Monsoon variability in different versions of the Met Office Climate Model

What is the relative importance to the simulation of monsoon variability of improved dynamics and physics in the atmosphere model against coupling the atmosphere model to an ocean model?

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Models used in this study

- HadAM3 AMIP-II 5-member ensemble 1979-1995
- HadCM3 coupled model run; 60 years selected (“1979-2038”)
- Prototype-HadGAM1 AMIP-II run 1979-1995
  - Non-hydrostatic; semi-implicit, semi-Lagrangian advection; Charney-Phillips grid; changes to boundary layer, convection, microphysics and gravity wave drag schemes
- Proto-HadGEM coupled model run; 30 years (“1979-2008”)
- All at “N48” horizontal resolution (3.75 by 2.5 degrees)
- HadAM3/CM3 with 19 levels
- HadGAM1/GEM with 38 levels

NOTE: HadGAM/GEM is currently under development; the prototypes used in this study do not represent the final version.

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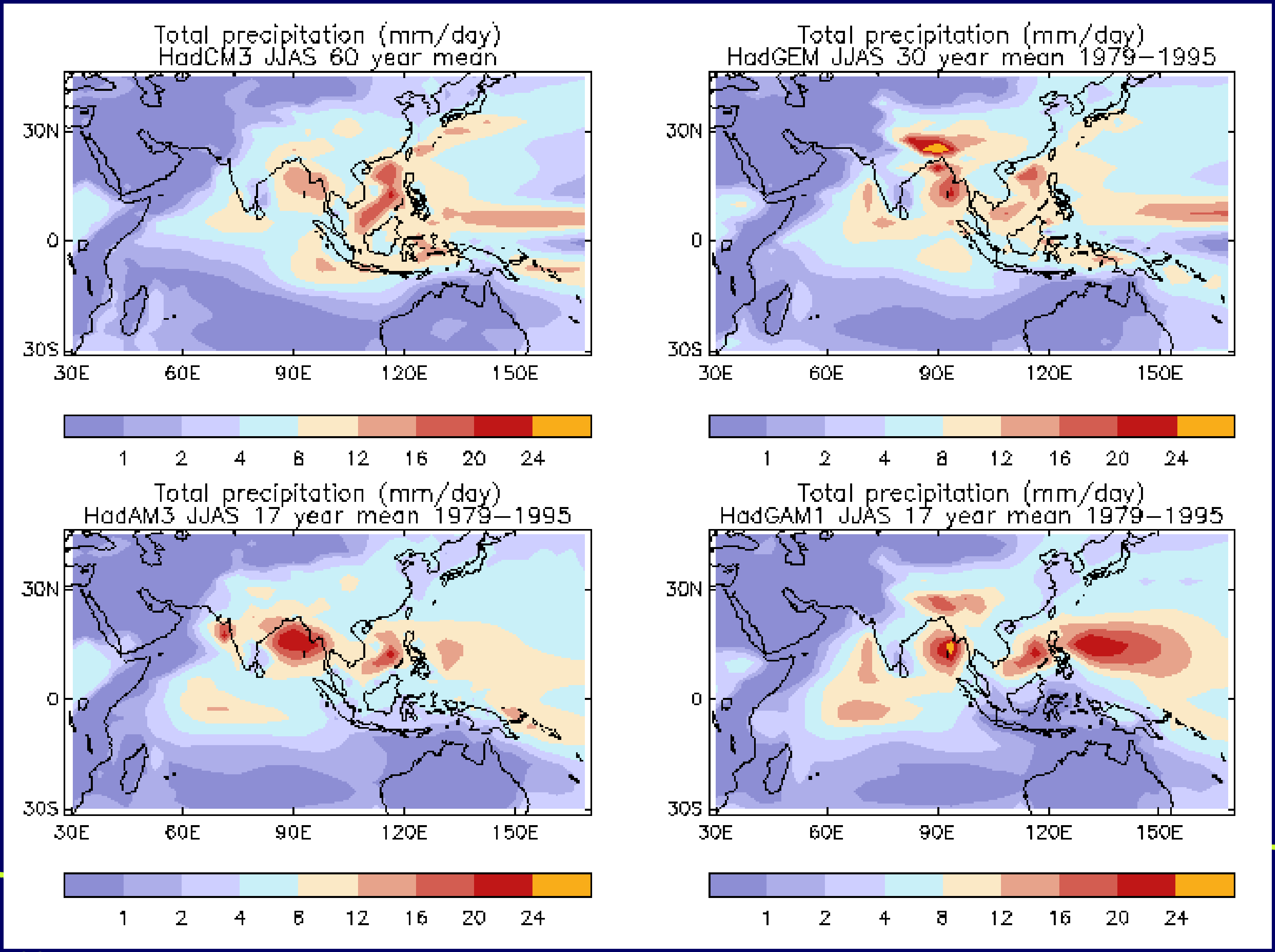
Monsoon climatology - JJAS precipitation

CM3

GEM

AM3

GAM



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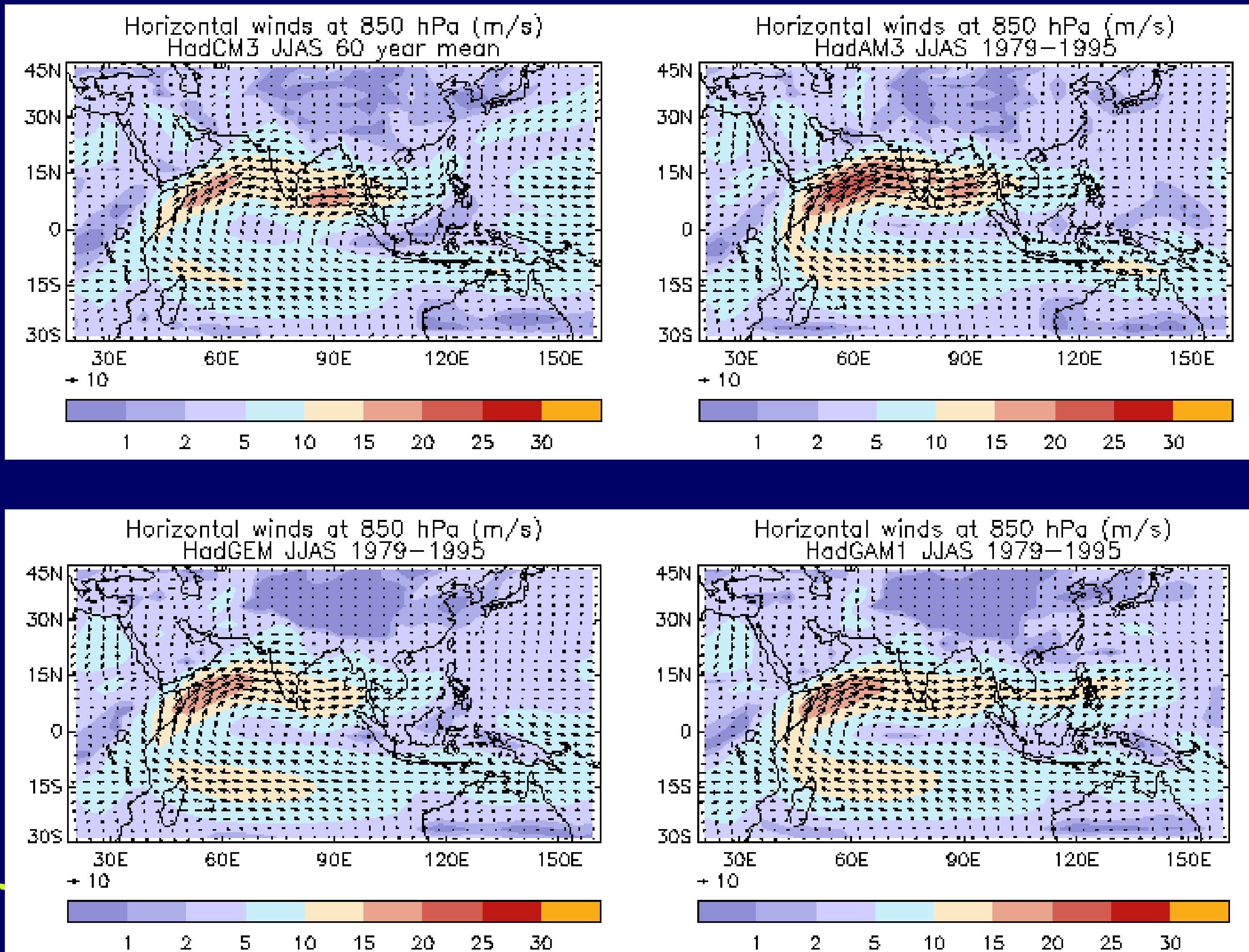
JJAS 850 hPa winds

CM3

AM3

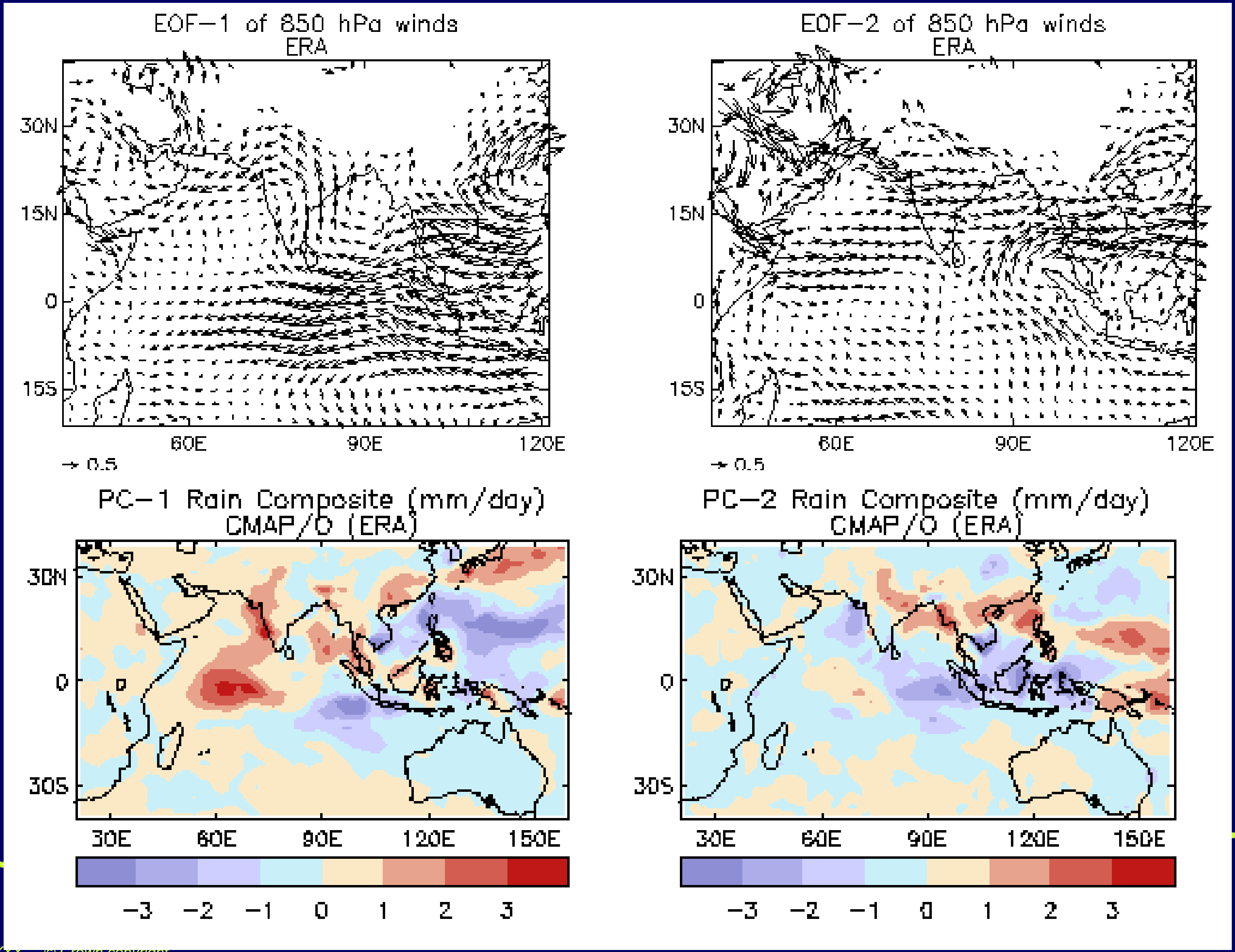


GEM

GAM

INTERANNUAL VARIABILITY

ERA EOF-1 24% variance | ERA EOF-2 21% variance



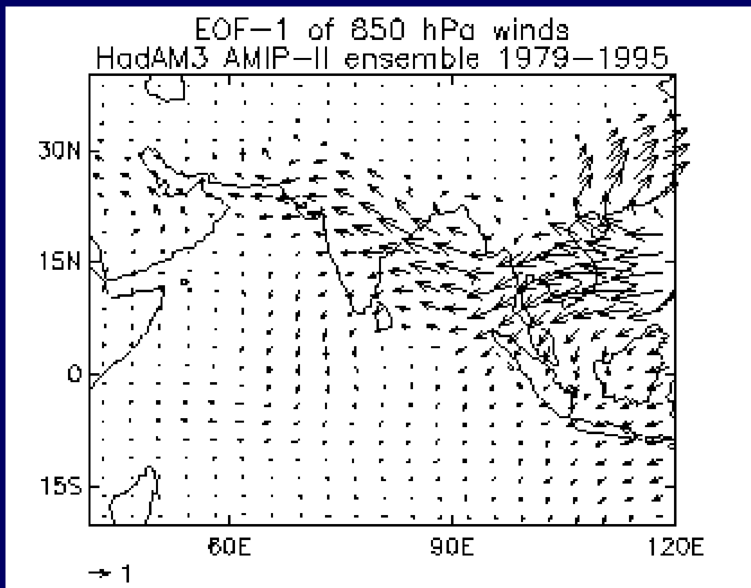
850 hPa winds

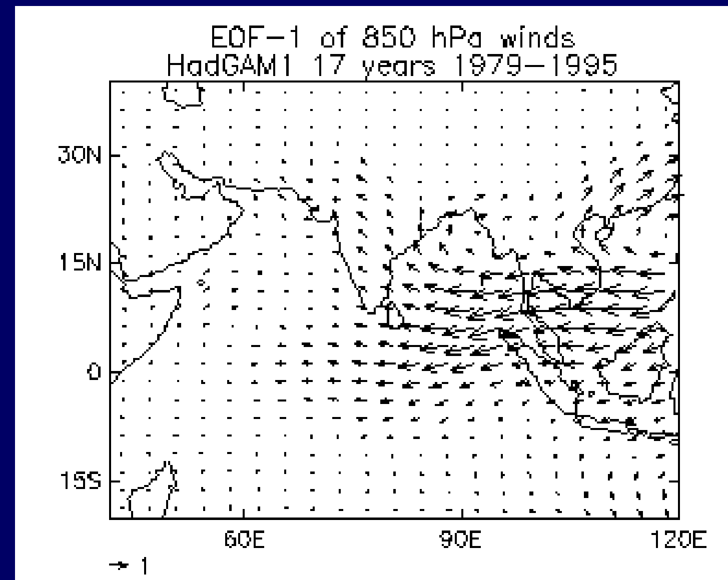
Precip

Met Office

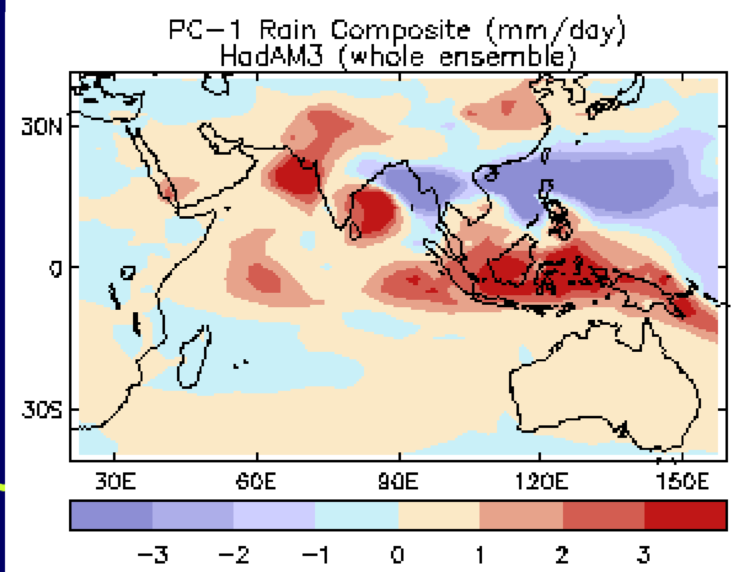
HadAM3 EOF-1
38% variance

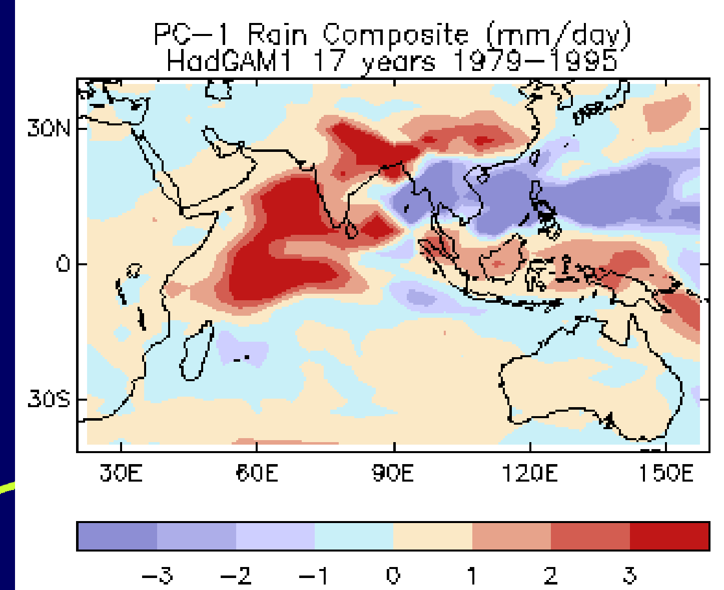
HadGAM EOF-1
49% variance





850 hPa winds

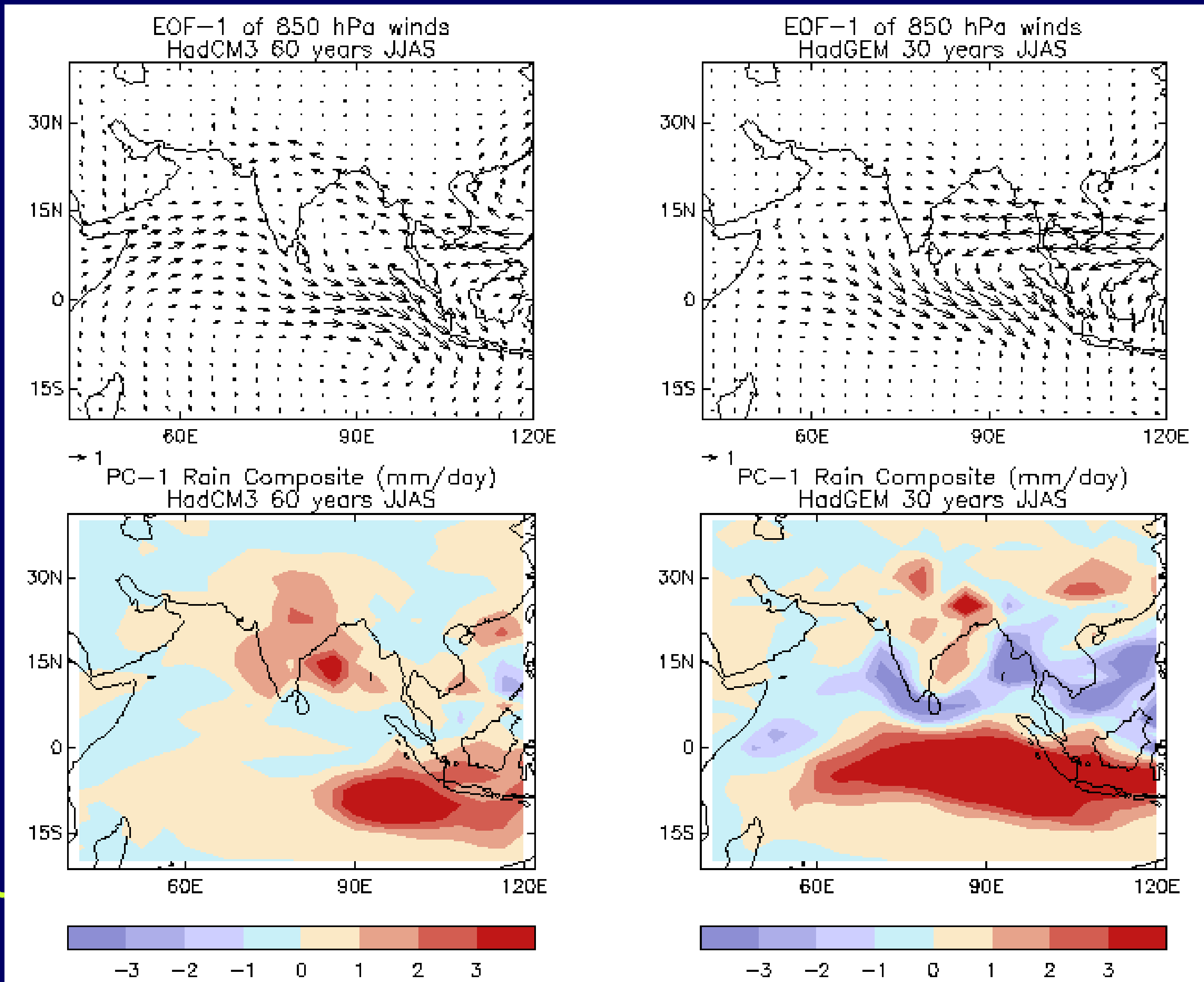




Precip

HadCM3 EOF-1
30% variance

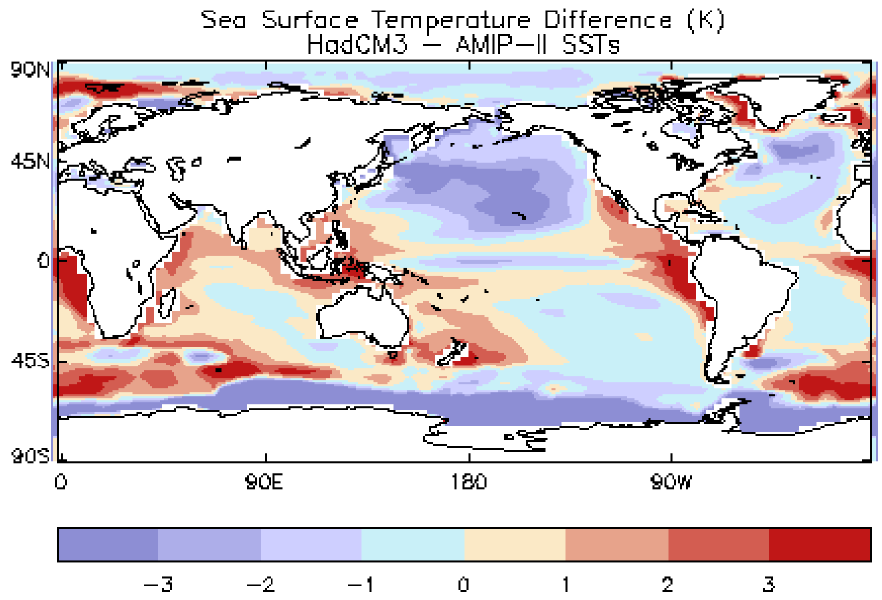
HadGEM EOF-1
36% variance



850 hPa winds

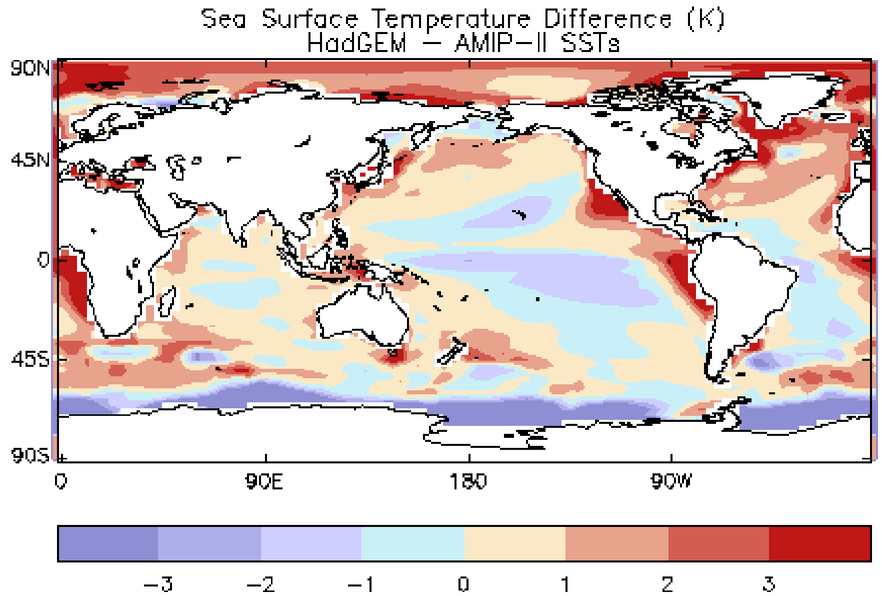
Precip

SST errors in the coupled runs



HadCM3

Differences from 17-year AMIP-II SSTs

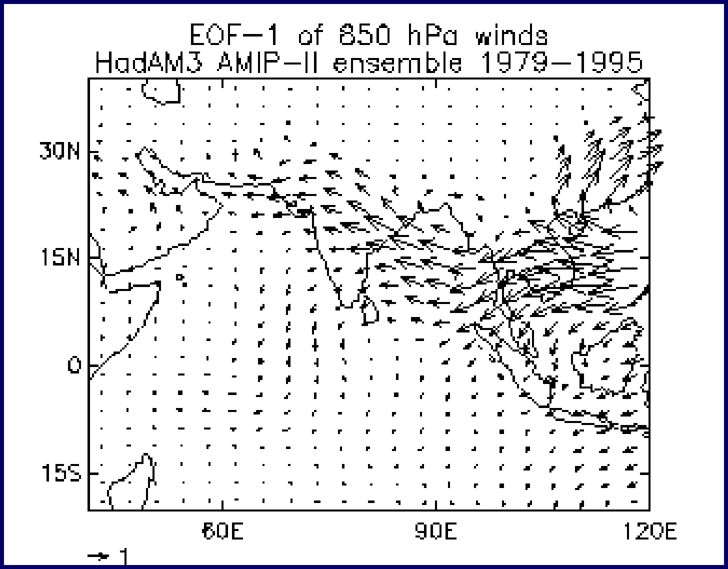


HadGEM

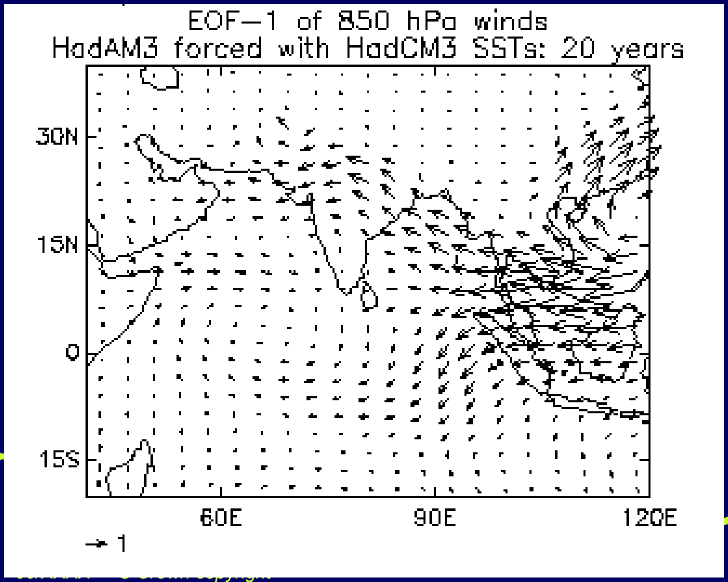
Coupling versus SST bias

- Test: Force HadAM3 with SSTs from HadCM3 [Hilary Spencer, CGAM]
- Impact on interannual variability is small.
- This implies that the atmosphere-ocean coupling is influencing interannual variability in HadCM3.

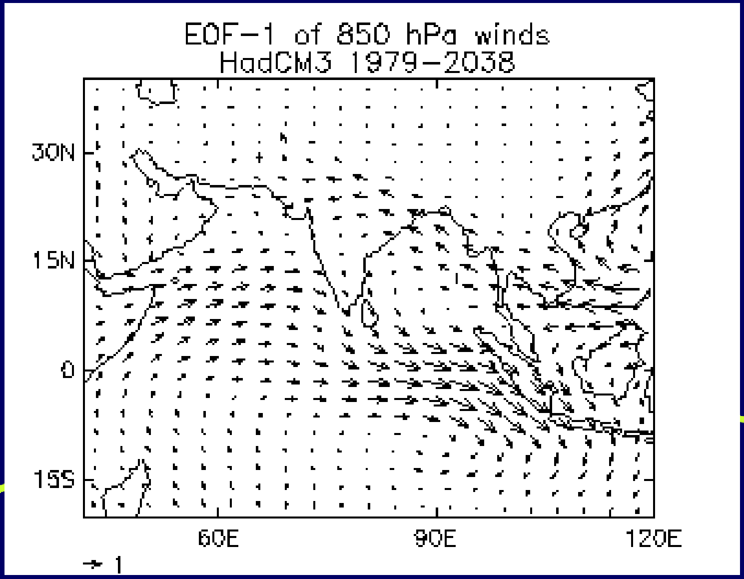
HadAM3 EOF-1 (38%)



HadAM3 forced with HadCM3 SSTs EOF-1 (35%)

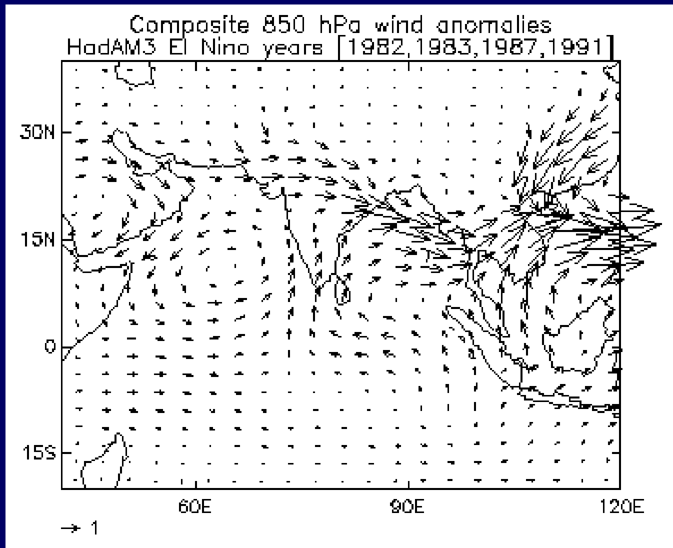


HadCM3 EOF-1 (30%)

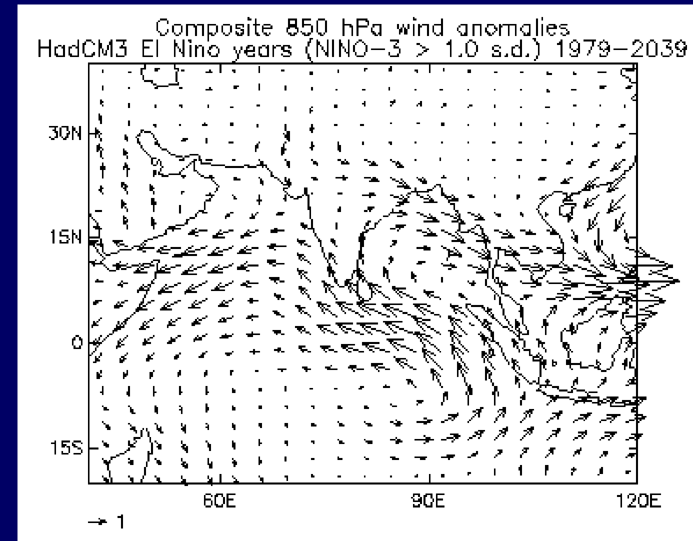


850 hPa wind anomalies El Nino years

HadAM3

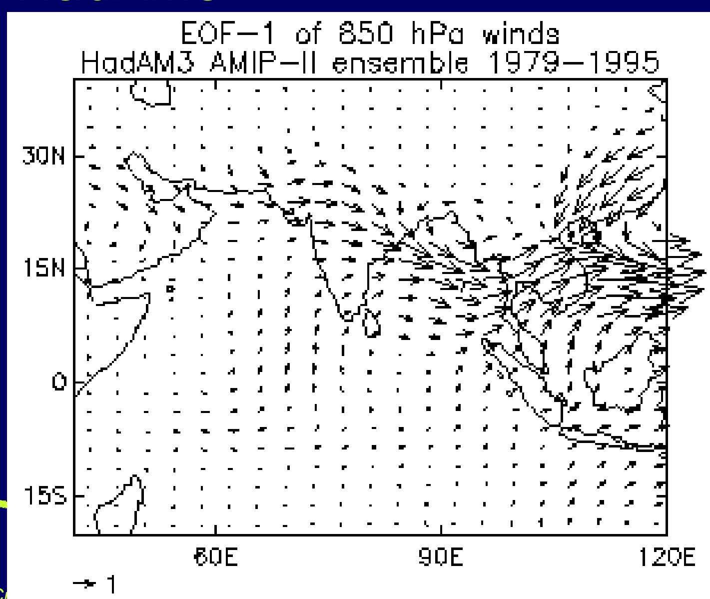


HadCM3

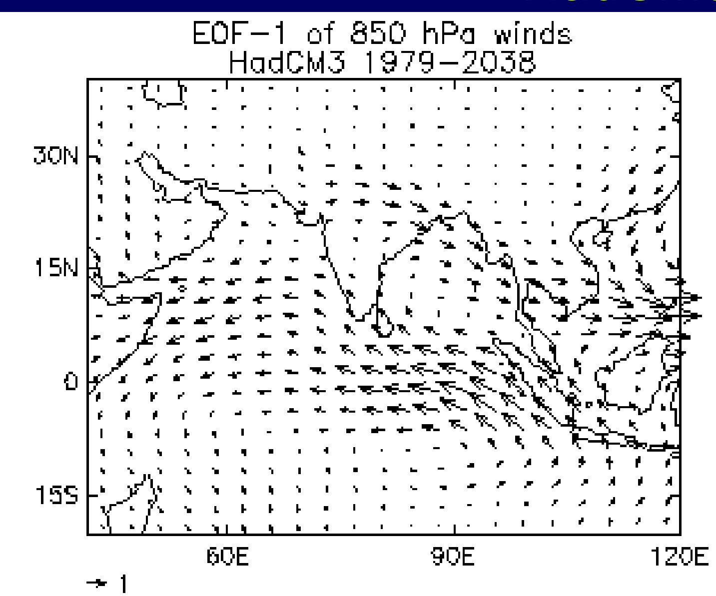


EOF-1 of 850 hPa wind

HadAM3



HadCM3



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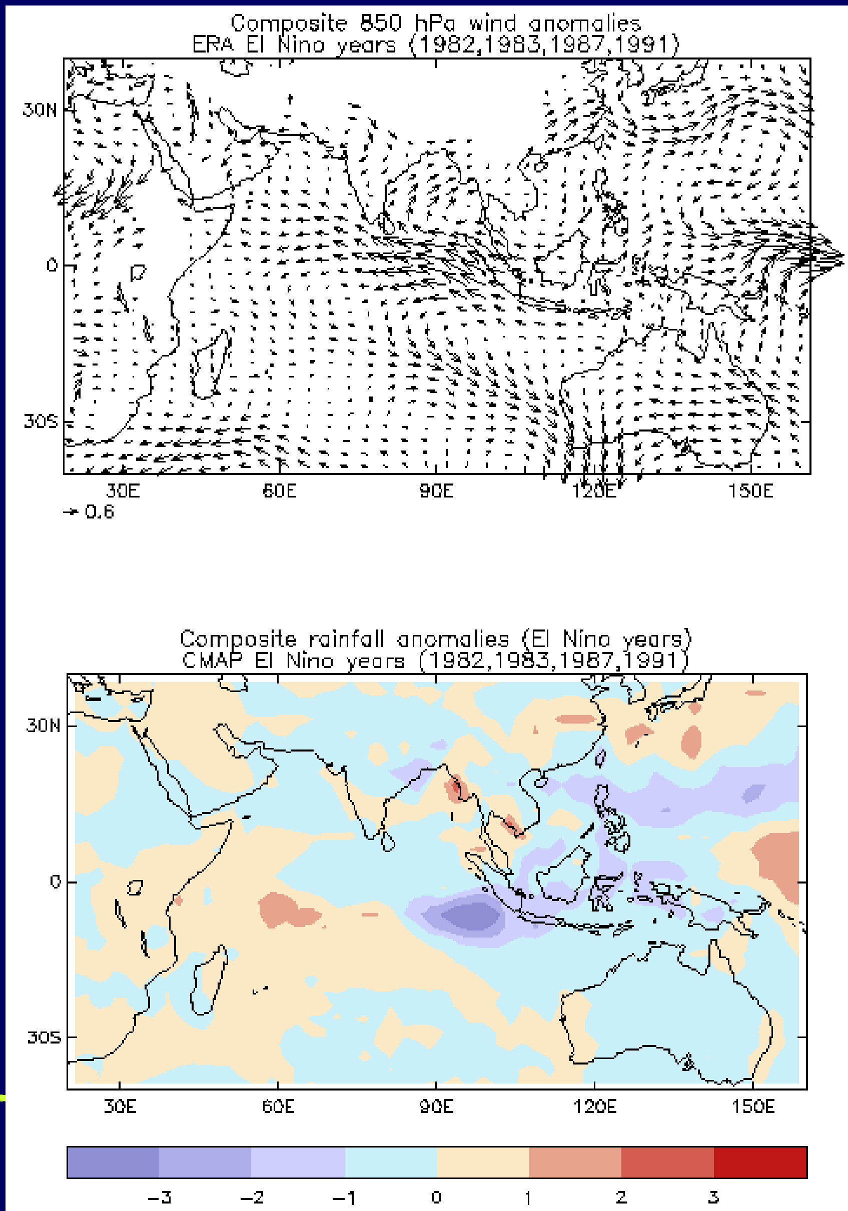
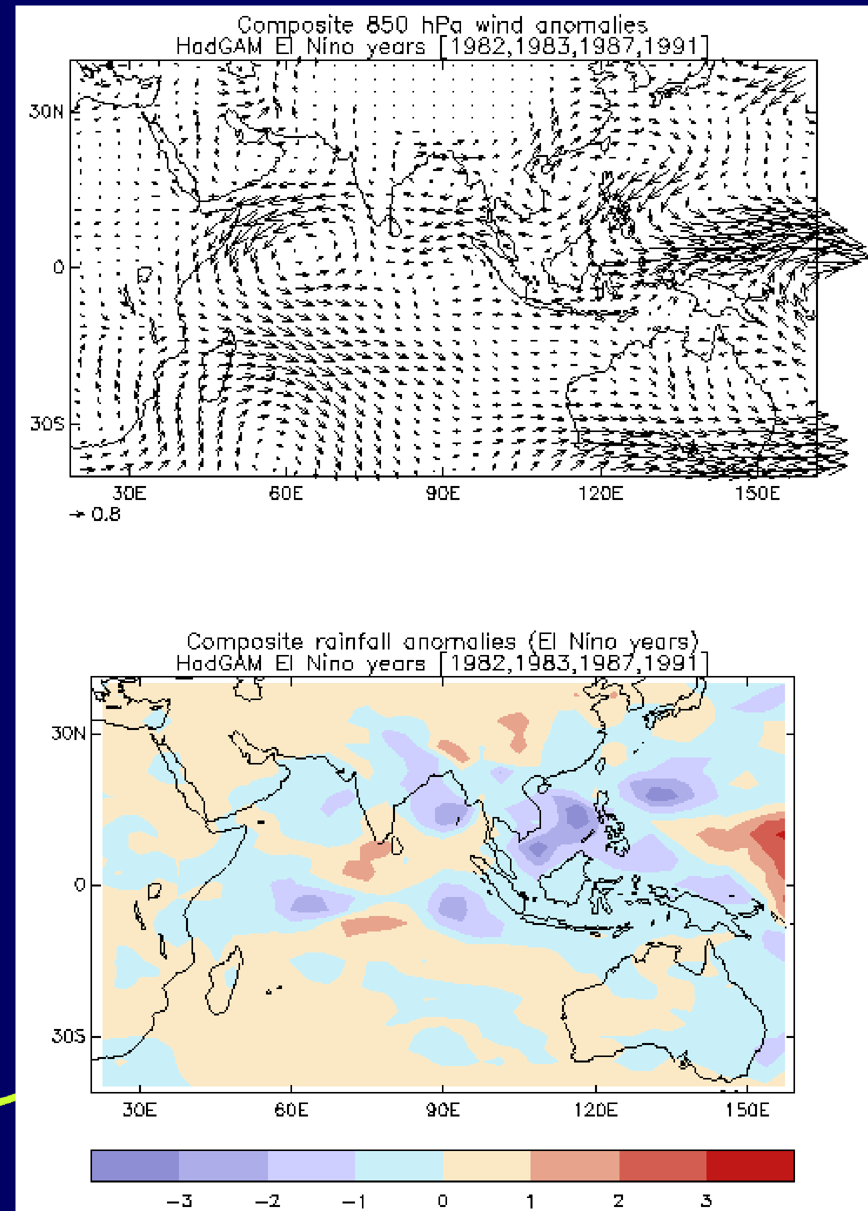
850 hPa wind and precipitation anomalies El Nino years

ERA/CMAP



HadGAM

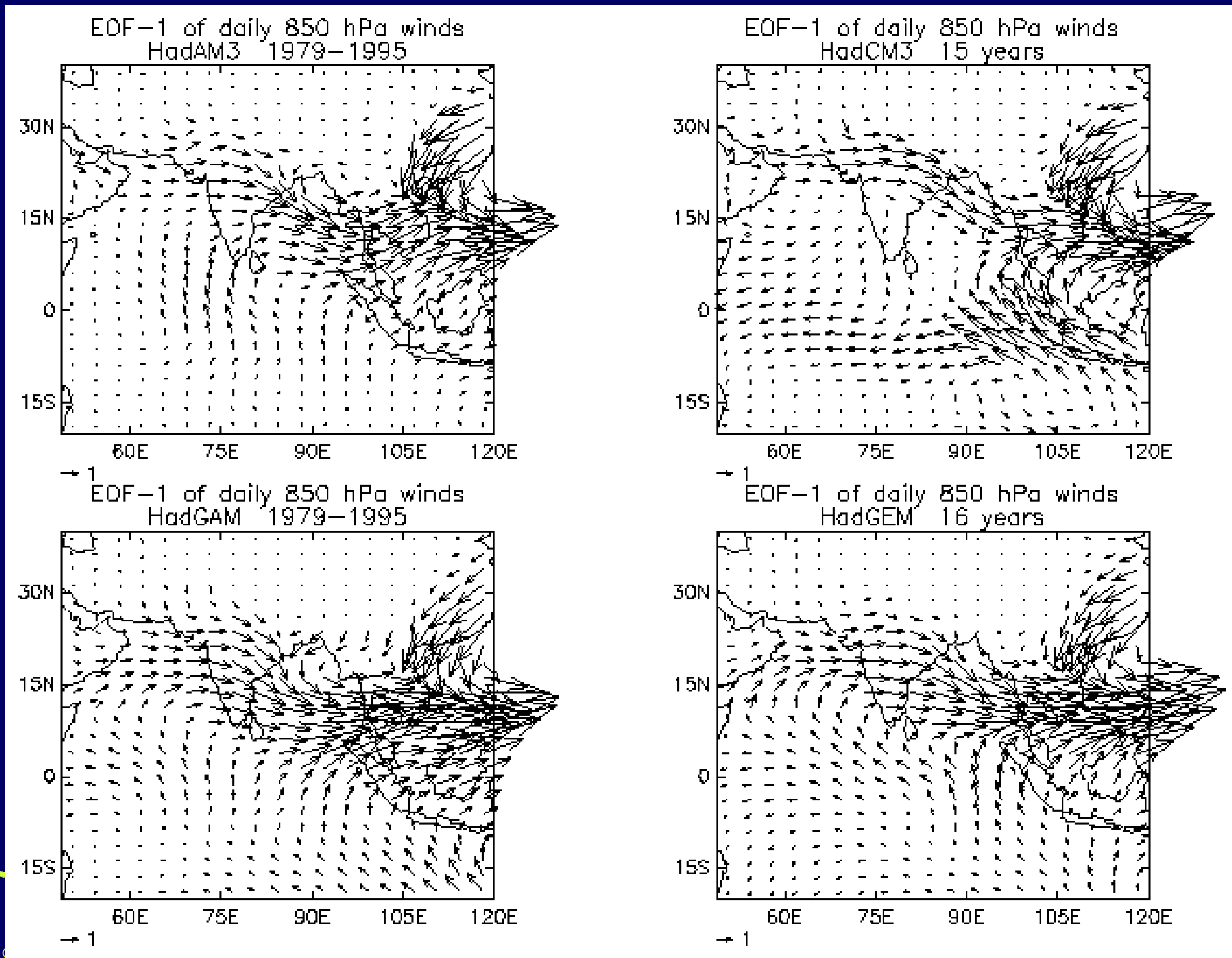


INTRASEASONAL VARIABILITY

EOF-1 of daily 850 hPa winds

AM3
13.3%

CM3
11.1%



GAM
13.6%

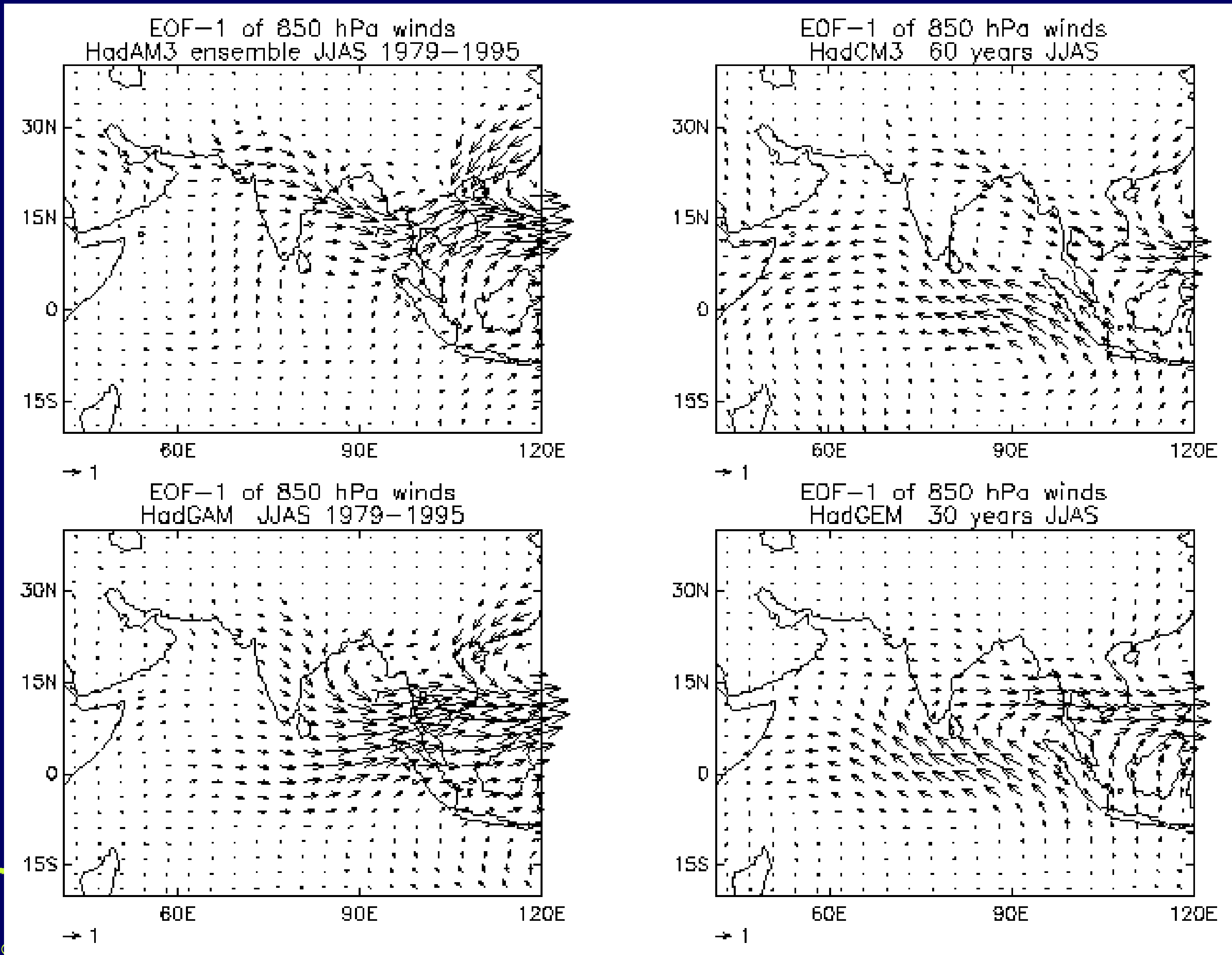
GEM
14.6%

INTERANNUAL VARIABILITY - Recap

EOF-1 of seasonal 850 hPa winds

AM3
38%

CM3
30%



GAM
42%

GEM
36%

INTRASEASONAL VARIABILITY: NO IAV

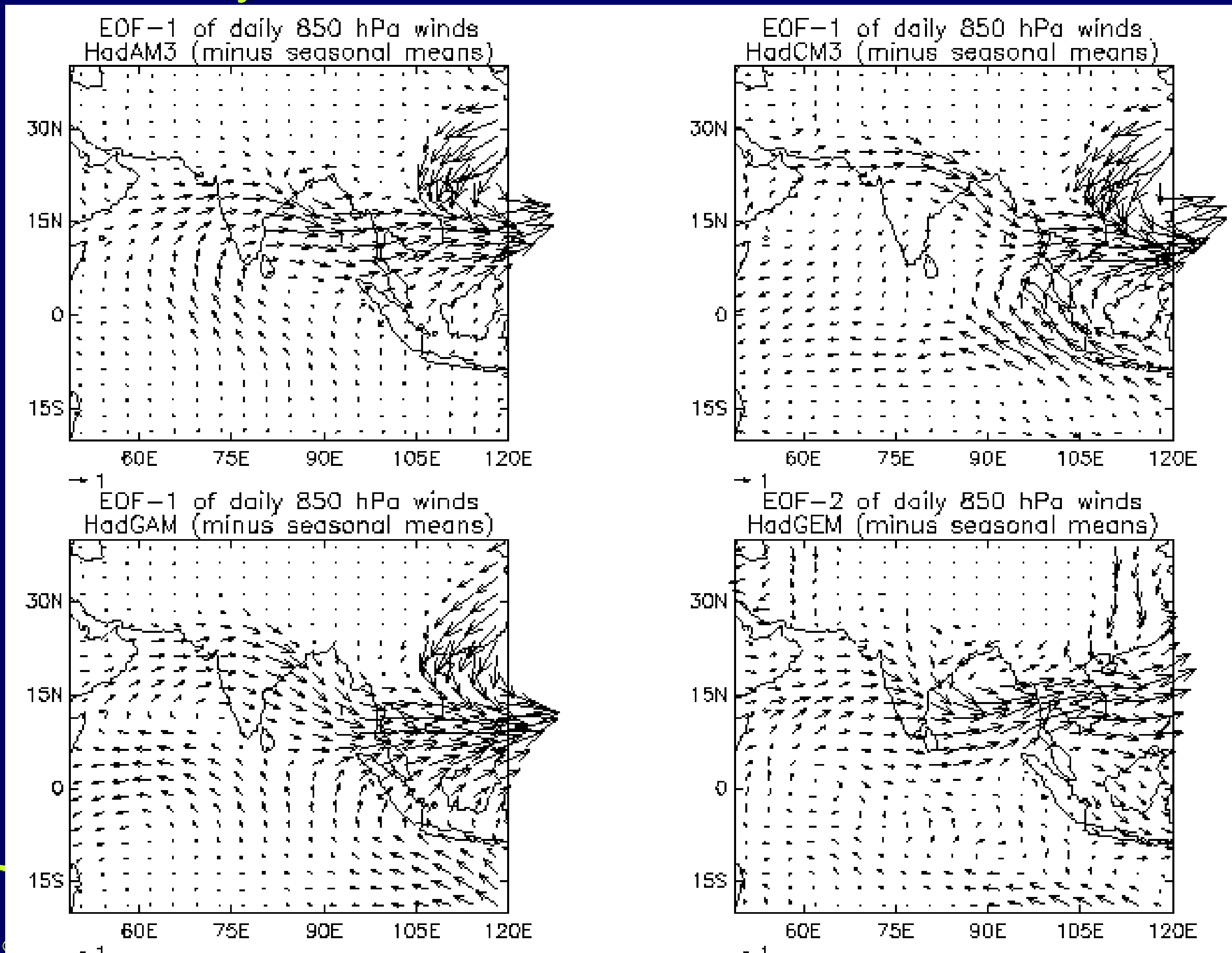
EOFs of daily 850 hPa winds; Seasonal means subtracted

AM3
10.1%

CM3
9.2%

GAM
11.4%

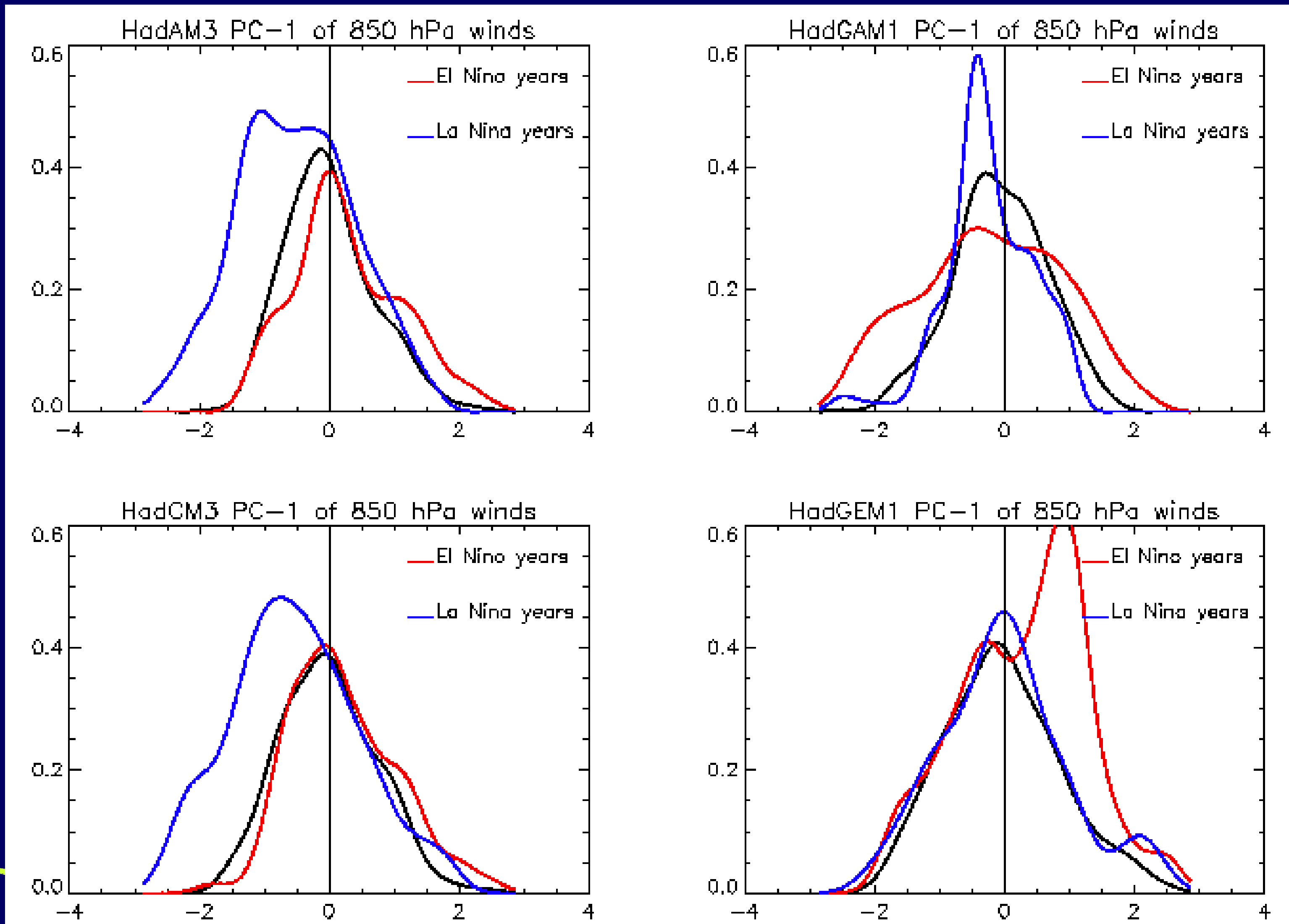
GEM
5.5%



Probability Distribution Functions of PC-1 in El Nino and La Nina years

AM3

GAM



CM3

GEM

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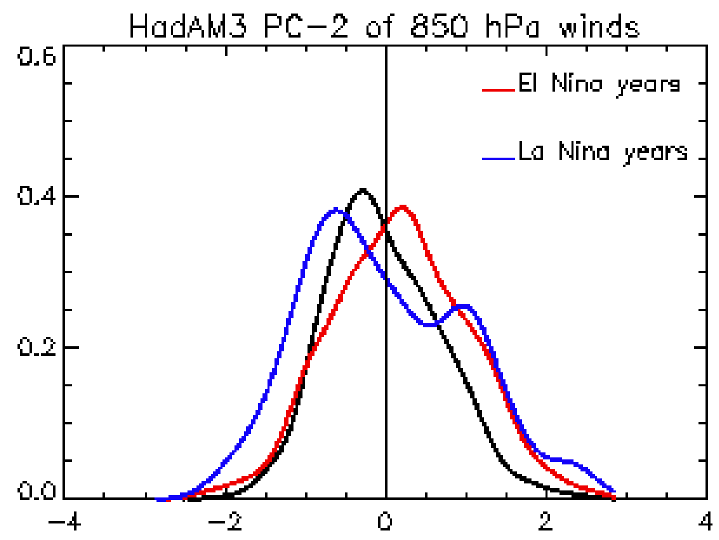
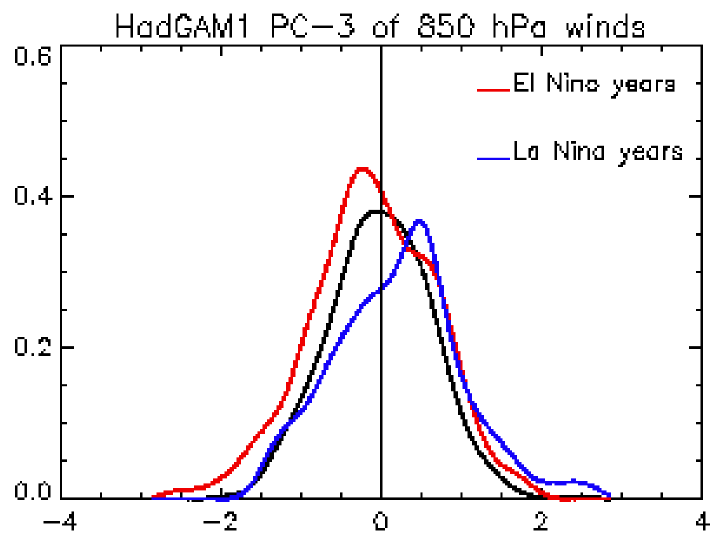
Probability Distribution Functions in El Nino and La Nina years

HadAM3 PC-2



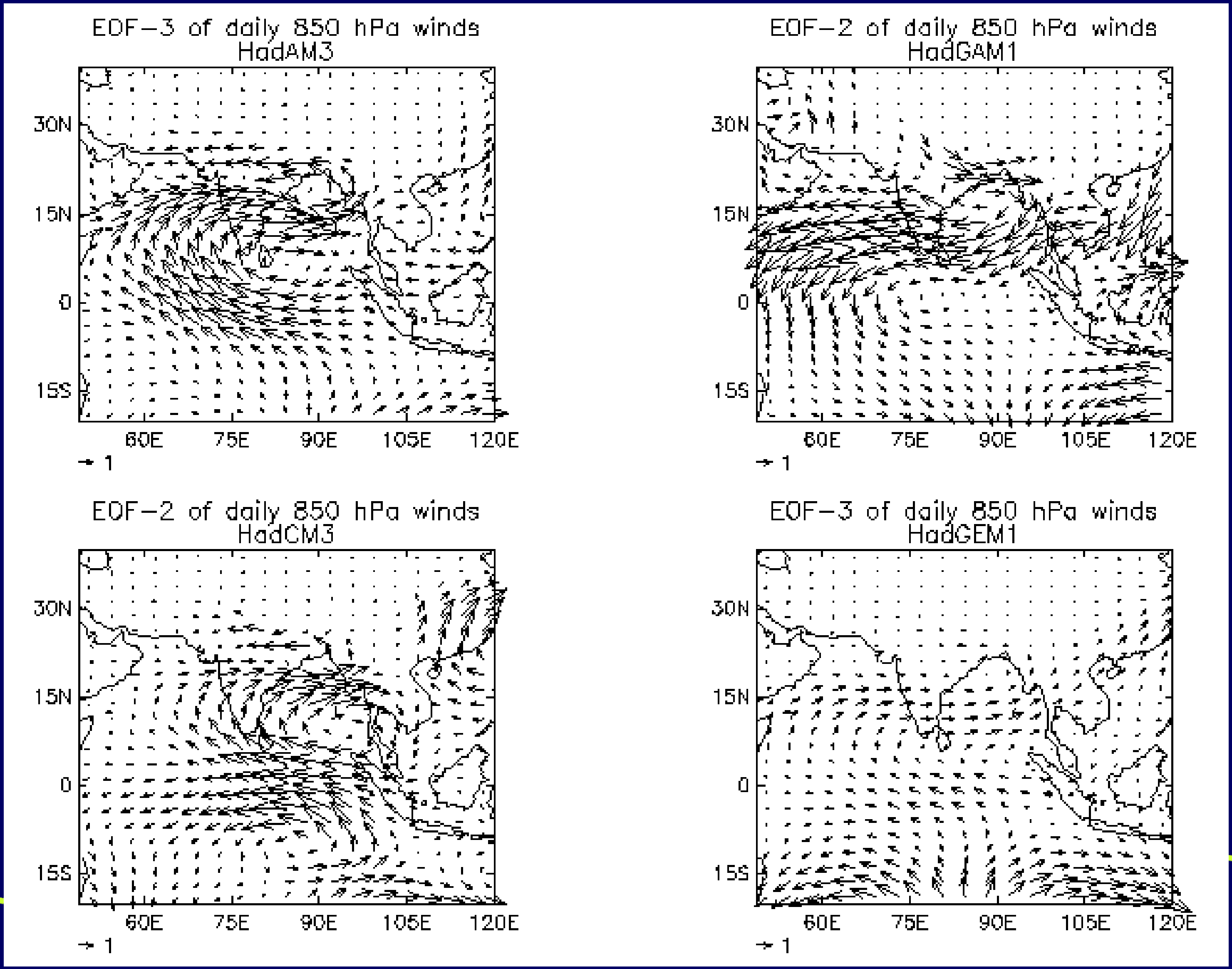
HadGAM PC-3



Intraseasonal mode associated with All-India Rainfall variability

AM3
EOF3

GAM
EOF2



CM3
EOF2

GEM
EOF3

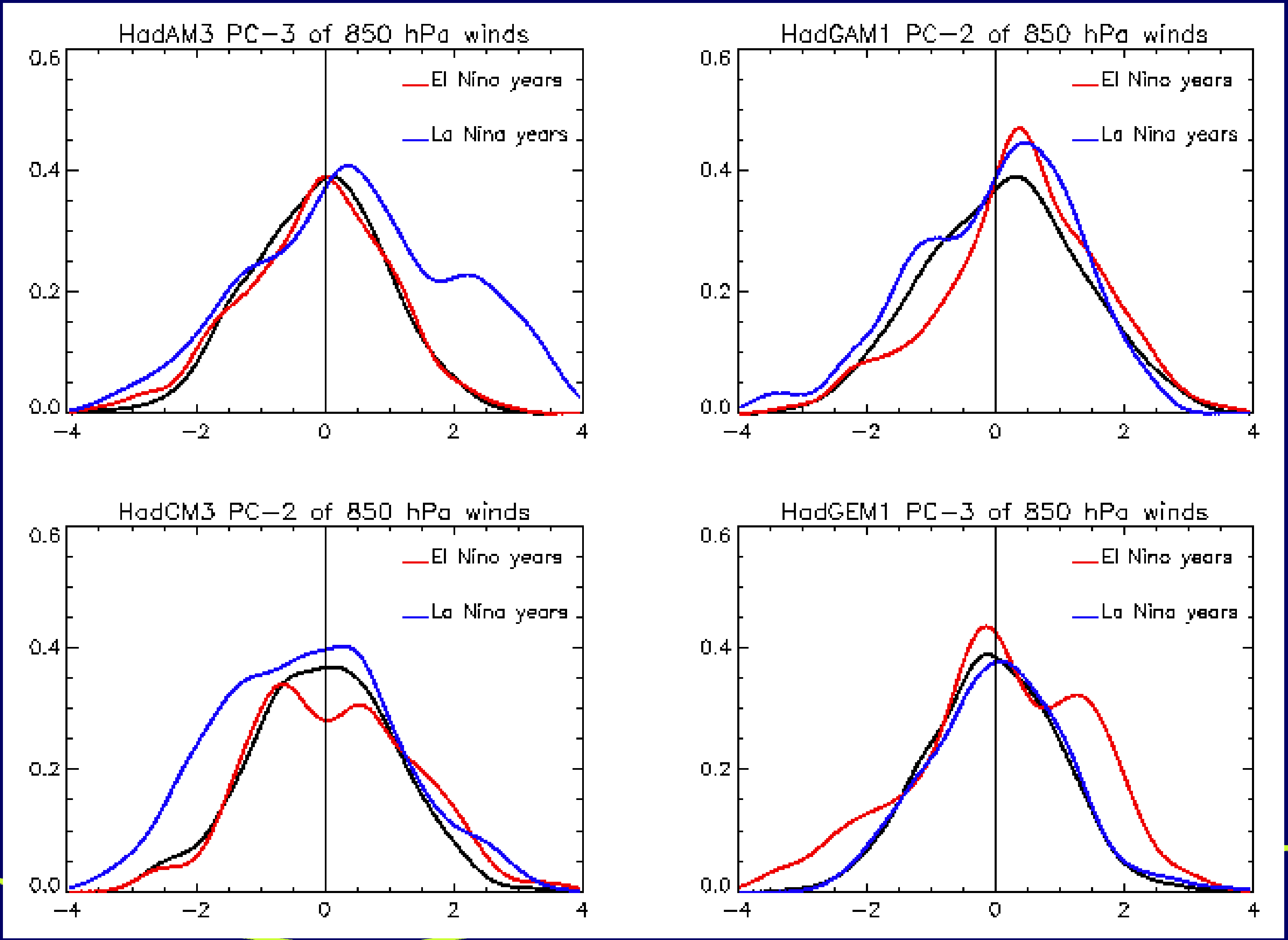
PDFs in El Nino and La Nina years
"AIR" intraseasonal mode

AM3
PC-3

GAM
PC-2

CM3
PC-2

GEM
PC-3



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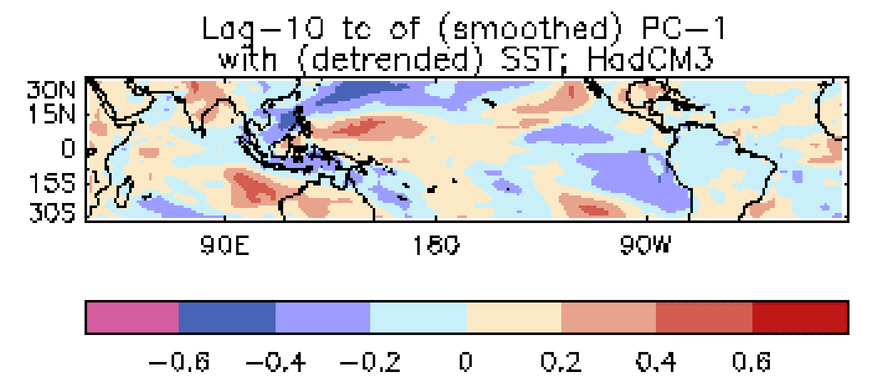
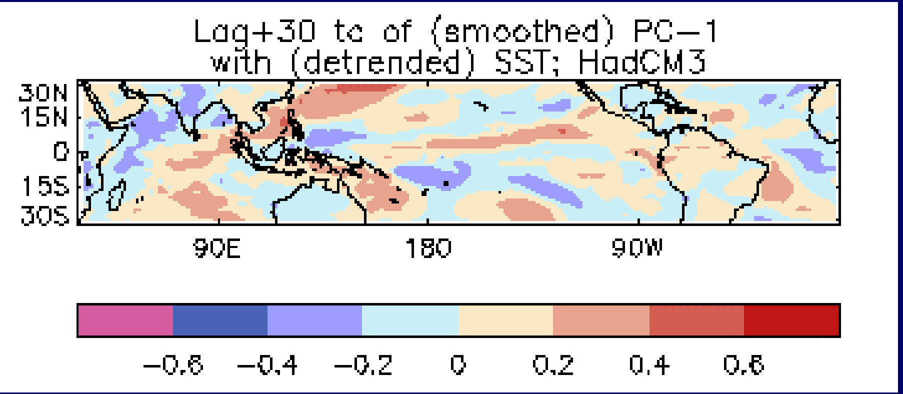
Lag/lead correlations of dominant intraseasonal mode with surface temperatures

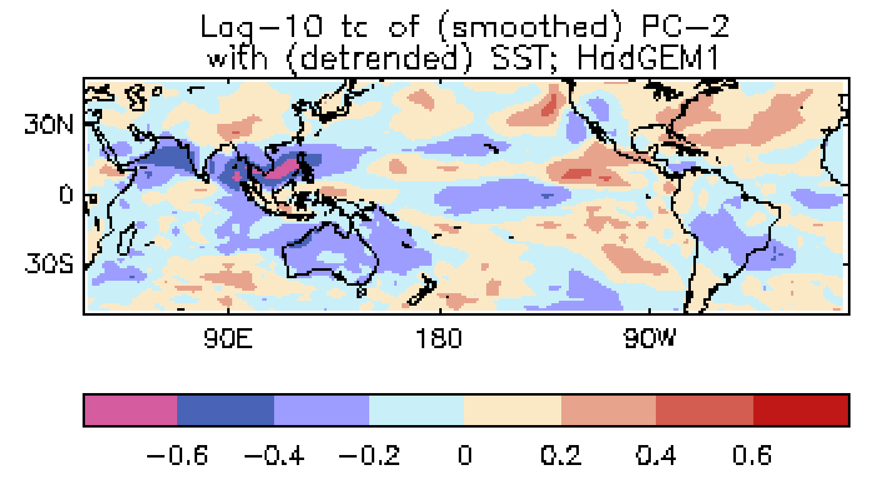
HadCM3 Lag-10 days



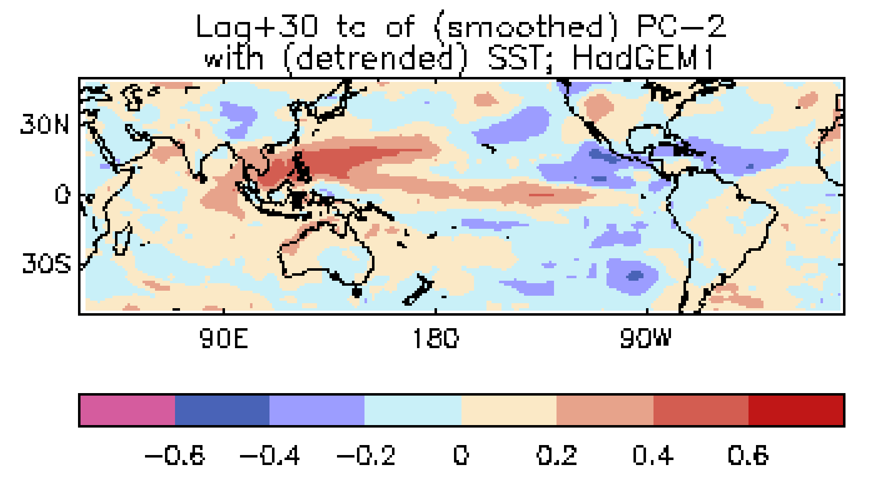
HadCM3 Lag+30 days



HadGEM1 Lag-10 days



HadGEM1 Lag+30 days



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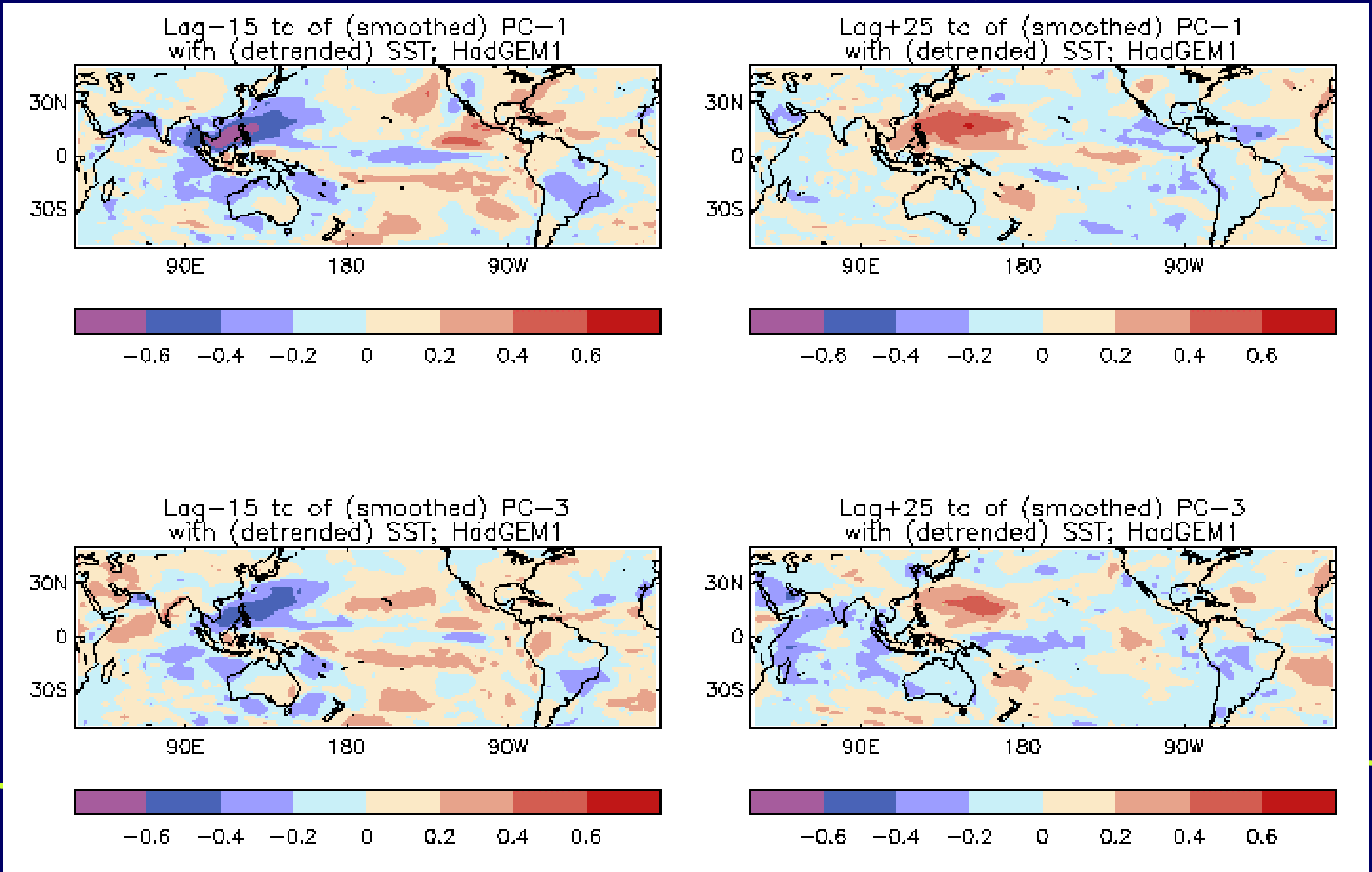
Lag/lead correlations of two intraseasonal modes with surface temperatures in HadGEM1

Lag-15 days

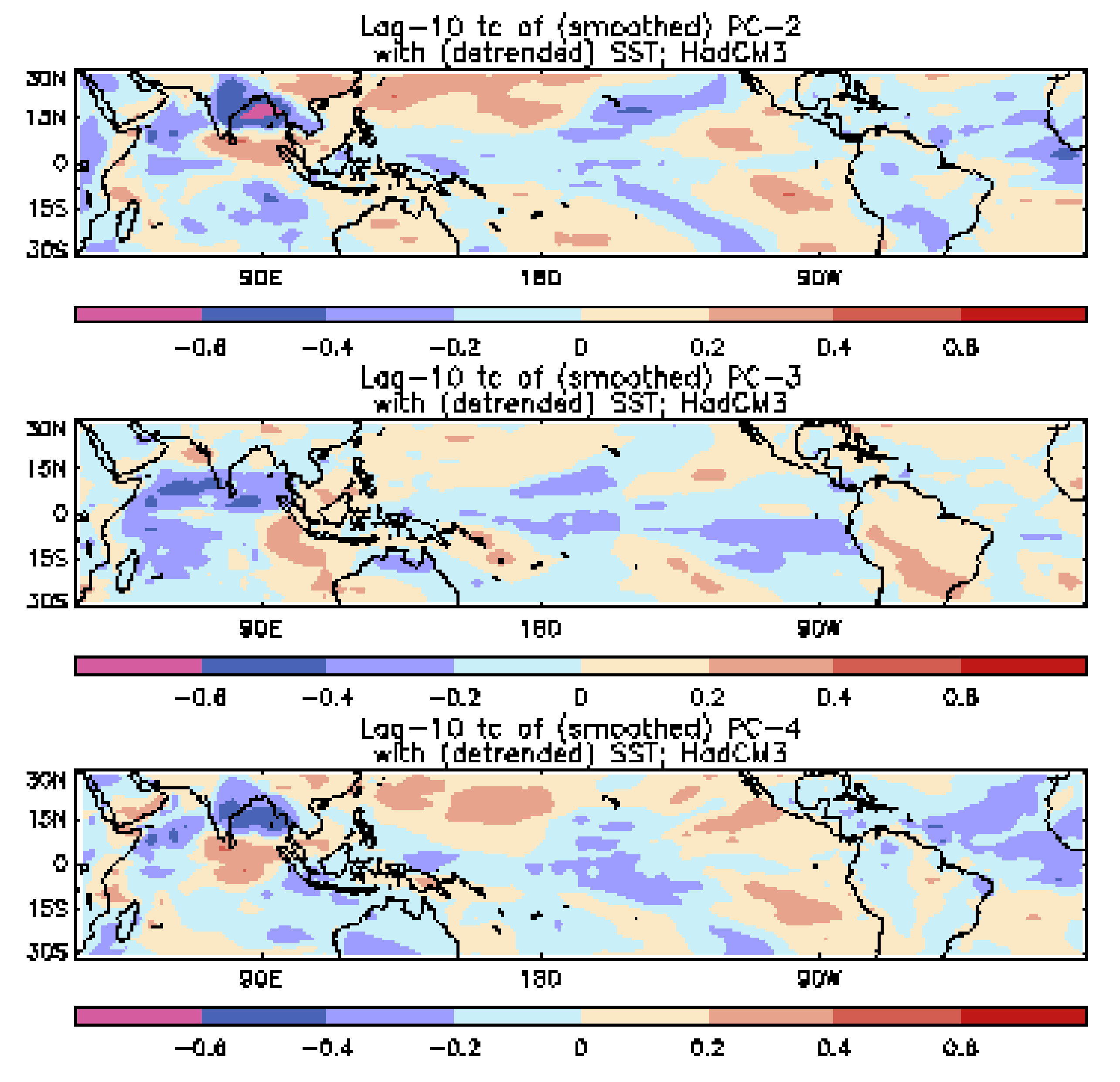
Lag+25 days



PC-1

PC-3

Lag-10 correlation of HadCM3 PCs with surface temps



PC-2

PC-3

PC-4

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Summary

- Despite the vast differences between the two atmosphere-only models, the dominant mode of interannual variability is very similar and explains ~40% of the variance.
- The dominant modes in the coupled models are similar to those in the atmosphere-only versions, although there is an additional contribution from the equatorial Indian Ocean. This does not appear to be associated with coupled model SST errors.
- In HadAM3/CM3 the interannual variability is significantly linked to ENSO. In HadGAM/GEM, internal variability appears to dominate, although anomalies in ENSO years are realistic.

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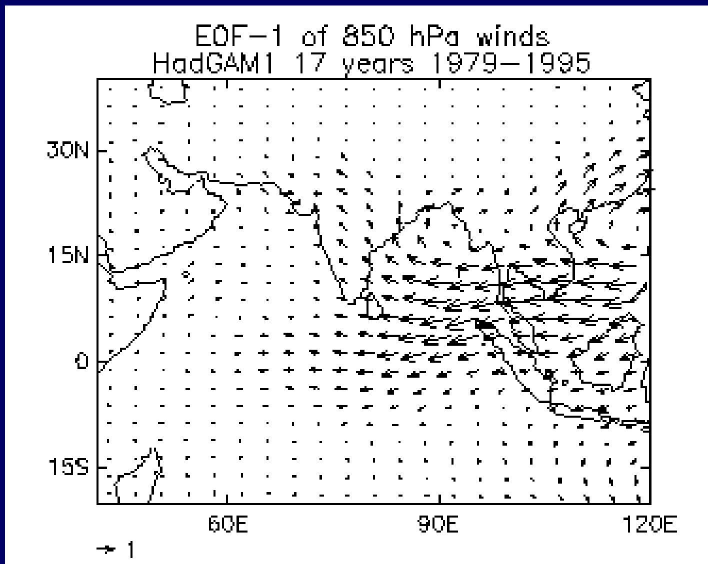
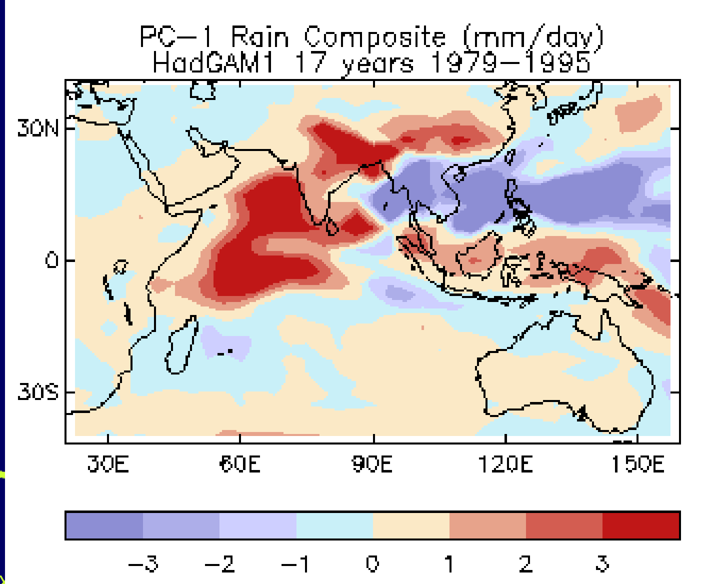
Summary [cont.]

- The dominant mode of intraseasonal variability is very similar in all four models. This mode strongly resembles the dominant interannual mode, even when the interannual signal is removed.
- There is a realistic mode of variability in all of the models which is associated with variations in All-India Rainfall.
- Intraseasonal variability in HadAM3/CM3 appears to be chaotic.
- There is a lagged impact of monsoon intraseasonal variability on local SSTs in the coupled models.
- There is some evidence of intraseasonal SST forcing of variability in HadGEM1.

HadGAM 17 years

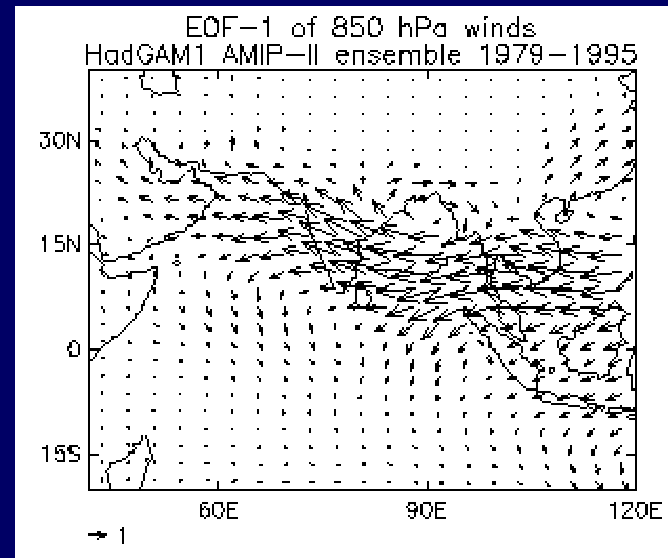
EOF-1 42% variance

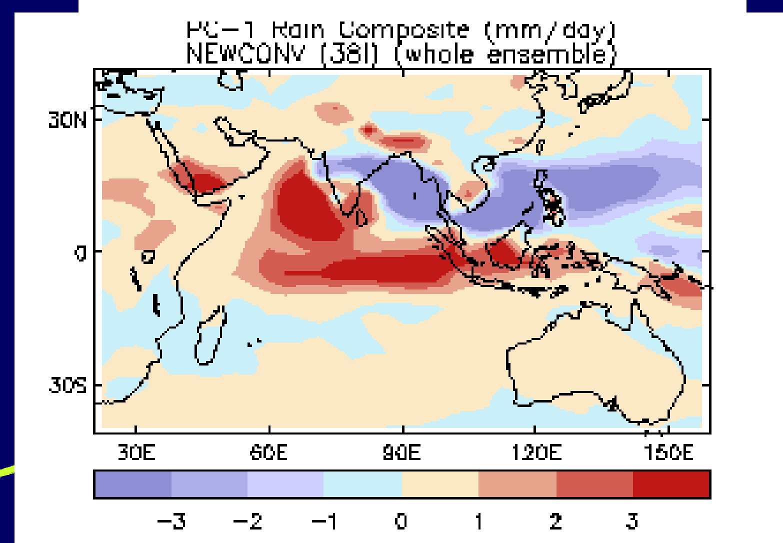




HadGAM 5-member Ensemble

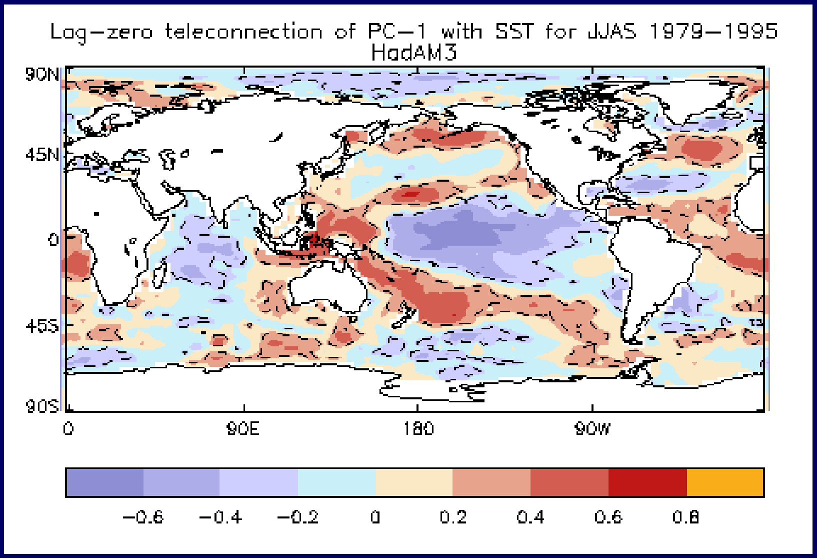
EOF-1 47% variance



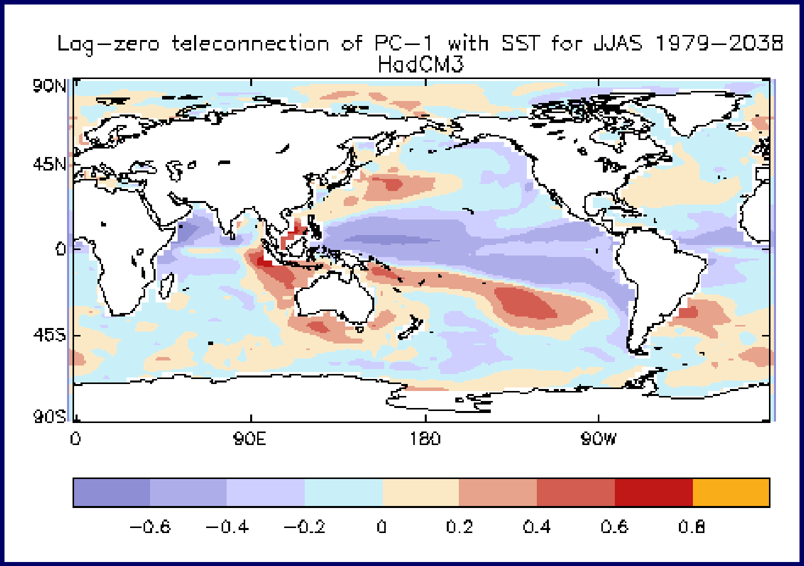


Teleconnections of PC-1 with SST

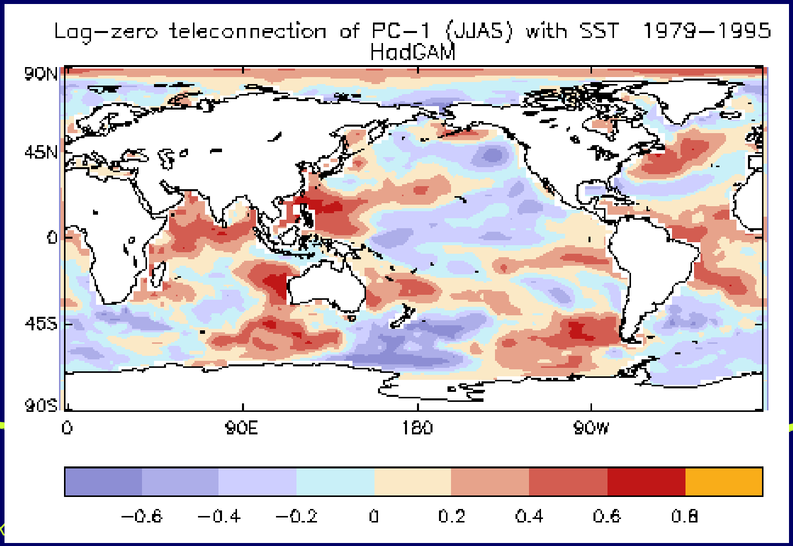
HadAM3



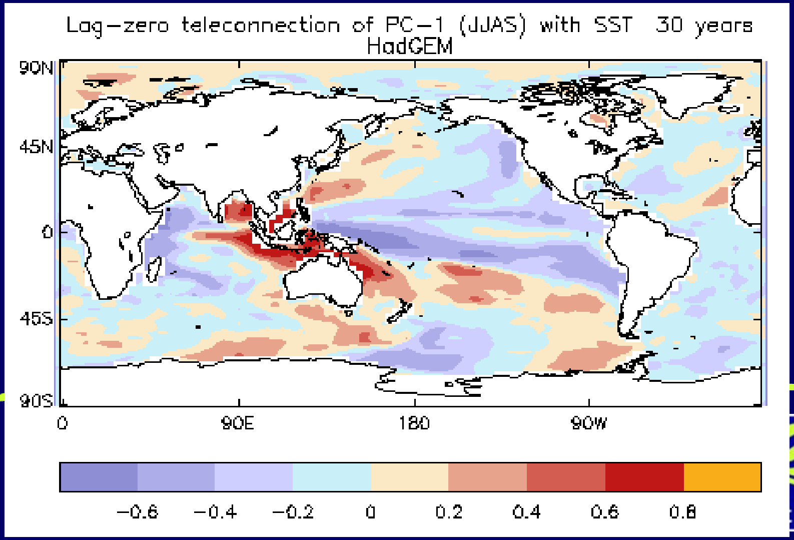
HadCM3



HadGAM

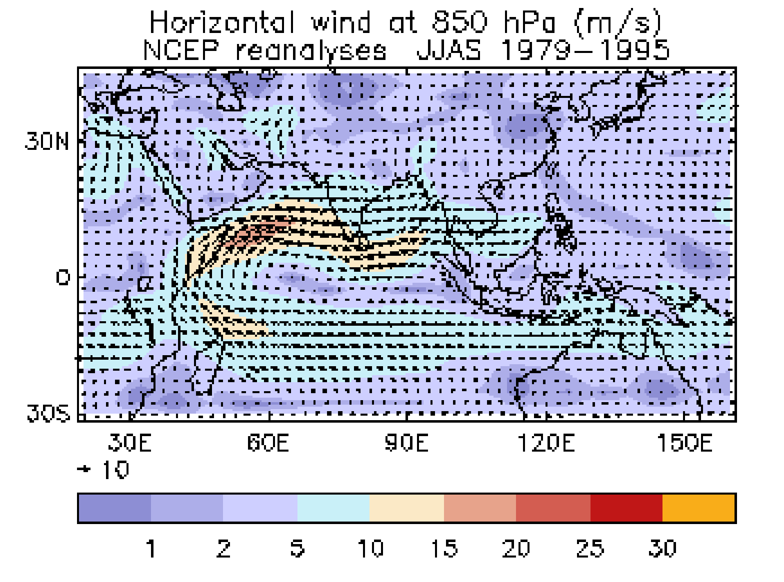


HadGEM

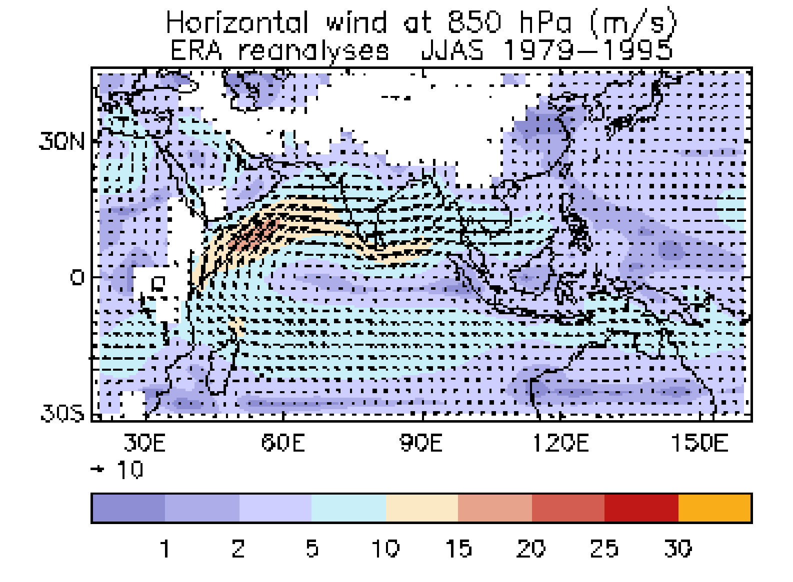


Observed monsoon climatologies

NCEP



ERA



CMAP/O