Pacific Climate Change Science

Seasonal Prediction of Sea-Level Anomalies in the Western Pacific

Elaine Miles[1], Claire Spillman[1], John Church[2] & Peter McIntosh[2]

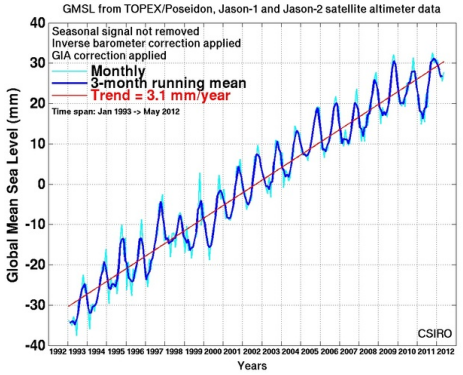
[1] Centre for Australian Weather and Climate Research, Bureau of Meteorology, Australia
[2] CSIRO Marine and Atmospheric Research, Australia

ICTP-Trieste, November 13th 2012

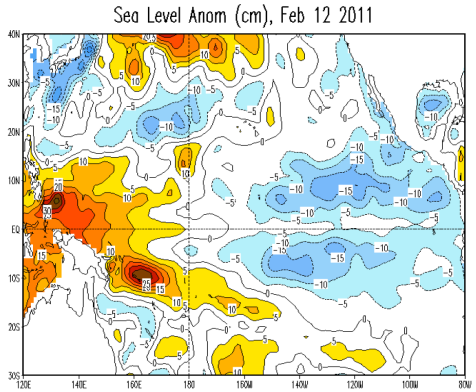
Pacific-Australia Climate Change Science and Adaptation Planning Program

Australian Government

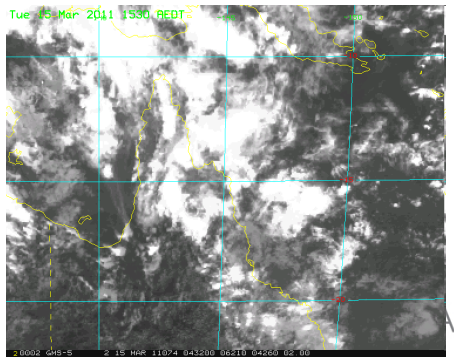
Sea level extremes



Seasonal variability + Global SL rise



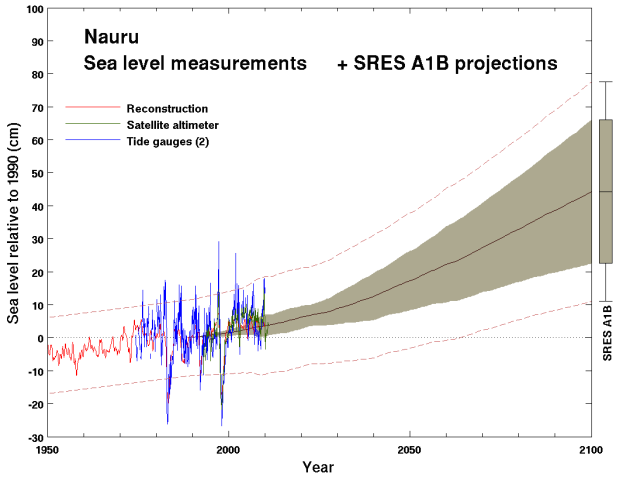
Regional variability



Weather + Tides

Tuvalu

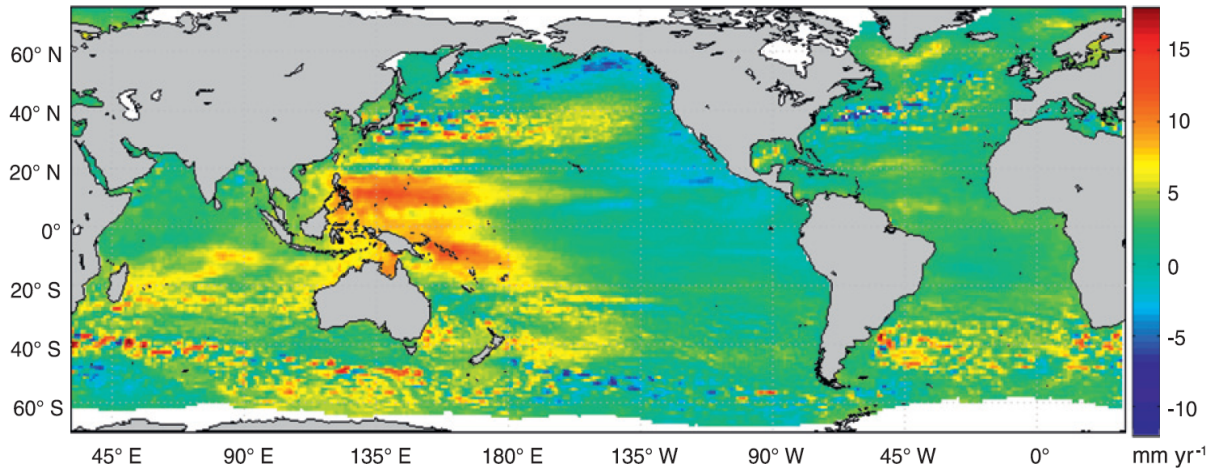
Fiji



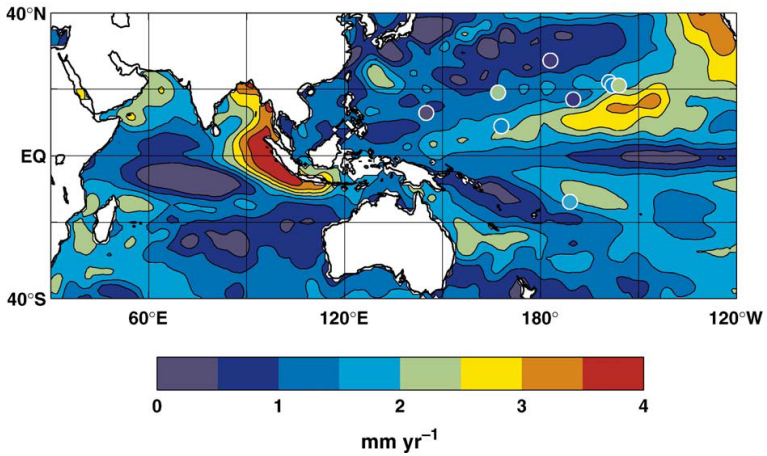
The future under climate change…

Australian Government

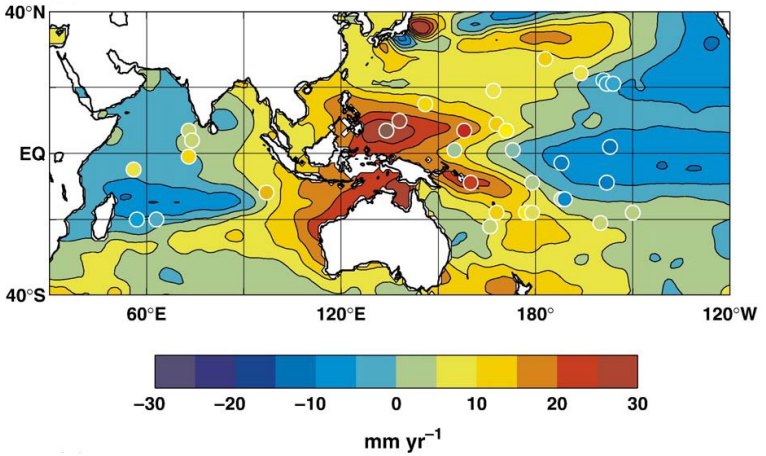
Regional changes to trends



Linear trend in satellite altimetry SSH for period 1993-2009 AVISO. Merrifield (2011)



1950-2001



1993-2001

Map of sea-level trends from reconstruction. Trends from the longer tide-gauge records are shown by the coloured dots. Church et al, (2006)

Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP)

- Small islands around the world are facing serious and immediate challenges from climate change.
- Many people living in the Pacific islands and East Timor report their climate is changing. Climate variability and change present challenges for economic activities, such as agriculture and tourism, as well as individual livelihoods and ecosystems.
- Despite widespread international awareness of the impacts of climate change in this region there is only very limited specific scientific information available to these countries. Better scientific knowledge is urgently needed to adapt and plan for the future.
- To help fill this gap by examining past climate trends and variability and providing regional and national climate projections and predictions.
- To actively engage with 15 partner countries and regional stakeholders to build their capacity to effectively apply the results and to build the climate science knowledge base.

Pacific partner countries

Cook Islands
East Timor
Federated States of Micronesia
Fiji
Kiribati
Niue
Palau
Papua New Guinea
Republic of Marshall Islands
Republic of Nauru
Samoa
Solomon Islands
Tonga
Tuvalu
Vanuatu

Seasonal prediction of SLA project: Key benefits and deliverables

- Create strong science base for understanding seasonal sea level variability and predictability.
- Development of experimental dynamical forecasts for sea level.
- Opportunities for better coastal zone management and thus enhanced resilience under climate change.
- Improved community & stakeholder awareness of how climate influences the coastal zone.
- A report on the assessment of the skill of seasonal predictions of sea level anomalies (SLA) for the Western Pacific region at lead times up to seven months.
- A suite of experimental regionally relevant, seasonal forecast products for SLA.
- A plan for the further development of sea-level prediction (including a pathway to experimental products and their use in risk assessment).

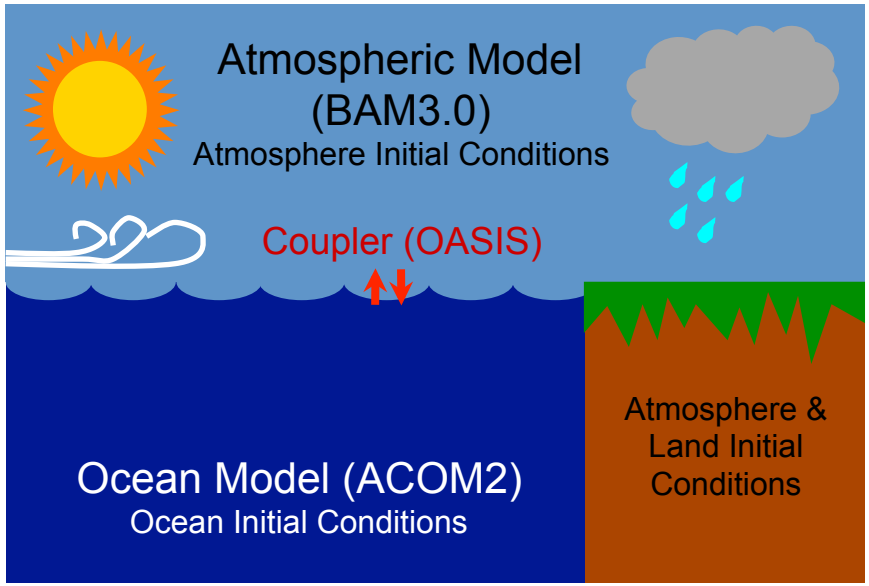
http://news.com.au

Filling in the gaps

Minutes Days **Seasonal** Annual Decadal Centuries

Variety	Periodic Source	Operating time scale	Global Vertical Effect (cm)	Local Vertical Effect (cm)
Meteorological and oceanographic processes	Inverted Barometer (IB) effect	Hours to months	To be established	7 (Ponte 2006)
	El Niño/southern oscillation	6 months every 5–10 years	0.5-2 (Boening et al. 2012; Chen et al. 1998)	20-30 (Becker et al. 2012)
	Water Vapour	6 months	0.2 (Landerer et al. 2008)	To be established
Seasonal Variations	Seasonal water steric changes (temperature and salinity)	6 months	0.37 (Willis et al. 2008)	To be established
	Water balance among oceans (mass)	6 months	0.6-0.8 (Chambers et al. 2004; Willis et al. 2008; Lombard et al. 2007)	To be established
Gravity	Seasonal Tide (Sa and Ssa)	6 – 12 months	N/A	0.6-5 (Pugh 1996)

Predictive Ocean Atmosphere Model for Australia (POAMA)



http://poama.bom.gov.au

ATMOSPHERIC MODEL: BAM3.0

- T47 (~250 km grid), 17 vertical levels.
- Simple bucket model for soil moisture with 3 levels for T.

OCEAN MODEL: GFDL MOM2

- 2º zonal, ~ 0.5-1.5º from equator to the poles.
- 25 vertical levels with a maximum depth of 5 km.

COUPLING OF MODELS: OASIS3

LAND-SURFACE AND ATMOSPHERIC IC: ALI

- Realistic atmospheric states created by nudging U, V, T and H generated prior by BAM3.0.

OCEAN IC: PEODAS

- Approximate ensemble Kalman filter system.
- Generates analyses and analysis increments for T, S and currents daily.
- Yields an ensemble of initial states, including a central unperturbed ocean analysis.
- Assimilates in-situ T and S observations from CTD, XBT (T only), TAO/TRITON/PIRATA, Reynolds and Argo profiles.

MULTI-MODEL MODE

- 3 different model configurations, each with 11 ensemble members.
- Coupled atmosphere-ocean perturbations produced by a coupled breeding scheme.
- Perturbations generated using the coupled ocean-atmosphere model with the first model configuration.

Sea surface height in POAMA – MOM2

- Rigid Lid i.e. Volume is conserved.
- Volume transfers are calculated from the horizontal forces from temperature, salinity and current gradients.
- Sea surface height is calculated from the amount of force this extra volume puts onto the lid.
- No Glacial Isostatic Adjustment correction (GIA).
- No height from atmospheric pressure – Inverted Barometer effect (IB).
- No global trend (GT).

Method

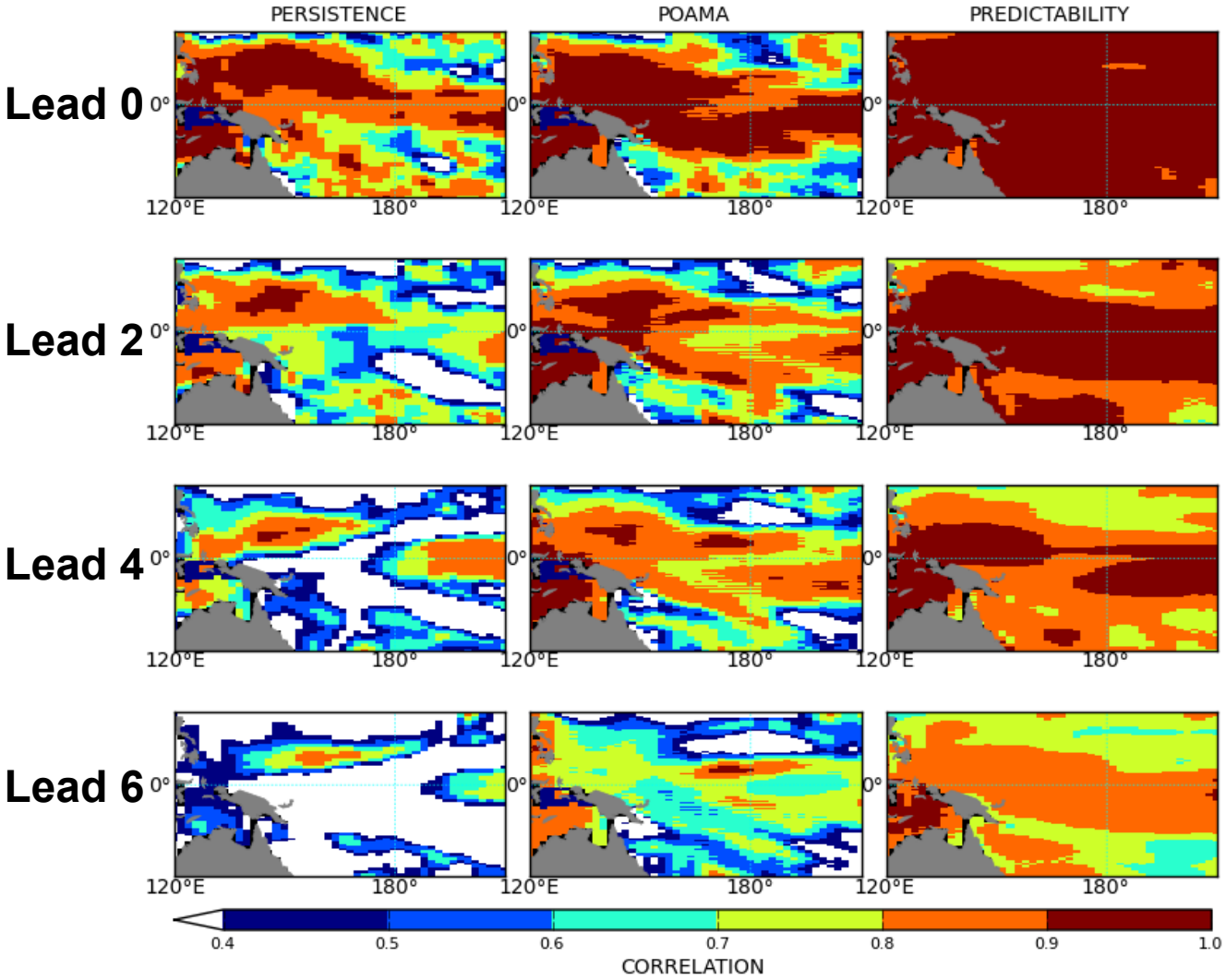
Evaluate skill of POAMA, a **DYNAMICAL MULTI-MODEL-ENSEMBLE SEASONAL PREDICITION SYSTEM**, to model seasonal SLA using…

- POAMA hindcasts, Jan 1981 – Dec 2010
- Altimeter record with GIA, GT and IB removed (Church et al. 2004, (CSIRO), Jan 1993 – Present
- Tide gauges, (available period site dependent)

Investigating…

- Phase
- Variability
- Teleconnections
- Extreme events

Model skill – DEC JAN FEB

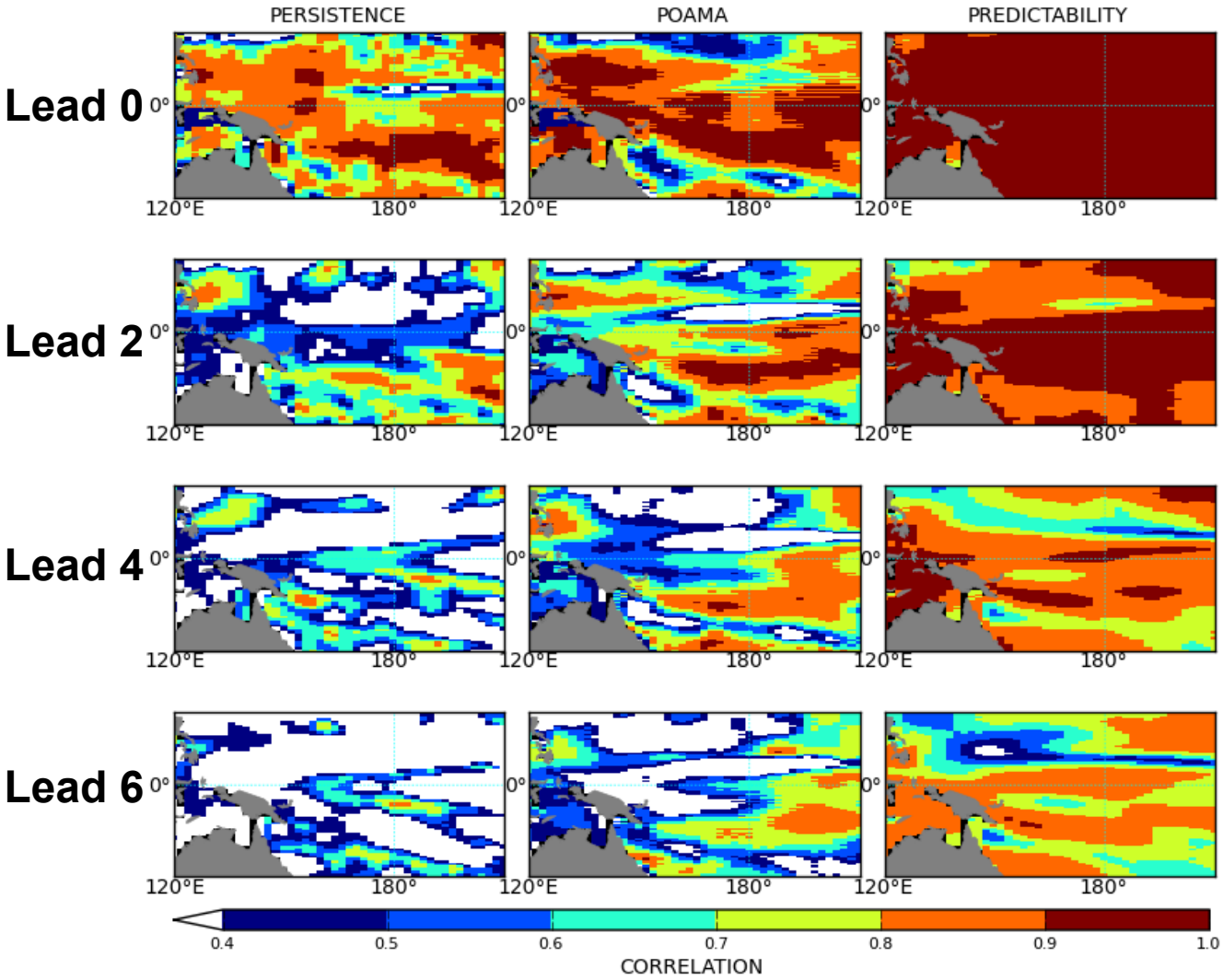


Correlations of seasonal forecasts for SLA for target season DEC JAN FEB from 1993 - 2010 for (a) persistence, (b) POAMA and (c) model predictability against altimeter for 0 to 6 months lead-times. Significant correlations are shaded (|r| > 0.400 is significant at the 90% confidence level; t-test, n = 17).

- **High skill in West and East equatorial Pacific.**

Miles, Spillman, Church, McIntosh (2012) *in prep*

Model skill – JUN JUL AUG

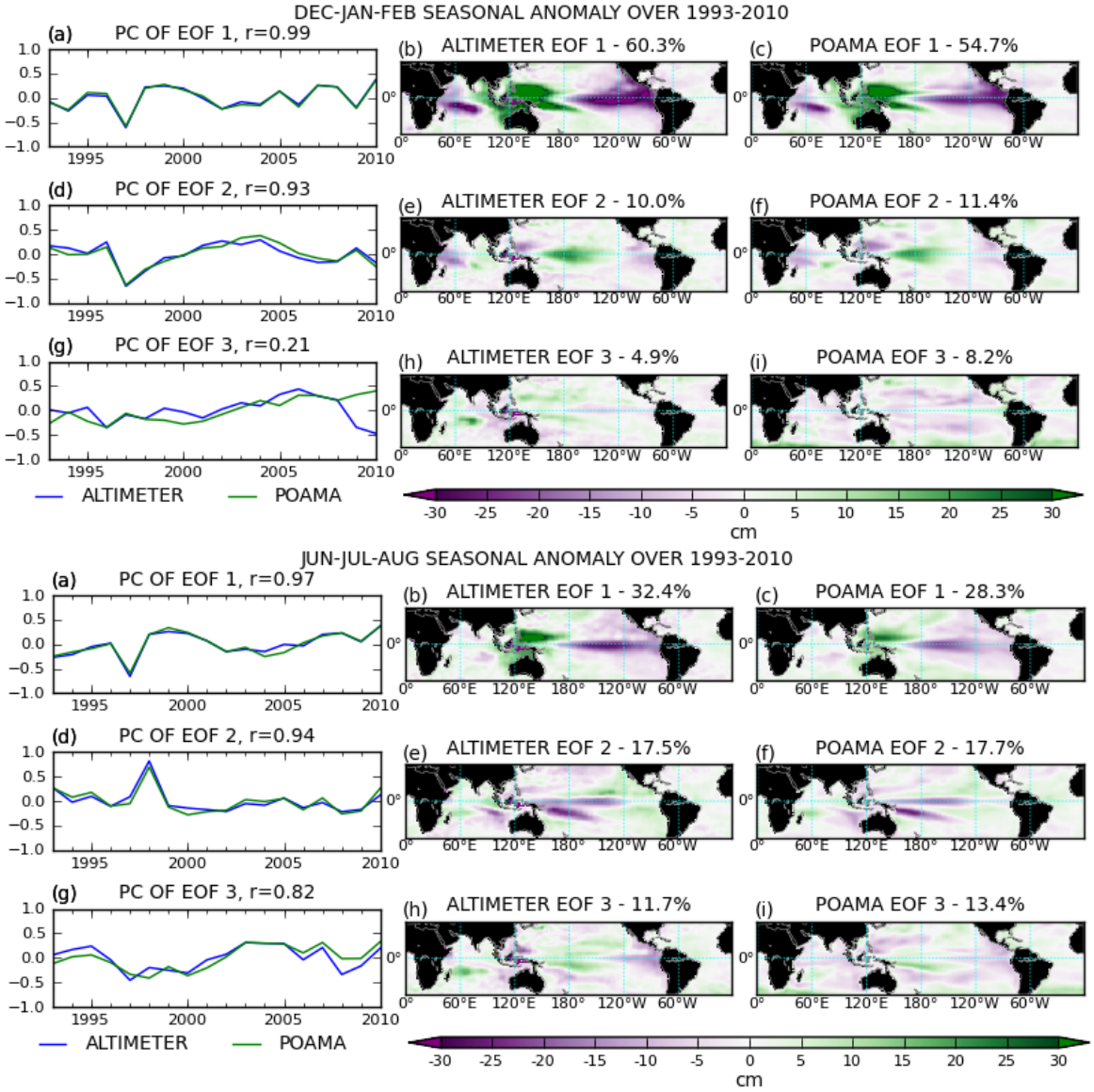


Correlations of seasonal forecasts for SLA for target season JUN JUL AUG from 1993 - 2010 for (a) persistence, (b) POAMA and (c) model predictability against altimeter for 0 to 6 months lead-times. Significant correlations are shaded (|r| > 0.400 is significant at the 90% confidence level; t-test, n = 17).

- **Lower skill compared to DJF.**
- **High skill central Pacific.**

Miles, Spillman, Church, McIntosh (2012) *in prep*

EOF Analysis



- **During DJF EOF 1 is dominated by ENSO pattern.**
- **This pattern is balanced by reloading pattern in JJA.**

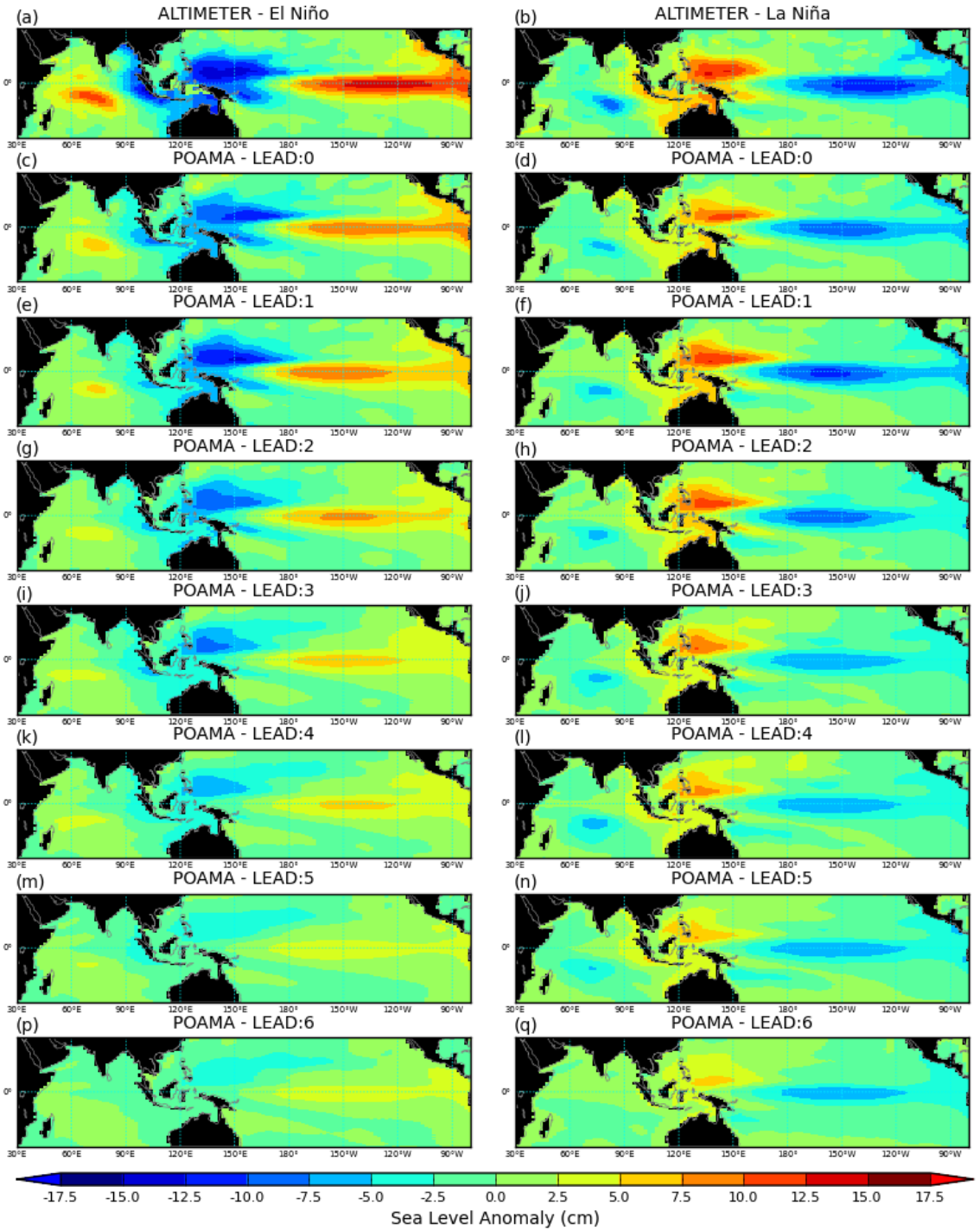
Miles, Spillman, Church, McIntosh (2012) *in prep*

ENSO events

El Niño	La Niña
1994.11-95.01	1995.10-95.12
1997.10-97.12	1998.11-99.01
2002.10-02.12	1999.11-01.01
2006.10-06.12	2007.10-07.12
2009.11-10.01	2010.10-10.12

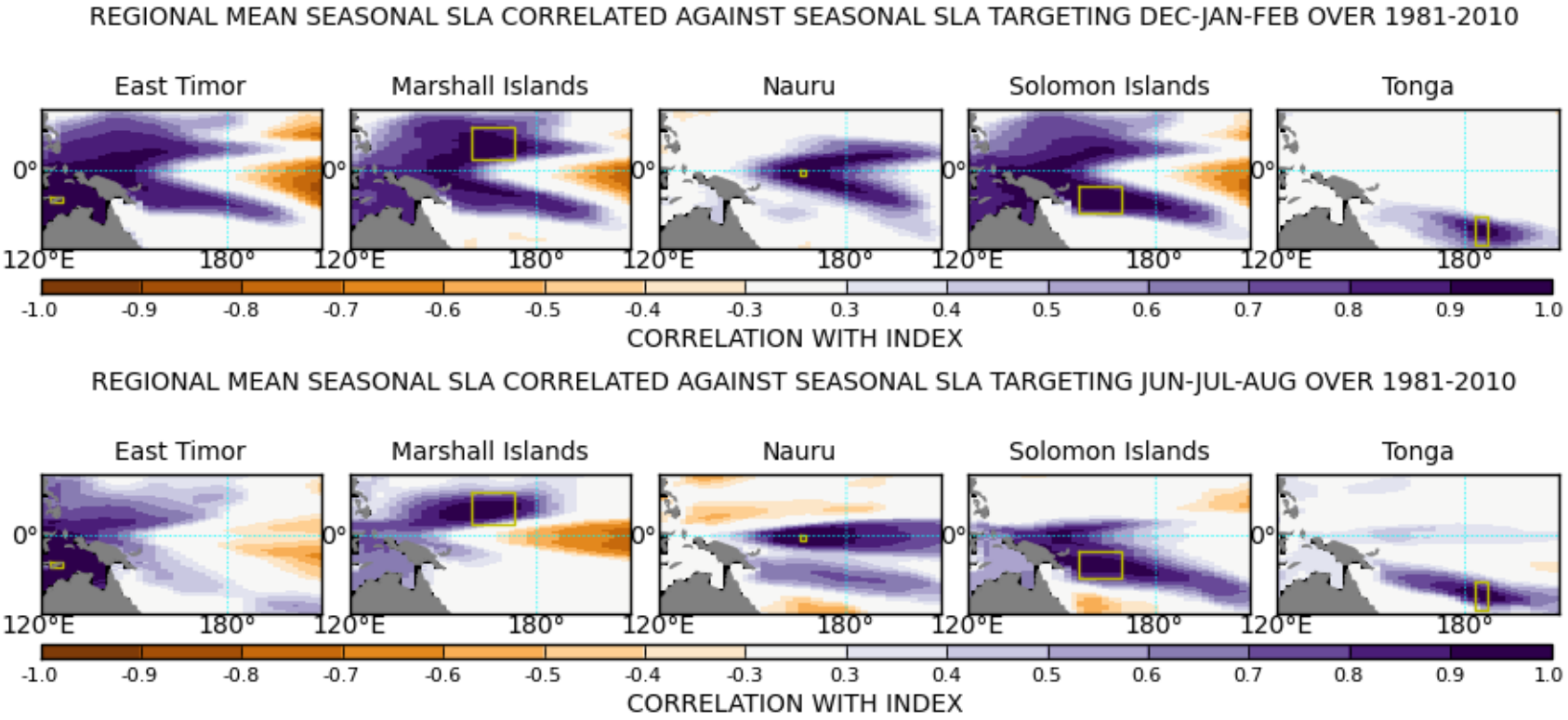
Composites of seasonal SLA for the mature phases of El Niño and La Niña. Five El Niño and La Niña events between the years 1993-2010 are used.

- **POAMA ENSO pattern shifted and dampened compared to reanalysis.**
- **SLA shows dipole in Indian Ocean not seen in SSTA.**



Miles, Spillman, Church, McIntosh (2012) *in prep*

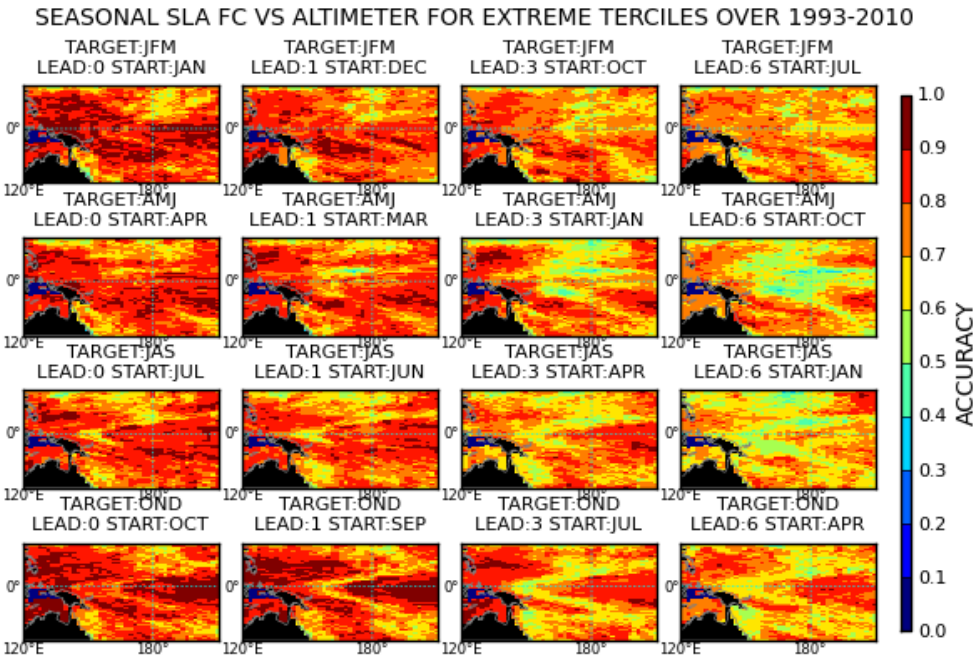
Country indexes

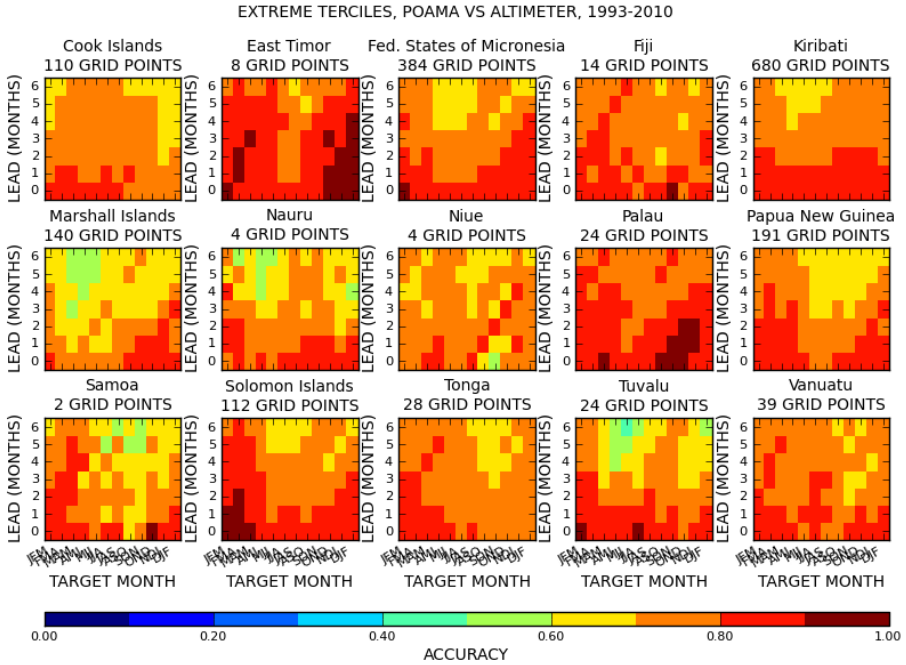


- **Strongest connections occur during ENSO season.**
- **East Timor is similar to NW pacific islands e.g. Palau.**
- **Southern islands have lowest teleconnection to other countries.**

Miles, Spillman, Church, McIntosh (2012) *in prep*

Extreme Tercile Events - Accuracy



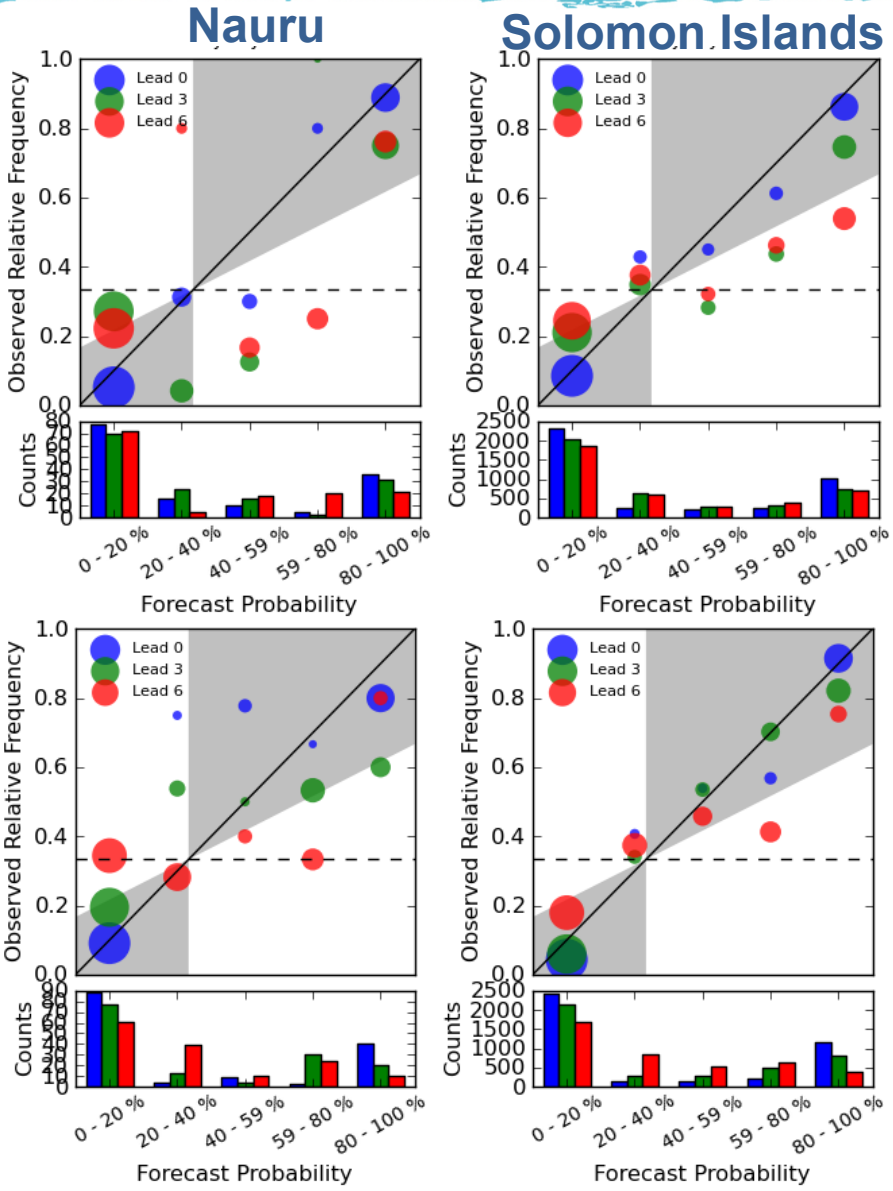


	FC Yes	FC No
Obs Yes	Hit	Miss
Obs No	False Alarm	Correct Negative

$$ACC = \frac{Hits + CorrectNegatives}{Total}$$

- **High accuracy for all countries out to 6 months lead time**

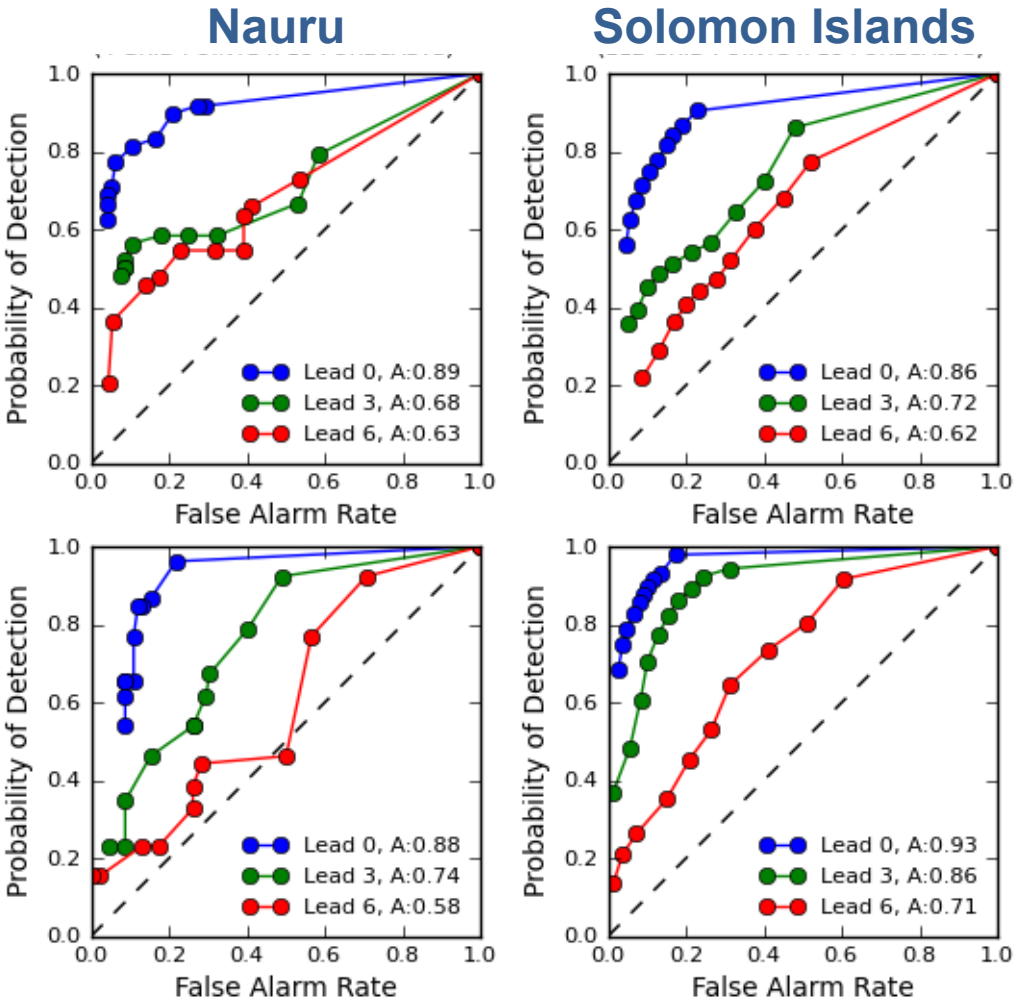
Extreme Tercile Events - Reliability



Forecasts are…

- **Very emphatic at short lead-times**
- **Lose resolution/becomes overconfident with lead-time**
- **Fairly reliable**
- **Some regions suffering from low sample number**

Extreme Tercile Events - ROC Plots



- **Good resolution which decreases with lead-time**

Tide gauge stations

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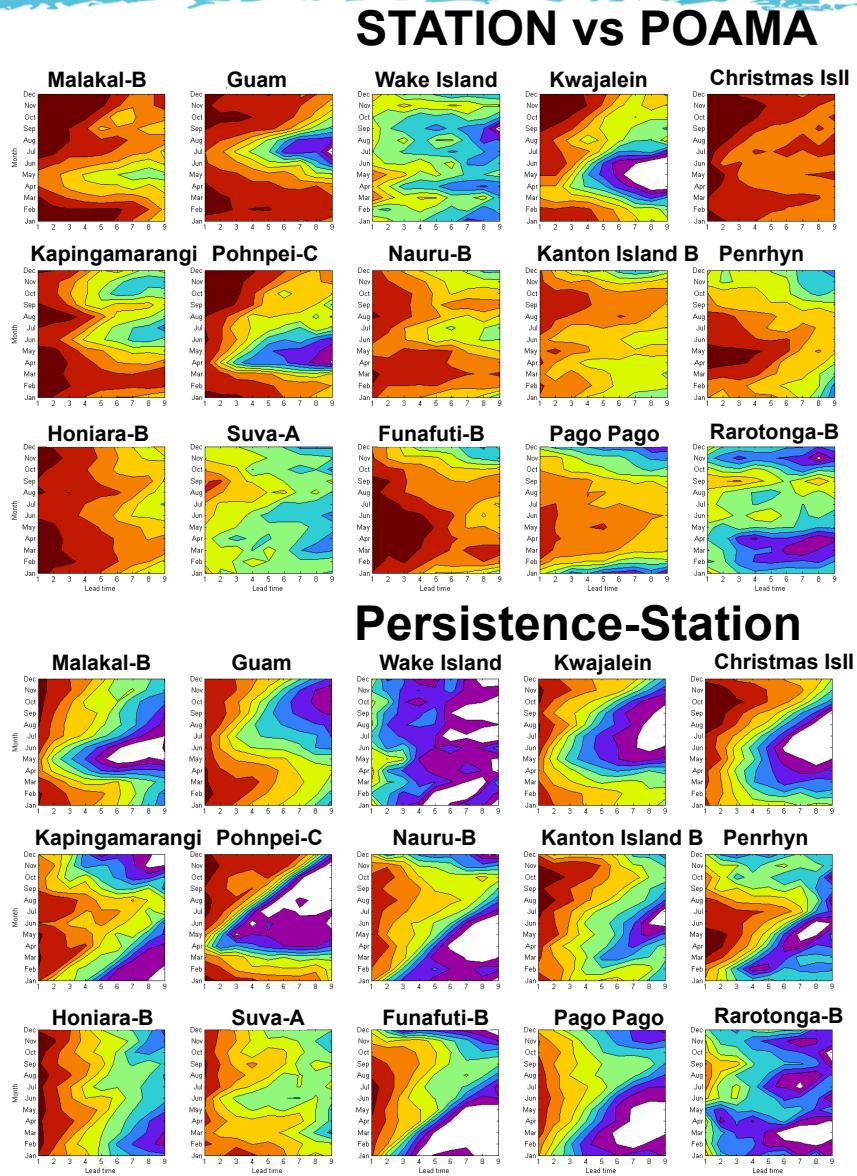
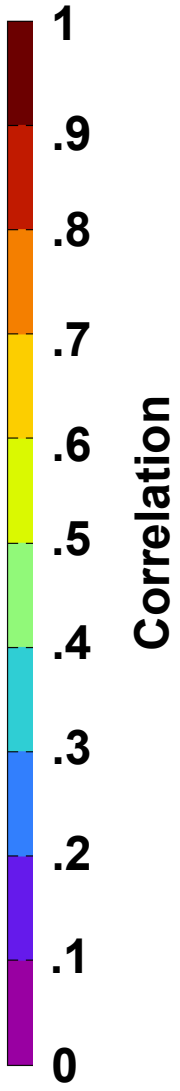
Tide gauges



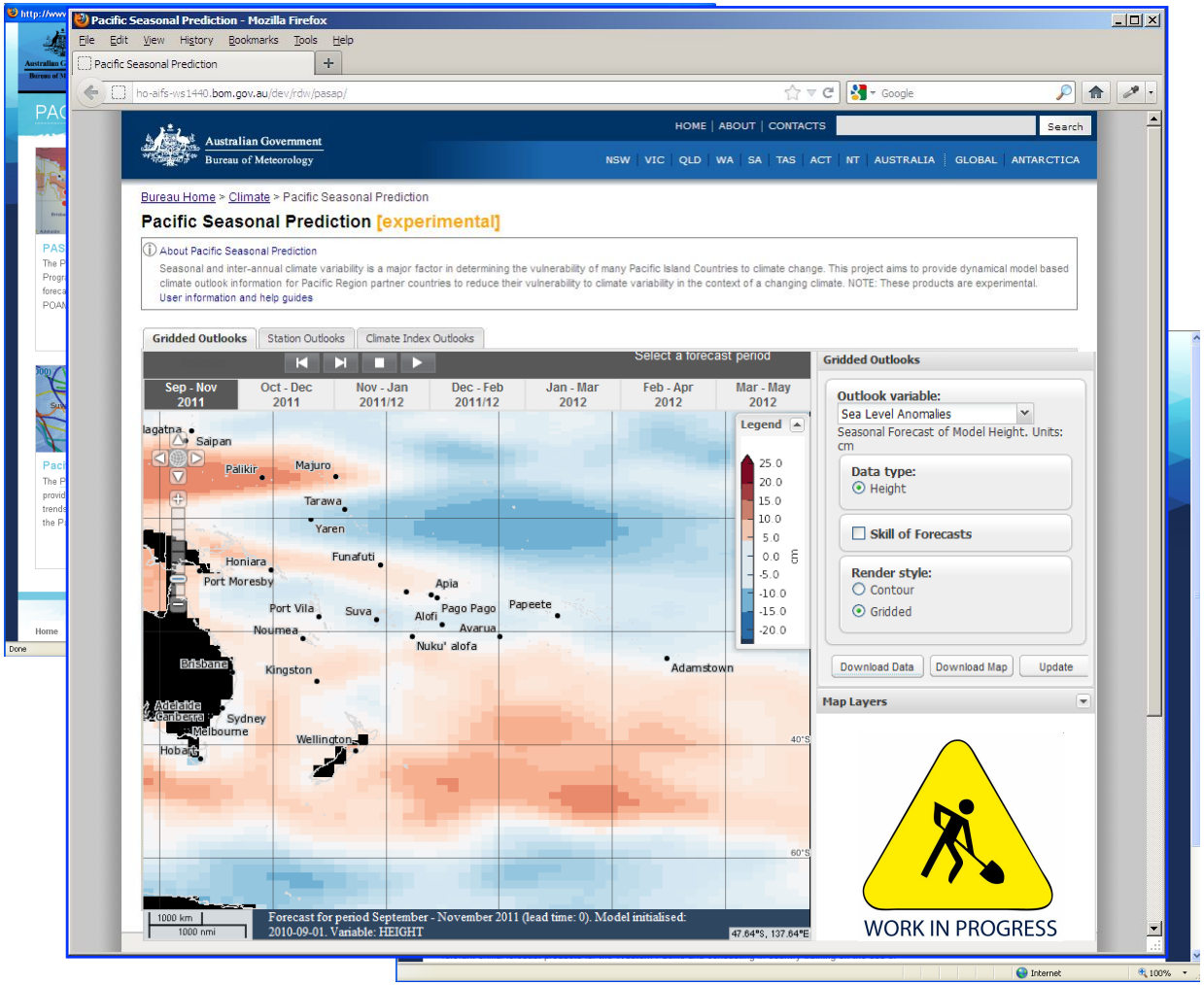


Tide gauges correlated with nearest POAMA grid cell.

- **Seasonal skill viewable around equator.**
- **Persistence beaten in most cases.**
- **Region between ENSO dipoles shows lowest skill.**

McIntosh

Forecast delivery



- Online portal to deliver seasonal sea level forecasts for the Western Pacific under development.
- Potential experimental forecast products:
  - Sea height & anomalies.
  - Probabilities.
  - Country indexes.

http://www.bom.gov.au/climate/pacific/

Summary

- POAMA is capable of forecasting seasonal SLA with high skill out to 7 months in Western Pacific.
- Captures phase, variability, teleconnections and physical processes in Western Pacific.
- Initial studies show good skill with tide gauge stations, beating persistence.
- First dynamical seasonal forecast of SLA (that we are aware of)!
- Online portal early next year.

Thank you

For further information…

Elaine Miles

Email: E.Miles@bom.gov.au
C.Spillman@bom.gov.au
John.Church@csiro.au
Peter.McIntosh@csiro.au

Phone: +61 (0) 3 96694582

http://www.bom.gov.au/climate/pacific/
http://poama.bom.gov.au

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