Applications of Seasonal Prediction in Australia

Oscar Alves and the POAMA Team

**Centre for Australian Weather and Climate Research,
Bureau of Meteorology**

Outline

Brief description of POAMA System

System Skill

-Seasonal

-Multi-week

-Modes and case studies (MJO, Modoki, SAM, etc)

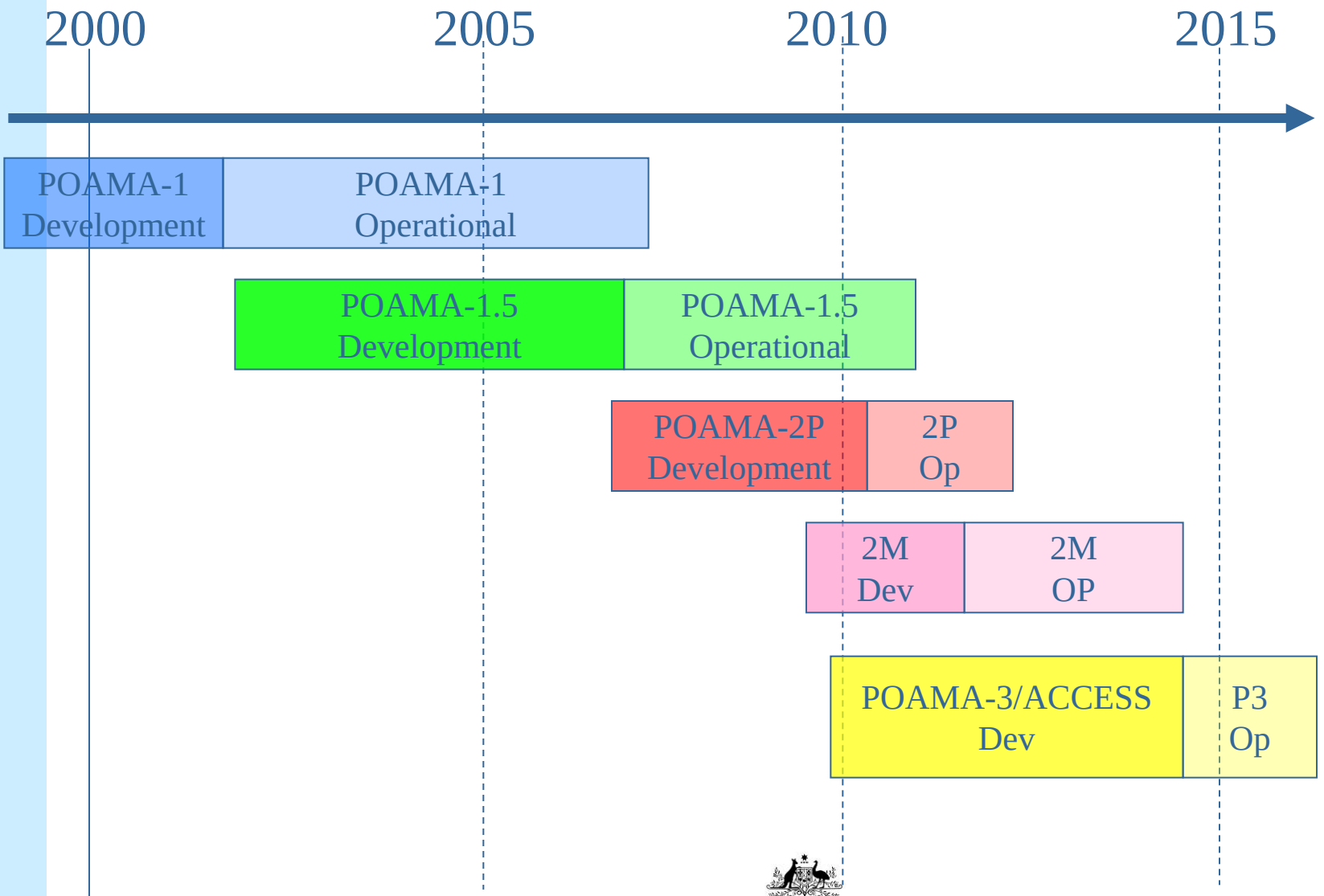
Applications of Seasonal Forecast

-General

-Agriculture

-Marine (Reef bleaching, fisheries, etc)

Timelines



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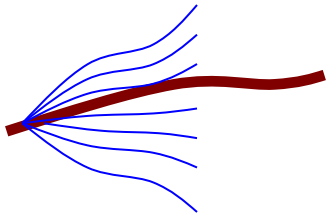
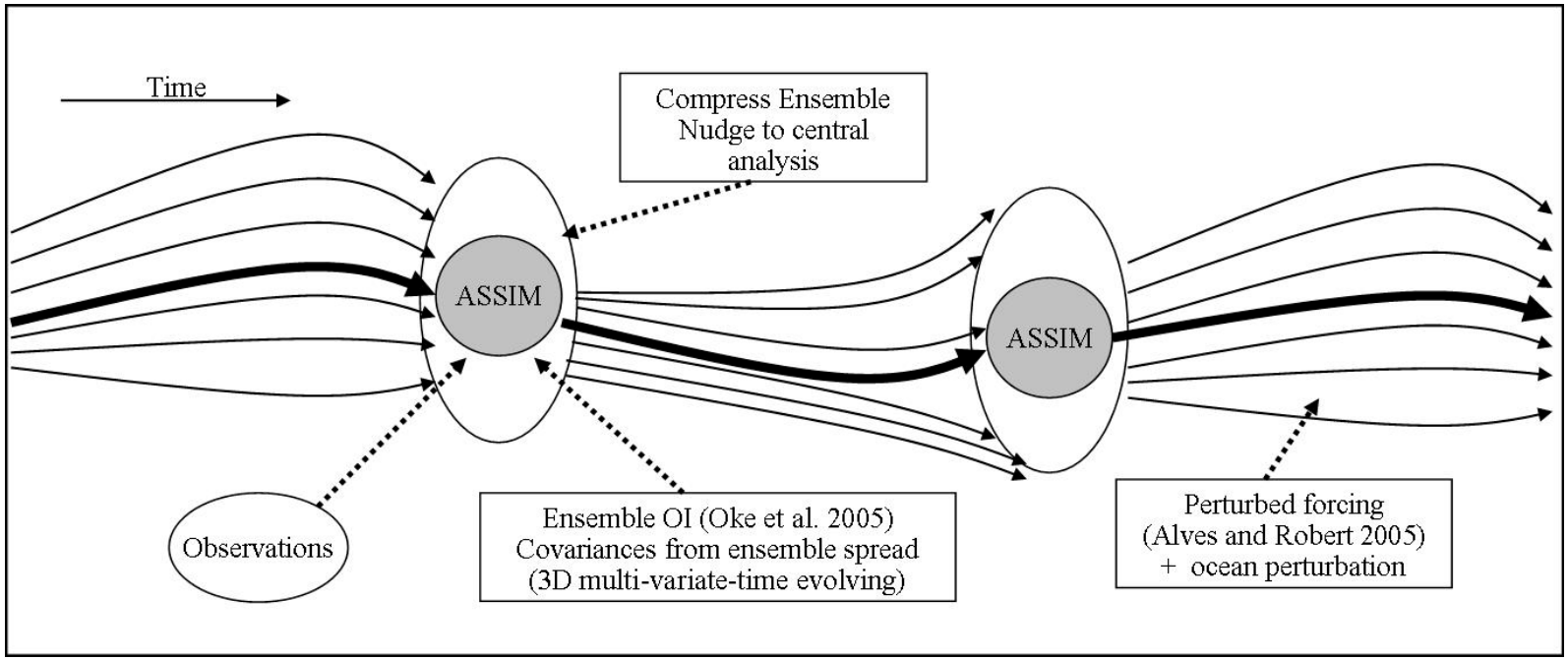
POAMA-1.5/POAMA-2 Differences

	POAMA-1.5	POAMA-2P
Model	T47L17 Bureau Atmos + GFDL MOM2	Same but 3 versions, one with bias correction
Initialisation	OI (Univariate Smith Optimum Interpolation) Temperature Atmos: Nudging to NWP	PEODAS (Multivariate pseudo-Ensemble Kalman Filter) Temperature + Salinity Atmos: Nudging to NWP
 **Ensemble generation**	10 members Time-lagged atmos. ensemble No ocean perturbations	30 members Multi-model (3 versions) No time-lagged ensemble Ocean perturbations from PEODAS No atmosphere perturbations in seasonal version

POAMA-2 Intraseasonal system

	POAMA-2P (Seasonal)	POAMA-2M (Monthly+Seasonal)
Ensemble generation	30 members Multi-model (3 versions) No lagged ensemble Ocean perturbations from PEODAS; No atmosphere perturbations	33 members Multi-model (3 versions) No lagged ensemble **Ocean and atmosphere perturbations from Coupled Breeding Scheme**
Operational	30 member every 15 days out to 9 months	**33 members every Thursday out to 4 months**

PEODAS: POAMA Ensemble Ocean Data Assimilation System (Yin et al 2010)



Pseudo Ensemble Kalman Filter

3D Multivariate ocean assimilation

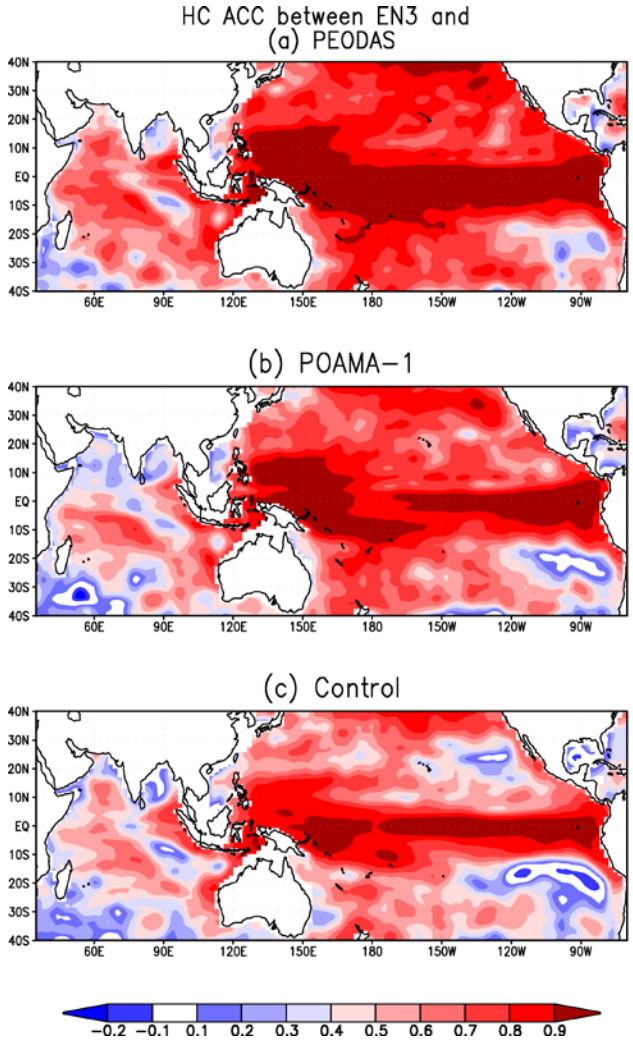
Temperature and Salinity profiles

Re-analysis from 1960-present

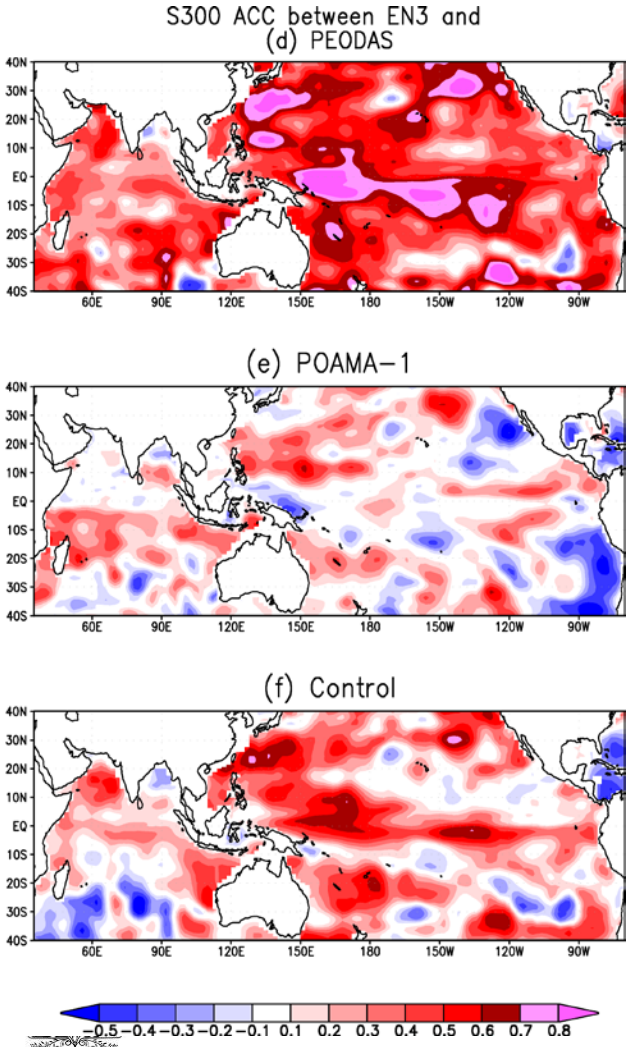
Produces an ensemble of 11 states (pseudo breeding like NCEP)

Correlation between re-analysis and UKMO EN3 dataset

Heat Content



Salt Content



Produced by Maggie Zhao

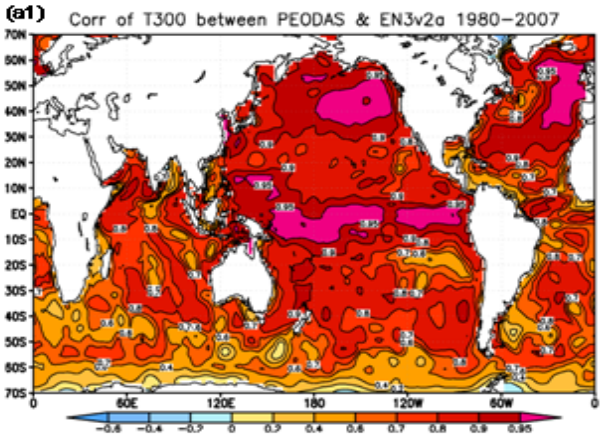
Comparison with Other Centres

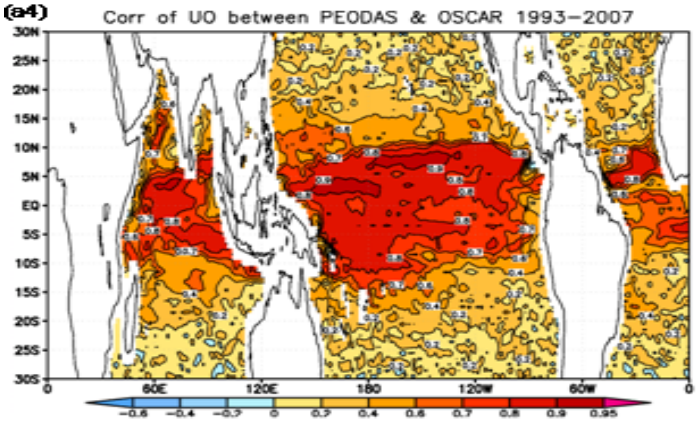
Correlation with "Observations"

Heat Content

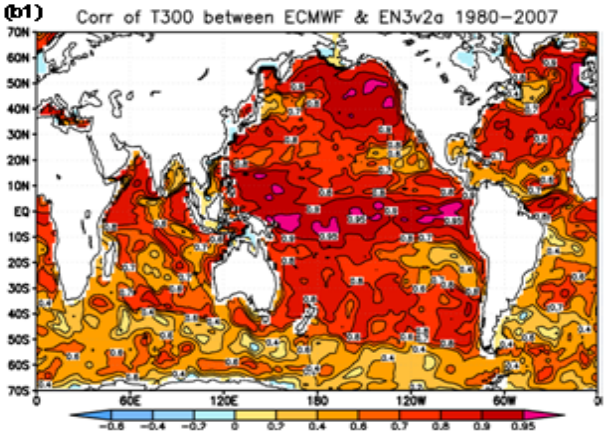
Surface Current

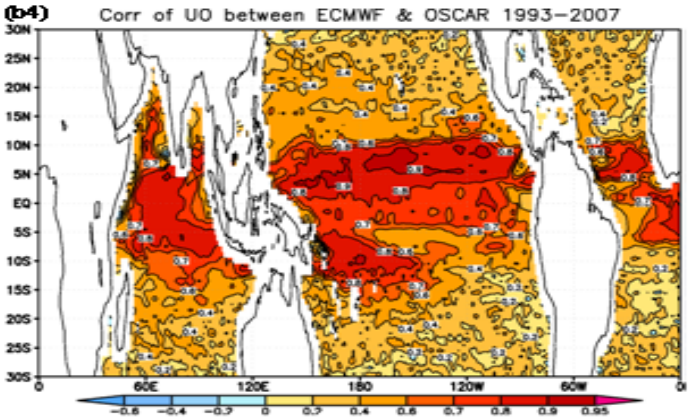
PEODAS





ECMWF





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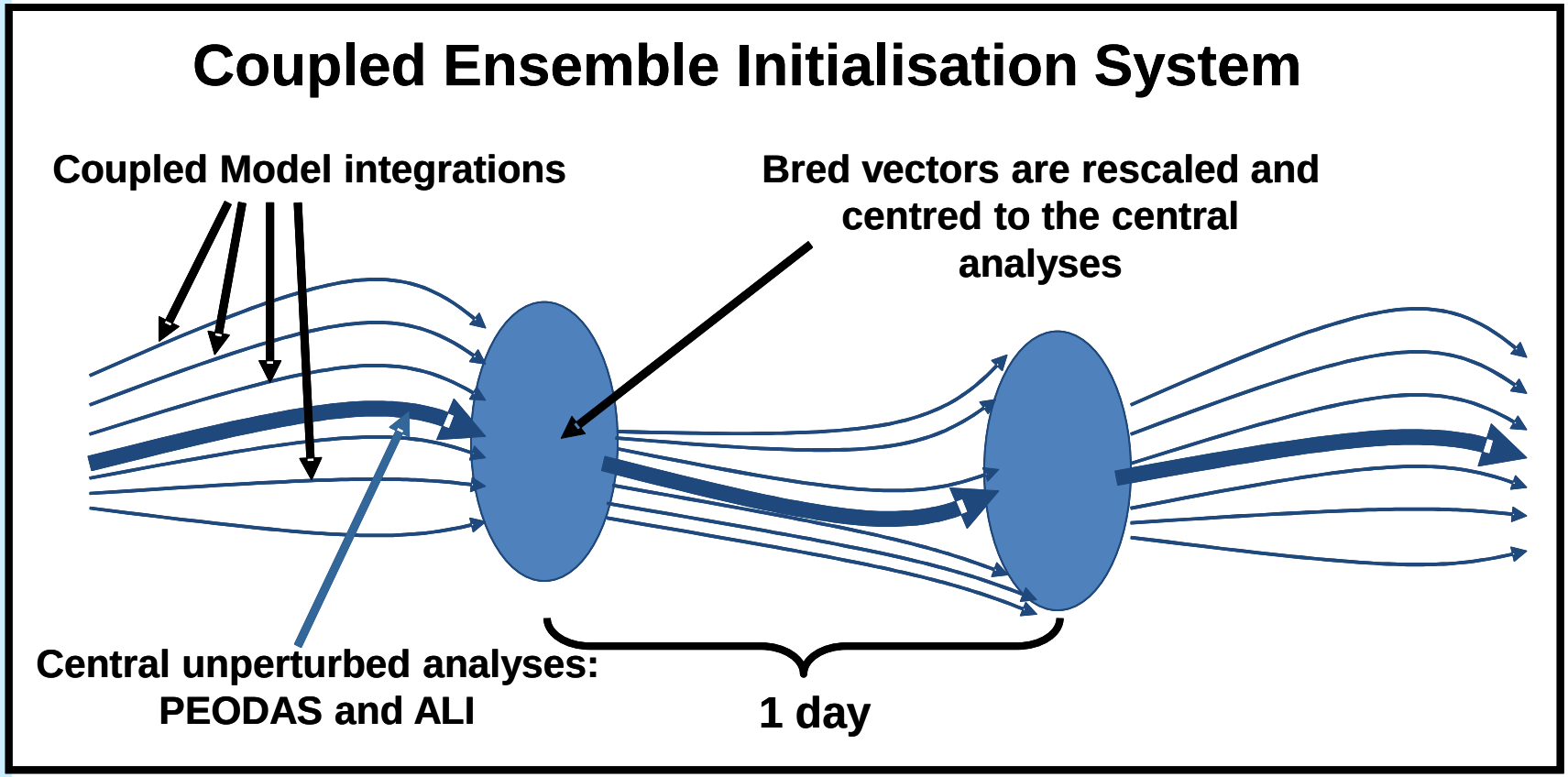
Initial Conditions for the Intraseasonal System 2M

Towards Coupled Assimilation...

Based on the PEODAS infrastructure



(Yonghong Yin)

Generates coupled bred perturbations of the atmosphere and ocean based on a breeding method

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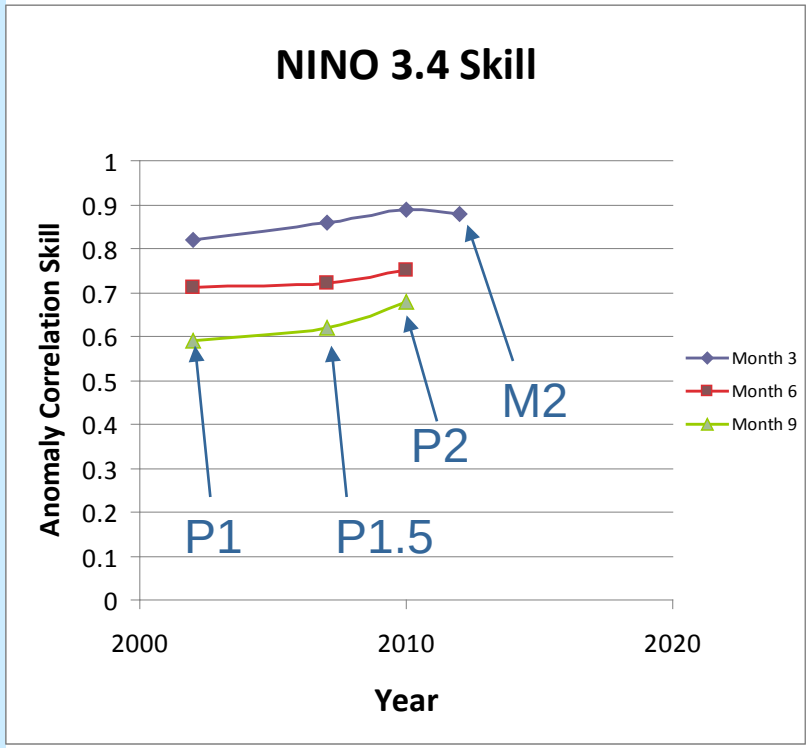
SST Skill

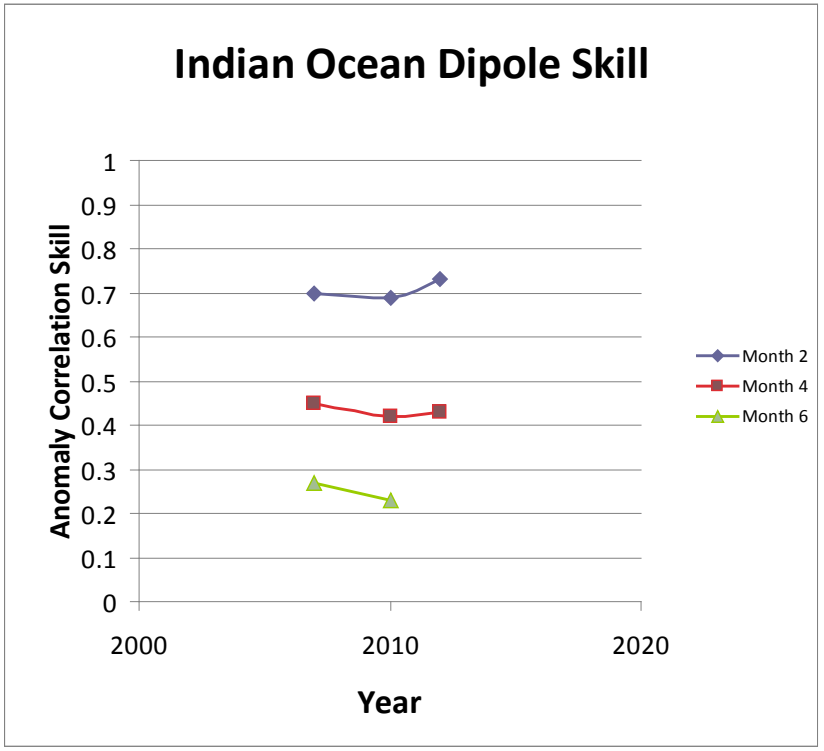
El Nino and IOD

(& Comparison with other models)

Mostly Based on hind-casts from ~1982-2006

POAMA Progress – SST Skill

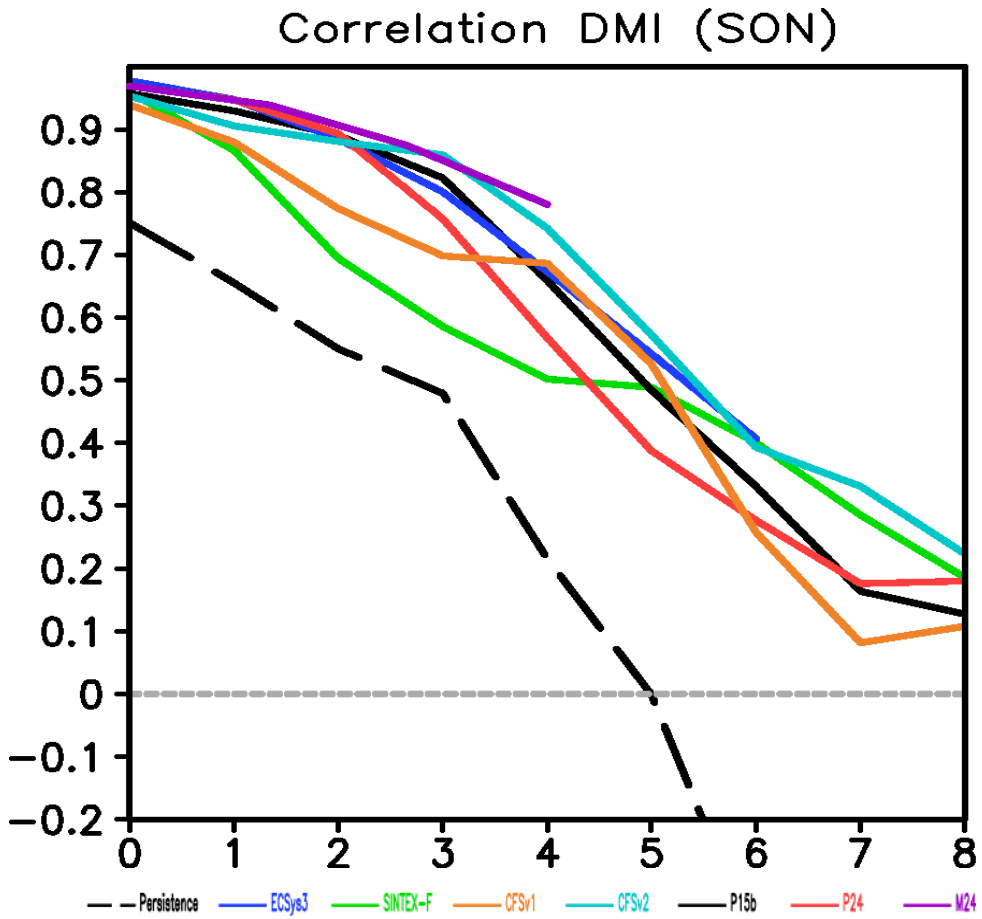




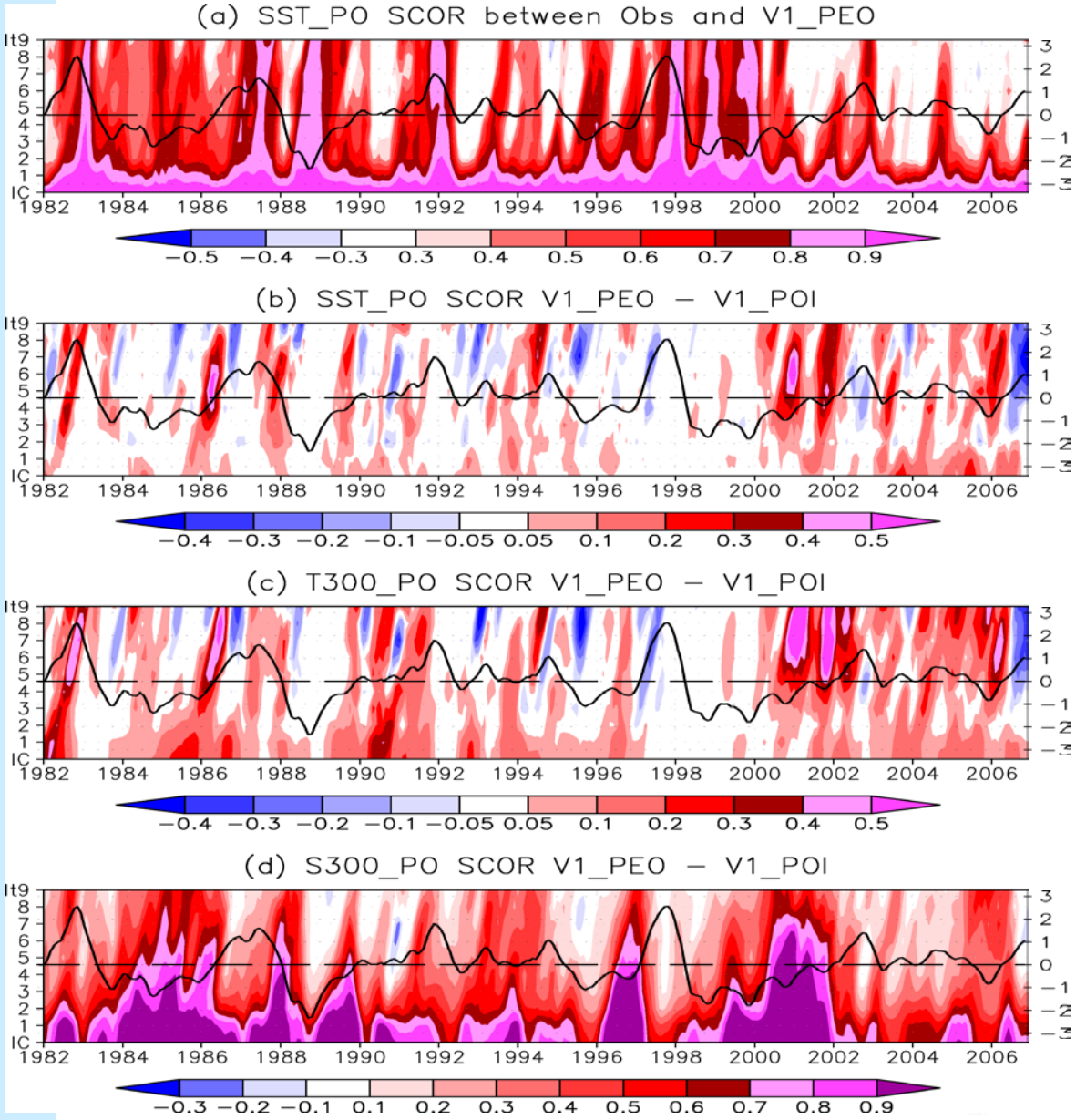
Improvements due to

- Increased supercomputing
- Improved forecast system (model, physics, initialisation strategy)
- New observing Systems

Indian Ocean Dipole Skill



Impact of POAMA-2 assimilation in Pacific



POAMA-2 Skill in Pacific (spatial ACC)

SST

POAMA-2-POAMA1.5 Skill

Heat Content

POAMA-2-POAMA1.5 Skill

Salt Content

POAMA-2-POAMA1.5 Skill

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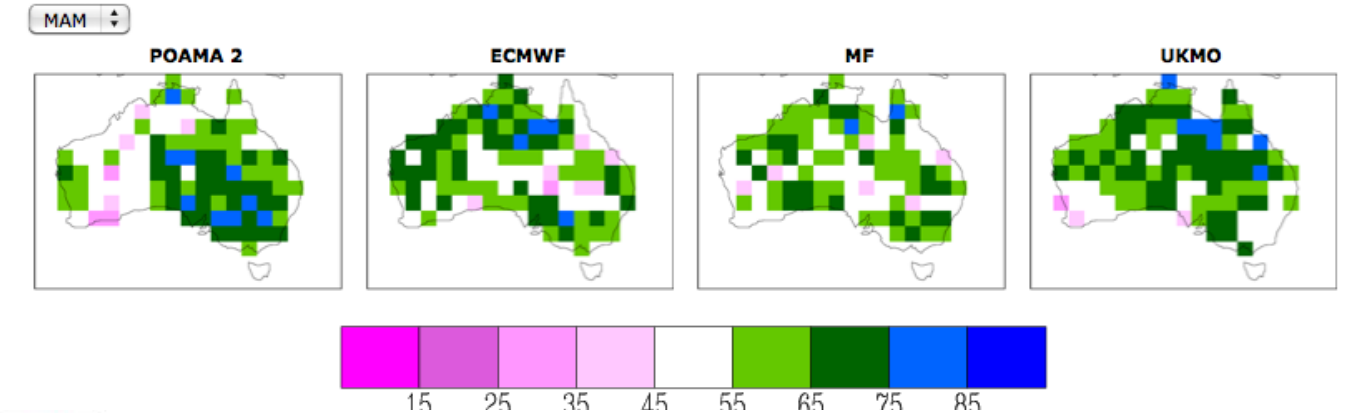
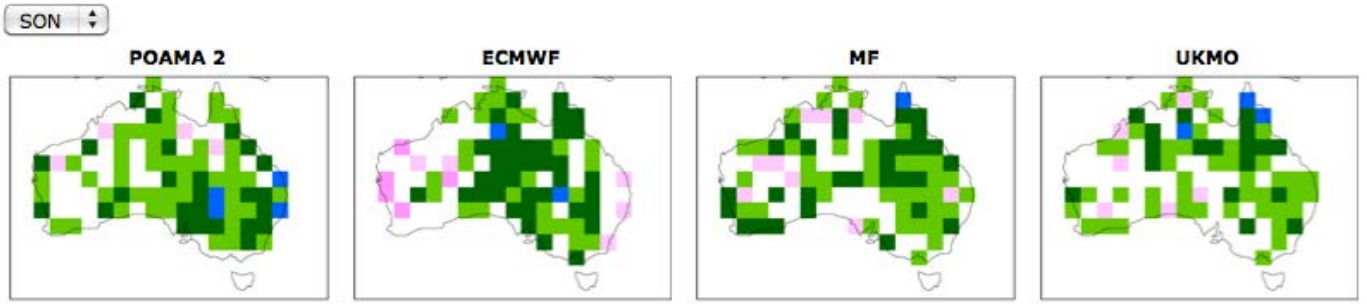
Rainfall Skill

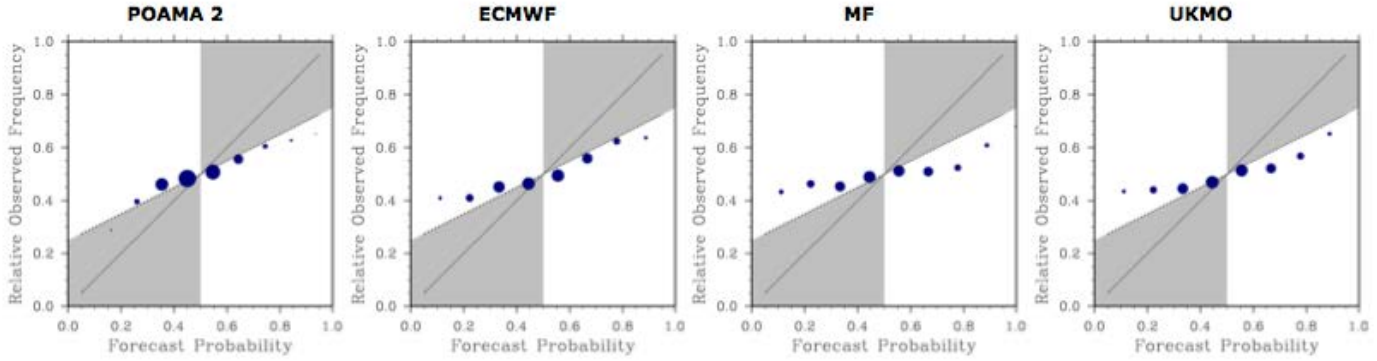
Skill Intercomparison – Hit rate above median rainfall

Technical report – Langford et al



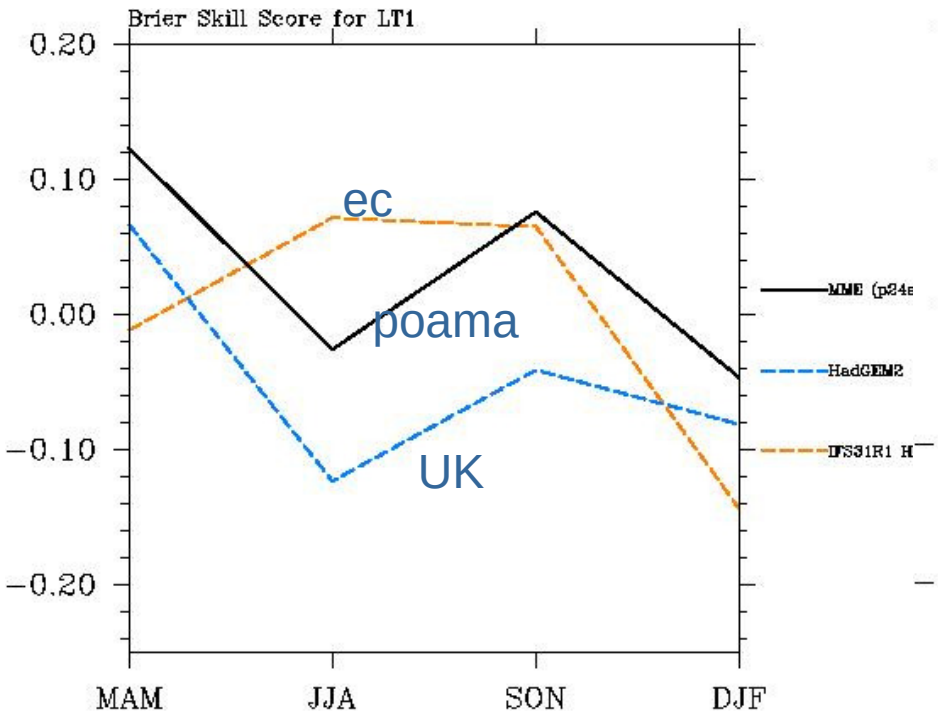


Attributes diagram for above median rainfall

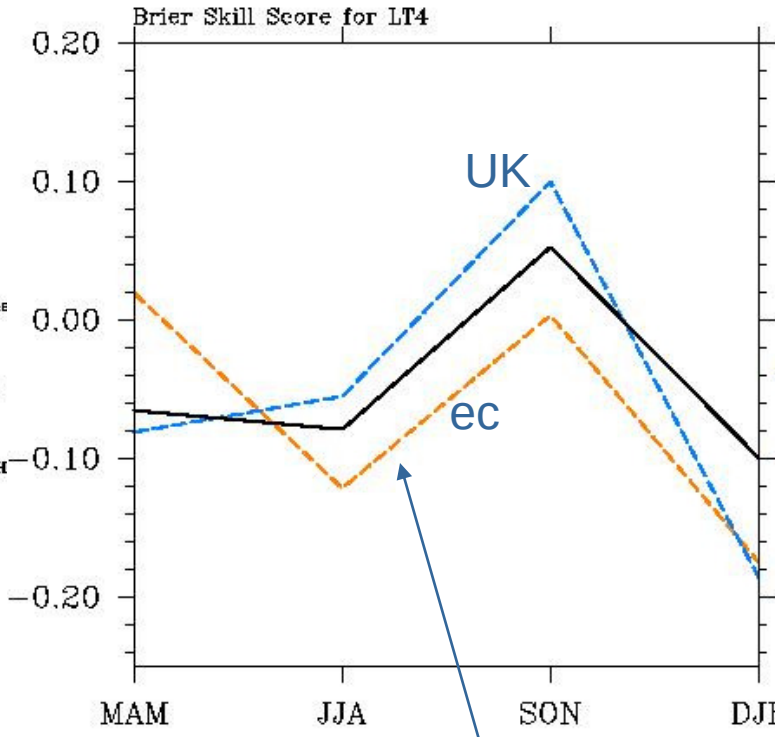


Brier Skill Score for SE – POAMA2P

Lead 1 month



Lead 4 month



EC teleconnections not so good

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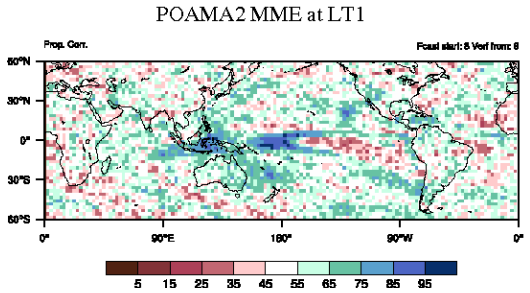
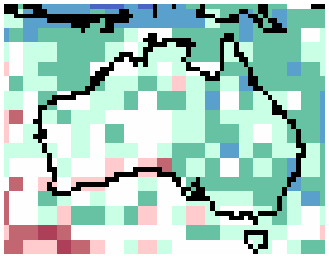
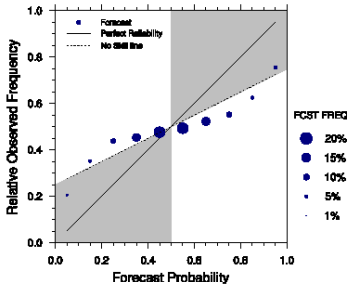
SON Skill lead 1 from 2P version

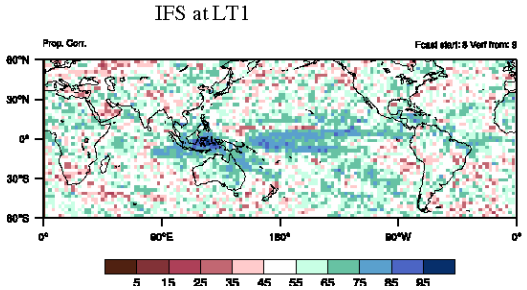
POAMA-2 MME

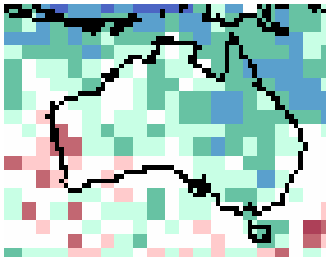


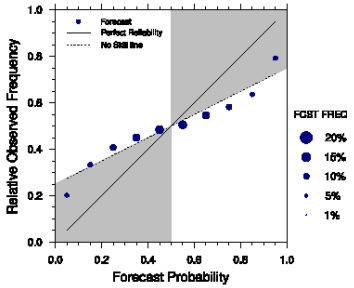




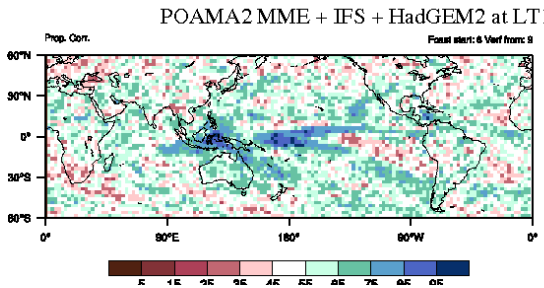
ECMWF

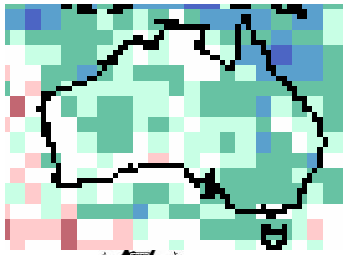


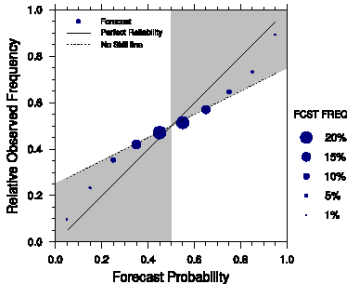




POAMA-2 +EC+UKMO







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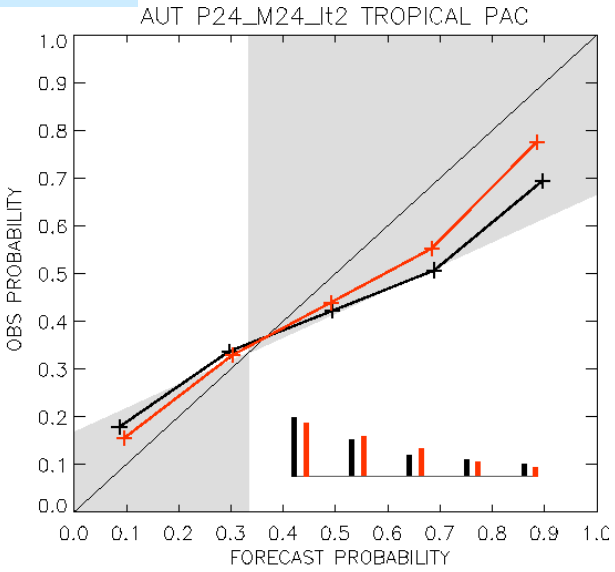
Produced by Eun-Pa Lim

POAMA-2M Seasonal Forecasts

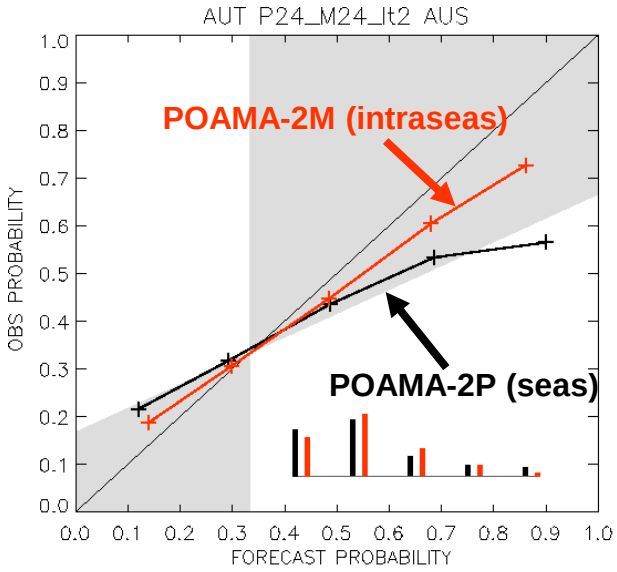
POAMA-2 intraseasonal system has added benefits on the seasonal timescale…

Rainfall (above the upper tercile) Reliability: Skill of **first season**

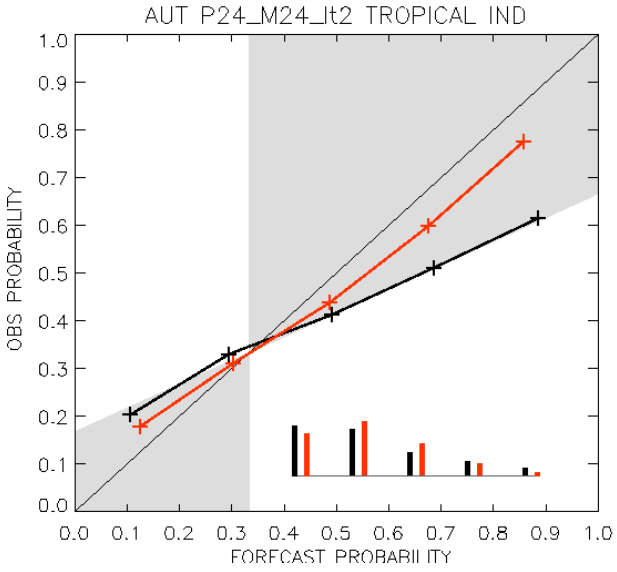
Tropical Pacific



Australia



Tropical Indian



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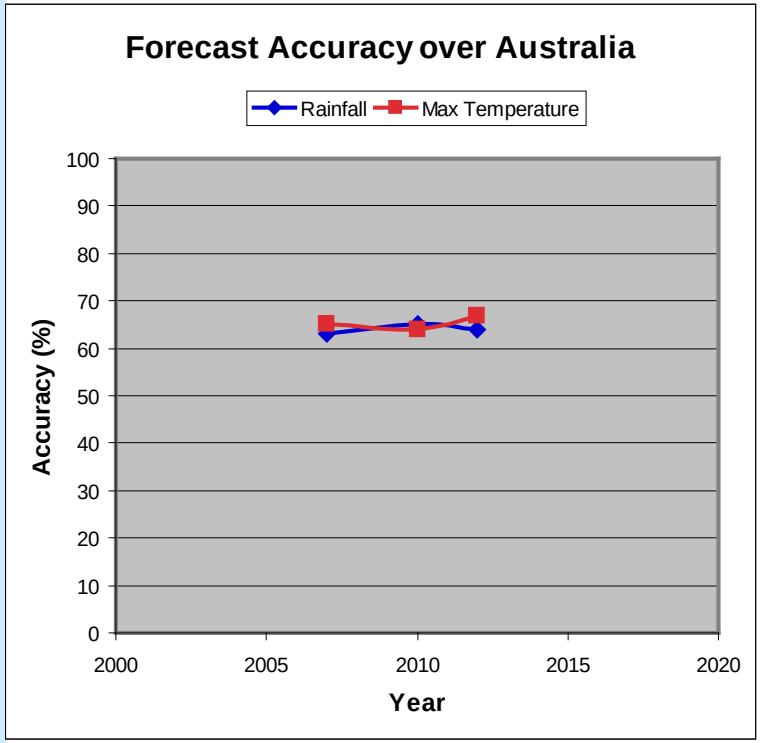
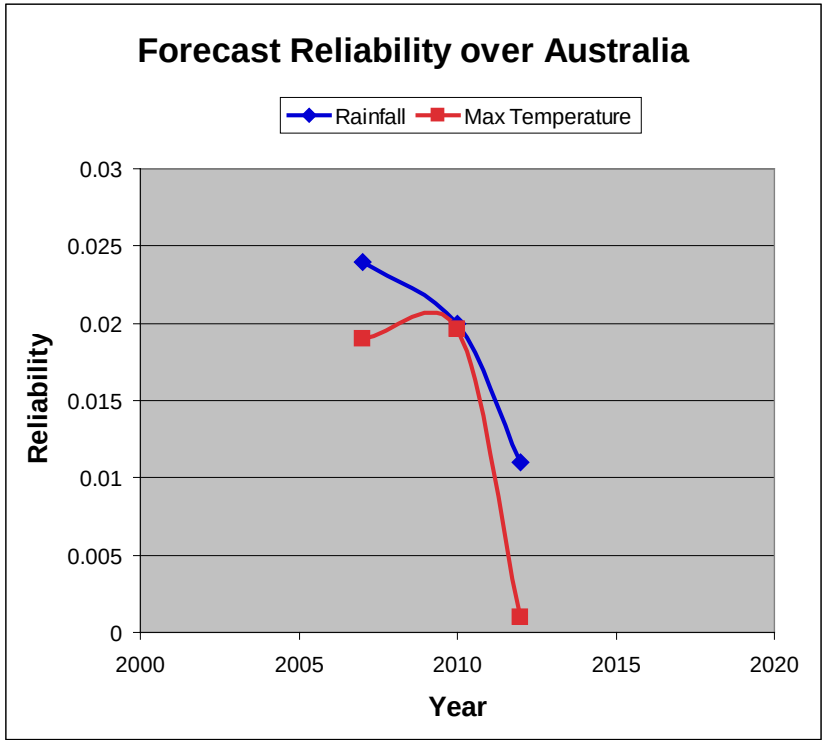
(Guomin Wang)

POAMA Progress – Regional Skill



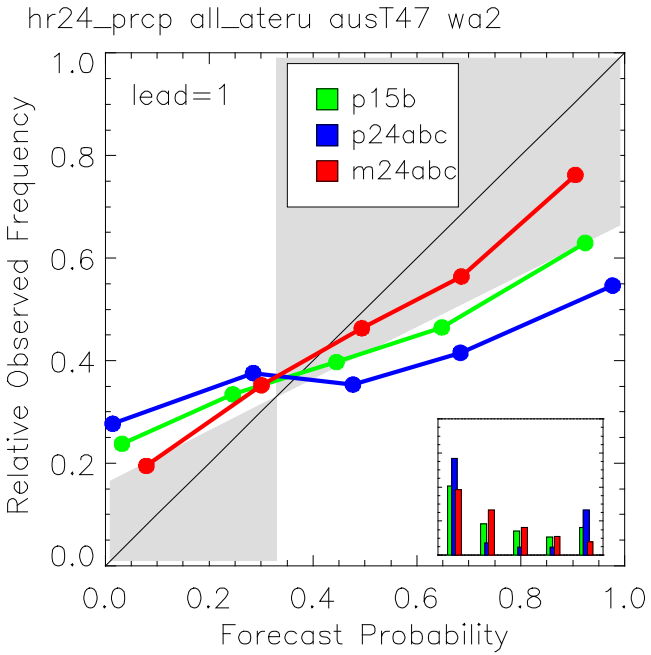


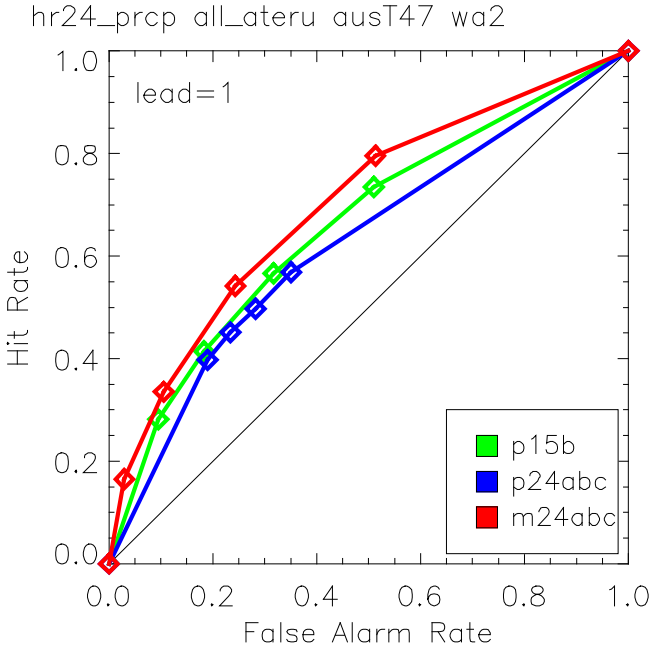
First Seasonal Rainfall/Max temperature – skill scores for upper tercile forecasts

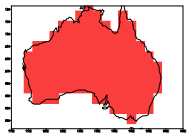
Multi-week Skill

Australian RAINFALL above upper tercile: all forecast start months

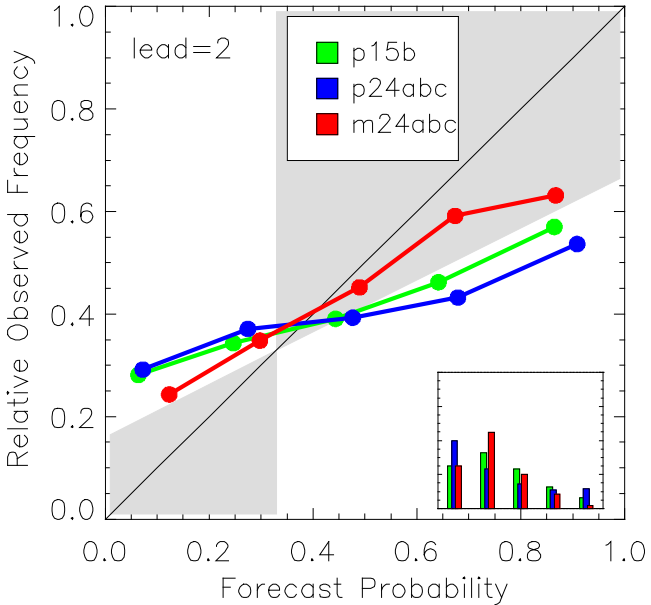
Fortnight 1

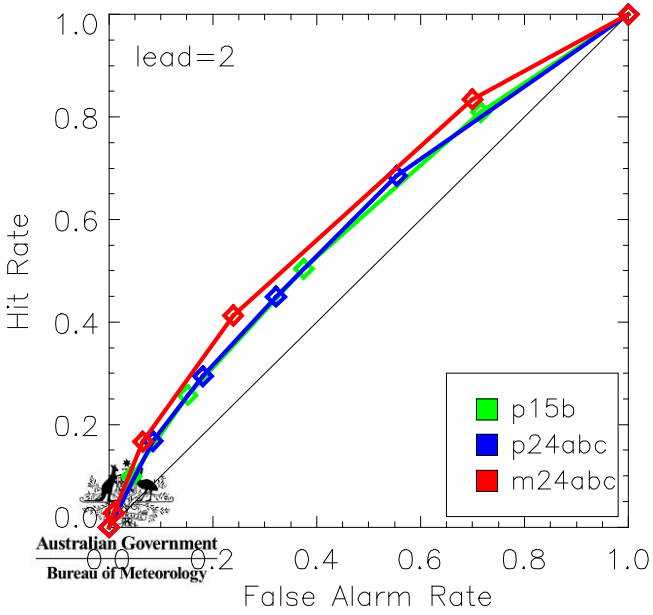






Fortnight 2





POAMA-1.5

POAMA-2P (seas)

POAMA-2M (intraseas)

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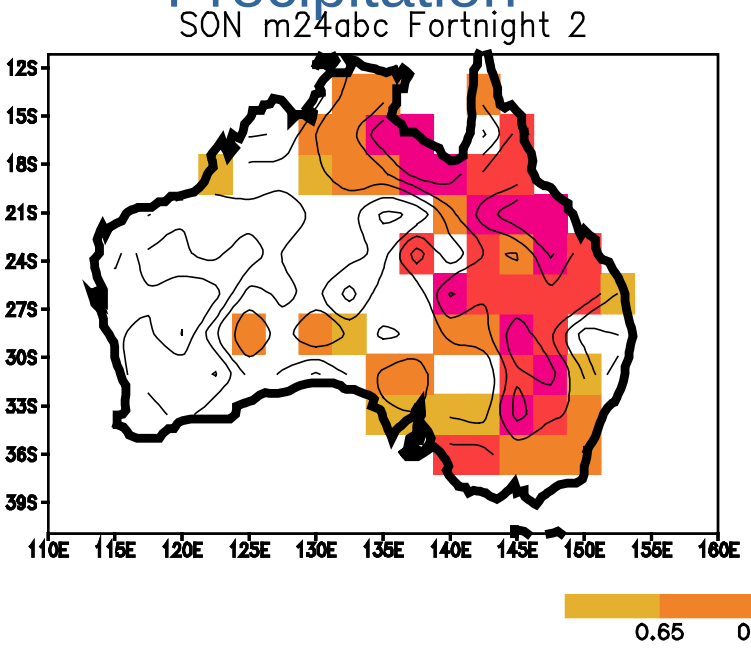
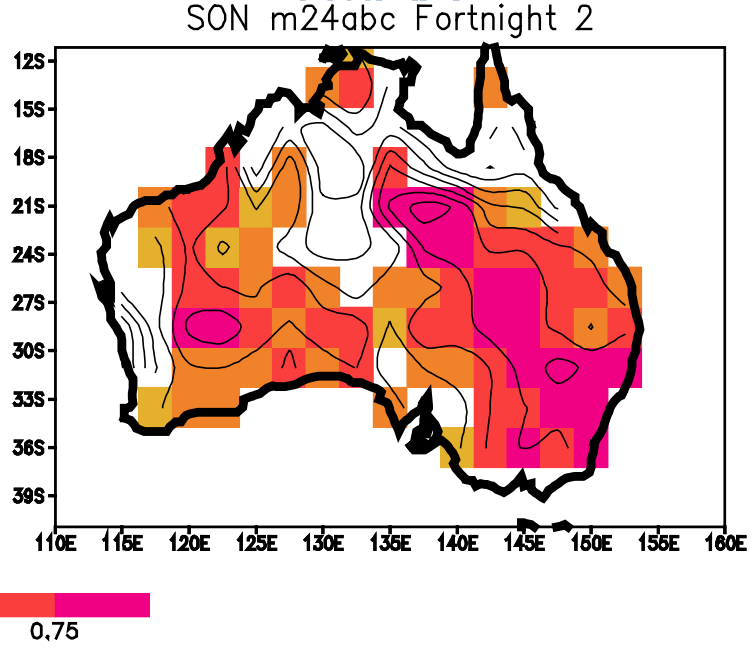
POAMA has good skill in predicting rainfall and TMAX over eastern Australia in the second fortnight of the forecast, particularly during spring forecast months.

Precipitation



TMAX

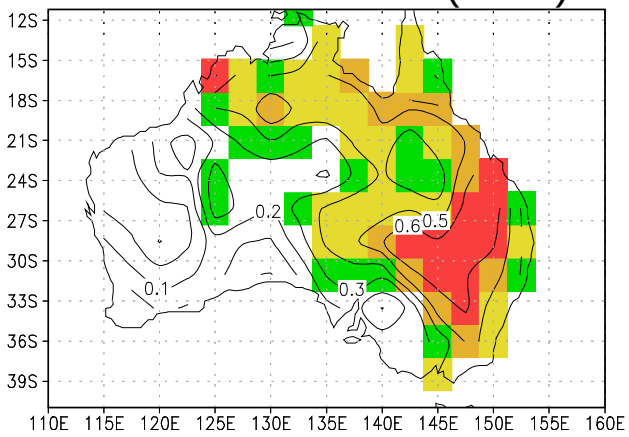


ROC area of the probability that rainfall (left) and TMAX (right) for the 2nd fortnight of the forecast is in the upper tercile for spring forecast months (SON, 1989-2006). ROC areas significantly more skilful than climatology are shaded (5% significance level).

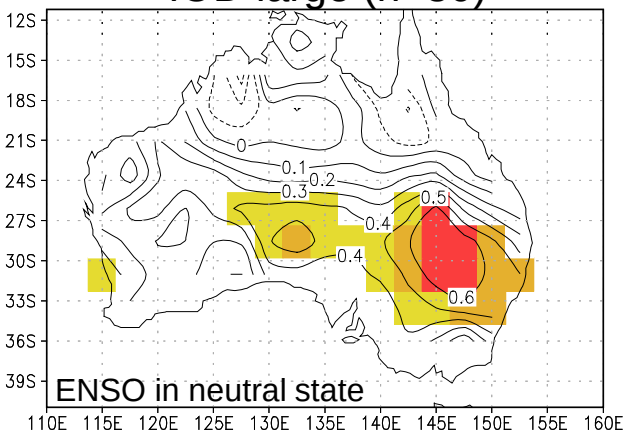
Climate drivers operating on timescales longer than intraseasonal influence prediction skill

For rainfall forecast in the 2nd fortnight, there is higher skill when the IOD is strong and when ENSO is in an extreme (JJASON)

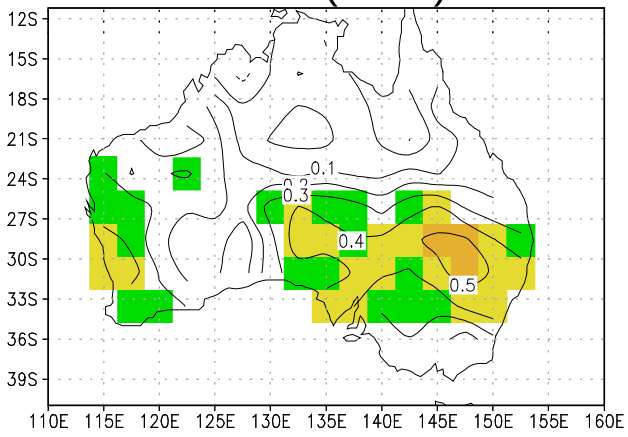
El Nino / La Nina (n=48)



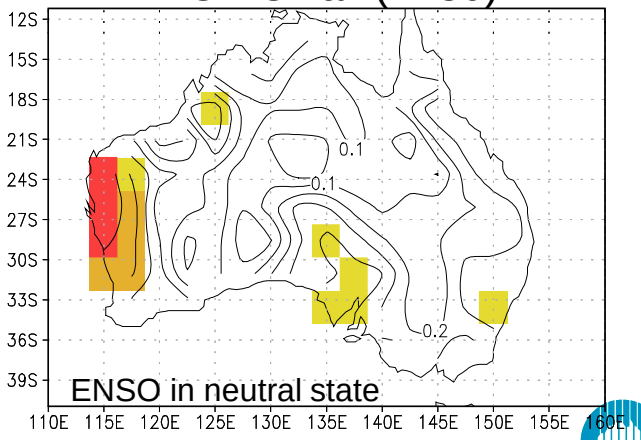
IOD large (n=30)



Neutral (n=60)



IOD small (n=30)



Rainfall correlation skill

0.3 0.4 0.5 0.6

(Hudson et al 2011)

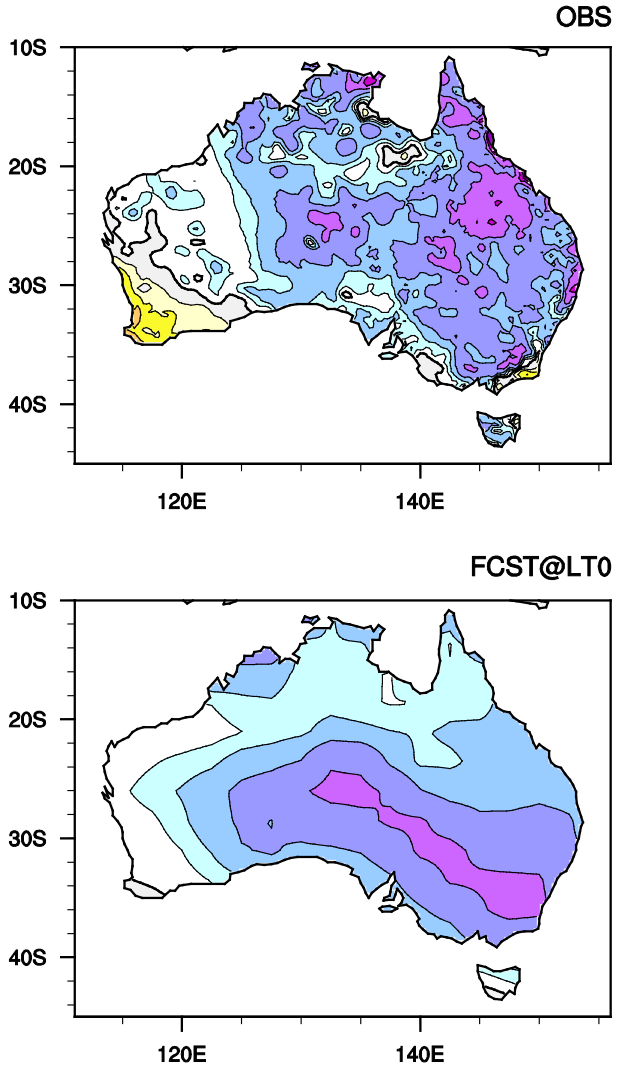
CSIRO

2010 La Nina

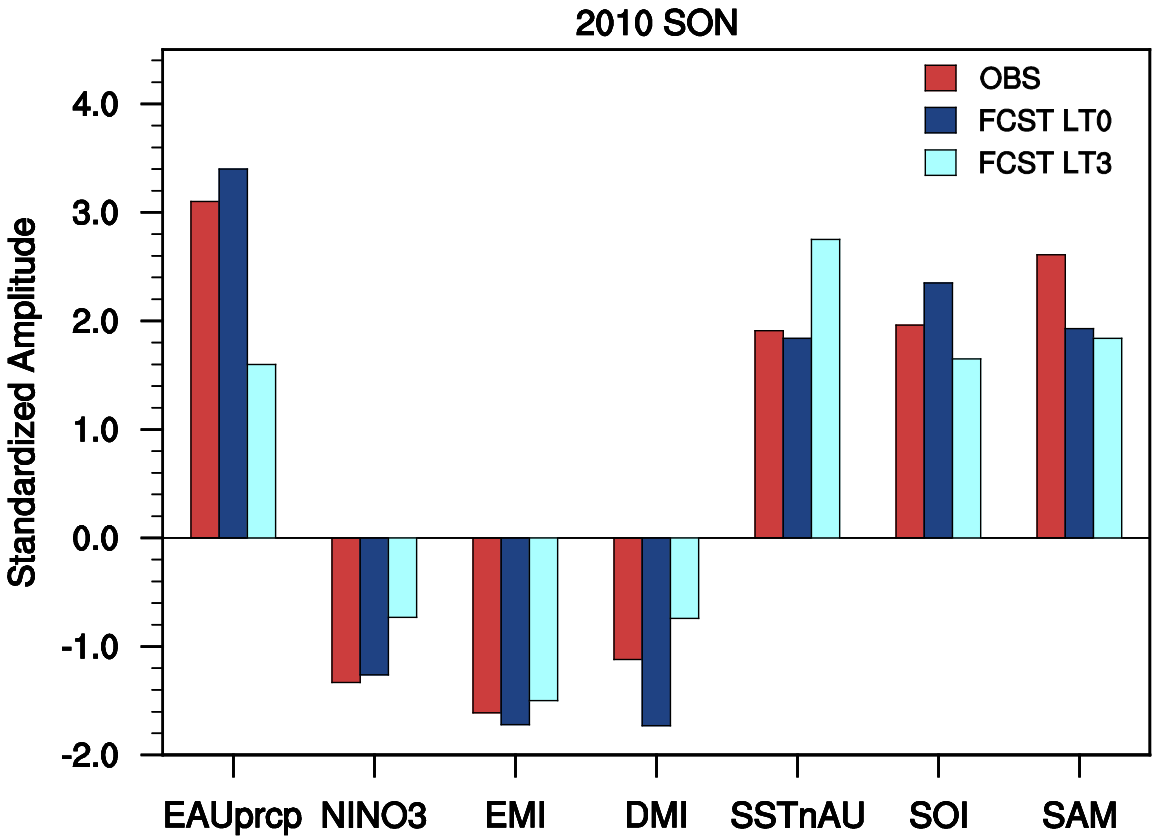
2010 September-October-November mean rainfall anomalies over Australia in the

TOP: observation

BOTTOM: POAMA2 ensemble mean forecast at LT0.



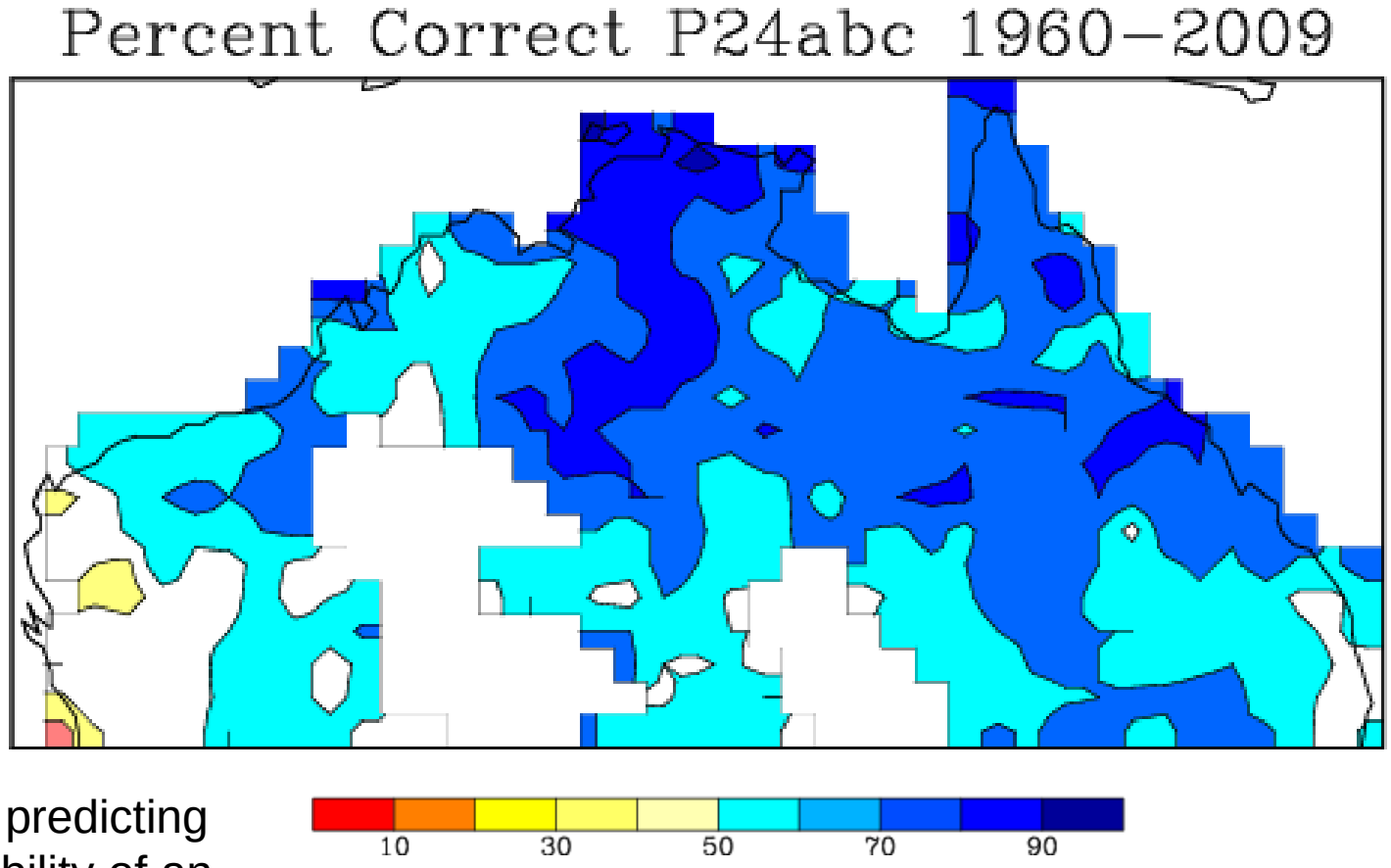
Forecast of different components



Skill for other modes

Predictions of Northern Australian Wet Season Onset

Definition: Date of accumulation of 50 mm after 1st September



SKILL in predicting the probability of an early onset (forecasts initialised 1 Sep)

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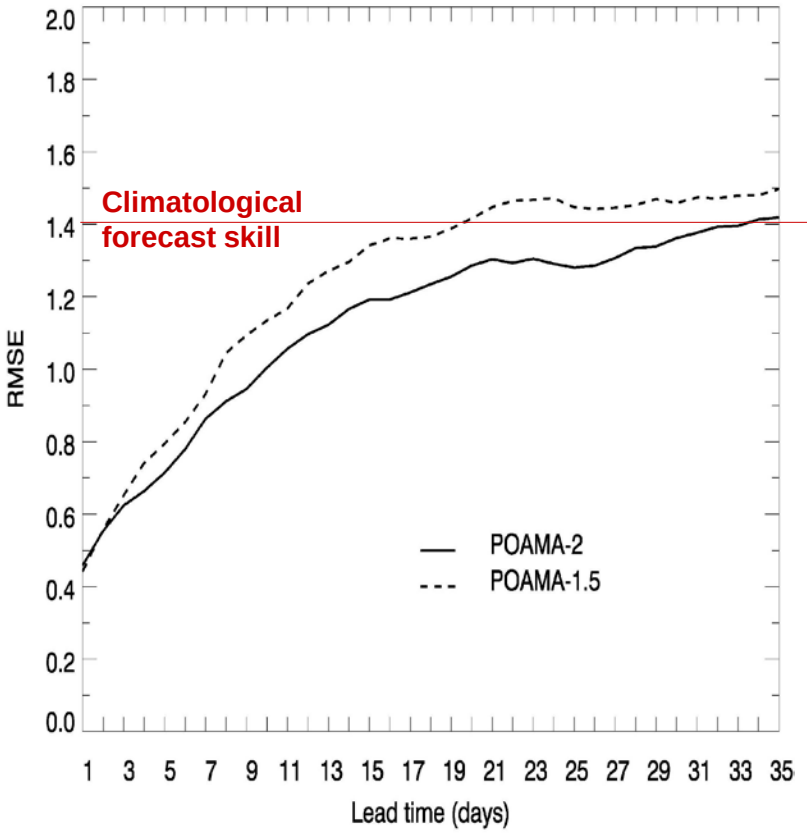
(Drosdowsky and Wheeler)

MJO – Prediction of Index

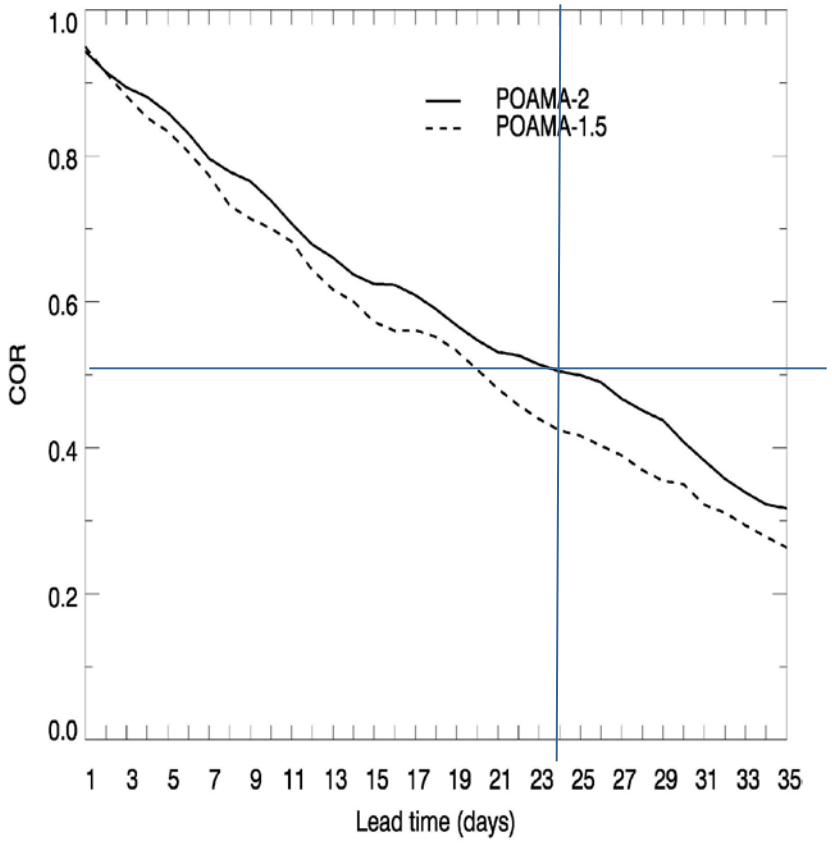
Wheeler and Hendon (2004) RMM Index

RMSE & correlation between observed and POAMA RMM indices (over all start months)

RMSE



COR



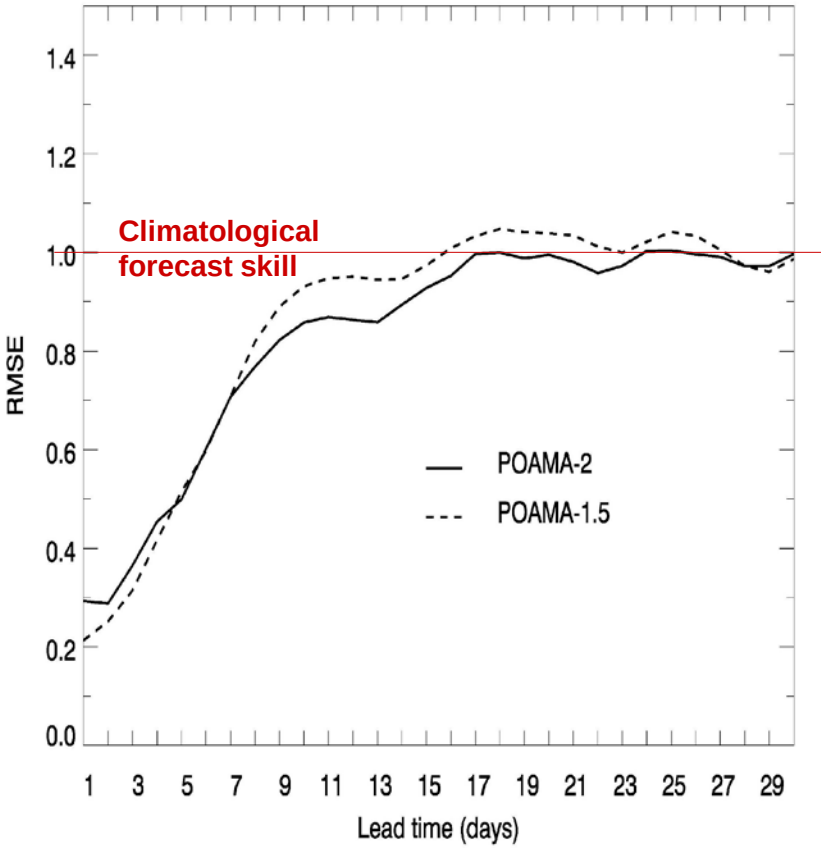
POAMA-2 skill exceeds POAMA-1.5

(Rashid et al 2010, Marshall et al 2011)

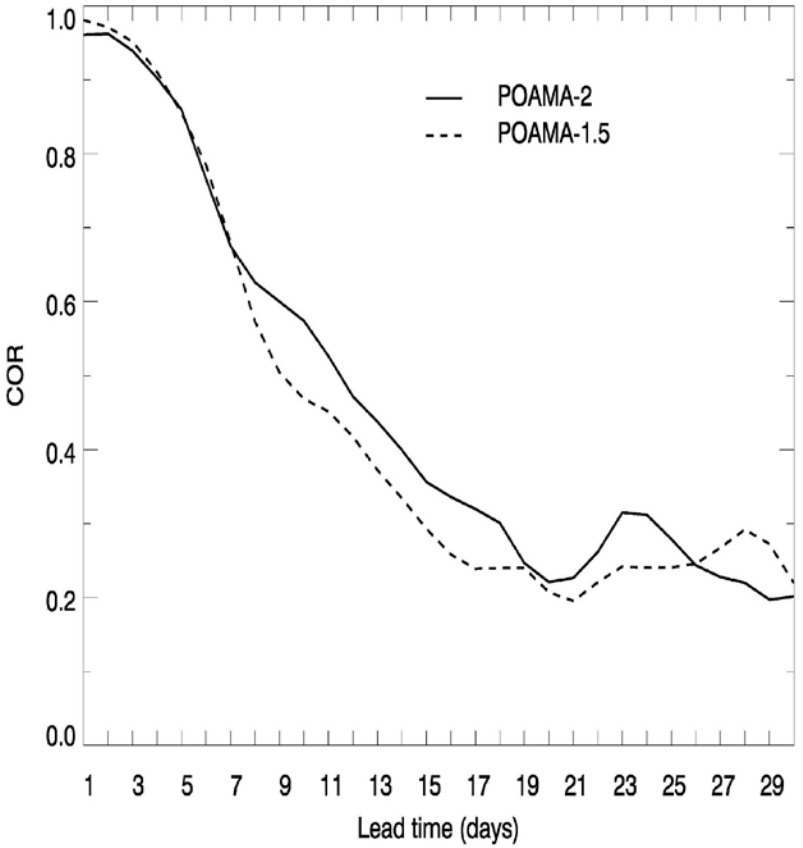
SAM – weekly prediction of index

RMSE & correlation between observed and POAMA SAM indices (over all start months)

RMSE



COR



POAMA-2 skill exceeds POAMA-1.5

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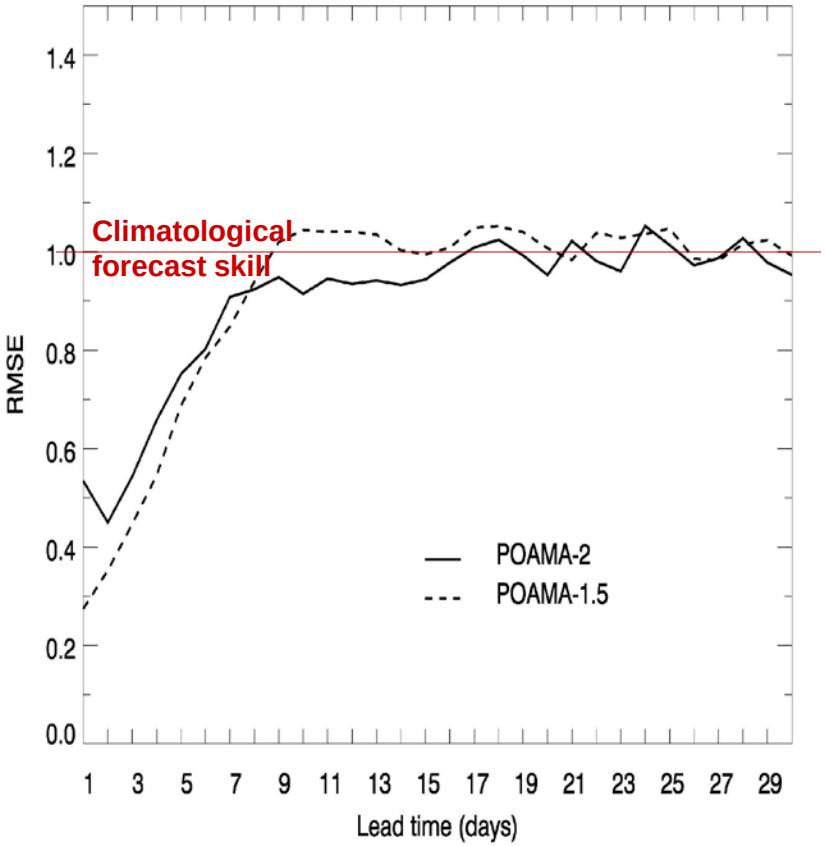
(Marshall et al 2011)

BLOCKING – prediction of index

RMSE & correlation between observed and POAMA blocking indices at 140°E (all start months)

RMSE



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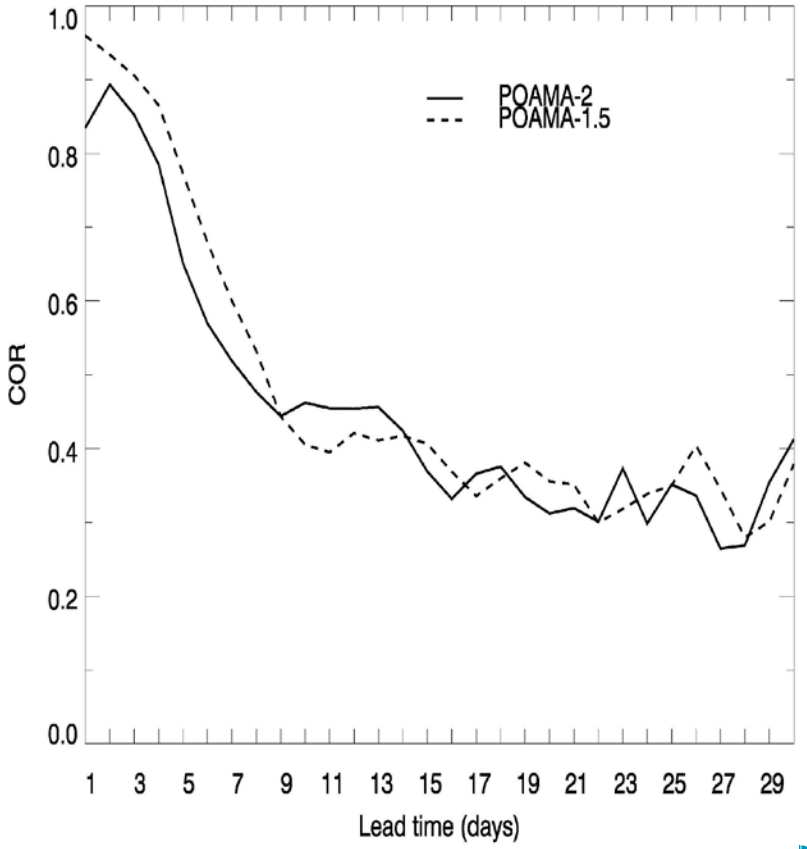

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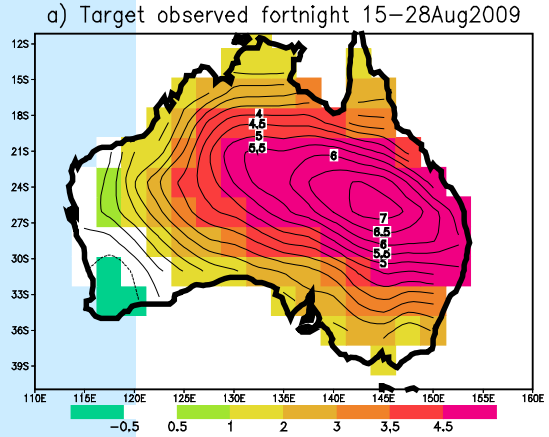
(Andrew Marshall)

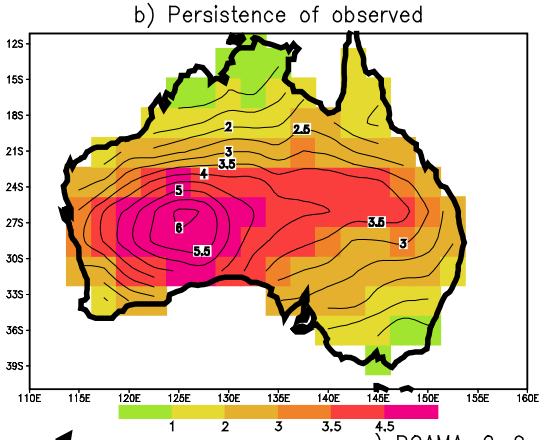
Hudson, Marshall, Alves 2011. Intraseasonal forecasting of the 2009 summer and winter Australian heat waves using POAMA. Weather and Forecasting. 26, 257-279.

Winter heat wave: Aug 2009

Maximum temperature anomalies

Predicting fortnight:
15-28 August

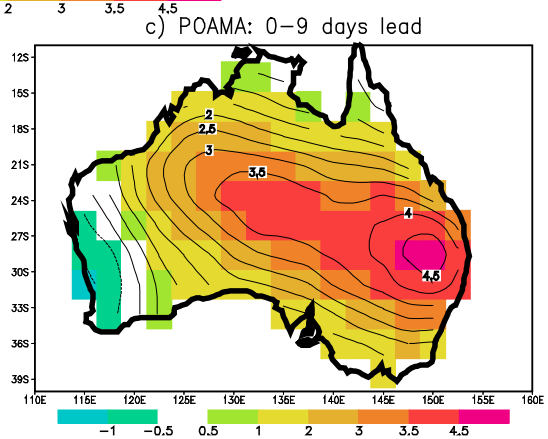


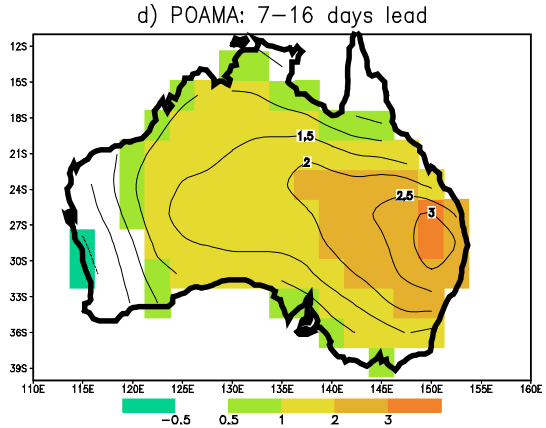


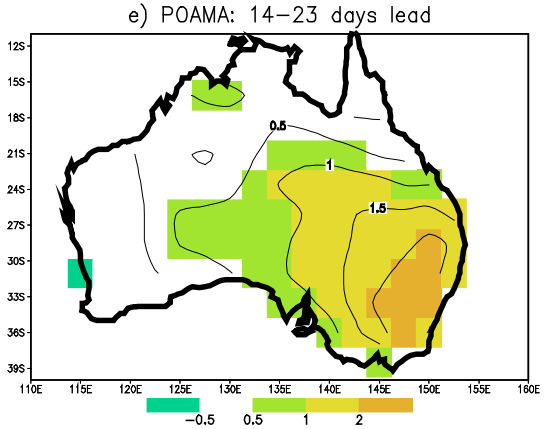
Observed

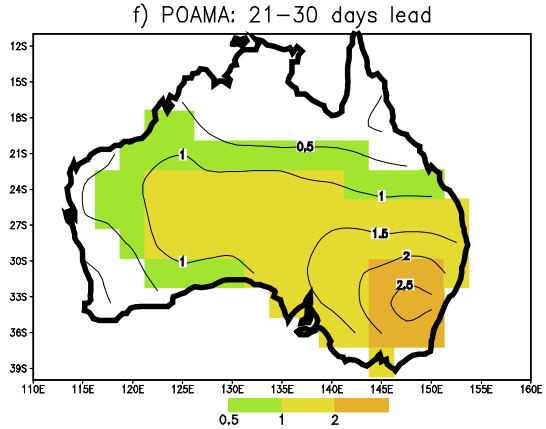
Persistence of observed (average of observed fortnight 1-14 August)

POAMA 10-member ensemble mean forecasts









General applications

Products

SST: NINO, IOD, Modoki (Operational)

Reef Bleaching Risk (Operational)

Hydrological Stream Flow (Pre Operational)

Pacific Islands Temp/Rain (Pre Operational)

Regional Rainfall/Temperature e.g. Median/Tercile probs (Pre-Operational)

Wet season onset (Trial)

Multi-week rainfall/temperature (Trial)

MJO (Trial)

SAM (Trial)

Seamless products (e.g. Distributions of daily) (Trial)

Application specific Trial Products

Research into Applications

General (Temperature and Rainfall – e.g. for agriculture)

Hydrological Streamflow prediction

Reef Bleaching Risk

Setting Tuna Quota regions in Tasman Sea

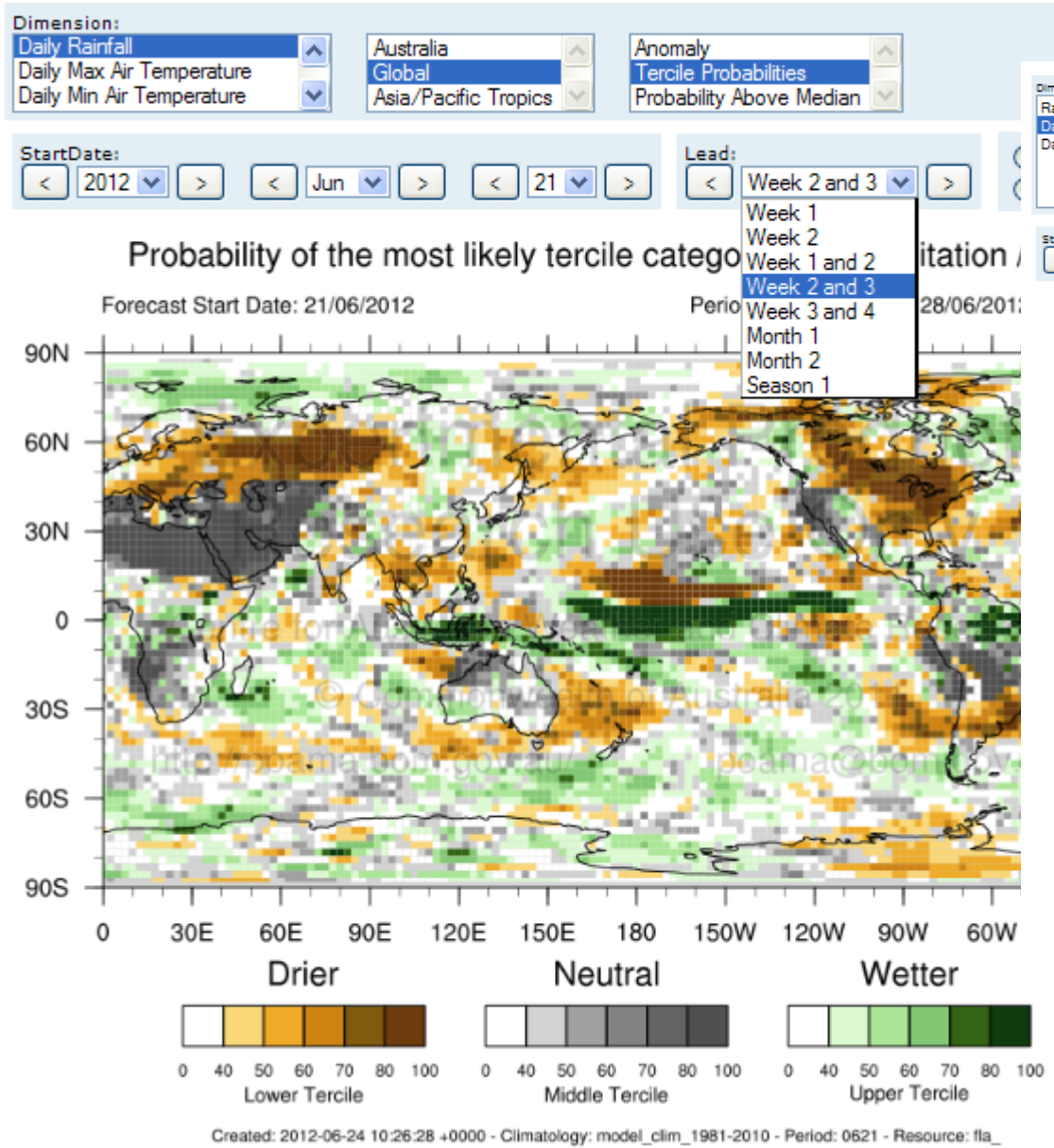
Salmon farming in Tasmania

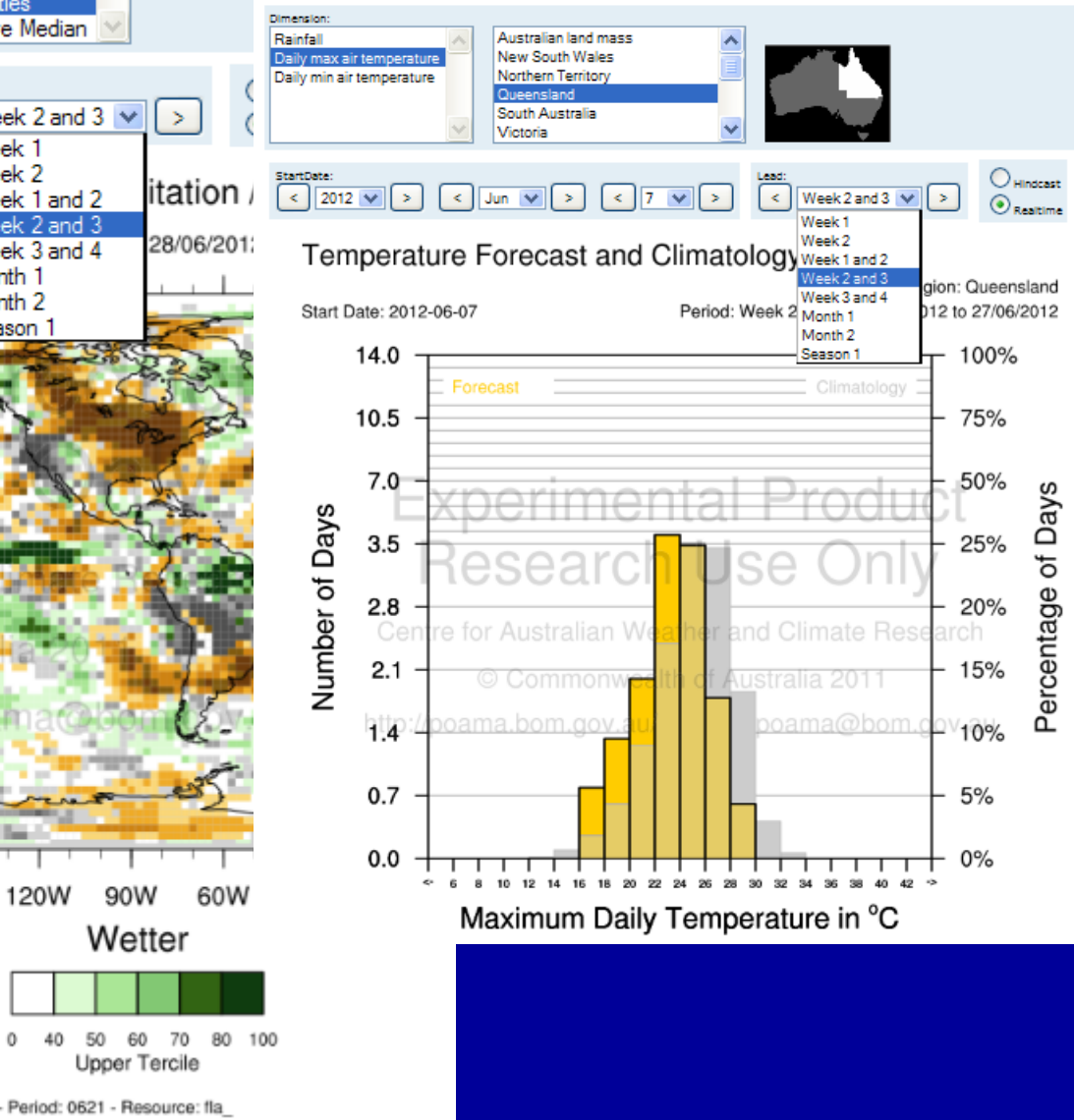
Prawn farming in Queensland

Pacific Islands (temperature, rainfall, sea level, bleaching risk, TCs)

Prediction of heat extremes

Seamless Products http://poama.bom.gov.au/





Agriculture applications

Value of a POAMA forecast for N management

(2500 ha wheat at Nyabing, WA)

	Climatology (history)	POAMA forecast (70% skill)	Correct forecast	POAMA % of best possible
Realistic risk averse ($1 N for $2 return)	$235,000	$402,500	$490,000	66%
Maximise GM (risky!)	$410,000	$420,000	$527,500	9%

The Lesson: A realistic risk-averse management strategy can benefit greatly from even a moderately skilful forecast.

Senthold Asseng and Peter McIntosh

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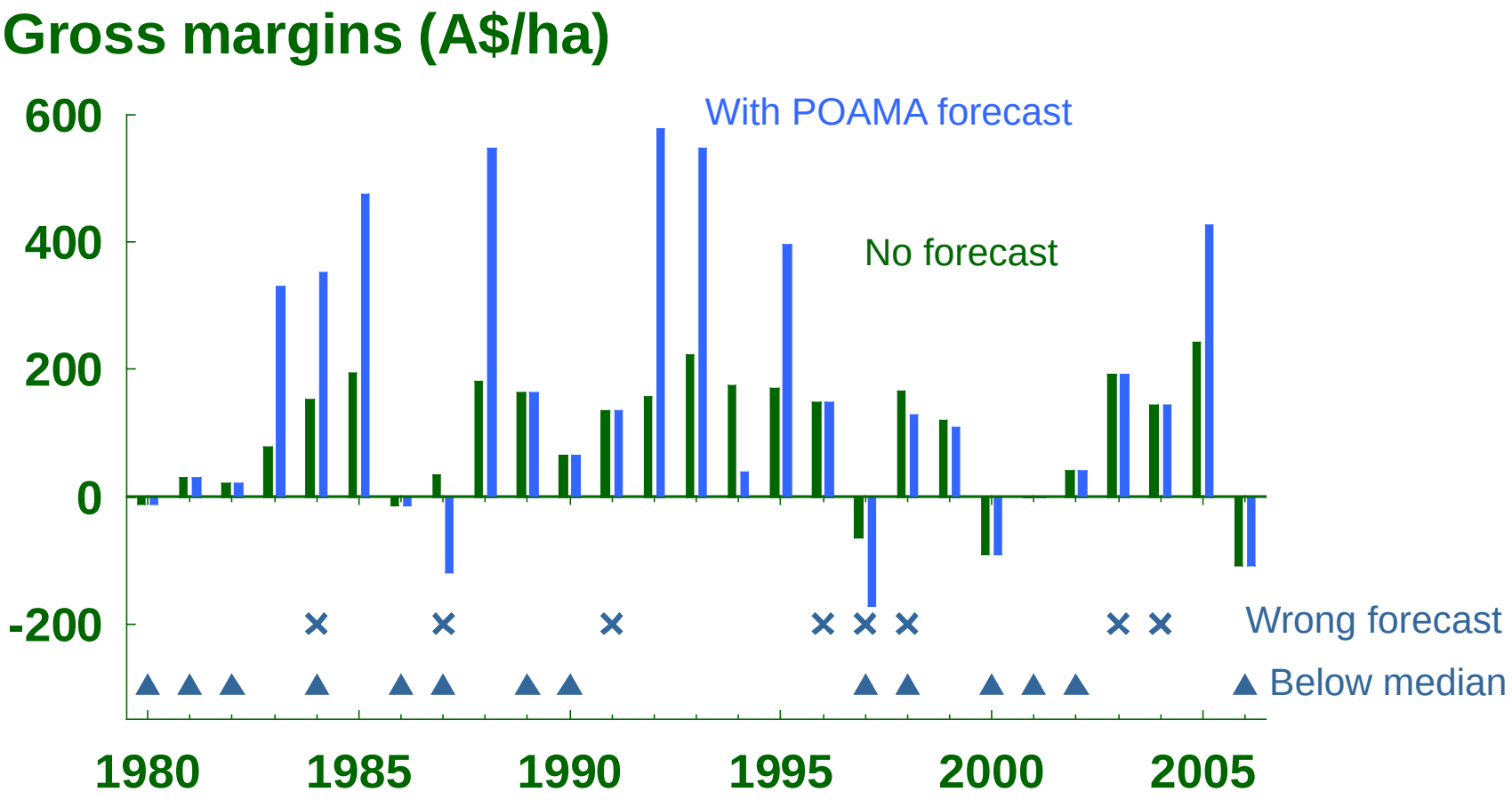
Benefit of POAMA forecast year by year

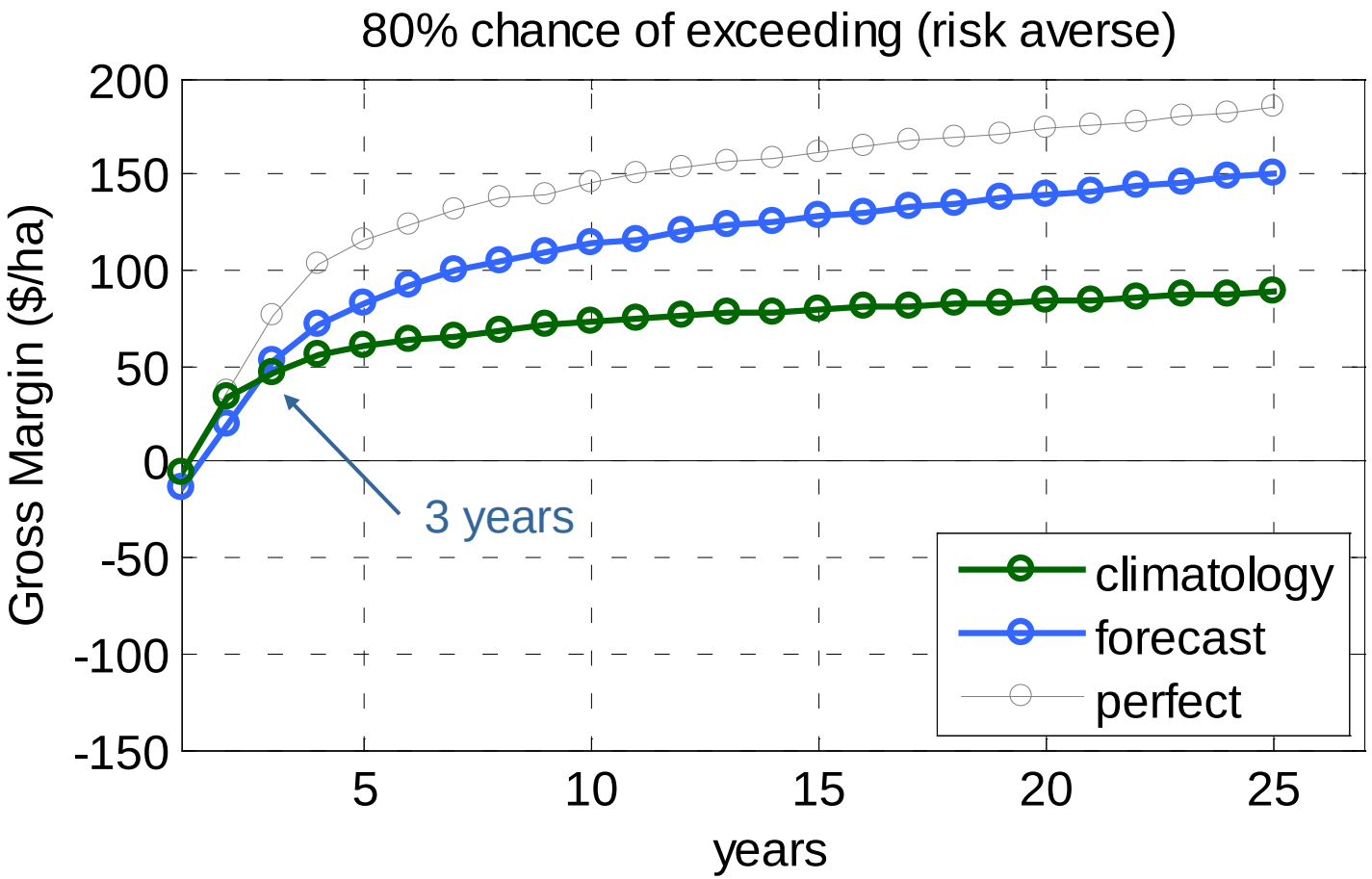


Realistic (risk averse) N application

Peter McIntosh and Senthold Asseng

Australian Government
Bureau of Meteorology
CSIRO

How long for a forecast to pay off?

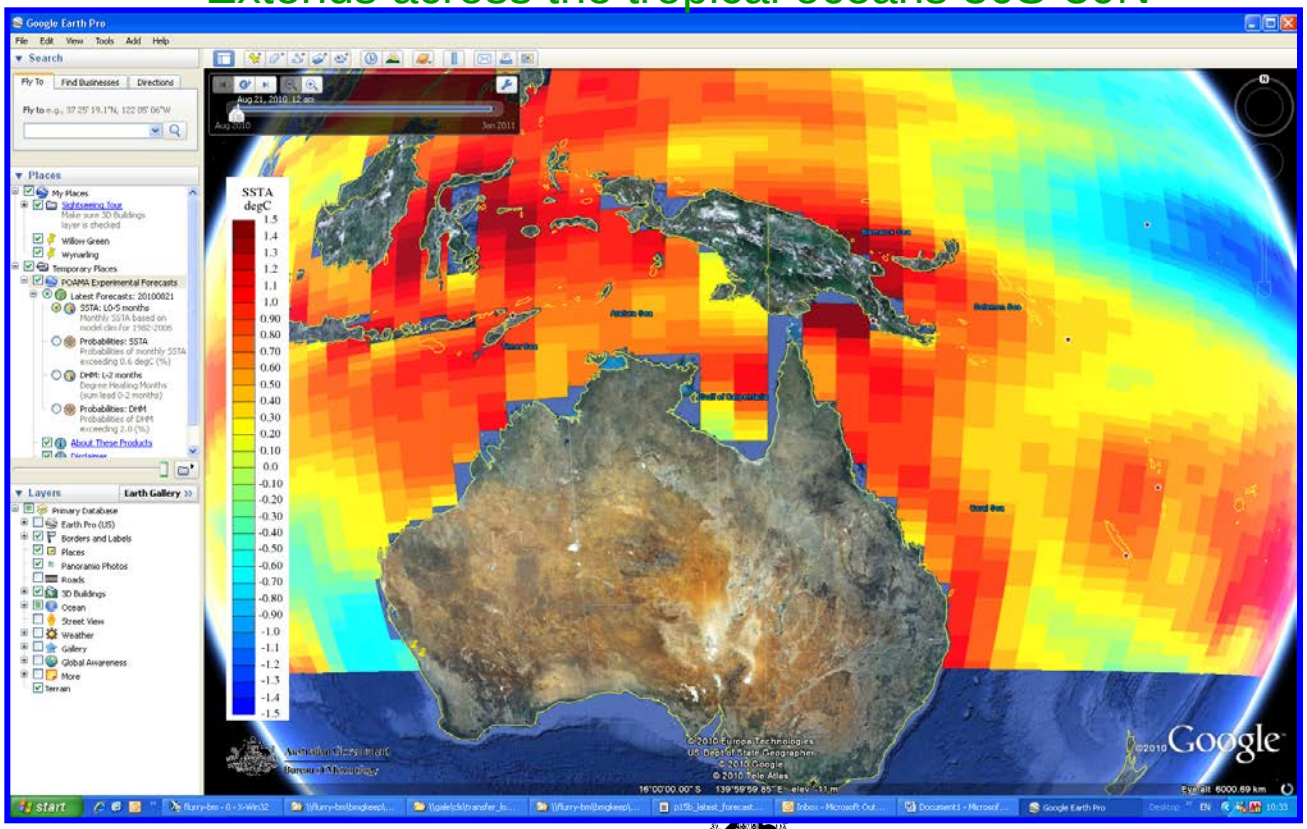


The Lesson: A farmer is 80% sure of making more money after just 3 years of using the POAMA forecast at Nyabing.

Marine applications

Tropics Reef SST Forecasts

- Real-time forecasts available in Google Earth
- SSTA, thermal stress & probability forecasts
- Extends across the tropical oceans 30S-30N



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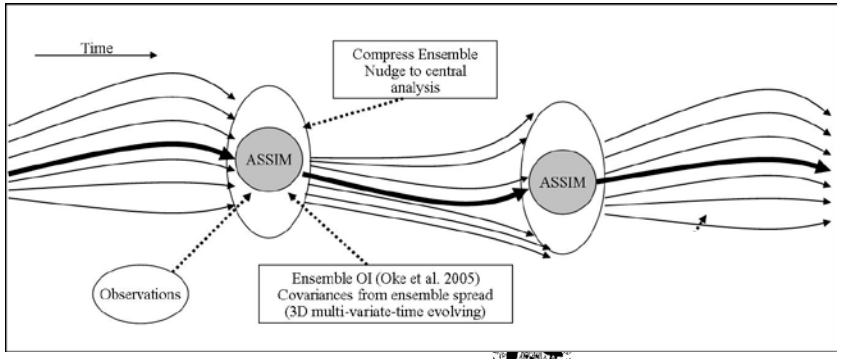
POAMA-3/ACCESS

Model Features

- Based on the New ACCESS coupled model (UKMO UM + MOM + CABLE)
- Resolution tbd between N96 and N216, L~38-80, depending on supercomputing
- Preliminary version in 2012 with limited hind-casts (N96L38, simple initialisation (SST nudging)

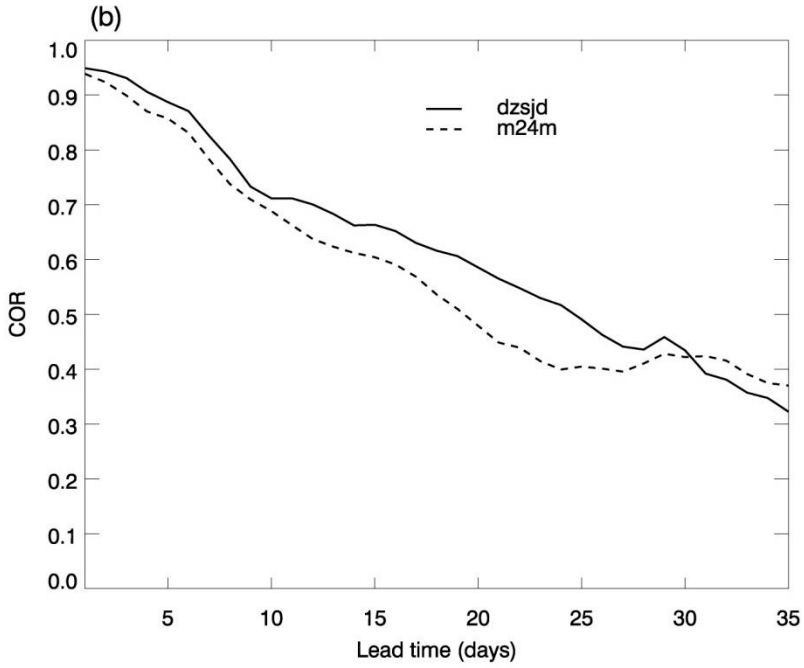
Initialisation Features

- Full coupled initialisation (coupled PEODAS) with cross-covariances and implicit breeding



ACCESS Trial Multi-week Results

MJO Skill (index correlation)



Trial hind-casts with ACCESS

Solid – ACCESS (atmosphere only)

Dash – POAMA-2M

Once full POAMA initialisation system is implemented seasonal hind-casts will be evaluated

Significant increase in supercomputing resources on the NCI from 2013

Summary

- POAMA-2P Significant improvement due to Ocean Assimilation and Pseudo Multi-model
- POAMA-2M significant improvement due to ensemble generation, especially reliability
- Forecasts have been demonstrated to be useful for various applications
- Future: Seamless products, including extremes
- Future: Focus on new model and coupled assimilation/ensemble gen