

Dynamical Model Seasonal Prediction of Summer Monsoon Rainfall: Successes and Challenges

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acknowledge

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Outline

Review capability to predict seasonal summer monsoon rainfall using dynamical coupled models

focus on **1 month lead** seasonal prediction, as typically issued operationally
e.g. initialized on 1 May for June-Aug season

Hindcasts from variety of coupled model forecast systems

ENSEMBLES (6 models), BoM POAMA, operational models (CFSv1/2, EC Sys3, SINTEX-F)

All systems are ensemble-based (typically 9 members, 30 members for POAMA2)

All but SINTEX-F initialized with observed ocean/atmos states.

All have comparable ocean resolution (~150km x 50km)

Atmospheric resolution varies greatly (POAMA T47/L17 - EC Sys T159/L64)

Hindcasts initialized on 1st each month (except CFS, which is lagged)

Outline

Analyse hindcast performance and skill 1980-2005 (1960-2005)

Mean model bias removed, otherwise uncalibrated

Verification with CMAP/GPCC 2.5 deg rainfall and Reynolds OI 2 SST

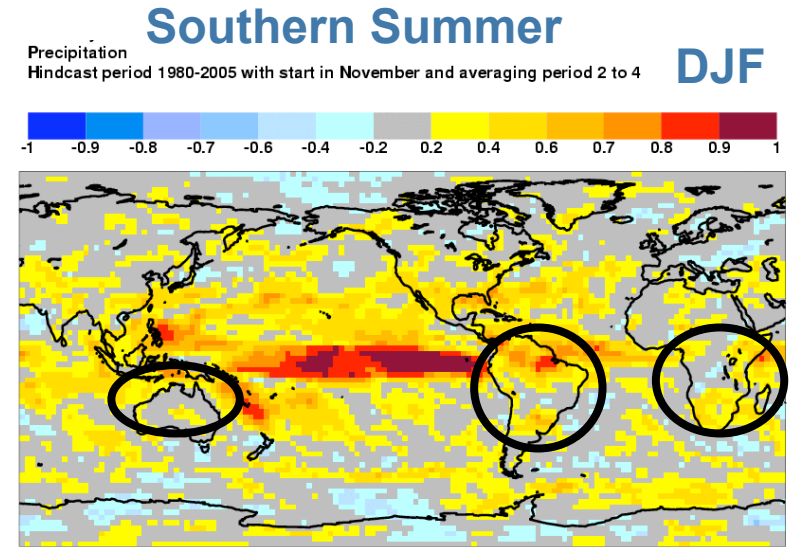
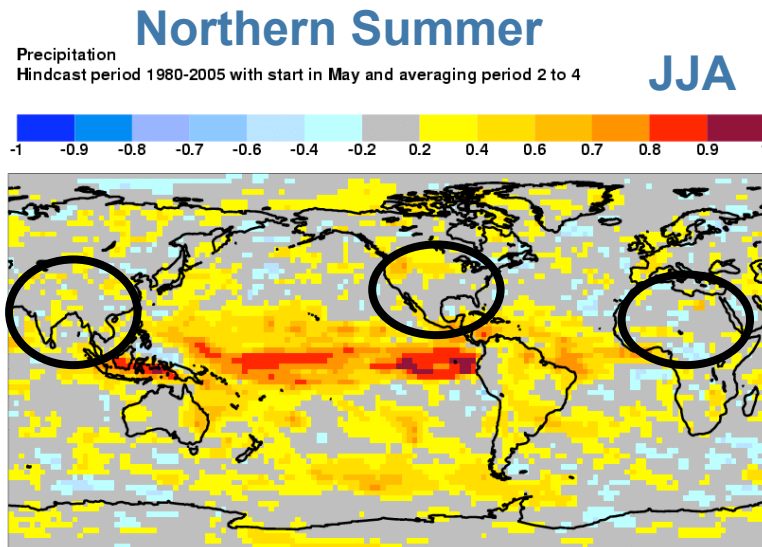
Results for individual models and Multi Model Ensemble mean (MME)

Summary of results

- Low skill for monsoon rainfall (except Amazon Basin)
- Reflects intrinsically low predictability (except where ENSO-signal is strong)
- Systematic model errors (ENSO-teleconnections) imply full potential has yet to be reached

LT 1 Multimodel Ensemble Mean Seasonal Forecast (ENSEMBLES)

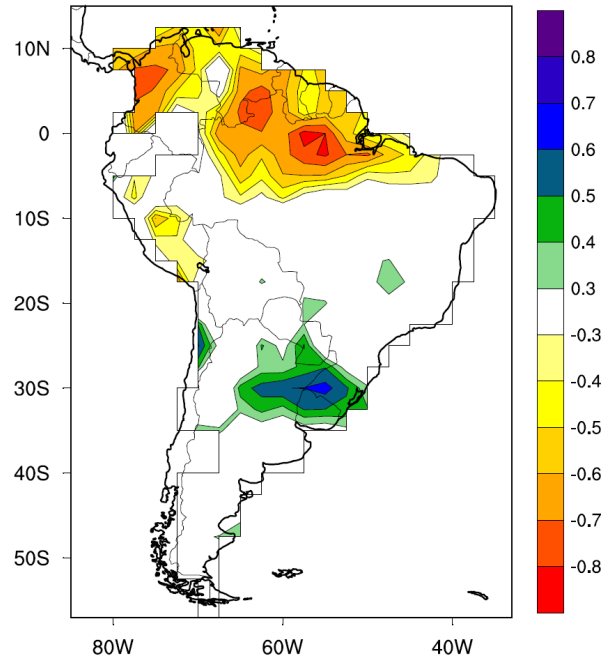
Rainfall correlation using 45-member multi-model ensemble mean 1980-2005



Analyses from http://www.ecmwf.int/research/EU_projects/ENSEMBLES

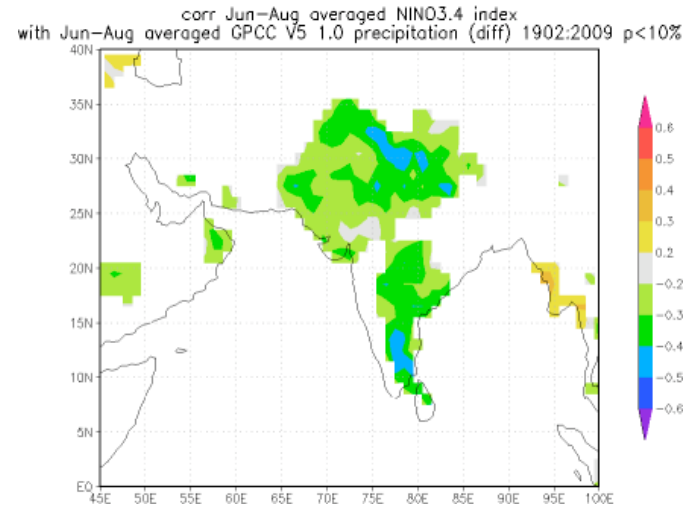
Monsoon-ENSO relationship

Correlation
Precip vs Nino34 1982-2010 DJF

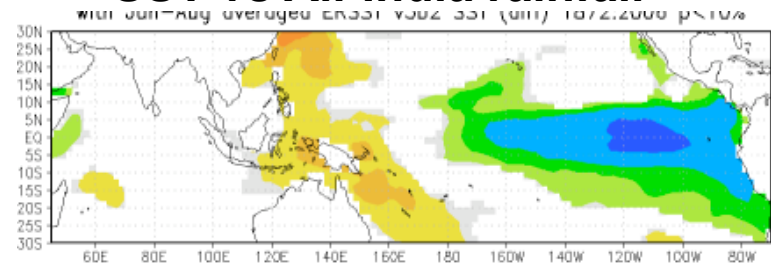


gridded rainfall from Liebmann and Allured (2006)

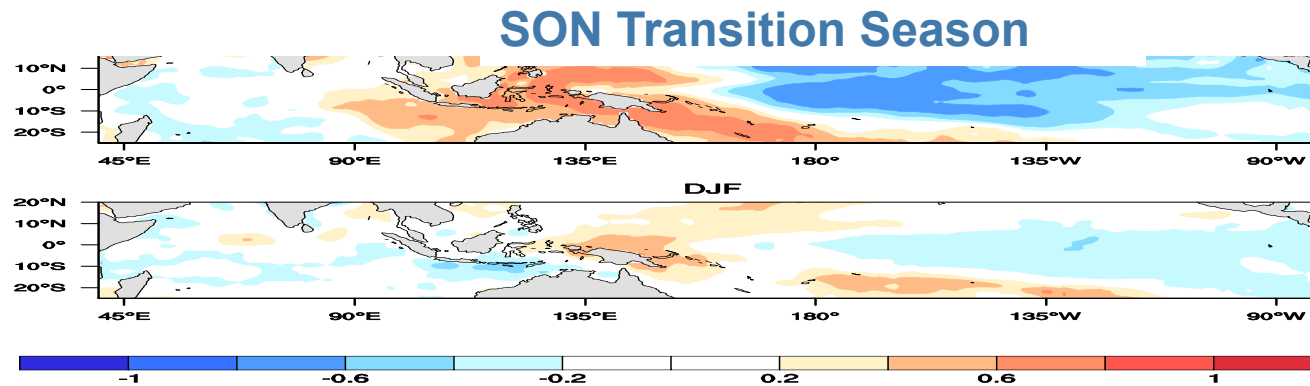
GPCC vs Nino34 1902-2009 JJA
high pass filtered (first difference)



SST vs All-India rainfall



SST vs Australian rainfall (north of 25S) 1980-2008



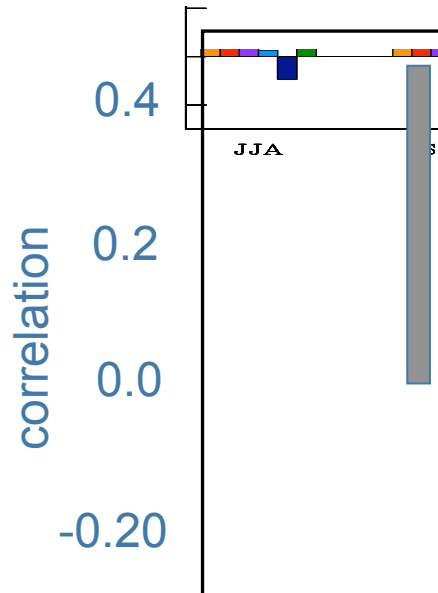
DJF Monsoon Season

correlation

Hendon et al. 2011

LT 1 month JJA 1980-2005 ENSEMBLES

All-Indian Rainfall (correlation)



Compare to Rajeevan (et al 2011)

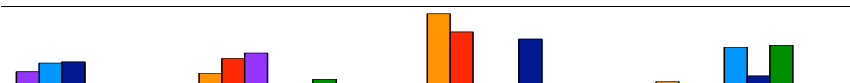
1960-2005

ENSEMBLES MME 0.45

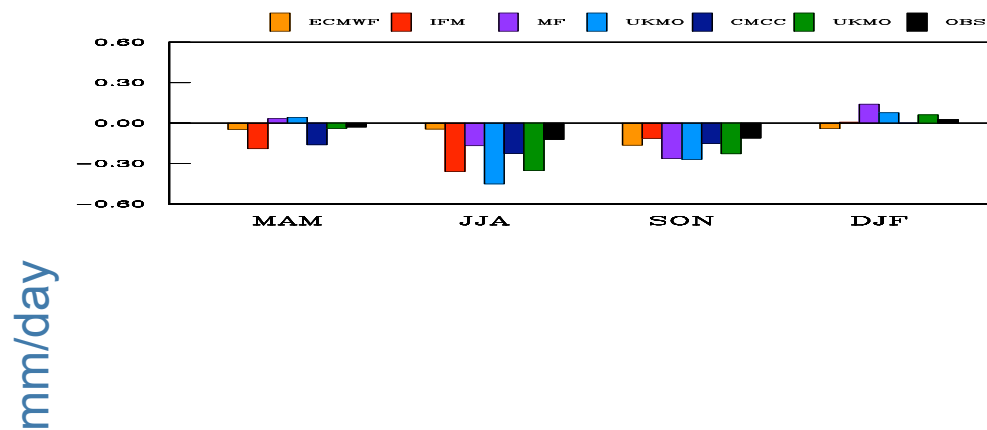
DEMETER MME 0.28

IMD's operational forecasts
(1988-2010) 0.29

ECMWF IFM MF UKMO CMCC UKMO

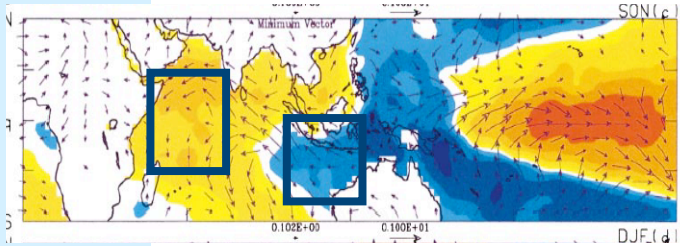


ENSEMBLES

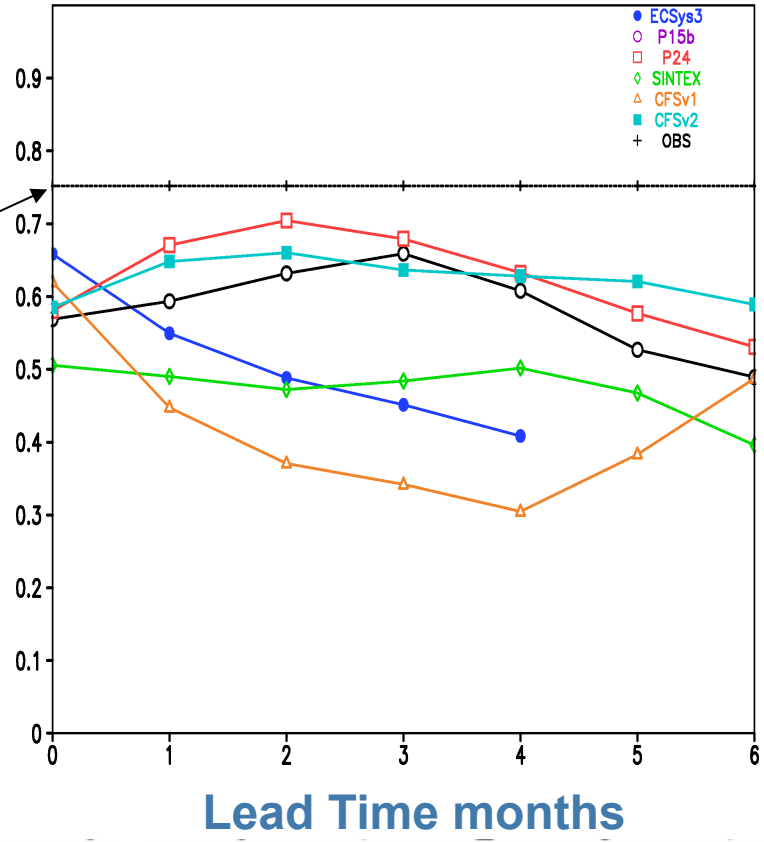


Regression of ensemble mean rainfall onto standardized Nino34 LT1 forecasts
1980-2005

Nino3-IOD correlation operational forecasts (individual members) 1980-2006



Observed $r(\text{Nino3-IOD})$

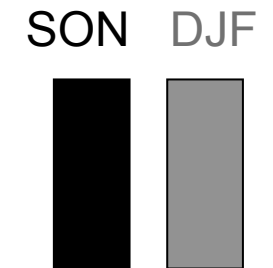
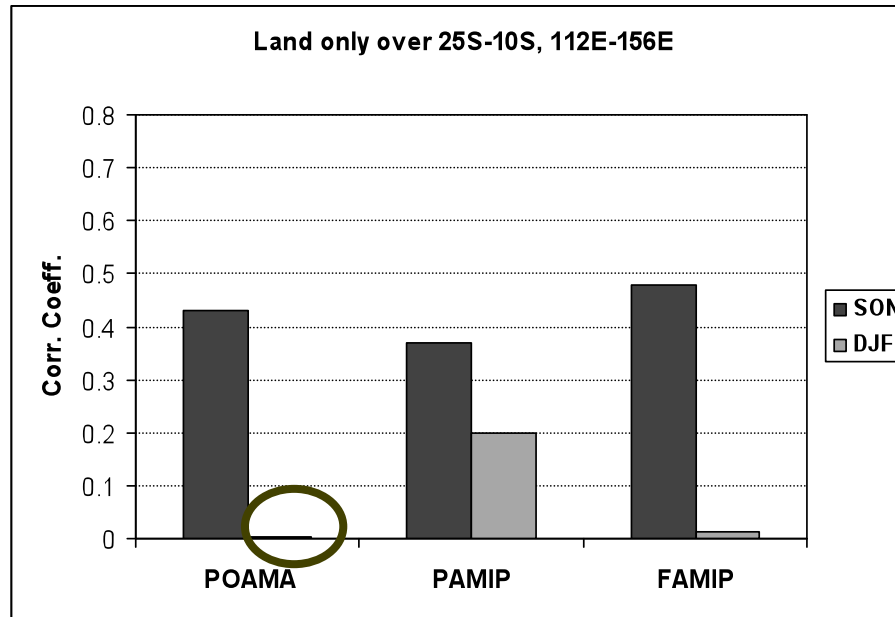


3 month means

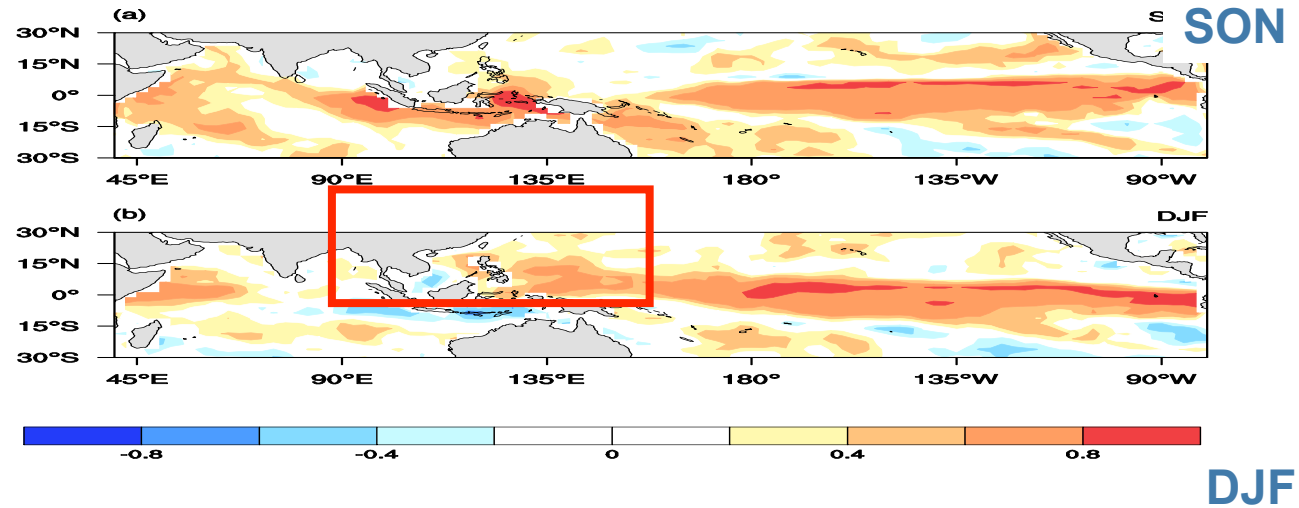
ECMWF-S3 SINTEX-F CFSV1 CFSV2 P15b P24

Despite good skill to predict El Niño, models systematically under-represent the teleconnection to the Indian Ocean

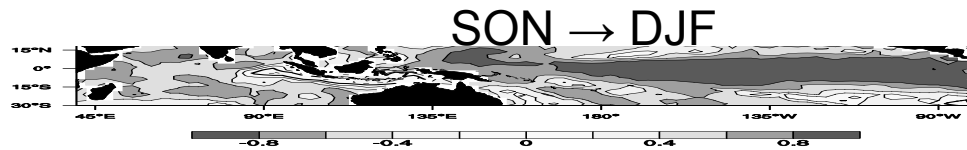
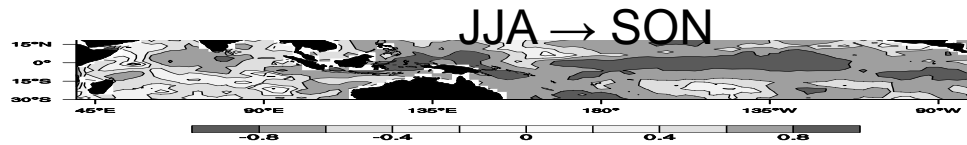
Forecast N. Austr. Rainfall (correlation) LT 1 mnth POAMA 1980-2008



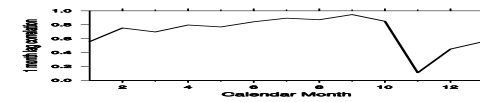
Point-wise correlation CMAP rainfall and OI SST 1980-2008



Lag-1 SST Correlation (obs)

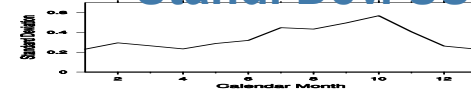


Lag-1 correlation



Jan Apr Jul Oct Jan

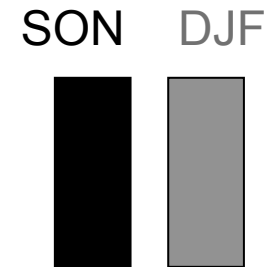
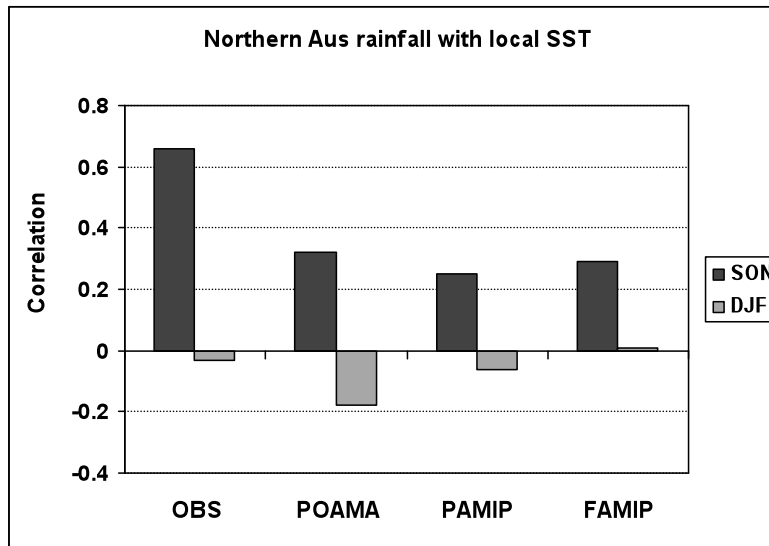
Stand. Dev. SST



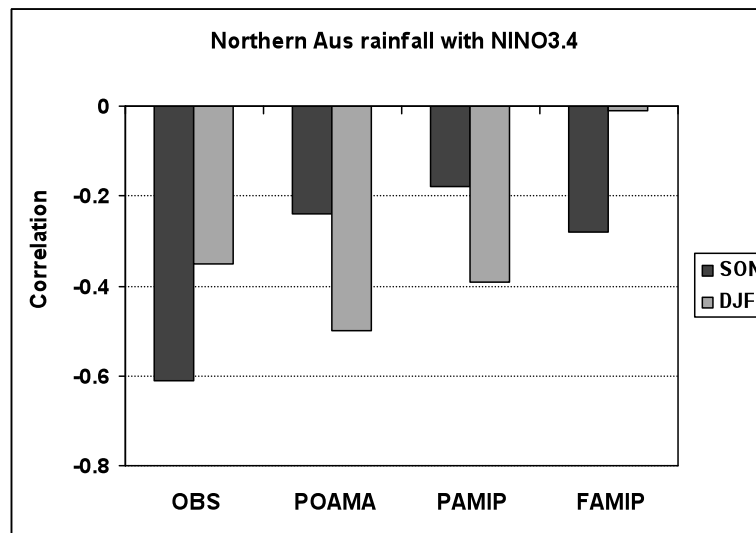
Jan Apr Jul Oct Jan

Hendon et al. 2011

Correlation N. Austr Rainfall with local SST 1980-2008



Correlation N. Austr Rainfall with Nino34



Conclusions

- **Seasonal forecast skill for summer monsoon rainfall is low**

Intrinsic limits: weak ENSO signal, local air-sea interaction, low variability, strong intraseasonal variability,.....

- **Numerous model biases suggest upper limit of prediction not reached**

ENSO (SST pattern) and its teleconnections to land and ocean
Mean rainfall bias over land and ocean >affects teleconnections
Mean state bias impacts coupled variability

- **CLIVAR CHFP (an expanded ENSEMBLES)**

understand monsoon predictability and prediction and highlight model errors

success will be gauged by feedback to model development

- **Land surface interactions (aerosols)**

basic understanding of role for monsoon variability/predictability

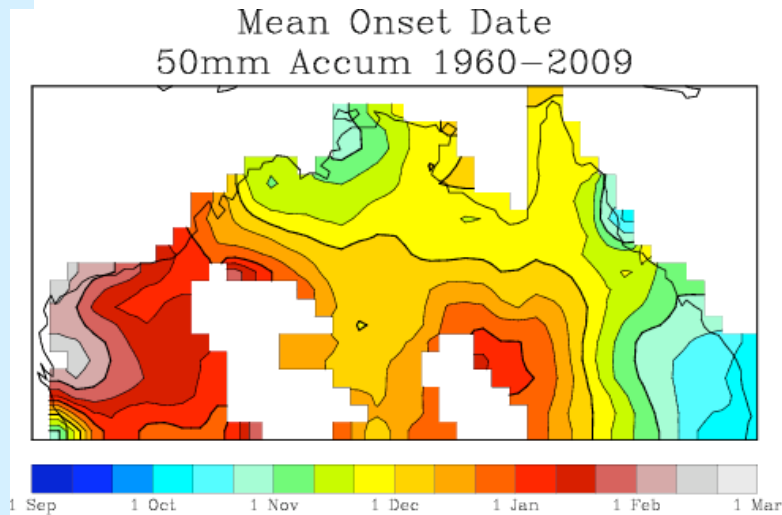
fidelity of models

initialization

- extras

Predicting wet season onset: date of accumulation of 50mm after 1st September

Drosowsky and Wheeler 2012

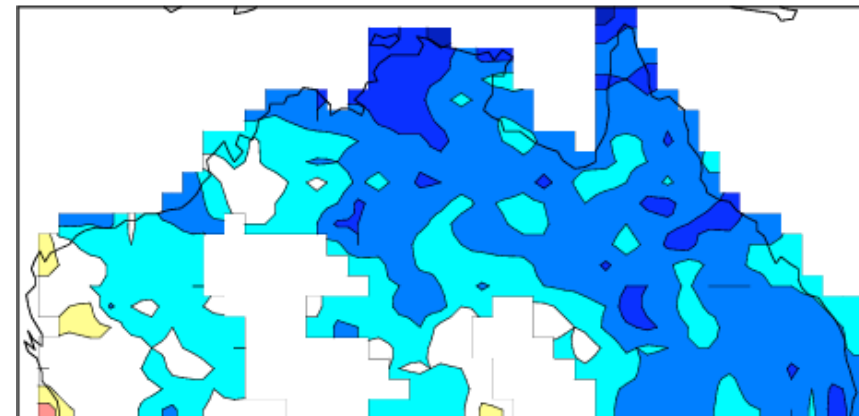


Mean onset date from observations

ranges from early Nov around Darwin/east coast to Dec inland

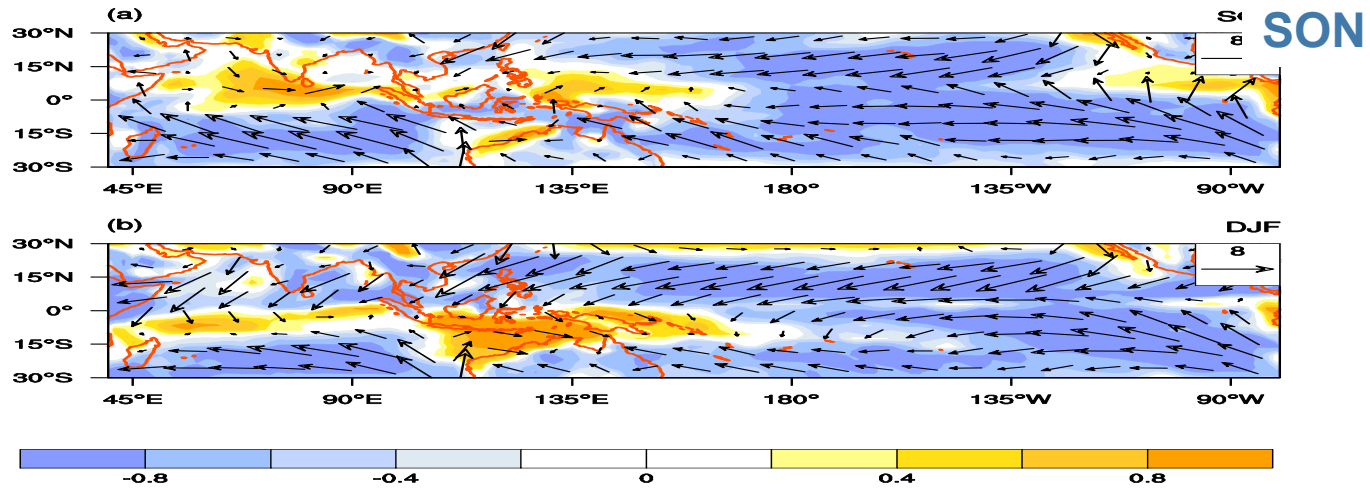
POAMA2 forecasts initialized on 1 September

Percent Correct P24abc 1960–2009



Per cent correct for predicting onset date above/below median
(50, 60, 70%)

Correlation V' and u' and mean V (vectors) NCEP2 1980-2008



DJF

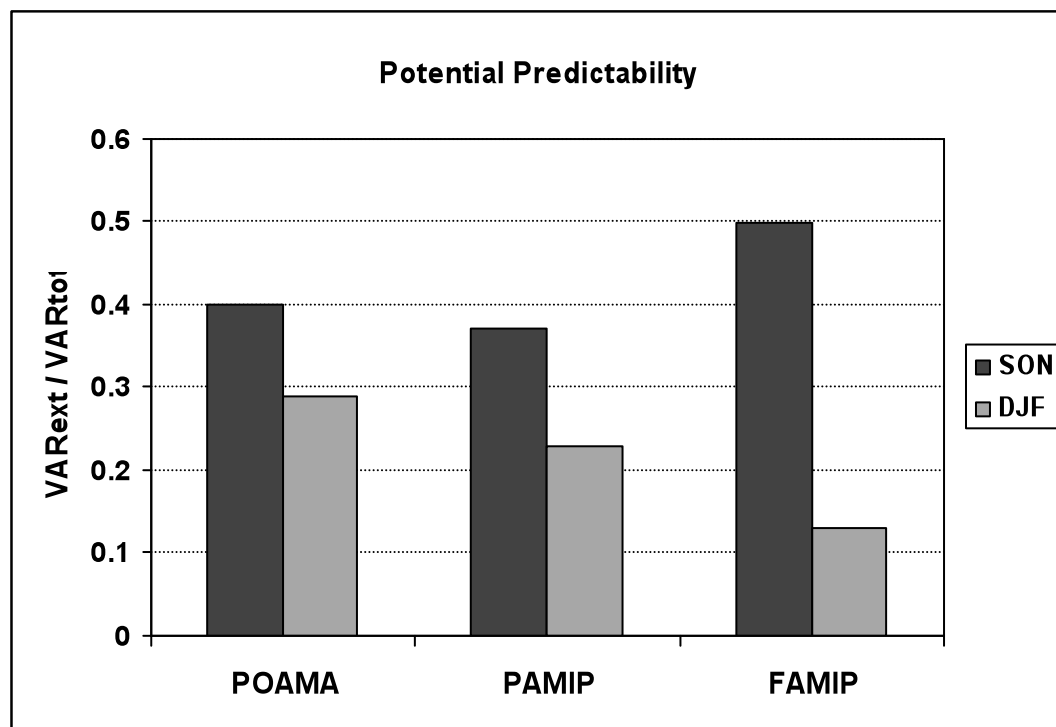
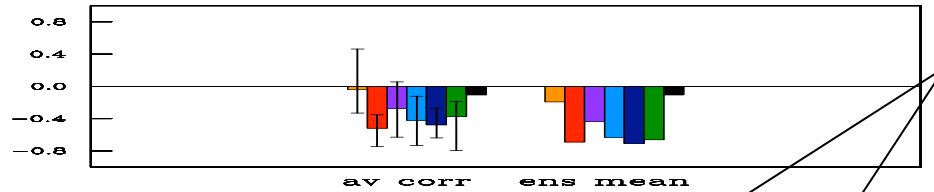


Fig. 10

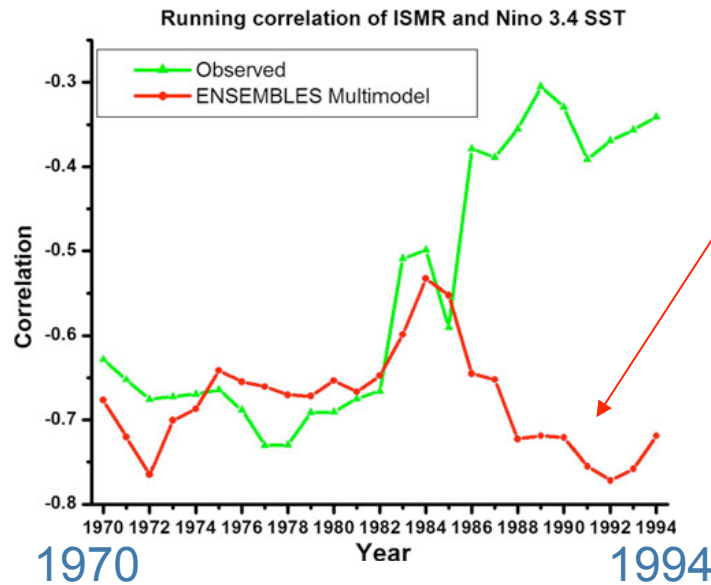
Correlation Nino3 with All-India Rainfall 1980-2005 LT 1 Forecasts



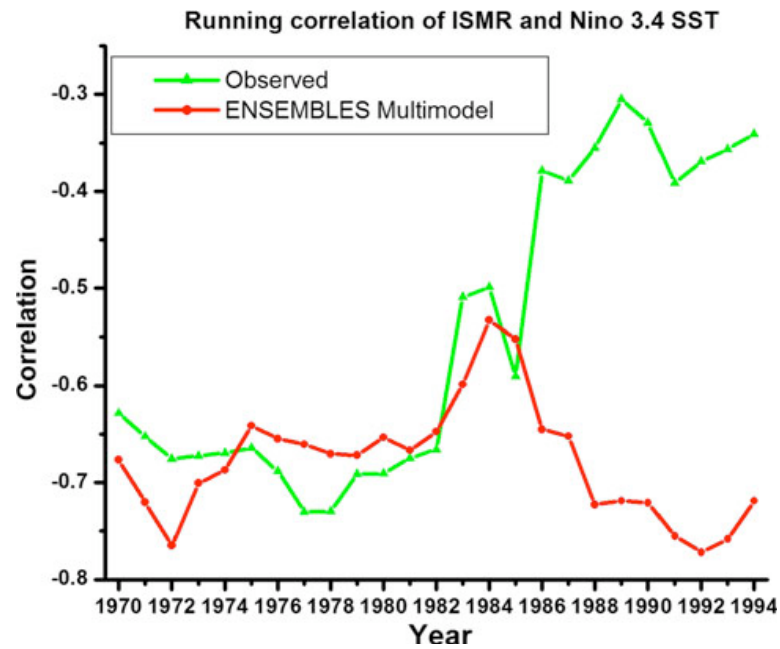
Individual members

Ensemble mean

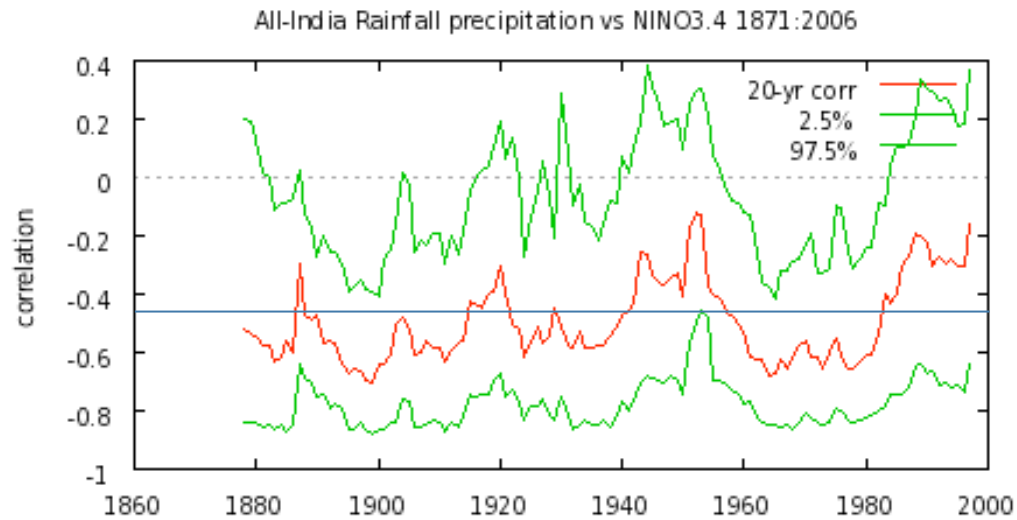
Rajeevan et al (2011) correlation based on ENSEMBLES MME



Correlation in 21 year sliding window



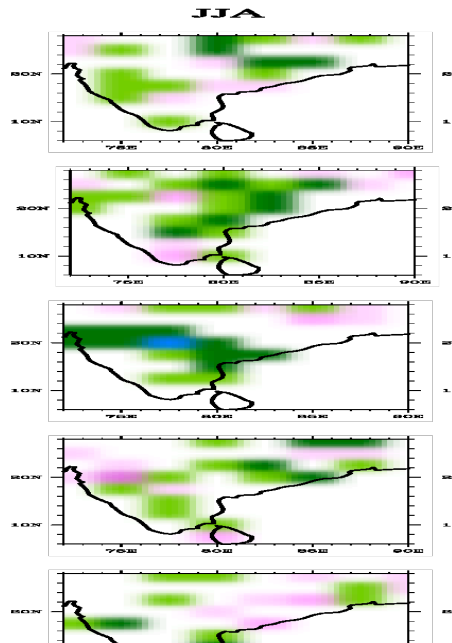
Rajeevan et al. 2011



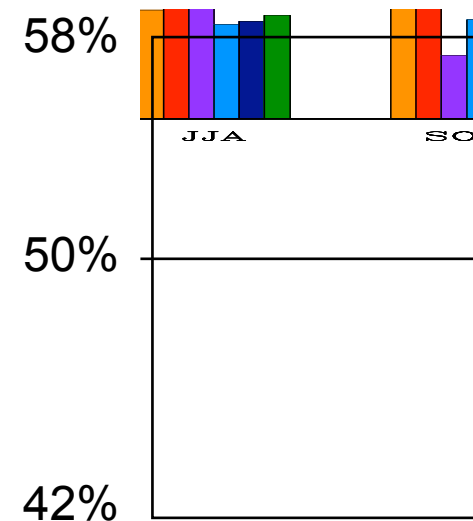
LT 1 month JJA 1980-2005 ENSEMBLES

Accuracy score for above/below median rainfall

ECSys3



Average score over all grids over India



ECMWF IPM MF UKMO CMCC UKMO

