Understanding teleconnections with the Indo-Pacific region during the northern winter

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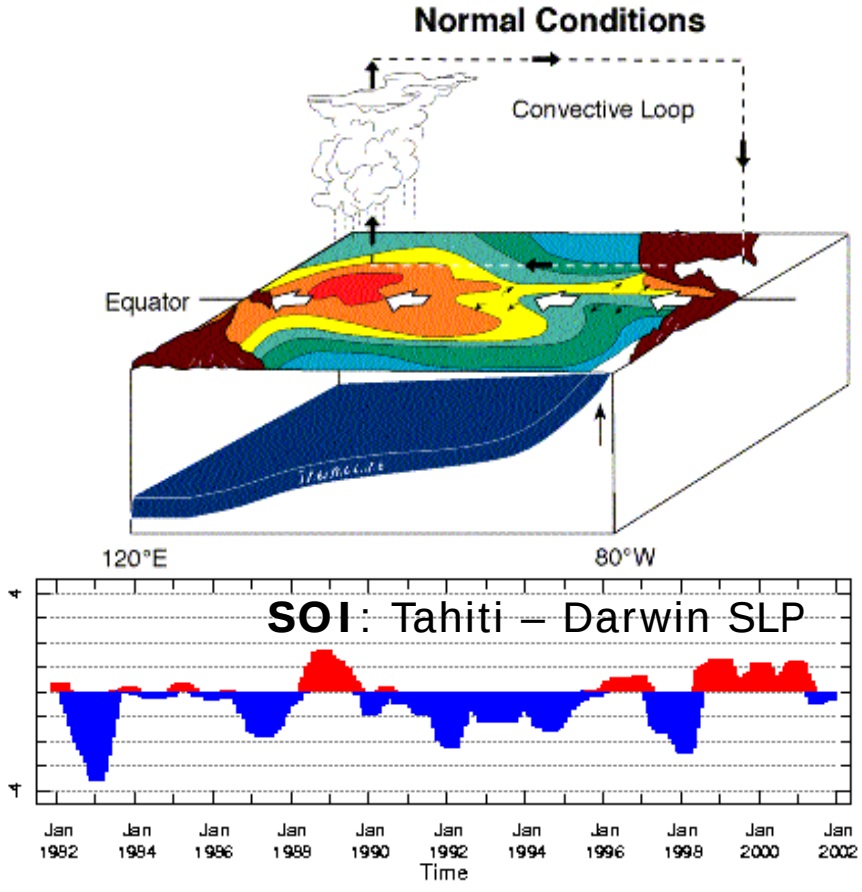
Acknowledgements to: T. Stockdale, F. Vitart and colleagues in the Predictability Division

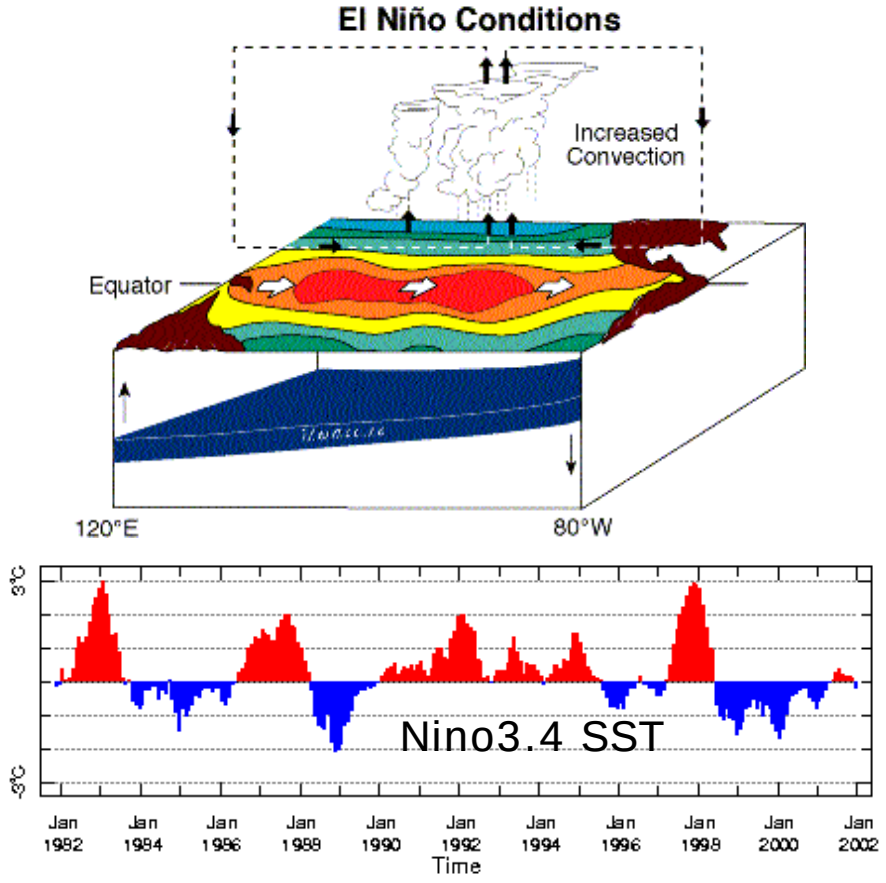
Outline

- Seasonality in the connections between the tropical Pacific and Indian Oceans: limitations of the SST viewpoint
- Understanding the impact of Indo-Pacific SST anomalies in AGCM experiments
- Comparison between teleconnections in observational datasets and the ECMWF System-4 re-forecasts:
  - Covariances with SST indices
  - Covariances with rainfall indices
  - Predictability of Indo-Pacific SST and rainfall anomalies
- Analogies between intra-seasonal and inter-annual teleconnections, and links with decadal variability
- Conclusions: a rainfall-oriented view of Indo-Pacific teleconnections

Major teleconnection drivers: ENSO

The El Niño - Southern Oscillation

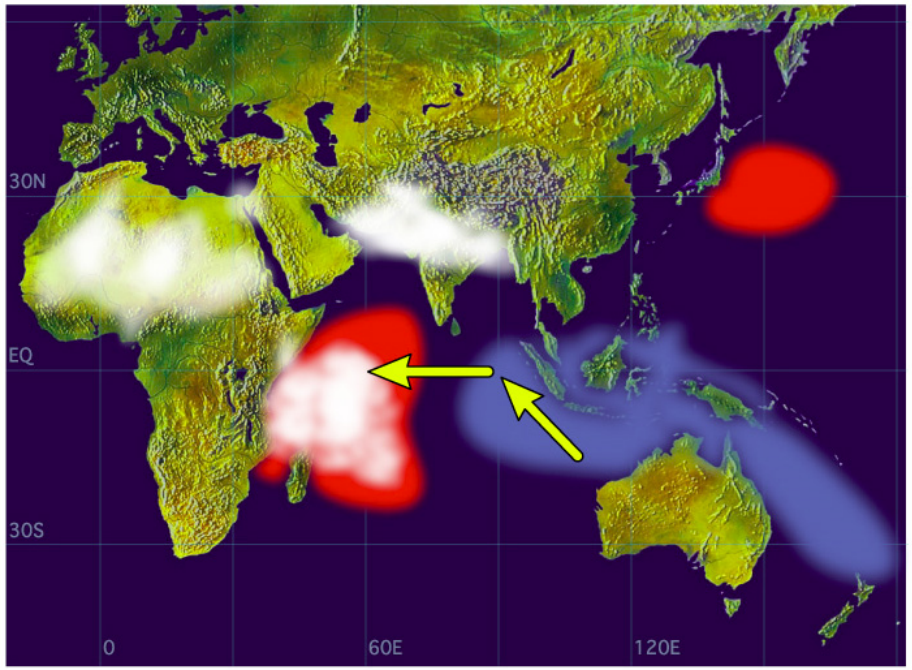




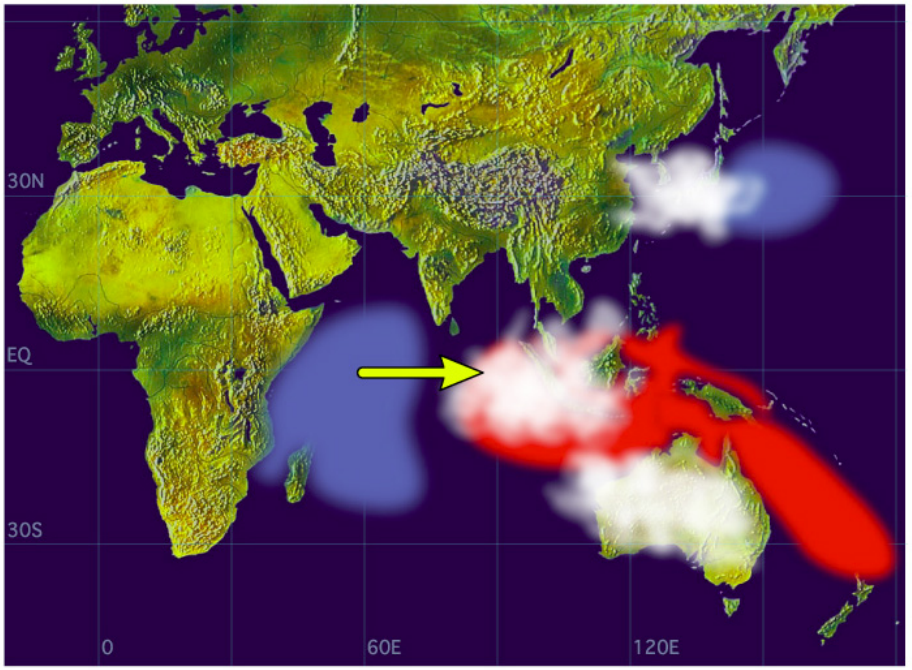
Major teleconnection drivers: IOD

The Indian Ocean Dipole (or I.O. Zonal Mode)

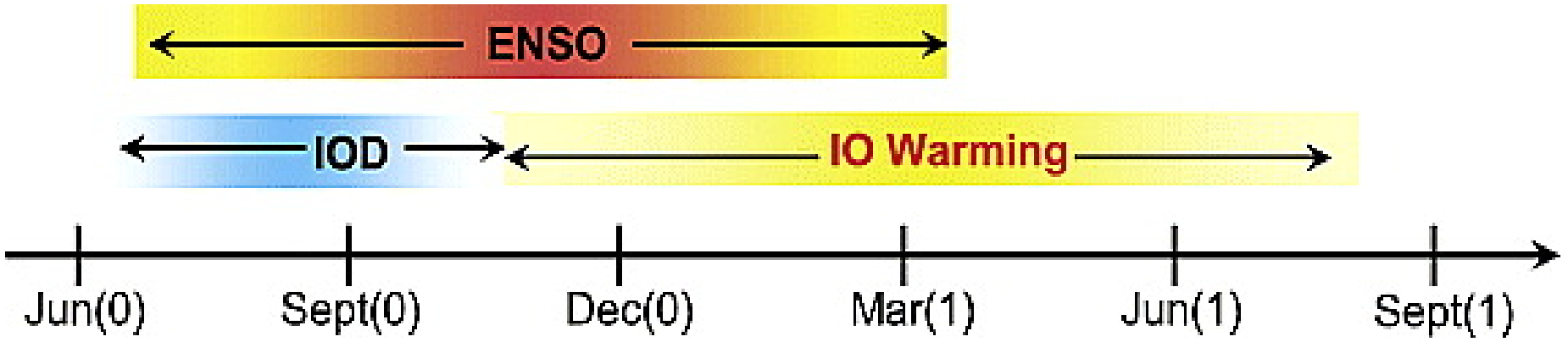
Positive Dipole Mode

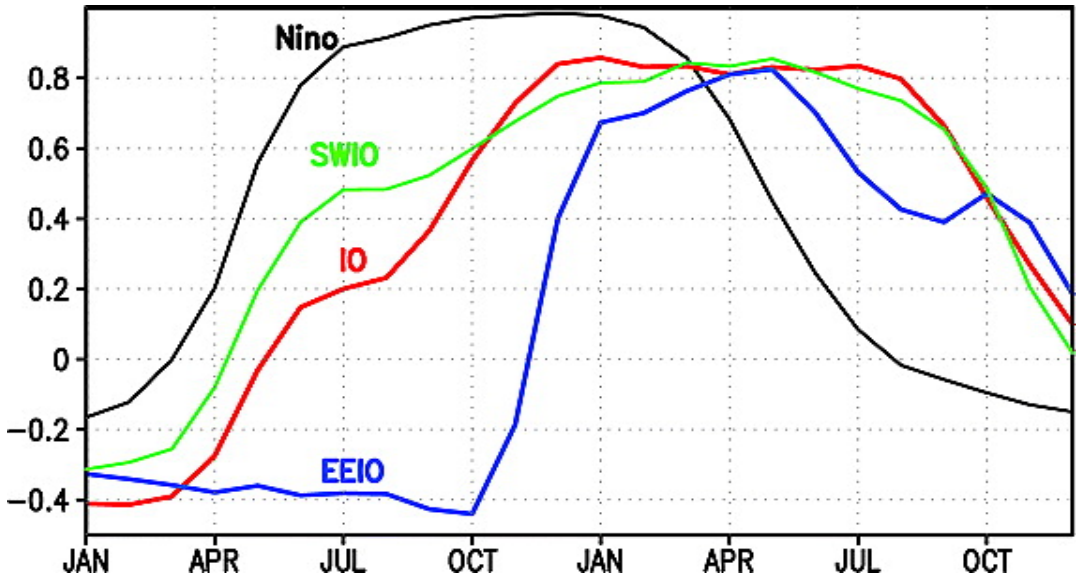


Negative Dipole Mode



Seasonal evolution of ENSO and IOD

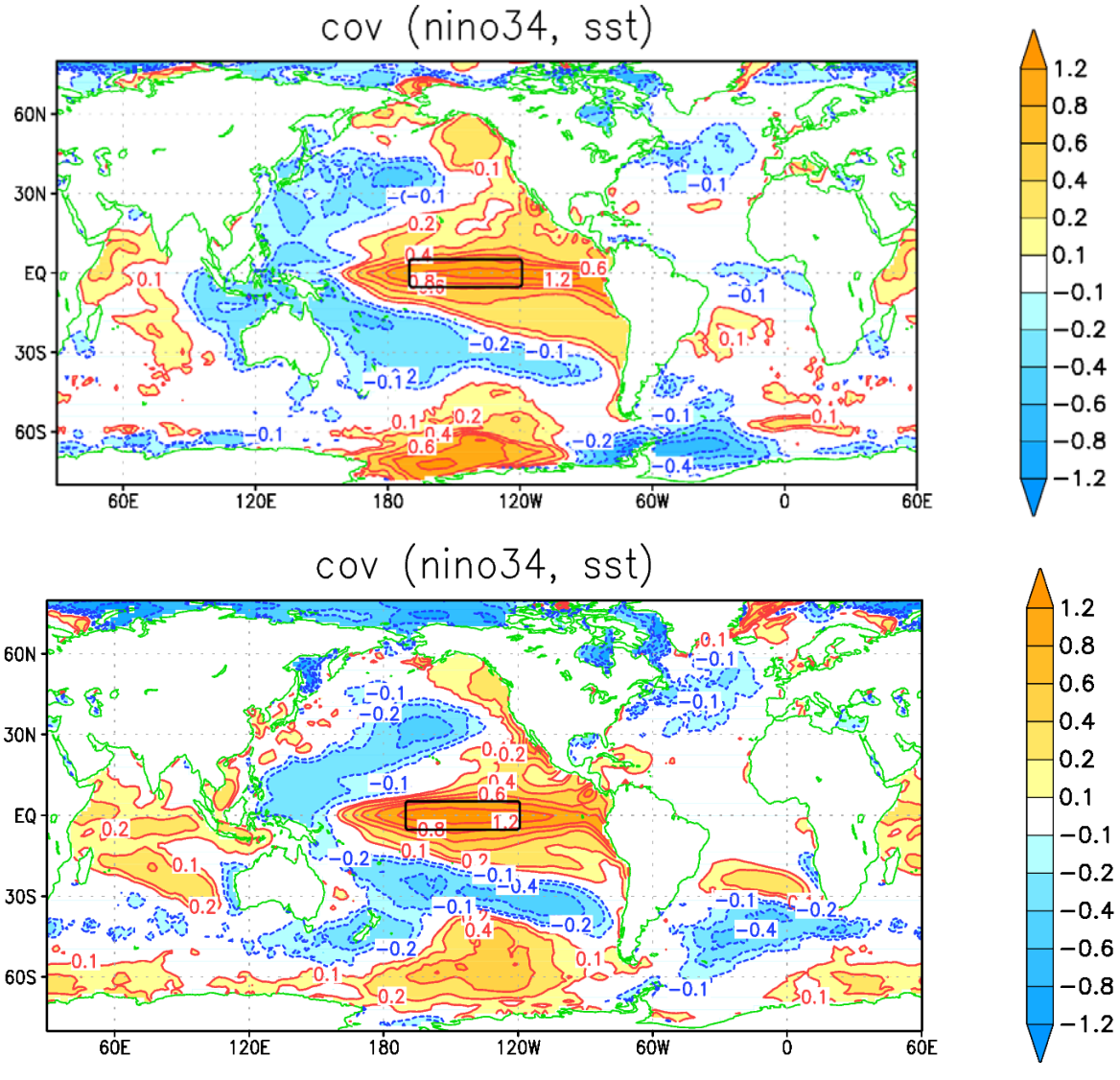




Correlation with Nino3 SST in NDJ

From Schott et al. Rev. Geoph. 2009

Covariance of global SST with stand. Nino3.4 index



ERA Interim, 1981-2010

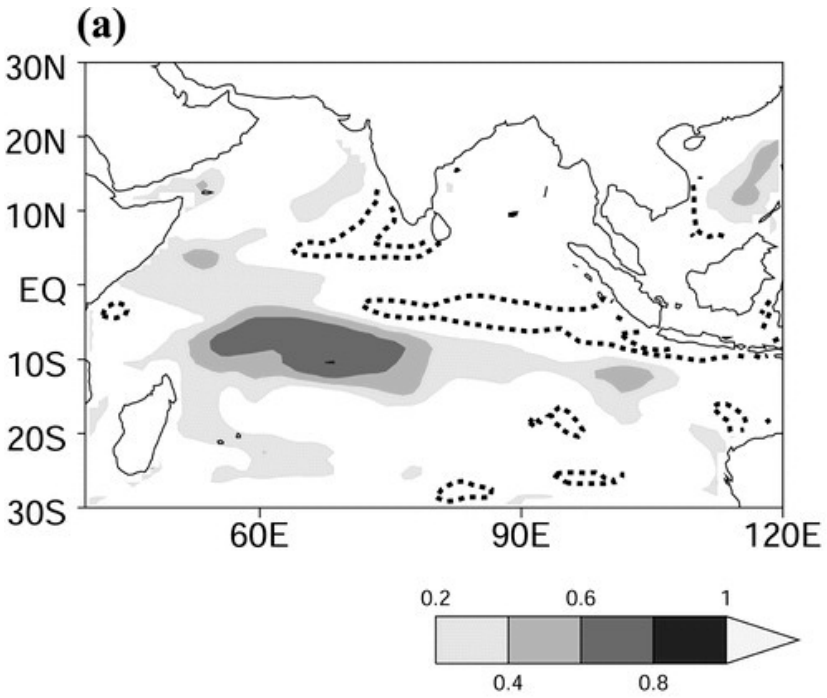
SON

DJF

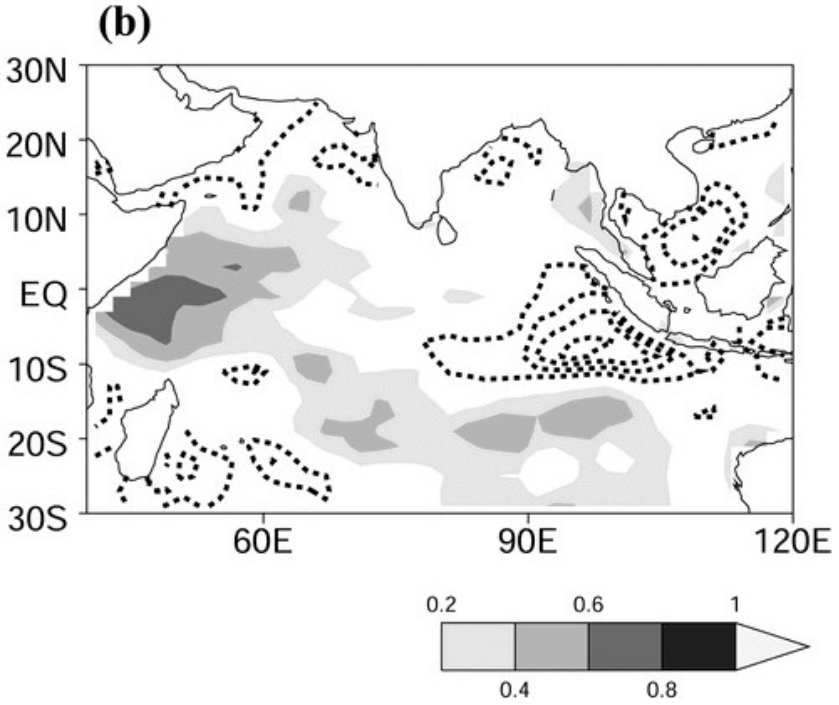
AGCM exp.: response to ENSO SST, Annamalai et al. 2007

Local correlation between JFM SST and:

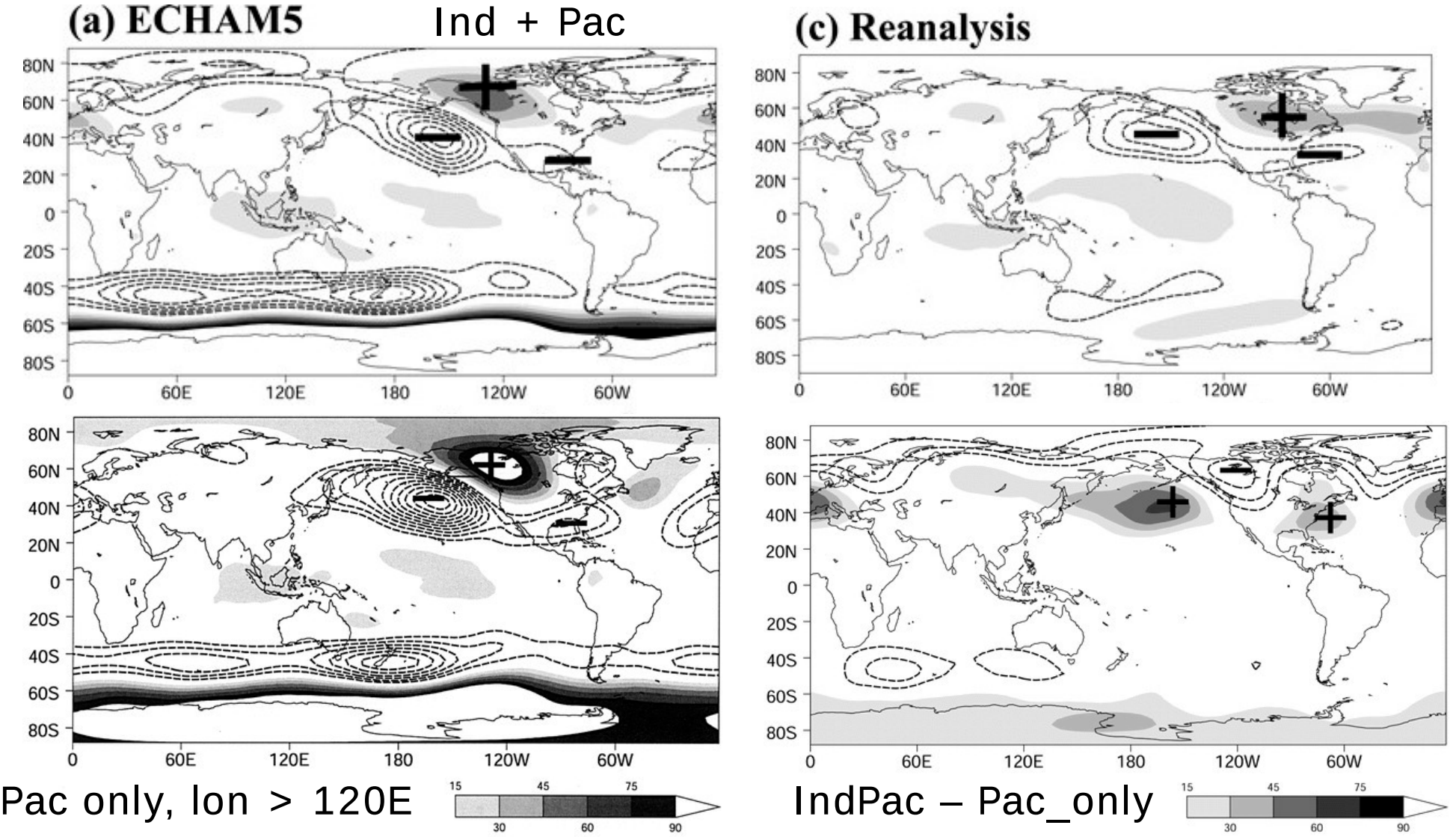
a) 20-C isotherm depth



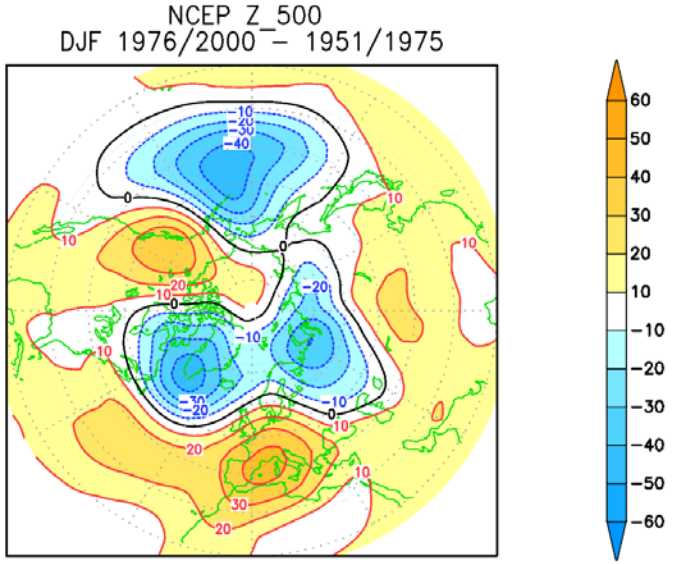
b) precipitation

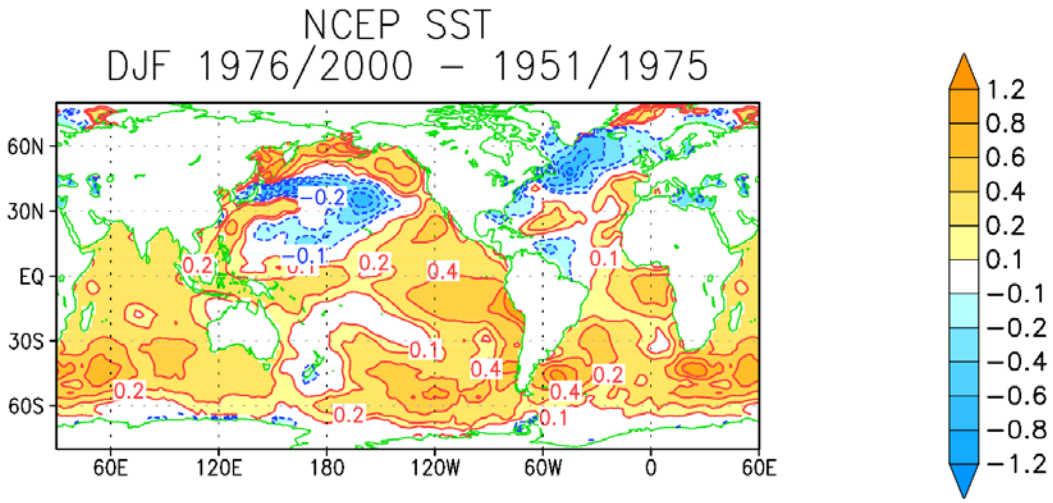


AGCM exp.: response to ENSO SST, Annamalai et al. 2007

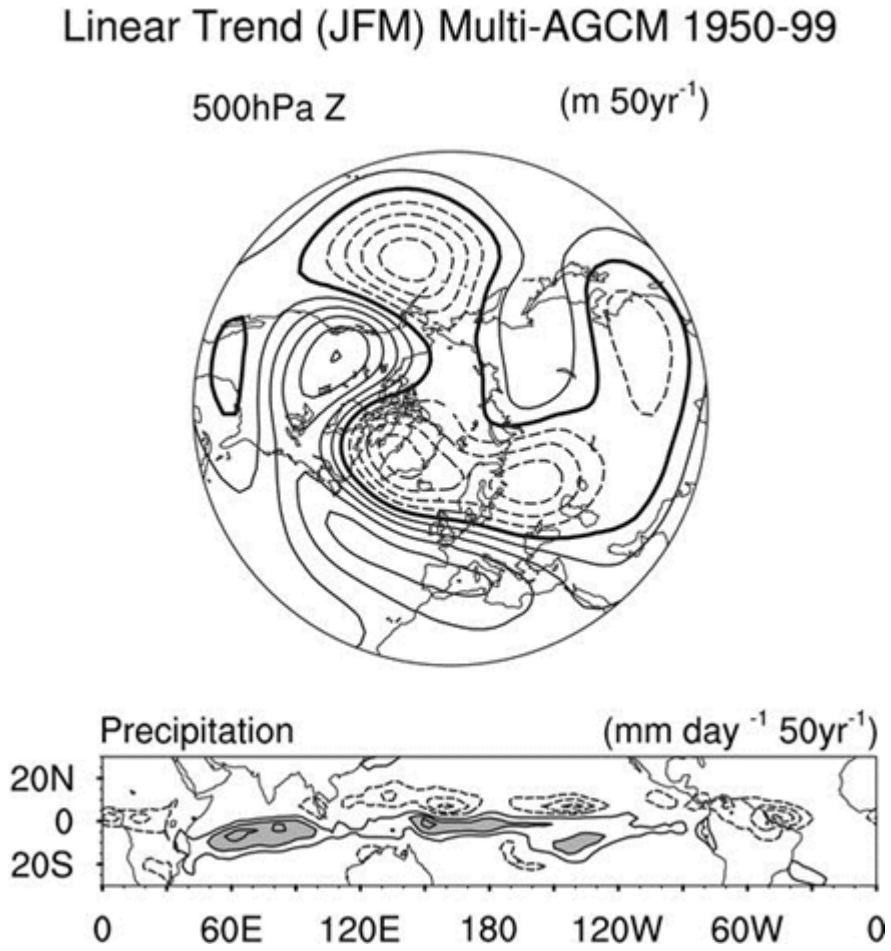


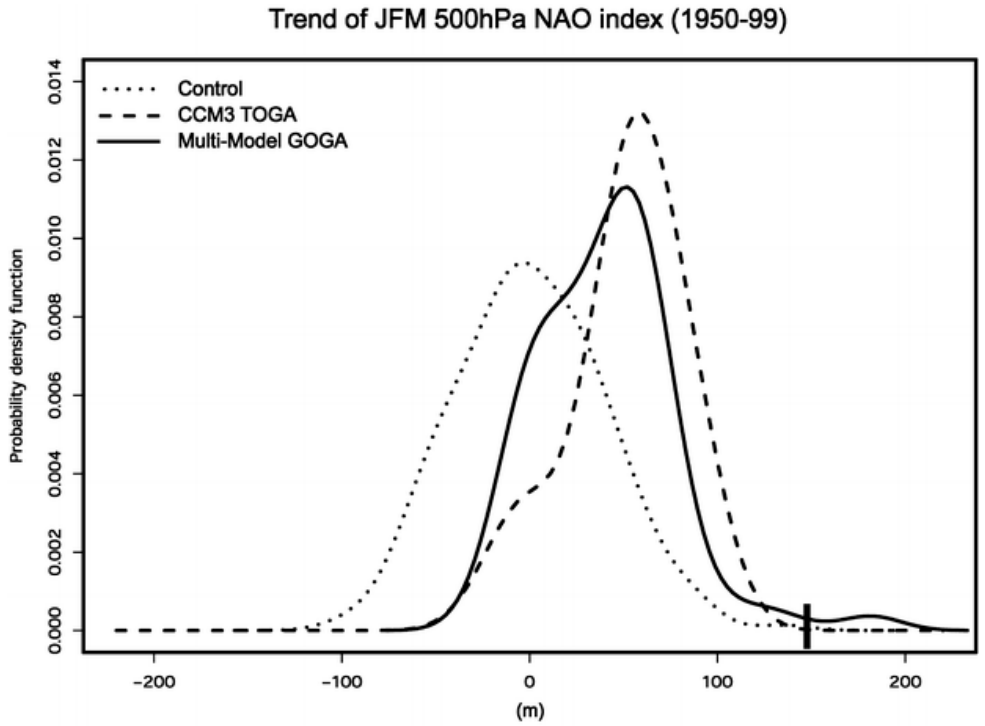
Decadal variability in the late 20th century





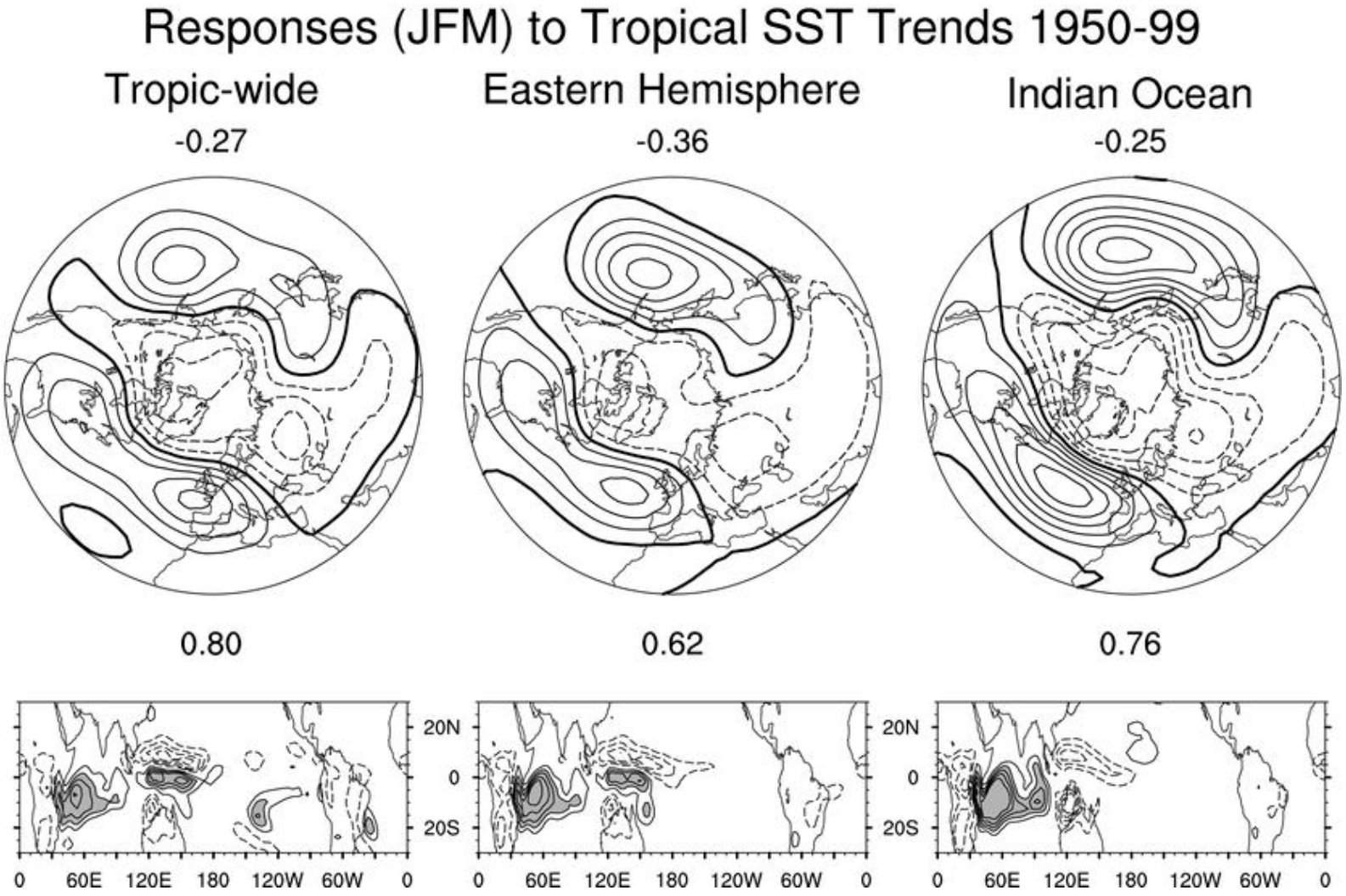
AGCM exp: late 20th cen. trends, Hurrell et al. 2004





JFM NAO index

AGCM exp: late 20th cen. trends, Hoerling et al. 2004

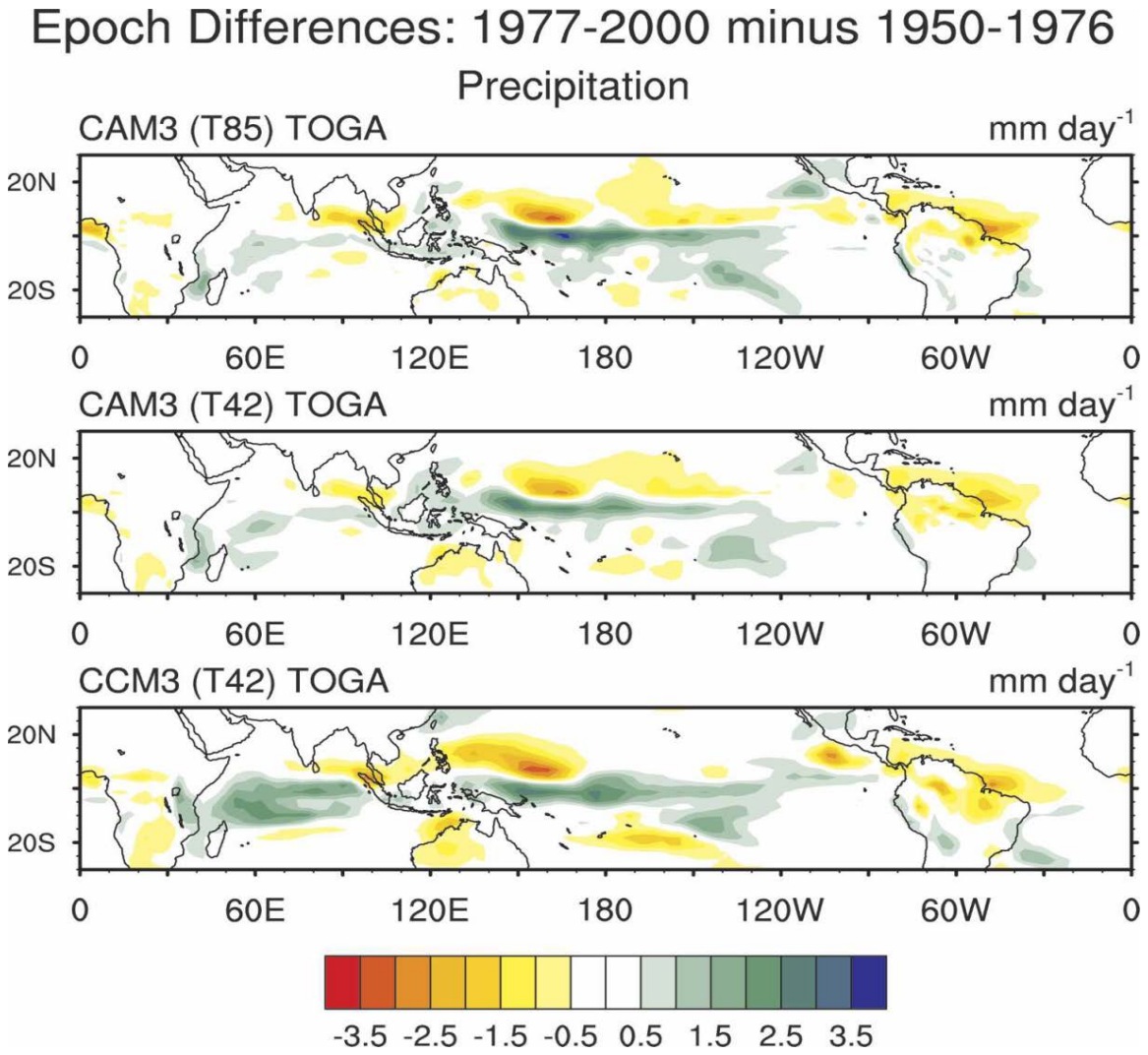


CCM3

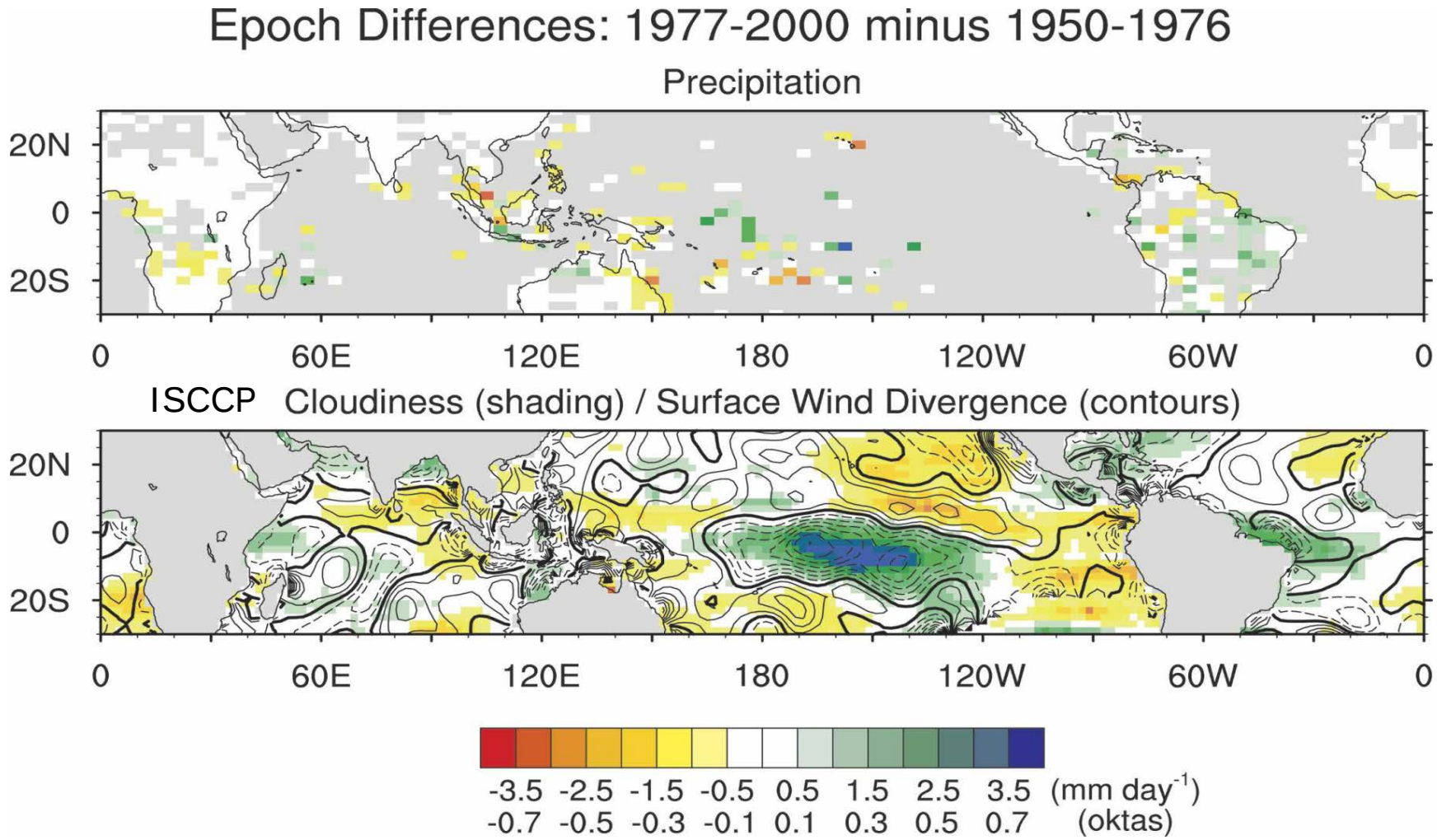
Z 500

Prec.

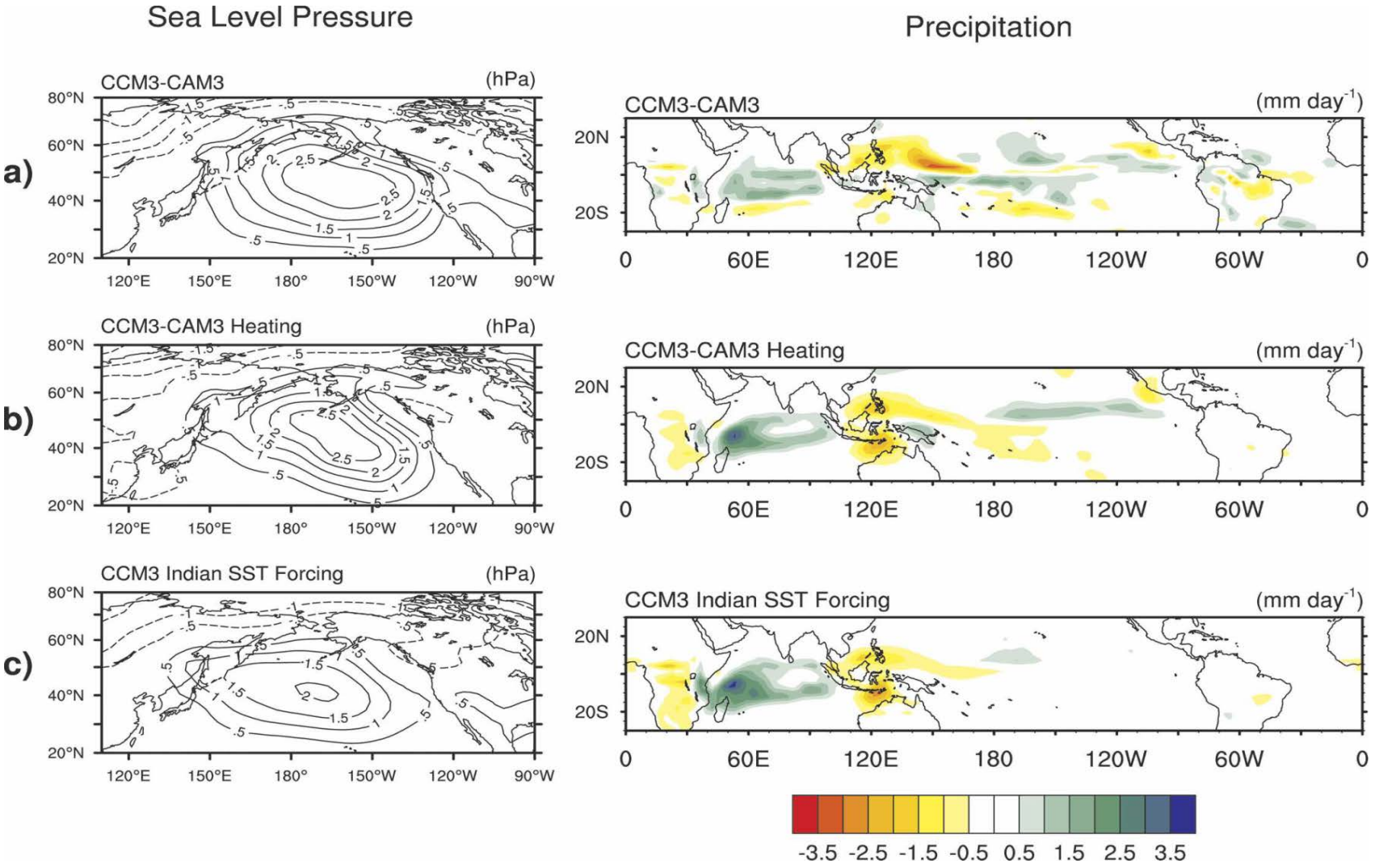
AGCM exp: mid-1970s transition, Deser & Phillips 2006



Obs. change in prec + clouds, Deser & Phillips 2006



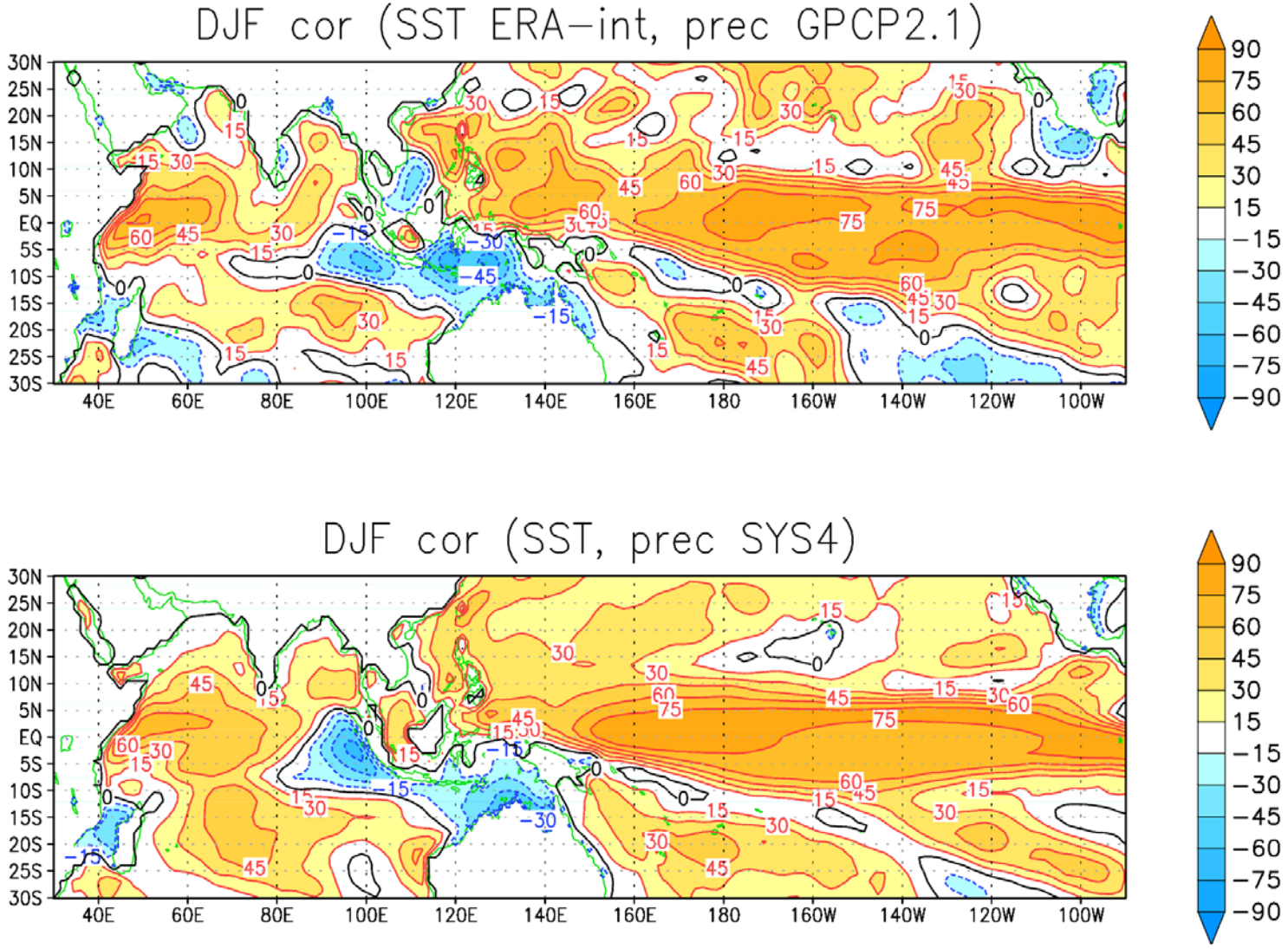
Response over N. Pacific: Deser & Phillips 2006



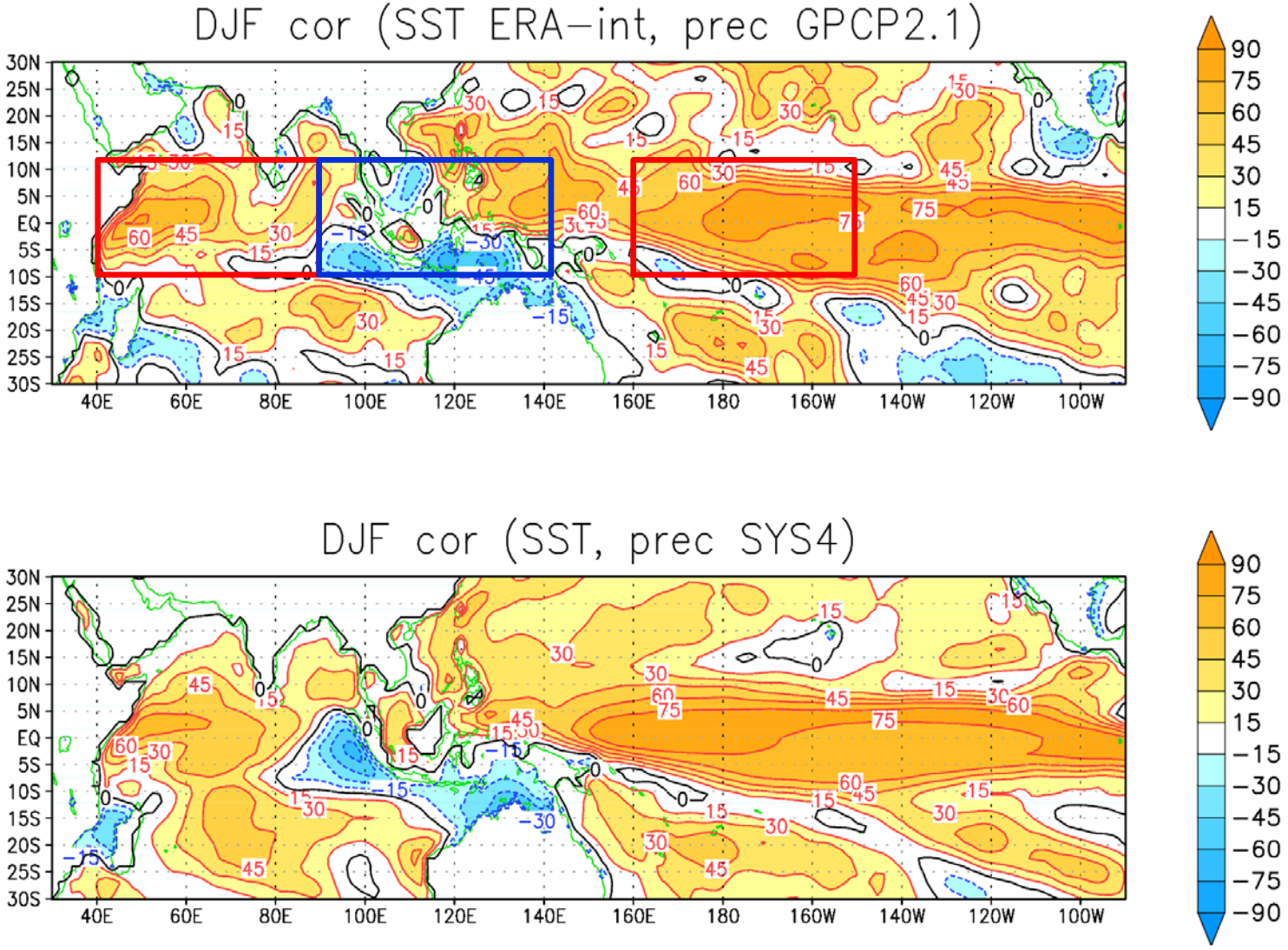
ECMWF seasonal fc. System 4: main features

- **IFS model cycle: 36r4** (op. Nov. 2010-May 2011), **T255-L91**
- **Ocean model : NEMO (v. 3.0 + 3.1 coupling interface)**
  - ORCA-1 configuration (~1-deg. resol., ~0.3 lat. near the equator)
  - 42 vertical levels, 20 levels with z < 300 m
- **Variational ocean data assimilation (NEMOVAR)**
  - FGAT 3D-var, re-analysis (ORA-S4) and near-real-time system
  - Collaboration with CERFACS, UK Met Office, INRIA
- **Operational forecasts**
  - 51-member ensemble from 1st day of the month, released on the 8th
  - 7-month integration
  - 13-month extension (with 15 ens. members) from 1st Feb/May/Aug/Nov
- **Re-forecast set**
  - 30 years, start dates from 1 Jan 1981 to 1 Dec 2010
  - 15-member ensembles, 7-month integrations
  - 13-month extension from 1st Feb/May/Aug/Nov

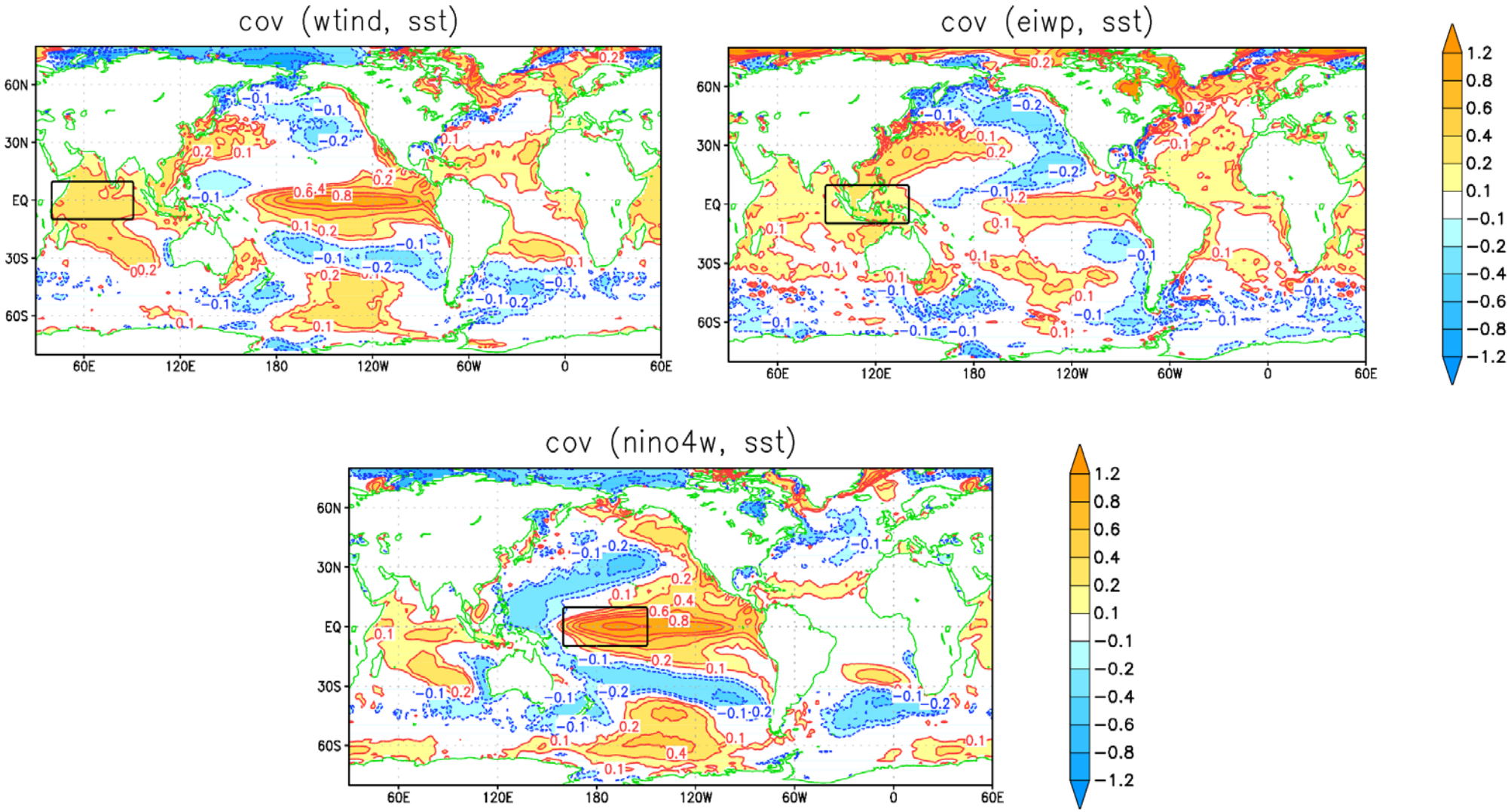
Local correlation SST – precip, DJF 1981-2008



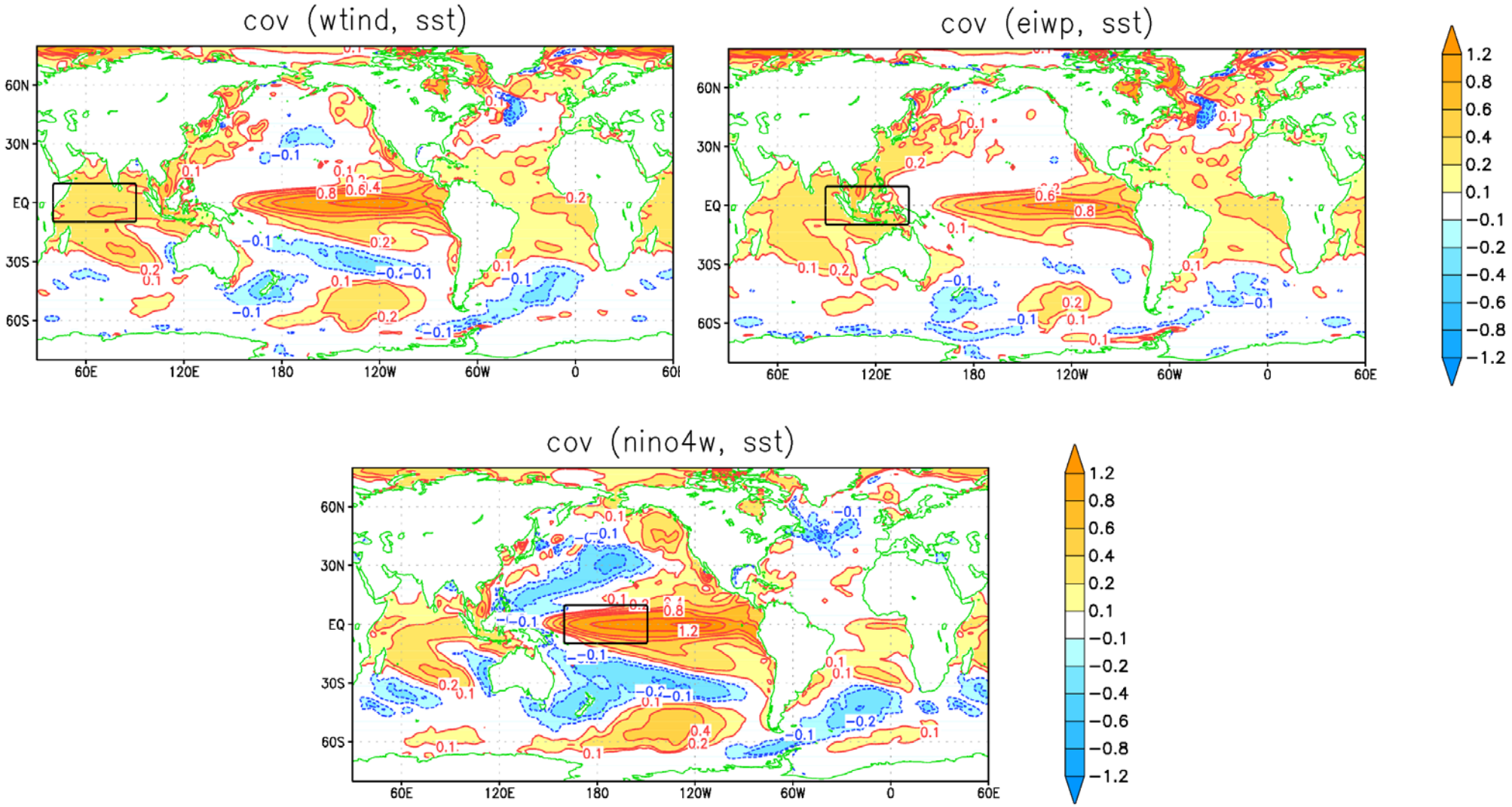
Local correlation SST – precip, DJF 1981-2008



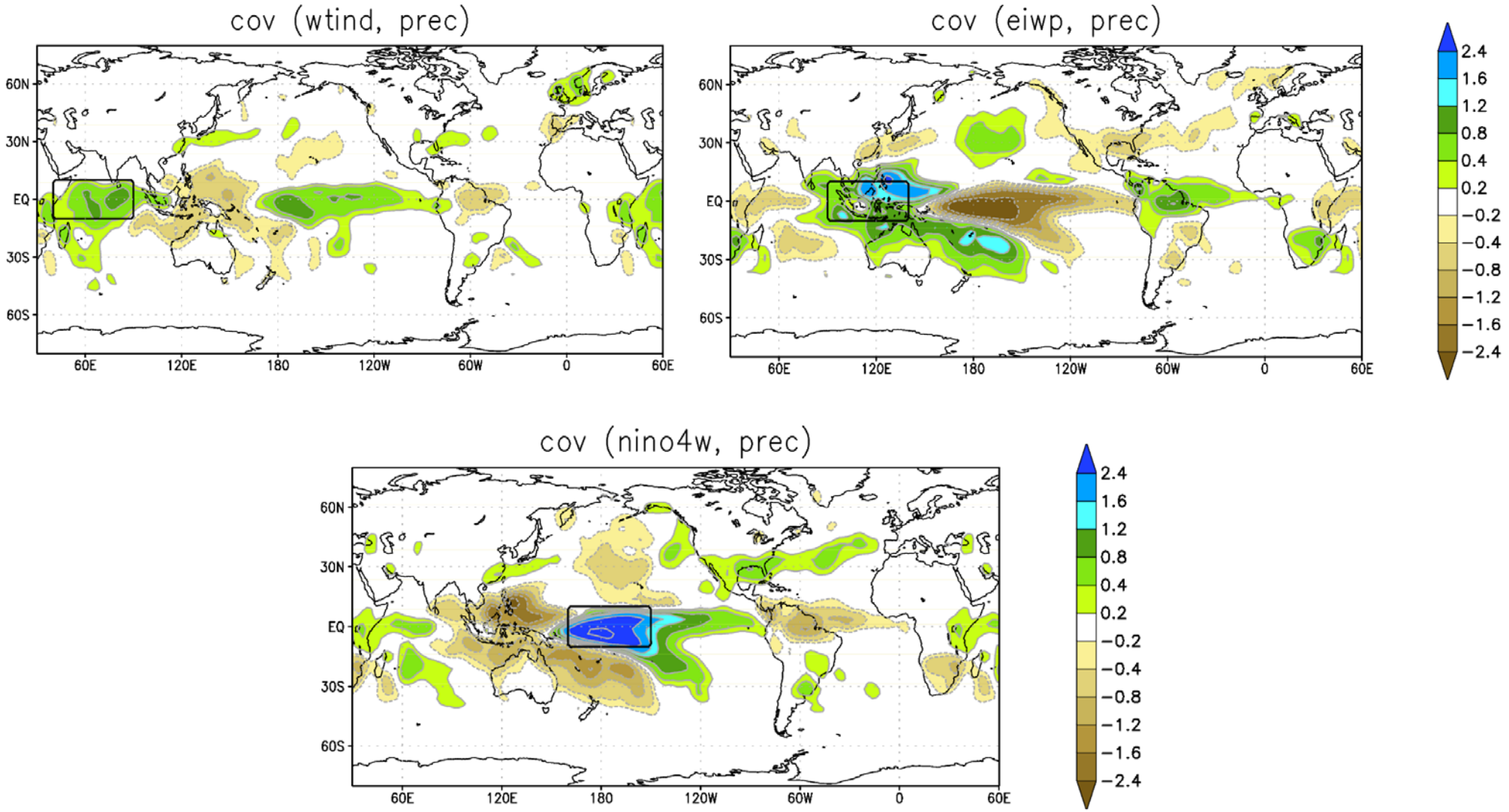
SST teleconnections in DJF: ERA Interim



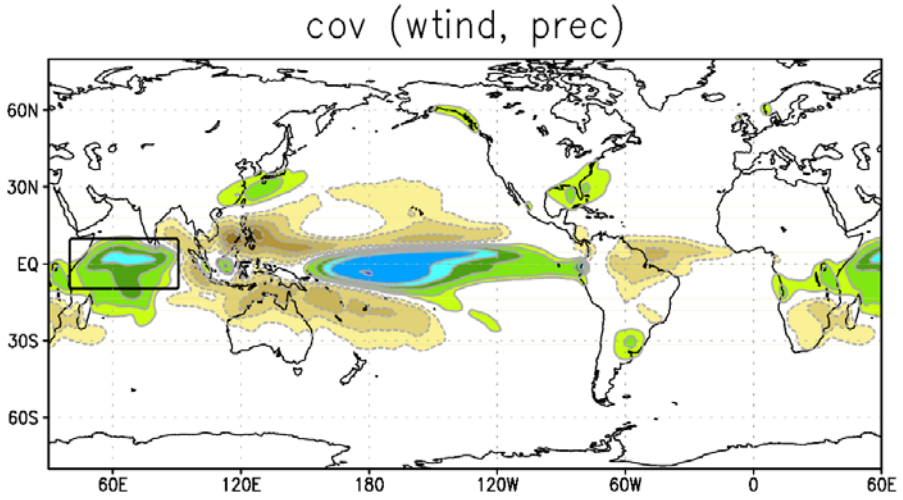
SST teleconnections in DJF: System 4 (from Nov.)

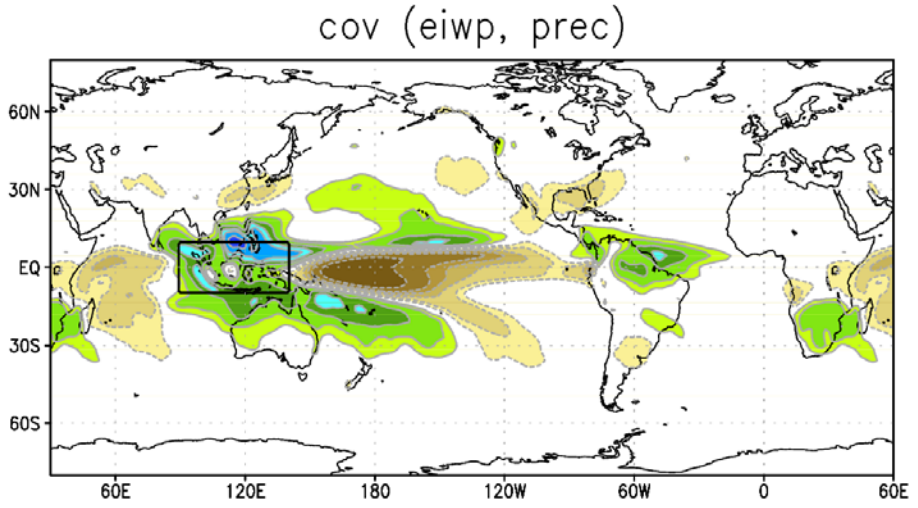


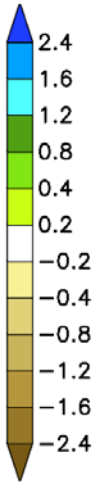
Precip. teleconnections in DJF: GPCP 2.2

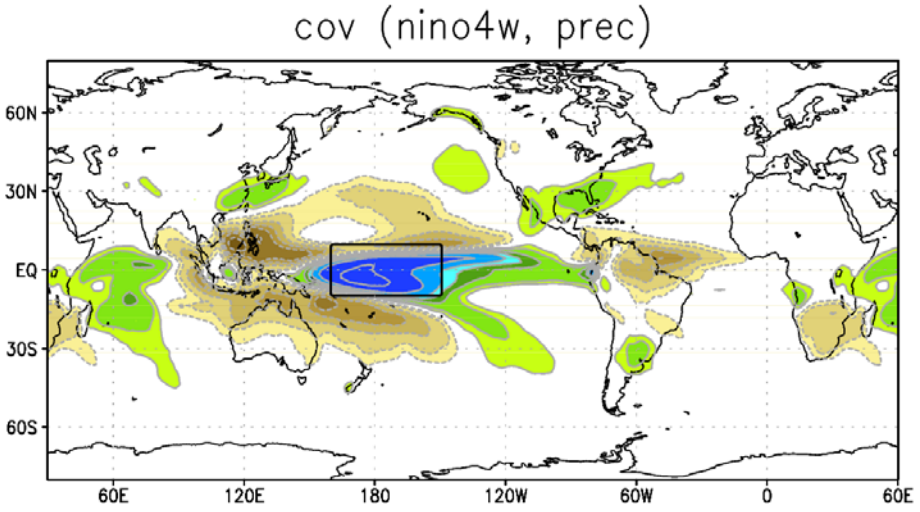


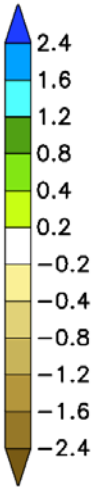
Precip. teleconnections in DJF: System 4 (from Nov.)





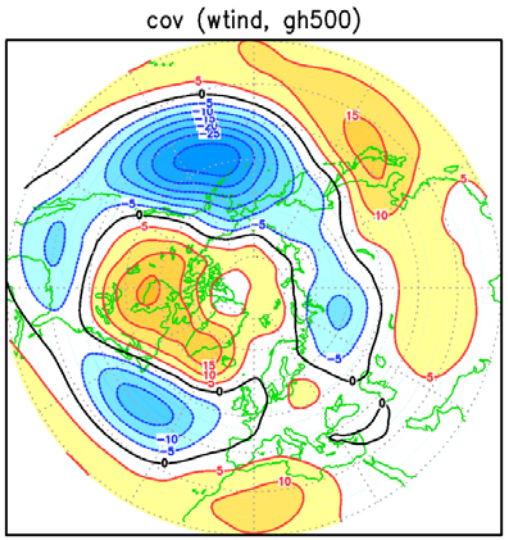


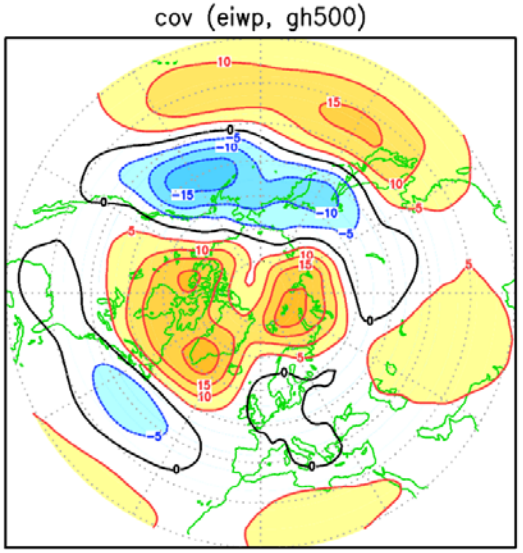


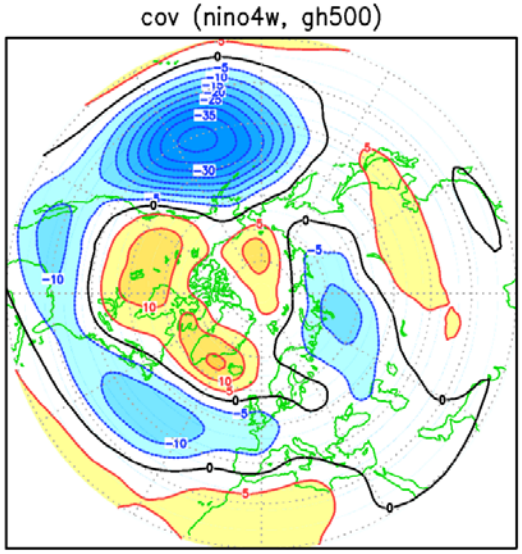


Z 500_hPa vs. SST: ERA-Int. and System-4

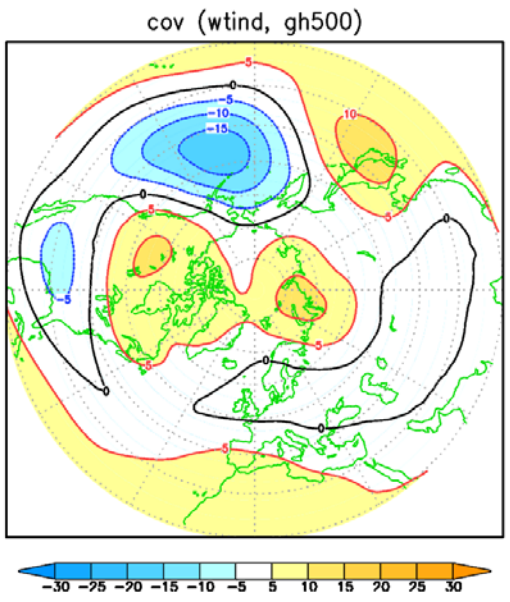
ERA

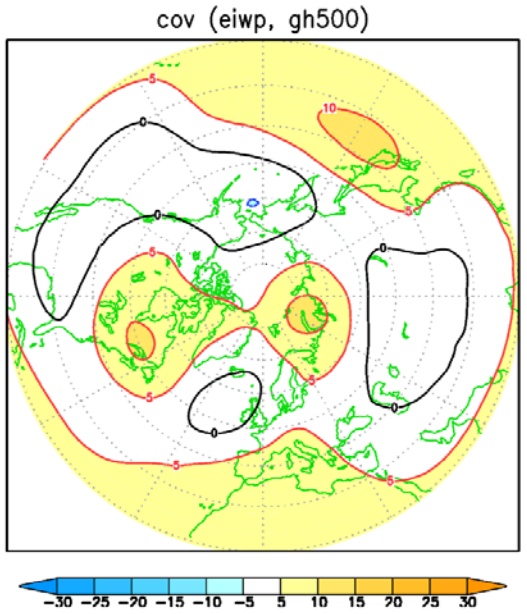


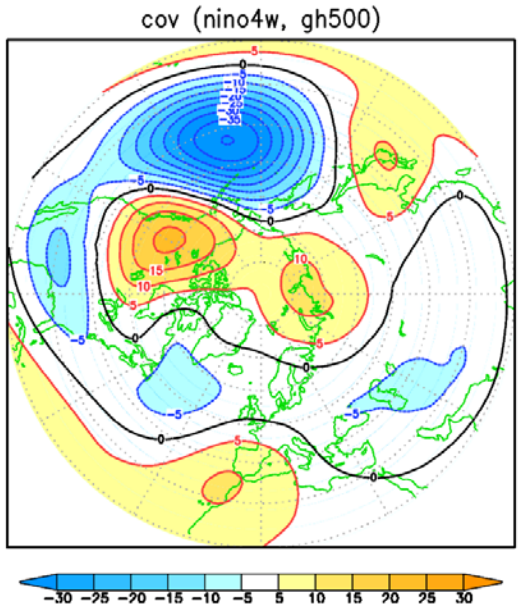




Sys4

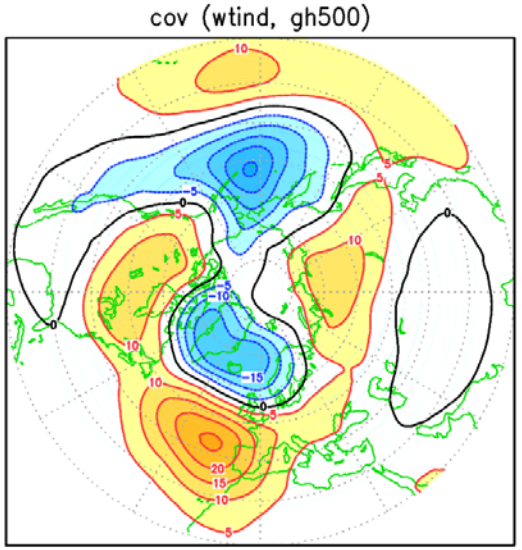


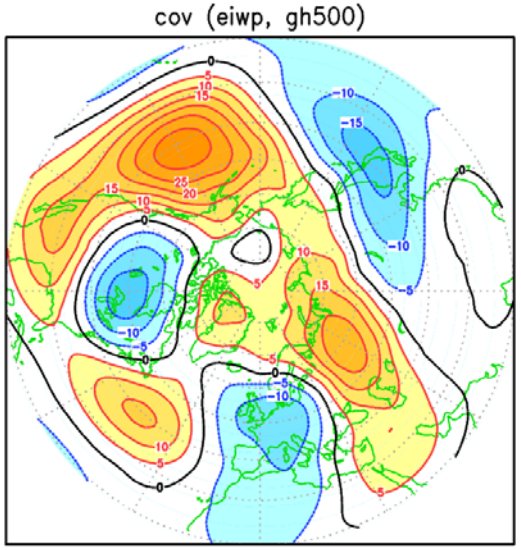


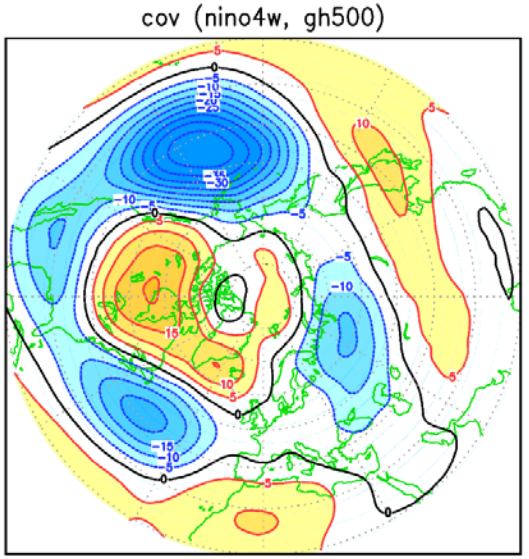


Z 500_hPa vs. precip: ERA-Int. and System-4

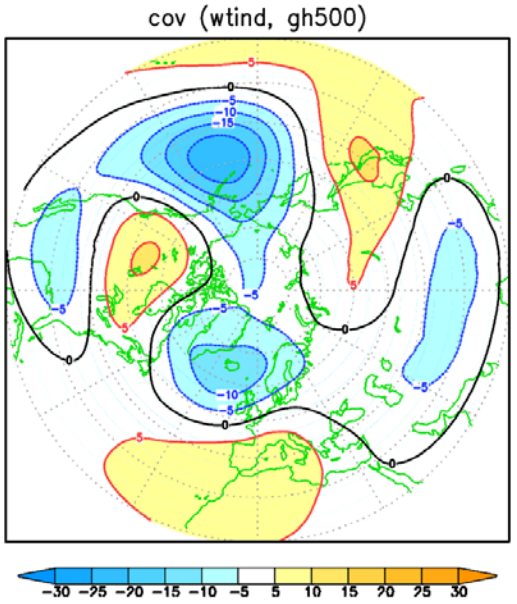
ERA

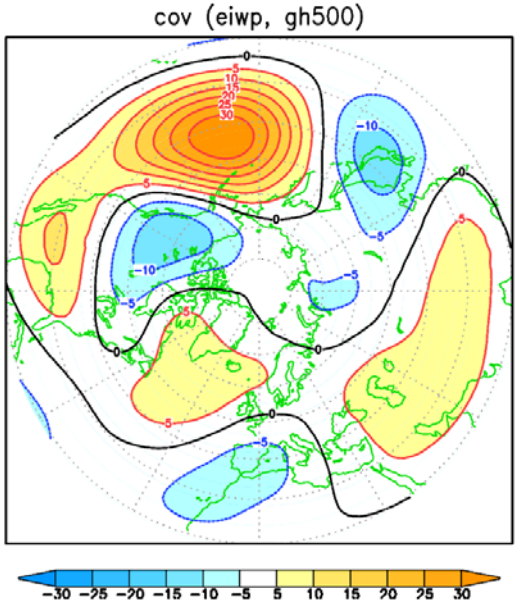


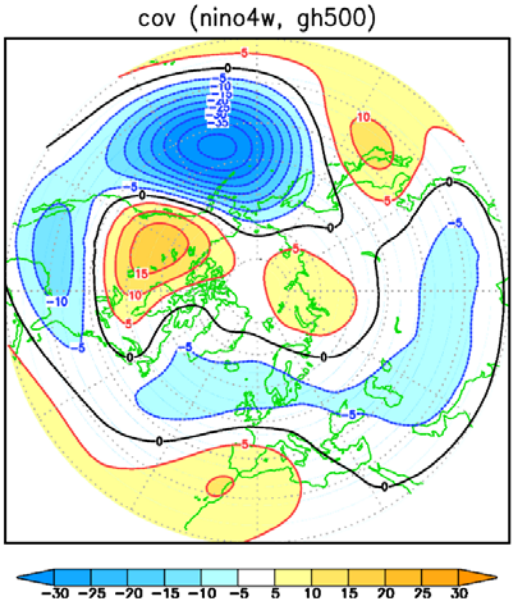




Sys4



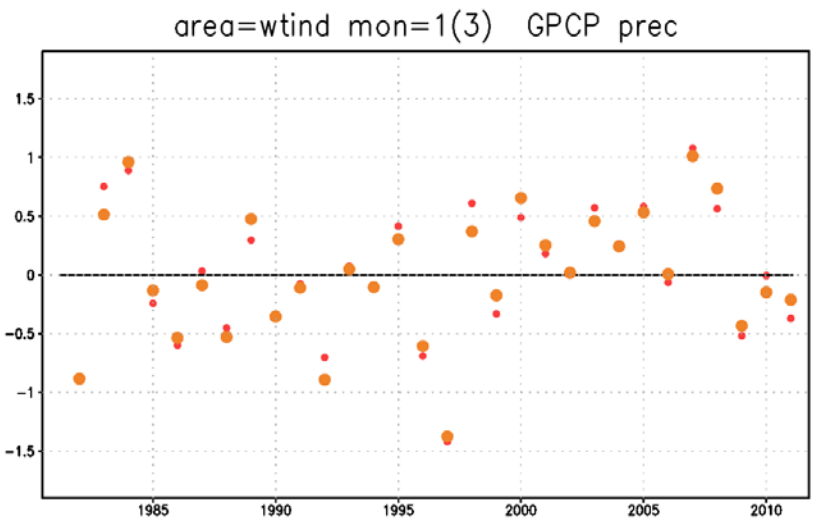


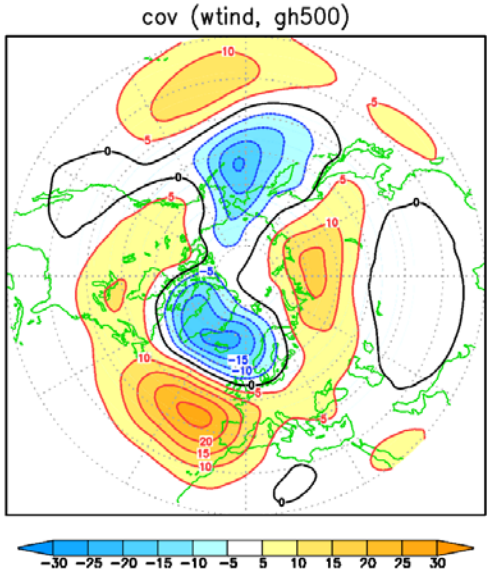


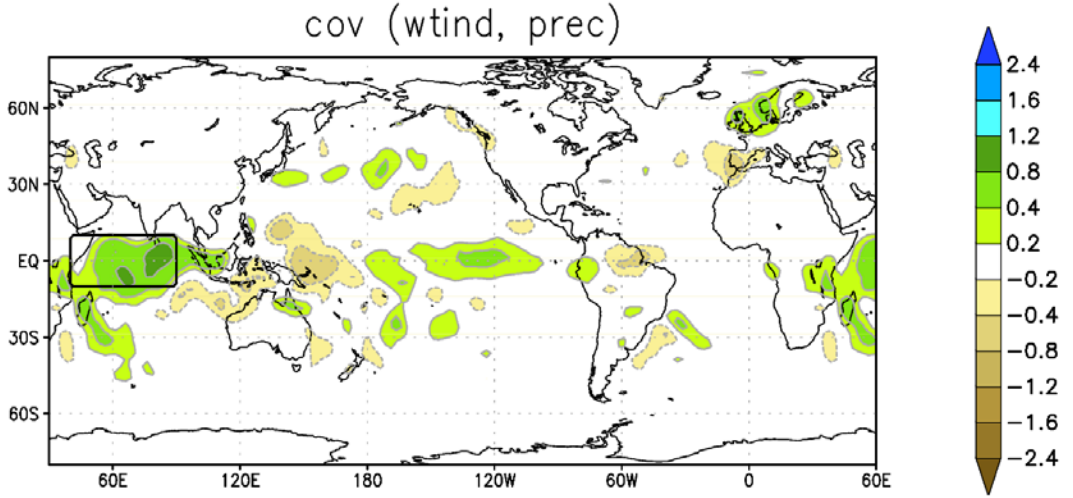
W. Indian Oc. teleconnections, ENSO removed

Full precip anomaly

Anomaly orthogonal to Nino3.4 SST

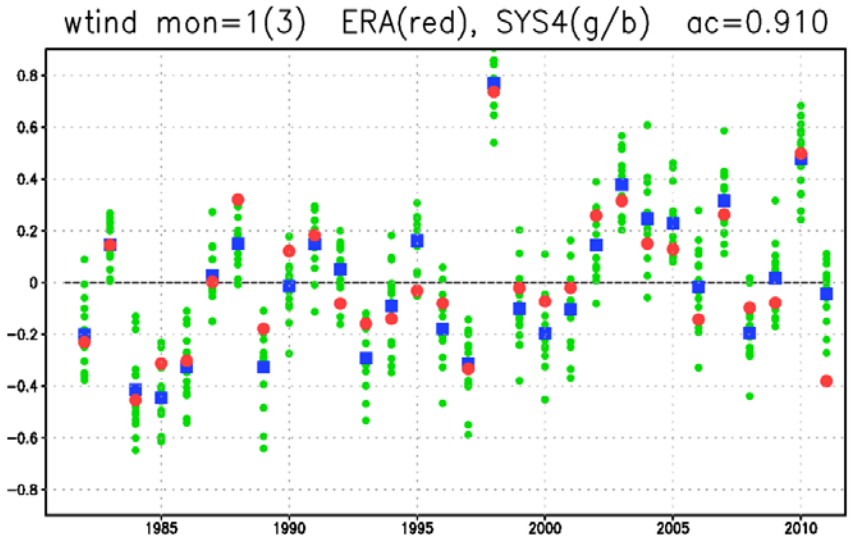


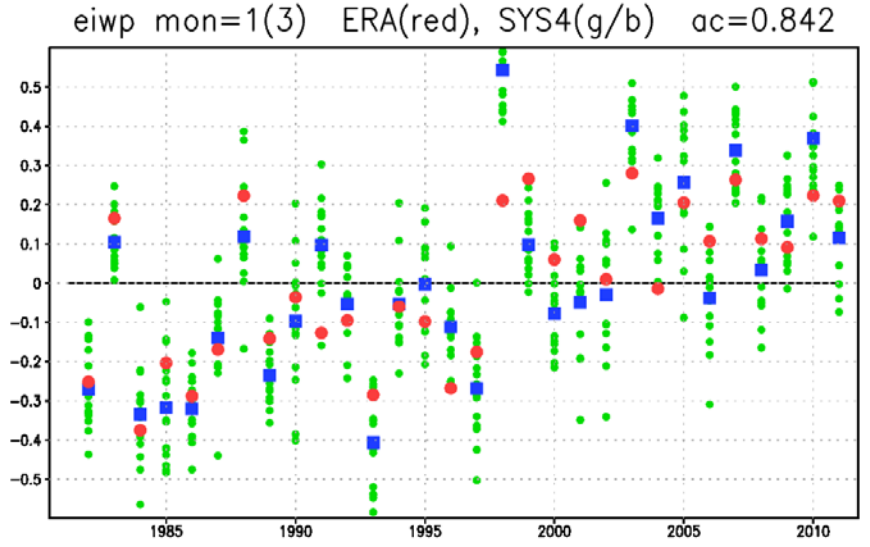




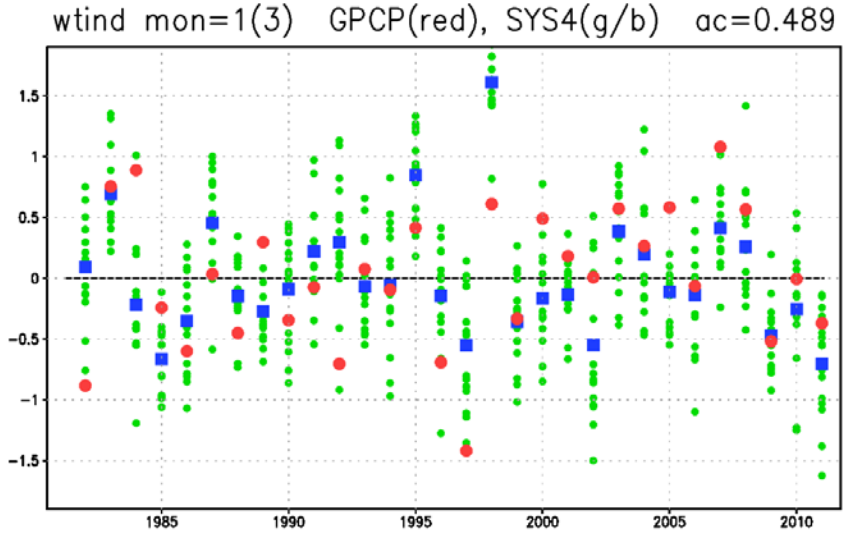
Predictive skill for W.Ind and E.Ind-W.Pac SST/precip

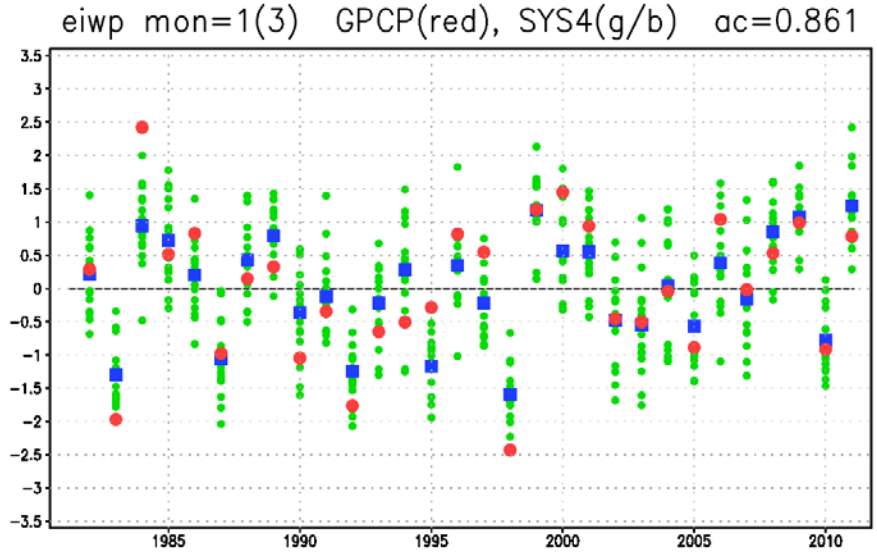
SST





prec





MJO impact on DJF precipitation in EPS (Vitart & Molteni 2010)

Wheeler-Hendon 2004

Phase 2-3

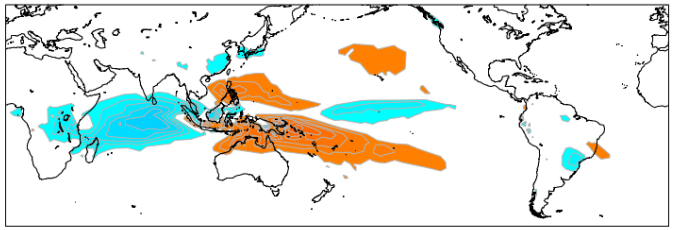
Phase 4-5

Phase 6-7

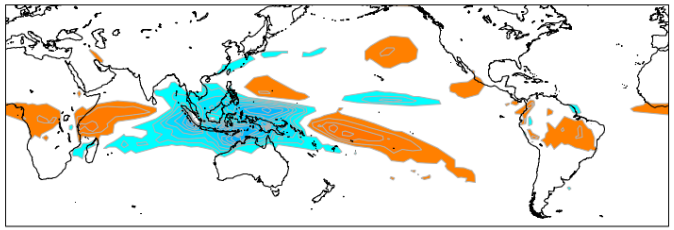
Phase 8-1

EPS

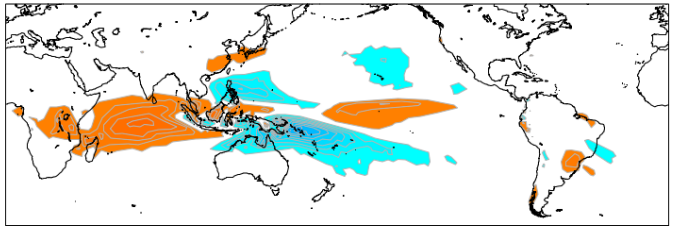
A) Model Phase 23



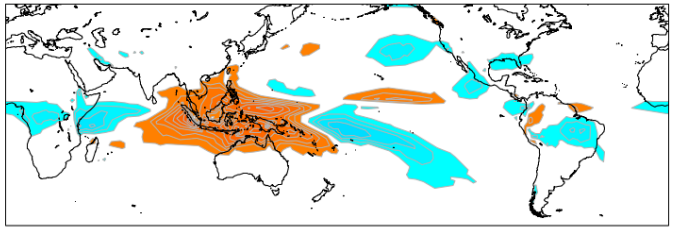
B) Model Phase 45



C) Model Phase 67

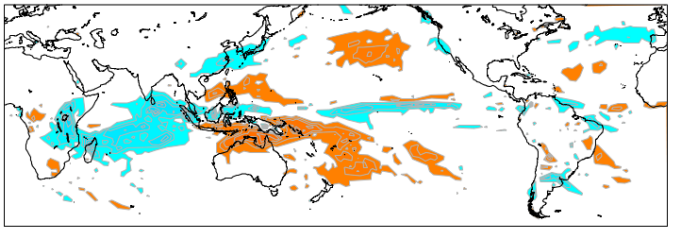


D) Model Phase 81

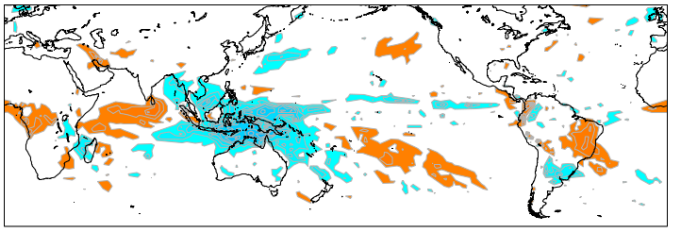


ERA-Interim

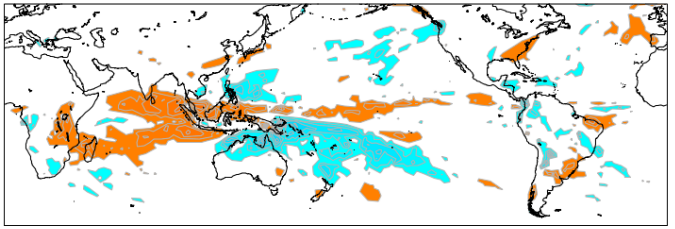
E) ERA Phase 23



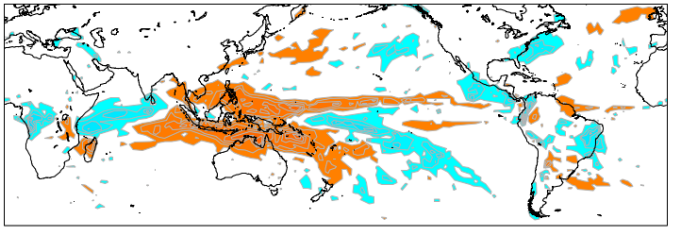
F) ERA Phase 45



G) ERA Phase 67

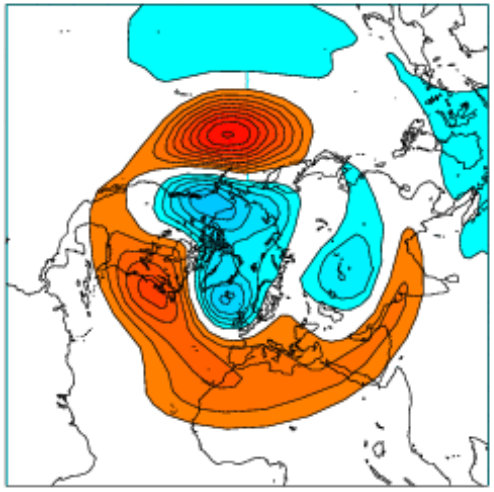


H) ERA Phase 81

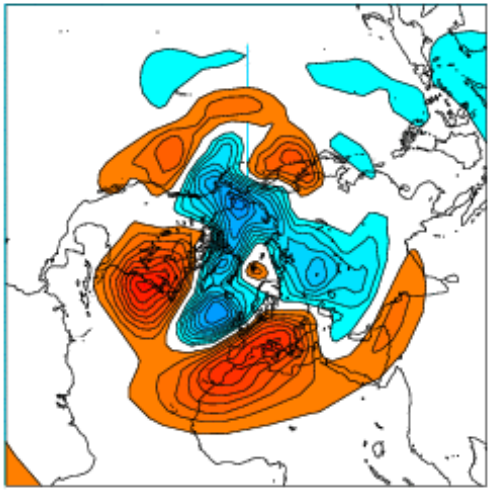


MJO impact on DJF Z_500hPa in EPS (Vitart & Molteni 2010)

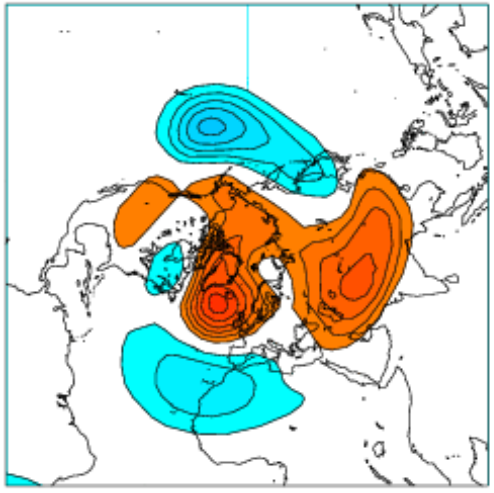
MODEL Phase 3 + 10 days



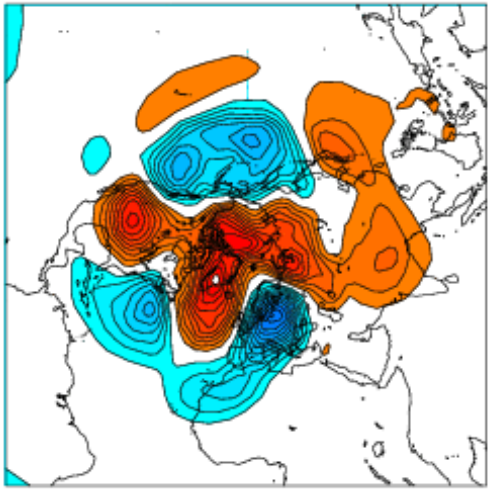
ERA Phase 3 + 10 days



MODEL Phase 6 + 10 days

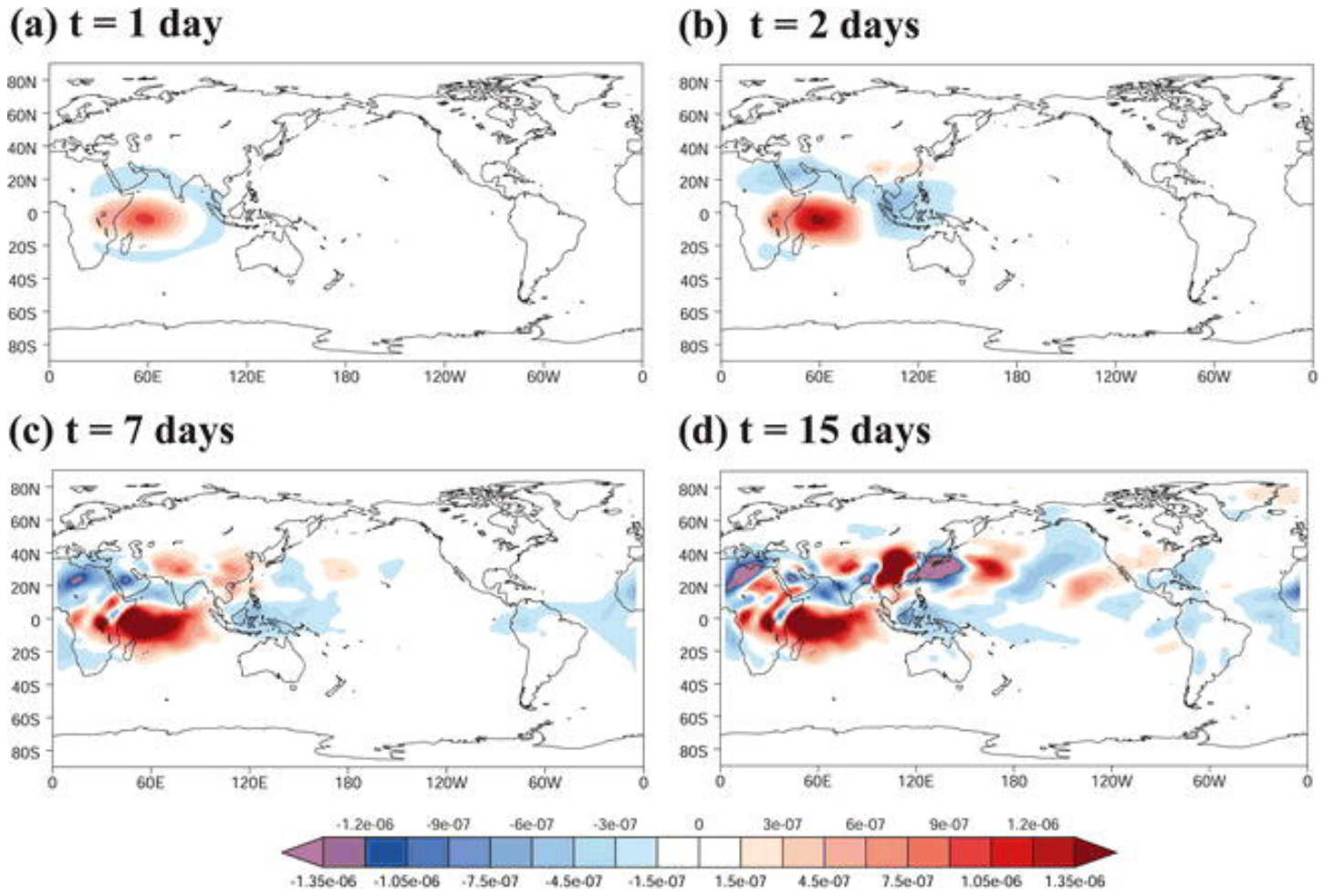


ERA Phase 6 + 10 days

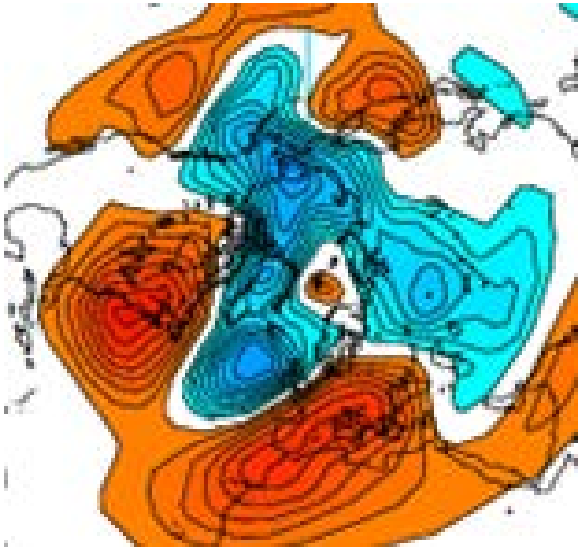


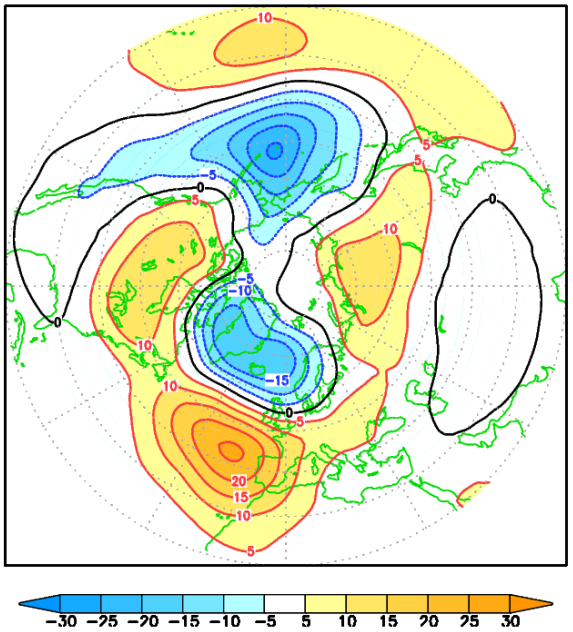
Response to WIO heating, Annamalai et al. 2007

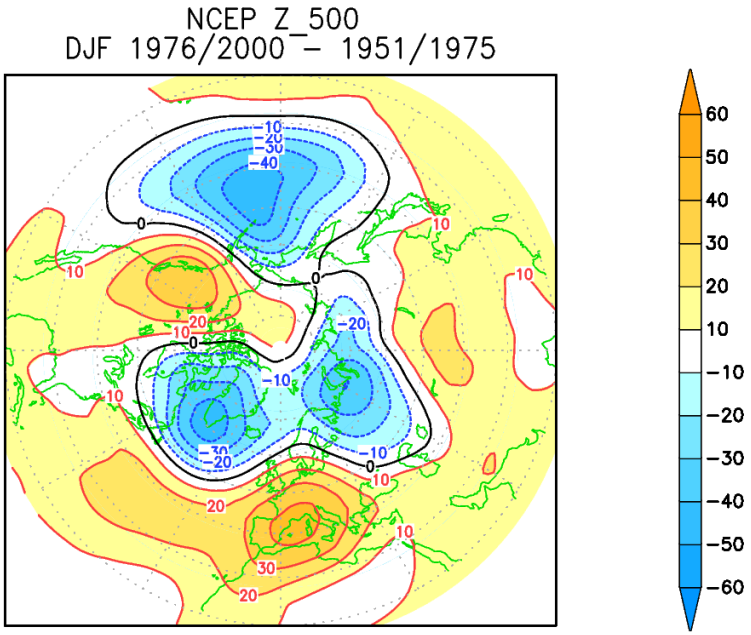
200 hPa divergence response in a linearized PE model



A planetary-wave signal common to different time scales?







Z 500hPa anomaly

MJO phase3 + 10d

DJF W. Indian Oc. Rain

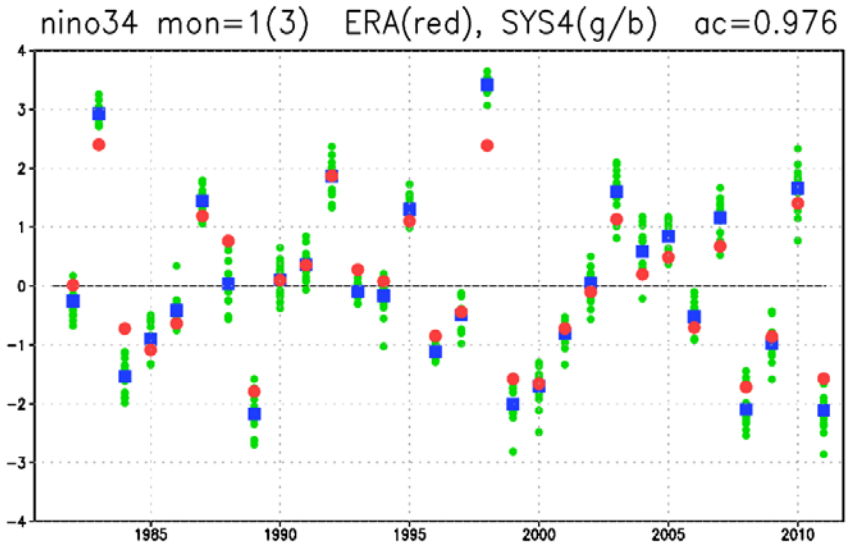
20th C. decadal variability

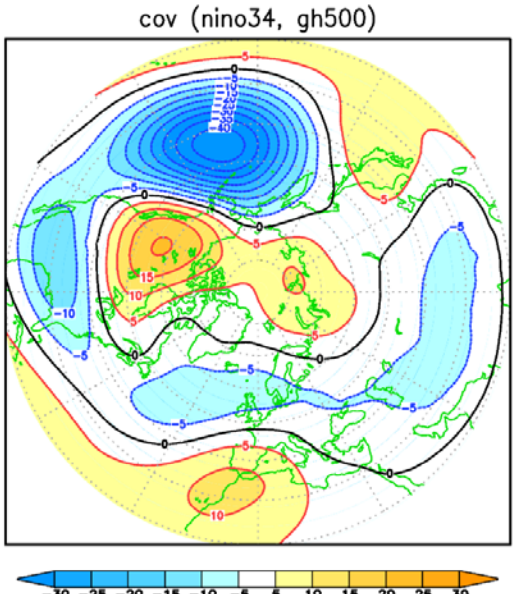
Conclusions

- Indo-Pacific teleconnections during the northern winter cannot be understood simply on the basis of the “SST forces the atmosphere” framework; results from AGCM exp. should be taken with caution.
- Differences between Western and Eastern trop. Indian ocean still exist during winter in terms of rainfall anomalies and rain-SST correlation.
- A 3-modal anomaly in the Walker circulation (and rainfall) can be forced either from either the western or the eastern side of the Indo-Pacific domain; over the tropical E. Indian - W. Pacific ocean, SST-rainfall correlation is weak or negative.
- Looking at Indo-Pacific teleconnections in relation to rainfall anomalies (rather than SST) produces more coherent results:
  - between observational and model data;
  - across different time scales (intraseasonal – interannual – interdecadal)
- Periods with increased rainfall over the Western Indian Ocean and reduced rainfall over the equat. E. Indian – W. Pacific are associated with a COWL-like, +NAO anomaly in N.Hem. geopotential height.

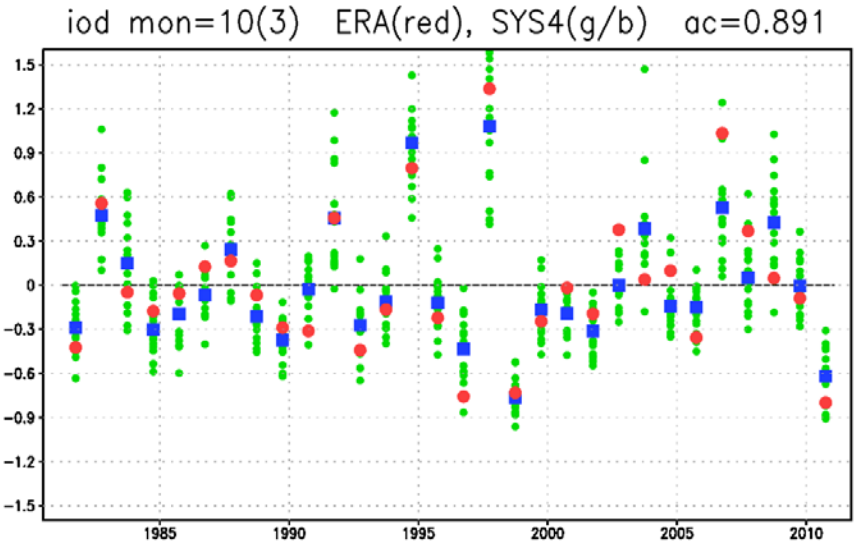
Predictability of teleconnections in Sys4: Nino3.4, IOD SST

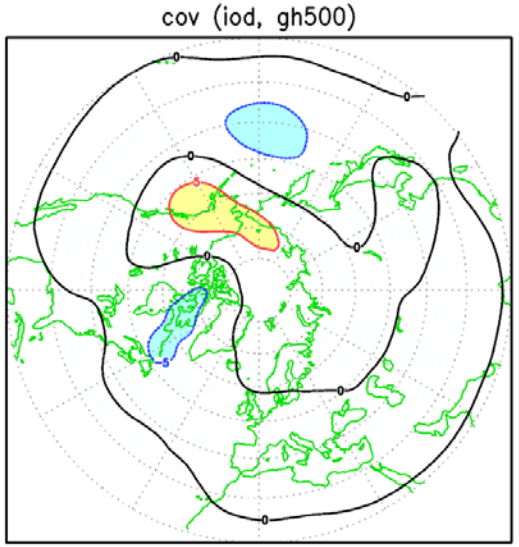
Nino3.4
DJF





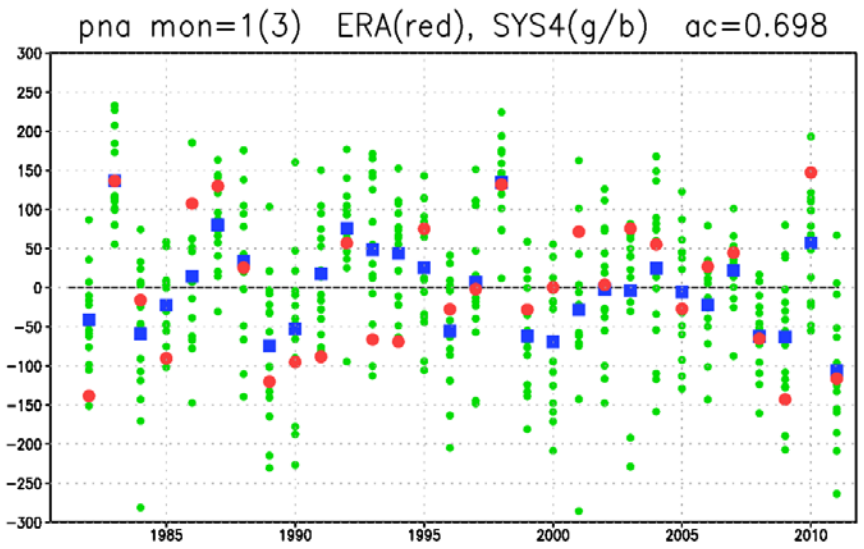
IOD
SON

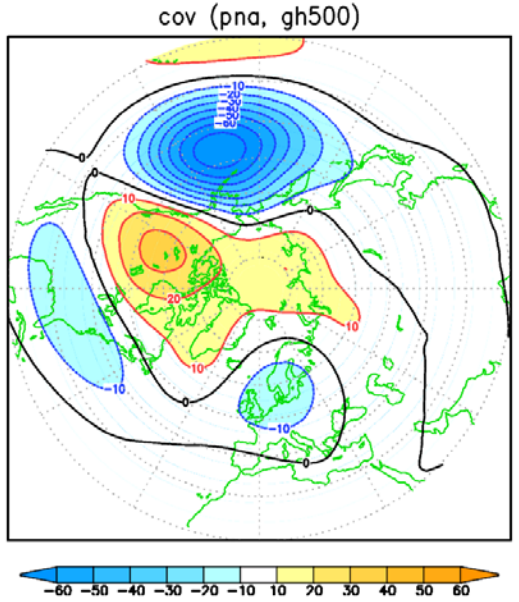




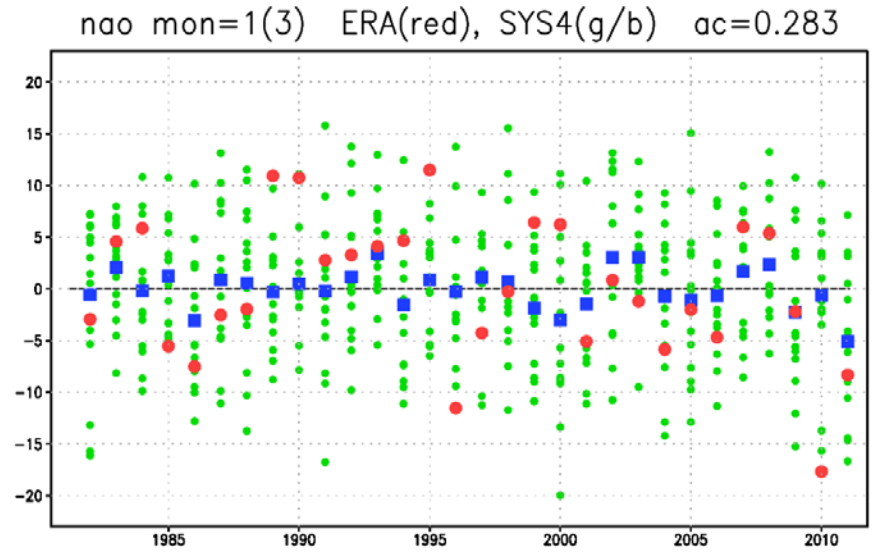
Predictability of teleconnections in Sys4: PNA, NAO (DJF)

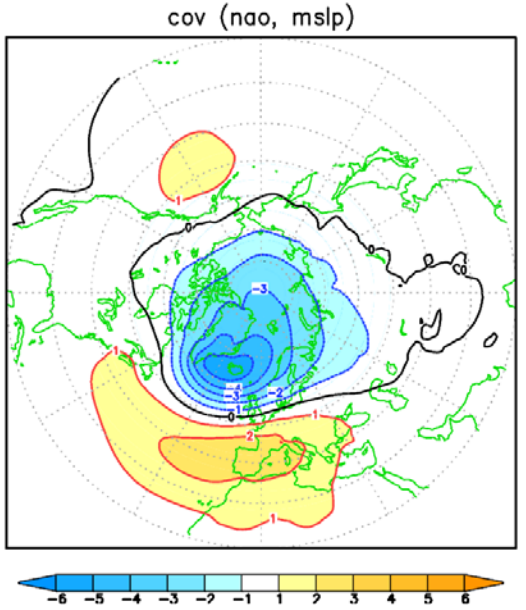
PNA



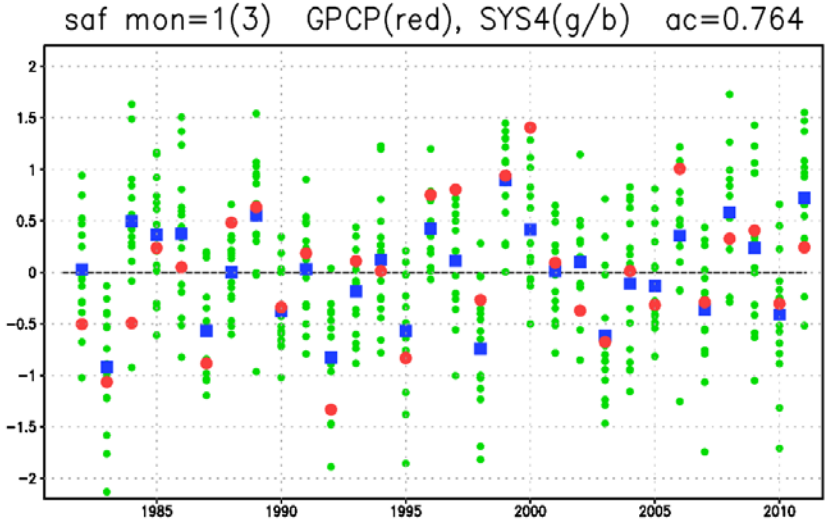


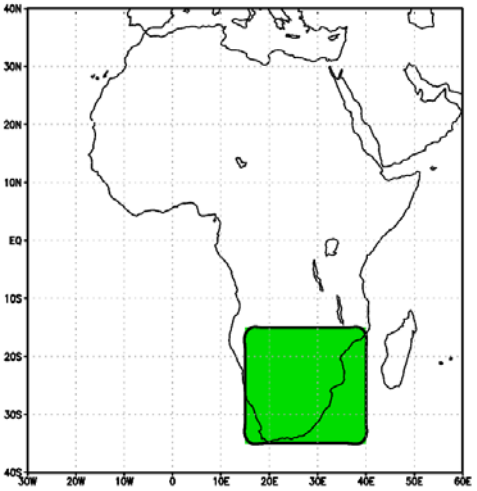
NAO

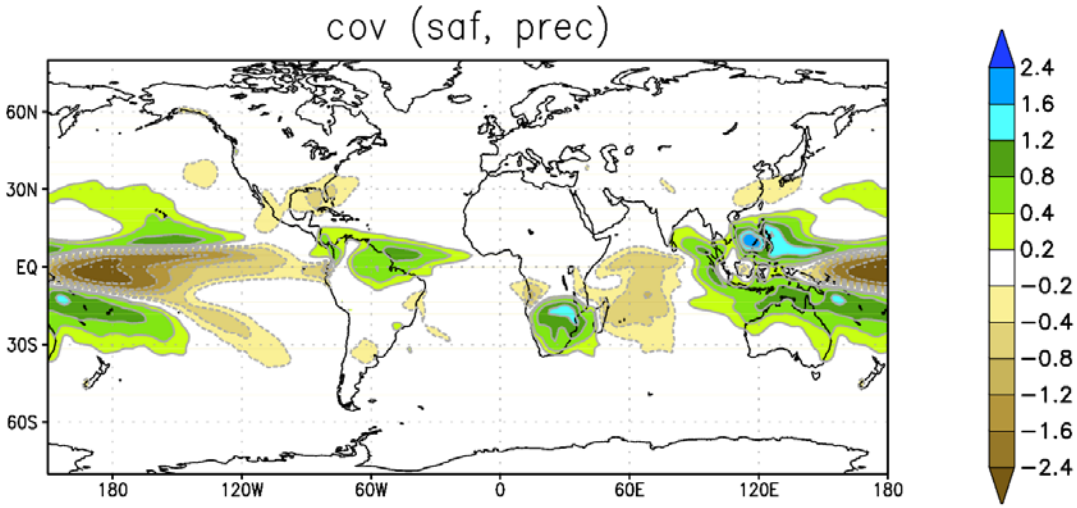




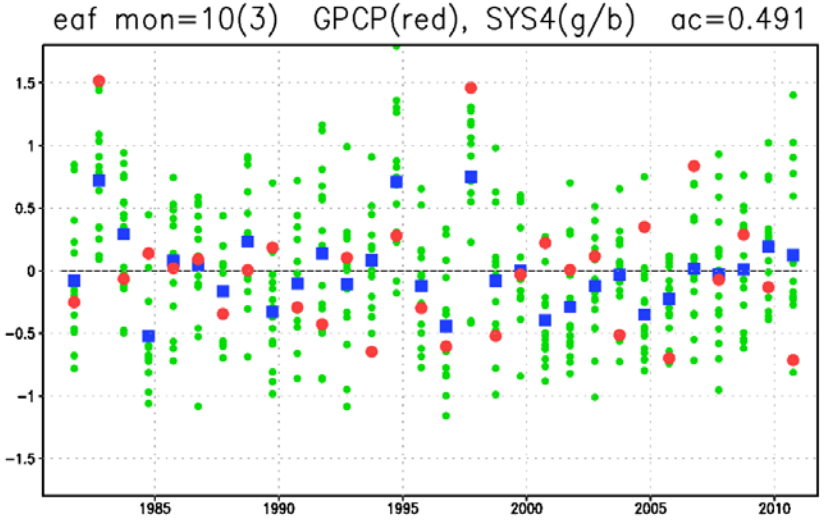
Predictability of telecon. in Sys4: South Africa rain (DJF)

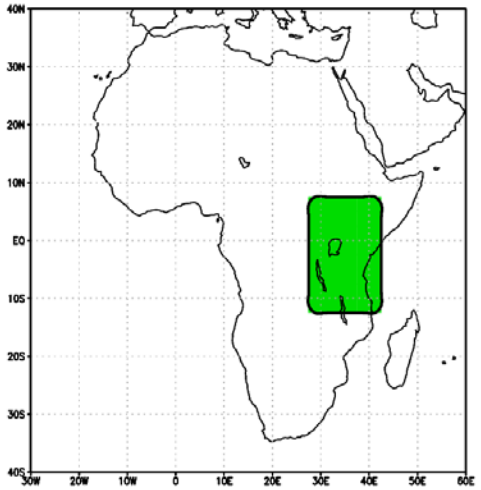


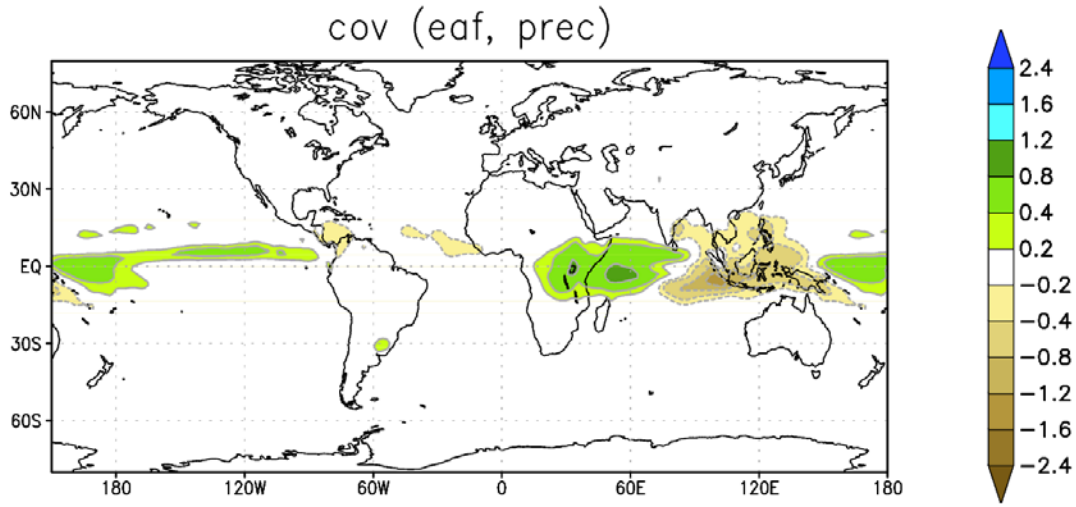




Predictability of telecon. in Sys4: East Africa rain (SON)







Predictability of teleconnections in Sys4: Sahel rain (JJA)