The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

1956-17

Targeted Training Activity: Seasonal Predictability in Tropical Regions to be followed by Workshop on Multi-scale Predictions of the Asian and African Summer Monsoon

4 - 15 August 2008

ISV of Indian summer monsoon rainfall in the ECMWF Seasonal Fc.System 3: predictability and ISV diagnostics

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Indian summer monsoon rainfall in the ECMWF seasonal fc. System-3: predictability and ISV diagnostics

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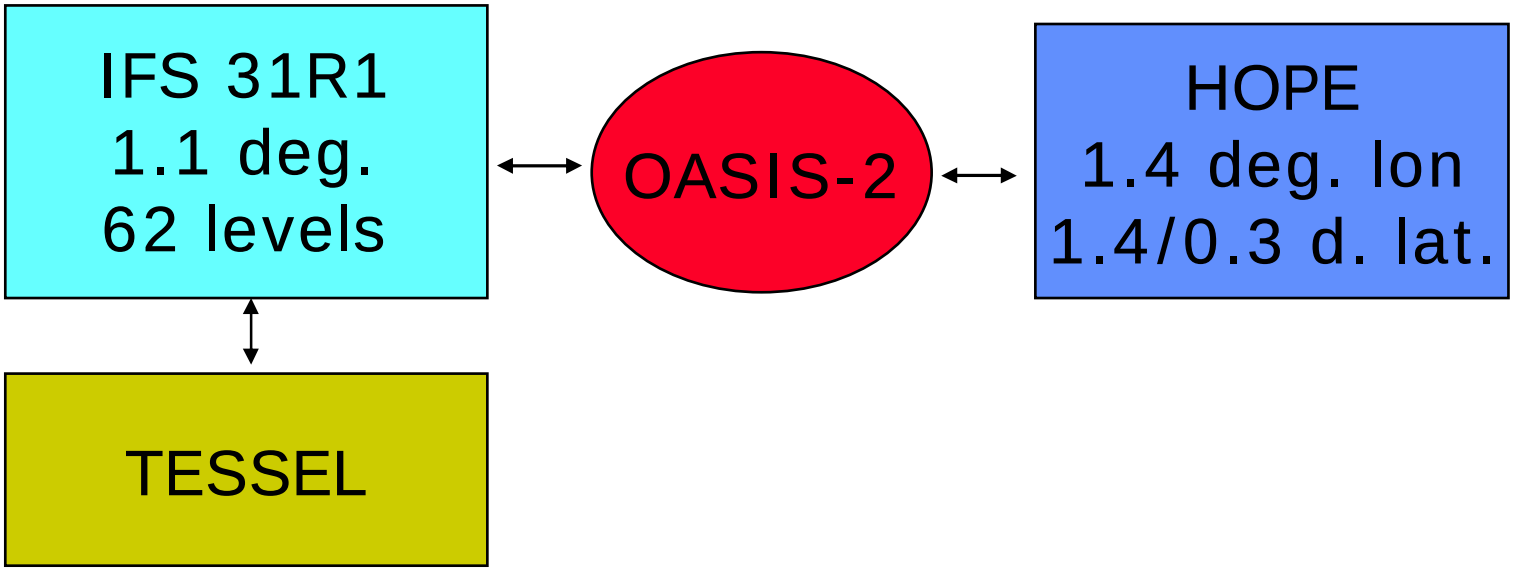
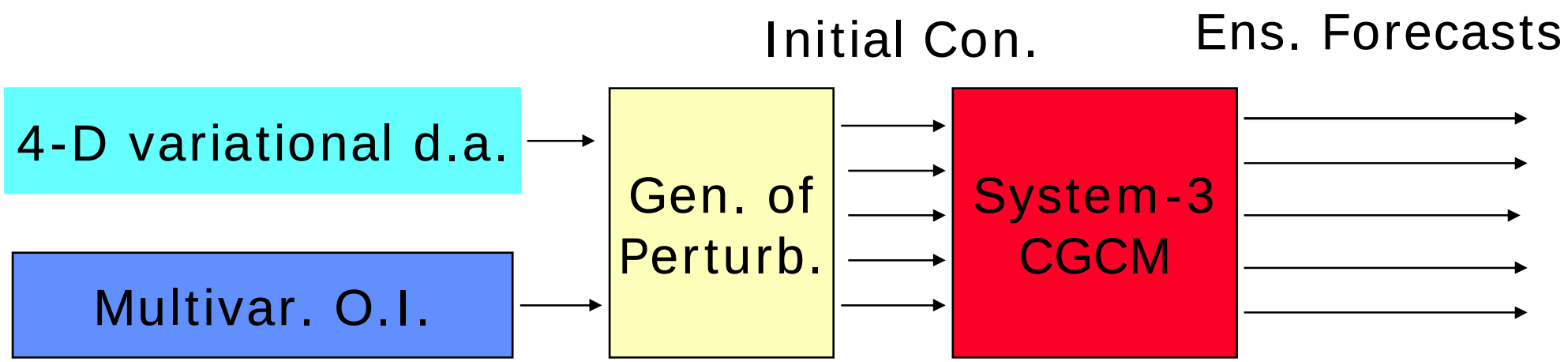
European Centre for Medium-Range Weather Forecasts, Reading, U.K.

contributions from: ECMWF Seasonal Forecast Section,
Laura Ferranti, Milind Mujumdar (IITM, Pune)

ECMWF Seasonal forecast system (Sys-3)

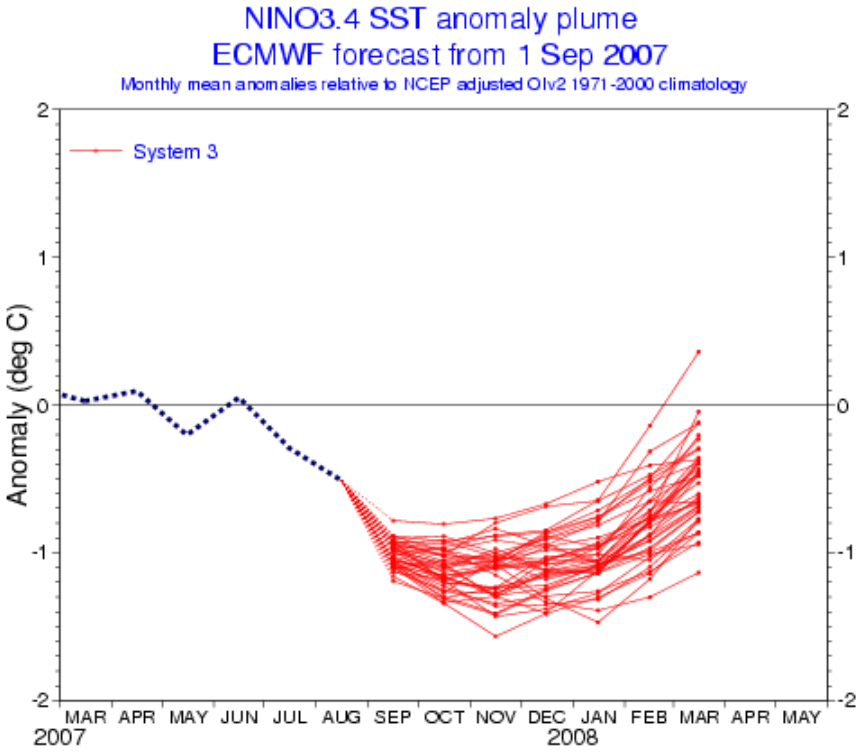




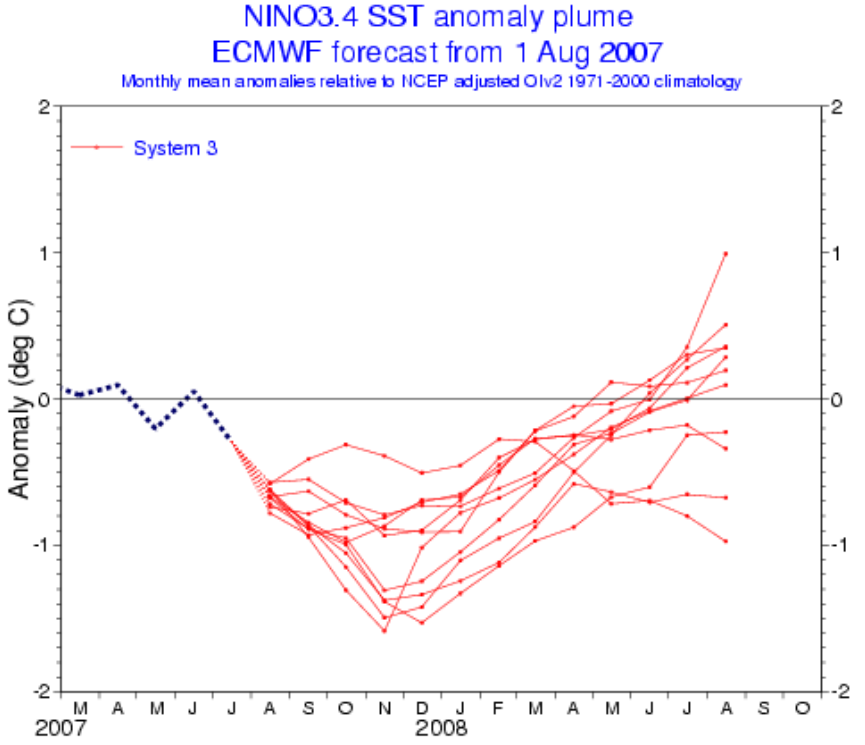
The seasonal forecast System-3 (implem. March 07)

- COUPLED MODEL (IFS + OASIS2 + HOPE)
  - Recent cycle of atmospheric model (Cy31R1)
  - Atmospheric resolution TL159 and 62 levels
  - Time varying greenhouse gasses.
  - Includes ocean currents in wave model
- INITIALIZATION
  - Includes bias correction in ocean assimilation.
  - Includes assimilation of salinity and altimeter data.
  - ERA-40 data used to initialize ocean and atmosphere in hindcasts
  - Ocean reanalysis back to 1959, using ENACT/ENSEMBLES ocean data
- ENSEMBLE GENERATION
  - Extended range of back integrations: 11 members, 1981-2005.
  - Revised wind and SST perturbations.
  - Use EPS Singular Vector perturbations in atmospheric initial conditions.
- Forecasts extended to 7 months (to 13 months 4x per year).

Products from Sys-3: “plumes” for El Nino indices

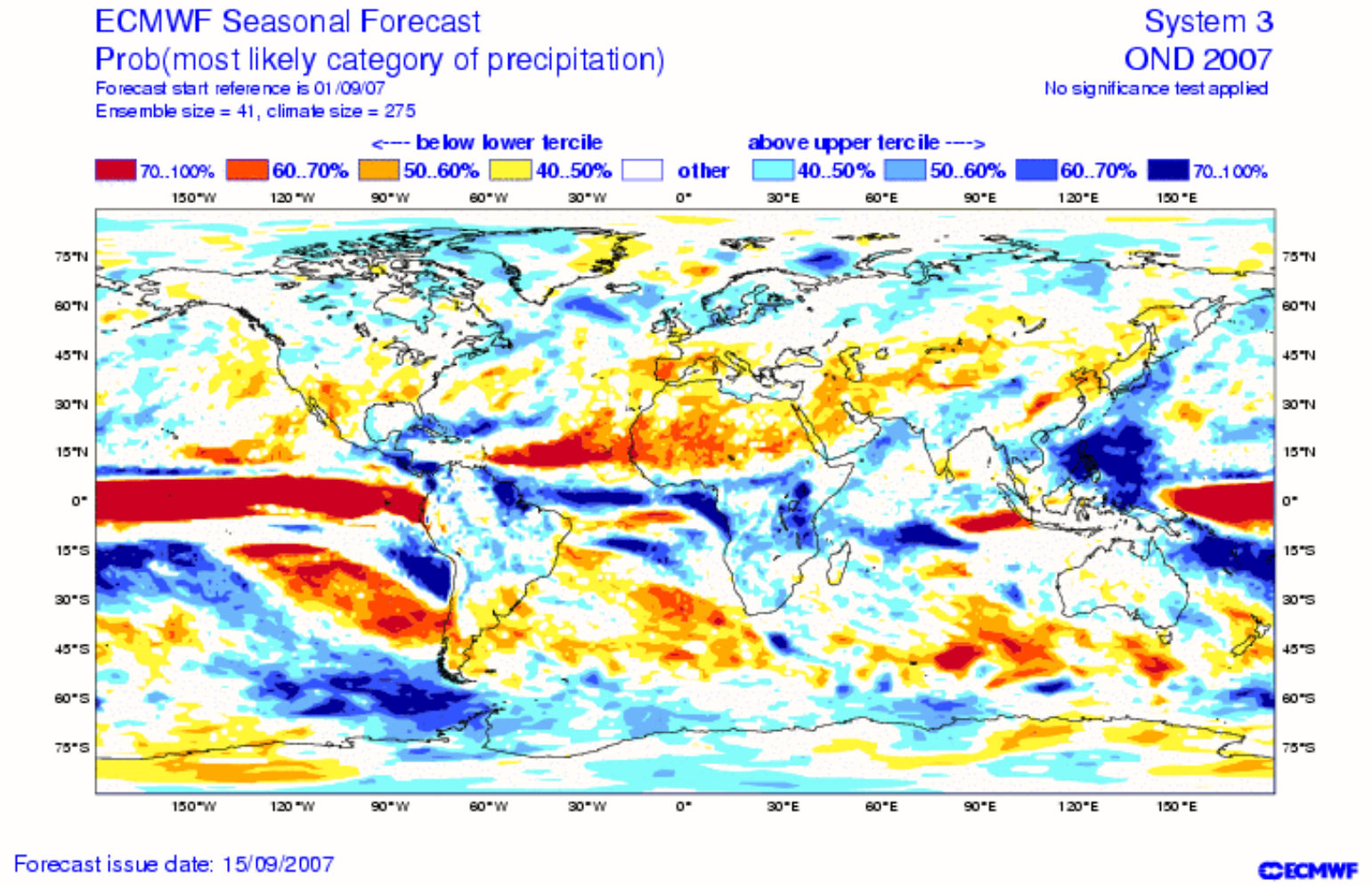


Forecast issue date: 15 Sep 2007

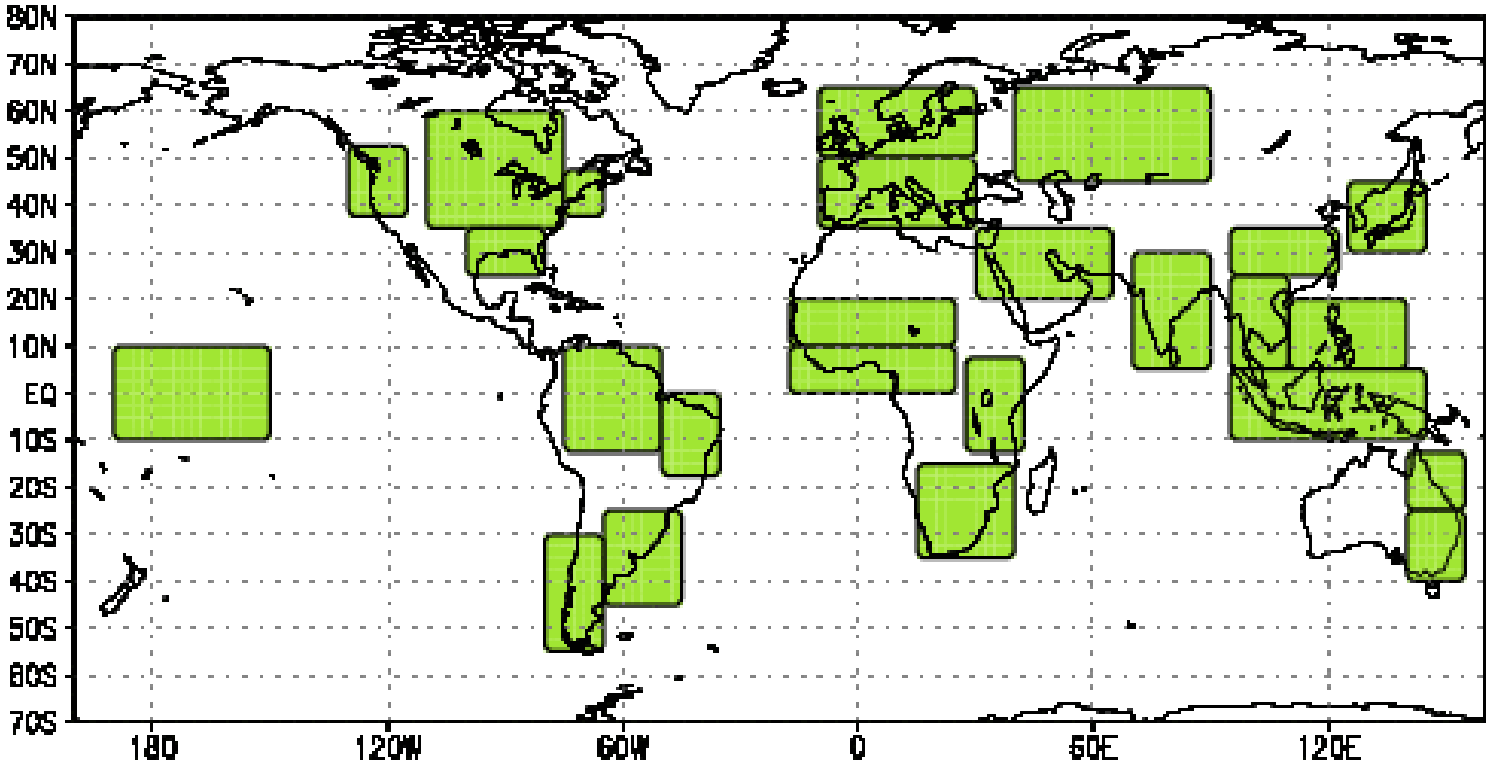


Forecast issue date: 15 Aug 2007

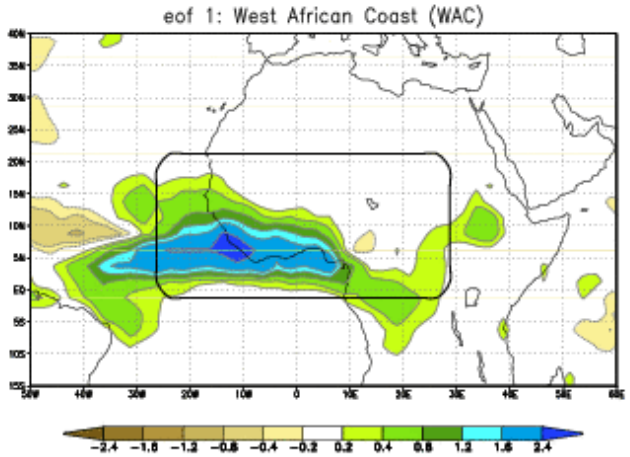
Products from Sys-3: 'tercile summary'

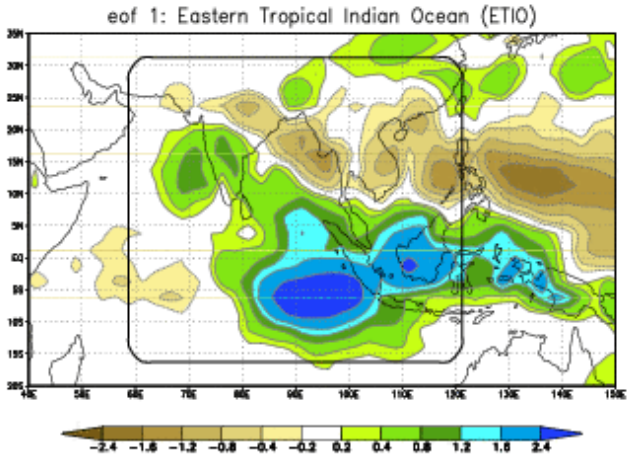


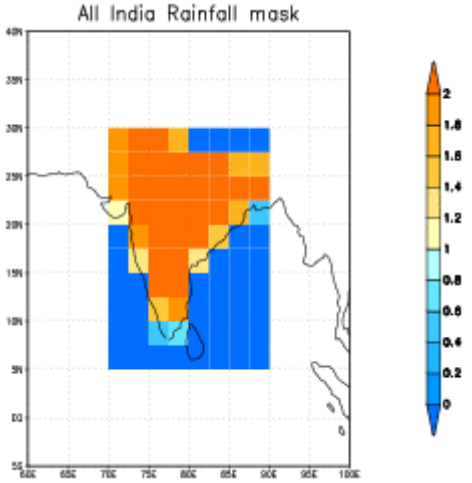
Climagrams : area-averages of 2mT and rainfall

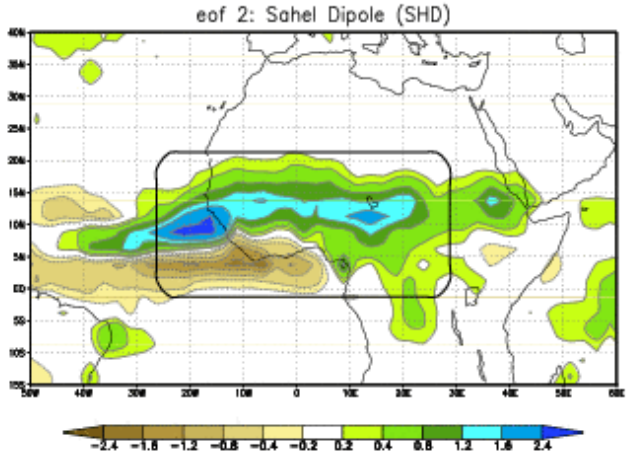


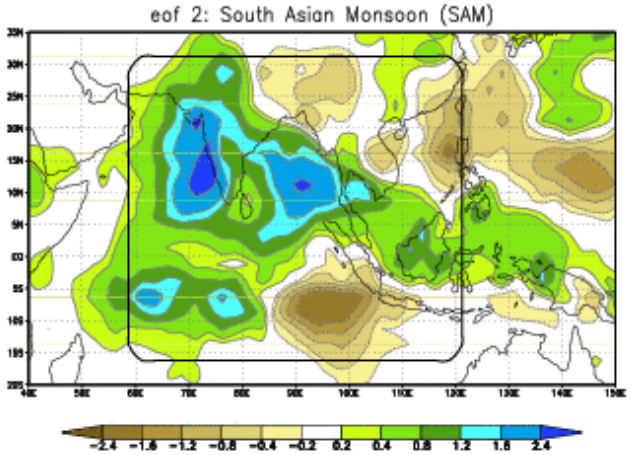
Climagrams : monsoon indices / teleconnections



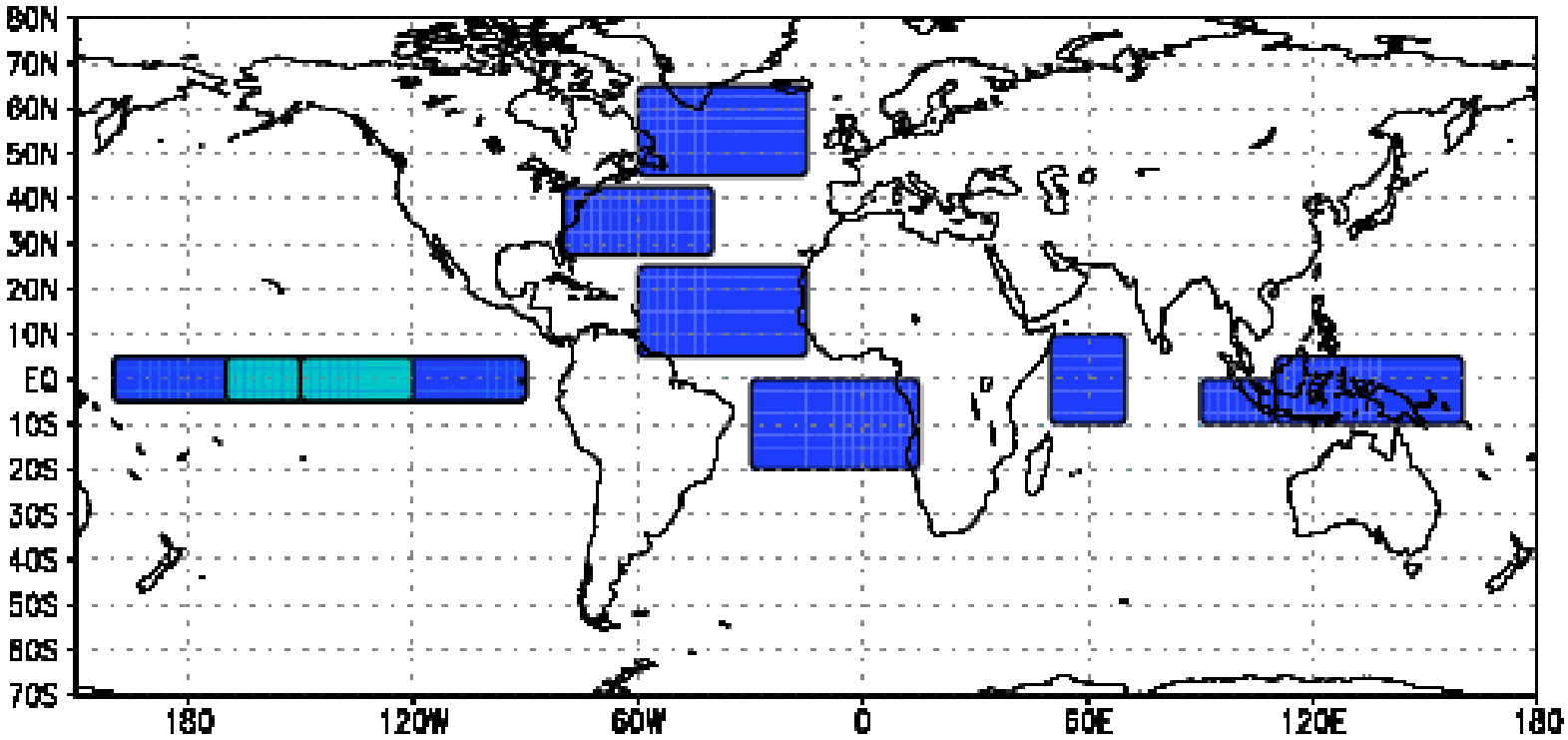




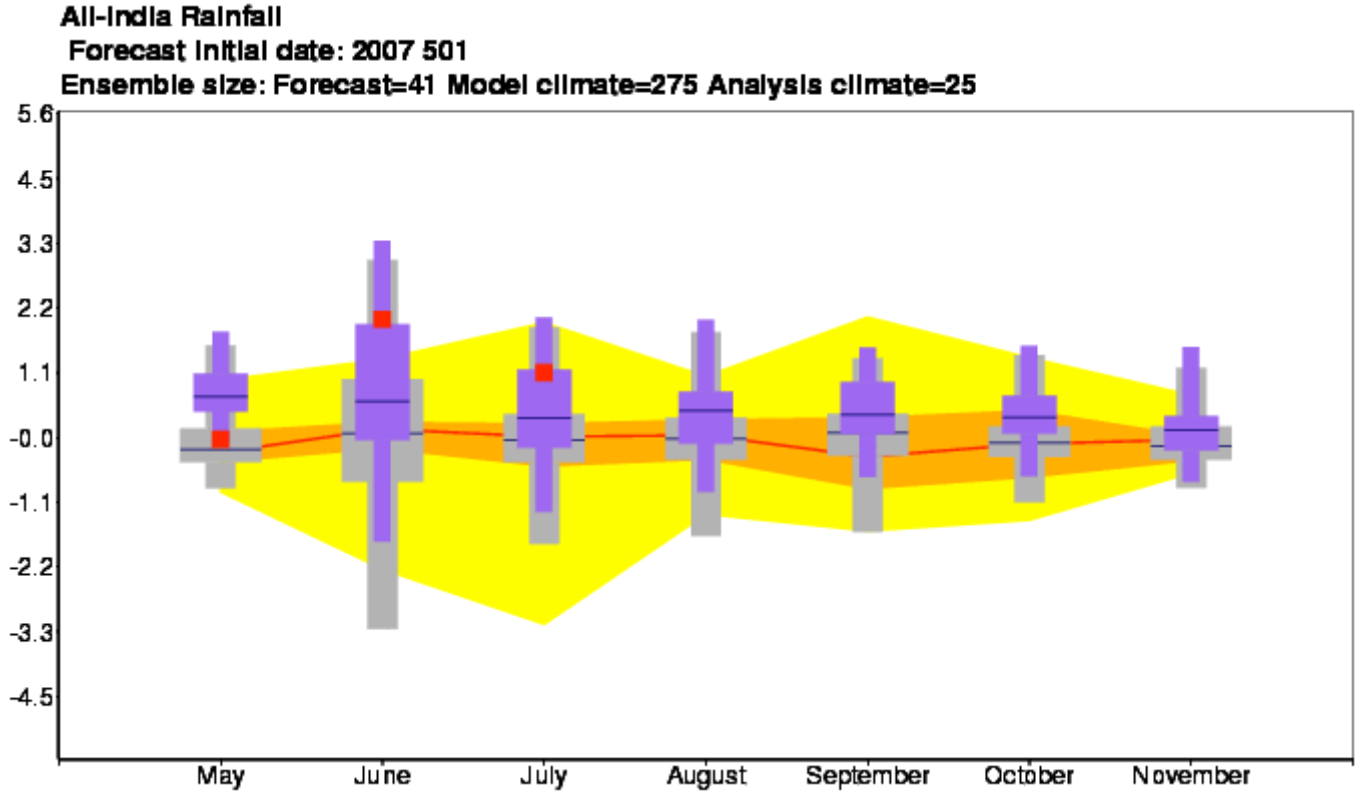




Climagrams :SST area-averages

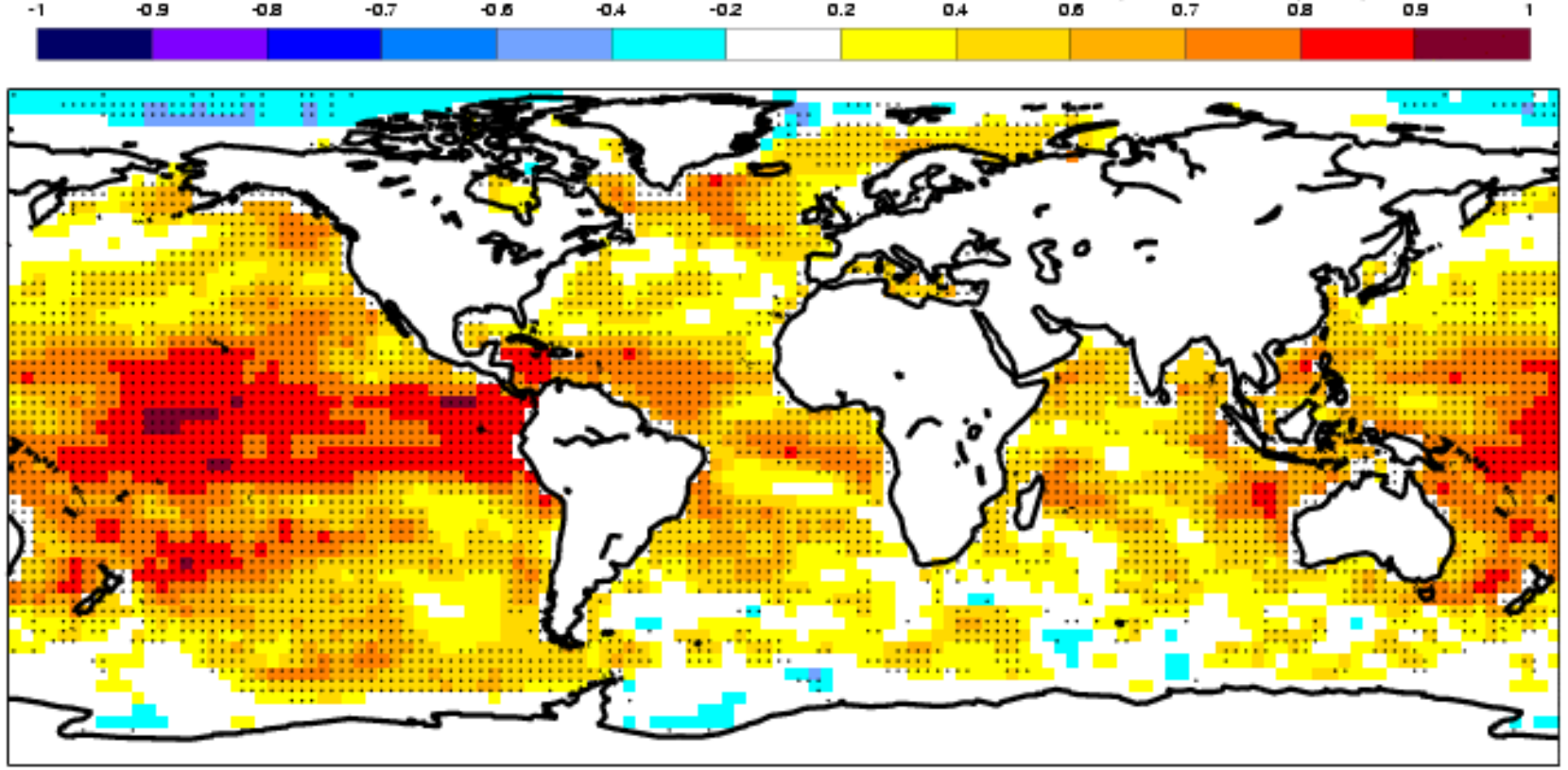


All India Rainfall: "climagram" from 1 May 2007



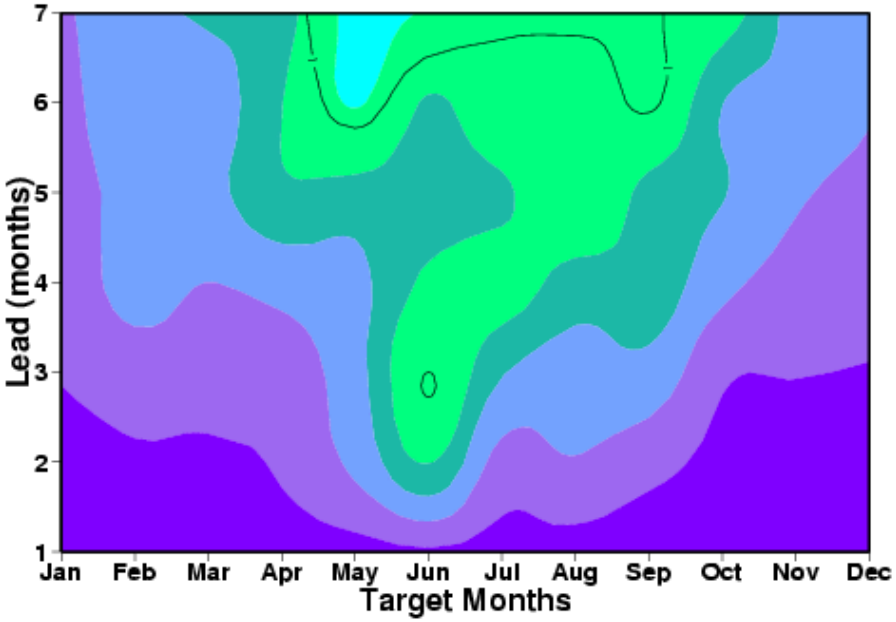
Verification for SST in JJA from 25-year hindcast set

Anomaly Correlation Coefficient for ECMWF with 11 ensemble members
Sea surface temperature
Hindcast period 1981-2005 with start in May average over months 2 to 4
Black dots for values significantly different from zero with 95% confidence (1000 samples)

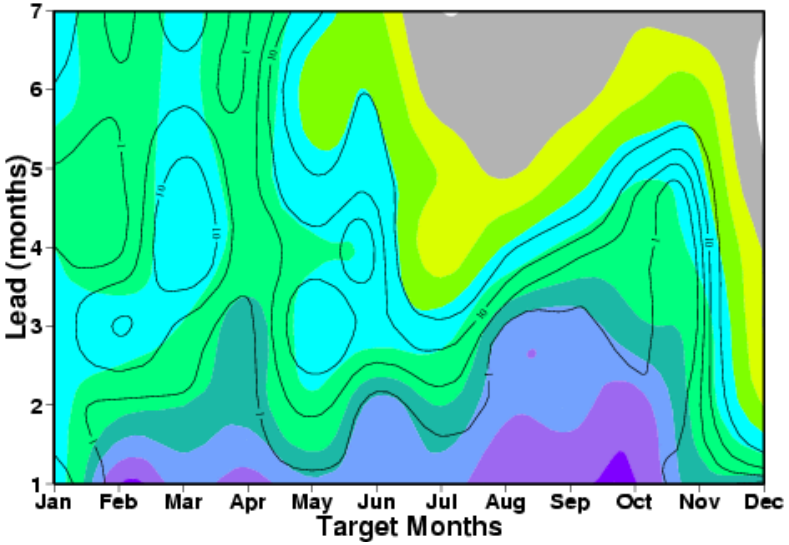


Climagram verification (ACC : f. of initial and lead time)

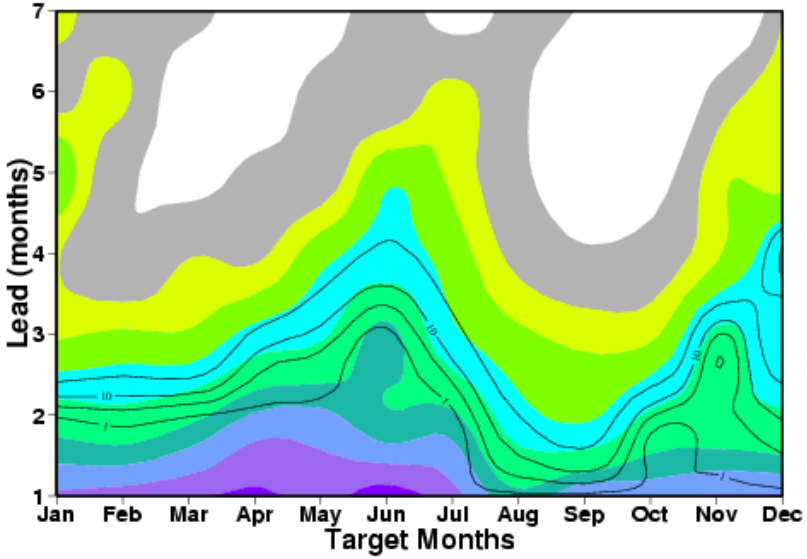
Nino3.4



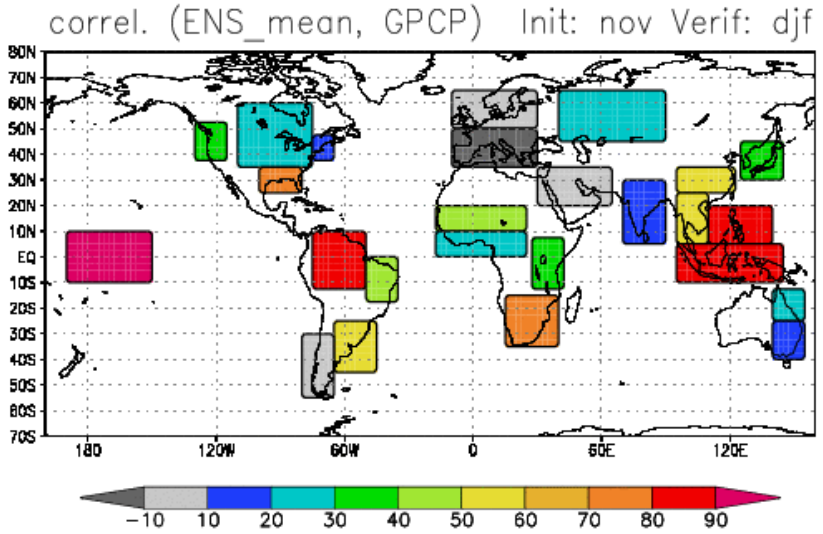
SE Trop. Ind. Oc.

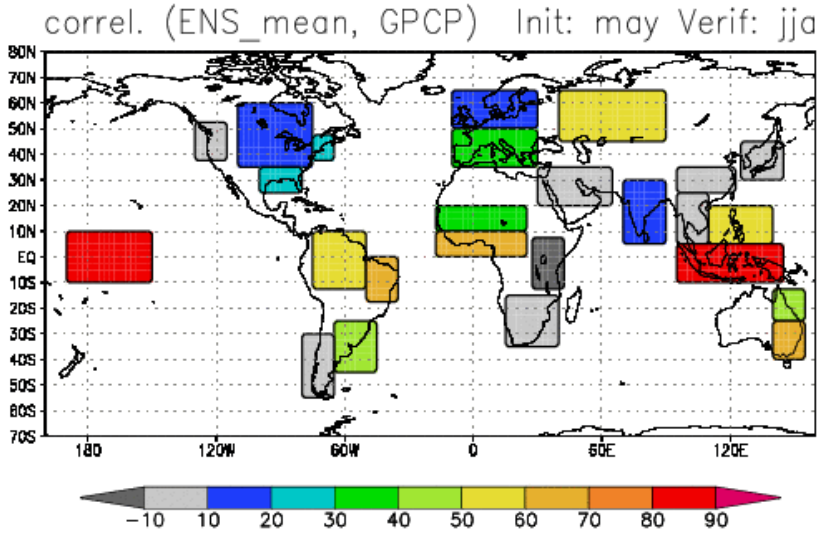


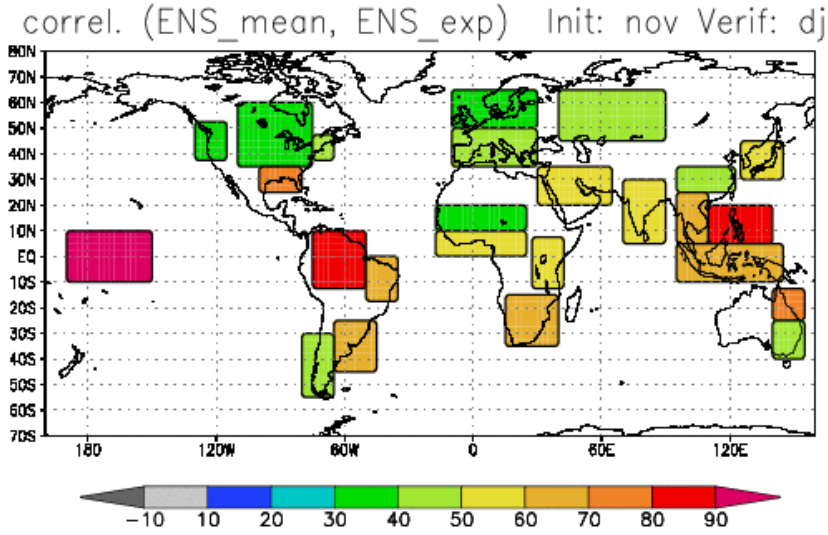
S Trop. Atlantic

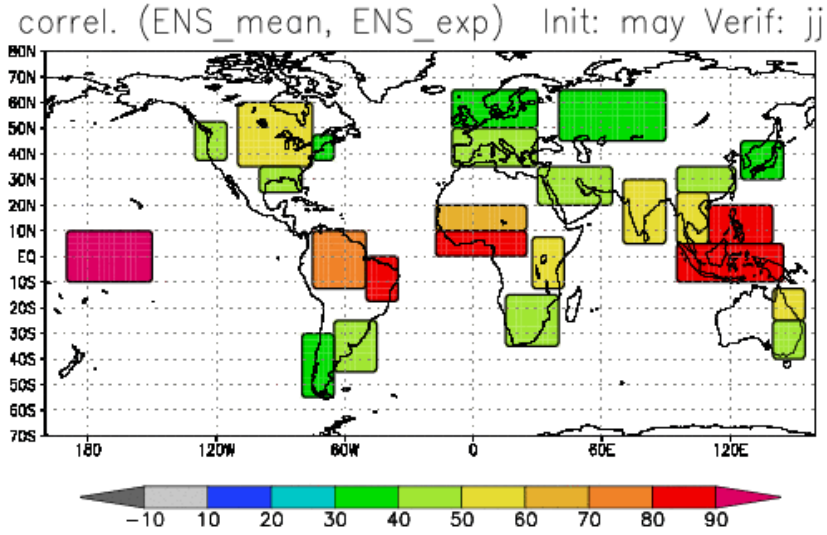


Anomaly correlation of seasonal-mean rainfall



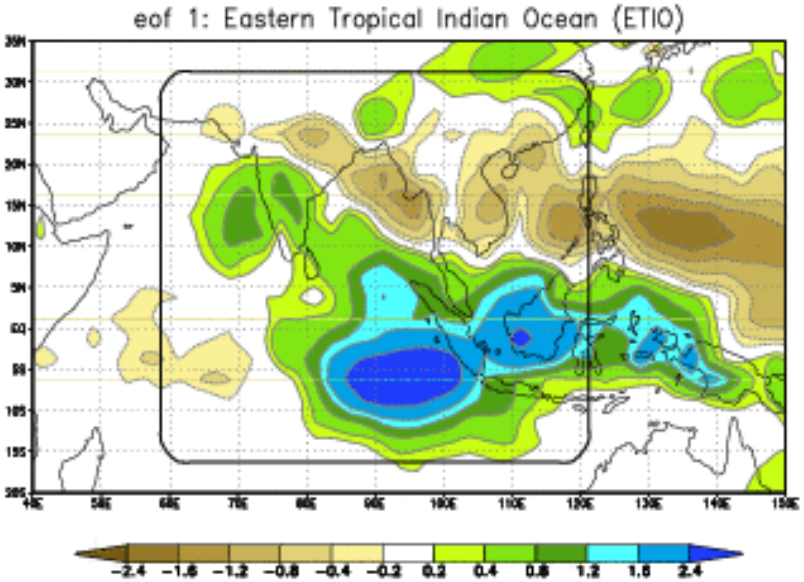


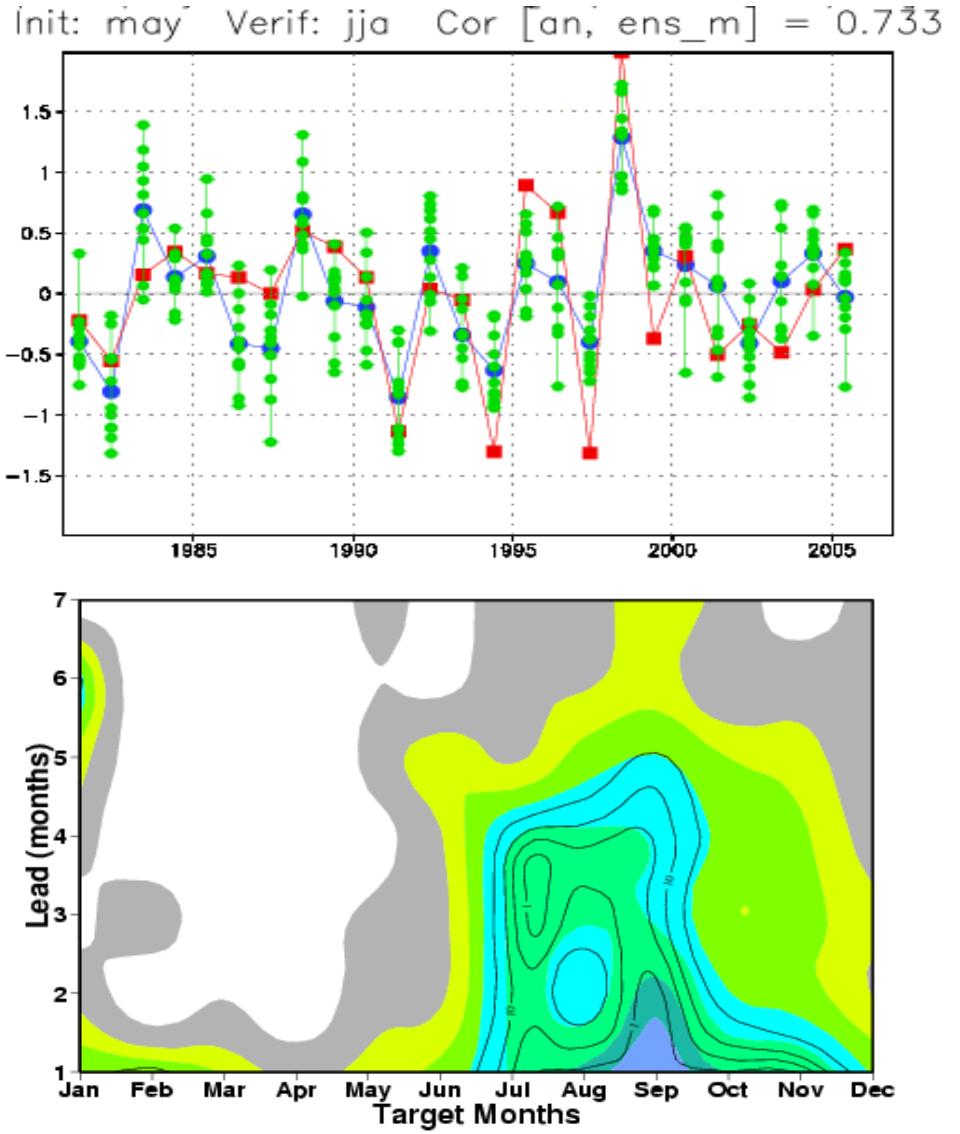




Predictability of teleconnection/EOF indices in S-3

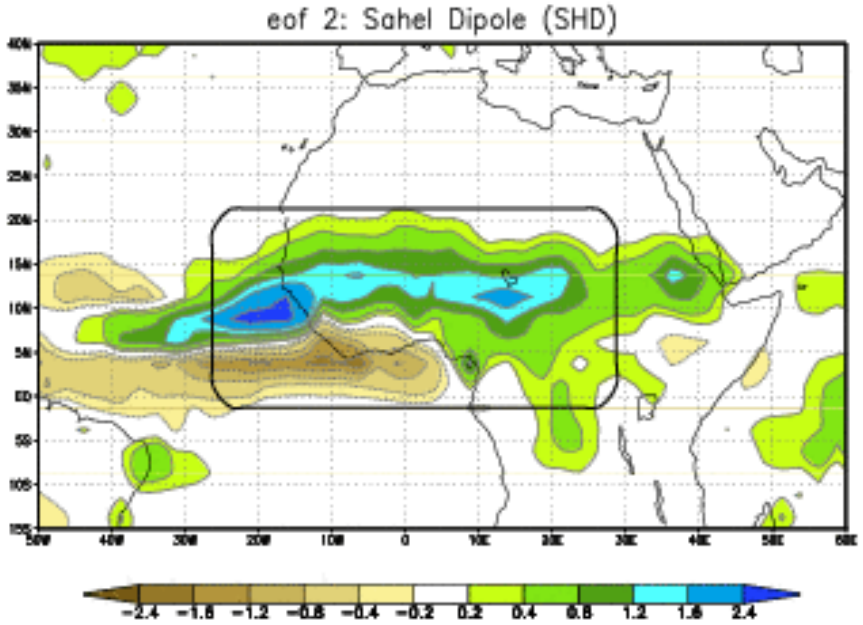
Rainfall: East. Tropical Indian Ocean pattern (JJA)

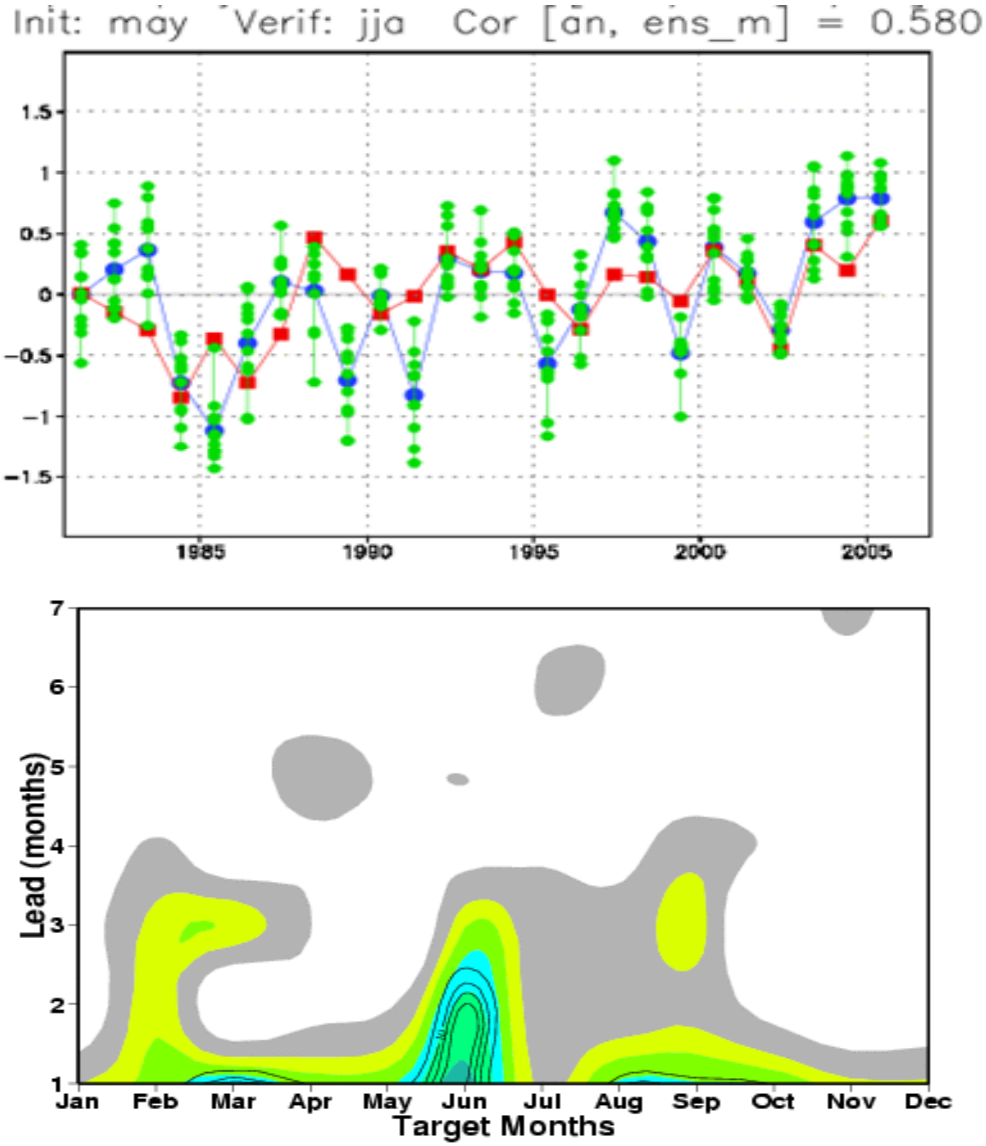




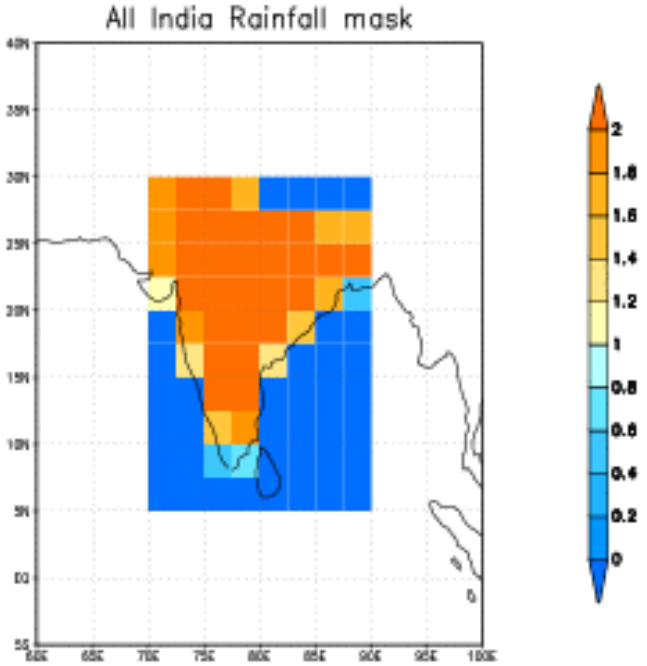
Predictability of teleconnection/EOF indices in S-3

Rainfall: Sahel / Guinea coast dipole (JJA)

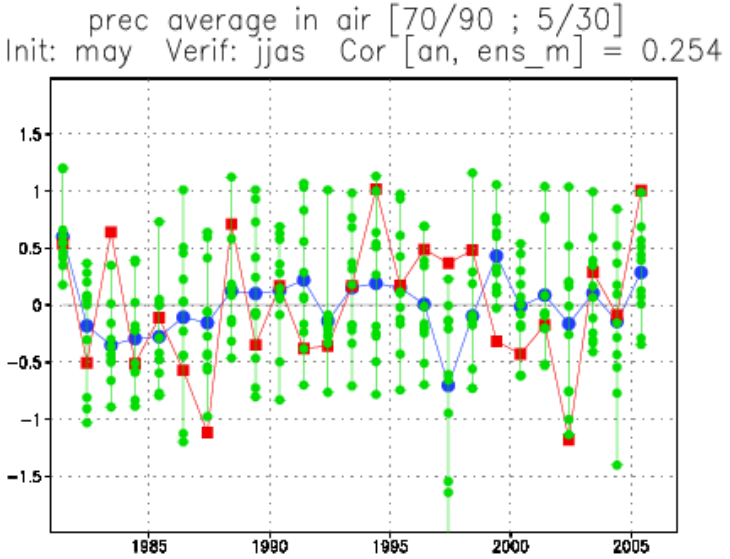




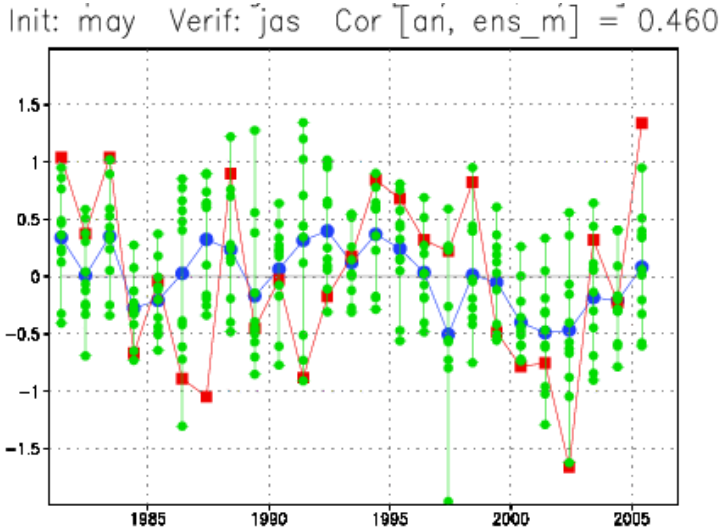
Predictability of AIR in S-3



JJAS
CC = **.25**

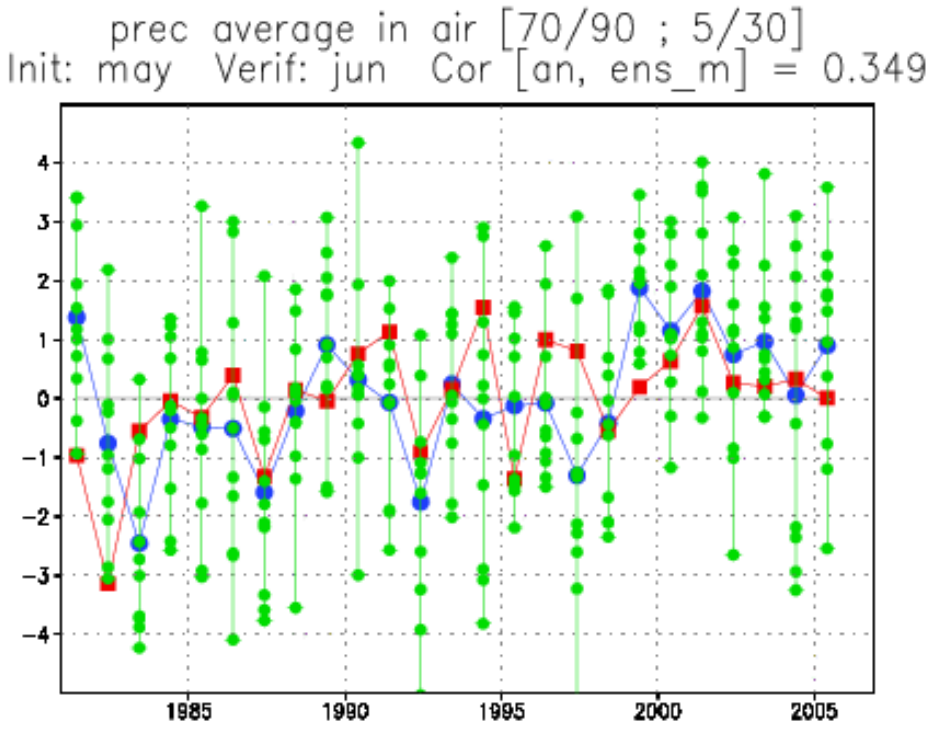


JAS
CC = **.46**

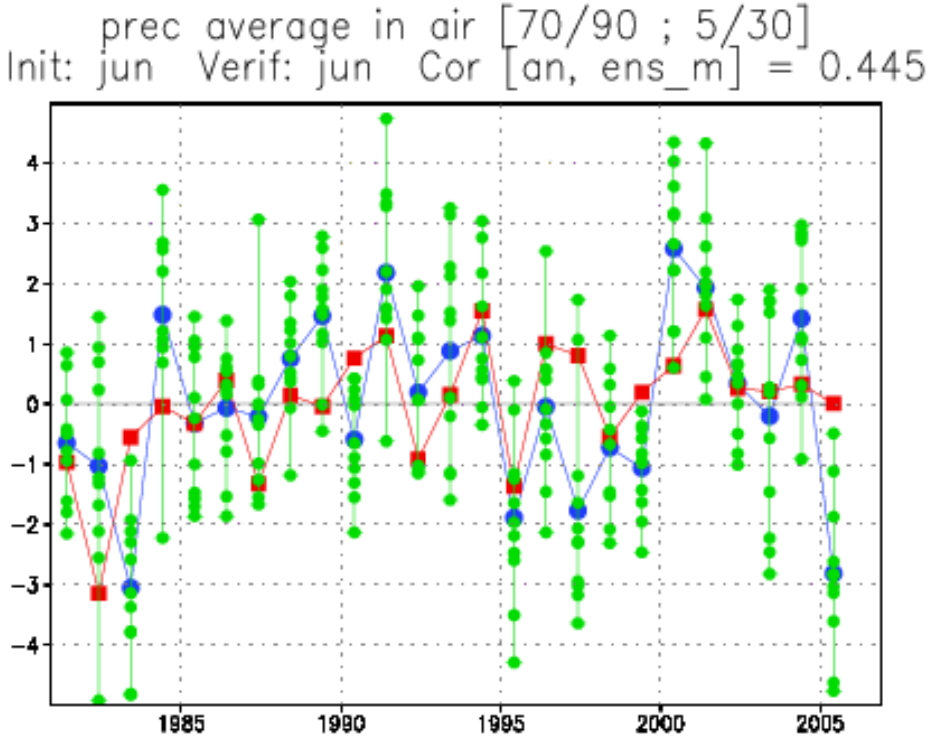


Monsoon onset in India: seasonal fc. for June

1-month-lead fc.
cc = 0.35



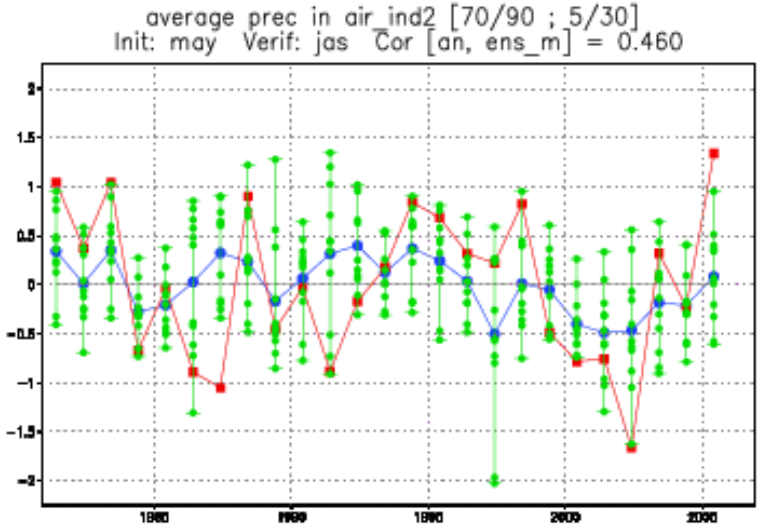
0-lead fc.
cc = 0.45

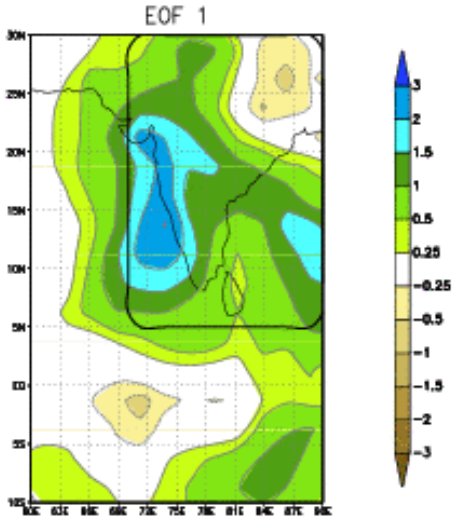


Forecast anomaly amplitude is ~ 2 x obs. !

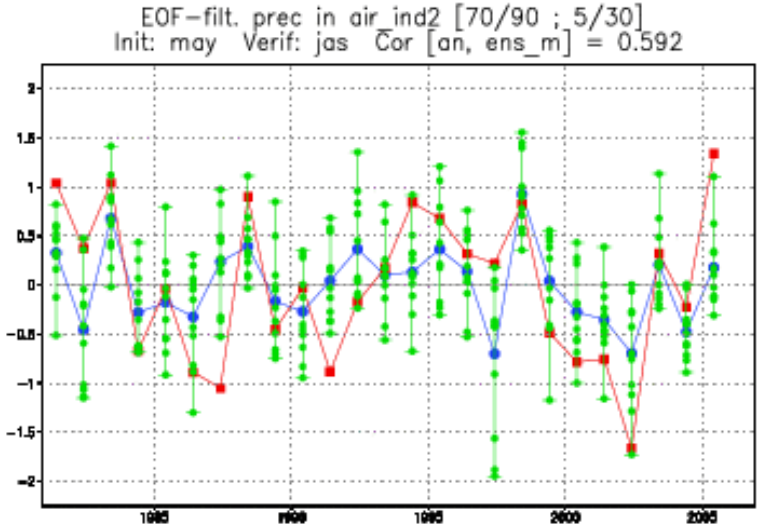
Predictability of AIR in S-3: EOF filtered JAS

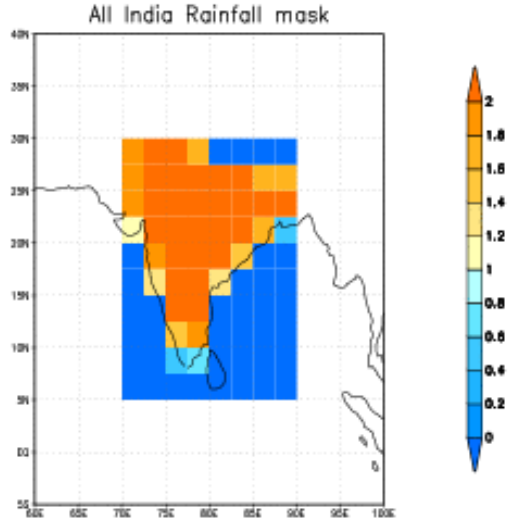
Unfiltered
CC = 0.46





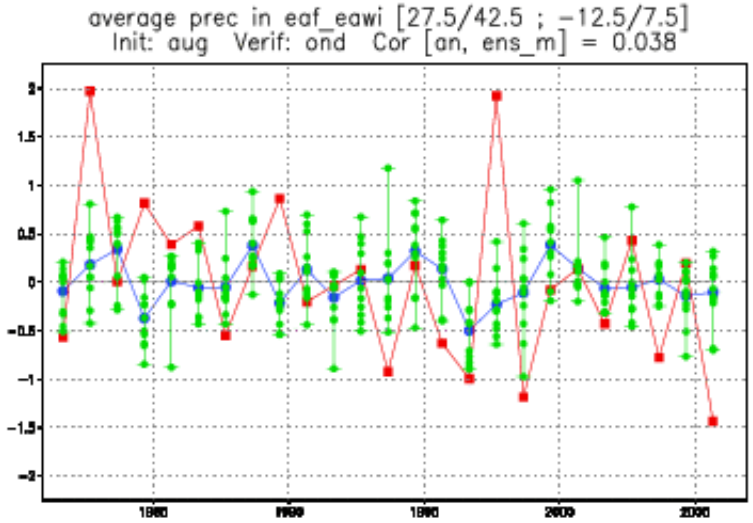
EOF proj.
CC = 0.59

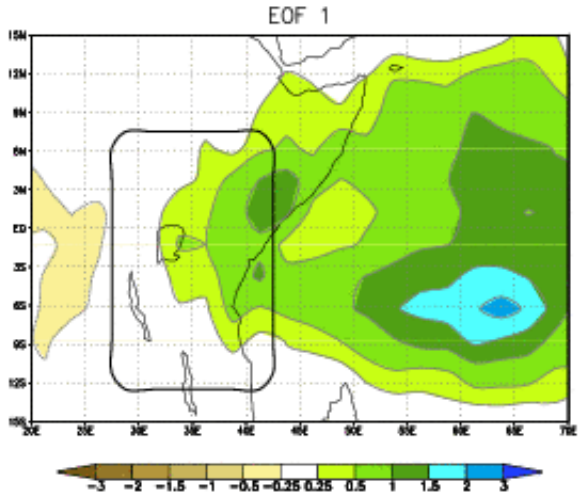




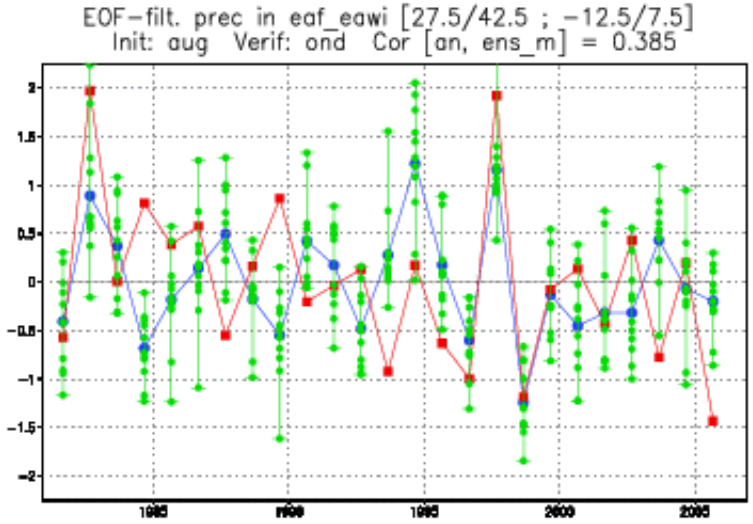
Predictability of East Africa short rains: EOF filtered OND

Unfiltered
CC = 0.04

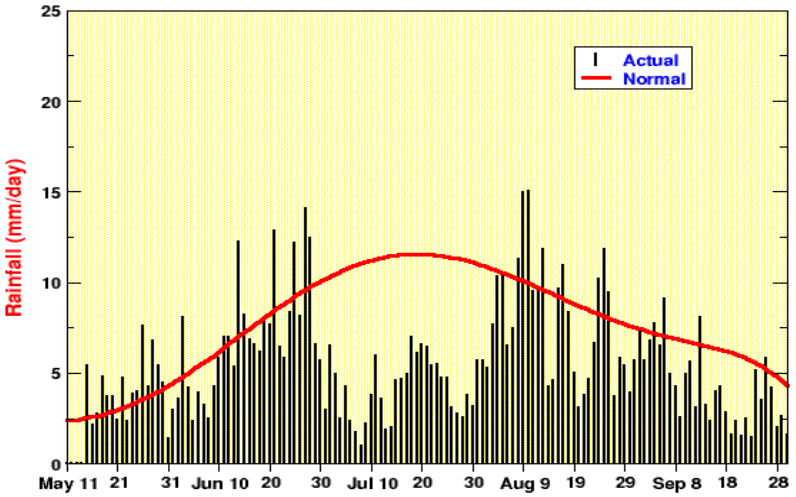




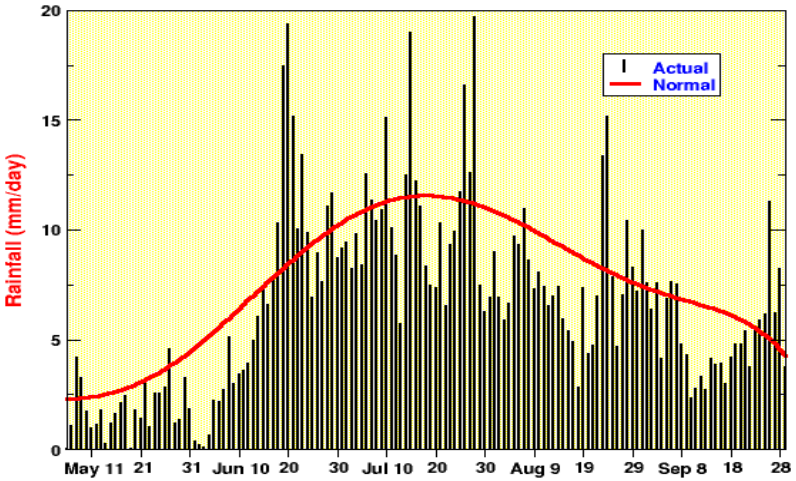
EOF proj.
CC = 0.39



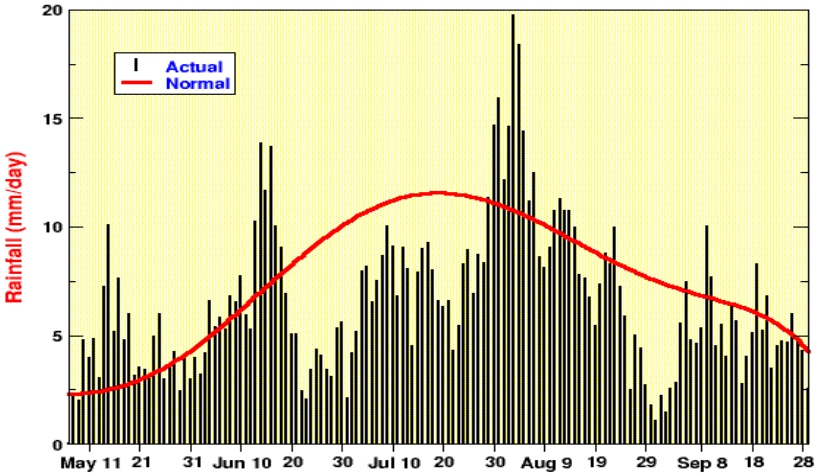
All-India Rainfall time-series (May-September)



2002



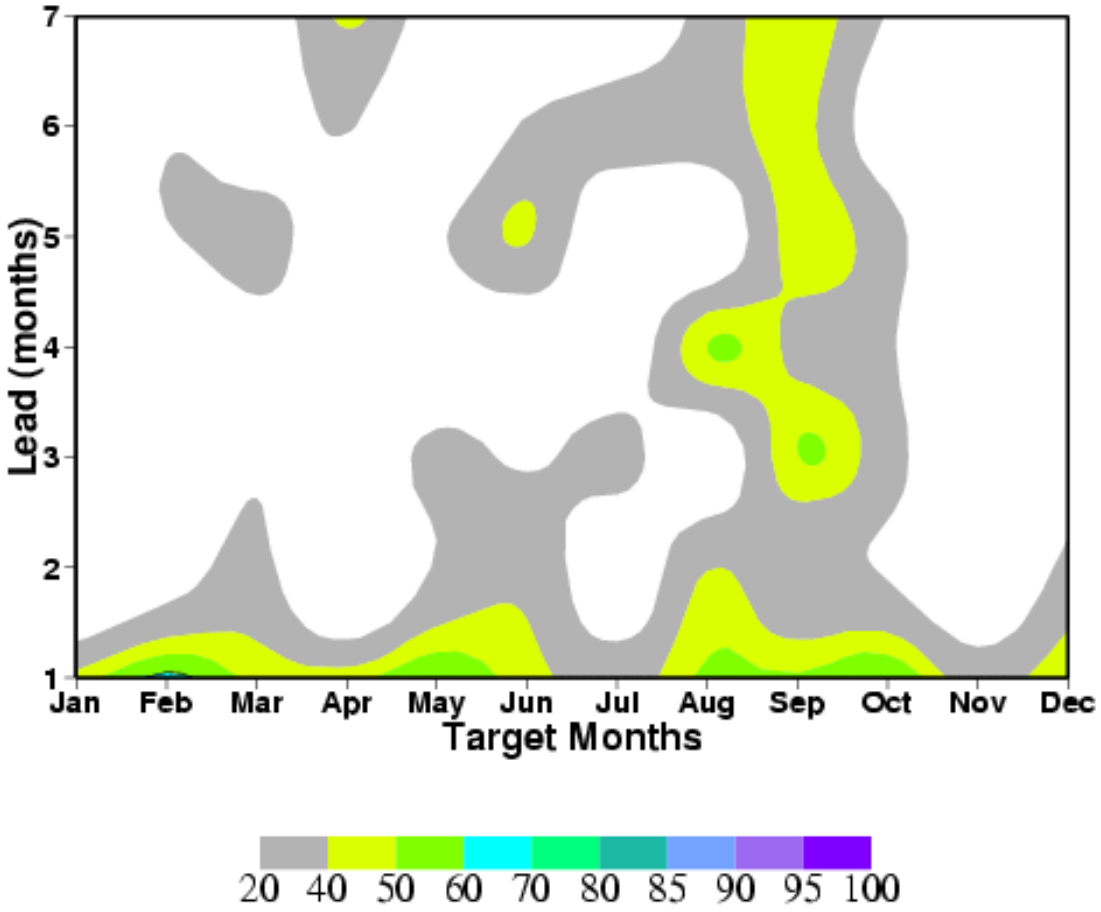
2003



2004

Climagram verification (ACC : f. of initial and lead time)

All-India Rainfall



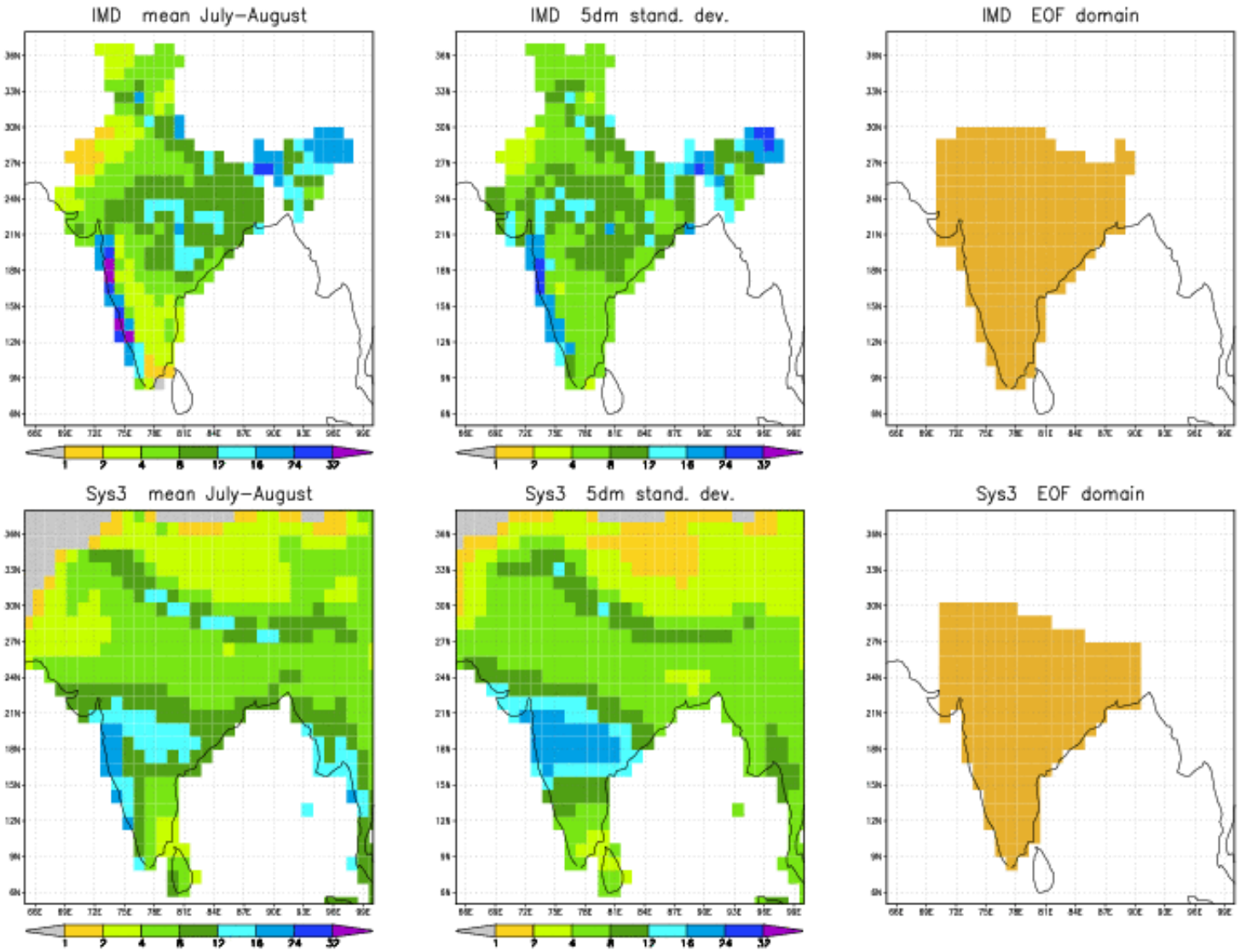
Diagnostics of monsoon ISV in Sys3 from pentad data

- Observations (5-day means from 2 June to 30 Sept. 1981-2005)
  - Rainfall: 5-day means computed from India Met. Dept. daily rainfall analysis on 1x1 deg grid (Rajeevan et al. 2005)
  - 850-hPa relative vorticity from ERA40 and operational ECMWF analysis (2002 onwards)
- Model data:
  - 5-day means of rainfall and 850-hPa vorticity from seasonal hindcast ensembles started on 1 May 1981-2005
- Diagnostics:
  - EOFs of pentad rainfall over India (70-90E, 7.5-30N) in July-August
  - Covariance of 850-hPa vorticity with 1st PC of rainfall at lag 0, -1, -2, -3 pentads

Rainfall mean, st.dev. and EOF domain for July-August

IMD data

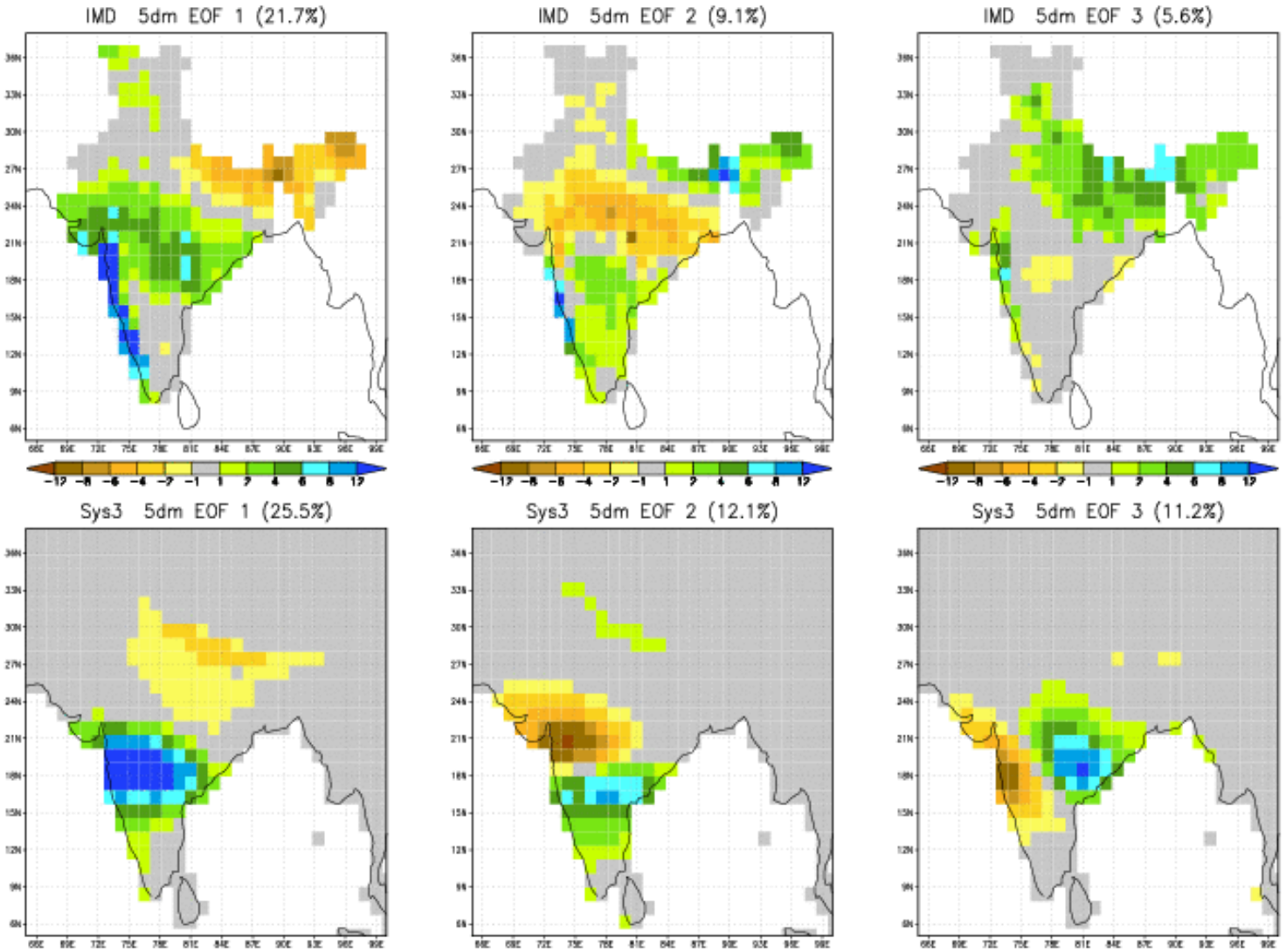
Sys3



5-d mean rainfall EOFs for July-August 1981-2005

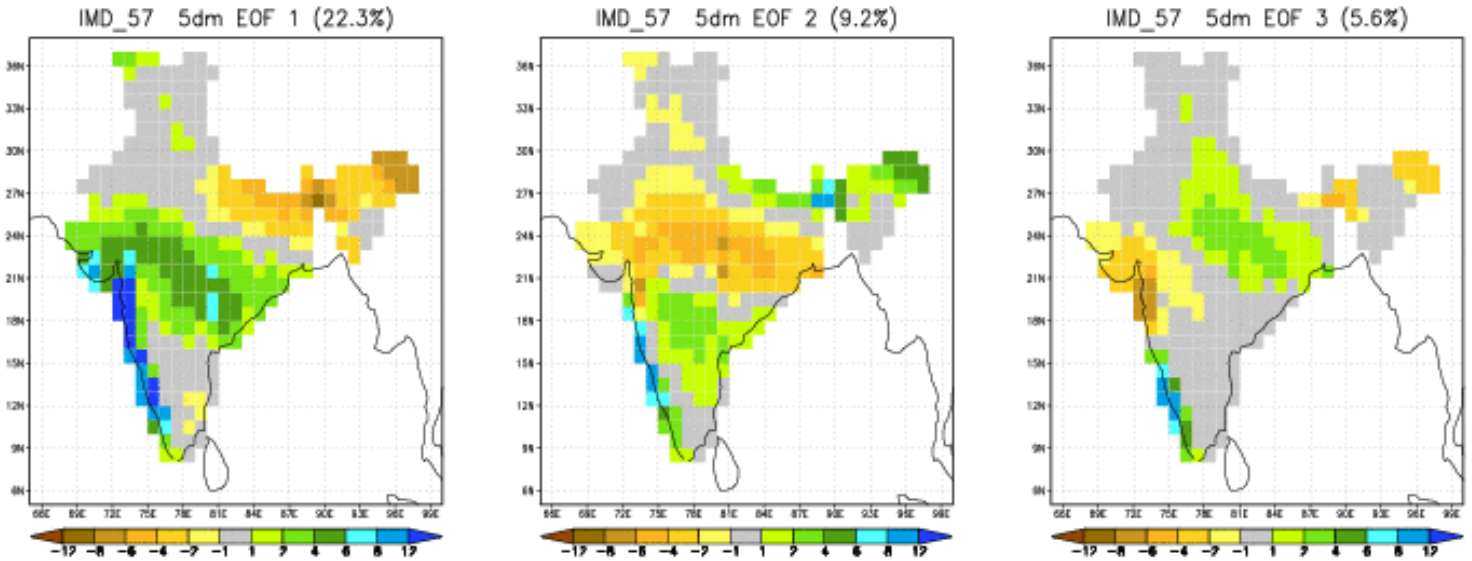
IMD data

Sys3

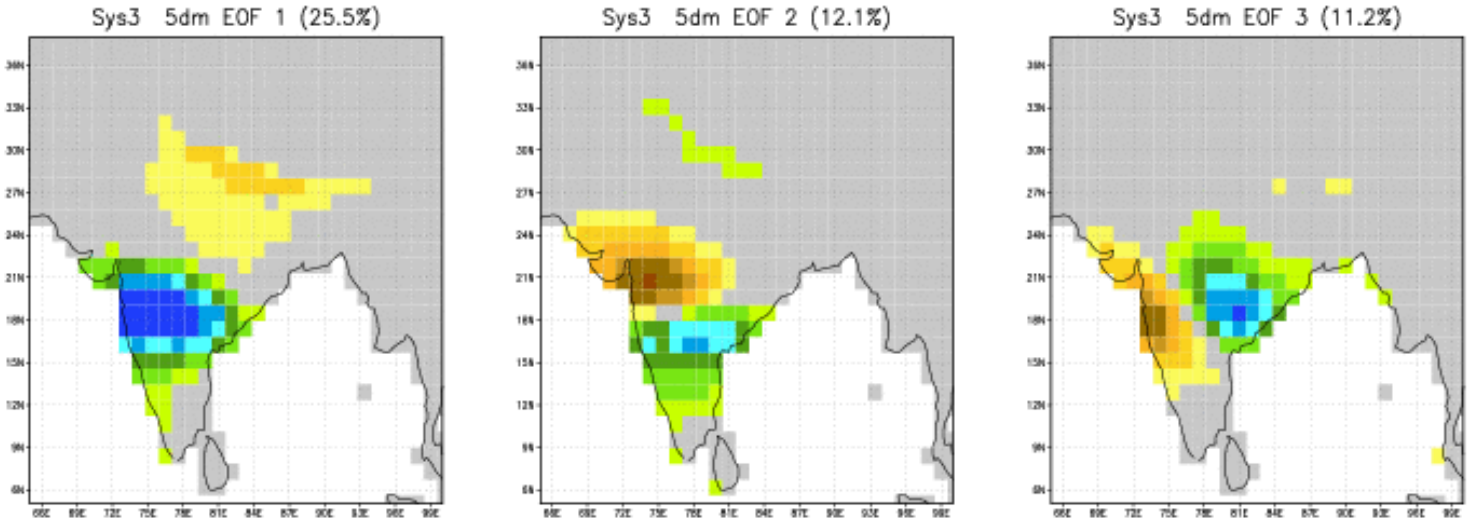


5-d mean rainfall EOFs for July-August

IMD data 1951--2007

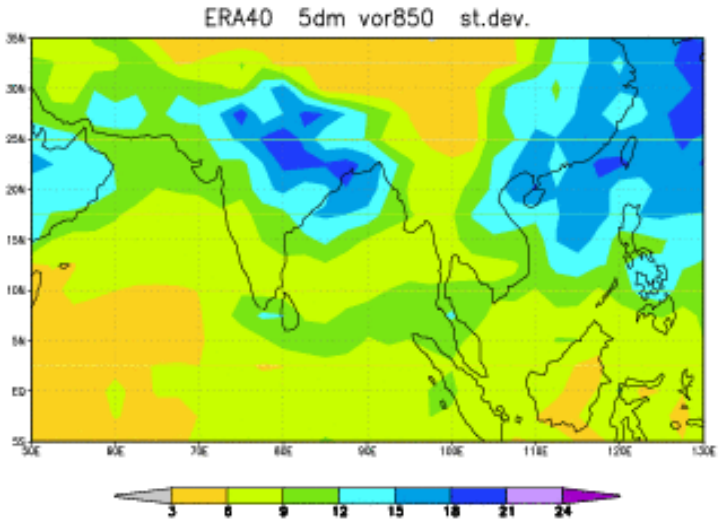


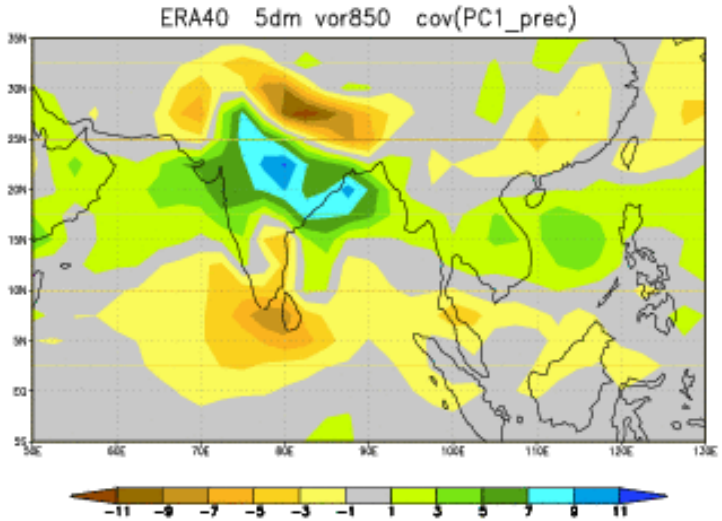
Sys3 1981--2005



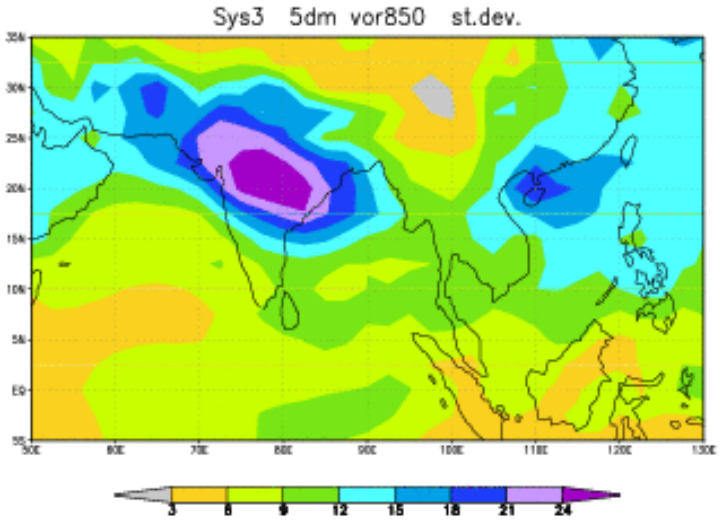
Vorticity 850 hPa: stand.dev. and cov. with rainfall PC1

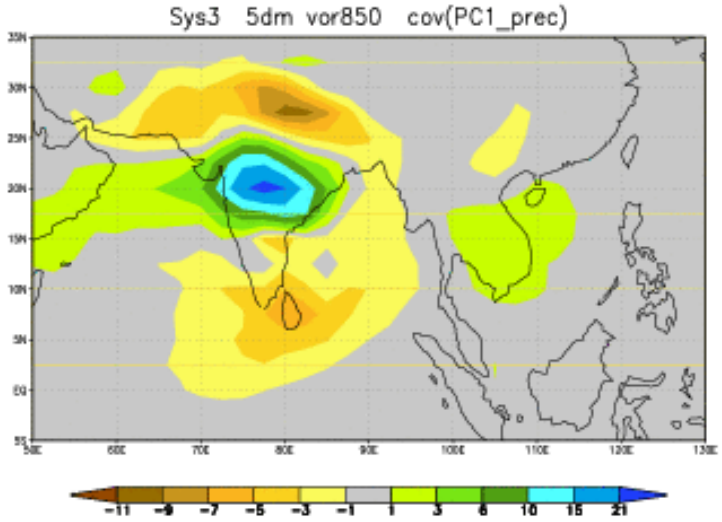
Era40 + oper. An.





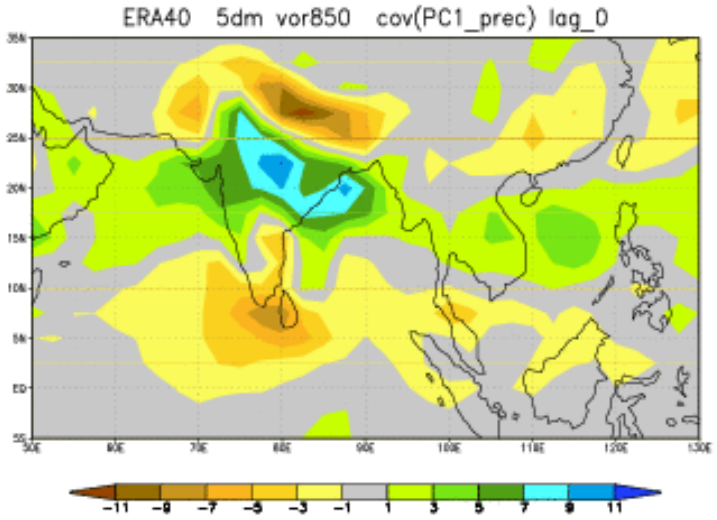
Sys3



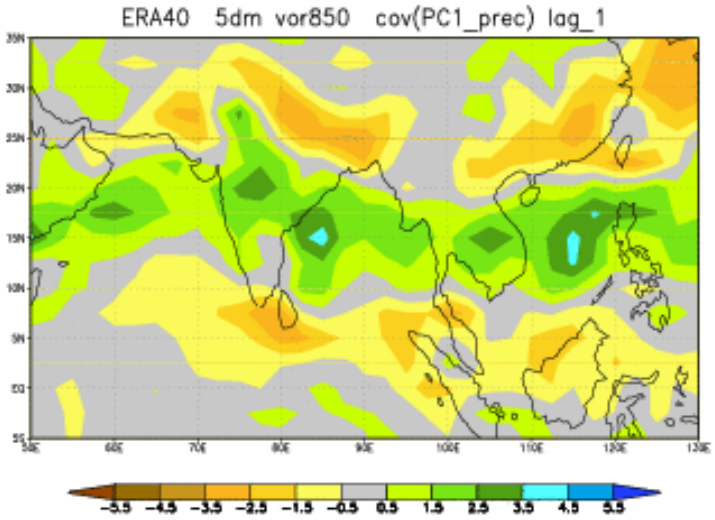


Vorticity 850: lagged cov. with rainfall PC1 (ERA40)

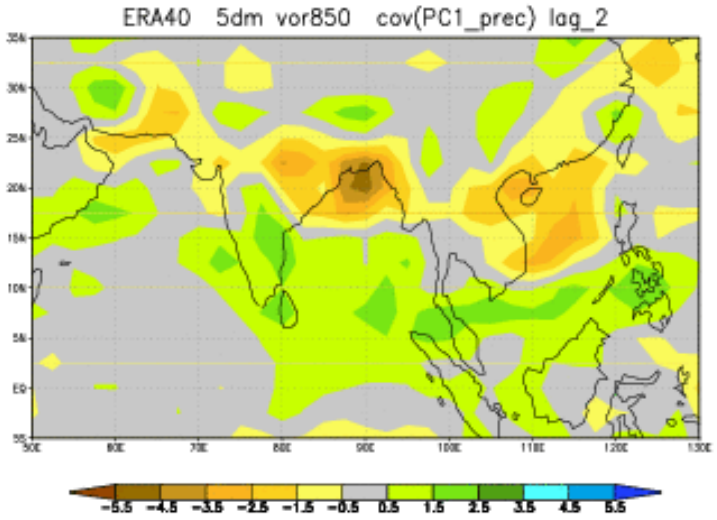
Vor (t0)



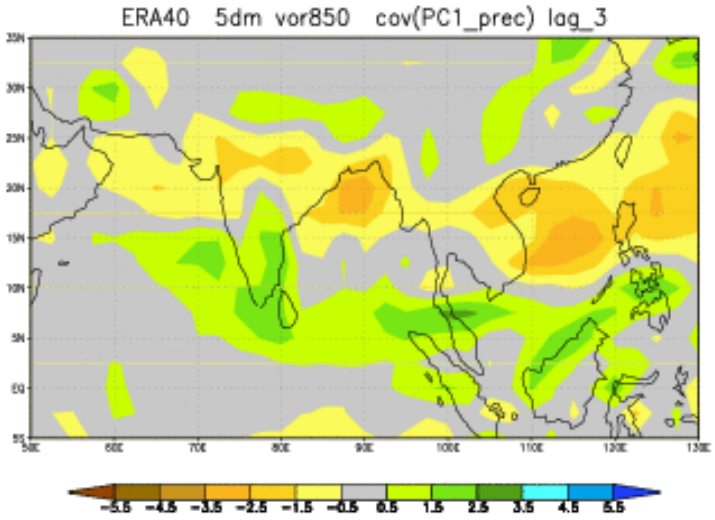
Vor (t-1)



Vor (t-2)

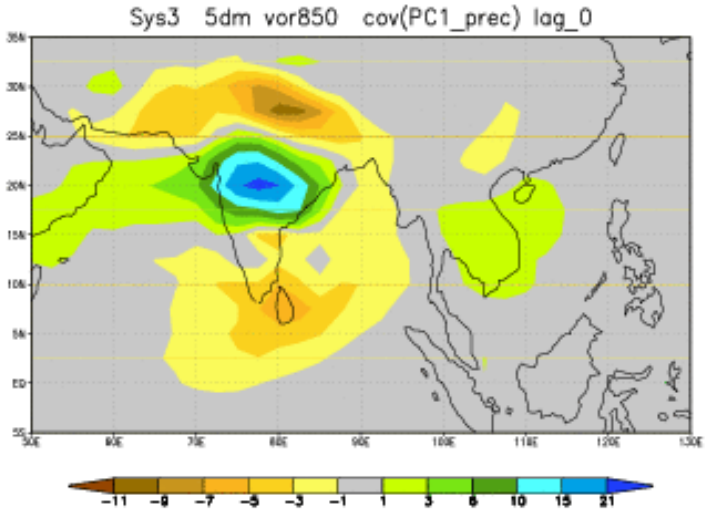


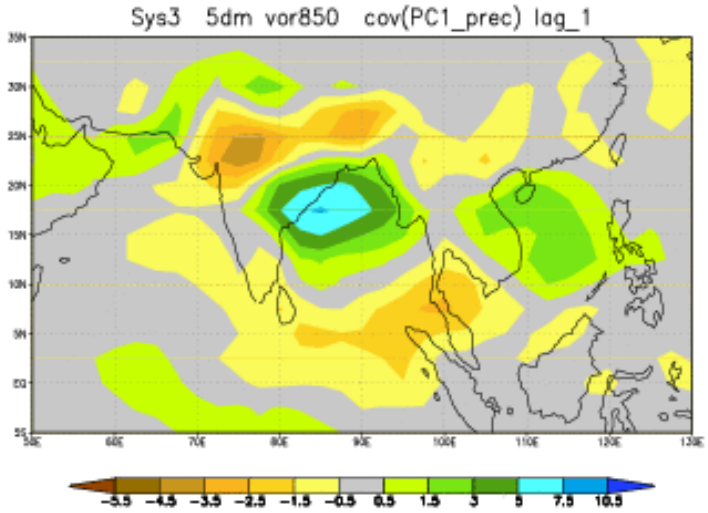
Vor (t-3)



Vorticity 850: lagged cov. with rainfall PC1 (Sys3)

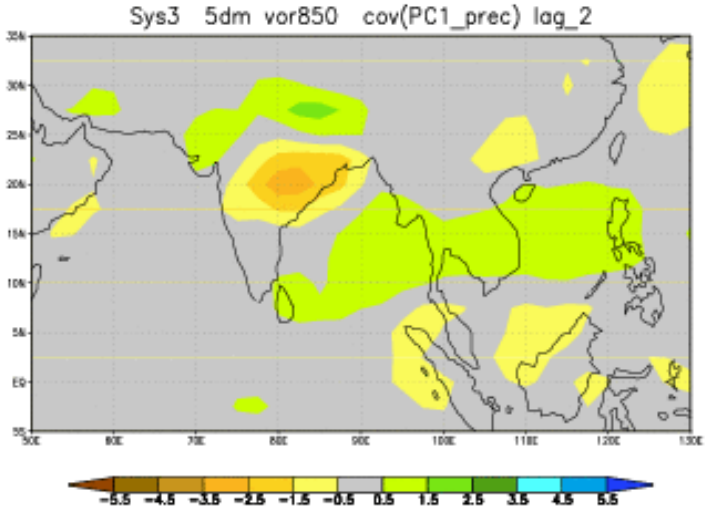
Vor (t0)

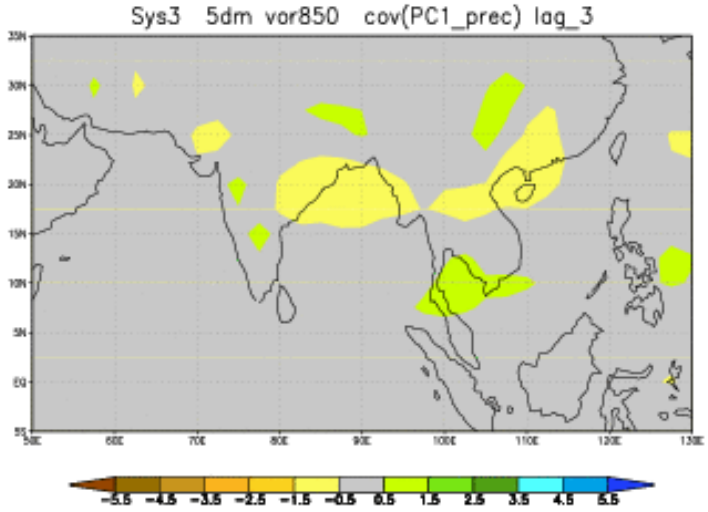




Vor (t-1)

Vor (t-2)

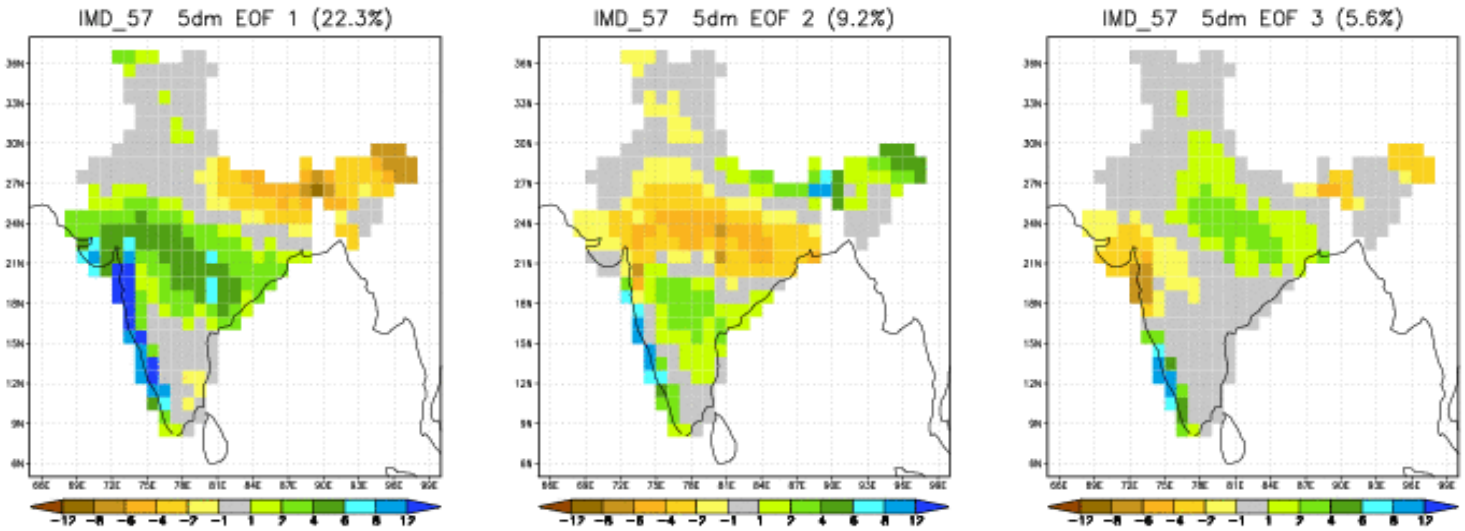




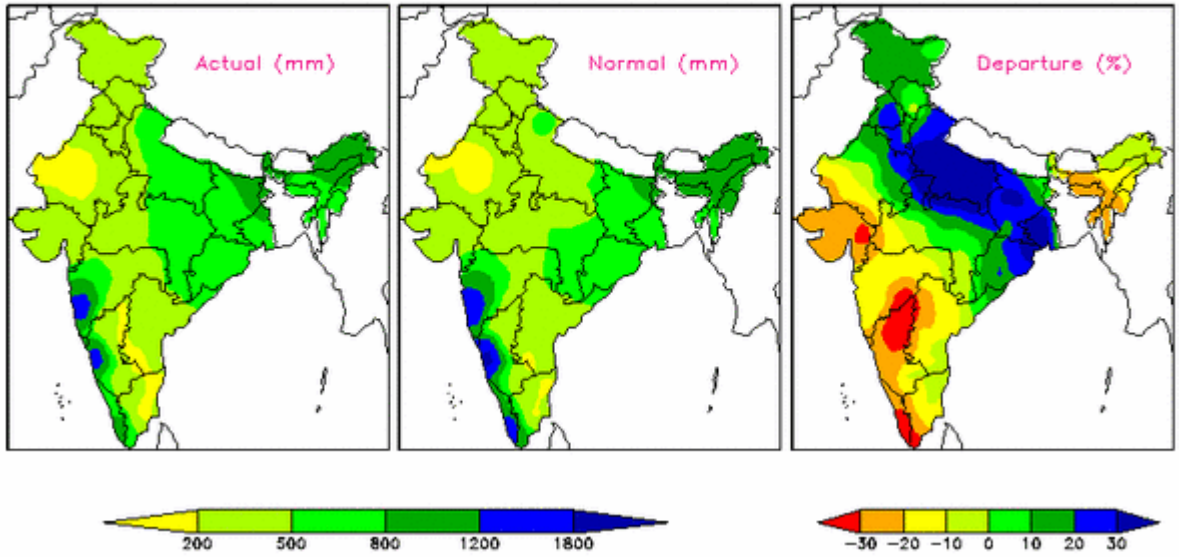
Vor (t-3)

5-d mean rainfall EOFs for July-August

IMD data 1951--2007



Observed Rainfall June-July 2008



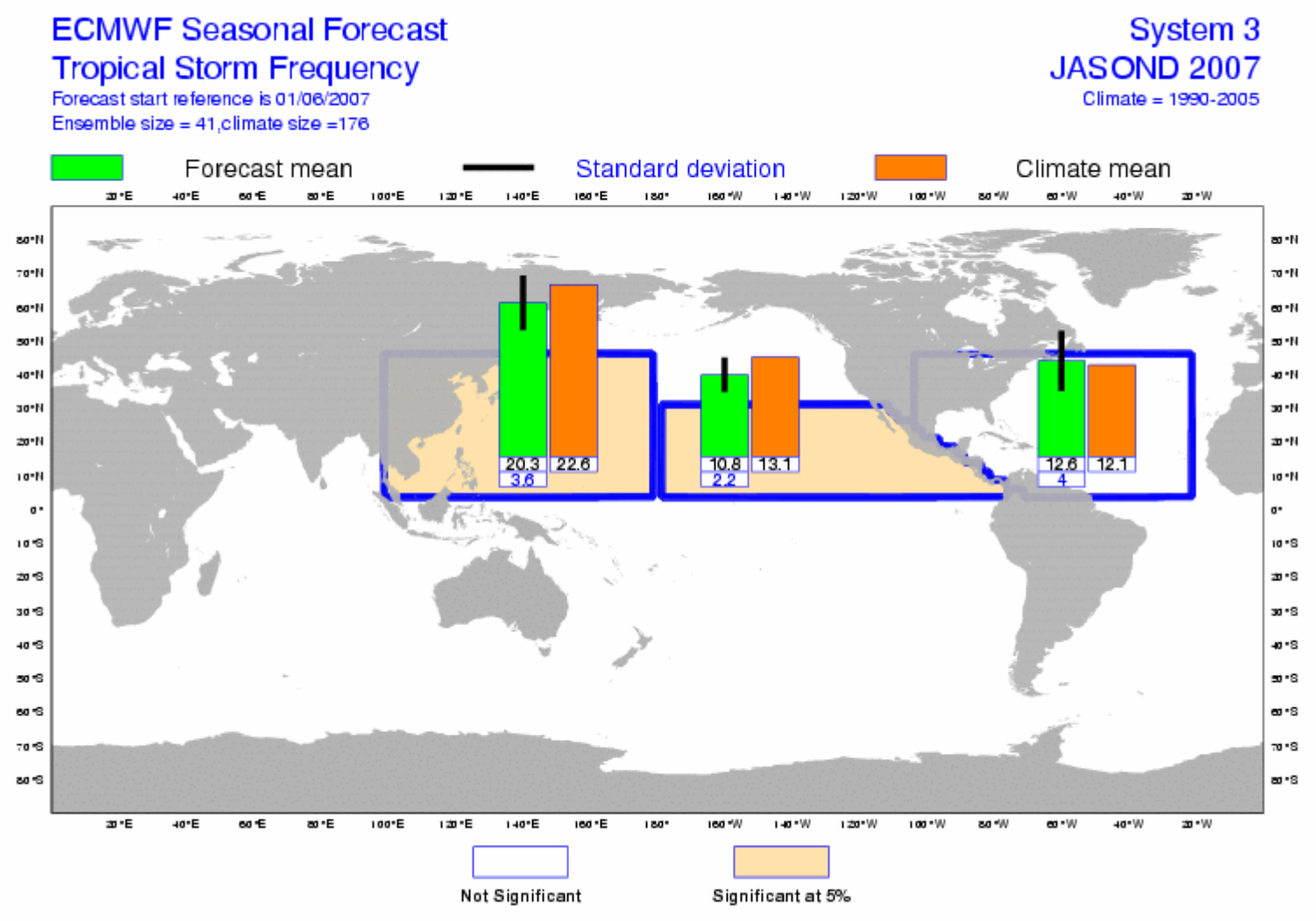
Conclusions (1)

- SST predictions from the ECMWF seasonal forecast system-3 show higher skill than those from previous system, particularly in the tropical Pacific and eastern Indian Ocean, but western Indian Oc. and tropical Atlantic are still not better than persistence in NH summer..
- Predictive skill for seasonal rainfall is generally good over the Pacific and tropical S. America, poor along the coast of the Indian Ocean in early summer. Skill for South Asian rainfall increases in the latter part of the monsoon season.
- Seasonal forecasts over land can be improved by exploiting teleconnections with adjacent ocean regions.

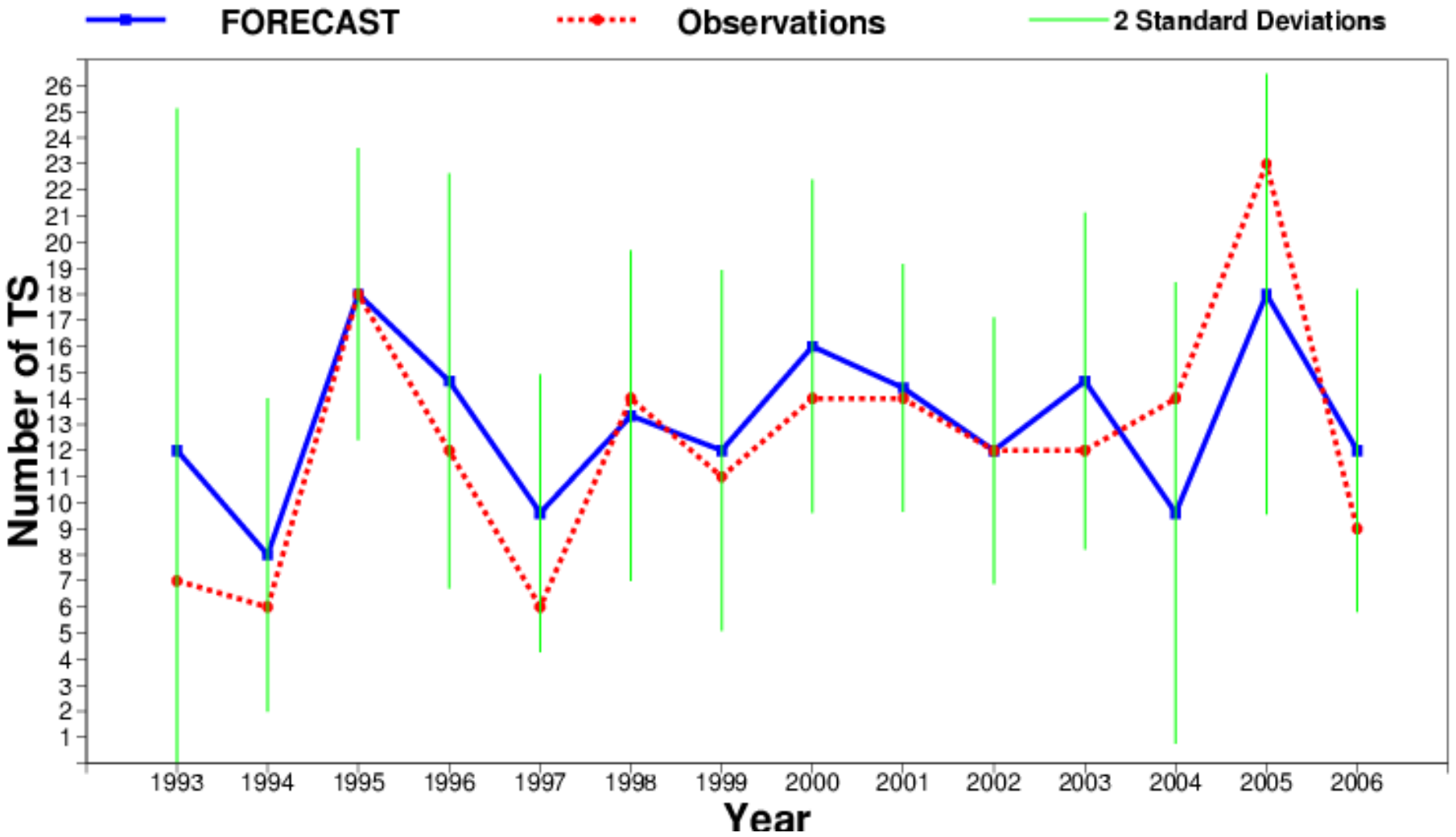
Conclusions (2)

- Predictive skill for monthly means of Indian rainfall in seasonal forecasts is generally low, with a maximum for September .
- 5-day mean rainfall analysis shows a deficient representation of variability in the northern part of India, while variability in the central peninsula is overestimated by the Sys3 model. This is reflected in the standard deviation of 850-hPa relative vorticity.
- Lag covariance maps indicate a less coherent organization of convection in the Sys3 model with respect to observation, with less evidence of meridional propagation and weaker teleconnections between the Indian and the South Asian region.
- Statistical corrections may be needed to extract information about year-to-year variations of monsoon ISV from Sys3 output.

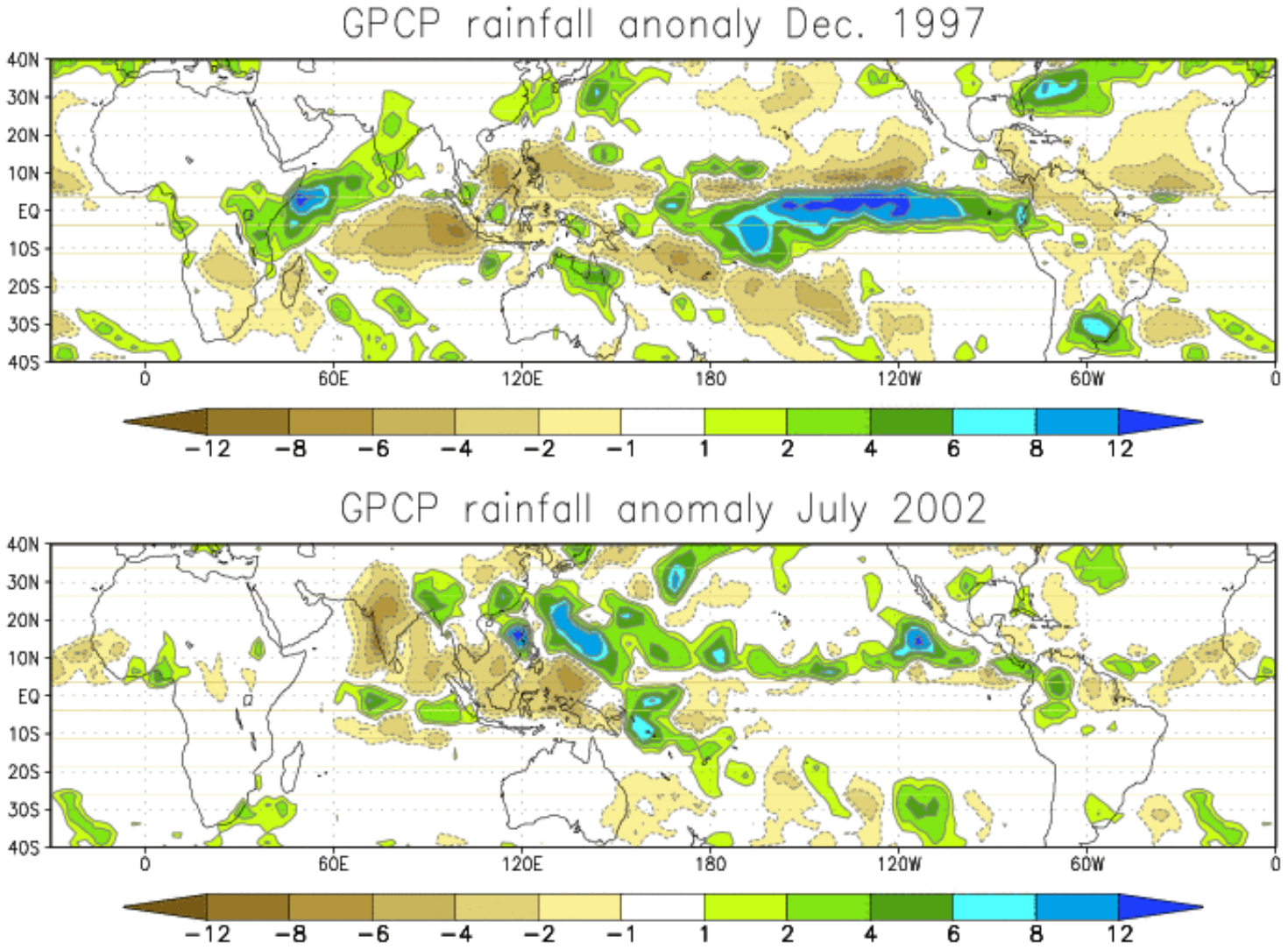
Products from Sys-3 : tropical storm frequency



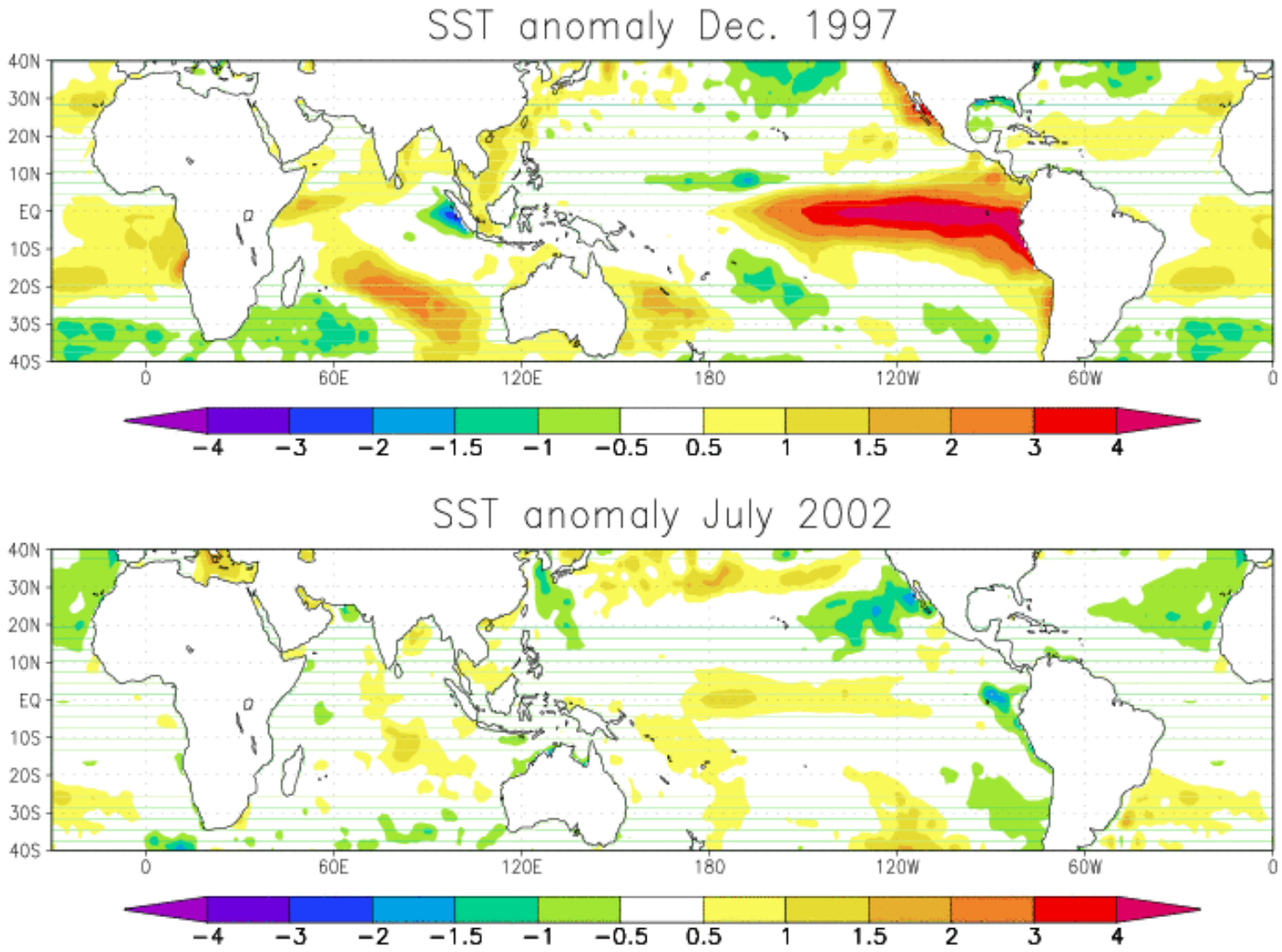
EUROSIP seasonal fc of tropical storms (from 1st June)



Rainfall anomalies in Dec. 1997 and July 2002

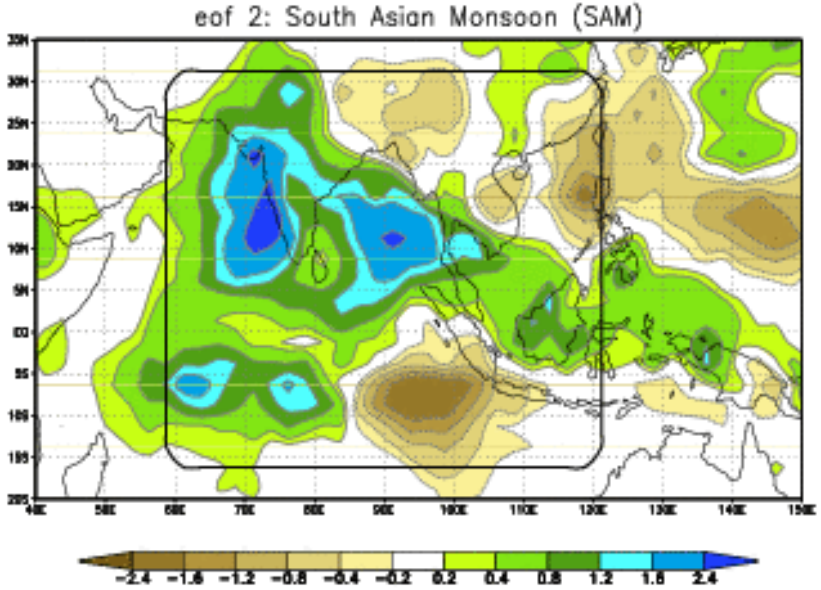


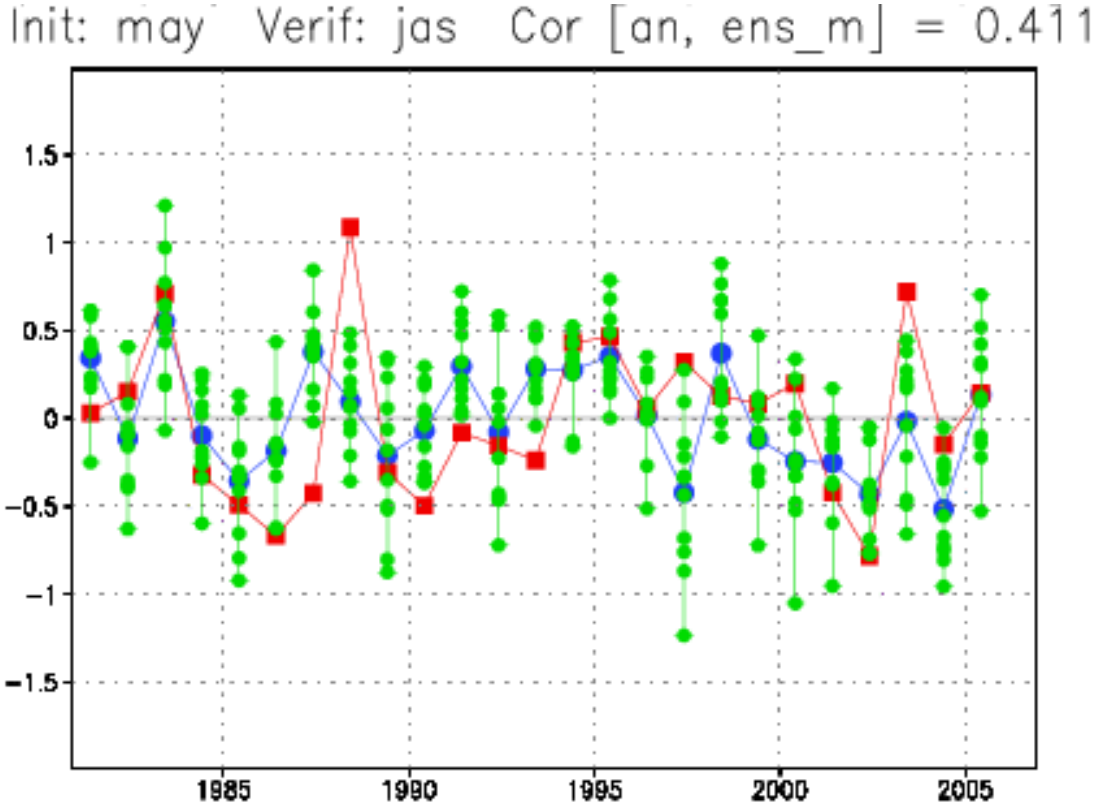
SST anomalies in Dec. 1997 and July 2002



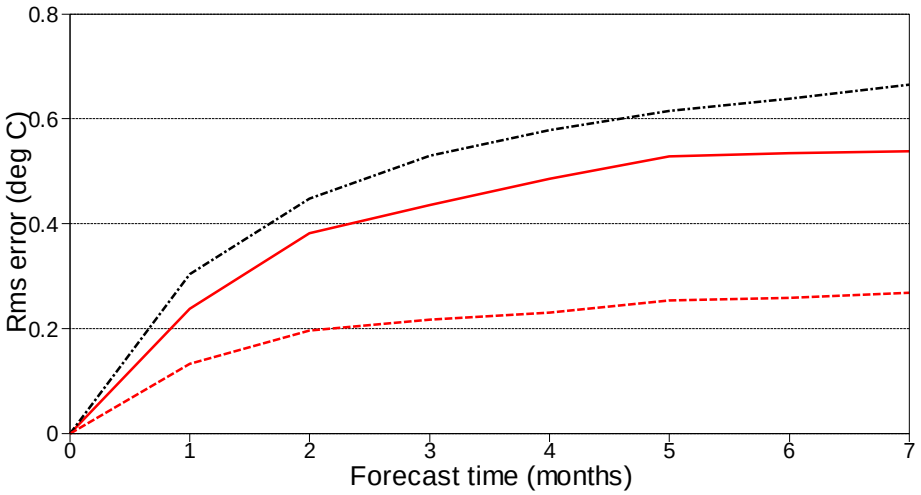
Predictability of teleconnection/EOF indices in S-3

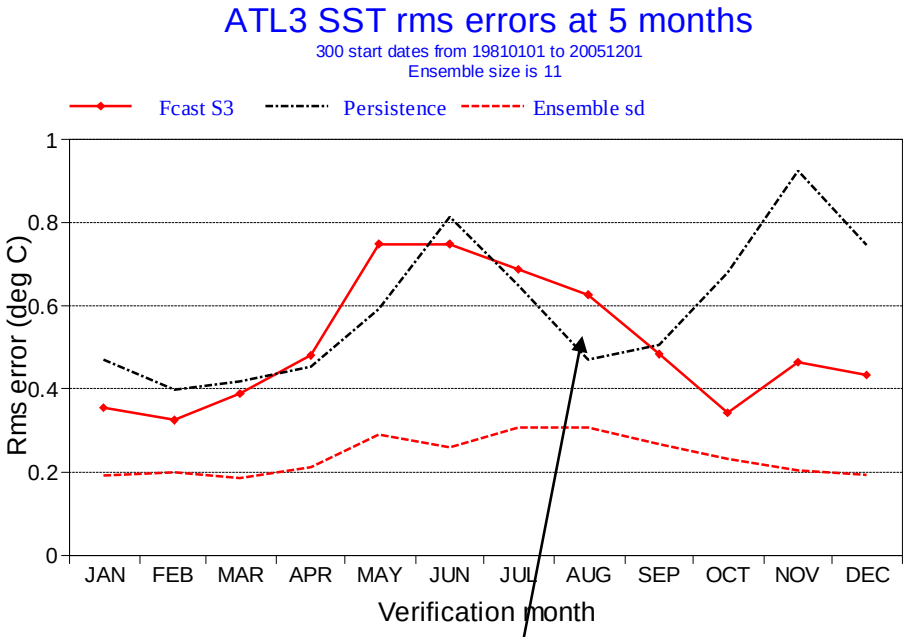
Rainfall: South Asian monsoon pattern (JAS)

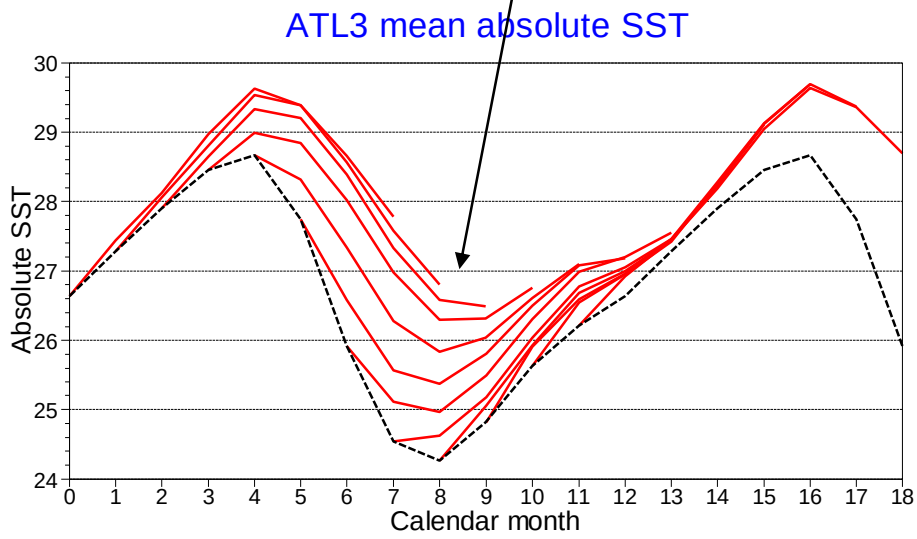




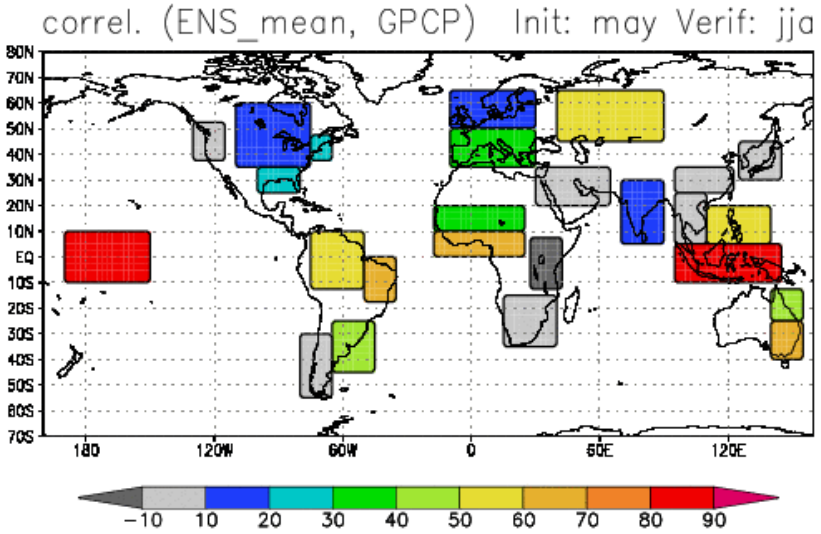
Equatorial Atlantic

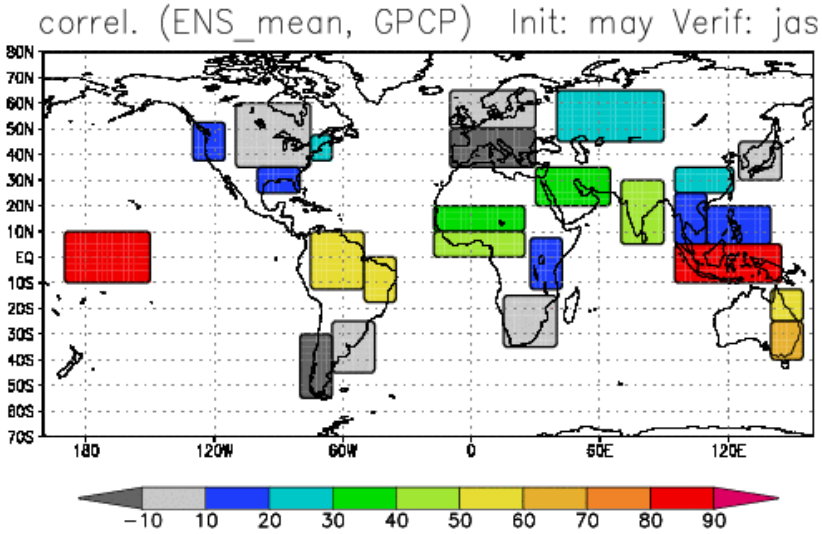


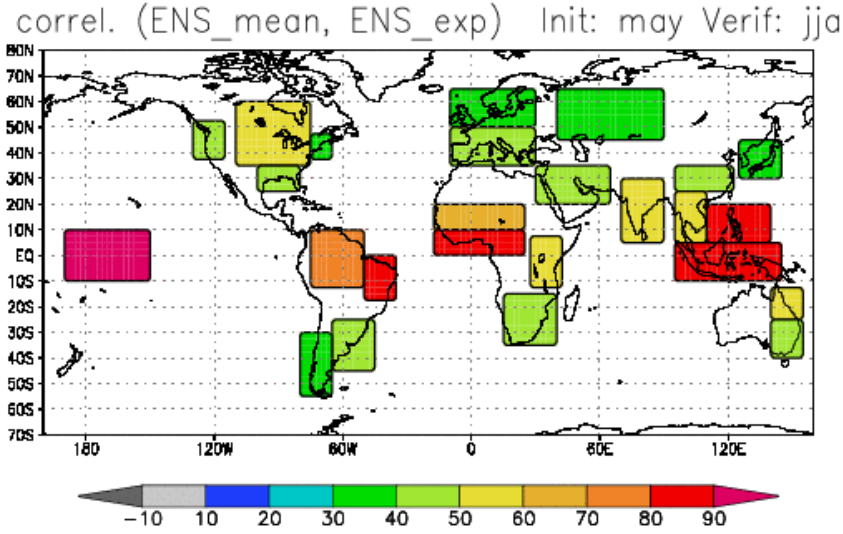


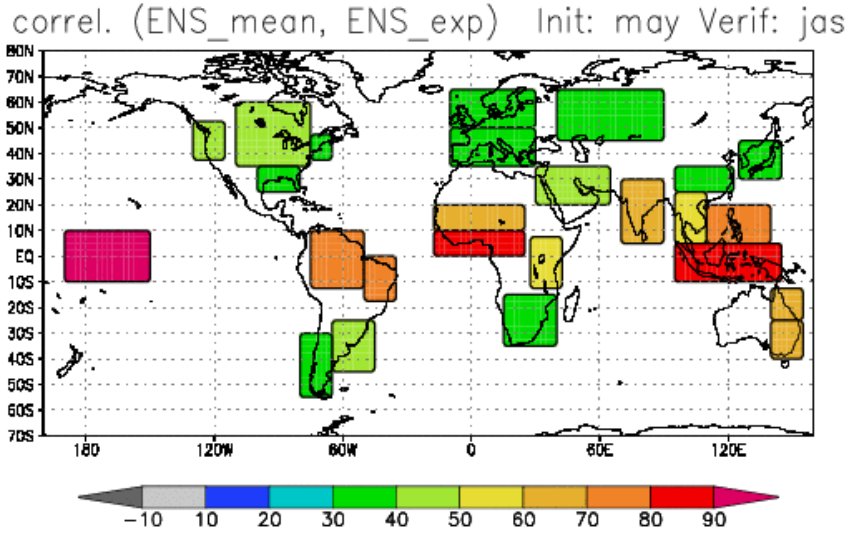


Anomaly correlation of seasonal-mean rainfall

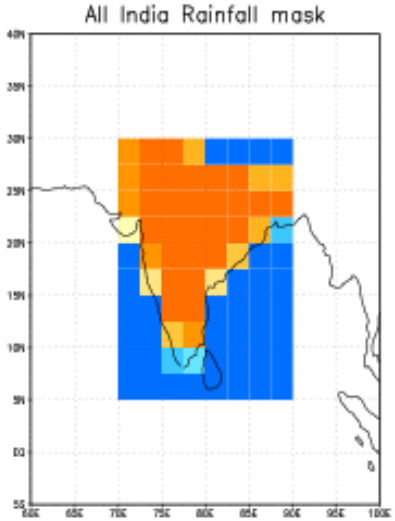


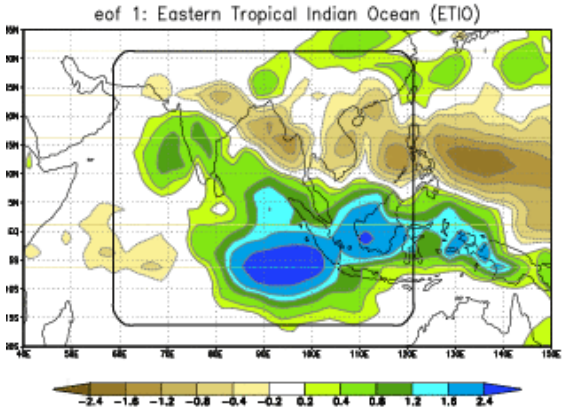


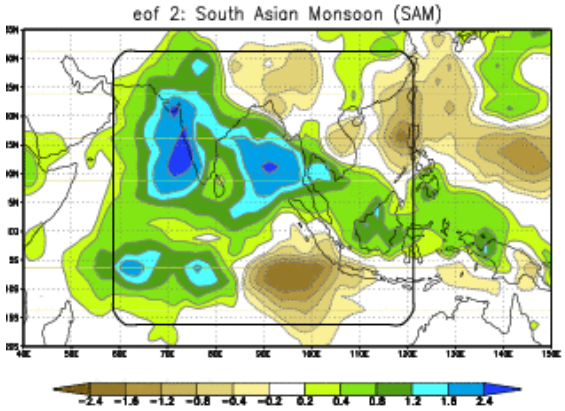


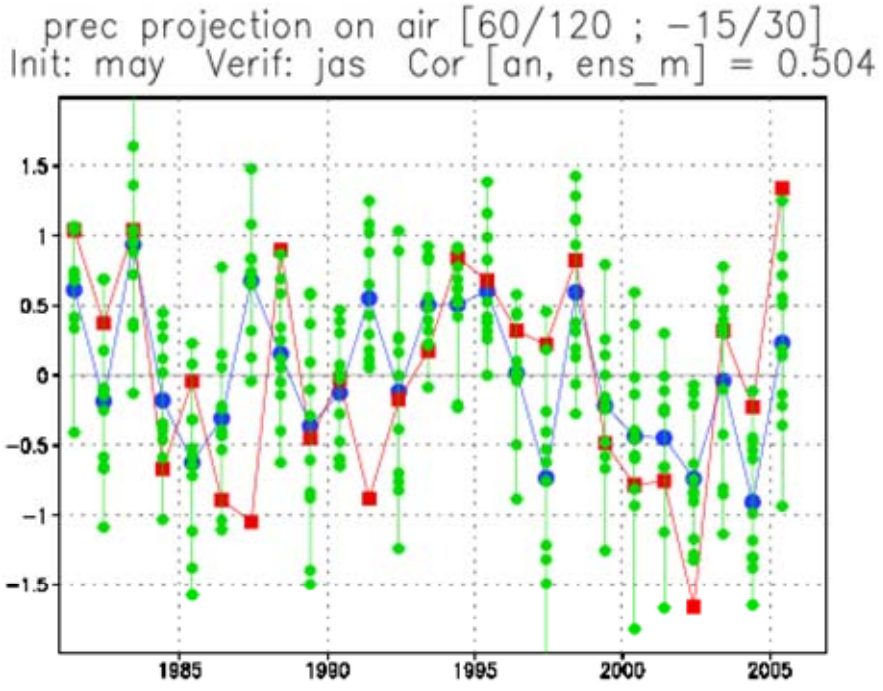


Predictability of AIR in S-3: EOF filtered JAS









CC = **.50**