Towards using subseasonal-to-seasonal (S2S) extreme rainfall forecasts for extended-range flood prediction

Christopher J. White[1,2]

[1] School of Engineering and ICT, University of Tasmania, Hobart, Australia

[2] Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC), Hobart, Australia

HEPEX Workshop on Seasonal Hydrological Forecasting – Norrköping, Sweden – 21st to 23rd September 2015

Session 5 – Quality and predictability of seasonal predictions

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Contents

01

The subseasonal-to-seasonal (S2S) timescale

The subseasonal-to-seasonal (S2S) timescale: A relatively underexplored forecasting timescale

Reduce hazard exposure, increase disaster preparedness, and improve decision-making for emergency disaster response

- The S2S timescale – **3-4 weeks (15-30 days) lead time** – has, until recently, been viewed as a predictive 'desert'
- However, there is a growing requirement for the employment of S2S predictions for a wide range of societal and economic applications including forecasts of high-impact events such as flooding and heatwaves, streamflow forecasting, and humanitarian planning and response to disasters
- Research is now looking for 'windows of forecast opportunity' on the S2S timescale using teleconnections to known large-scale climate drivers

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The S2S timescale:
The S2S project

International WWRP-WCRP coordinated research on S2S predictability and modelling

Goal is to improve the accuracy and use of forecasts at lead times from 2 weeks to 2 months

Focus is on science, forecasting and applications

New database of S2S forecasts from 11 global producing centers – <u>data portal is now OPEN:</u>

<u>http://s2sprediction.net/</u>

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The S2S timescale:
The S2S project

Subseasonal-to-Seasonal S2S Prediction Project

About S2S | Documents | Sub-projects | Database | Meetings | People | Notice

Research Priorities

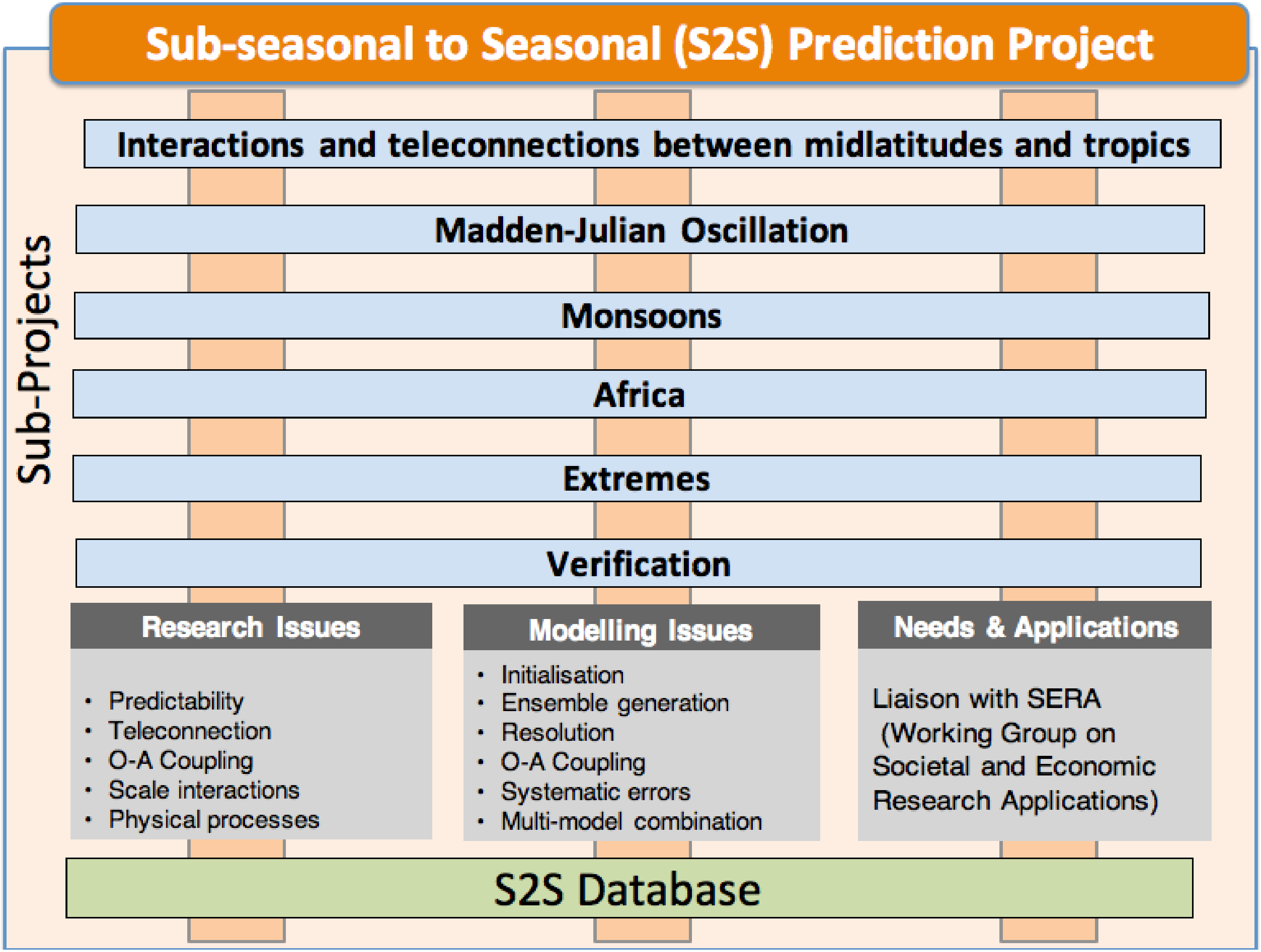
1. Evaluate potential predictability of subseasonal events, including identifying windows of opportunity for increased forecast skill.
2. Understand systematic errors and biases in the subseasonal to seasonal forecast range
3. Compare, verify and test multi-model combinations from these forecasts and quantify their uncertainty.
4. Focus on some specific extreme event case studies.

Scientific issues

1. Identify sources of predictability at the sub-seasonal to seasonal time-range.
2. Prediction of the MJO and its impacts in numerical models
3. Teleconnections - forecasts of opportunity
4. Monsoon prediction.
5. Rainfall predictability and extreme events
6. Polar prediction and sea-ice
7. Stratospheric processes

Modelling issues

1. Role of resolution
2. Role of ocean-atmosphere coupling
3. Teleconnections - forecasts of opportunity
4. Systematic errors.
5. Initialisation strategies for subseasonal prediction
6. Ensemble generation
7. Spread/skill relationship
8. Verification


Sub-seasonal to Seasonal (S2S) Prediction Project
Sub-Projects
Interactions and teleconnections between midlatitudes and tropics
Madden-Julian Oscillation
Monsoons
Africa
Extremes
Verification
Research Issues
• Predictability
• Teleconnection
• O-A Coupling
• Scale interactions
• Physical processes
Modelling Issues
• Initialisation
• Ensemble generation
• Resolution
• O-A Coupling
• Systematic errors
• Multi-model combination
Needs & Applications
Liaison with SERA (Working Group on Societal and Economic Research Applications)
S2S Database

02

S2S forecasting of extreme rainfall

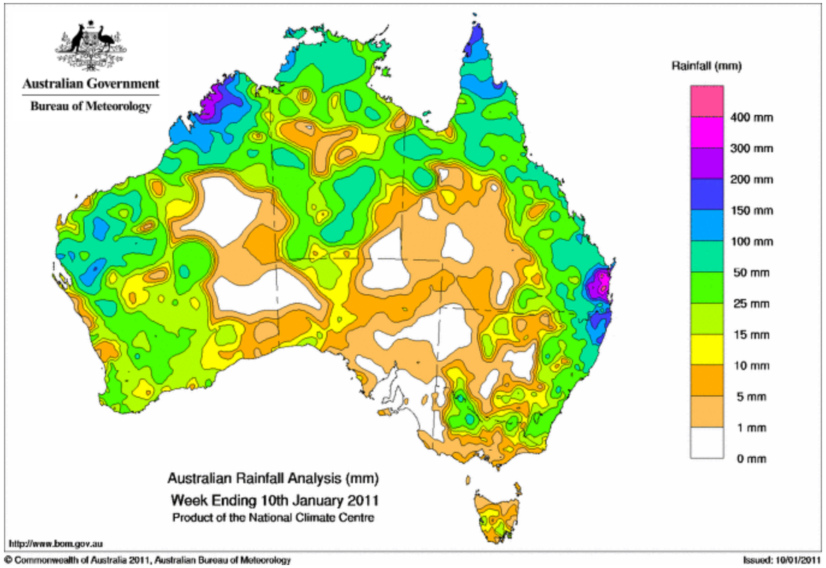
Floods in Australia:
Queensland and New South Wales floods 2011

Toowoomba, 10th January 2011

Lockyer Valley, 10th January 2011

Brisbane, 11th January 2011

Rainfall totals in the week leading up to the Queensland floods, January 2011



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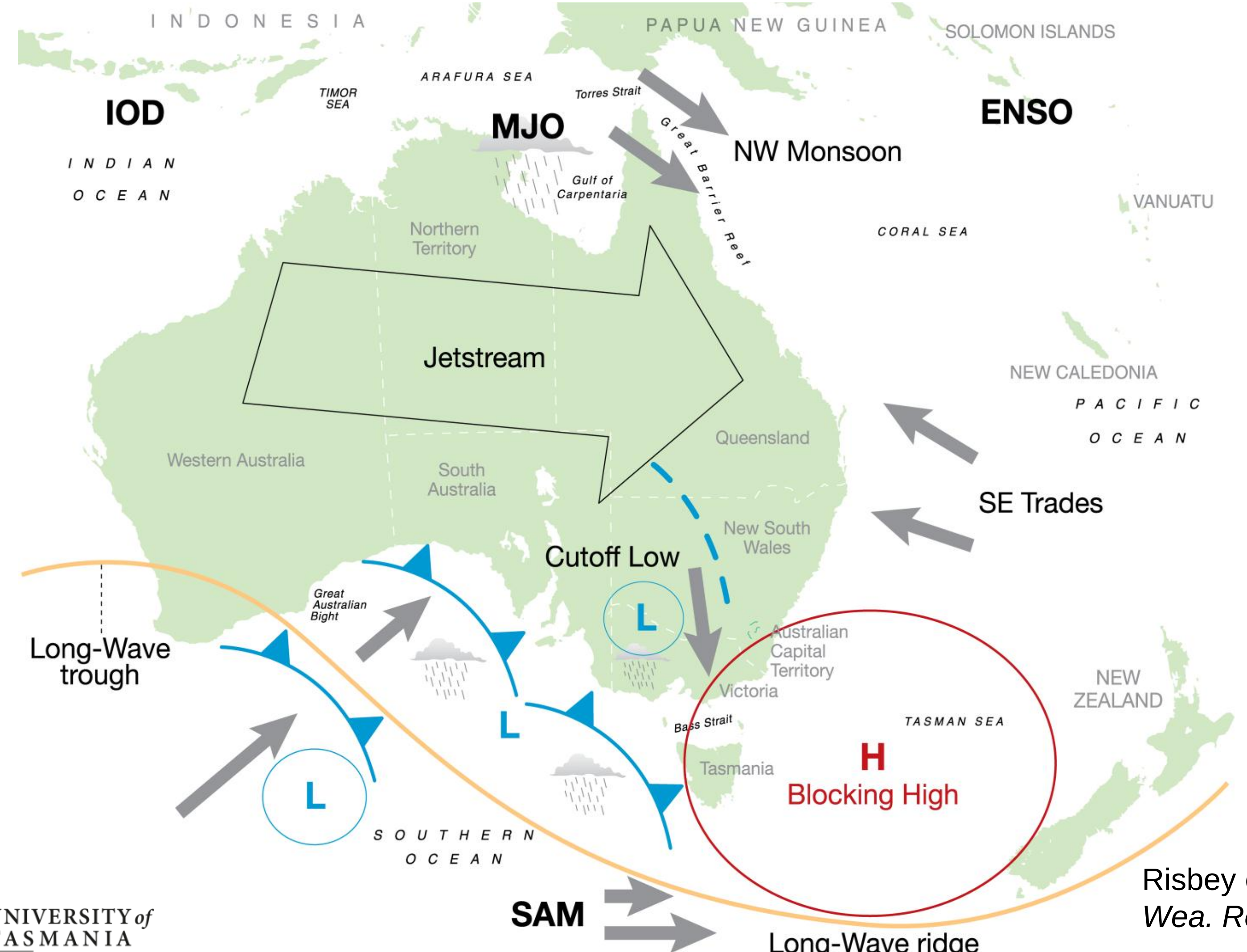
Predictors of Australian rainfall on the S2S forecasting timescale: sources of potential skill



Risbey et al. (*Mon. Wea. Rev.*, 2009)

Predictors of Australian rainfall on the S2S forecasting timescale: sources of potential skill

Although we are interested in the S2S timescale, climate drivers operating on longer seasonal timescales (e.g. ENSO, IOD) influence S2S prediction skill.

For example, La Niña events are associated with increased cloudiness that increases the likelihood of higher rainfalls and flooding. Similarly, positive IOD phases are associated with dryer, hotter spells over WA in winter and across southern Australia in spring, reducing rainfalls.

‘Seasonal’ timescale drivers

- El Niño – Southern Oscillation (ENSO)
- Indian Ocean Dipole (IOD)

‘Subseasonal’ timescale drivers

- Madden-Julian Oscillation (MJO): <u>predictable out to ~20 days</u>
- Southern Annular Mode (SAM)
- Blocking

S2S forecasting:
The POAMA system (Australian Bureau of Meteorology)

- Seasonal (and sub-seasonal prediction) at the Bureau of Meteorology is based on the **Predictive Ocean Atmosphere Model for Australia (POAMA)**
- POAMA is a global T47 dynamical coupled ocean-atmosphere climate model
- The latest version POAMA-2 has a 33-member ensemble of retrospective forecasts (1981-2010) and real-time forecasts run weekly, each with a different ocean and atmosphere initial condition
- As of May 2013, POAMA became the Bureau's operational model for the seasonal outlooks (some subseasonal forecasts are experimental and are available on the POAMA website)
- There is increasing demand for predictions on the subseasonal timescale, particularly of high-impact hazards such as heatwaves and floods

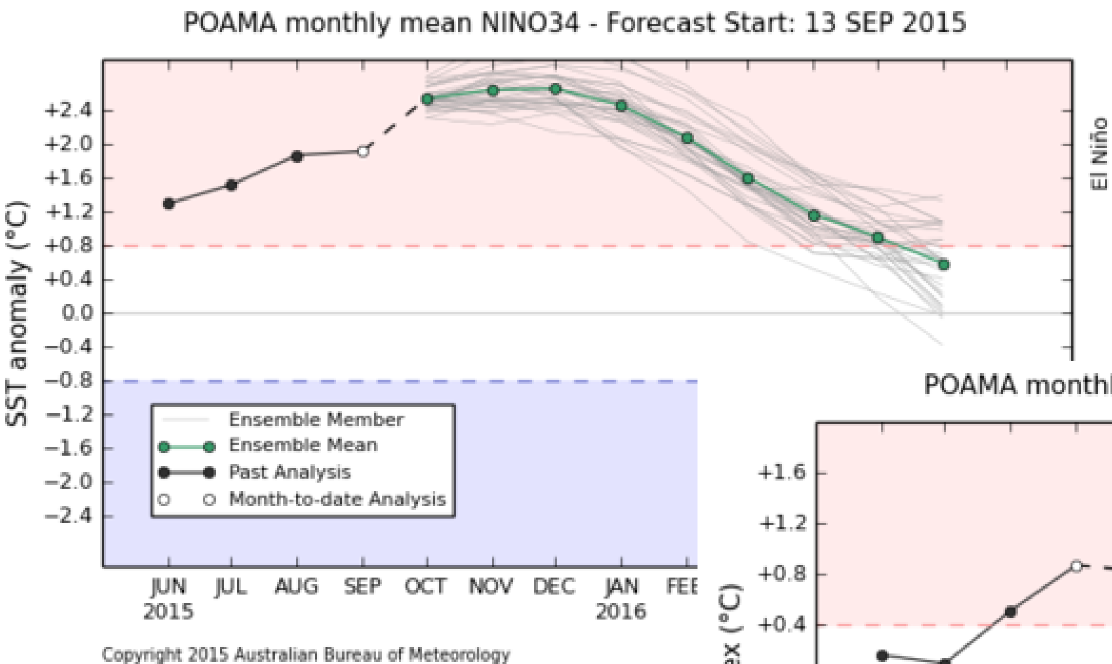
S2S forecasting:
Other forecasting centres

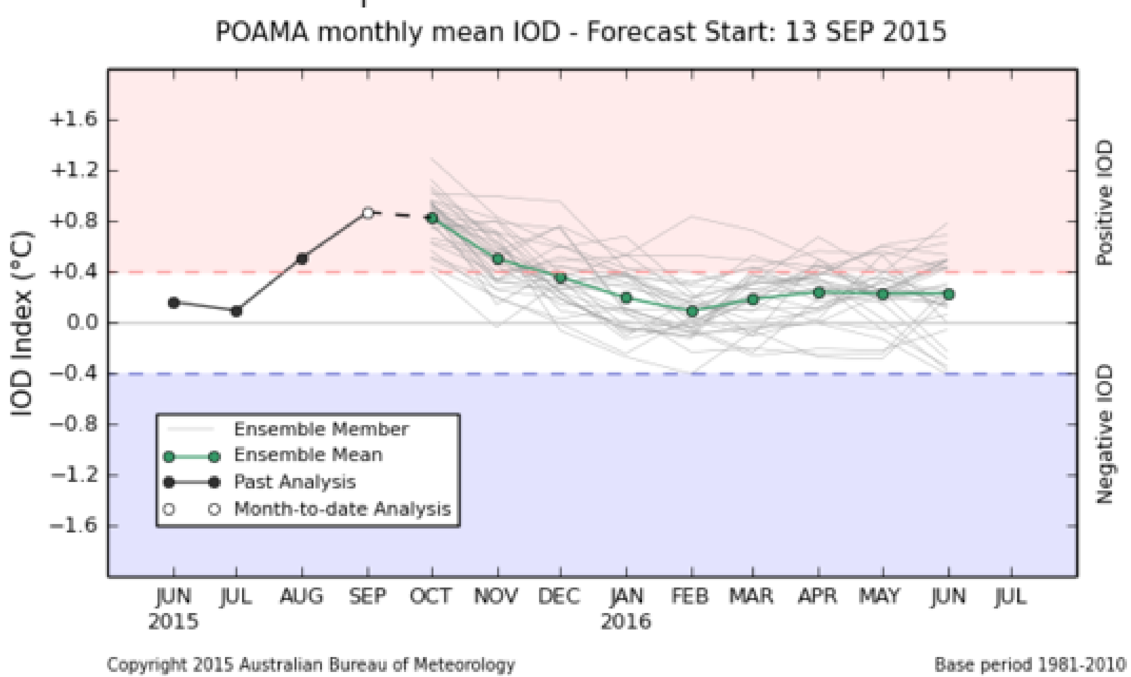
International operational seasonal forecasting models

Agency/Source/Provider	Latest NINO3.4	Latest IOD	Model	Model run used in this survey:
BOM - Bureau of Meteorology			POAMA	21 June 2015
Meteorological Service of Canada		Unavailable	CanSIPS	1 June 2015
ECMWF (EU)		Not public	System4	1 June 2015
JMA		Unavailable	JMA/MRI-CPS2	1 June 2015
METEO-FRANCE		Not public	ARPEGE	1 June 2015
NASA - GMAO (USA)			GEOS5	1 June 2015
NOAA - NCEP (USA)		Unavailable	CFSv2	13 June 2015
UKMO		Not public	GloSea5	1 June 2015

http://www.bom.gov.au/climate/ahead/models/model-summary-table.shtml

Operational POAMA products:
ENSO and IOD outlooks and model summaries





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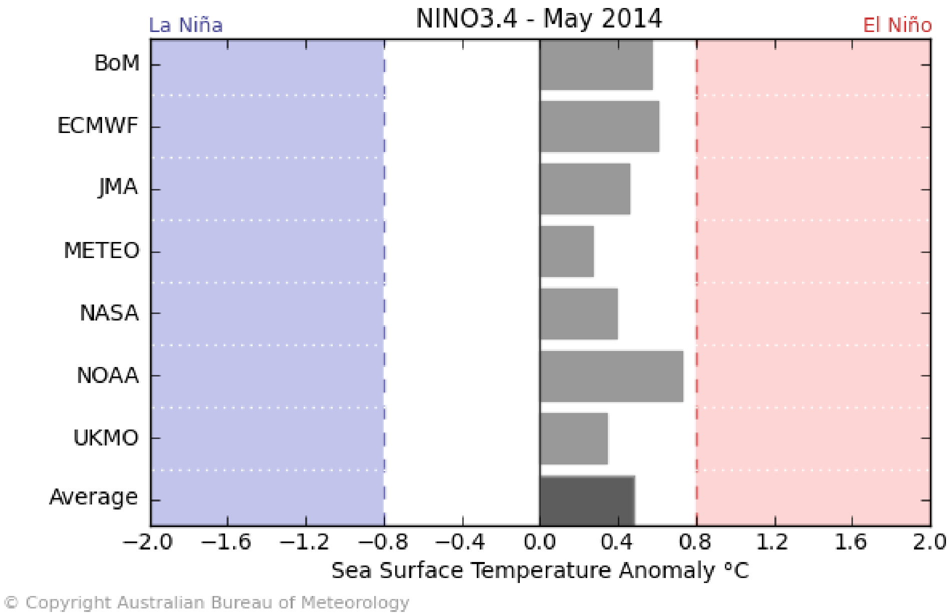
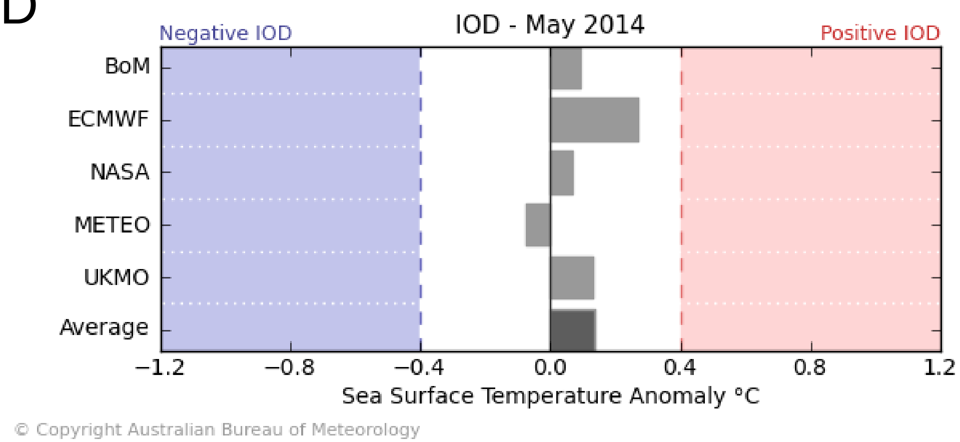
Operational POAMA products:
ENSO and IOD outlooks and model summaries

ENSO



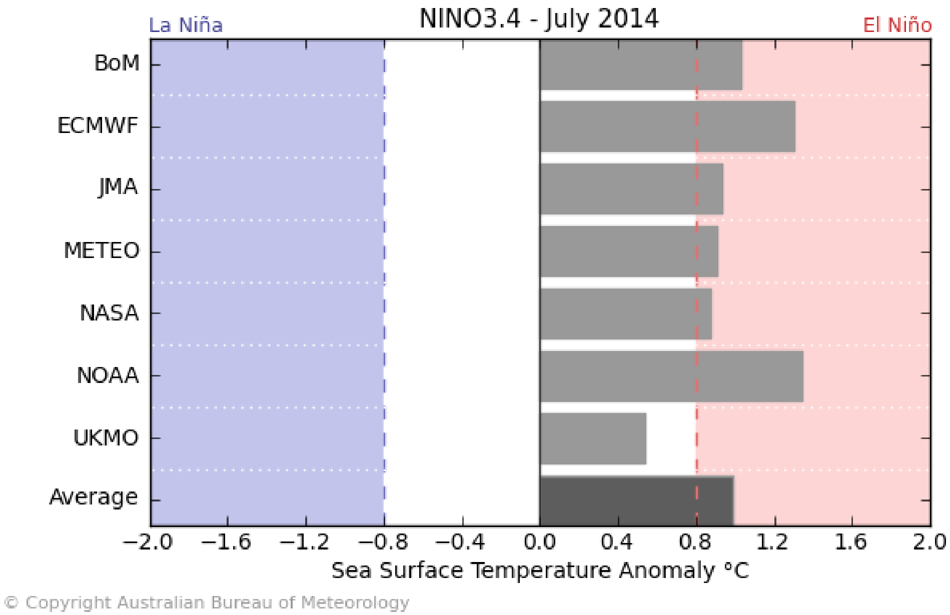
IOD

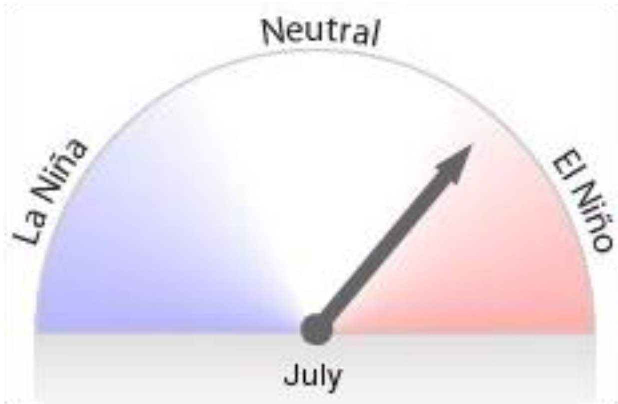


The Bureau of Meteorology accesses other centre's seasonal predictions (some publically available, others not), including UKMO, ECMWF and NOAA, to produce a transparent multi-model summary

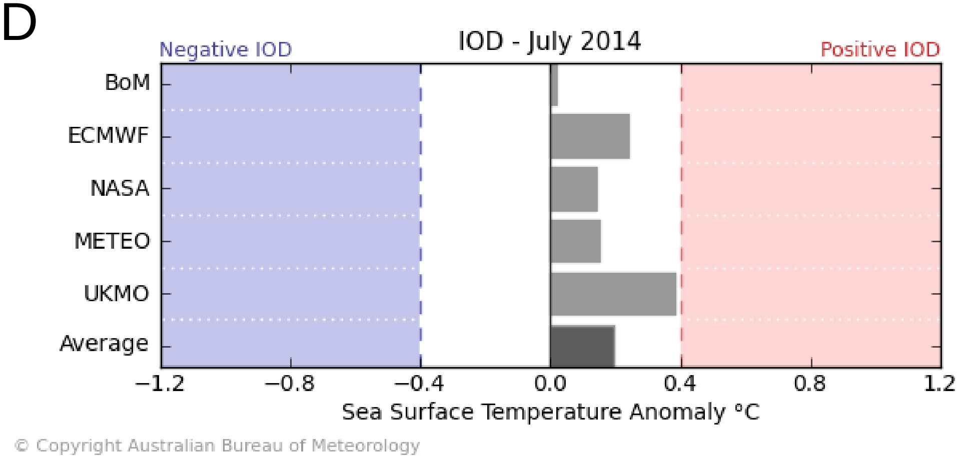
Operational POAMA products:
ENSO and IOD outlooks and model summaries

ENSO





IOD



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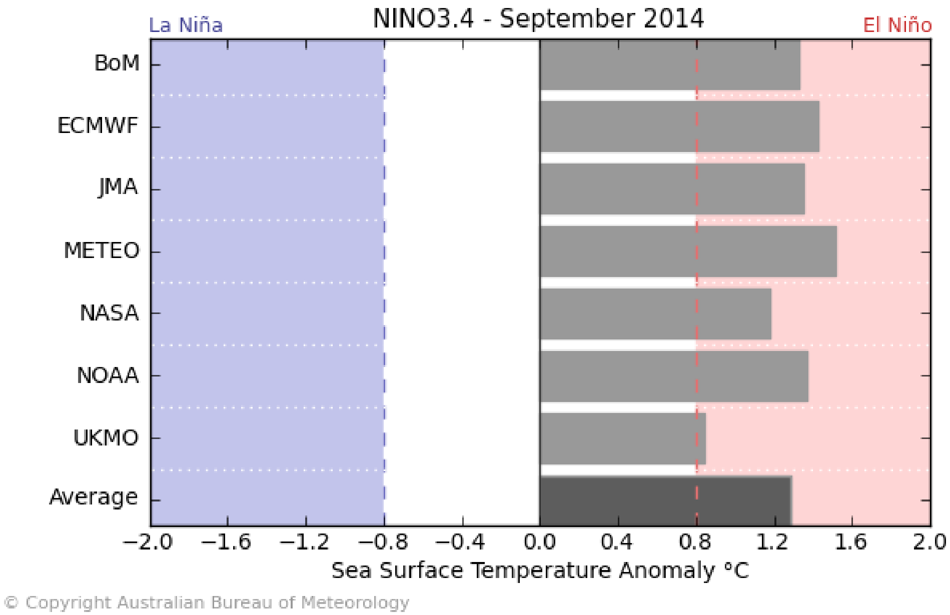
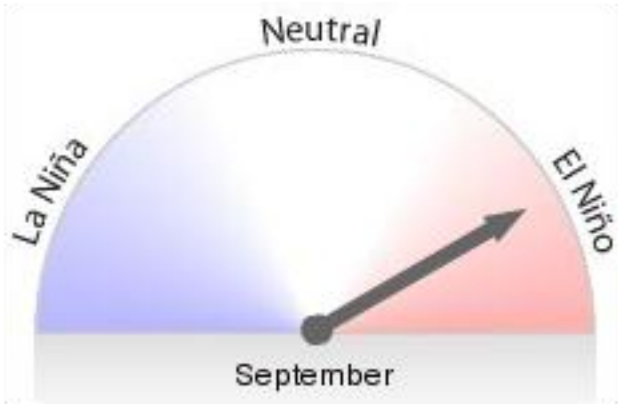
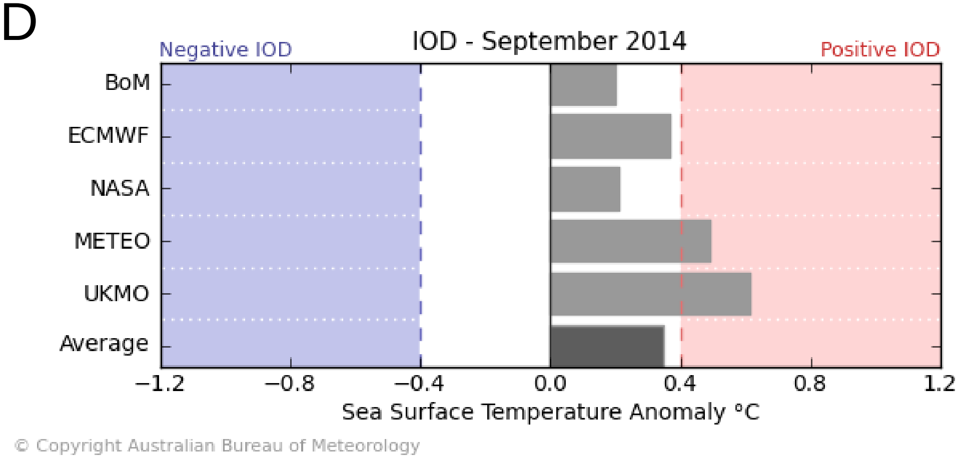
Operational POAMA products:
ENSO and IOD outlooks and model summaries

ENSO





IOD



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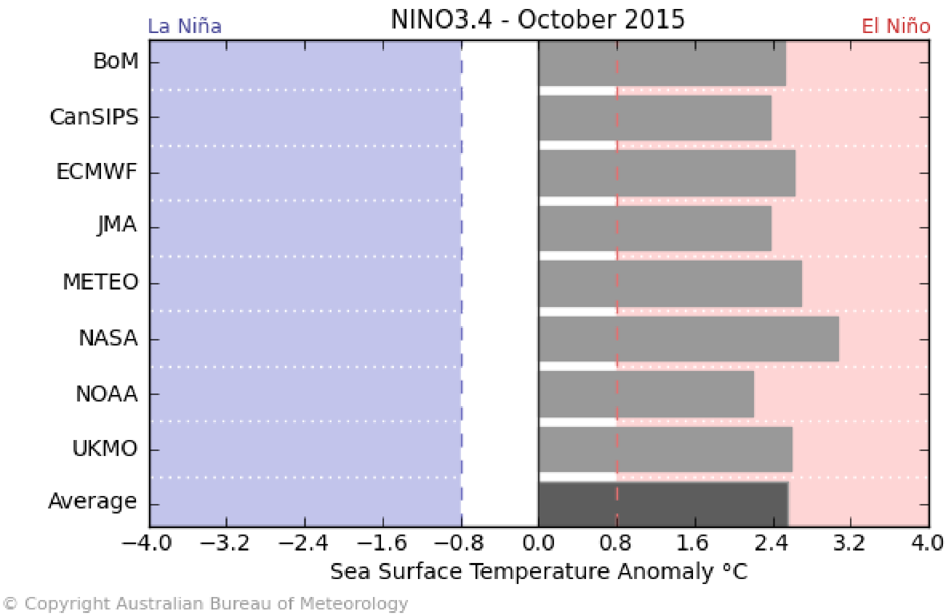
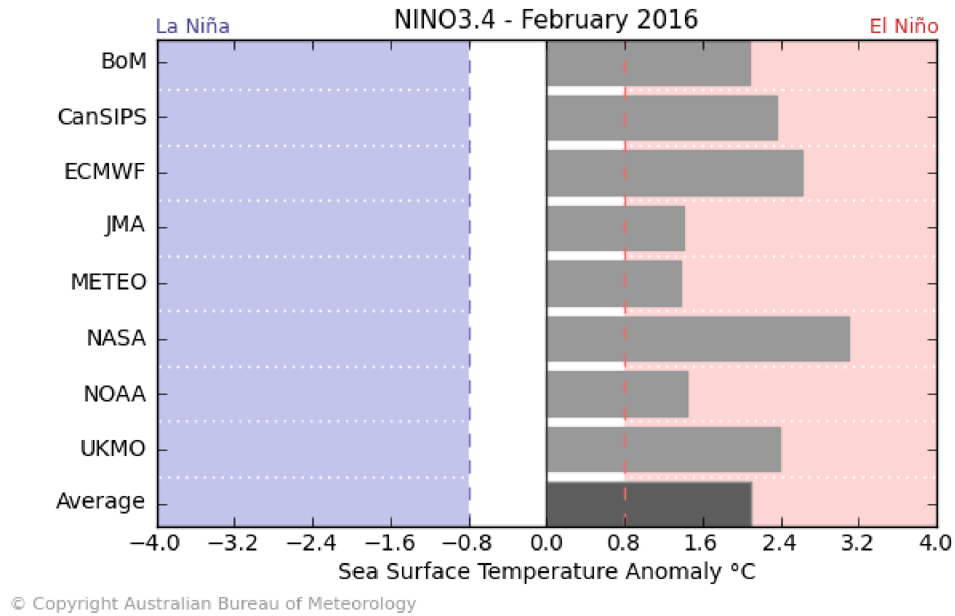
Operational POAMA products:
ENSO and IOD outlooks and model summaries

ENSO: current outlooks





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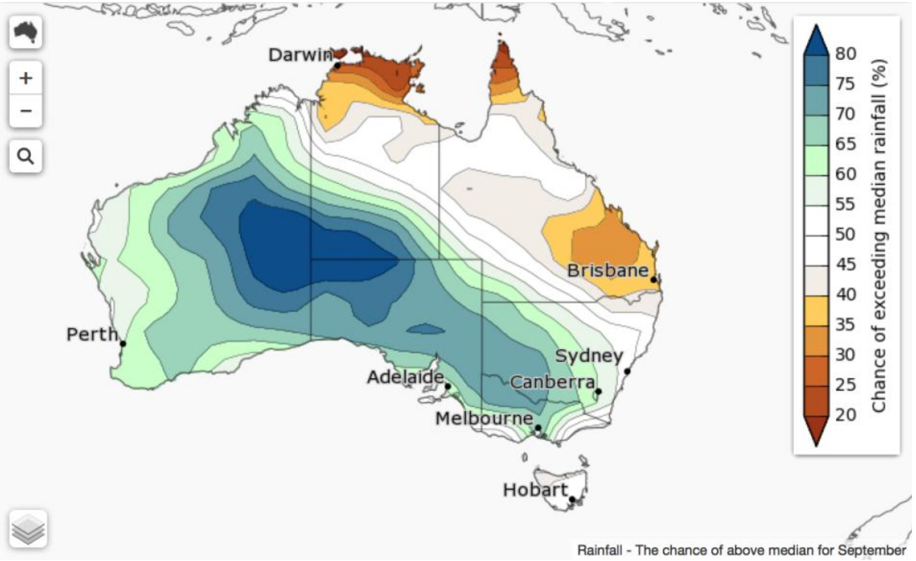
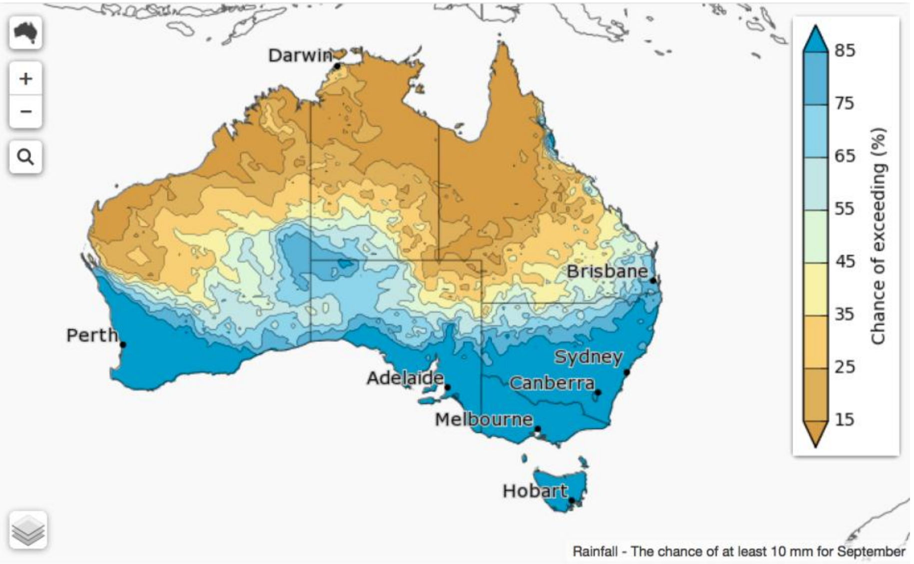
Operational POAMA products:
Rainfall outlooks



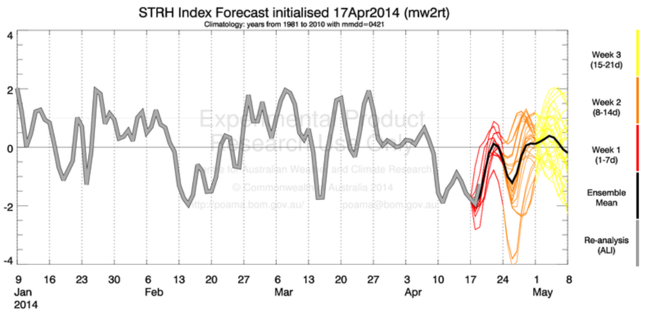


The Bureau of Meteorology produces monthly and seasonal rainfall (e.g. chance above median, or chance of at least 10mm) and temperature (maximum) outlooks… **but not extremes**

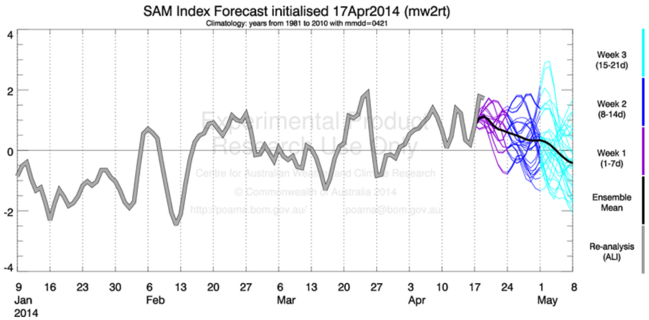
Experimental POAMA products:

POAMA experimental forecast products based on specific climate drivers

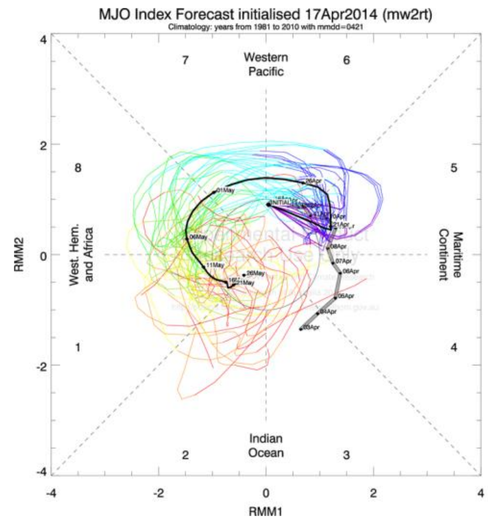
STRH



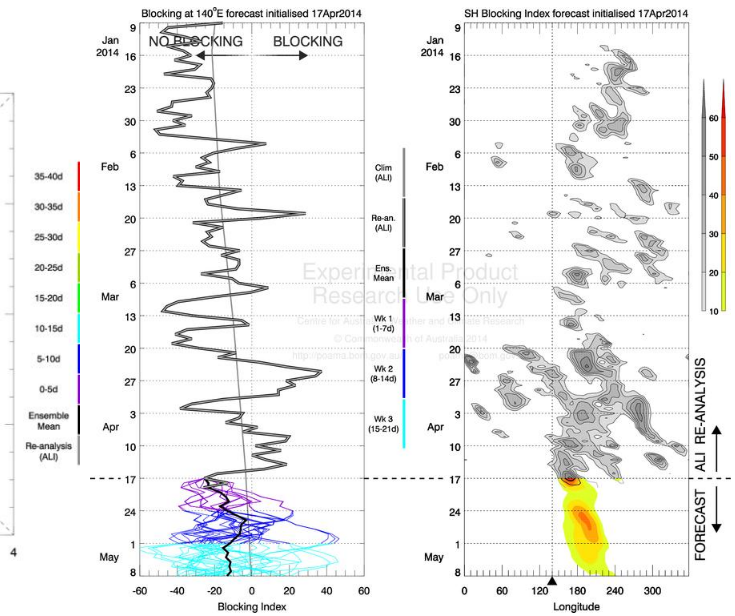
SAM



MJO

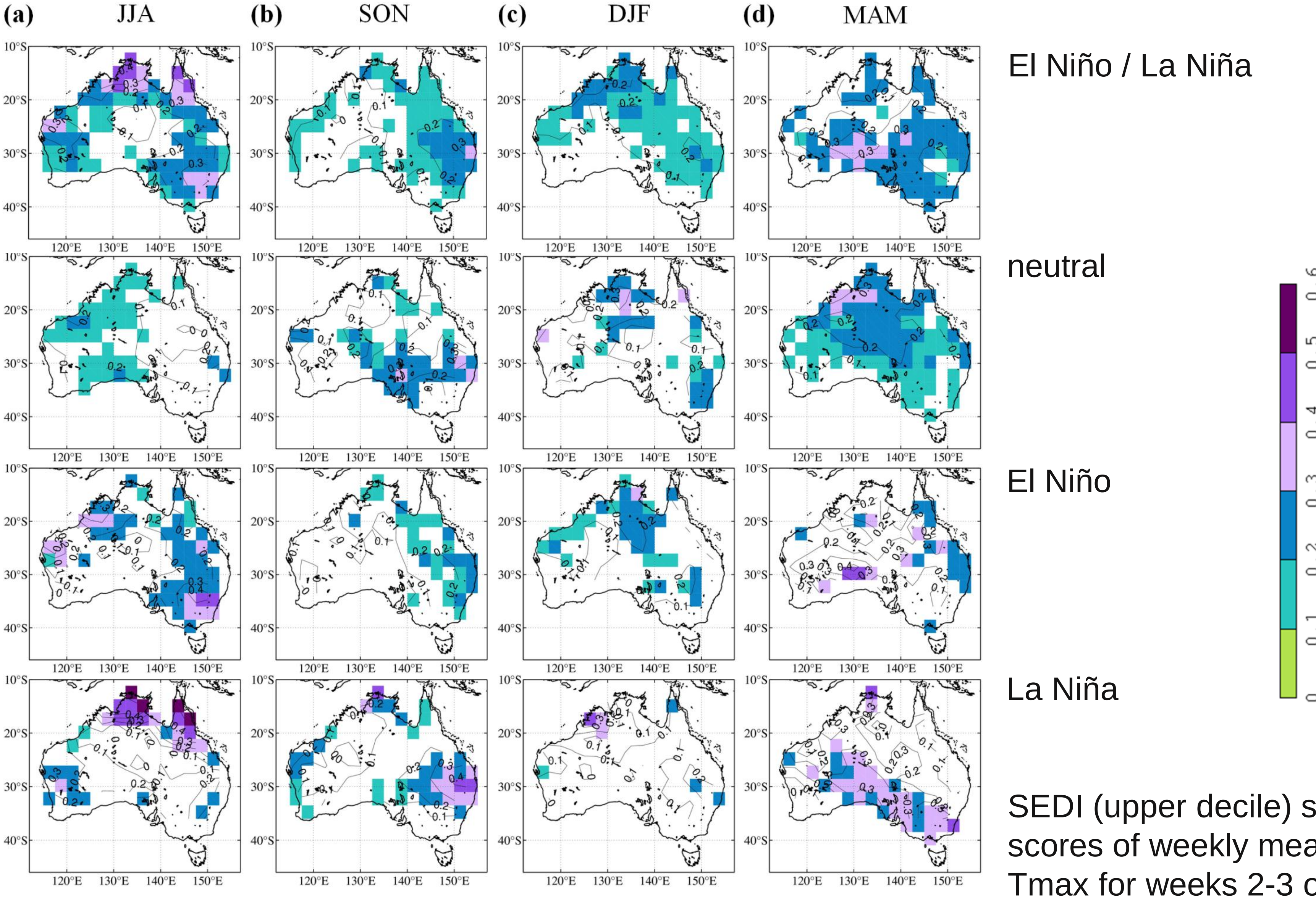


Blocking



Experimental climate driver forecast products (clockwise from top left): STRH Index (Sub-tropical Ridge High over Tasman Sea), MJO (Madden-Julian Oscillation), Blocking and SAM (Southern Annular Mode). For more info see (registration required): http://poama.bom.gov.au/

Experimental extreme heat S2S forecasts

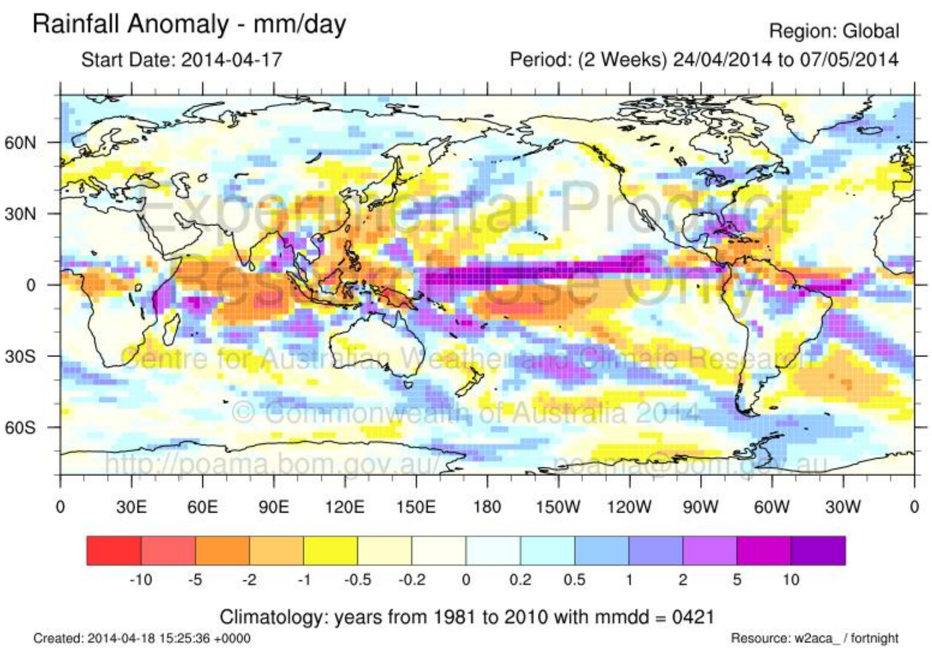


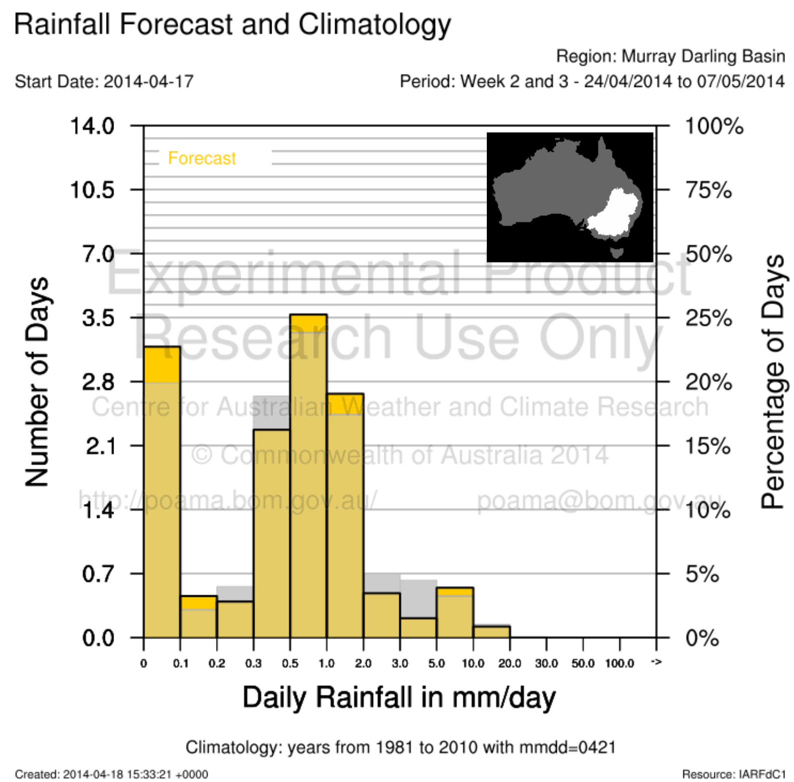
SEDI (upper decile) skill scores of weekly mean Tmax for weeks 2-3 of the POAMA forecasts

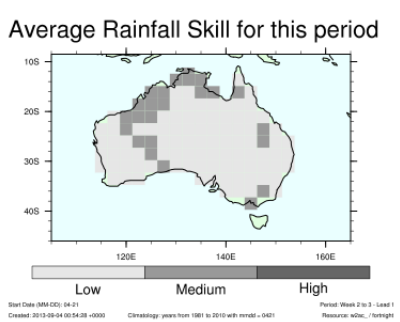
White et al. (*Clim. Dyn.*, 2013)

Experimental rainfall S2S forecasts

POAMA-2 experimental seamless rainfall forecast products spanning timescales from weeks to seasons





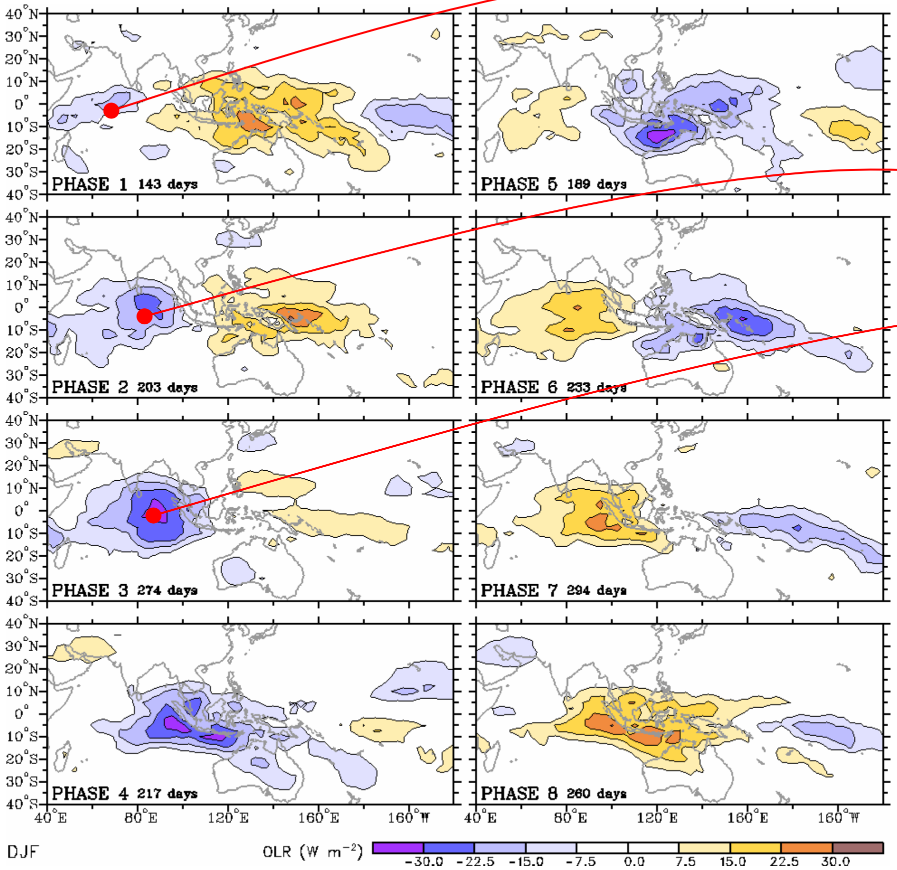


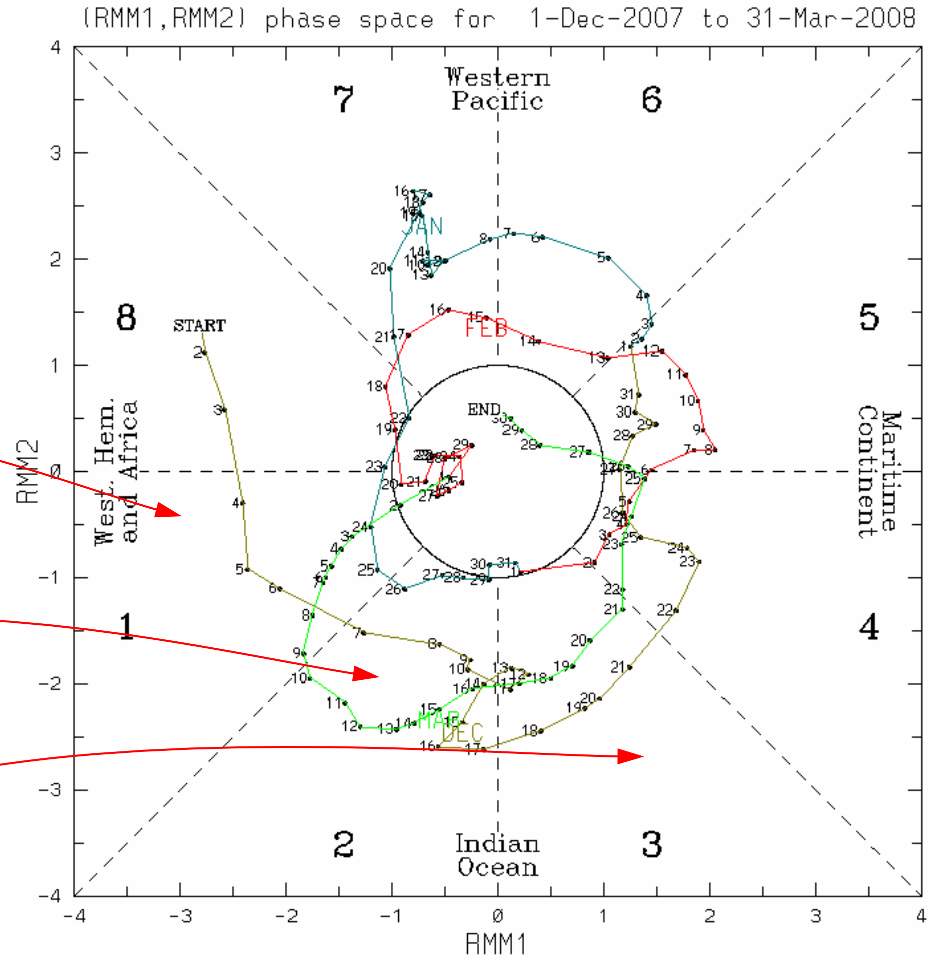
Experimental rainfall forecast products available (**not extremes**) for three regions (global, Asia/Pacific tropics and Australia) and for timescales ranging from week 2 to 9 months ahead (up to 3 months for histograms). Here the plots show global and MDB forecasts for weeks 2-3 *combined*.

For more info see (registration required): http://poama.bom.gov.au/

The Madden-Julian Oscillation (MJO) and rainfall

Wheeler and Hendon (*Mon. Wea. Rev.*, 2004)



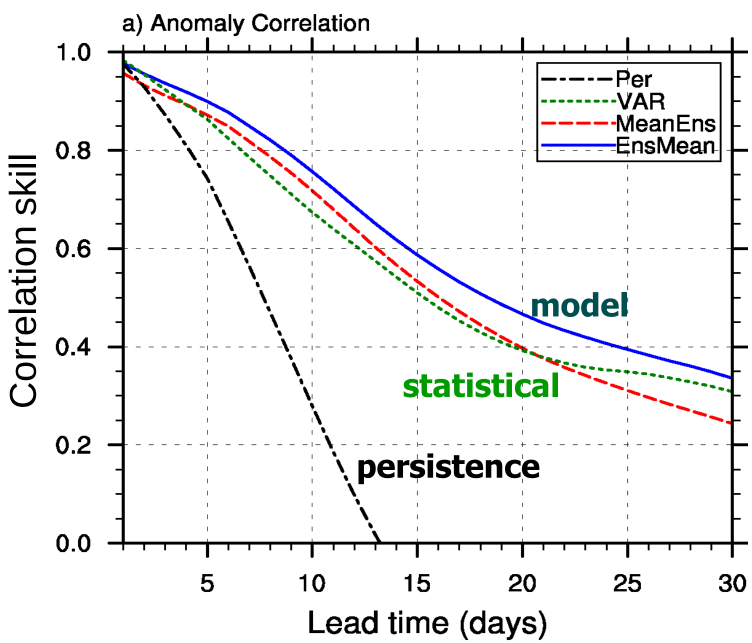


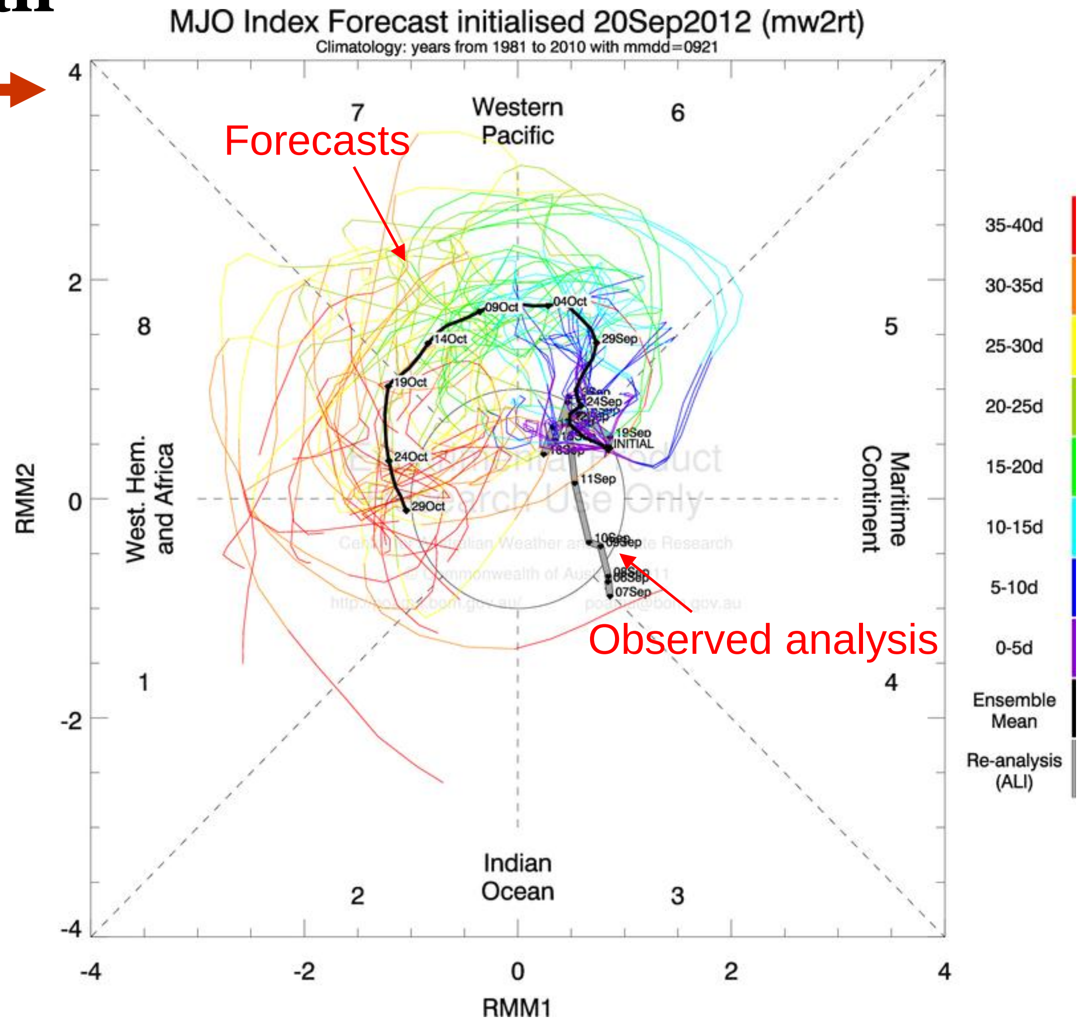
Phases 1-8 track the propagation of convection and wind anomalies eastward along the equator. Index is defined the same way in all seasons, but the impacts vary with season.

The MJO and rainfall

Forecasts from POAMA

Long-term performance from POAMA hindcasts

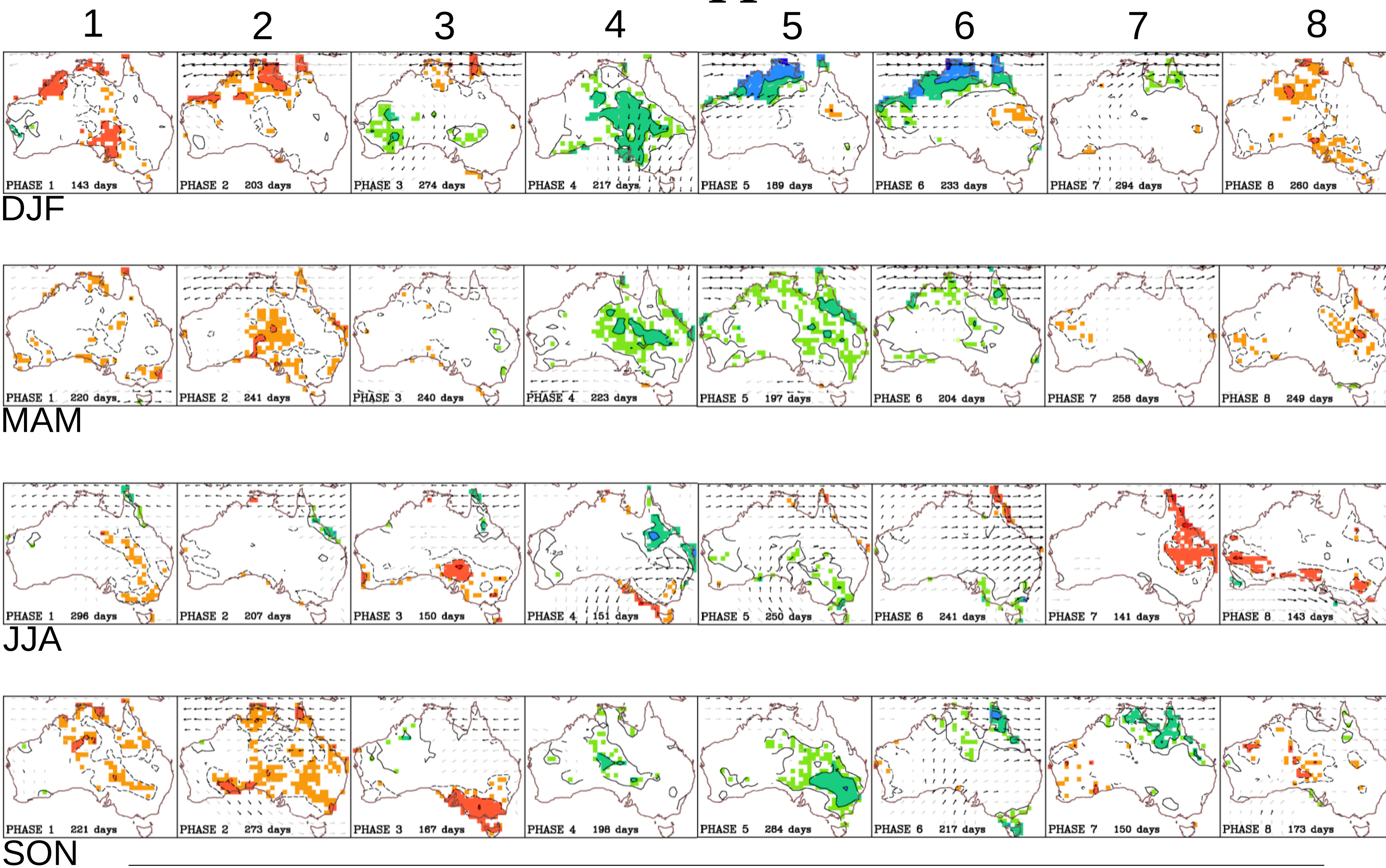


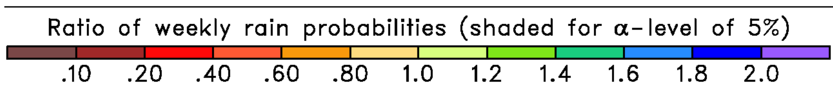


Rashid et al. (*Clim. Dyn.*, 2011); Marshall et al. (*Clim. Dyn*., 2011)

Wheeler et al. (*J. Climate*, 2009)

The MJO and rainfall (upper tercile)



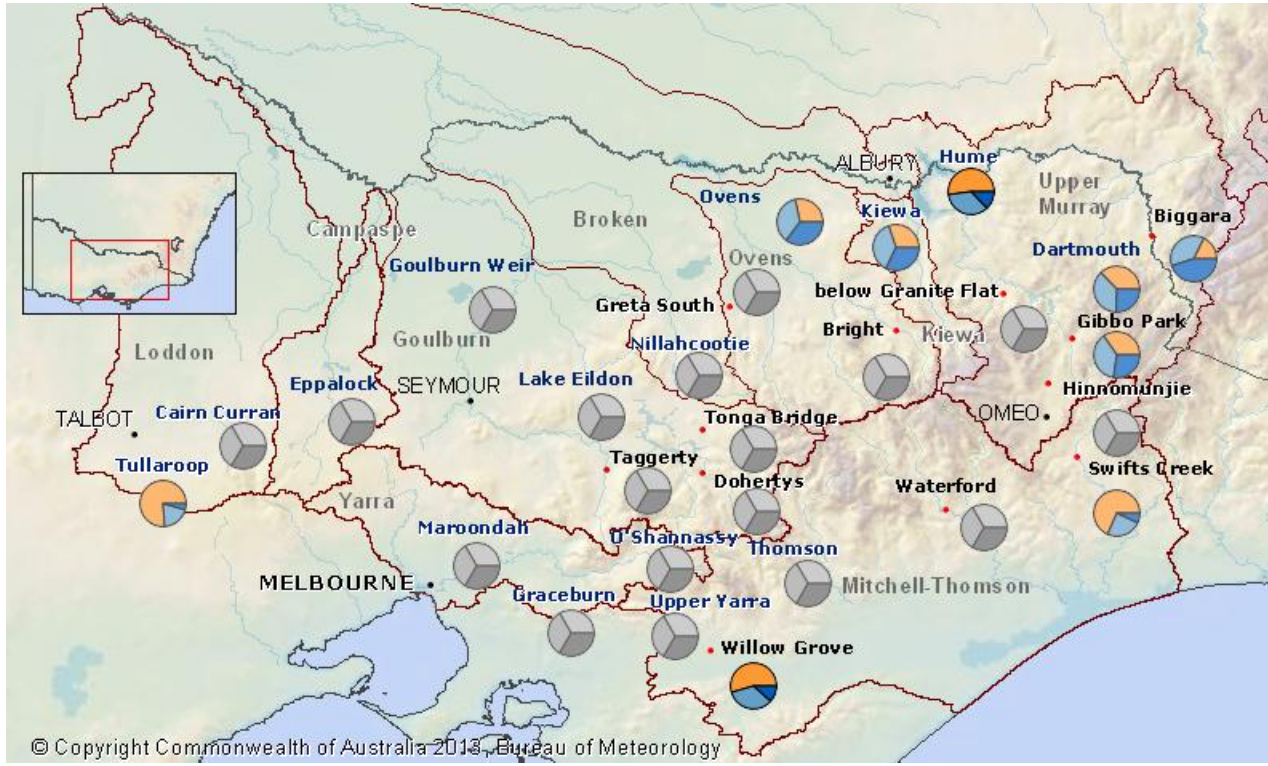


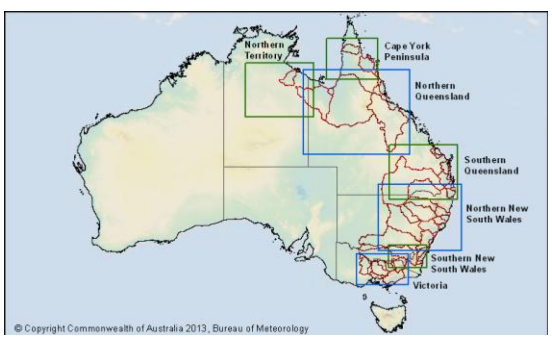
03

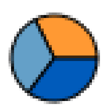
Employing S2S forecasts for flood forecasting

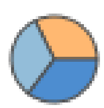
Seasonal streamflow forecasting in Australia

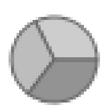
CSIRO, in partnership with the Bureau of Meteorology, produces **seasonal** streamflow forecasts across specific regions, using both statistical and dynamic modelling approaches






Moderate to high skill


Low skill or missing climate data


Very low skill or missing antecedent condition data

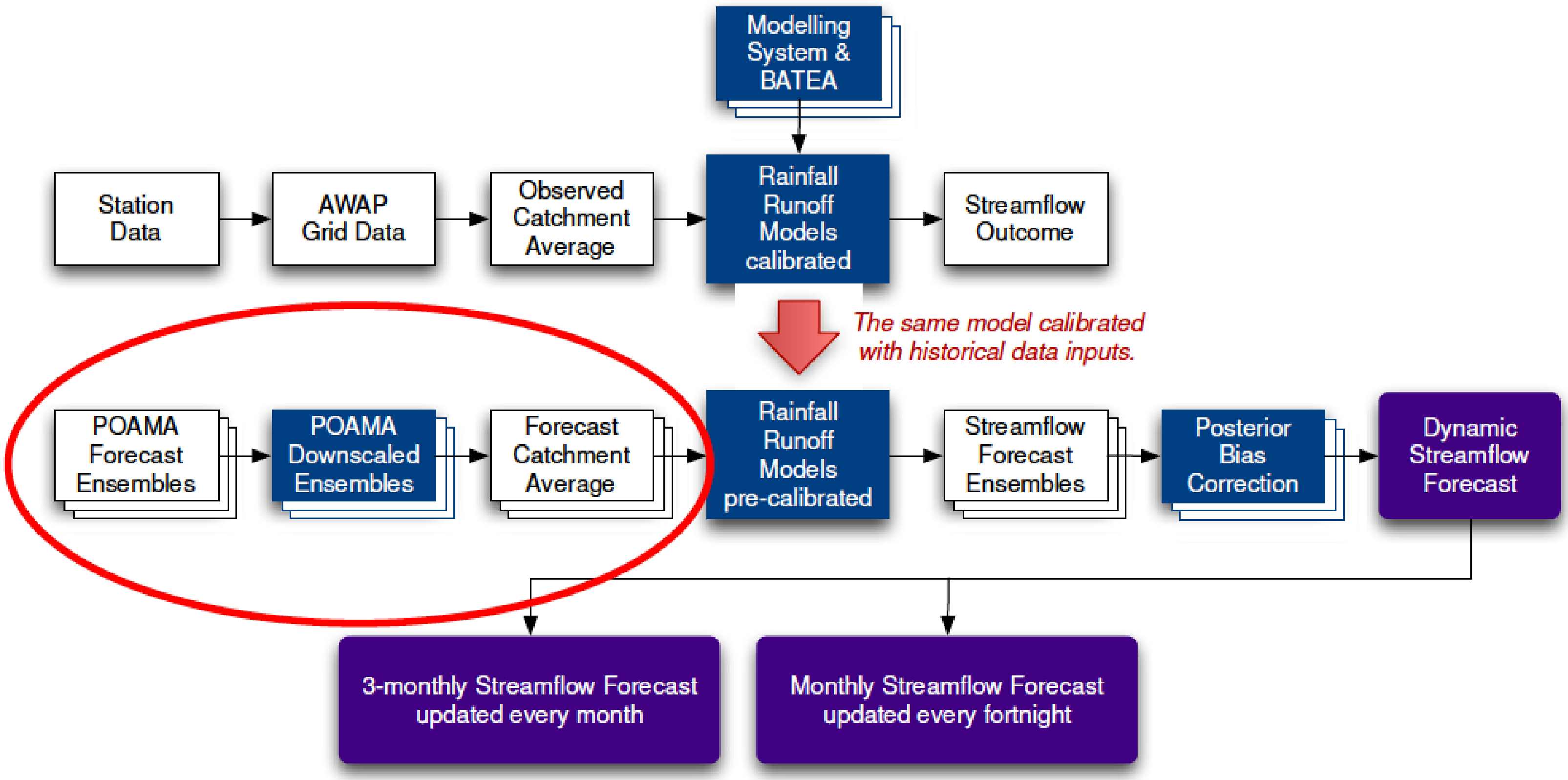
Downscaling of seasonal forecasts for hydrological applications

The Bureau of Meteorology Extended Hydrological Prediction group have looked at downscaling POAMA for dynamical streamflow forecasting (Tuteja et al., 2011)

Provide three month (**seasonal**) catchment scale rainfall forecasts with **monthly** updates to support seasonal streamflow forecasts

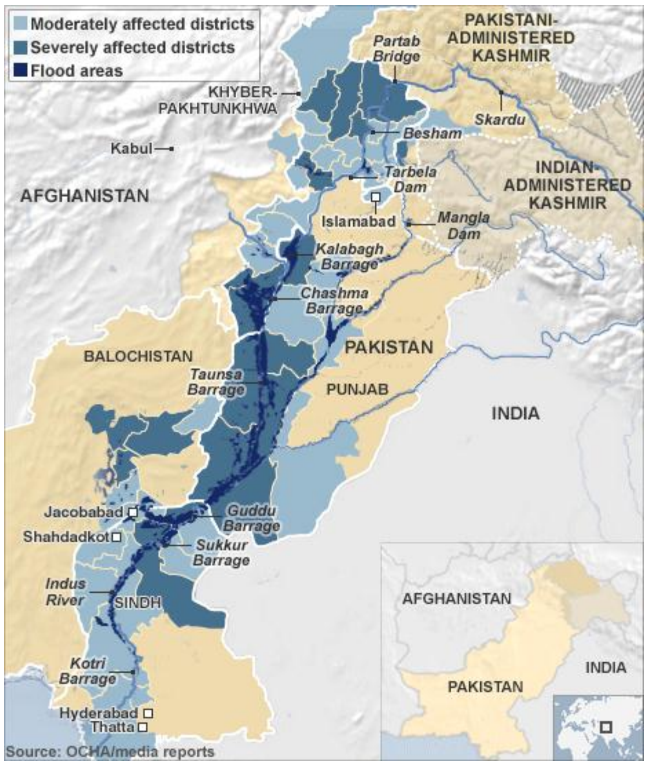
Have not explored the possibility of using extreme rainfall forecasts on the S2S timescale

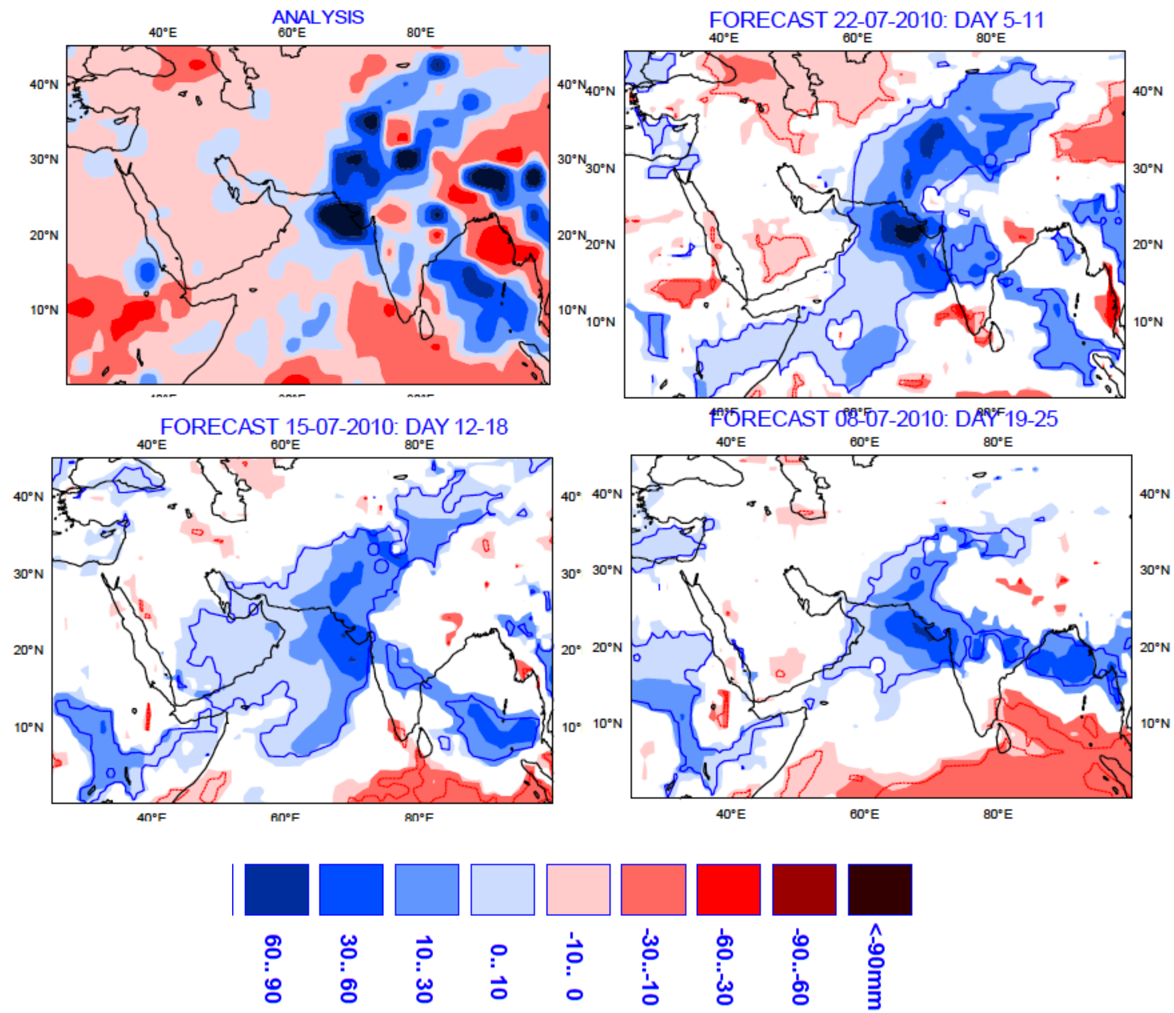
Downscaling of seasonal forecasts for hydrological applications



Kent (2013)

Example of extreme rainfall S2S forecasting:
S2S prediction of Pakistan floods (26 July–01 August 2010)





Vitart (2014)

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04

Science challenges (and opportunities)

Science challenges (and opportunities): Using S2S extreme rainfall forecasts for extended-range flood prediction

Opportunities

- There is a growing requirement for the employment of S2S predictions for a wide range of societal and economic applications **= opportunity**
- Research is currently exploring ‘windows of forecast opportunity’ on the S2S timescale where the skill in predicting extreme rainfall over certain regions is likely to be increased using teleconnections to known large-scale climate drivers (e.g. ENSO), but there is much work to be done in this area
- The new open source near real-time S2S project database (hosted by ECMWF), for the first time, presents an opportunity for researchers and practitioners to explore the skill and applications of S2S forecasts – see next slides

ECMWF

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About | Forecasts | Computing | Research | Learning

Origin
- BoM
- CMA
- ▸ ECMWF
- JMA
- Météo France
- NCEP

Statistical process
- ▸ Instantaneous and accumulated
- Daily averaged

Type of level
- Potential temperature
- Pressure levels
- ▸ Surface

Type
- ▸ Control forecast
- Perturbed forecast

About
- Conditions of use
- Documentation

Navigation
- Public Datasets

Subseasonal to Seasonal Instantaneous and Accumulated

Please login before retrieving data from this dataserver.

This dataset is available Mondays and Thursdays. read more

Select date

Select a date in the interval 2015-01-01 to 2015-06-01

Start date: 2015-01-01 End date: 2015-06-01

Reset

Select a list of months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	☐	☐	☐	☐	☐	☐						
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Select All or Clear

Select step

0	6	12	18	24	30	36	42	48	54	60	66	72
78	84	90	96	102	108	114	120	126	132	138	144	150
156	162	168	174	180	186	192	198	204	210	216	222	228
234	240	246	252	258	264	270	276	282	288	294	300	306
312	318	324	330	336	342	348	354	360	366	372	378	384
390	396	402	408	414	420	426	432	438	444	450	456	462
468	474	480	486	492	498	504	510	516	522	528	534	540
546	552	558	564	570	576	582	588	594	600	606	612	618
624	630	636	642	648	654	660	666	672	678	684	690	696

http://s2sprediction.net/

	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-32	T639/319L62	51	2/week	On the fly	Past 18y	weekly	5
UKMO	D 0-60	N96L85	4	daily	On the fly	1989-2003	4/month	3
NCEP	D 0-60	N126L64	16	daily	Fix	1999-2010	daily	4
EC	D 0-35	0.6x0.6L40	21	weekly	On the fly	Past 15y	weekly	4
CAWCR	D 0-120	T47L17	33	weekly	Fix	1989-2010	3/month	33
JMA	D 0-34	T159L60	50	weekly	Fix	1979-2009	3/month	5
KMA	D 0-30	T106L21	20	3/month	Fix	1979-2010	3/month	10
CMA	D 0-45	T63L16	40	6/month	Fix	1982-now	monthly	48
CPTEC	*D 0-30*	*T126L28*	*1*	*daily*	*No*	-	-	-
Meteo-France	*D 0-60*	*T63L91*	*41*	*monthly*	*Fix*	*1981-2005*	*monthly*	*11*
SAWS	*D 0-60*	*T42L19*	*6*	*monthly*	*Fix*	*1981-2001*	*monthly*	*6*
HMCR	*D 0-60*	*1.1x1.4 L28*	*10*	*monthly*	*Fix*	*1979-2003*	*monthly*	*10*

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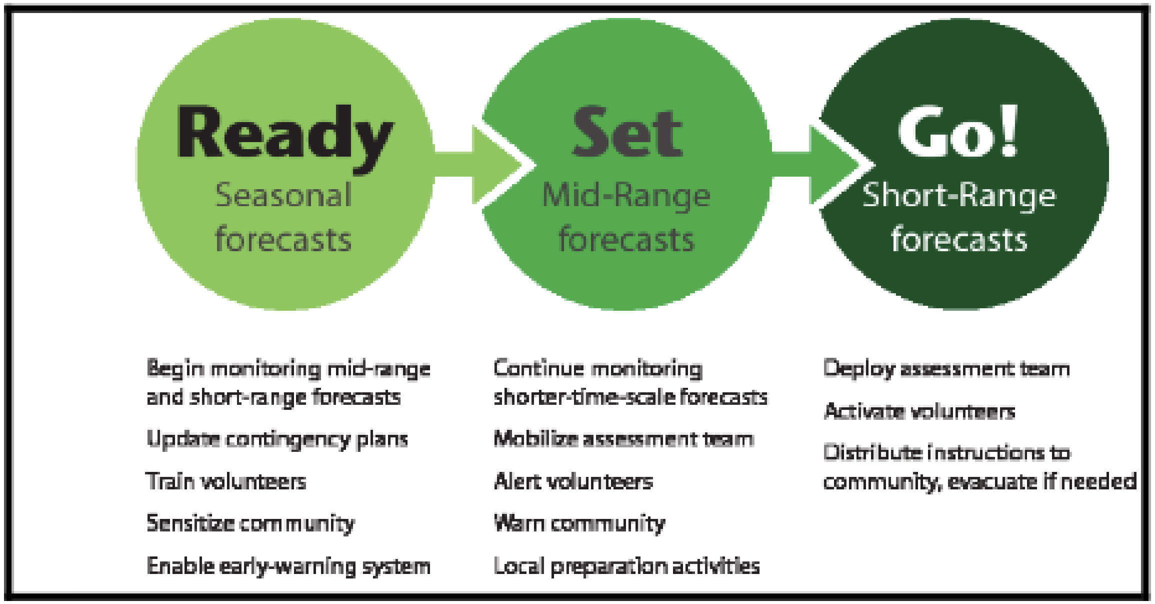
http://s2sprediction.net/

Science challenges (and opportunities): Using S2S extreme rainfall forecasts for extended-range flood prediction

Opportunities

– Opportunity to help bridge the gap between climate and weather forecasts (i.e. seamless multiple timescale forecasting) such as the Red Cross-IRI 'Ready-Set-Go!' approach:



Goddard et al. (*Earth Perspect.,* 2014)

Science challenges (and opportunities): Using S2S extreme rainfall forecasts for extended-range flood prediction

Challenges

– Model resolution, ensemble size, hindcasts, data availability, initialisation and (lack of) observations

– Dealing with the uncertainty, biases and systematic errors inherent in forecasts, especially extremes

– Promotion of the S2S timescale

– Focus needs to be more on applications (up to now it has been more focused on the research):

- Which sectors/end–users (emergency management, aid response, health, other)?

- What applications and methods of communication would be appropriate (adoption of ‘climate services’ approaches; inclusion of social sciences <u>from the beginning)</u>

Thank you

Email: chris.white@utas.edu.au

Web: http://www.utas.edu.au/engineering/people/dr-christopher-j.-white

IUGG Paper: http://www.proc-iahs.net/370/229/2015/piahs-370-229-2015.html

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