A coupled ensemble ocean data assimilation system for seasonal prediction in Australia and its comparison with other state-of-the-art reanalysis

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CAWCR (Centre for Australian Weather and Climate Research)

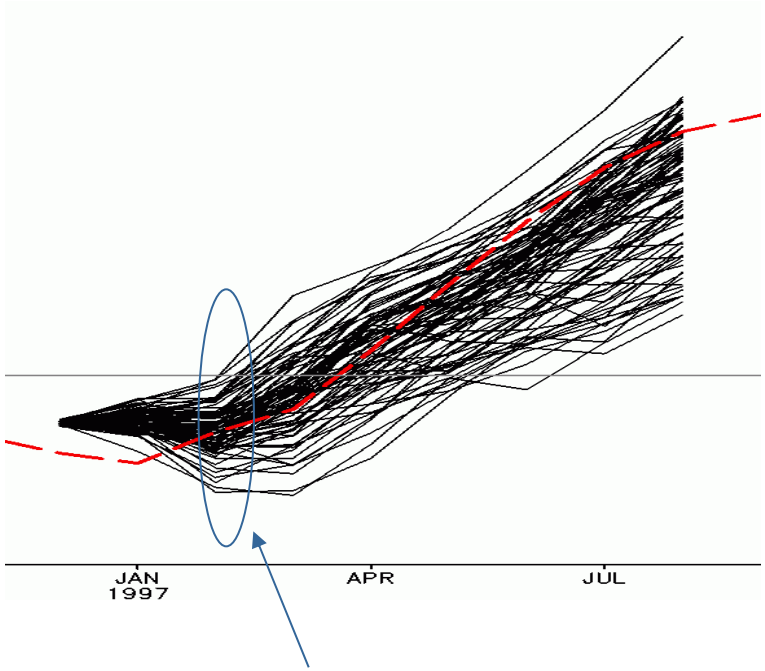
Australian Bureau of Meteorology

Outline

1. Introduction to coupled assimilation
2. Description of coupled data assimilation system
3. Performance of system
4. Comparison with other re-analysis
5. Impact on forecasts

What might coupled co-variances look like

Case study:
90 member
ensemble forecast
from Dec 1996



Estimate covariances
from ensemble (e.g.
after one or two months)

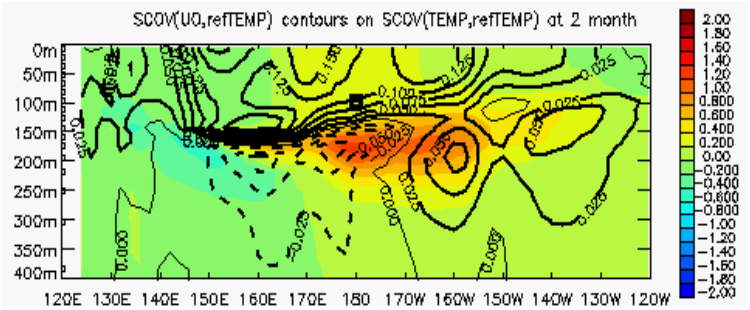
Patricia Okely and Li Shi

Coupled Covariances

Ref.: Temp. 100m

Colour: Temp.

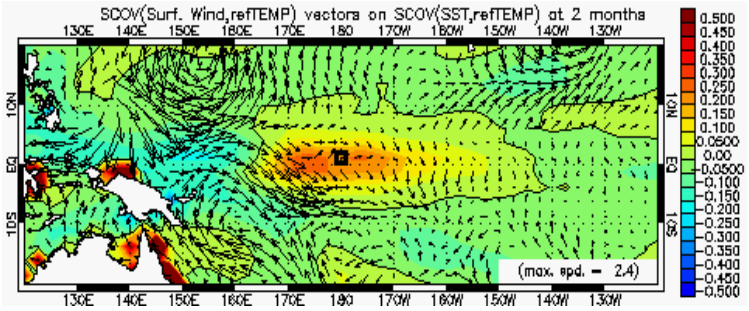
Cont.: Zon. Current



Ref.: Temp. 100m

Colour: SST

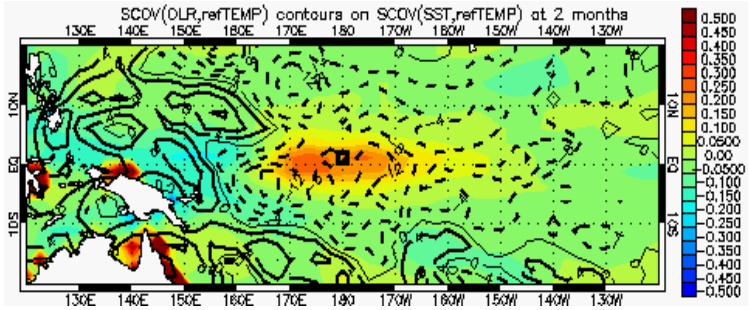
Vect.: Surf. Wind



Ref.: Temp. 100m

Colour: SST

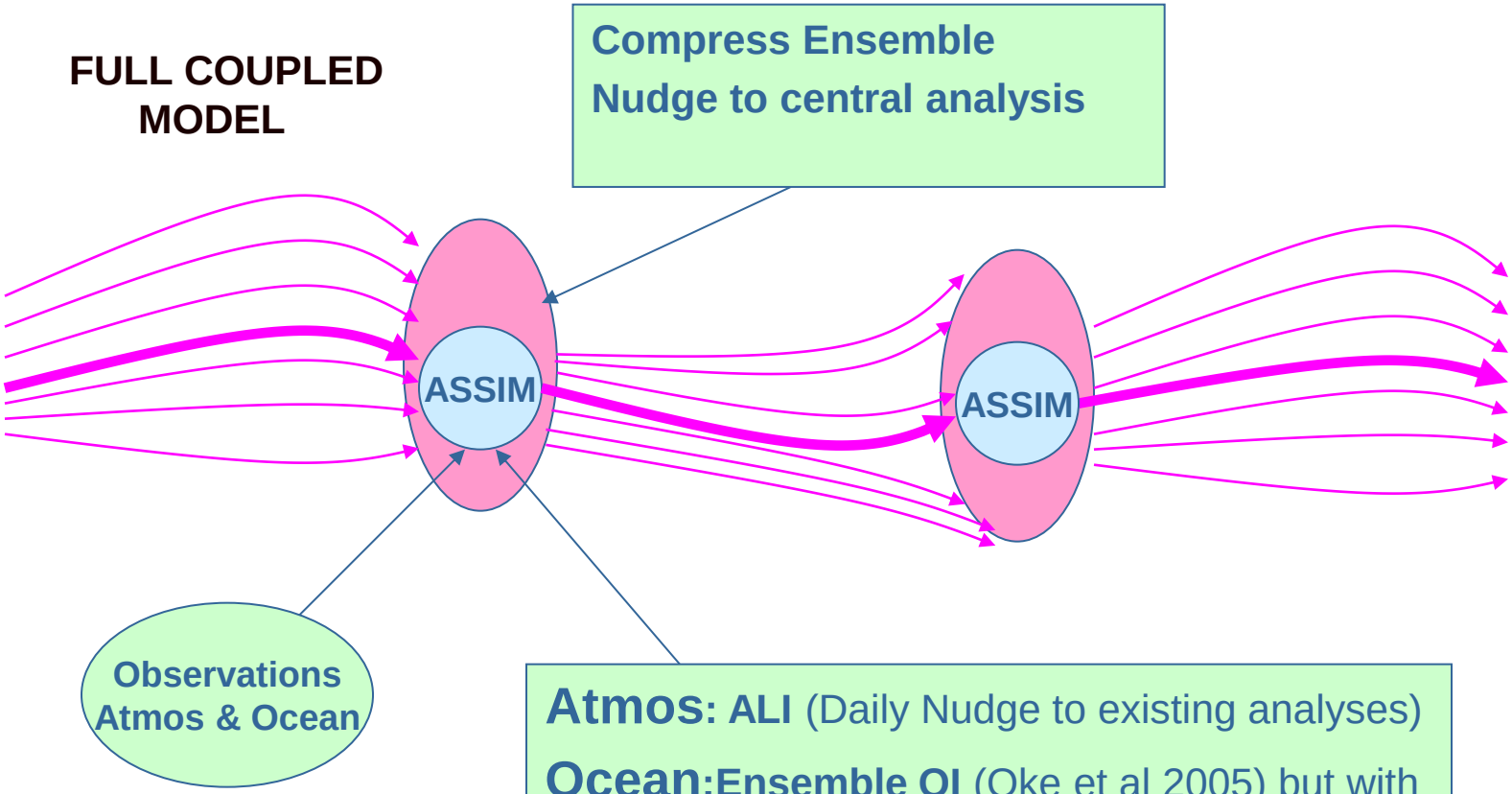
Cont.: OLR



1. Covariances consistent with intra-seasonal activity
2. Non-local covariances (real or not, desirable or not)
3. Large vertical extent (not shown)

Patricia Okely

PECDAS: POAMA Ensemble Coupled Data Assim System
Version 1: Weakly coupled



Preliminary version: PECDAS

Atmosphere: ALI nudging towards ERA-Interim

Ocean: PEODAS scheme (ensemble multivariate OI)

Perturbation generation: 30 mem coupled breeding method rather than EnKF

Assim: every 1 day with 1 day time window

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

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

Observation errors: uncorrelated in space

Covariance Localization: horizontally & vertically

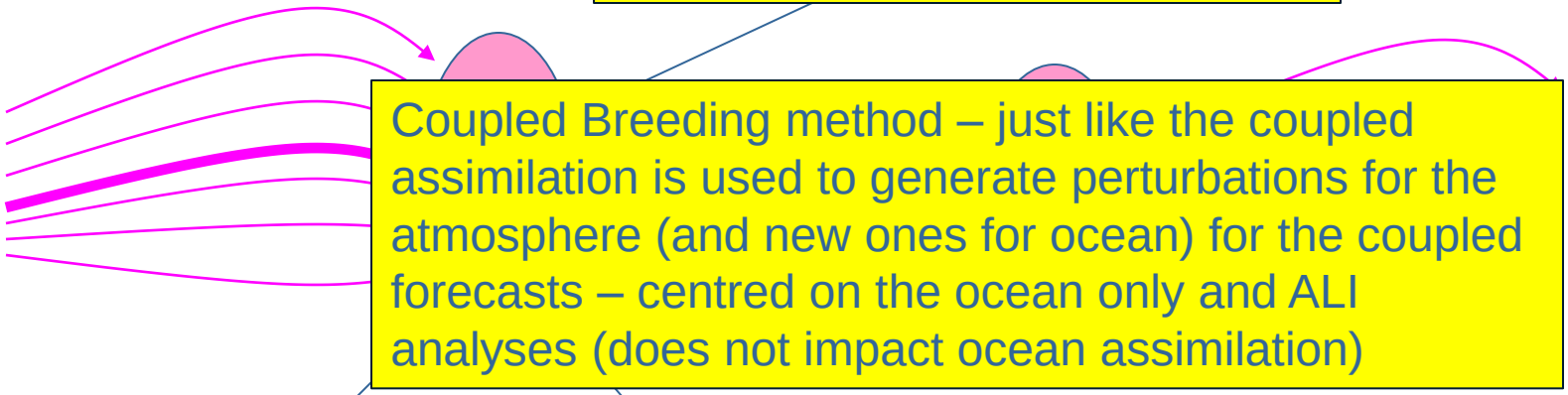
Keep error ratio being constant: σ(model) / σ(obs)= 0.47

30 years reanalysis done (1980-2010)

PEODAS: POAMA Ensemble Ocean Data Assim System

Ocean Model – perturbed forcing Yin et al 2011

Compress ensemble – nudge to central analysis by constant factor



Coupled Breeding method – just like the coupled assimilation is used to generate perturbations for the atmosphere (and new ones for ocean) for the coupled forecasts – centred on the ocean only and ALI analyses (does not impact ocean assimilation)

Observations Atmos & Ocean

Atmos: 6hrly nudge (weaker) done offline with observed SST

ses)

) but

with the flow dependent **Covariances from ensemble perturbations** (3D multi-variate)

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Summary

PE**C**DAS – weakly coupled assimilation, with implicit bred ensemble

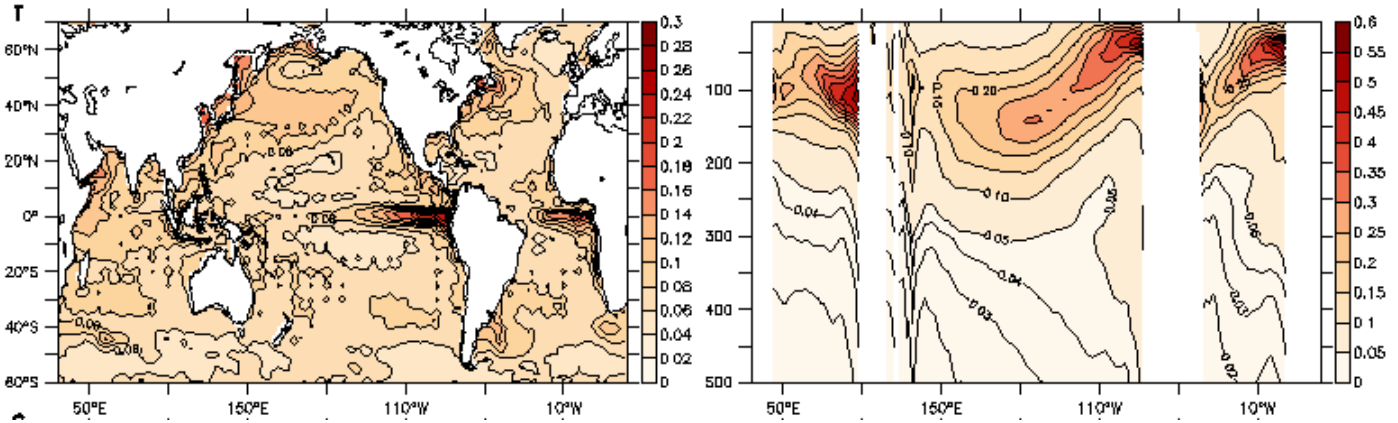
PE**O**DAS – ocean only assimilation + separate Atmos nudging, separate coupled bred ensemble

Ensemble Spread: SST and Temperature (averaged over 1980-2006)

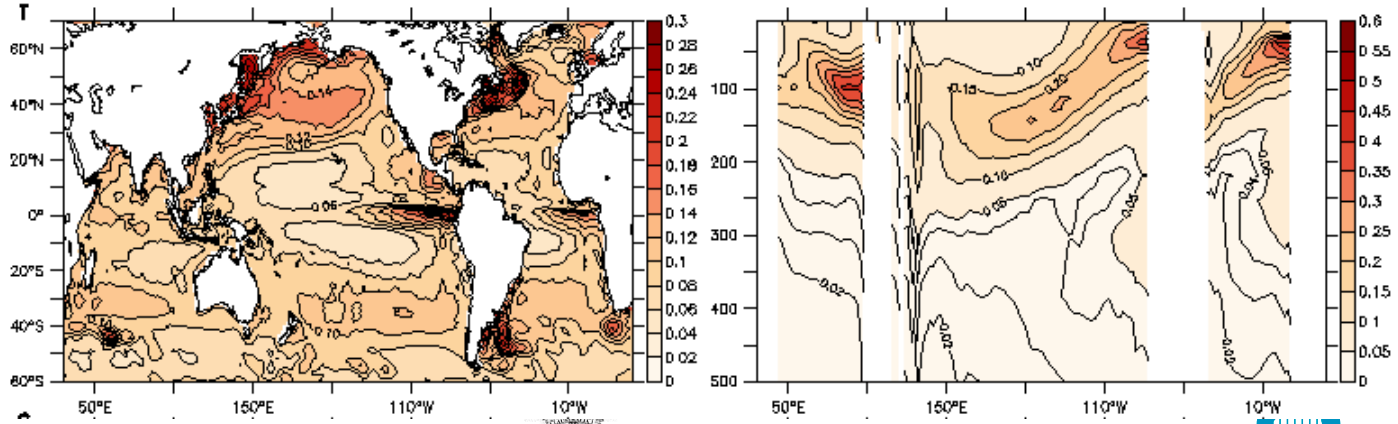
surface

equator

PEODAS



PECDAS



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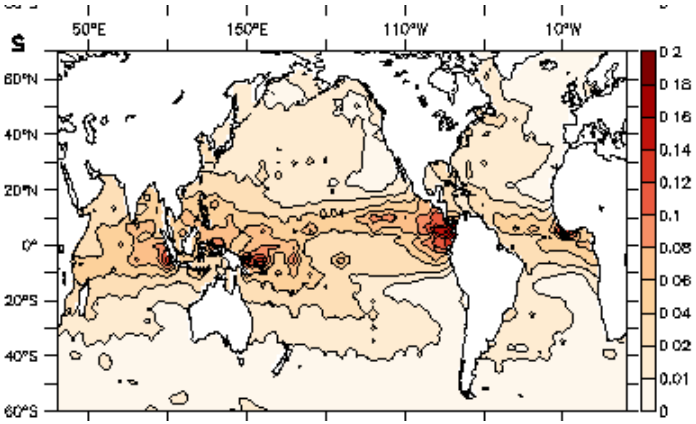
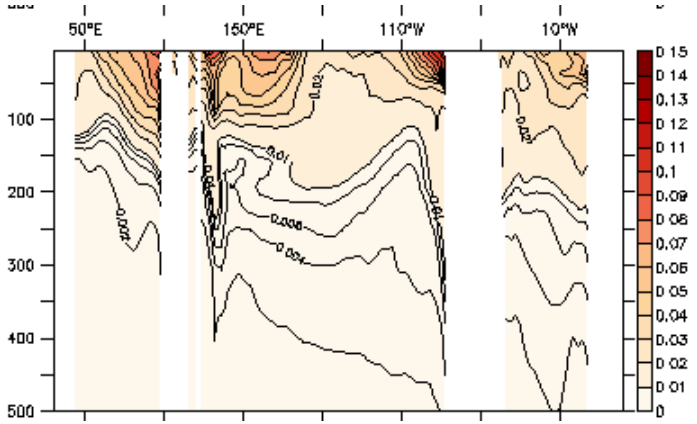
Ensemble Spread: Salinity

surface

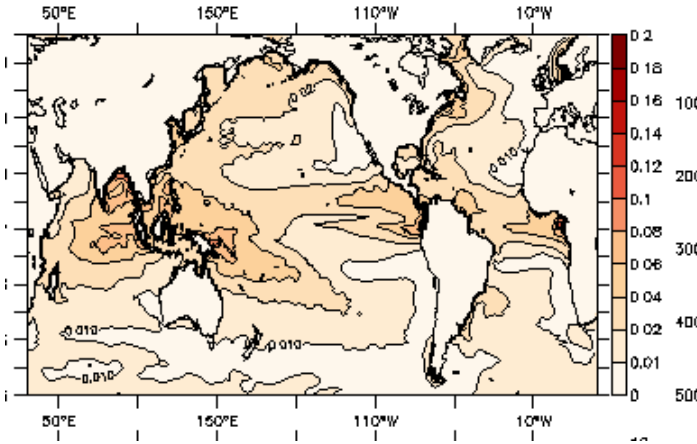
equator

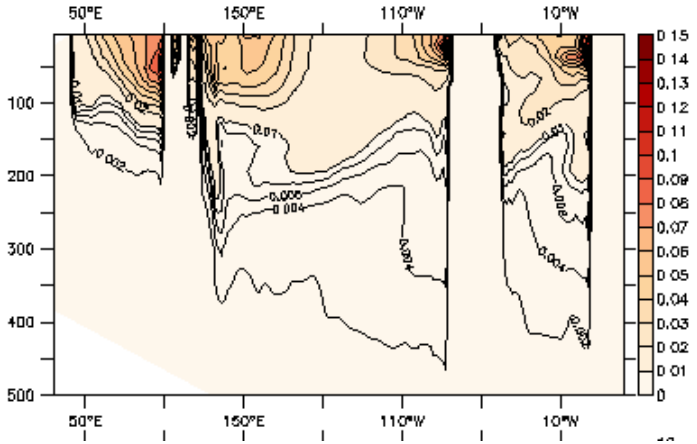
PEODAS





PECDAS





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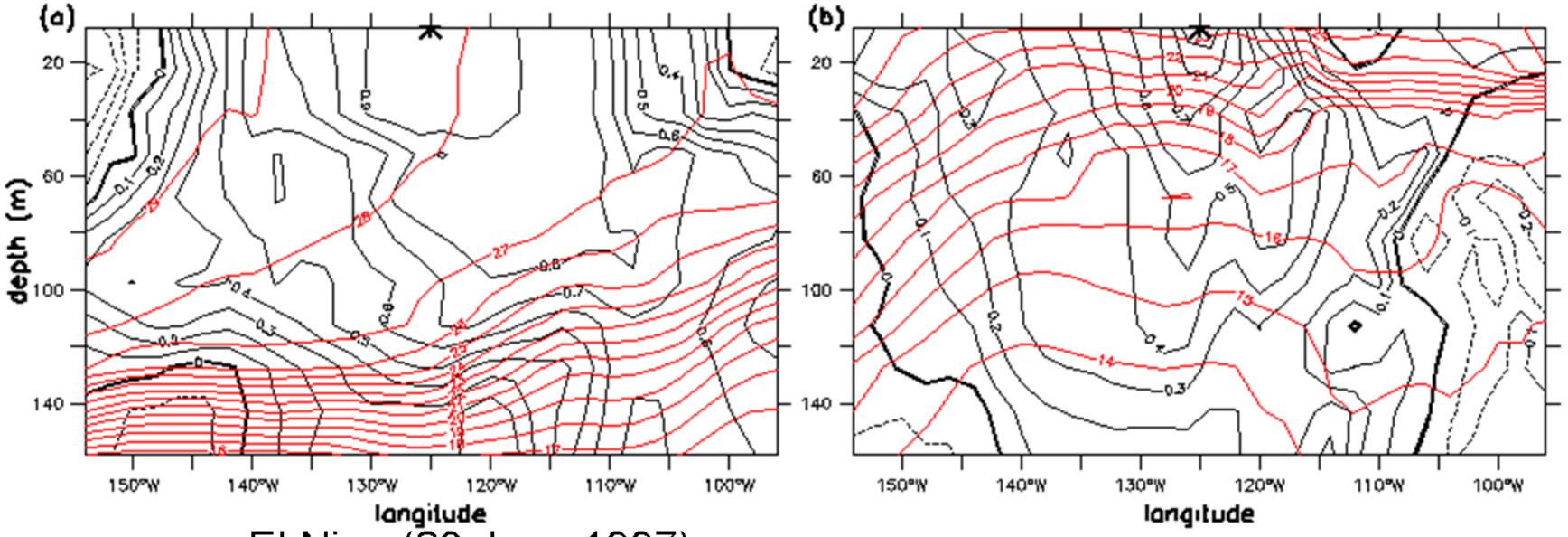
Ensemble-based covariance structures from PECDAS for equatorial eastern Pacific



El Nino (28 June 1997)

La Nina (29 June 1998)

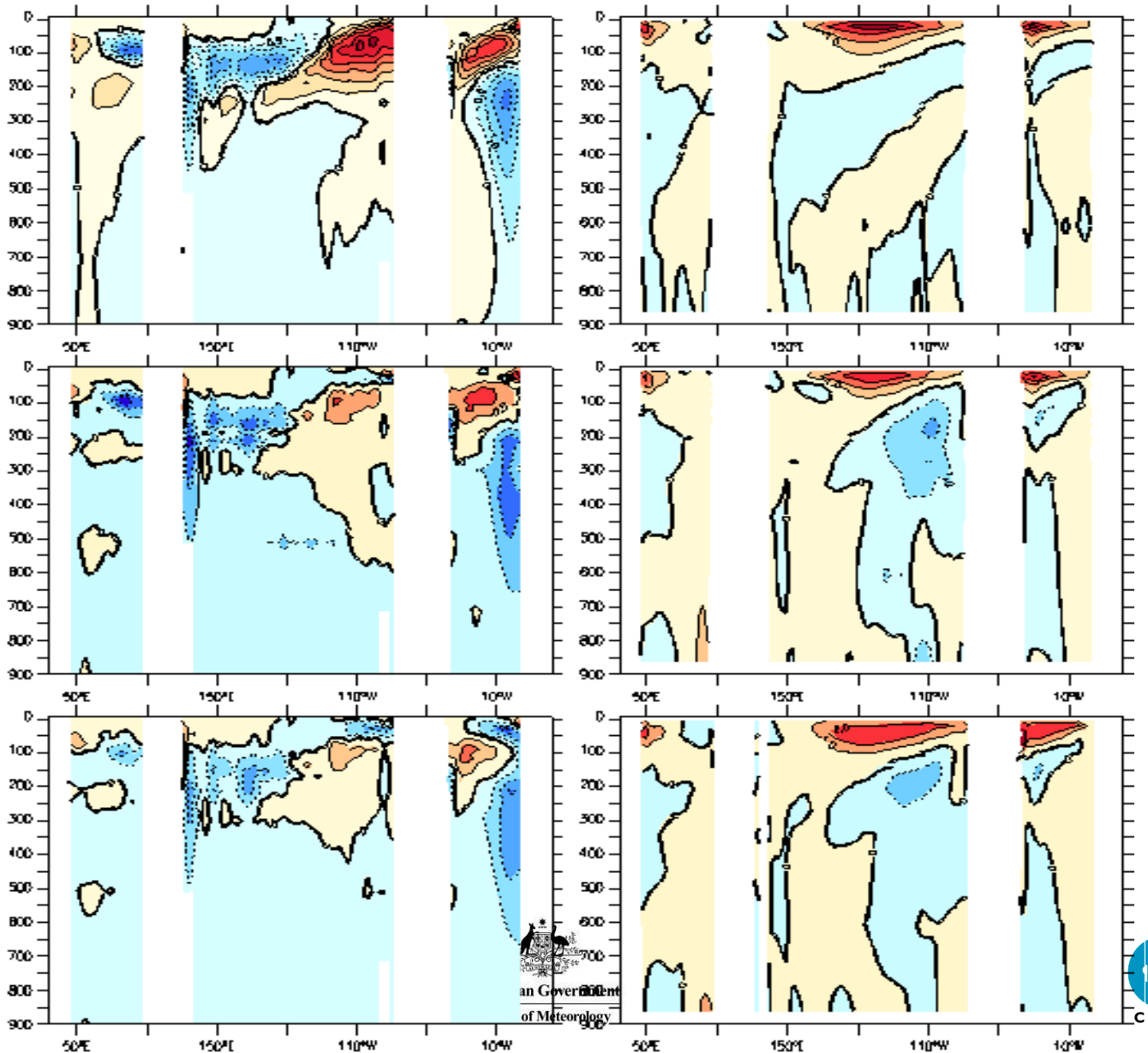
Temperature Reanalyses-WOA2001

Vertical velocity

PECDAS_no_oass

PECDAS

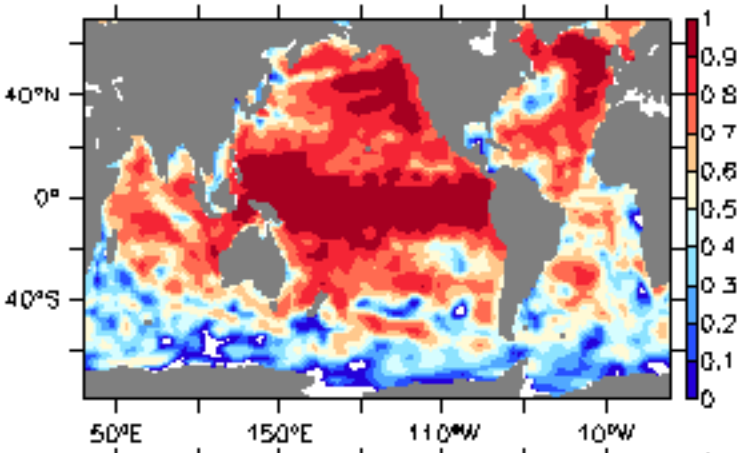
PEODAS

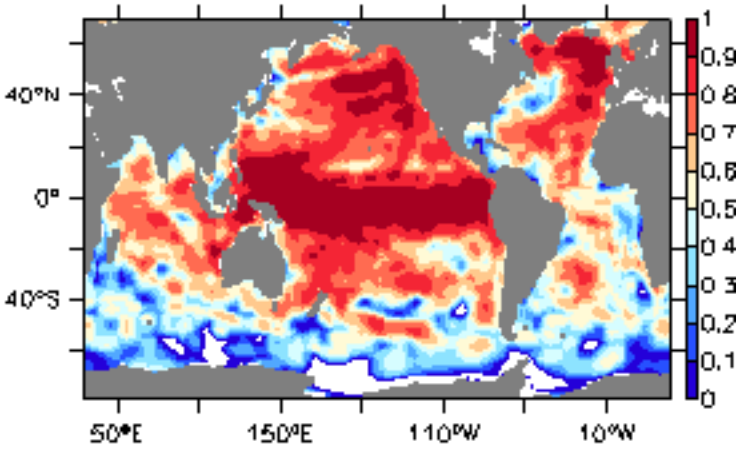


T300 correlations between EN3 and the reanalyses (1989.01-2008.12)

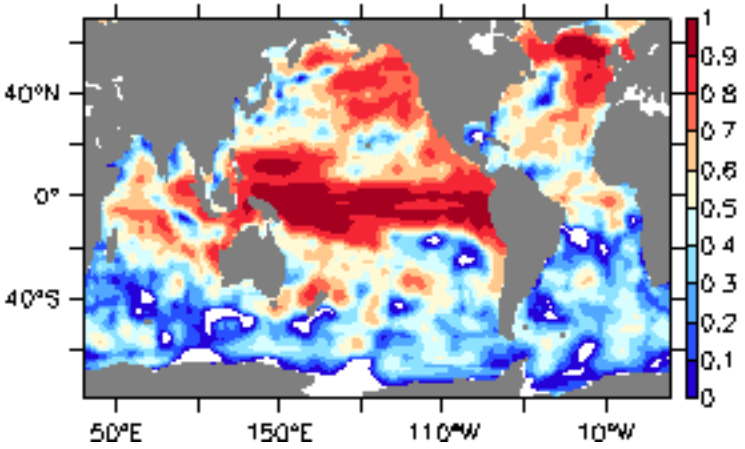
PEODAS

PECDAS





PECDAS _no_oass



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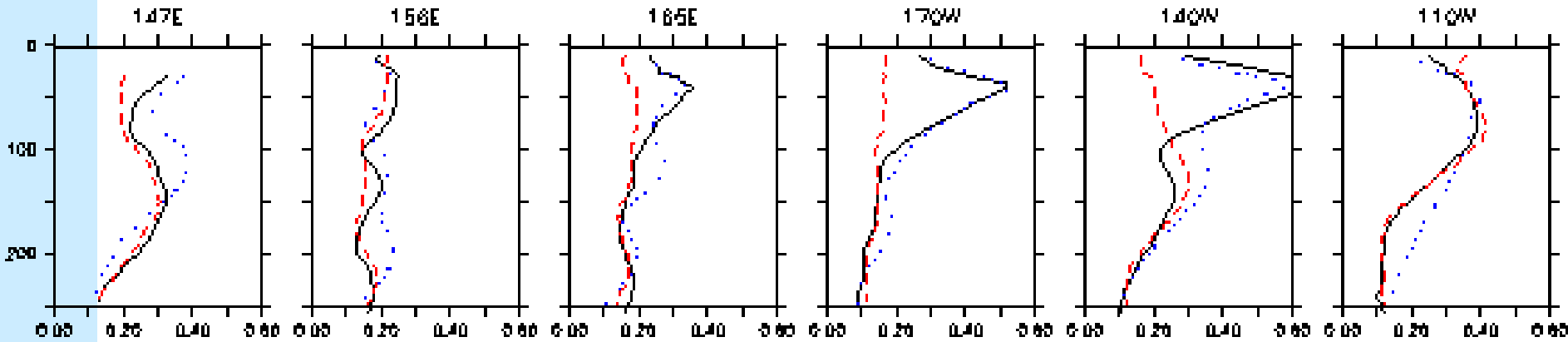
Profiles of RMSD (top) between zonal currents from TAO ADCP and from PECDAS (black), PEODAS (red), and PECDAS_no_oass (blue)



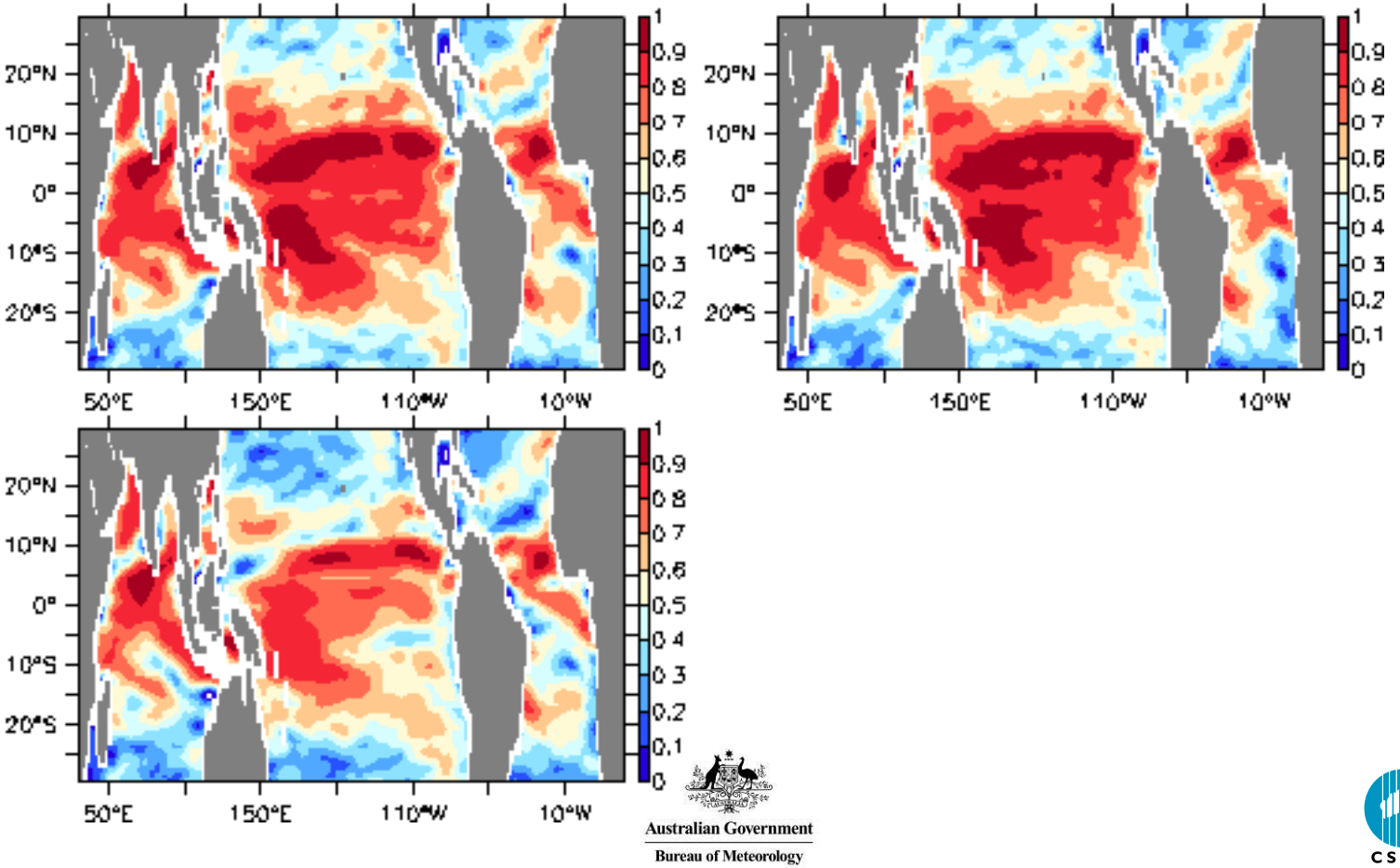
RMSD

Zonal current correlations between OSCAR and reanalyses

PECDAS

PEODAS

PECDAS _no_oass



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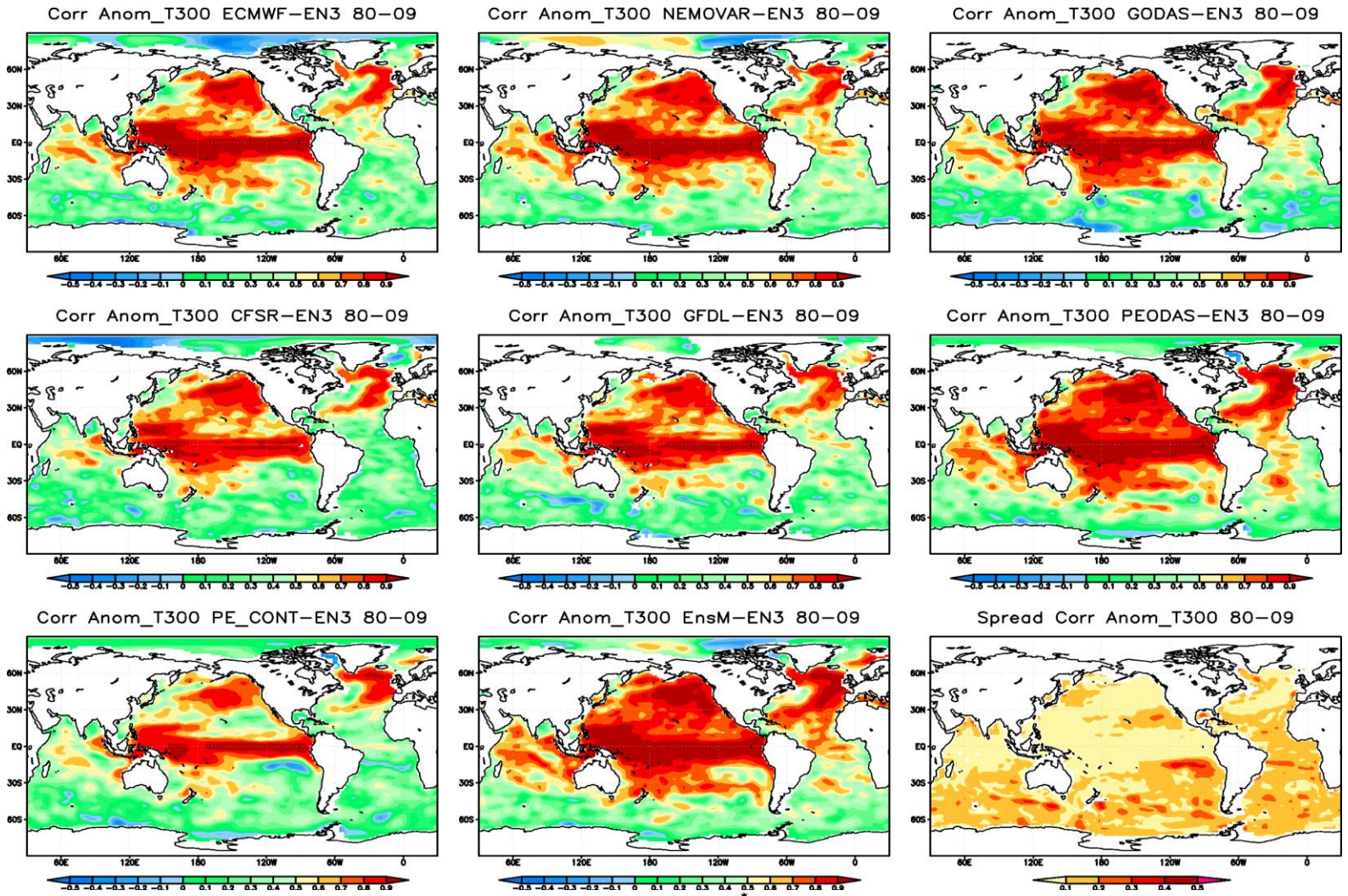
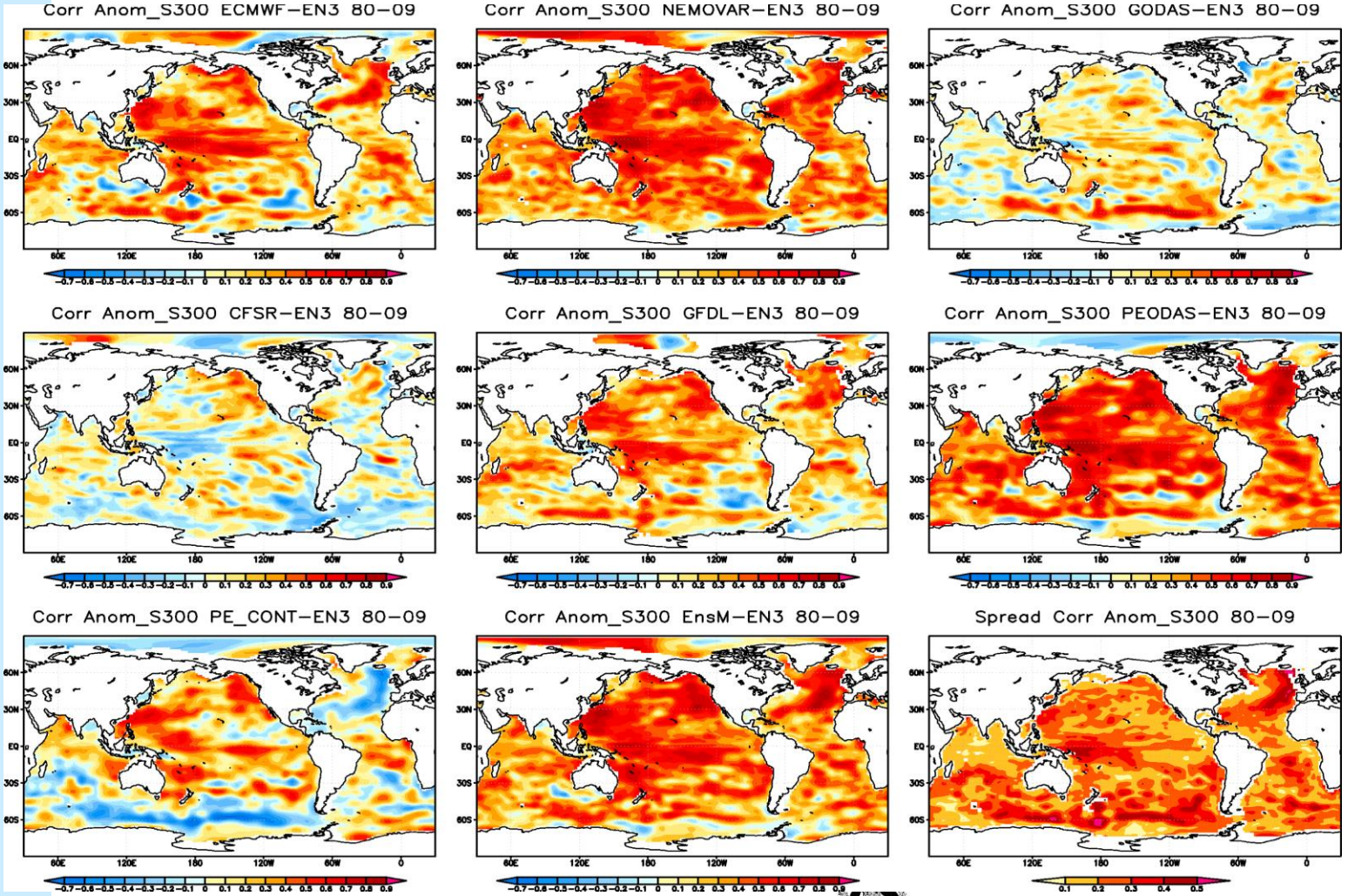
Comparison with other re-analysis

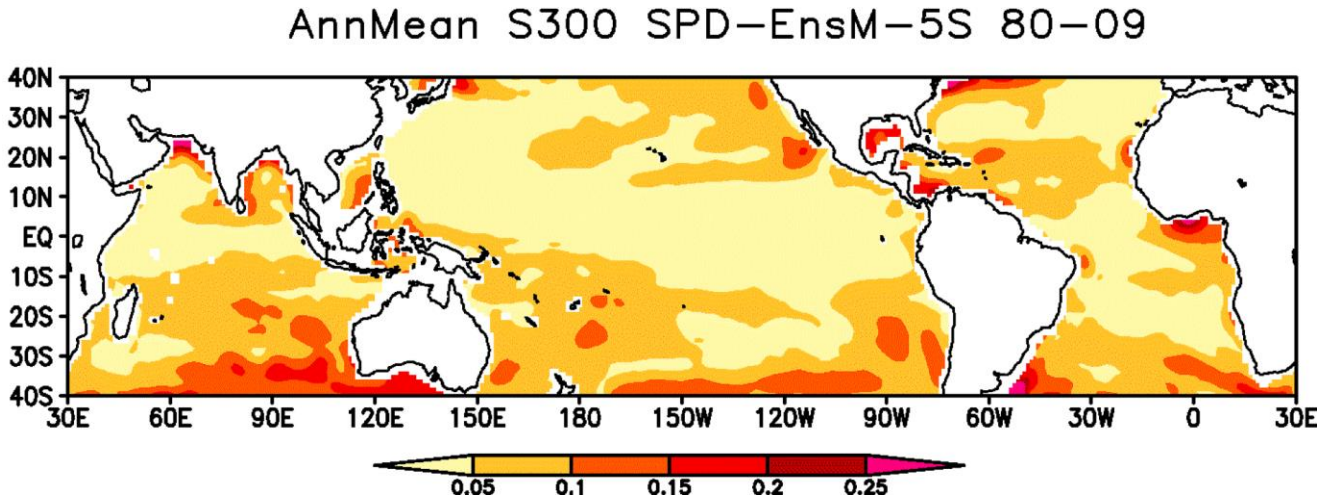
Correlation with ENACT temperature

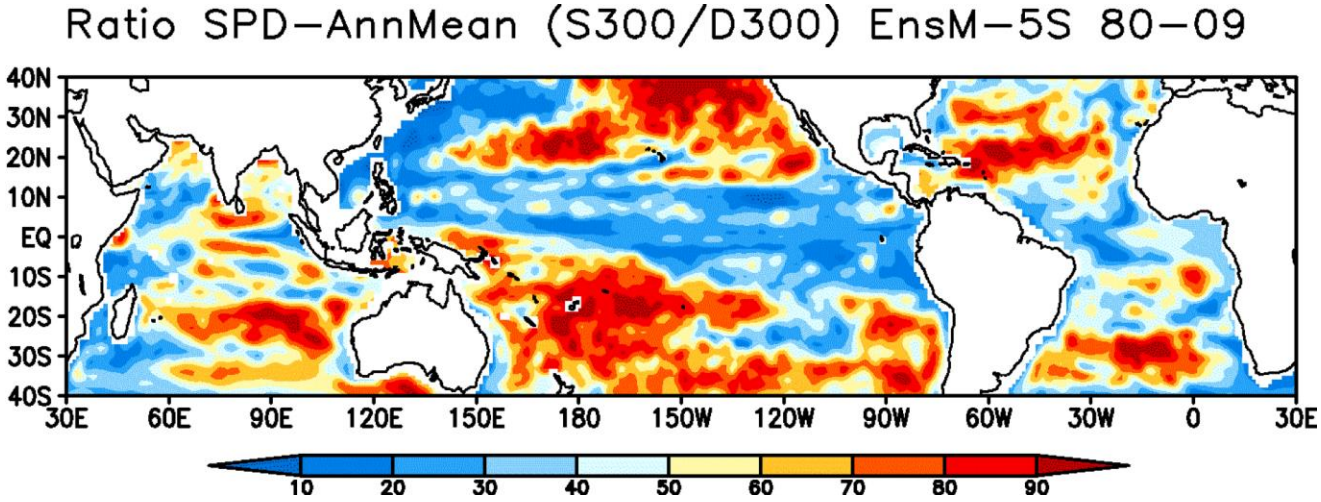


Correlation with ENACT salinity fields



Mean Salinity Spread





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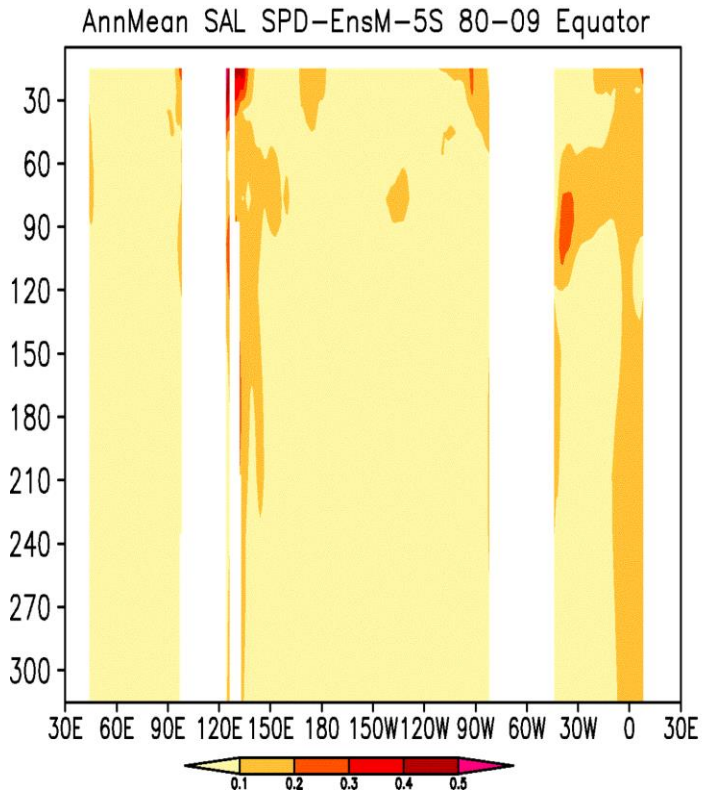
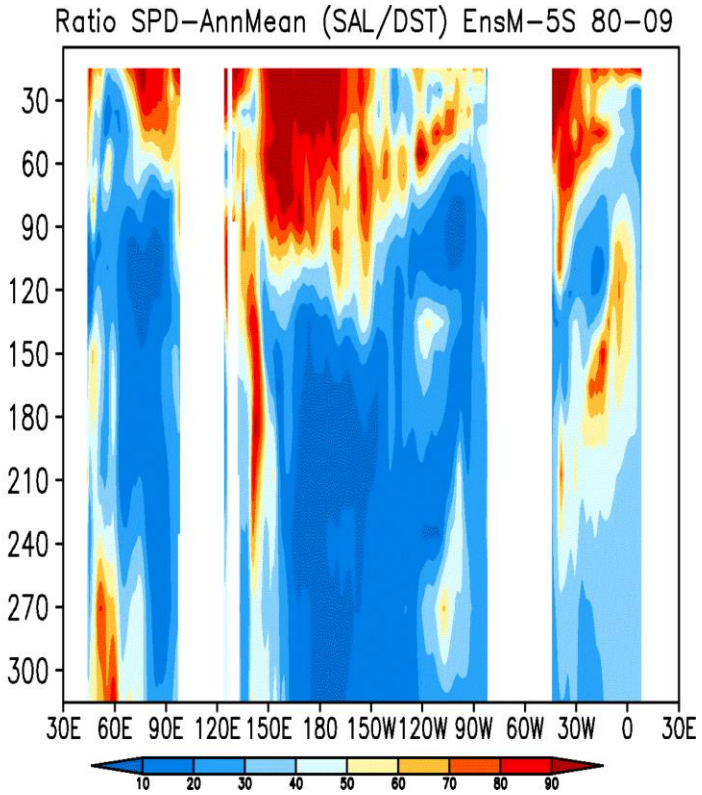
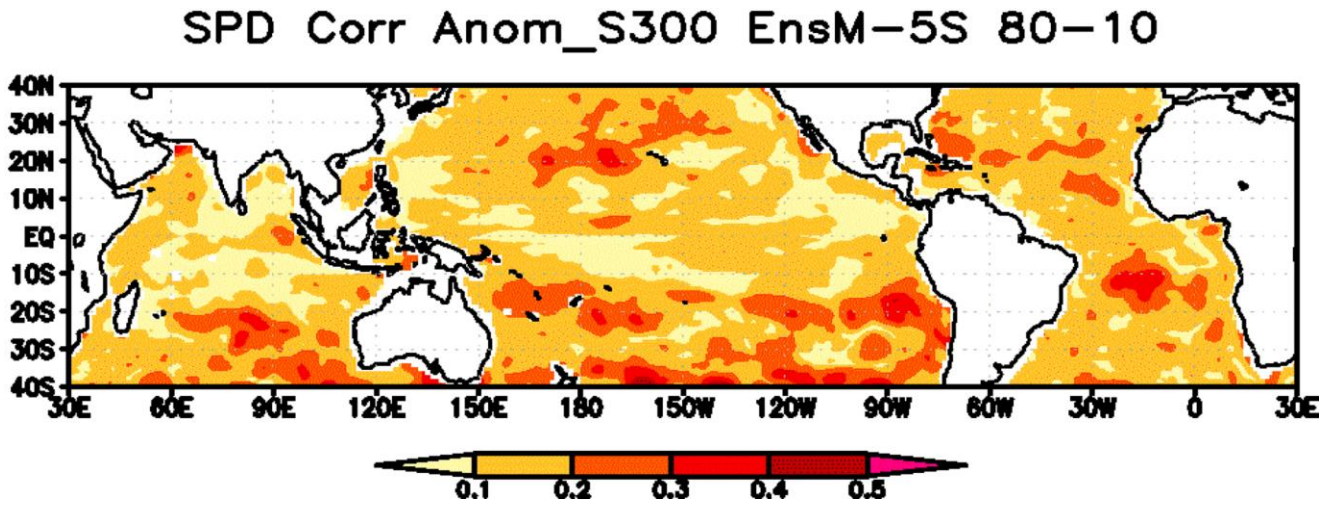
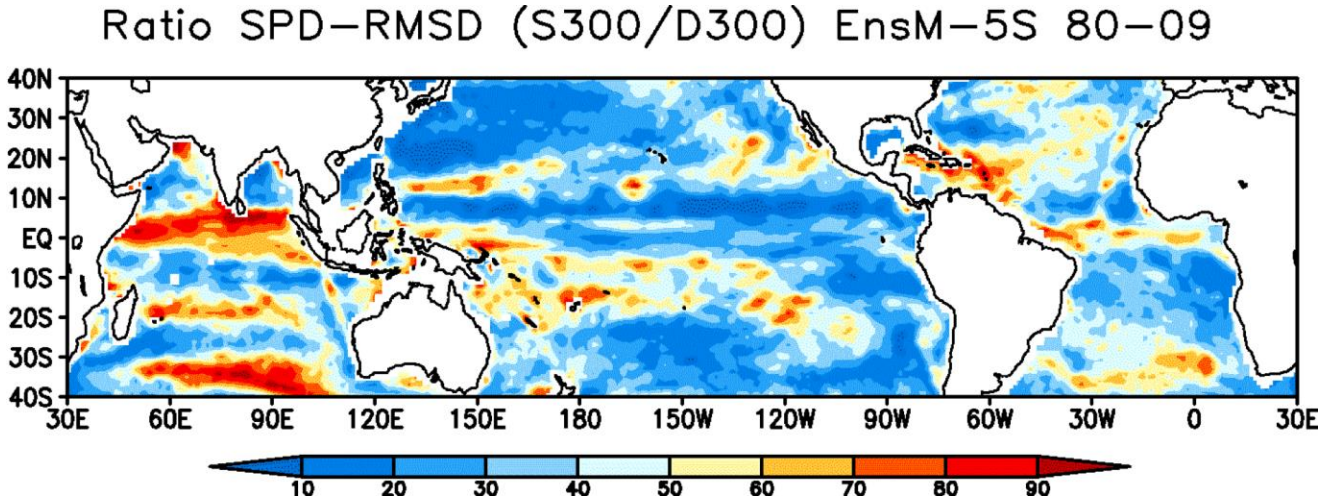
Mean salinity spread





Salinity versus Temperatures





Impact on Skill

JAN and JUL 01 starts

1989-2008

30 member ensemble for each start date

Each system uses their own ensemble members

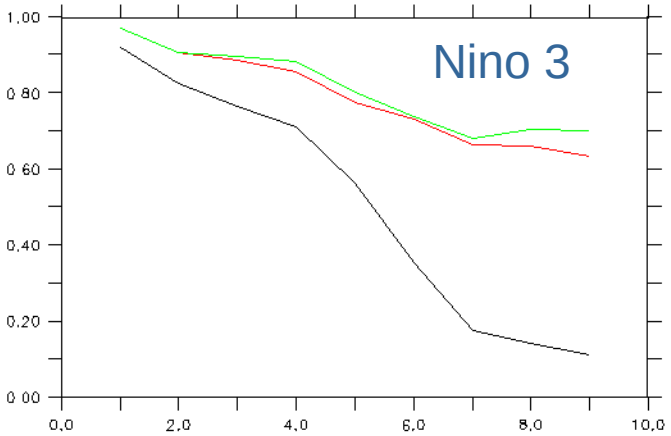
PE**C**DAS – weakly coupled assimilation, with implicit bred ensemble

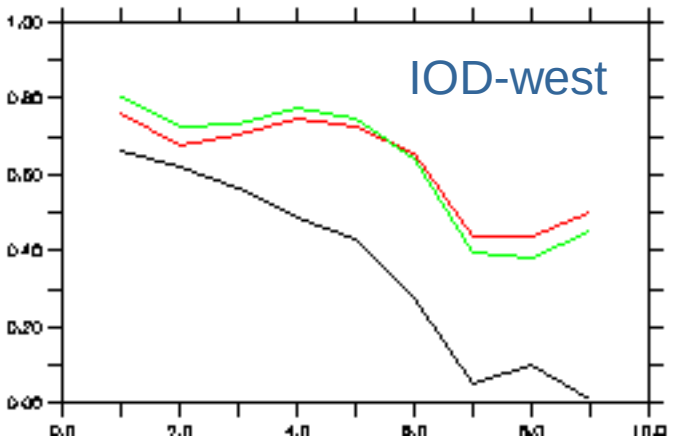
PE**O**DAS – ocean only assimilation + separate coupled bred ensemble

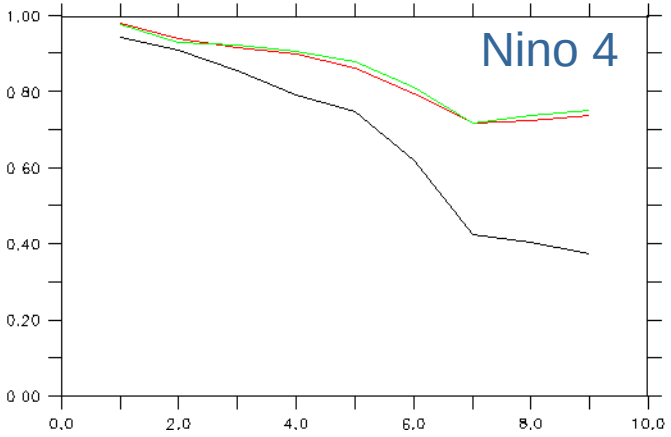
POAMA-2 (PECDAS)
POAMA-2 (PEODAS)
persistent

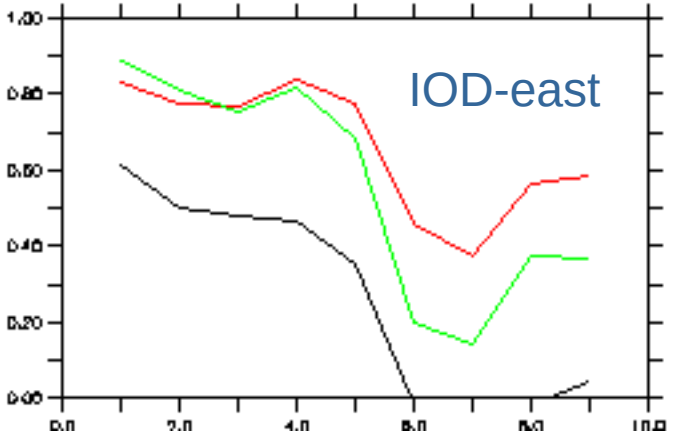
SSTA forecast skill

ACC









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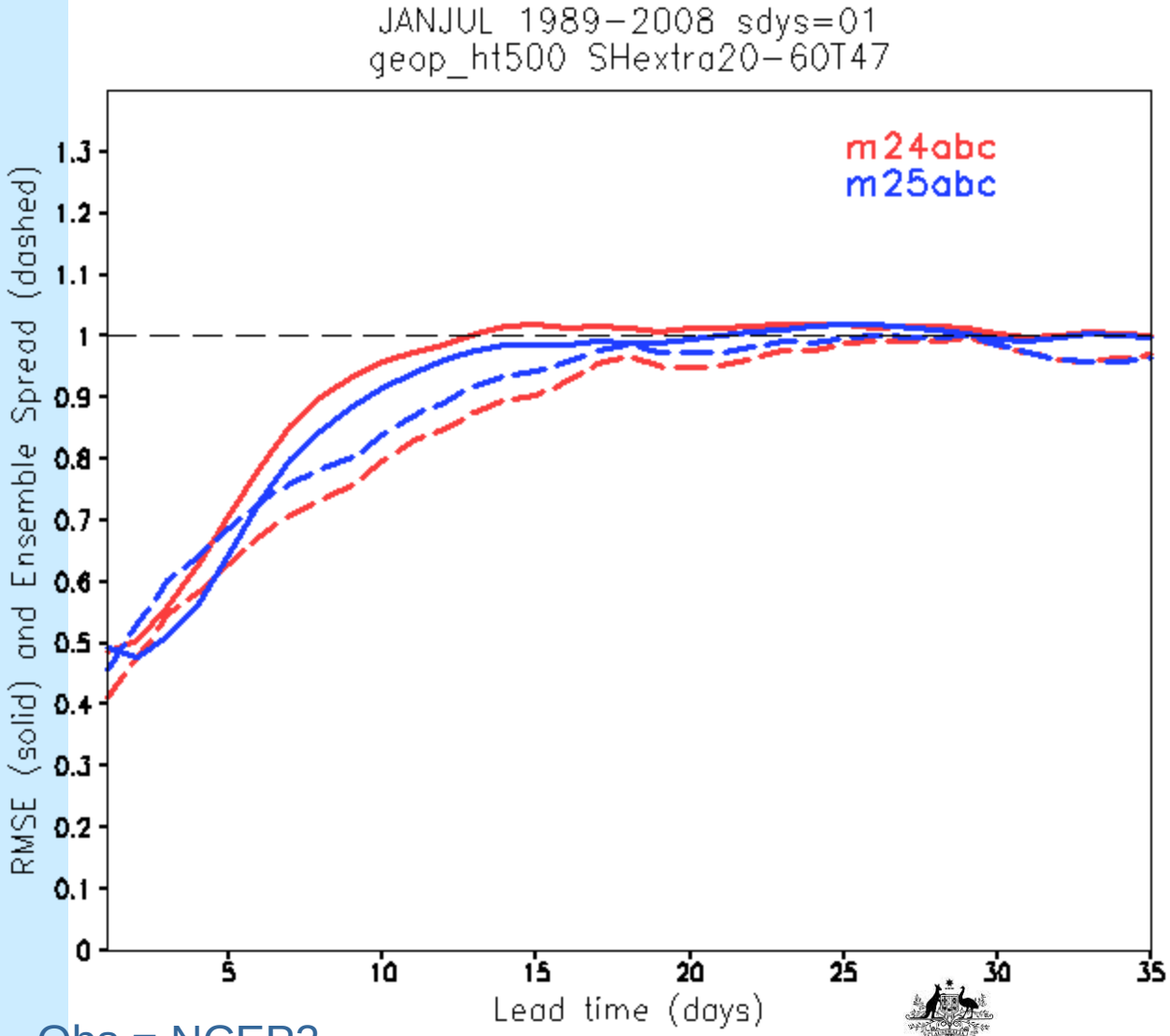
500 hPa geop_height Southern Extra-tropics



Red – PEODAS

Blue – PECDAS

Dash – spread

Solid – rms error

Obs = NCEP2

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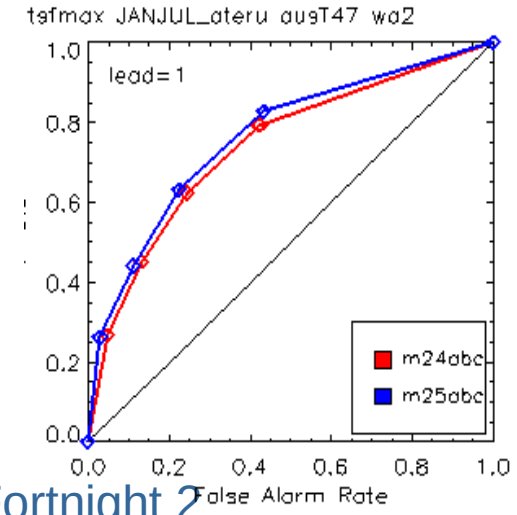
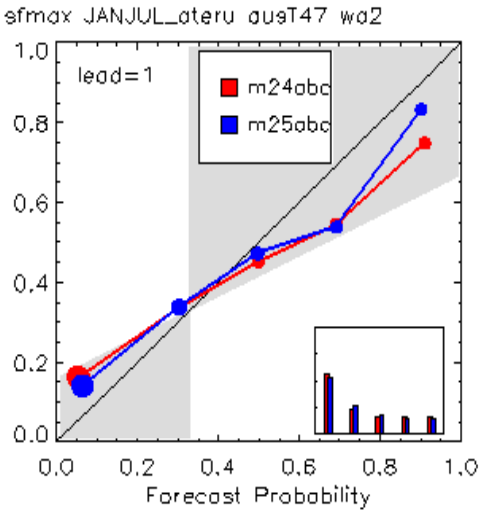
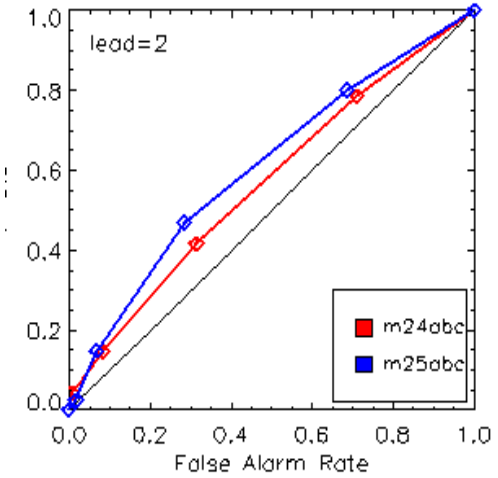
Australia TMAX above upper tercile

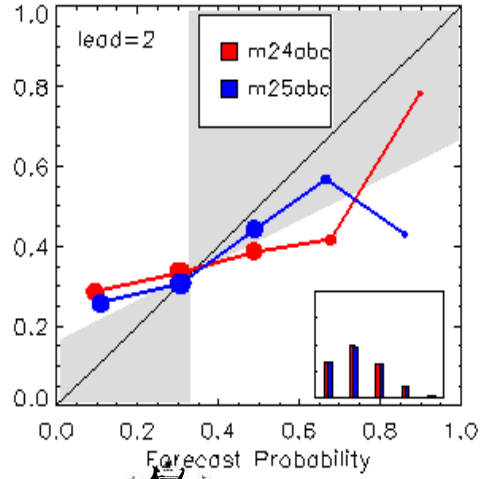
Fortnight 1





Fortnight 2





Red – PEODAS

Blue – PECDAS

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Summary

PECDAS weakly coupled assimilation at least as good as uncoupled

Coupled bred vectors implicit – main benefit

Current issues – due to atmosphere model bias when atmos constrained

Coupled assimilation not solution to shock due to model error (but will reduce shock from inconsistent initialisation)

Impact on forecasts small but positive (but untunned, due to ensemble ?)

Future: tunning of assim, SST assim, better model and fully coupled assimilation