Impacts of pseudo-coupled data assimilation and ensemble generation on intraseasonal forecast skill

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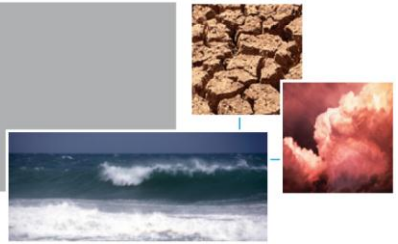
23 October 2012

Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

CSIRO

Outline



Background

- Developing intraseasonal forecasting capability
- The POAMA modelling system

Coupled ensemble generation scheme

- The CEI scheme
- Impact on forecast skill

Preliminary version of a coupled ensemble data assimilation system

Summary

Intraseasonal forecasting

Melbourne Forecast

View the current warnings for Victoria

Forecast issued at 5:05 am EDT on Thursday 18 October 2012.

Forecast for the rest of Thursday

Max 21
Dry. High cloud increasing.
Chance of any rain: 10%
Rainfall amount: 0 mm

Melbourne area
Dry. High cloud increasing during the day. Light winds and afternoon bayside sea breezes to 20 km/h.

UV Alert from 9:50 am to 4:20 pm, UV Index predicted to reach 7 [High]

Friday 19 October

Min 13 Max 27
Partly cloudy.

Melbourne area
Partly cloudy. Light winds becoming south to southwesterly 15 to 20 km/h in the late afternoon then becoming light in the evening.

Saturday 20 October

Min 11 Max 23
Mostly sunny.

Melbourne area
Mostly sunny. Winds south to southwesterly and lig

Sunday 21 October

Min 12 Max 18
Shower or two.

Melbourne area
Cloudy. Isolated showers from the morning. Winds southwesterly and light increasing to 20 to 30 km/h morning.

Monday 22 October

Min 10 Max 17
Morning shower or two.

Melbourne area
Partly cloudy. Isolated showers during the morning to southwesterly 20 to 25 km/h turning southerly 15 during the morning.

Tuesday 23 October

Min 8 Max 23
Mostly sunny.

Melbourne area
Mostly sunny. Light winds.

Wednesday 24 October

Min 14 Max 23
A little rain developing.

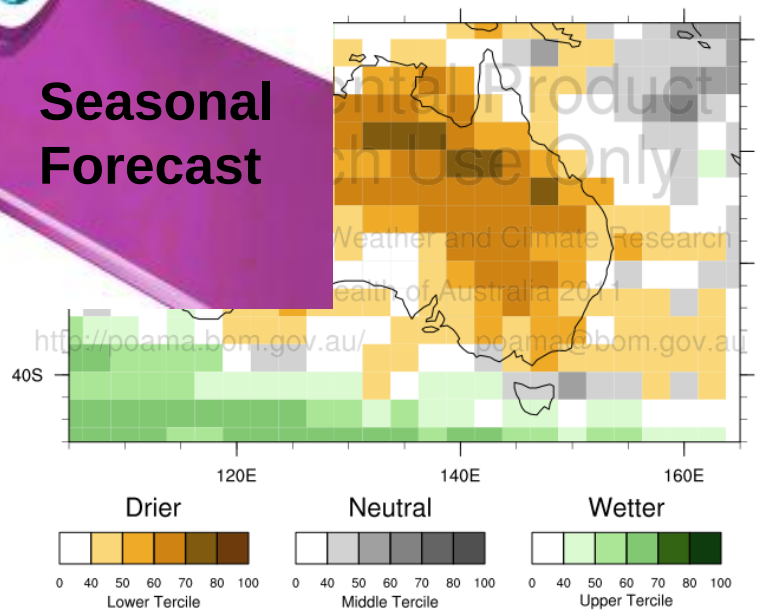
Melbourne area
Cloudy. Patchy rain later in the day. Winds north to and light.

Can POAMA fill the gap?

POAMA forecast: Nov-Dec-Jan

tercile category for Precipitation / Rainfall

Period: First Season - 01/11/2012 to 31/01/2013



Developing an intraseasonal capability

POAMA: **P**redictive **O**cean **A**tmosphere **M**odel for **A**ustralia

POAMA1
2002-2006

Developed for seasonal prediction

Basic ocean/atmos data assimilation

Atmos IC from AMIP (hindcasts)

No ensemble in the hindcasts (one member)

POAMA 1.5b
2007-2011

Basic ocean data assimilation

Developed atmos/land initialization scheme (ALI)

10 member ensemble

POAMA 2
2011-

Sophisticated ocean data assimilation (PEODAS)

Sophisticated ensemble generation

Multi-model

33 member ensemble

NB for intraseasonal prediction:

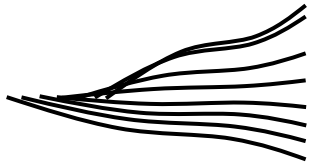
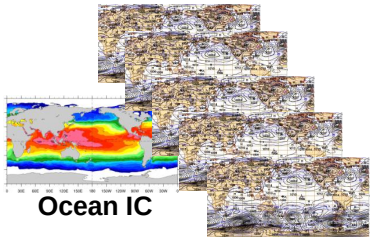
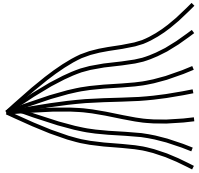
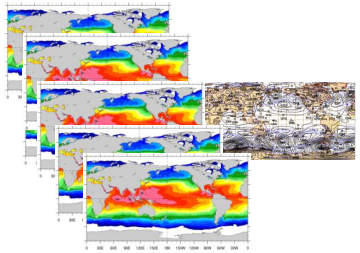
- Realistic atmospheric initial conditions
- Probabilistic forecasts

Intraseasonal forecasting not meaningful

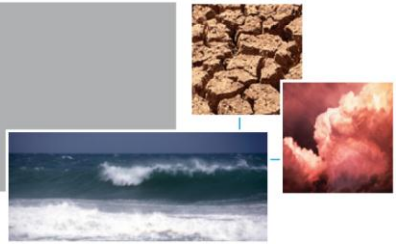
Intraseasonal forecasting investigated

Intraseasonal forecasting capability improved & products developed

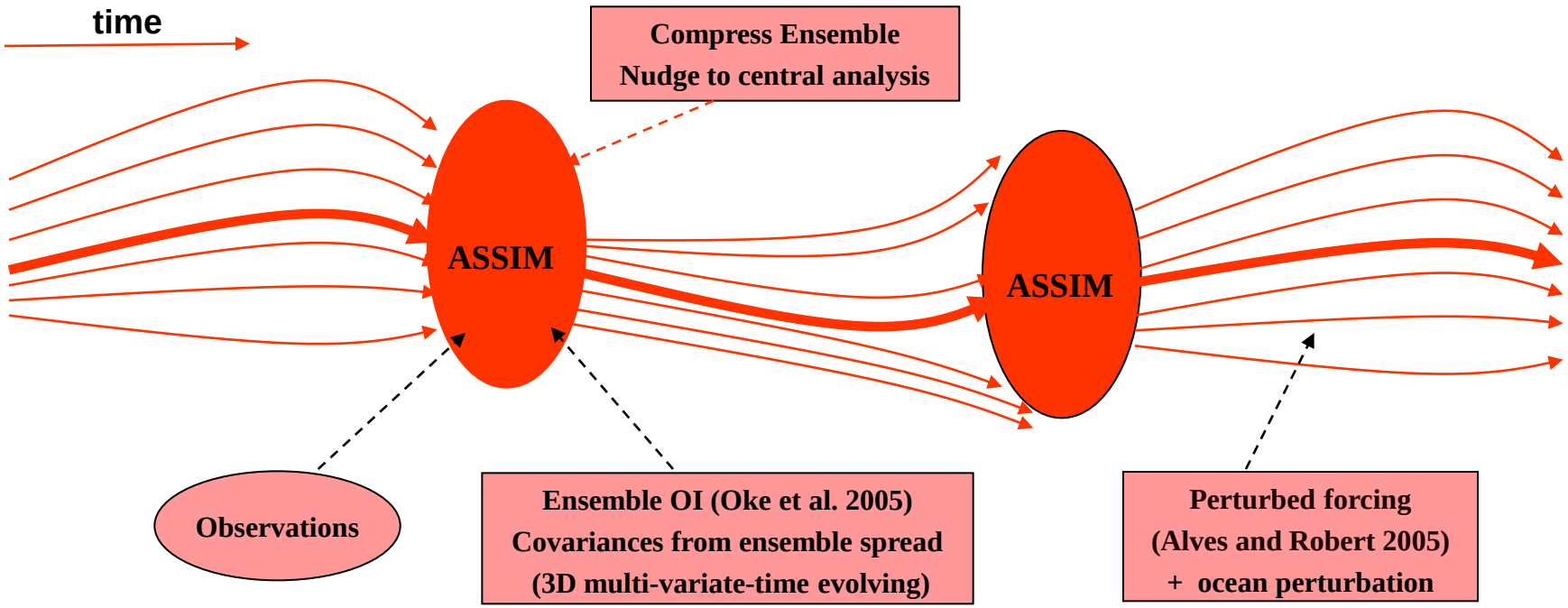
Data assimilation and ensemble generation

	POAMA-1.5	POAMA-2 (seasonal)
Atmosphere data assimilation	ALI (Atmosphere Land Initialisation Scheme)	ALI (Atmosphere Land Initialisation Scheme)
Ocean data assimilation	PODAS (Univariate Smith Optimum Interpolation)	PEODAS (Multivariate pseudo-Ensemble Kalman Filter)
Ensemble generation	10 members Time-lagged atmos. ensemble  No ocean perturbations  Ocean IC Atmos IC	33 members Multi-model (3 versions) No time-lagged ensemble: burst ensemble  Ocean perturbations of initial state (no atmos perturbations) 

PEODAS



POAMA Ensemble Ocean Data Assimilation System used in POAMA-2 (Yin et al. 2011)

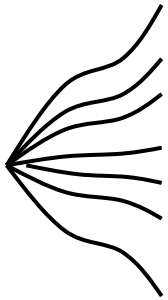


An approximate form of the EnKF so as to be efficient for operational implementation (it is more similar to a ESRF than to an EnKF)

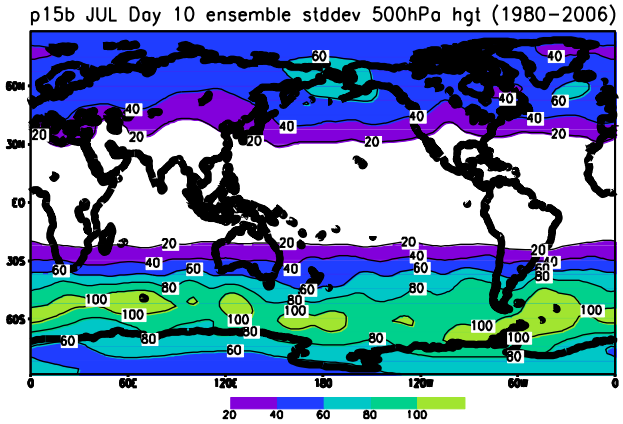
Data assimilation and ensemble generation

Ensemble Spread: 500hPa heights (July)

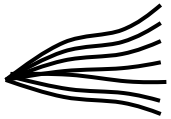
Day 10 of the forecast



POAMA-1.5

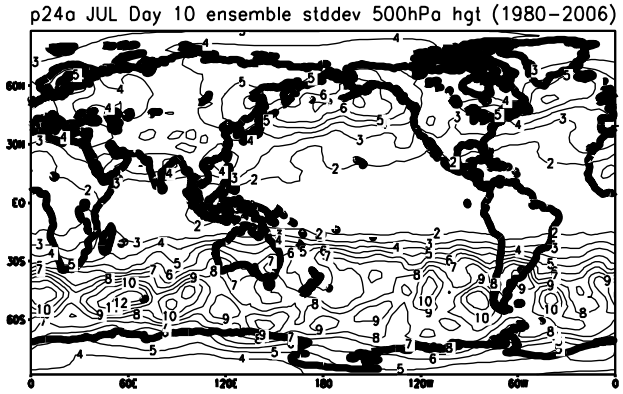


Ensemble from lagged atmospheric initial conditions



POAMA-2

(seasonal)



Ensemble from ocean perturbations only

- Ensemble spread is far too small in the first month of the forecast
- Intraseasonal timescale -- strong sensitivity to both atmospheric and ocean initial conditions

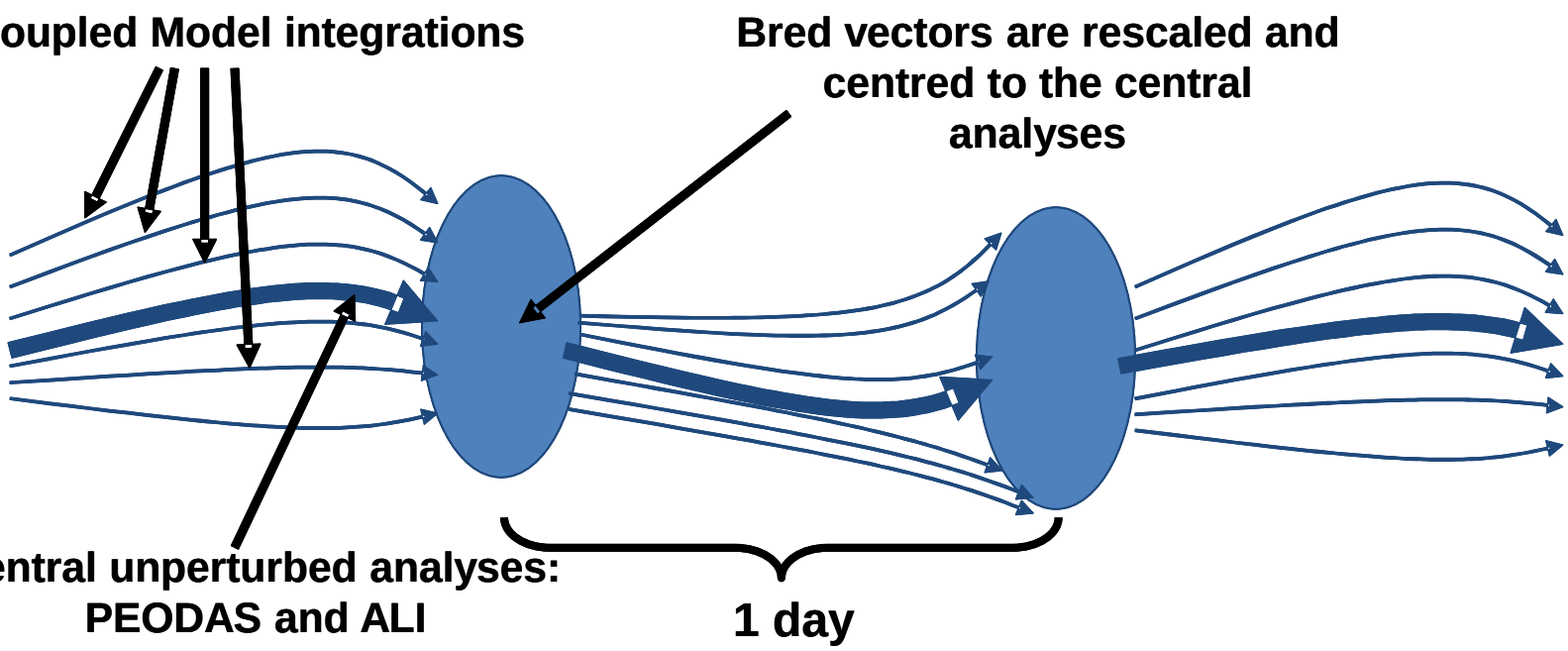
Revise the ensemble generation strategy for intraseasonal system

Coupled model ensemble generation scheme

Towards Coupled Assimilation...

Based on the PEODAS infrastructure

Coupled Ensemble Initialisation System

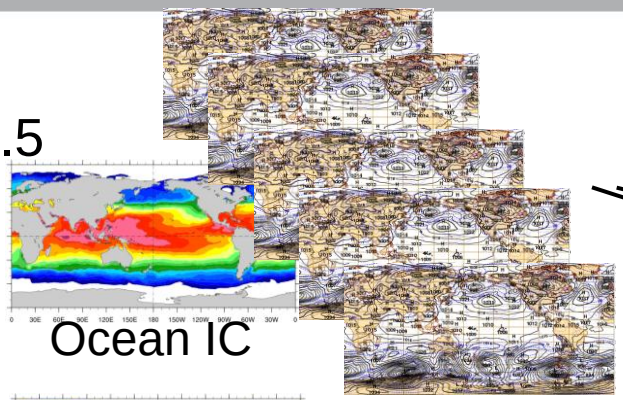


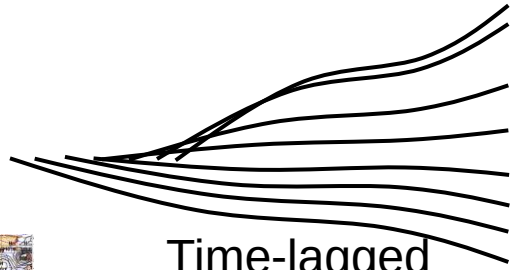
Generates coupled bred perturbations of the atmosphere and ocean based on a breeding method

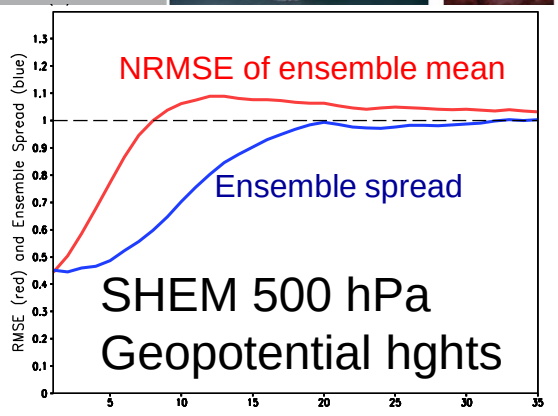
(Yonghong Yin)

Impact of ensemble generation

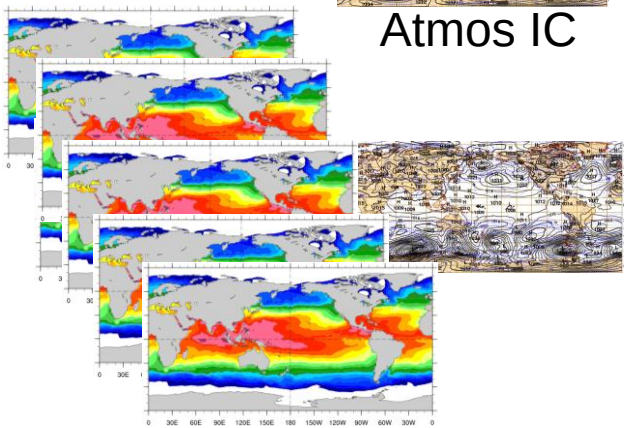
POAMA-1.5

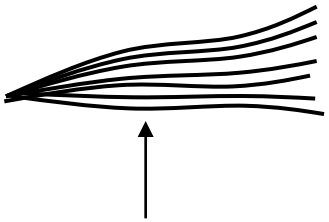


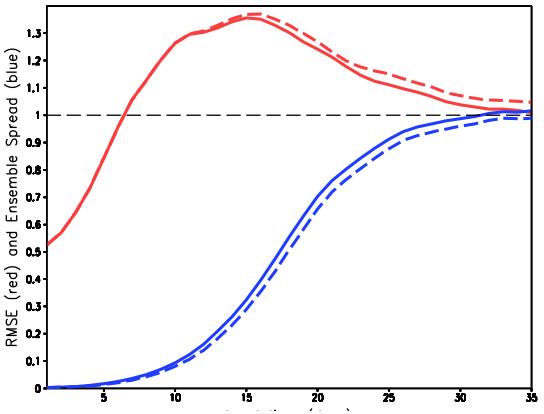




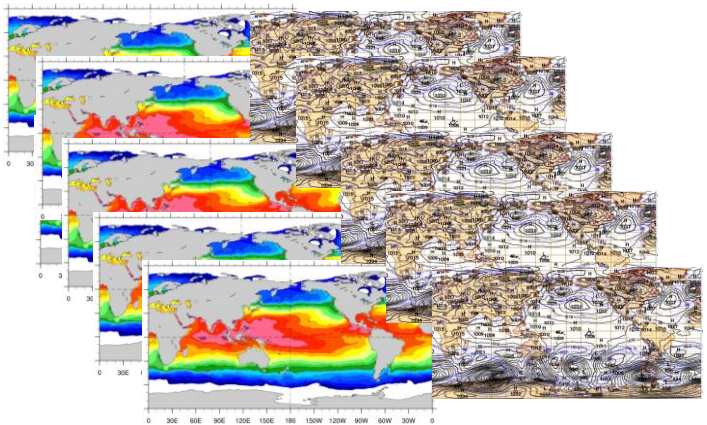
POAMA-2
seasonal

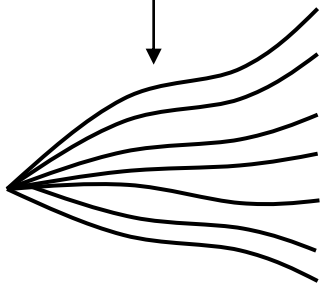


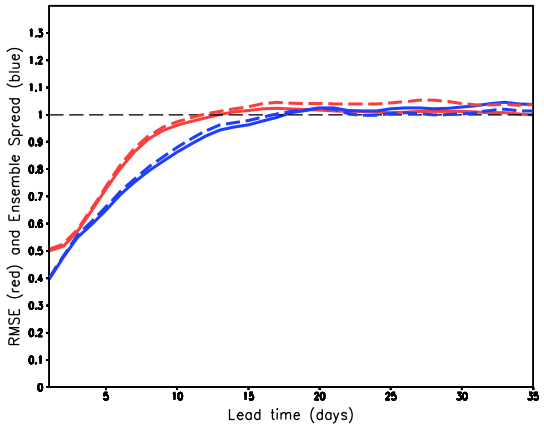




POAMA-2
intraseasonal





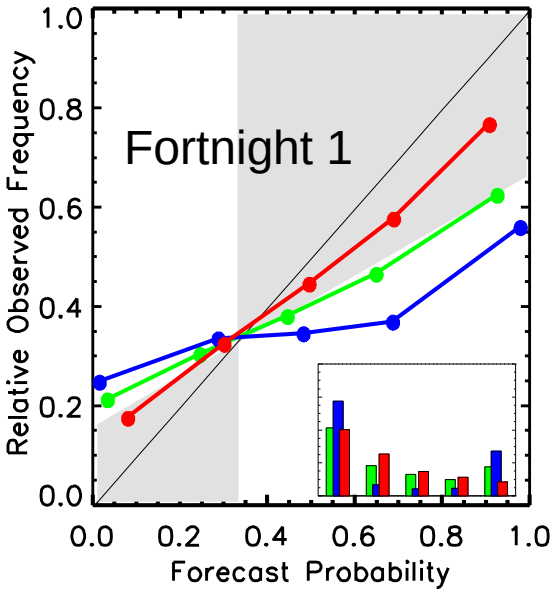


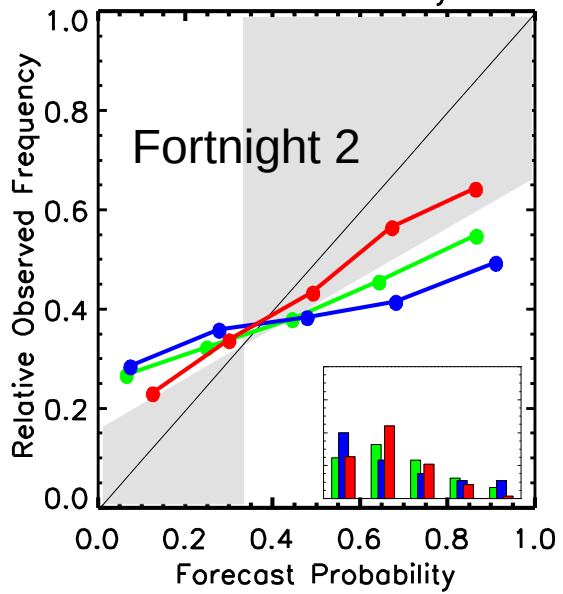
Improved forecast reliability

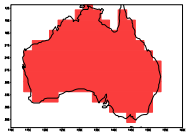
Rainfall and temperature forecasts over Australia are more reliable in the new POAMA-2 intraseasonal system compared to the POAMA-2 seasonal system and the old POAMA-1.5 system

(all forecast start months 1980-2006)

Upper tercile rainfall







POAMA-1.5

POAMA-2 (seas)

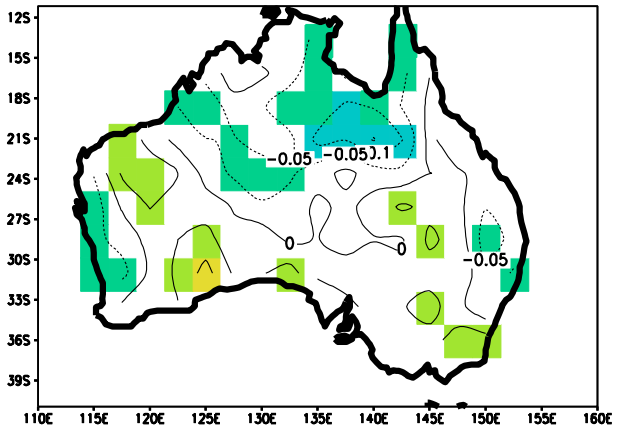
POAMA-2 (intra)

Improved forecast skill

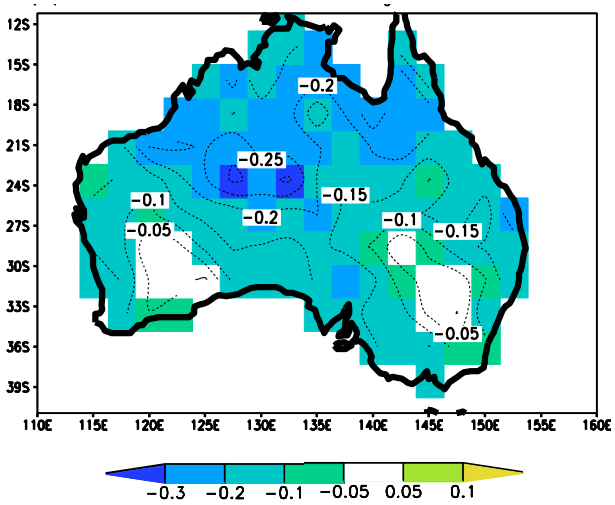
Brier Skill Score: Fortnight 2
Maximum Temperature above the upper tercile

(all forecast start months 1980-2006)

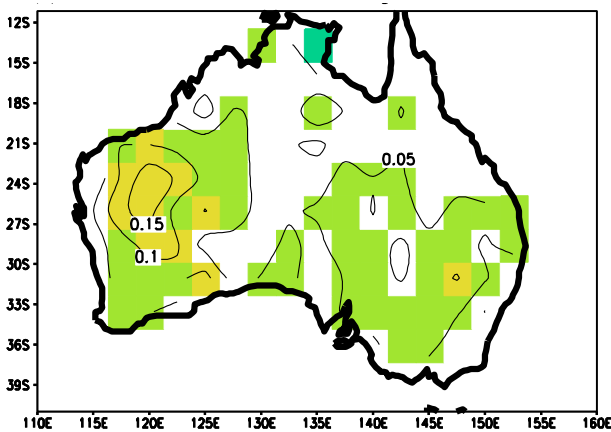
POAMA-1.5



POAMA-2 (seas)



POAMA-2 (intra)

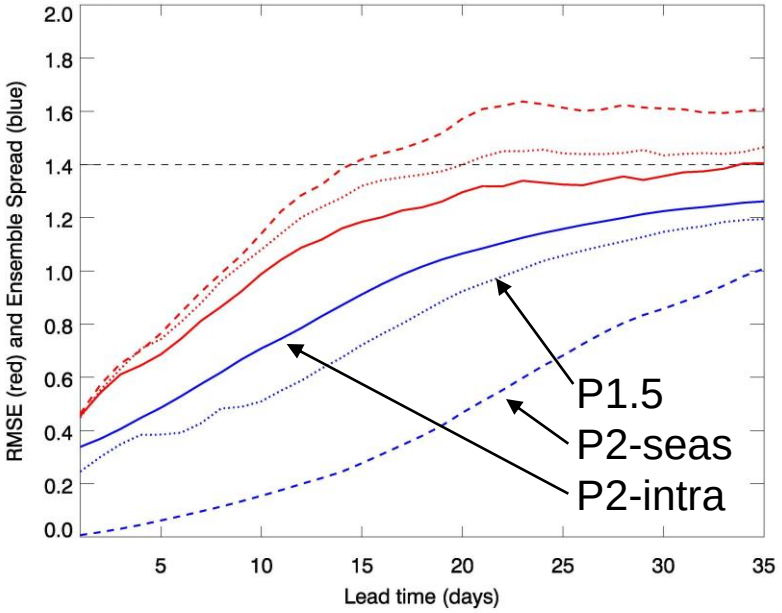


Proportion improvement over a climatological forecast

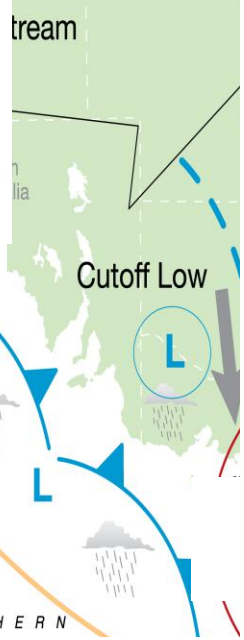
Note: Skill shown for 10-member ensembles and same model formulation

Prediction of key climate drivers

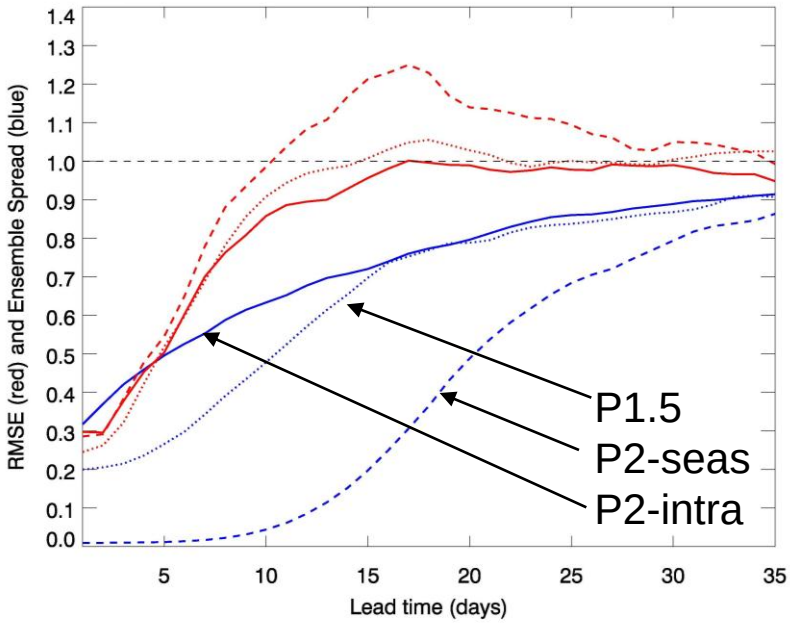
MJO RMM Indices: RMSE & spread



POAMA-2 (intra) skill out to ~3 weeks



SAM index: RMSE & spread



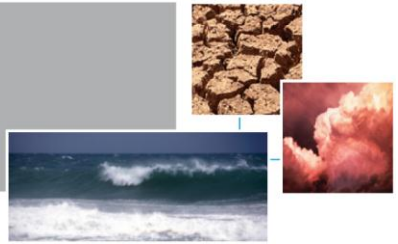
SAM

(Andrew Marshall)

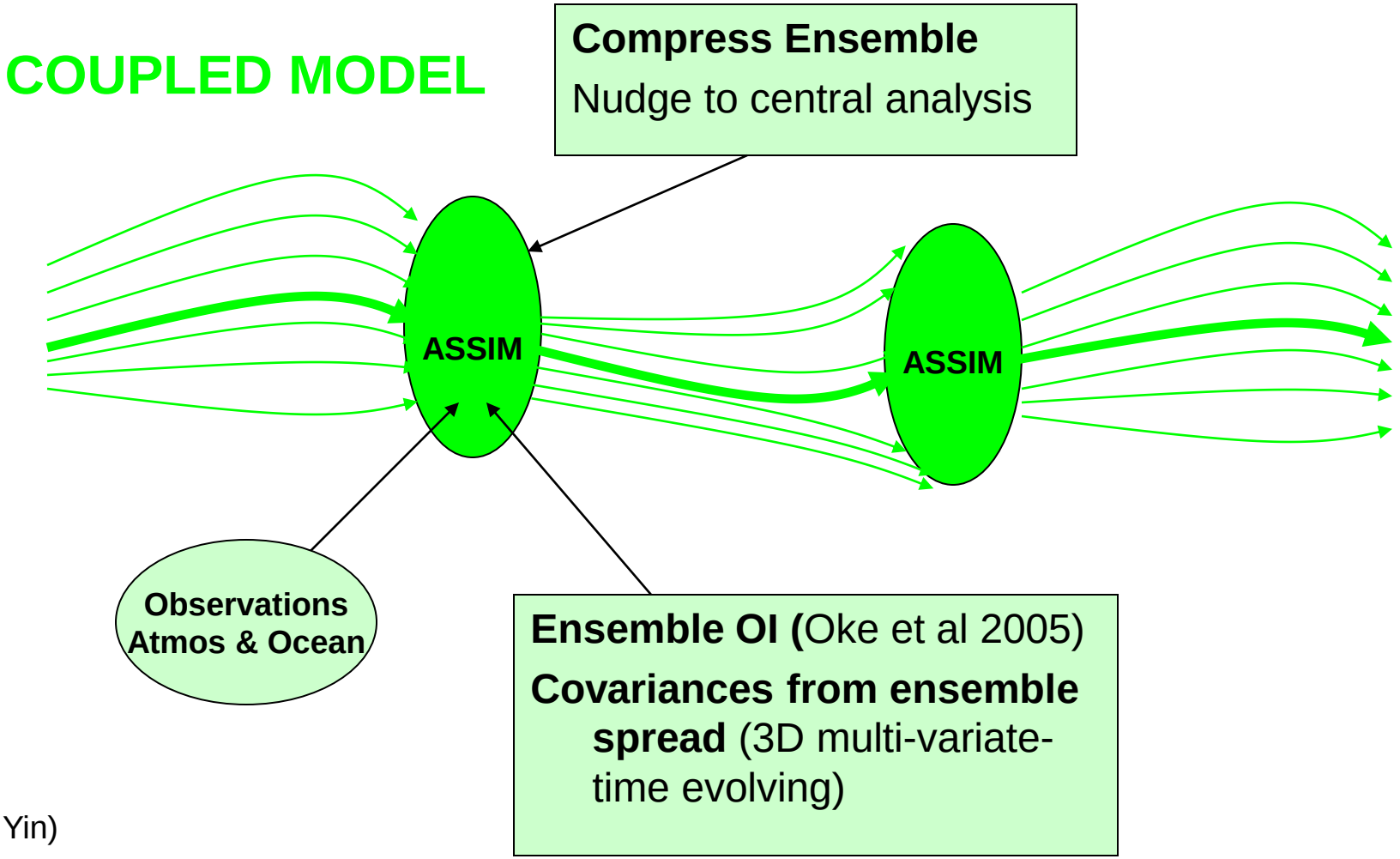
(Image from Risbey et al. 2009)

POAMA-2 (intra) skill out to ~2 weeks

PECDAS: Preliminary version

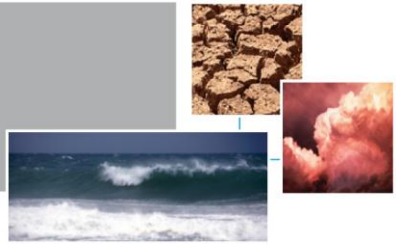


POAMA Ensemble Coupled Data Assim System
Version 1: Weakly coupled



(Yonghong Yin)

PECDAS: Preliminary version



Atmosphere: ALI nudging towards ERA-Interim

Ocean: PEODAS scheme (ensemble multivariate OI)

Perturbation generation: 30 member coupled breeding method

Assim: every 1 day with 1 day time window

Obs: EN3 Temp. & Sal. profiles, including CTD, XBT, Argo

Model: POAMA-2, T47L17 BAM and ACOM2 (MOM2)

Observation errors: uncorrelated in space

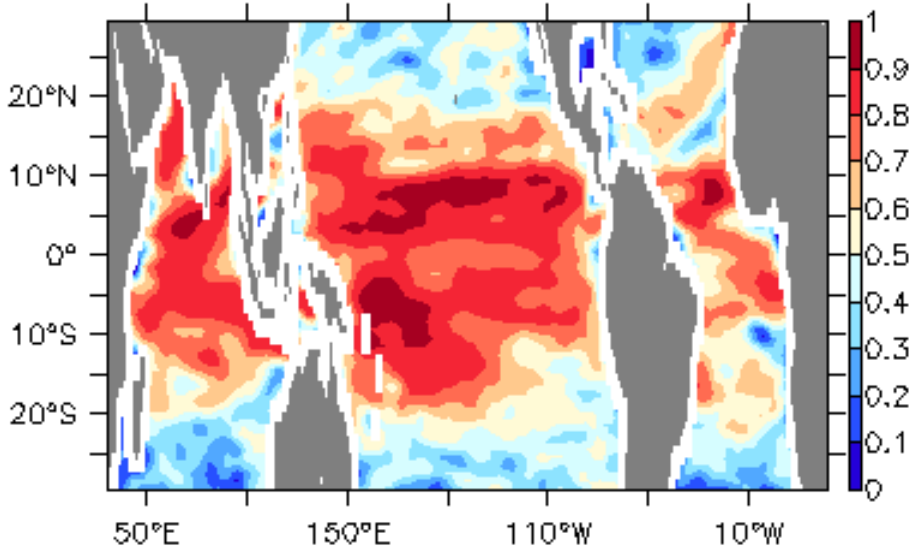
Covariance Localization: horizontally & vertically

PECDAS: Preliminary version

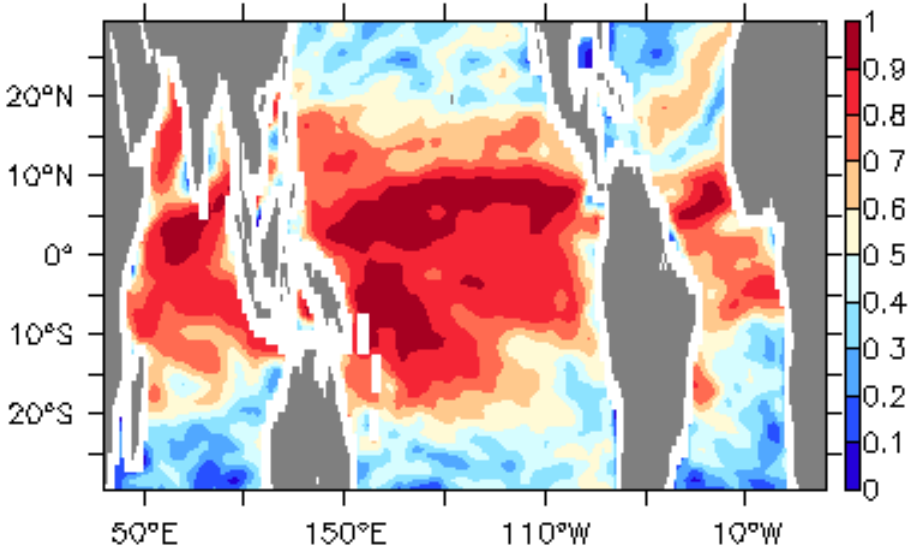
- Temperature and Salinity ensemble-based covariance structures and increments are comparable to that in PEODAS
- Main difference is in zonal currents
- There are large errors in zonal currents in PECDAS – might cause inaccurate increments and result in unbalanced initial ocean states

Zonal current correlations with OSCAR

PECDAS



PEODAS

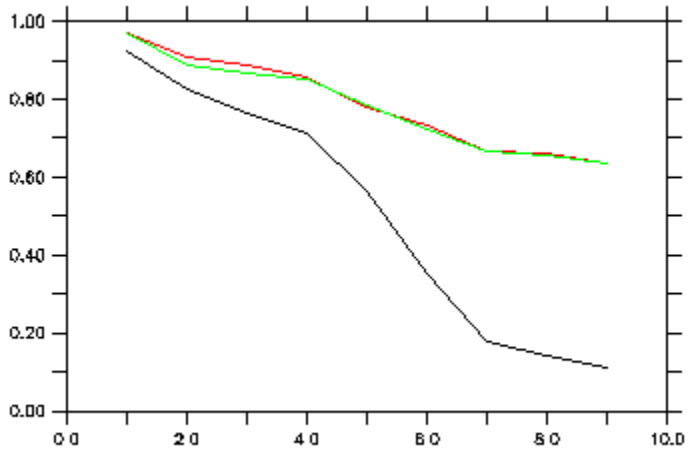


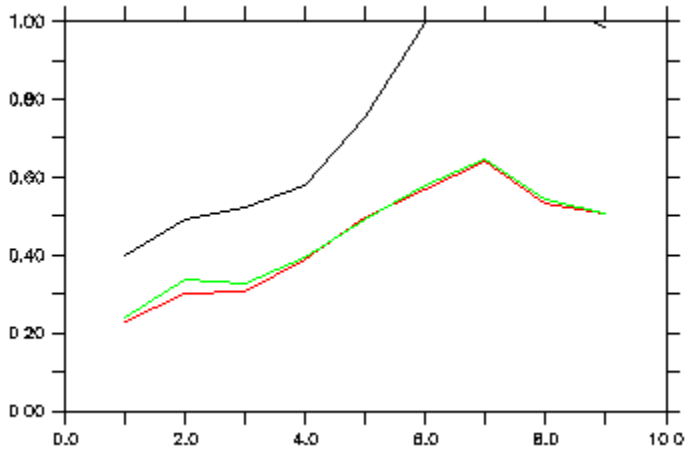
PECDAS: Seasonal forecast skill

ACC

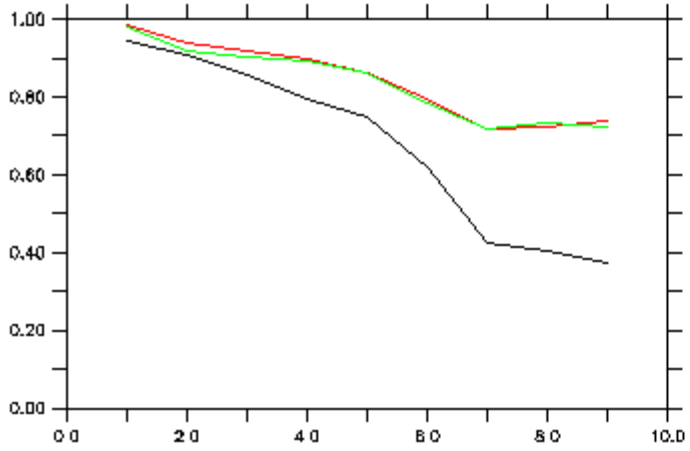
RMSE

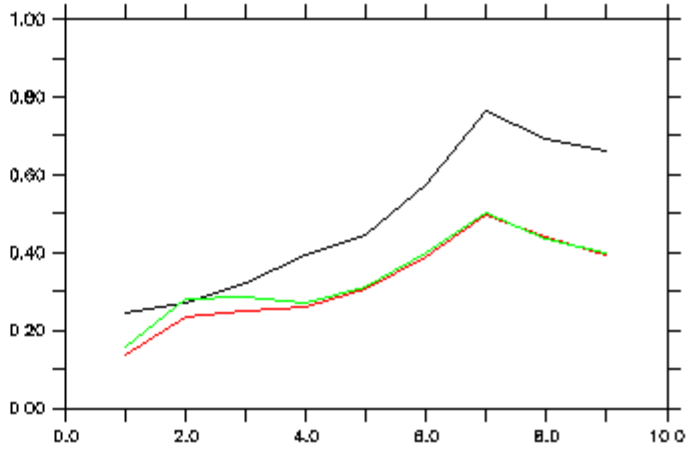
Nino3





Nino4

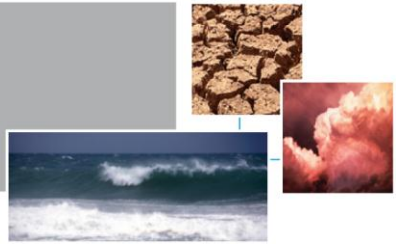




M25a: using PECDAS
P24a: using PEODAS
persistence

Jan & Jul forecast starts (1989-2008)

Summary



- Coupled breeding ensemble generation has lead to increased skill and reliability in POAMA-2
- Results of weakly-coupled DA (PECDAS) are promising
- Need to refine PECDAS to solve the ocean current increment problems. More fine tuning needed.
- Phase 2: Fully coupled assimilation, implement in new POAMA-ACCESS model