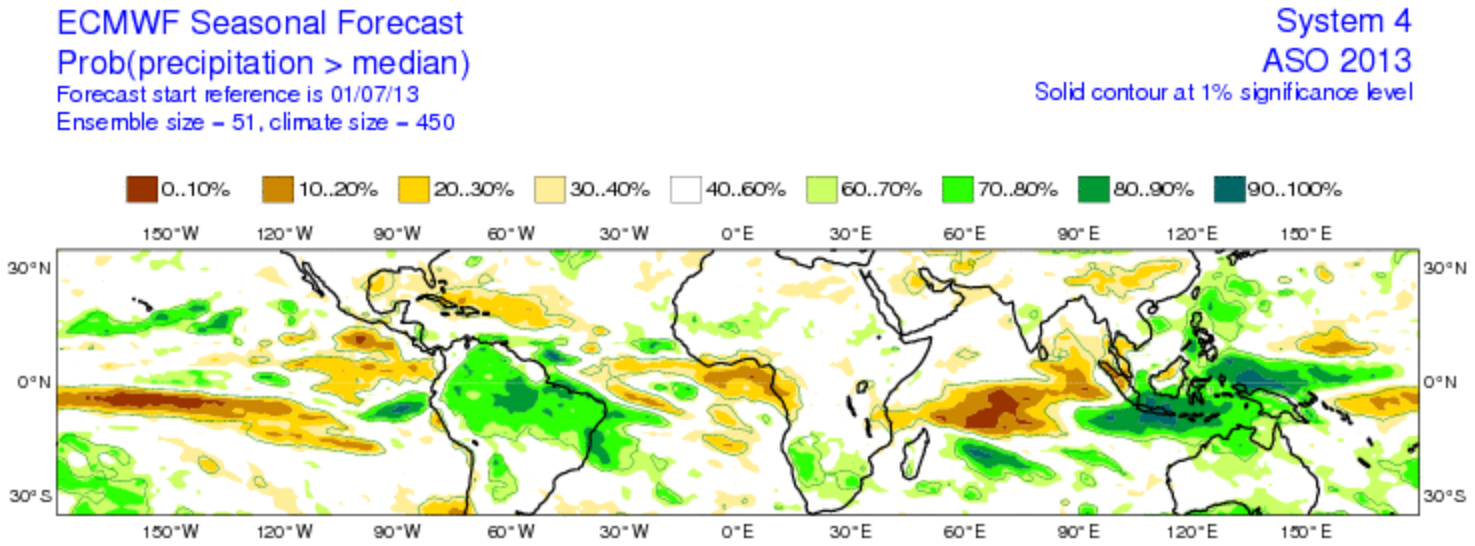


At what scale should information pass between models?





Mean/std production levels for peanuts SE USA associated with ENSO



A Global Perspective - seasonal forecasting example for global tropical regions(ECMWF) – forecast example for the August to October period, 2013.

ECMWF, Reading, UK.

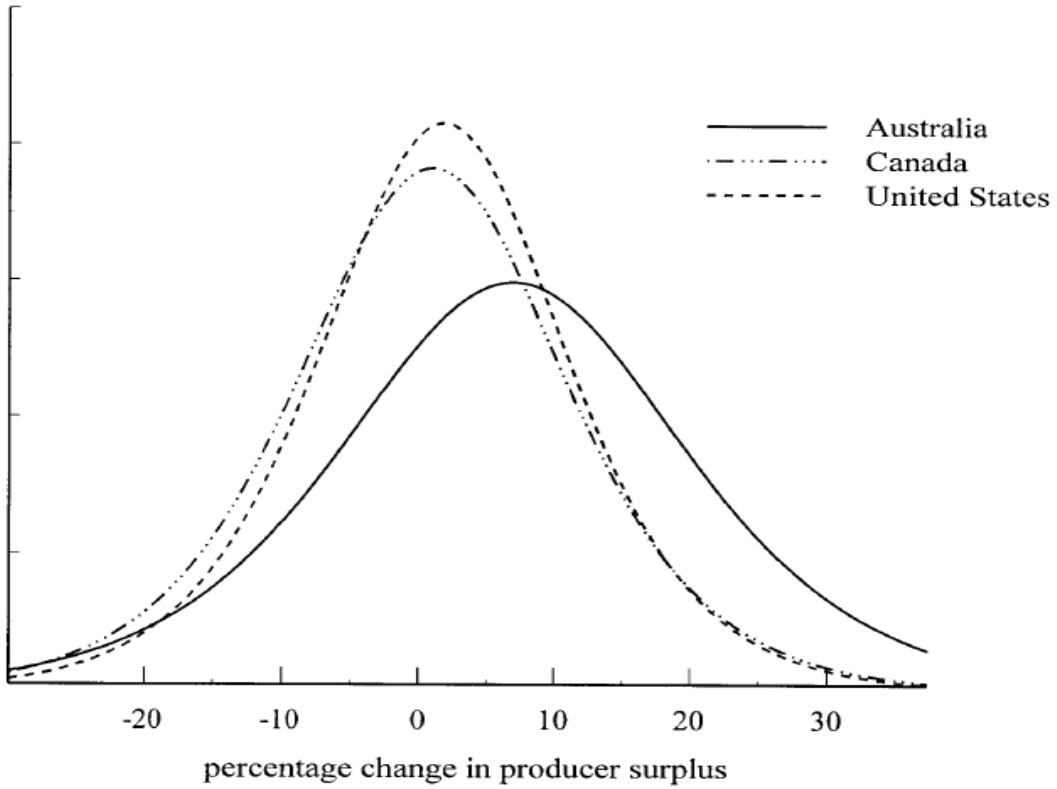
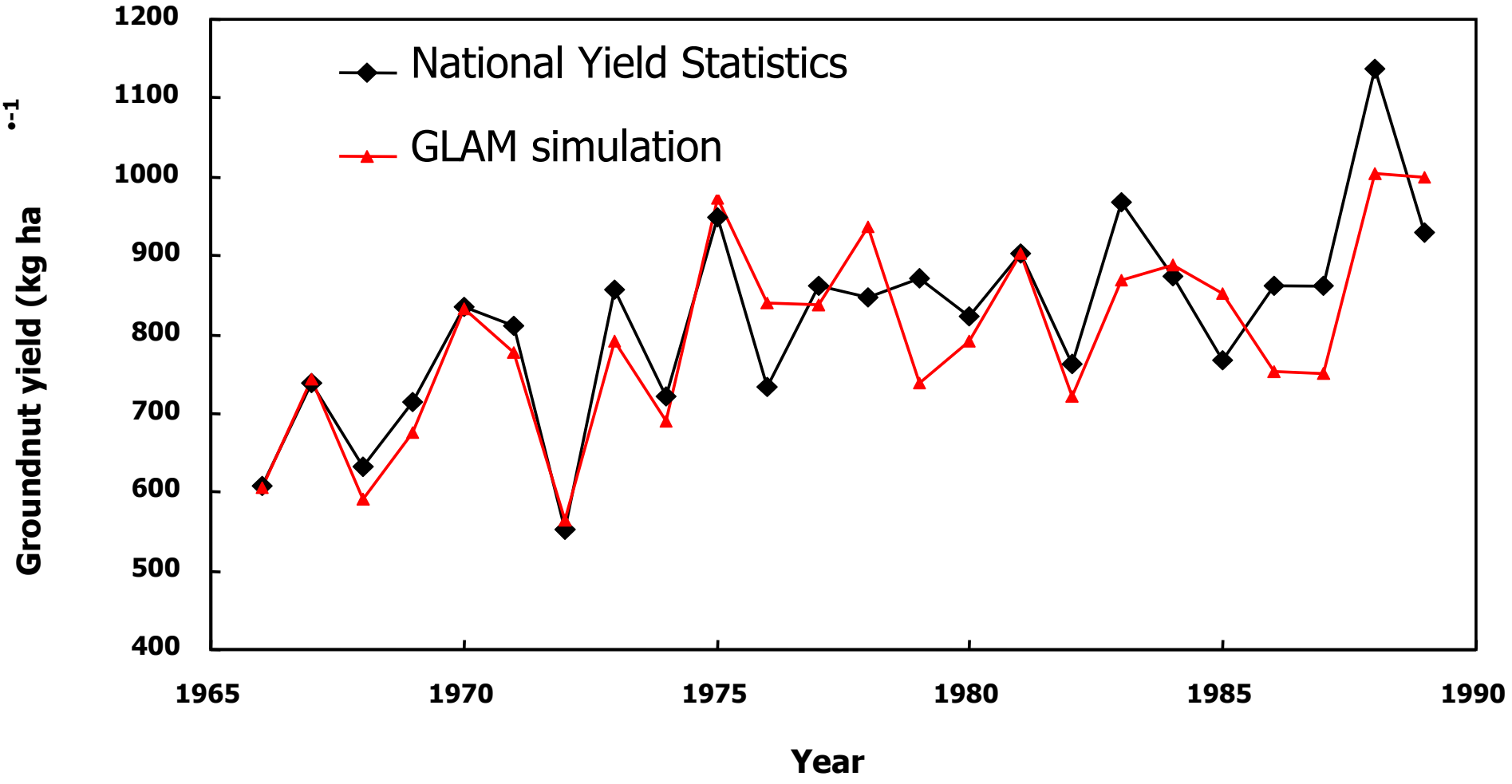


Figure 5. Distribution of percentage changes in mean Australian, Canadian and U.S. producer surplus caused by management responses to seasonal forecasts

Contrary to the findings of previous studies, producer surplus increases across all exporting countries; in fact, producers appear to be able to capture a large share of the economic surplus created by using SOI-based forecasts. It appears that the increase in the Australian and Canadian production, on average, does not affect the world price sufficiently to reduce the two countries' producer surplus. Consequently, the two countries can increase their average producer surplus by using seasonal forecasts. Given the stochasticity incorporated into the

Using forecasts – example of all India groundnut yield using the 'GLAM' coupled climate model

(Challinor et al, 2004)



Example for Europe - Wheat yields –

Use of 'new generation' climate models to directly forecast wheat yields – examples for Germany, France, Denmark, and Greece (from Challinor et al, 2004)

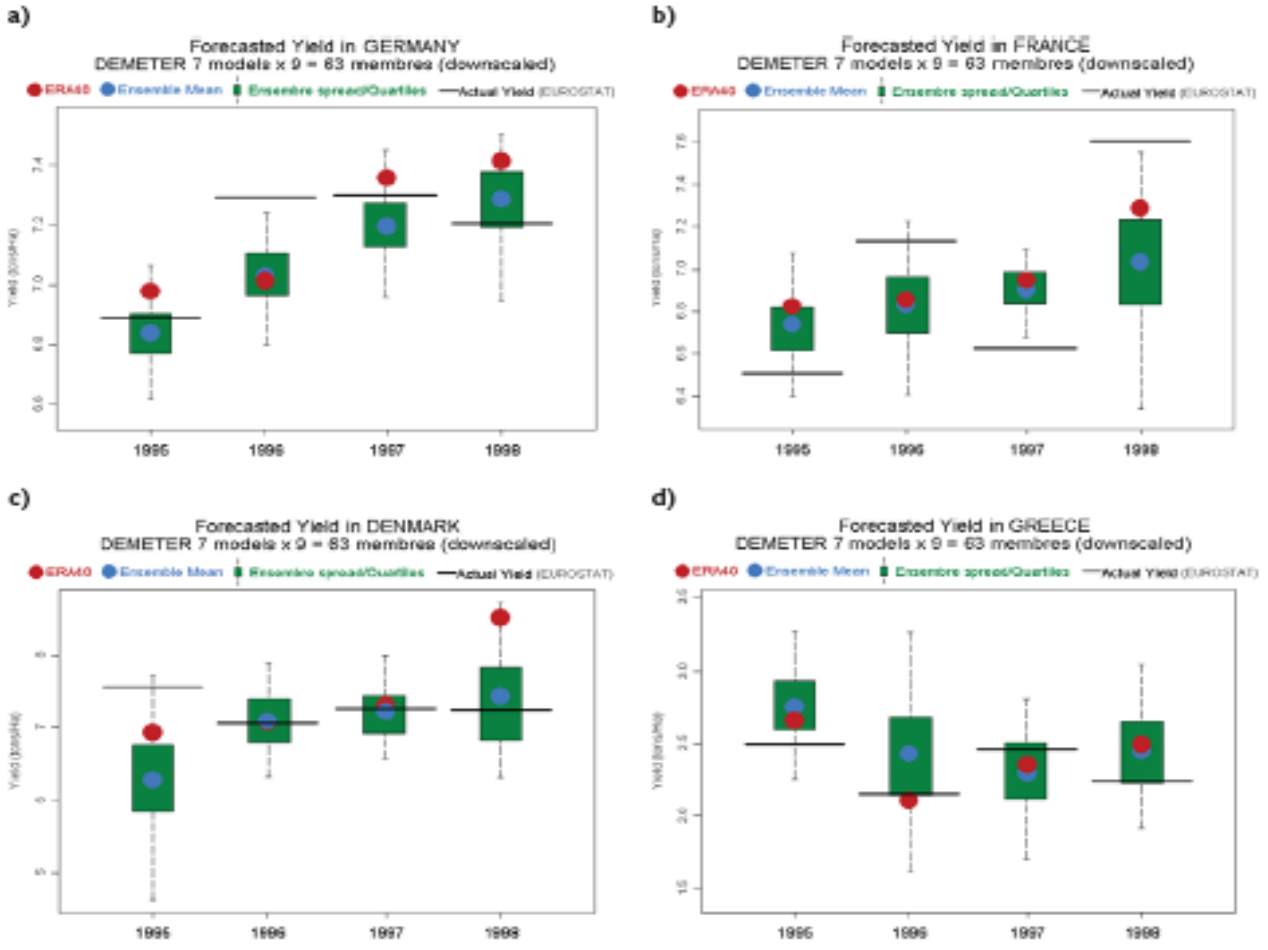
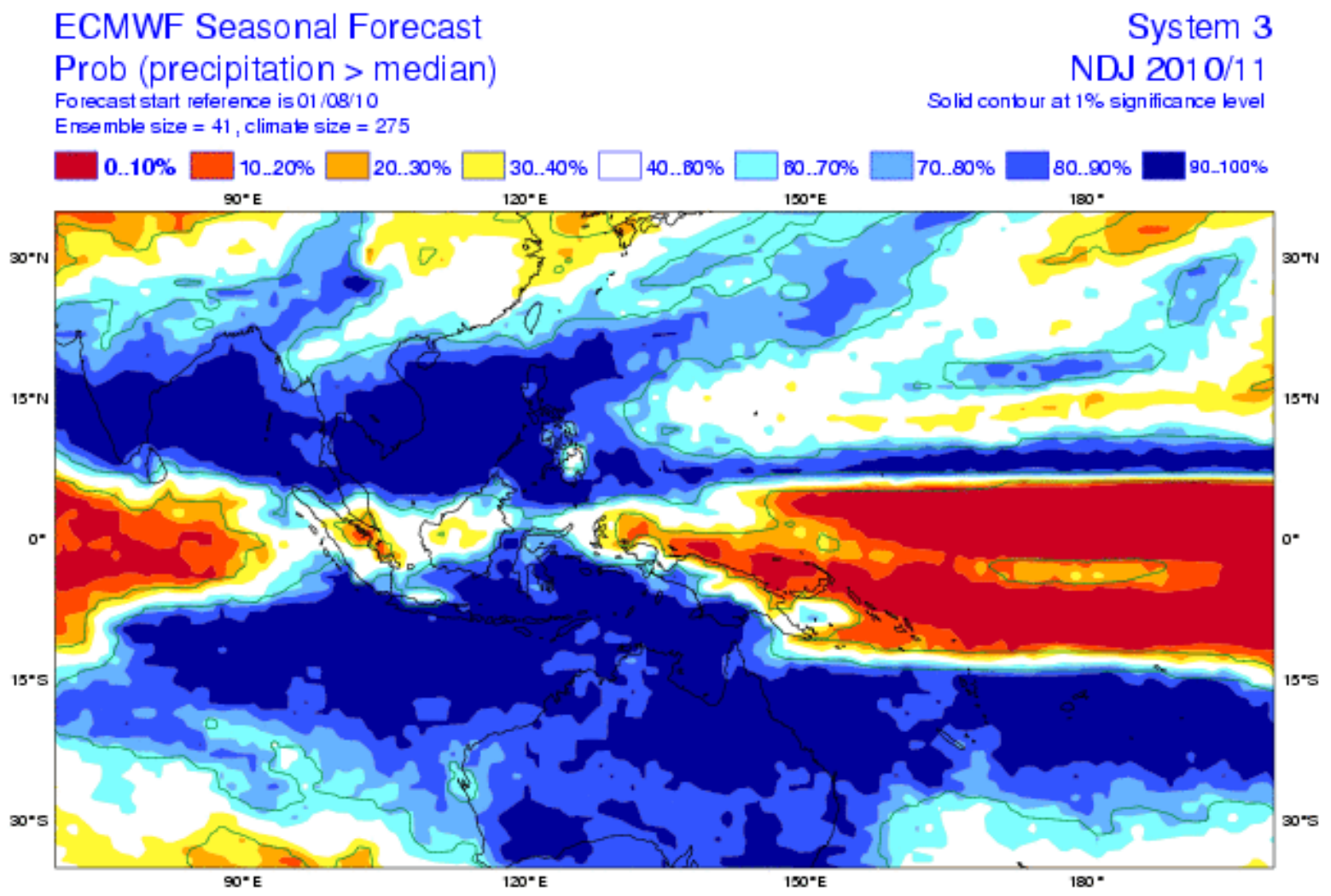
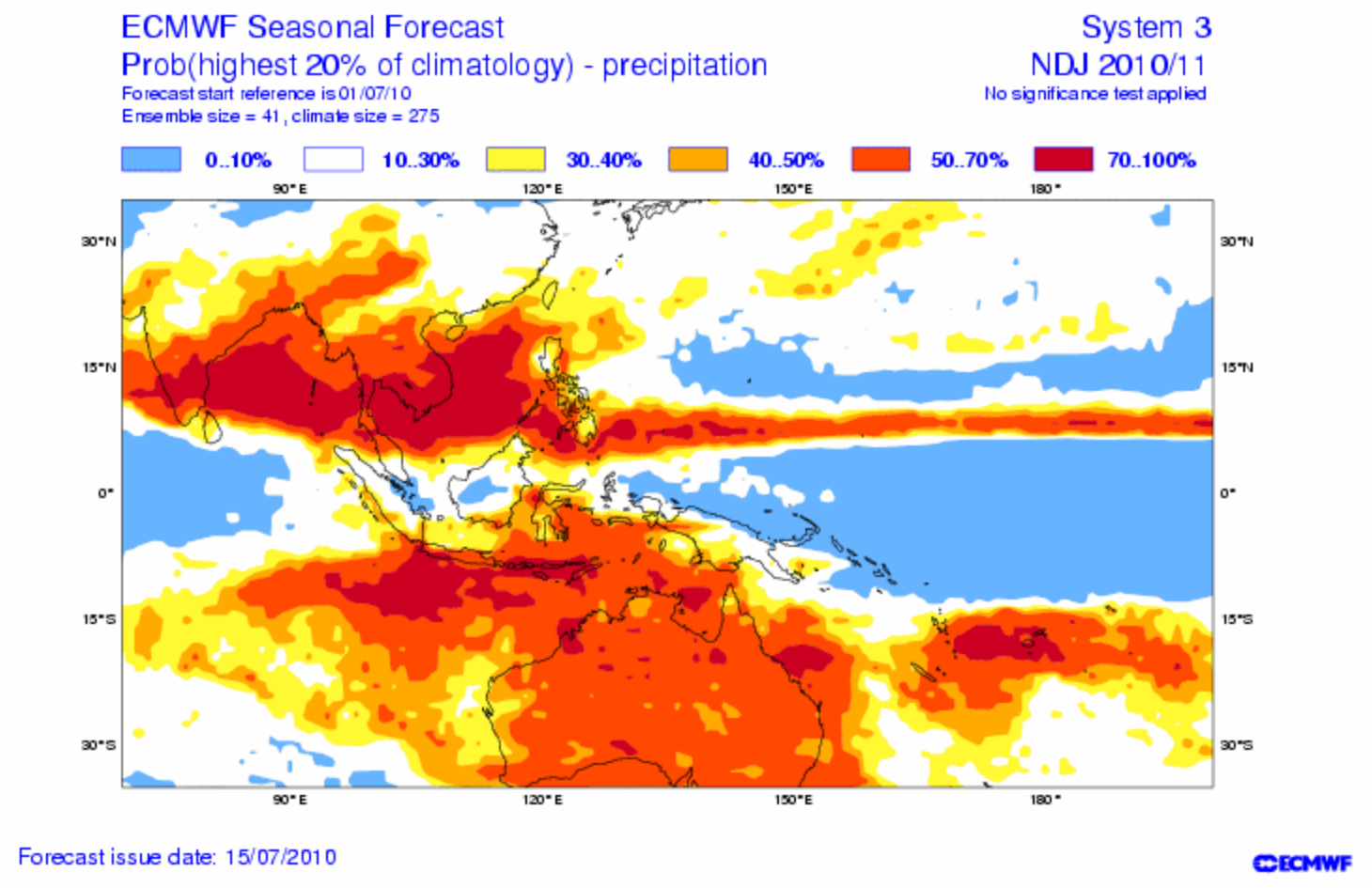


FIG. 7. Time series of the wheat yield predictions from downscaled data for (a) Germany, (b) France, (c) Denmark, and (d) Greece over the period 1995–1998. The multimodel ensemble spread is depicted by the box-and-whisker representation, with the whiskers containing the lower and upper quartile of the ensemble. The blue dots represent the ensemble mean, the yield obtained by forcing the crop model with ERA-40 data being displayed by slightly bigger red bullets. The black horizontal line corresponds to the reference value (Eurostat).



Example from 2010! Very useful input from ECMWF/Reading, UK

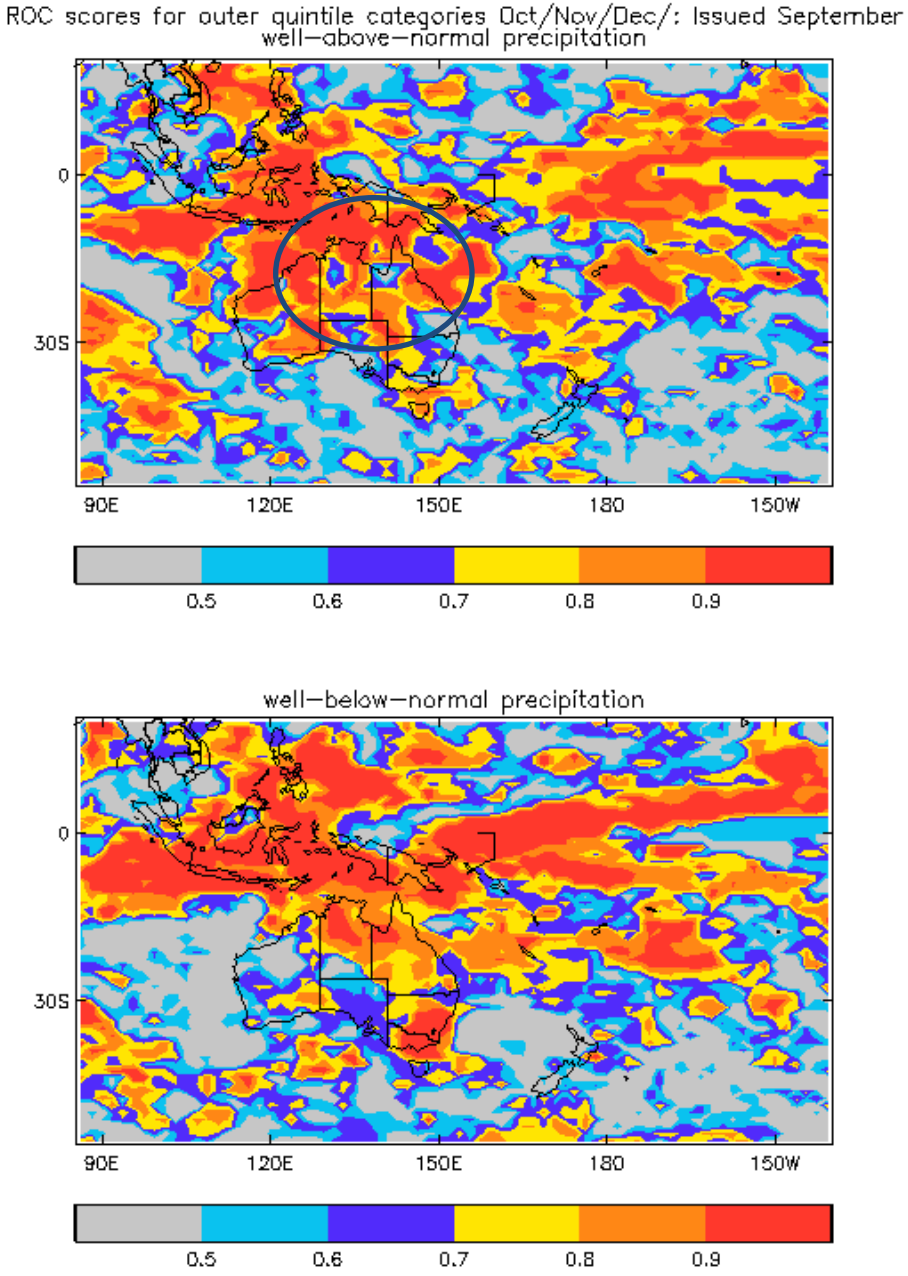


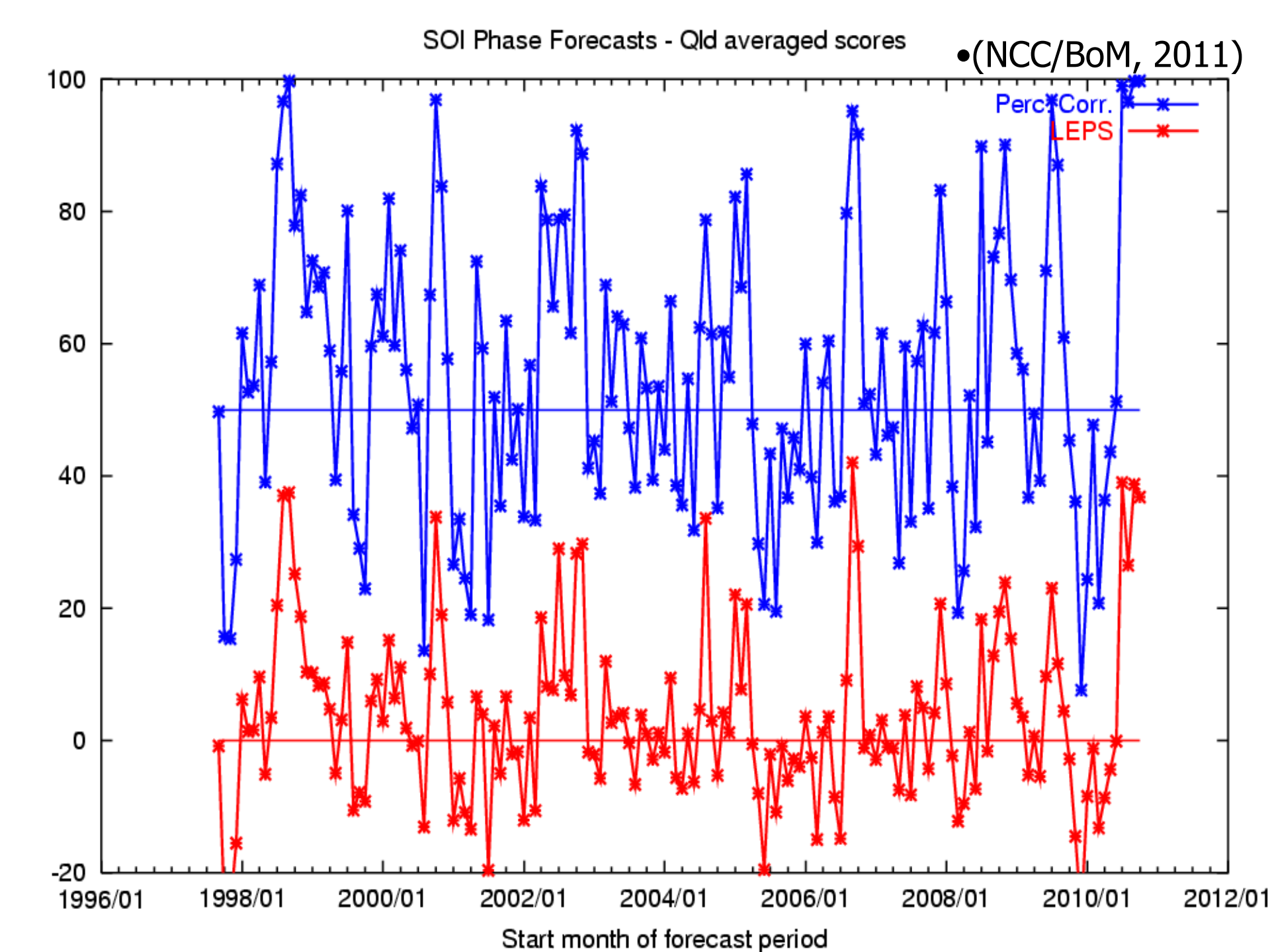
Key agricultural users may seek forecasts on extremes in order to make major decisions – (probability of precipitation being in the 'upper quintile'..NDJ 2010/11.. courtesy ECMWF)..

New generation model assessment':

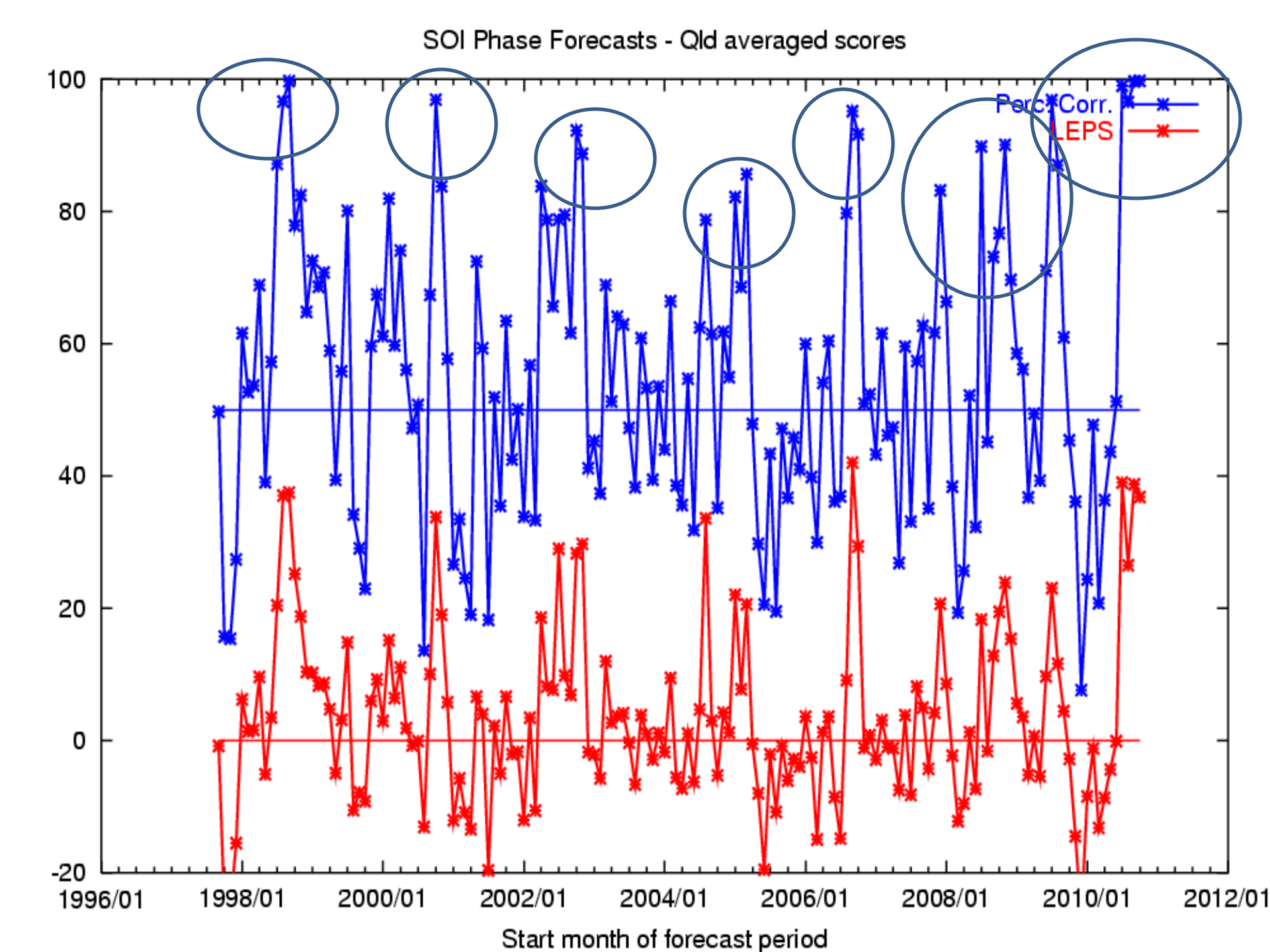
UK Met Office

<u>The value of forecast verification</u> forecasts for NE Australia (Oct-Nov-Dec) – capability to forecast well in upper or lower terciles (courtesy UKMO)..




SOI Phase Forecasts - Qld averaged scores
Perc. Corr.
LEPS
100
80
60
40
20
0
-20
1996/01
1998/01
2000/01
2002/01
2004/01
2006/01
2008/01
2010/01
2012/01
Start month of forecast period

•(NCC/BoM, 2011)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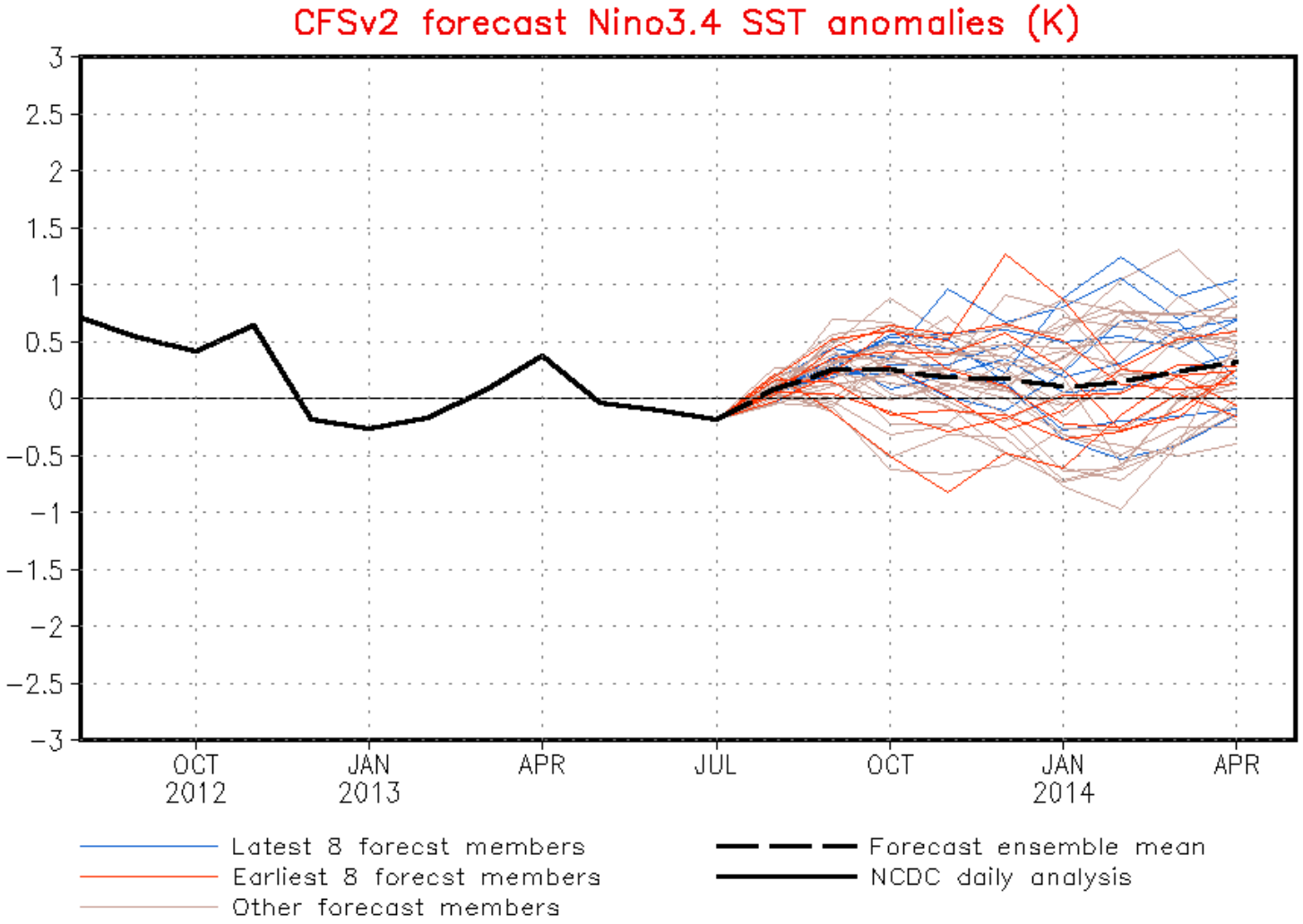
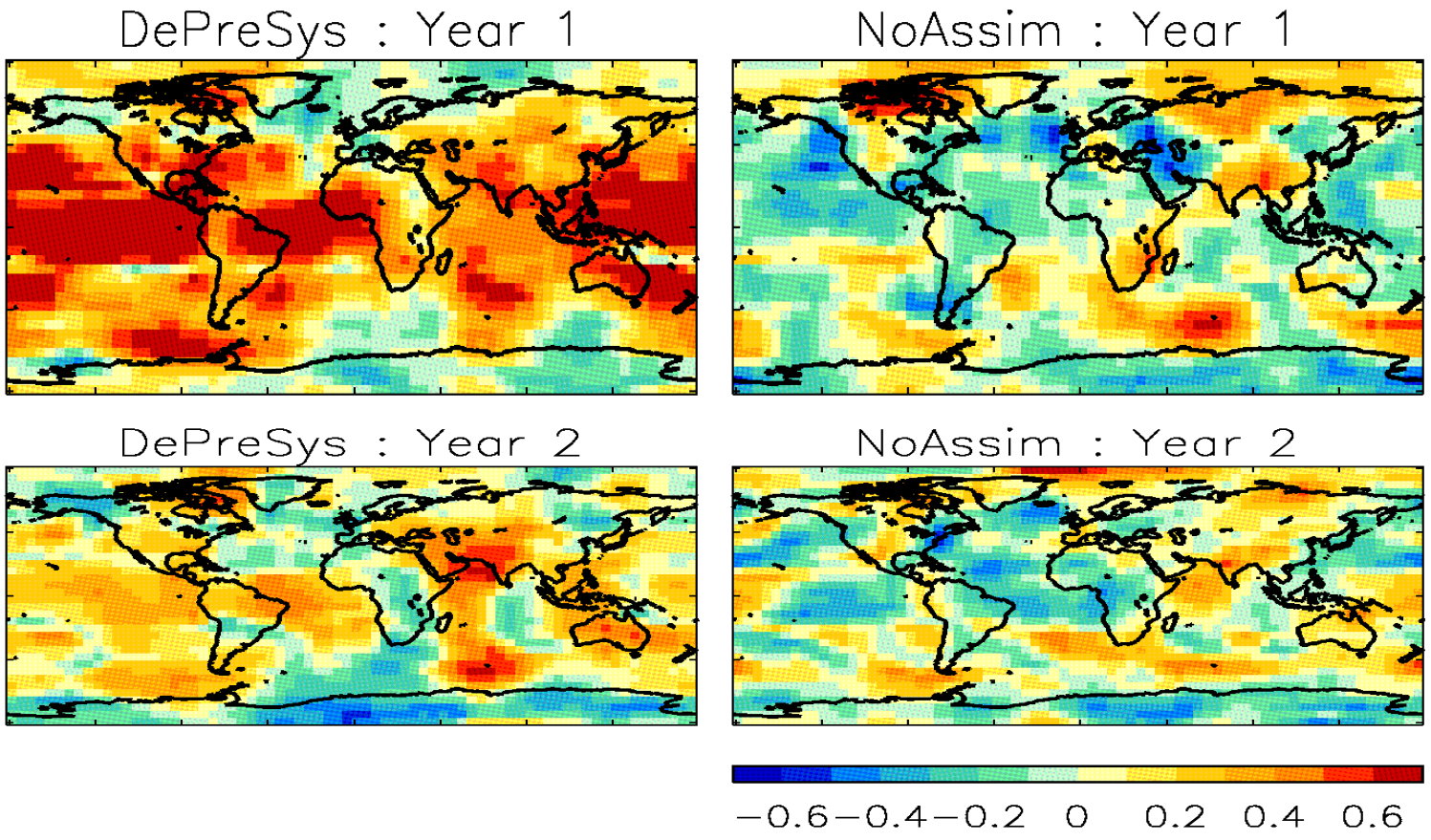
2008/01
2010/01
2012/01
Start month of forecast period

NWS/NCEP/CPC

Last update: Sun Jul 28 2013
Initial conditions: 18Jul2013–27Jul2013



Precip anomaly correlation (35x35^{o} lat/long boxes – (high potential skill for 2 years – courtesy UKMO Hadley Centre for Climate Research)



Release Date: Thursday, 7 March 2013

•The Food and Agriculture Organization of the United Nations' first forecast for world wheat production in 2013 stands at 690 million metric tons, representing an increase of 4.3 percent from the 2012 harvest and the second largest crop on record after that of 2011, according to the organization's latest report.

Europe

•The increase is expected mostly in Europe, driven by an expansion in area in response to high prices, and a recovery in yields from below-average levels in some parts in 2012, notably the Russian Federation.

•Aggregate plantings in the EU are estimated to be 3 percent higher and weather conditions have been generally favourable so far. Elsewhere in Europe, prospects are satisfactory in the Russian Federation: although winter plantings have decreased, this is expected to be more than offset by an increase in the spring wheat area, and assuming yields recover from 2012's drought-reduced levels, output is forecast to increase sharply.

•Also in Ukraine, a large recovery in wheat output is forecast as the winter wheat area recovered from 2012's reduced level and winter conditions have been generally satisfactory.

North America

•In North America, the outlook in the U.S. is less favourable than among the other major wheat-producing countries: although good precipitation in February has greatly improved the outlook in previously drought-affected winter wheat areas, it is likely too late for the stressed crops to make a full recovery.

•Thus, despite an estimated 1 percent increase in winter wheat plantings and the likelihood that spring plantings will at least match 2012's level, if not expand slightly, aggregate wheat output is tentatively forecast to decrease by about 6 percent to 58 million metric tons, below the average of the past five years.

Asia

•In Asia, prospects for the 2013 wheat crop, to be harvested from April, are mostly favourable in the main producing countries, according to the FAO report.

•In China, higher minimum purchase prices have encouraged farmers to maintain 2012's good area and favourable weather conditions have benefited crops and early official forecasts point to a record wheat output of some 121 million metric tons in 2013.

•Also in Pakistan, a record wheat output is forecast reflecting larger plantings and good yield prospects. In India, plantings are around 2012's good level and another bumper crop is in prospect although forecast slightly below the 2012 record because of limited rainfall in some important producing areas.

North Africa

•In North Africa, early prospects for the 2013 wheat crops are good. Soil moisture was reported to be ample for planting last autumn and winter conditions have favored crop development.

Australia

•In the southern hemisphere, the major wheat crops will be sown later in 2013. In Australia, where planting starts from April, early prospects are uncertain: tight supplies and strong prices are expected to provide incentive to farmers to increase plantings, but soil moisture reserves have been severely depleted by the summer heat wave in some major producing areas and much more precipitation is needed to ensure satisfactory planting conditions.

FAO now puts world wheat output in 2013 at 704 million tonnes, an increase of 6.8 percent, which would imply more than full recovery from the previous year's reduction and bring world production to its highest level in history.

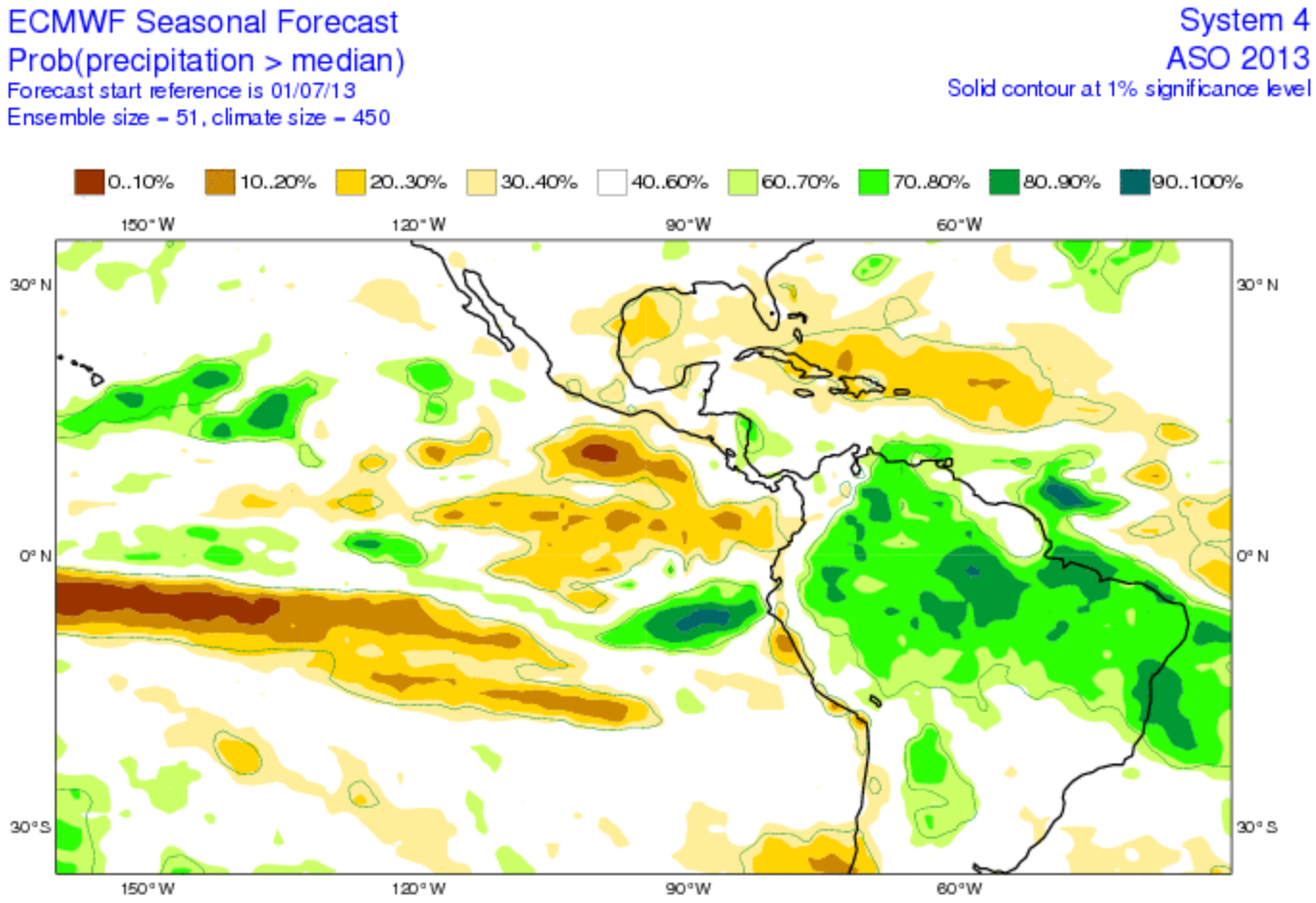
By far, the bulk of the increase this year is expected to originate in Europe, as prospects remain favourable overall in the EU and outputs in the major producing CIS countries are forecast to rebound sharply from drought-reduced levels in 2012.

The outlook is also positive in Canada, Australia and Argentina - other major exporters - and in most other wheat producing and consuming countries. The main exception is the United States, where wheat crop growth has been hindered by adverse weather conditions – drought in particular - this season.

World production of coarse grains in 2013 is now forecast by FAO at about 1 275 million tonnes, up sharply (9.7 percent) from 2012. Latest estimates confirm increased harvests in Argentina and Brazil, the two major producing countries in the Southern Hemisphere, while a smaller crop has been harvested in South Africa. Elsewhere, increased outputs are forecast among the major Northern Hemisphere producing countries.

In the United States, where maize plantings increased and yields are expected to return to normal after last year's drought-reduced levels, production is expected to recover markedly.

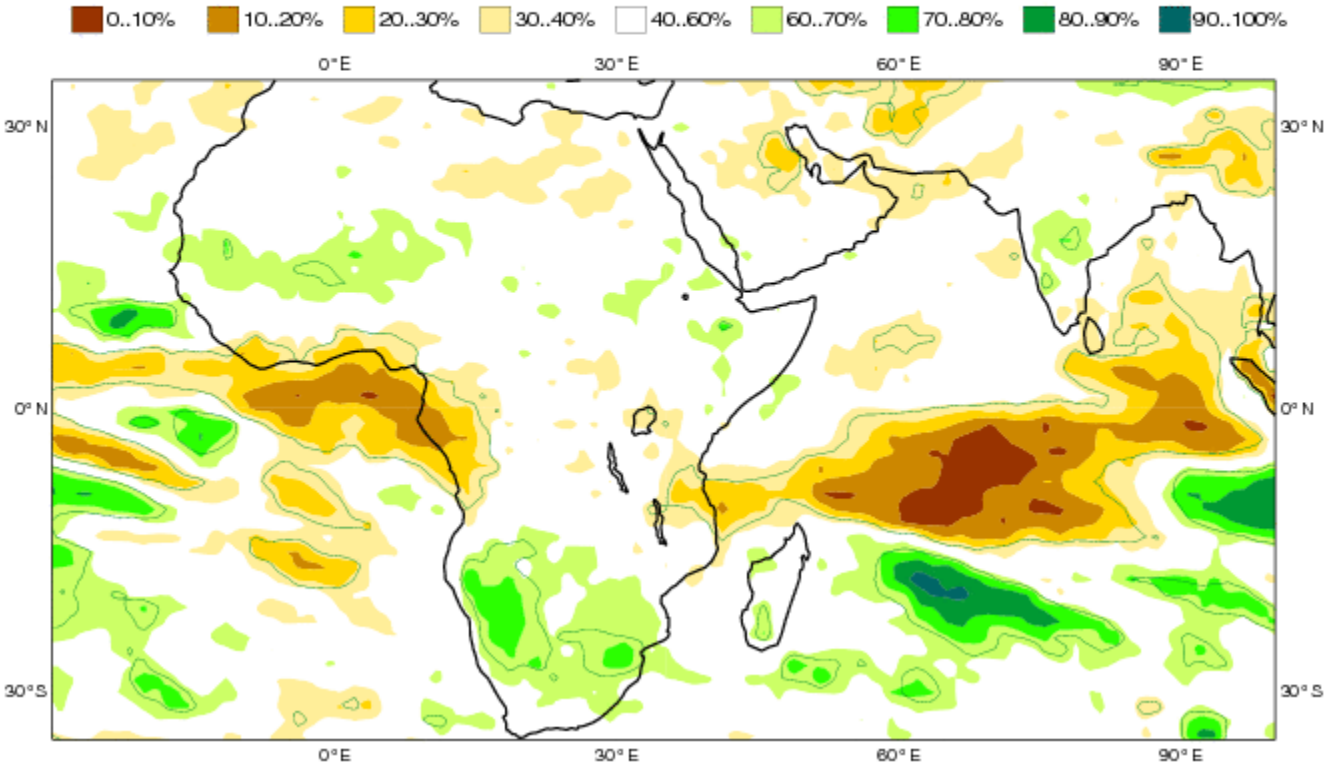
Maize output is also set to increase in China, which accounts for the bulk of the production in Asia, and in the EU, where prospects are particularly favourable in the large maize producing areas of Romania and Hungary.

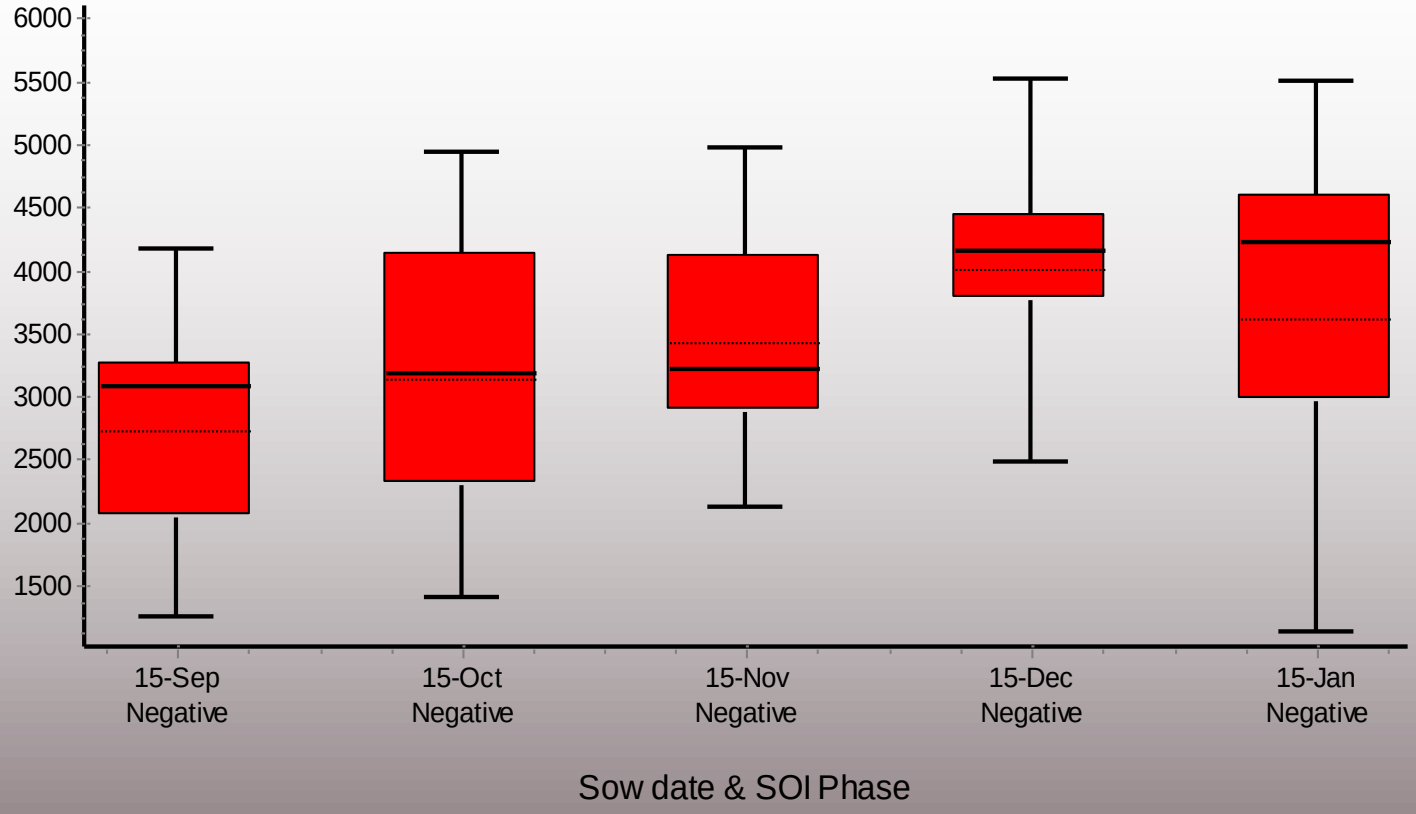


Focussing on Central America…….(ECMWF, issued July 2013)

ECMWF Seasonal Forecast
Prob(precipitation > median)
Forecast start reference is 01/07/13
Ensemble size = 51, climate size = 450

System 4
ASO 2013
Solid contour at 1% significance level





Farm-level decisions - Australia - Utilising seasonal climate forecasts in management and adaptation – eg of forecasts of potential sorghum yields associated with varying climate regimes (example for a 'consistently negative SOI phase') – varying management decisions (sowing dates) : example for Miles, Australia.

Effect of sowing date on sorghum yield at Miles South QLD with a 'consistently negative' SOI phase for September/October (Other parameters - 150mm PAWC, 2/3 full at sowing, 6pl/m2, medium maturity (WhopperCropper)