

Temporal Structure of ENSO in 20th Century Coupled Simulations

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Questions

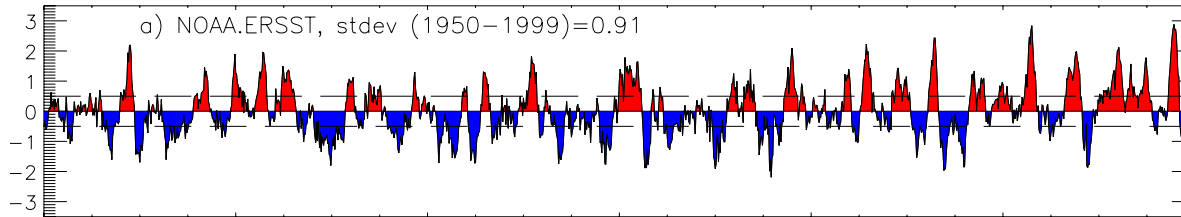
- Is ENSO dynamics consistent with the leading paradigms?
- Can we relate the dominant ENSO timescale to ocean dynamics and atmospheric forcing?
- Is that relationship consistent across different models?

Models

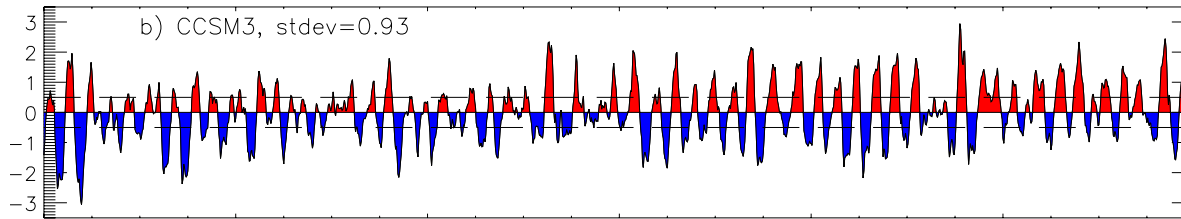
- CCSM3 (USA)
- GFDL-CM2.0 (USA)
- GISS-EH (USA)
- PCM (USA)
- IPSL-CM4 (France)
- CNRM-CM3 (France)
- UKMO-HadCM3 (UK)
- MRI-CGCM2.3.2 (Japan)
- CSIRO-CM3 (Australia)

Niño3.4 index

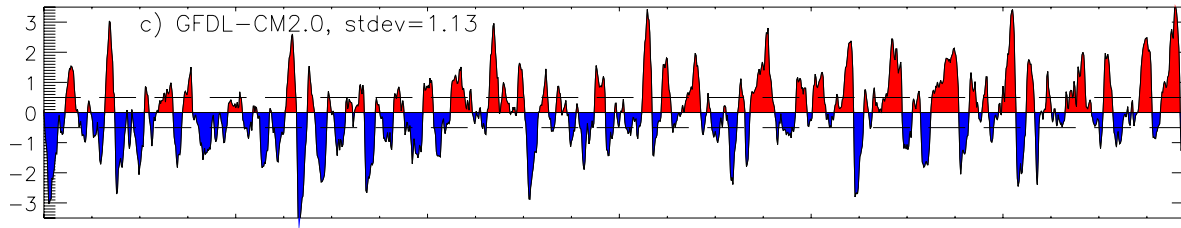
OBS
NOAA.ERSST



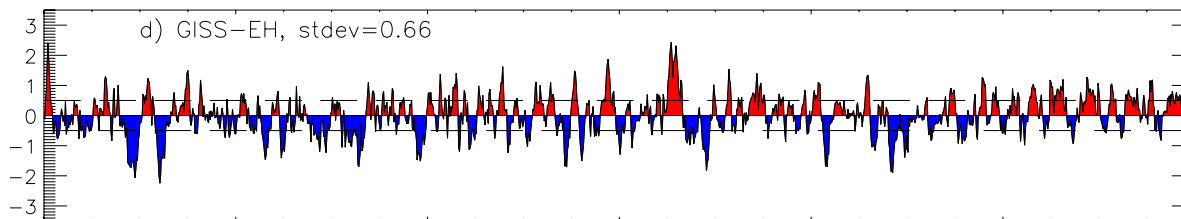
CCSM3



GFDL-CM2.0



GISS-EH

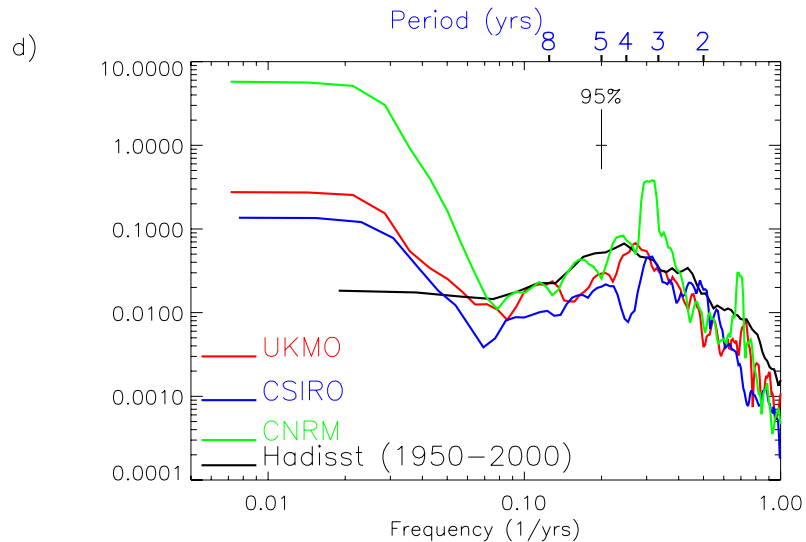
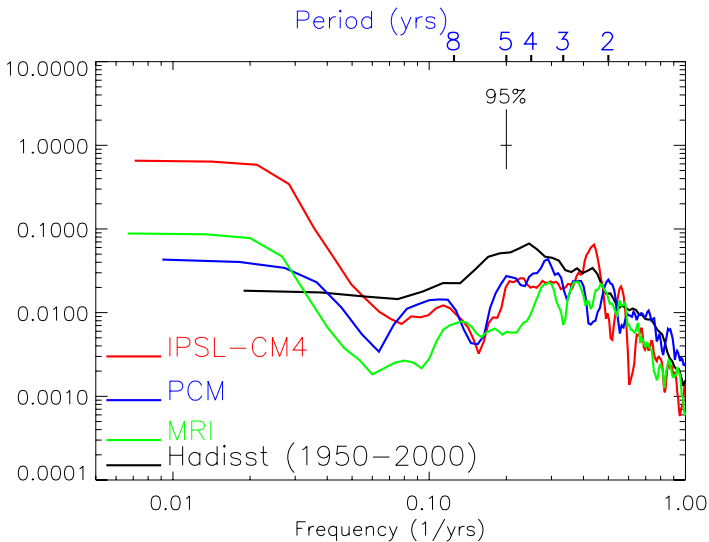
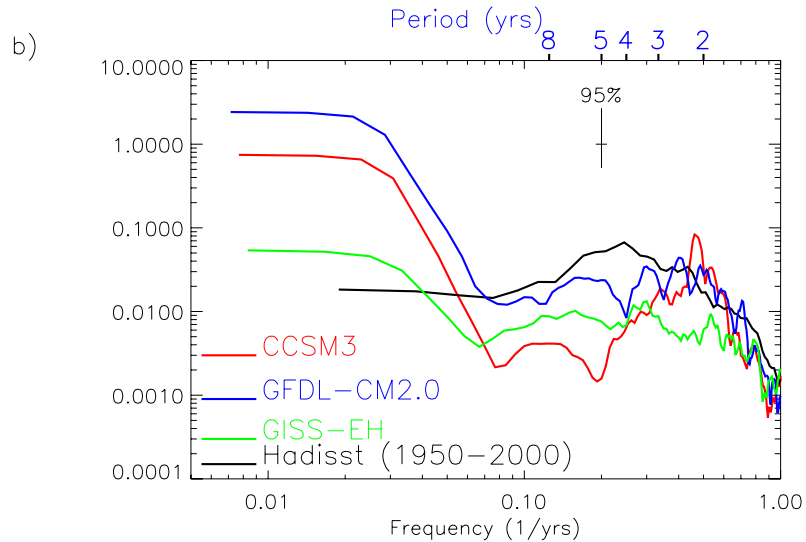
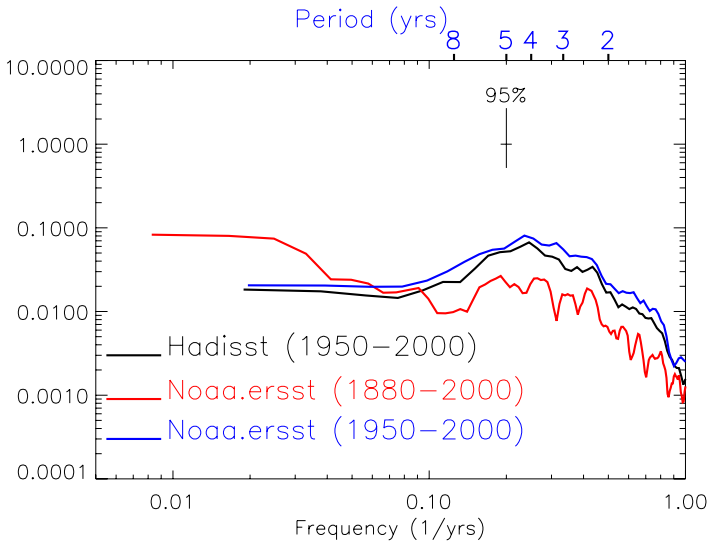


1880 1900 1920 1940 1960 1980 2000

1880

2000

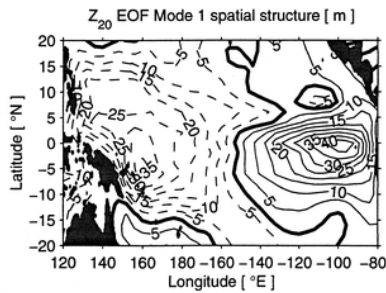
Niño3.4 spectra



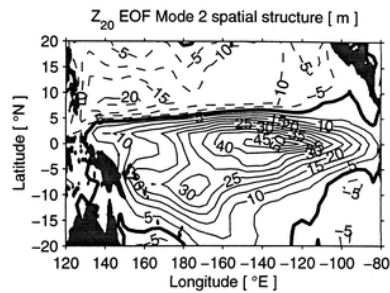
Thermocline Variability

Depth of 15°C isotherm (Z15)

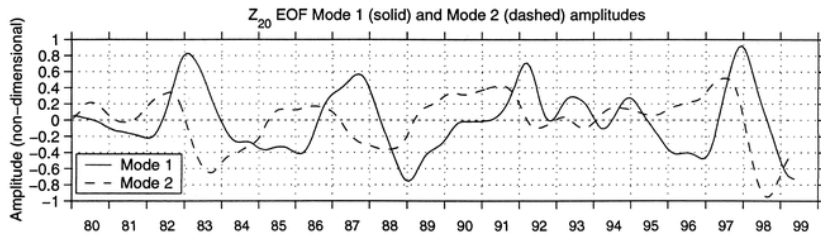
Meinen and McPhaden 2000



EOF1

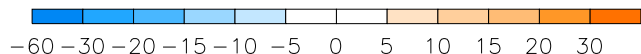
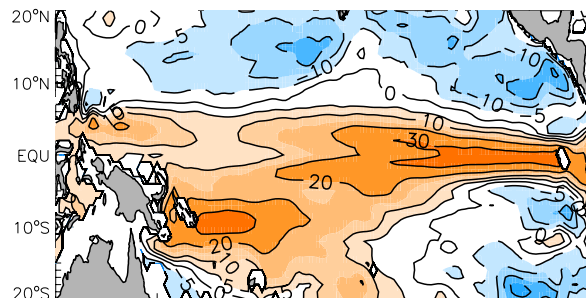
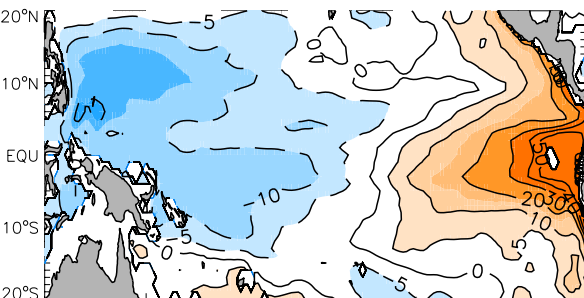


EOF2

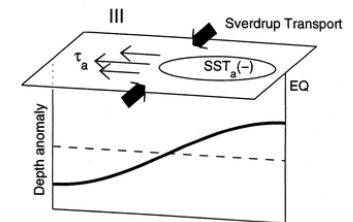
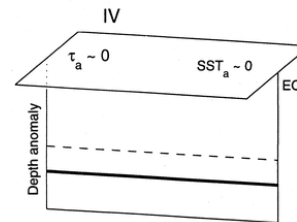
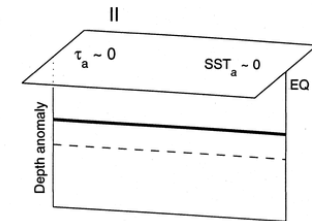
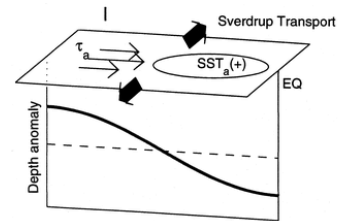


EOF1 45%

EOF2 16%

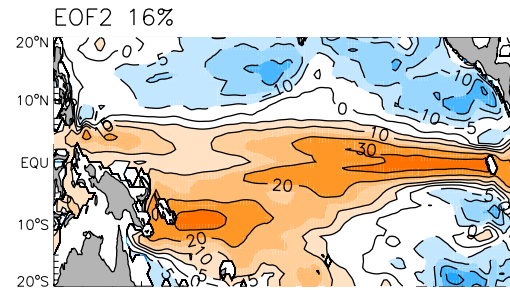
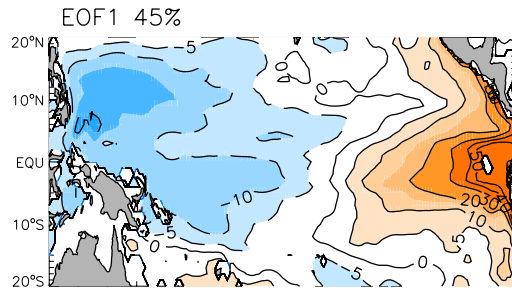


“Recharge oscillator”

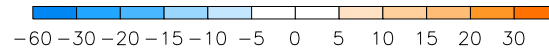


INGV ocean analysis

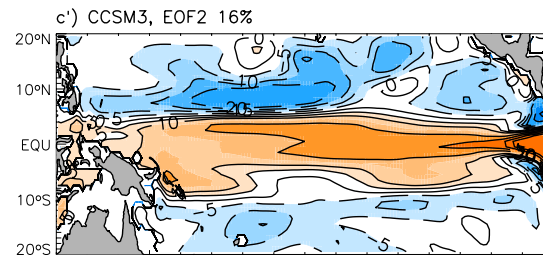
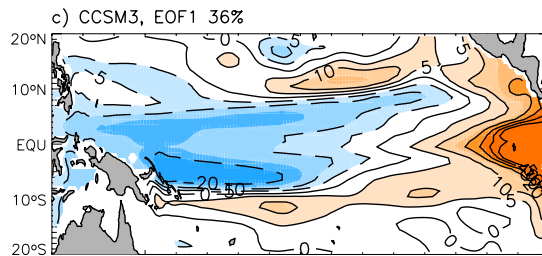
EOFs of Z15



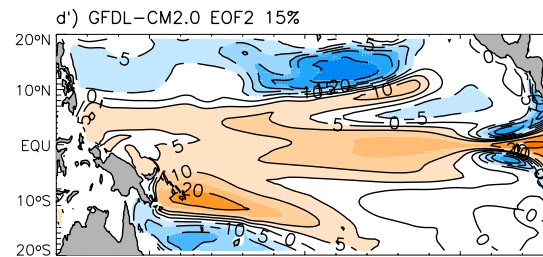
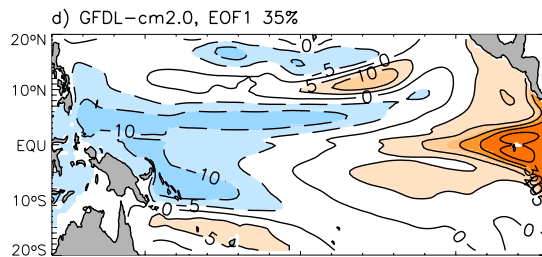
INGV



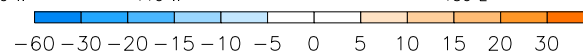
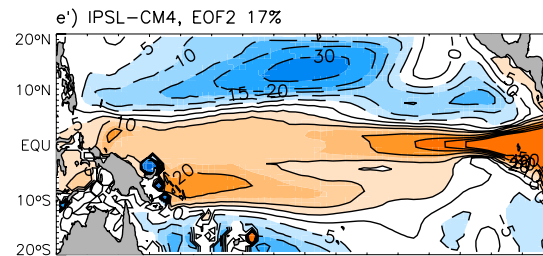
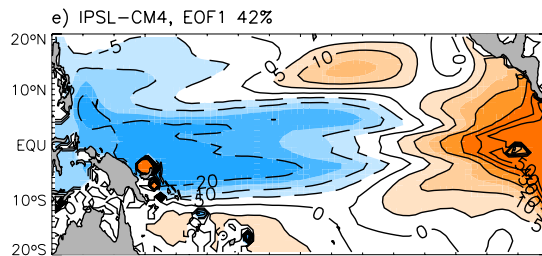
CCSM3



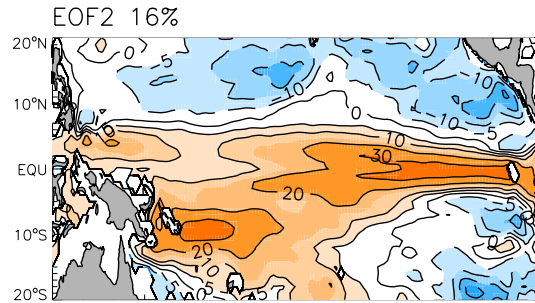
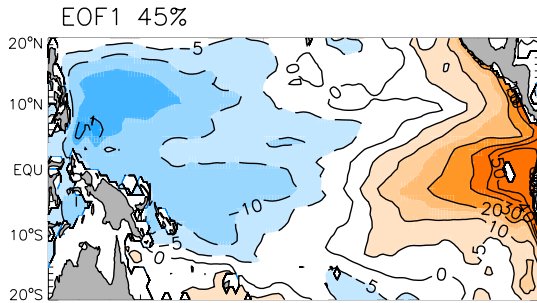
GFDL-CM2.0



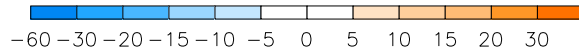
IPSL-CM4



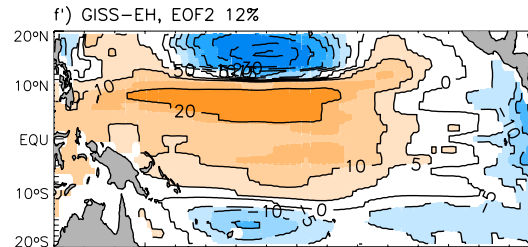
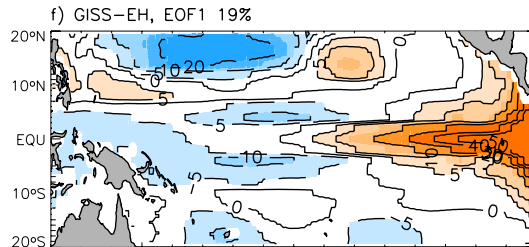
EOFs of Z15



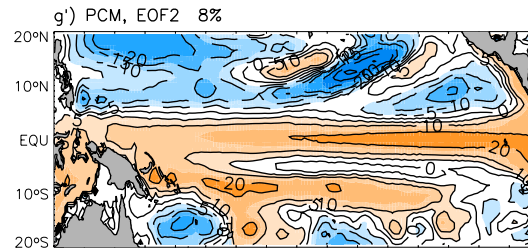
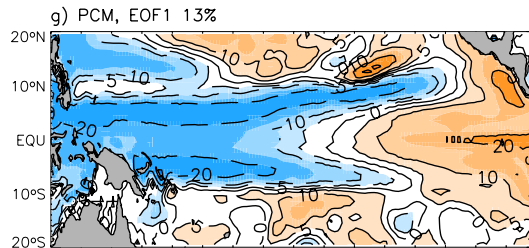
INGV



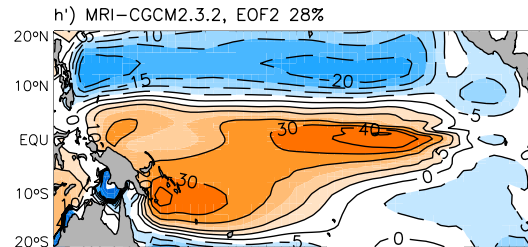
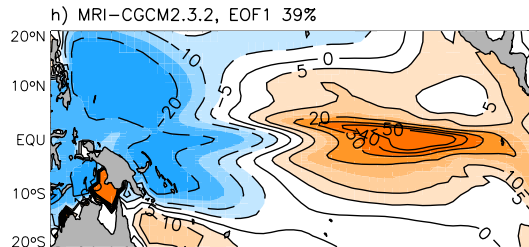
GISS-EH



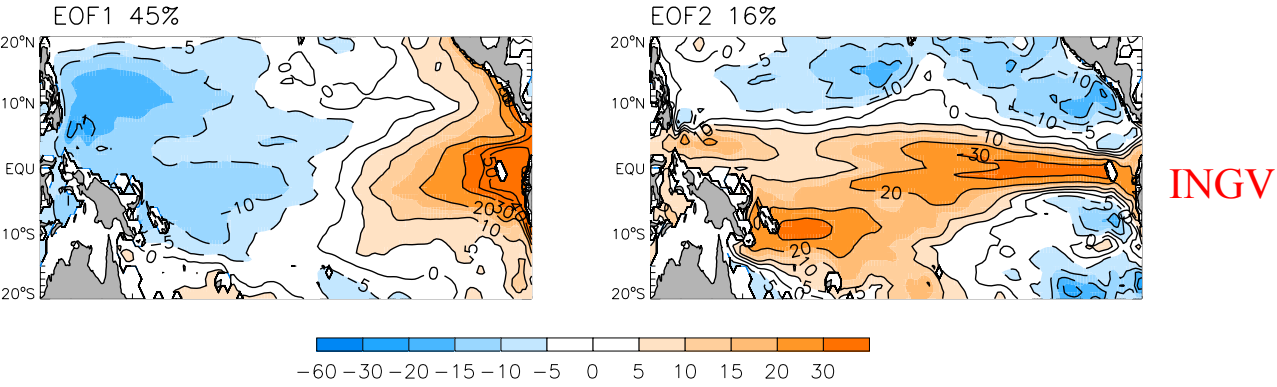
PCM



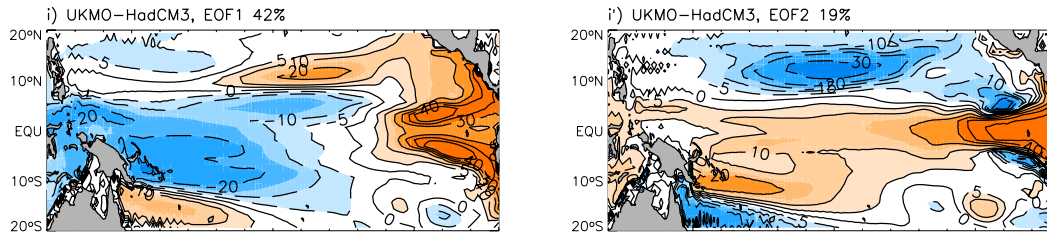
MRI



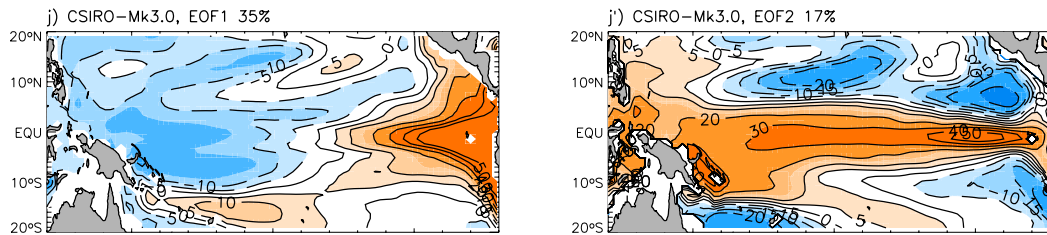
EOFs of Z15



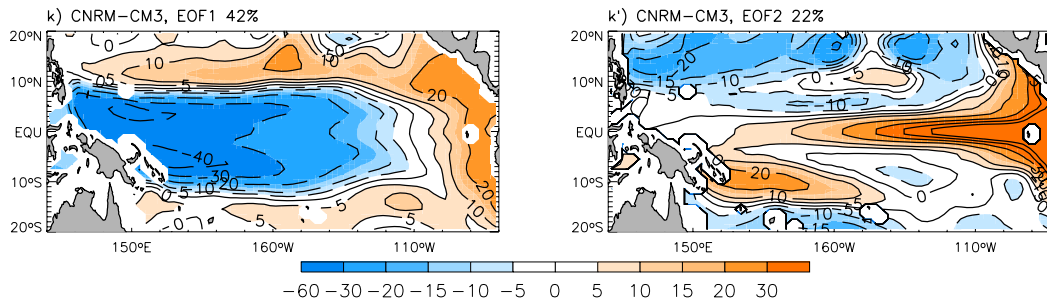
UKMO-HadCM3



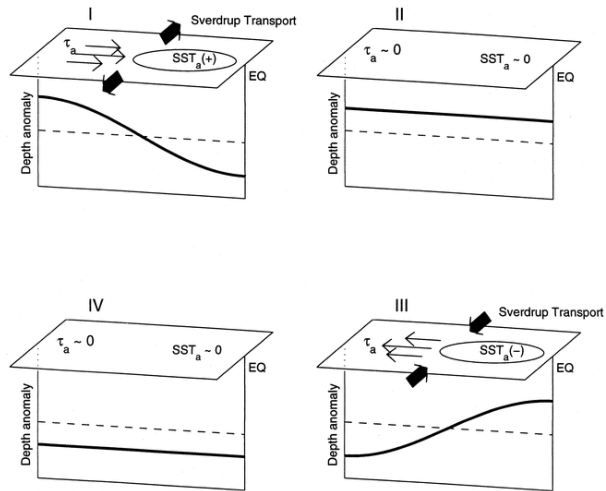
CSIRO



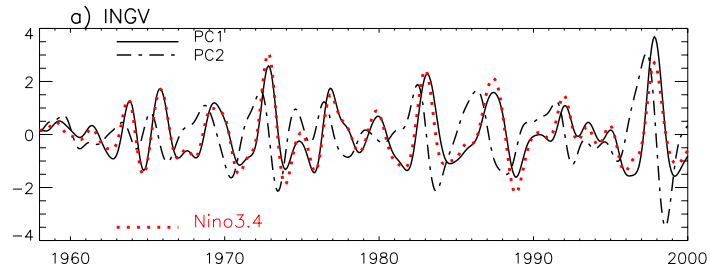
CNRM



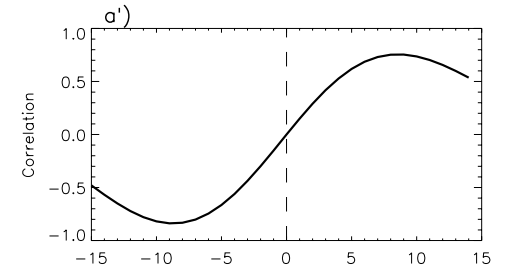
Phase relationship between the Z15 modes



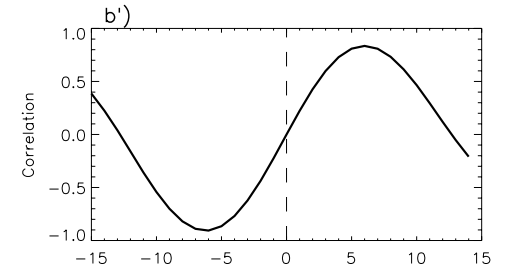
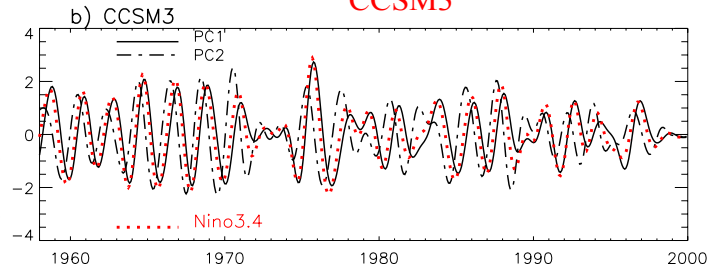
INGV



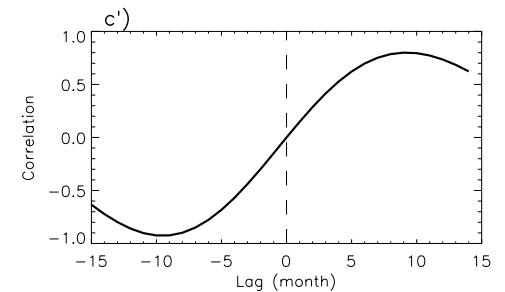
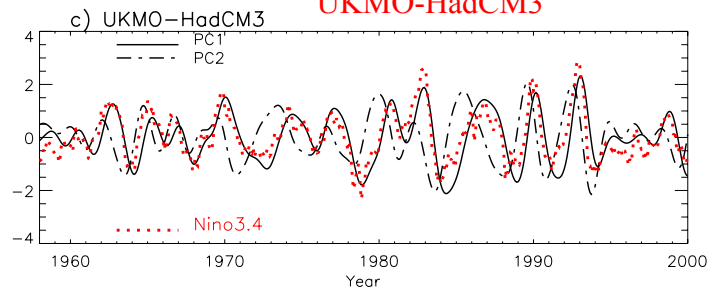
PC2-PC1 lag-correlation



CCSM3



UKMO-HadCM3

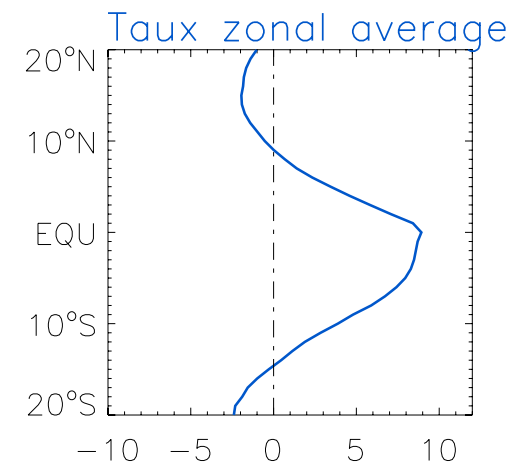
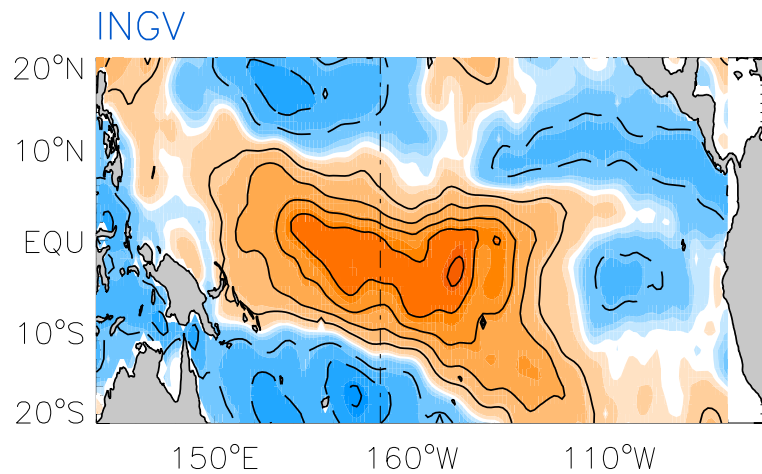


Wind forcing

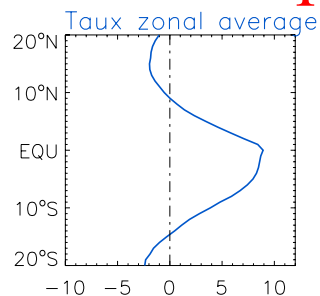
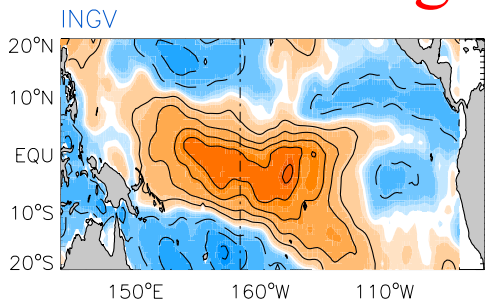
Studies performed with intermediate coupled models have shown that the spatial structure of the wind stress anomalies can influence the ENSO timescale.

- Meridional width of the wind stress anomalies: if the wind stress extends over a broader range of latitudes the adjustment timescale of the equatorial ocean increases.
- Longitudinal position of the wind stress anomalies: it influences the zonal advective feedback. Eastward displacement of the wind stress anomalies favors ENSO growth and longer duration.

Regression of τ^x upon the Niño3.4 index

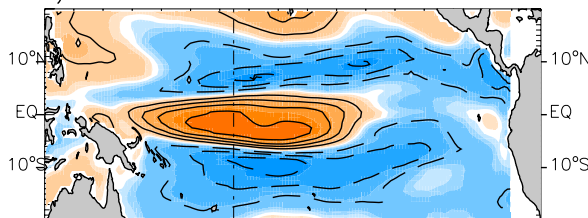


Regression of τ^x upon the Niño3.4 index

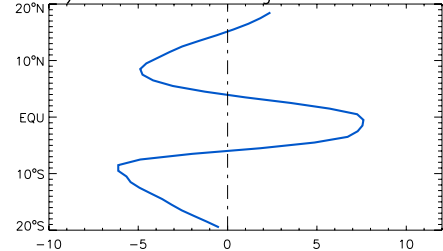


CCSM3

c) CCSM3 nino34_std=0.81

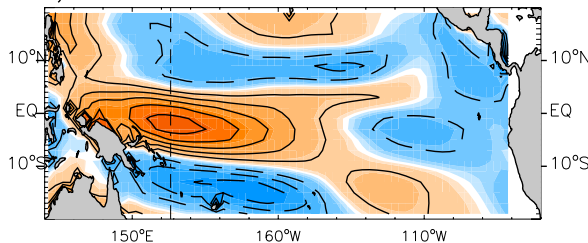


c') Taux zonal average

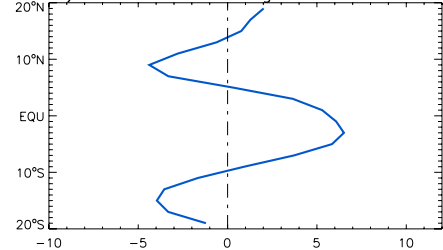


GFDL-CM2.0

d) GFDL-CM2.0 nino34_std=0.88

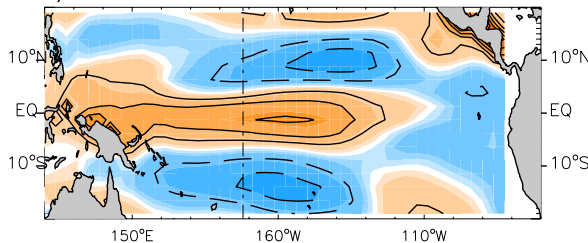


d') Taux zonal average

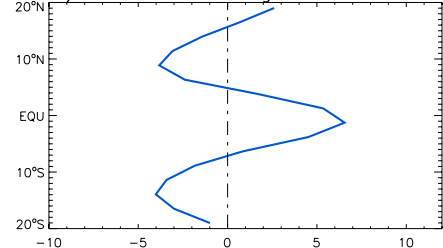


IPSL-CM4

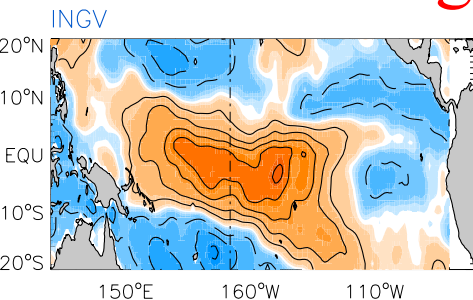
e) IPSL-CM4 nino34_std=0.85



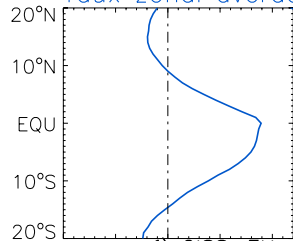
e') Taux zonal average



Regression of τ^x upon the Niño3.4 index

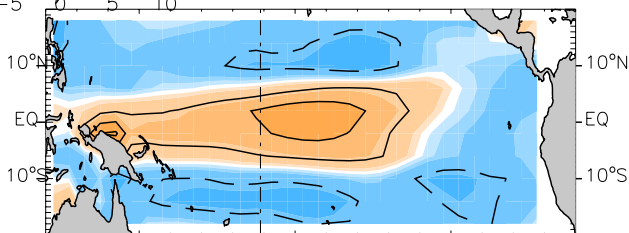


Taux zonal average

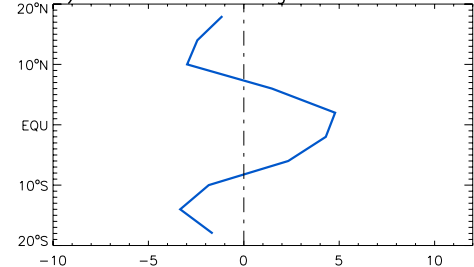


GISS-EH

f) GISS-EH nino34_std=0.46

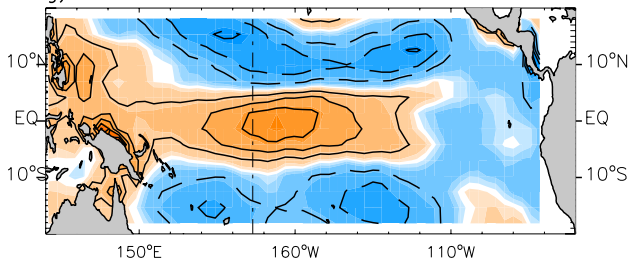


f') Taux zonal average

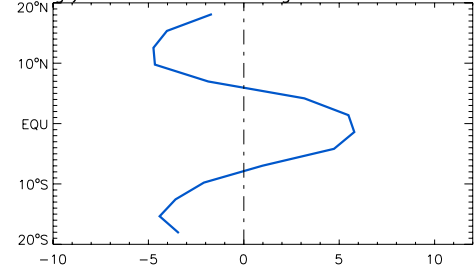


PCM

g) PCM nino34_std=0.71

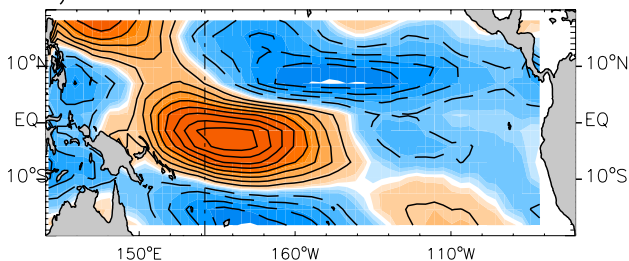


g') Taux zonal average

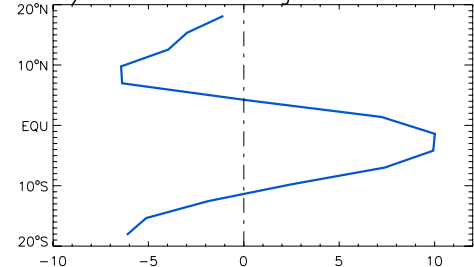


MRI

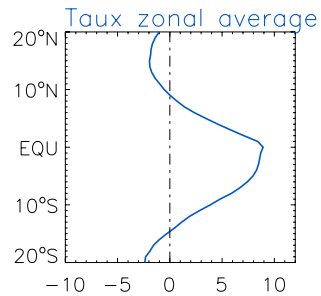
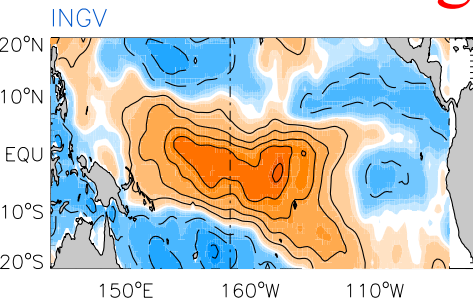
h) MRI-CGCM2.3.2 nino34_std=0.69



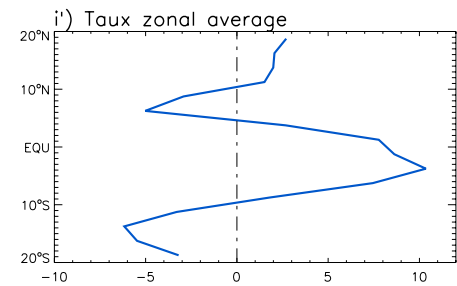
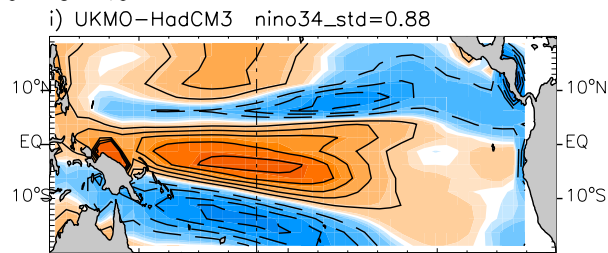
e') Taux zonal average



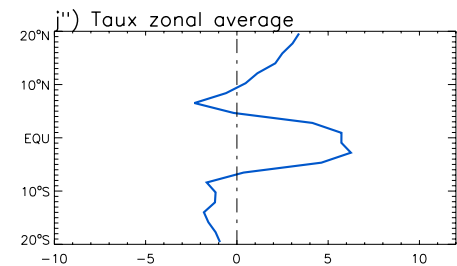
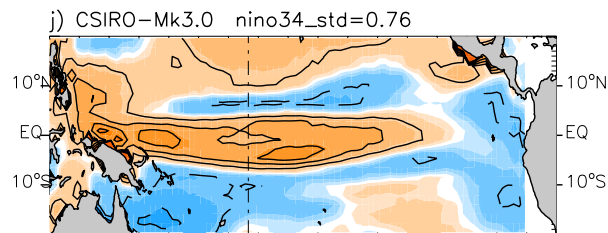
Regression of τ^x upon the Niño3.4 index



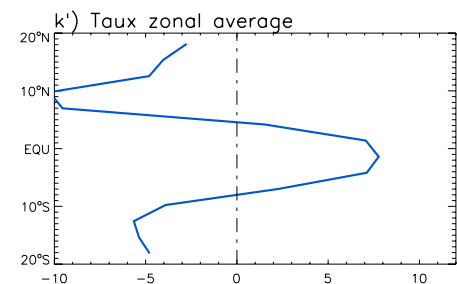
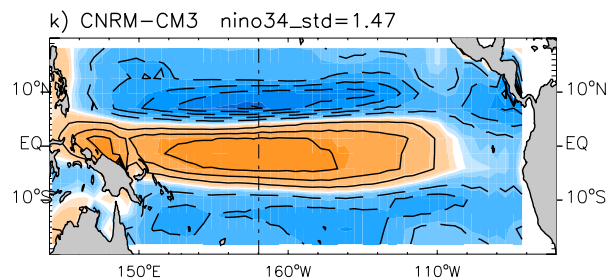
UKMO-HadCM3



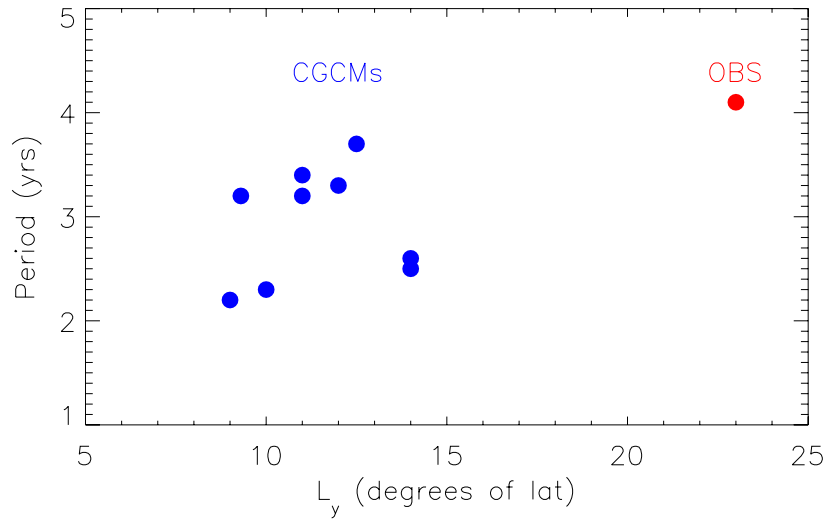
CSIRO



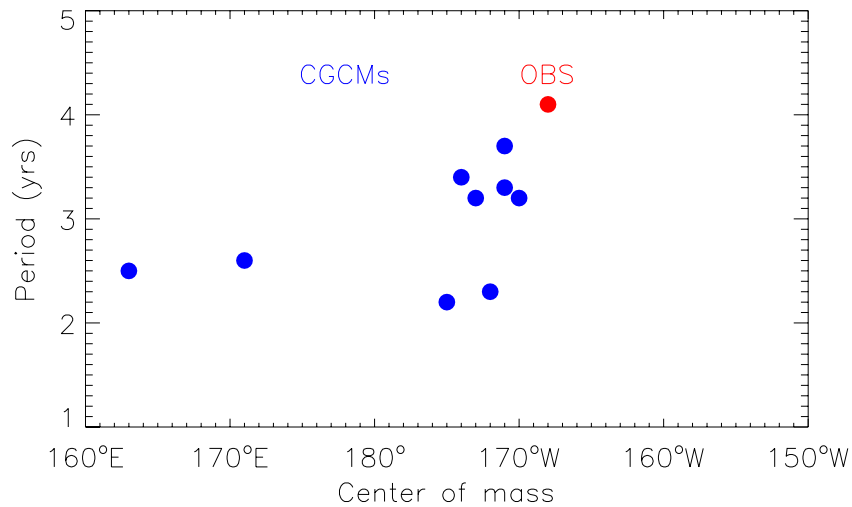
CNRM



CGCMs vs. OBS.



All the CGCMs have wind stress anomalies narrower than obs.



All the CGCMs have wind stress anomalies displaced westward with respect to the obs.

Conclusions

- Thermocline variability in the CGCMs is consistent with the “recharge oscillator” paradigm for ENSO.
- Wind stress forcing in the CGCMs has a narrower meridional scale and is displaced westward compared to observations. Both factors can lead to a shorter timescale for ENSO.