The Impact of Mean Climate on ENSO: Simulation and Prediction

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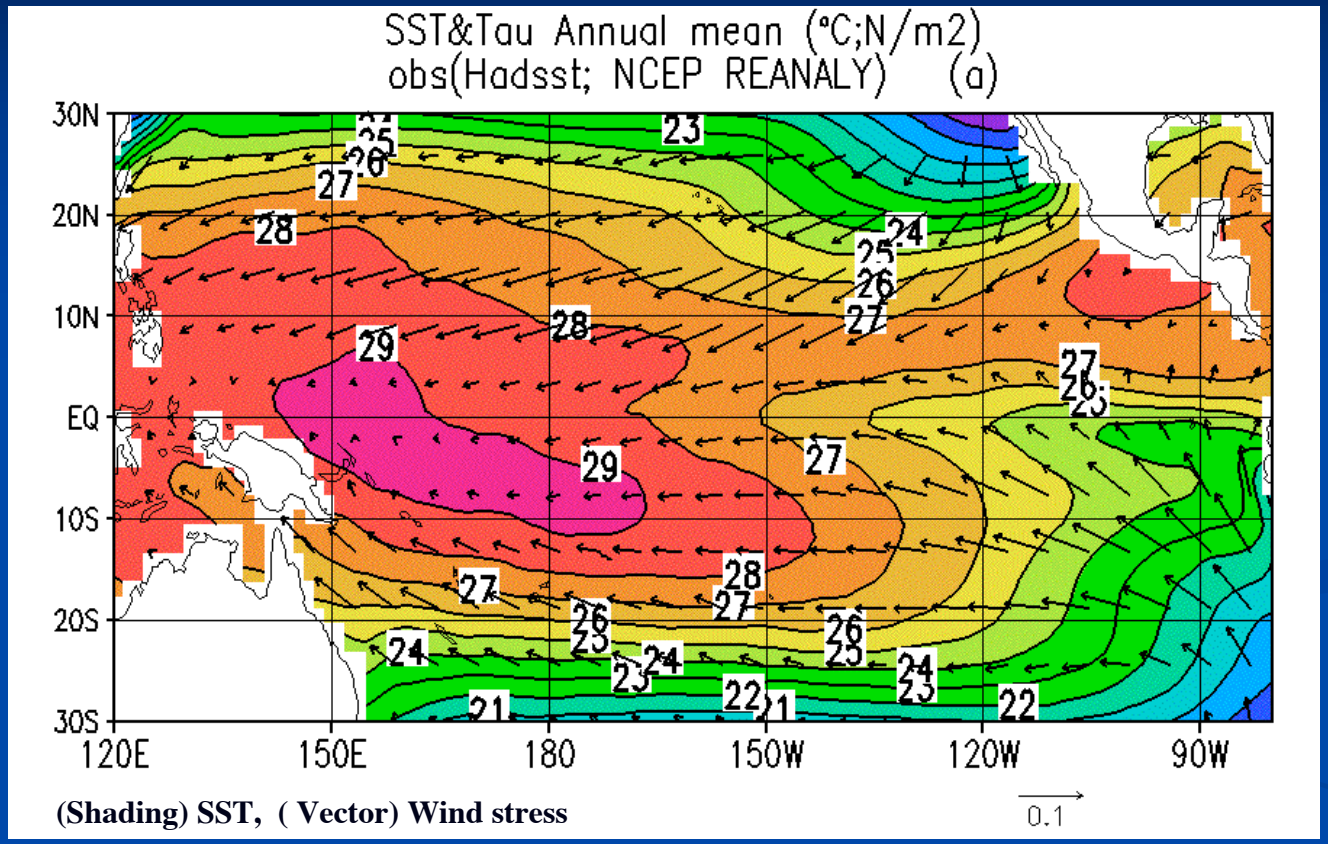
The Mean Climate in The Tropical Pacific from Observations



How important

1. Annual cycle (Xie 1994)
2. Walker circ.
3. Bjerknes (1969)

- **East-West asymmetric structure**: east-cold tongue & west-warm pool; easterly
- **South-North asymmetric structure**: south-cold tongue & north-warm water; southerly; ITCZ

The motivation of this study

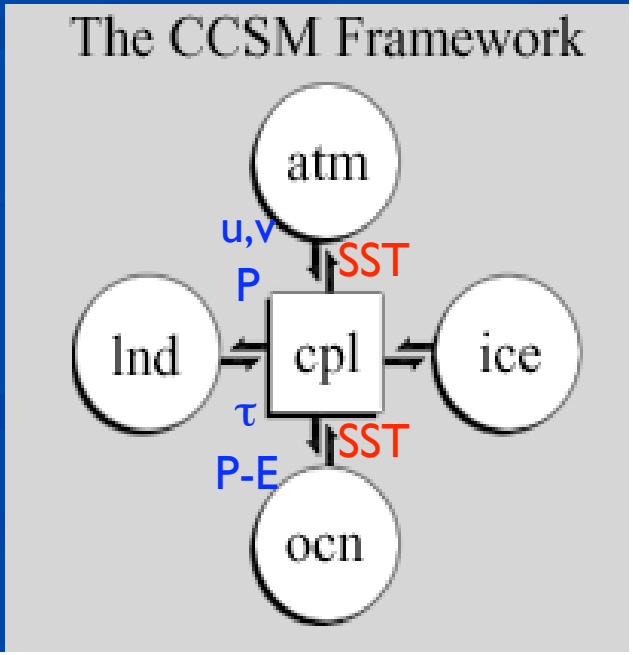
1. **Major goal**: Investigate the impact of mean climate on the simulation and prediction of ENSO by looking into one CGCM (CCSM3, developed by NCAR)
2. Provide some information about the prediction skill of ENSO with CCSM3, which has been considered as one part of national Multi-model ensemble in operational forecasts.

Model:CCSM3

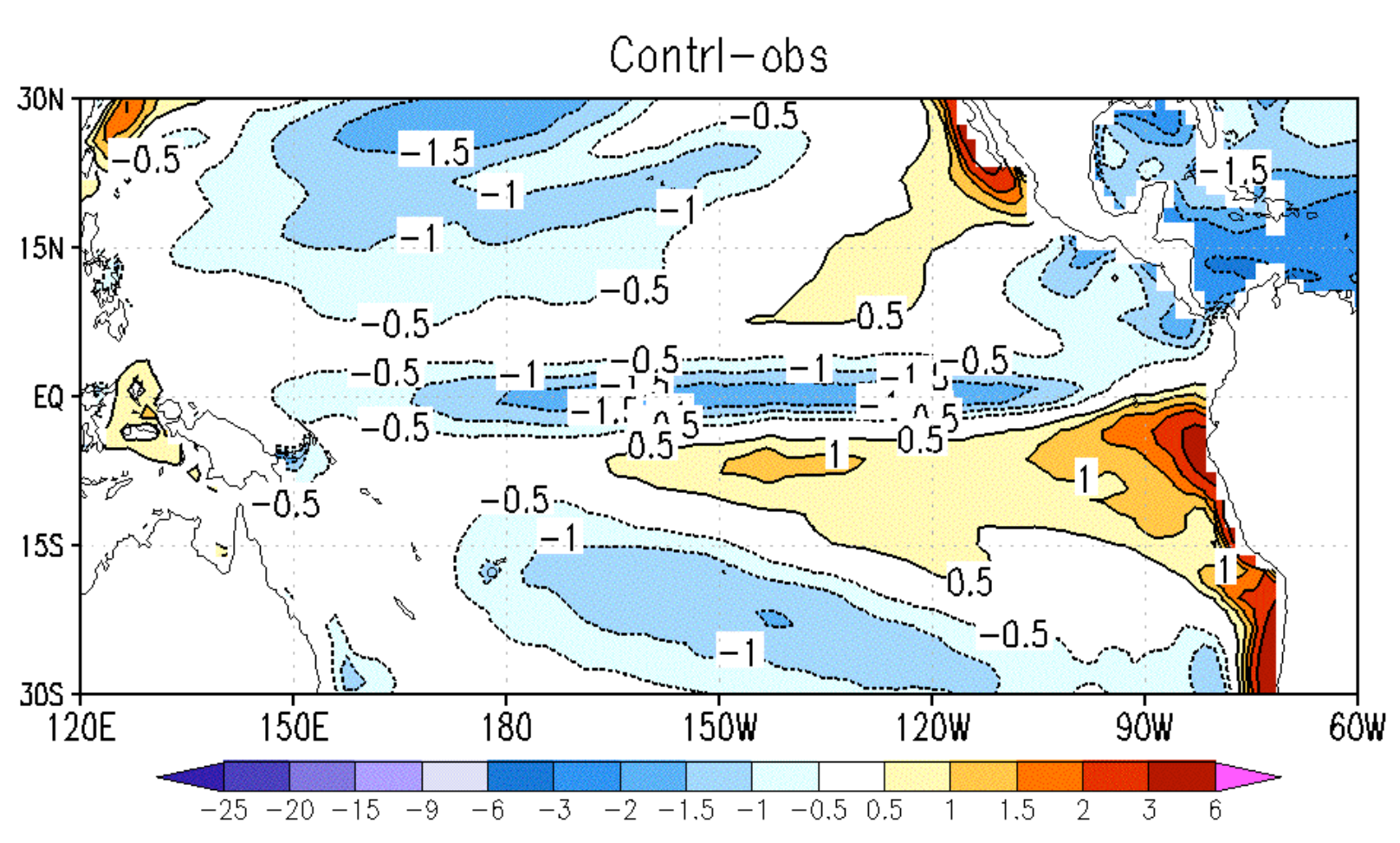
- **Community Climate System Models v3 (CCSM3)**
- **One of the state-of-art CGCMs**
- **Resolution**:

  Atmosphere: T85 (1.4° x1.4°; 26 levels)

  Ocean: gx1v3 (1°x1°, higher than 0.5° in equator; 40 levels)
- **Coupling**: daily
- **IPCC mode**: 20 century climate



SST biases of mean climate in CCSM3



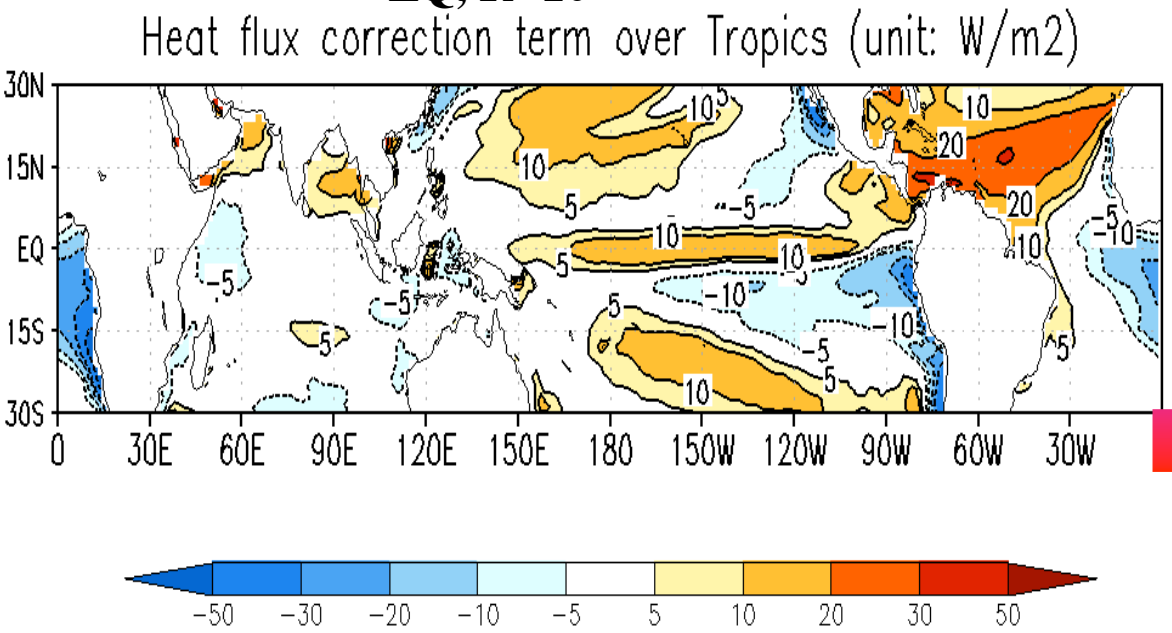
Experiment design: Heat flux correction

$$\Delta Q = -\Delta SST * R$$

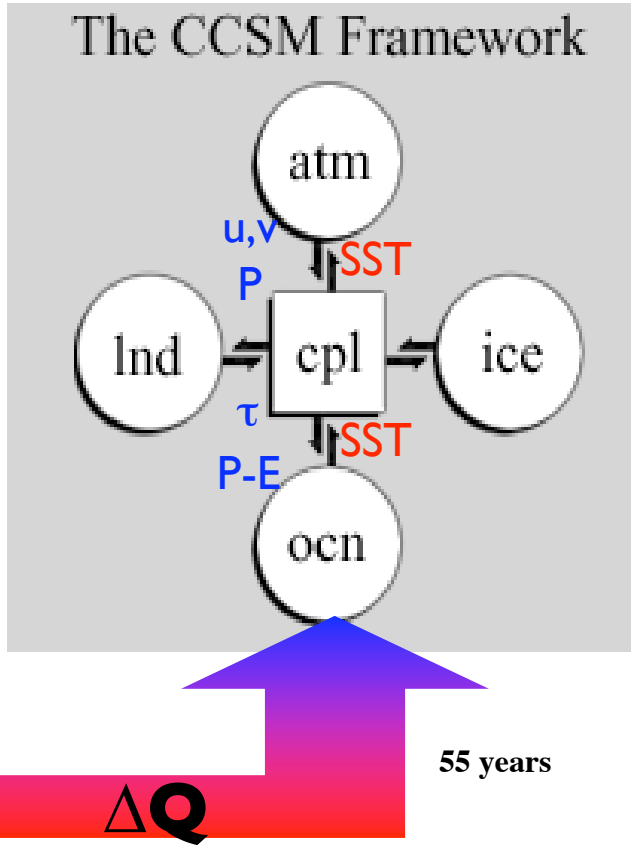
ΔSST :SST biases of mean climate in control

R: relaxation coef, adjustable, unit W/(m^{2}K)

ΔQ, R=10

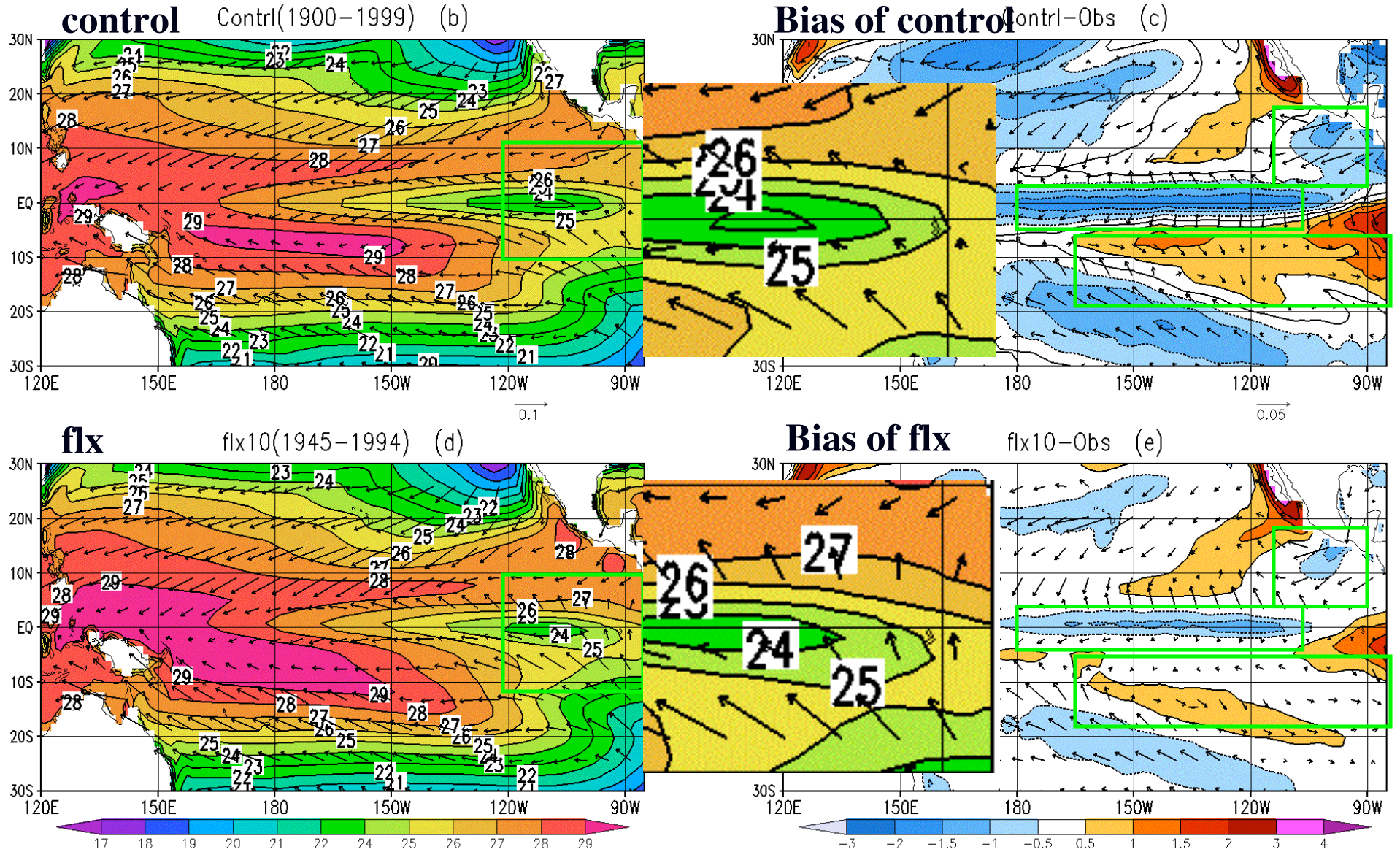


(Refer to Manganello and Huang 2008)



- Annual-varying
- Purpose

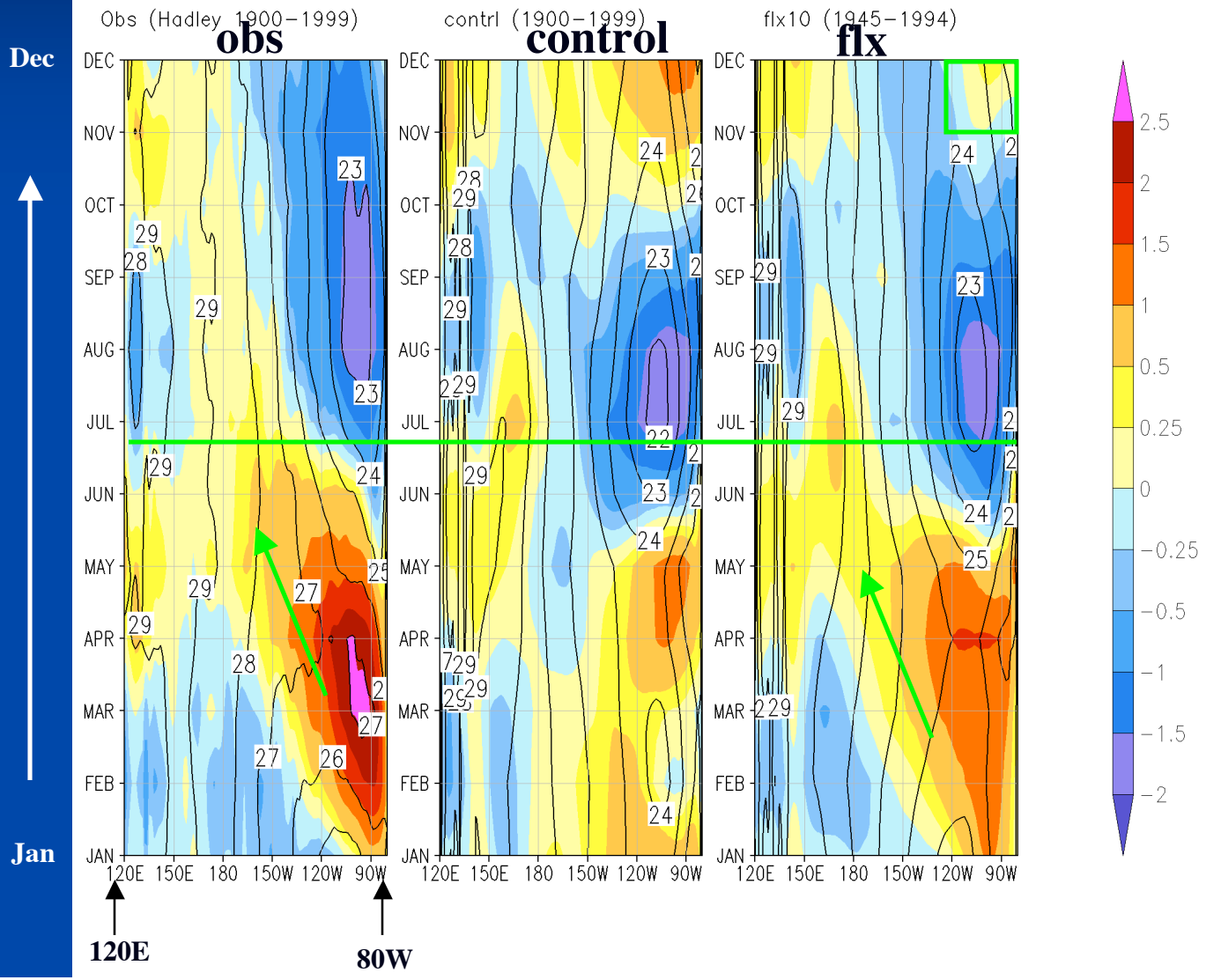
Mean climate: SST & wind stress



The Impact on seasonal cycle: SST

The seasonal cycle of SST anomaly at Equator

(anomaly: relative to the annual mean)



Heat flux correction

↓ **Artificially**

Mean climate improved

↓ **Dynamically**

An annual cycle generated

(heat flux correction term is not Seasonal varying)

How is a persistent southerly generated?

Constant cooling in the south (by design)

↓

Air mass is denser in south

↓

Southerly blows from south to north

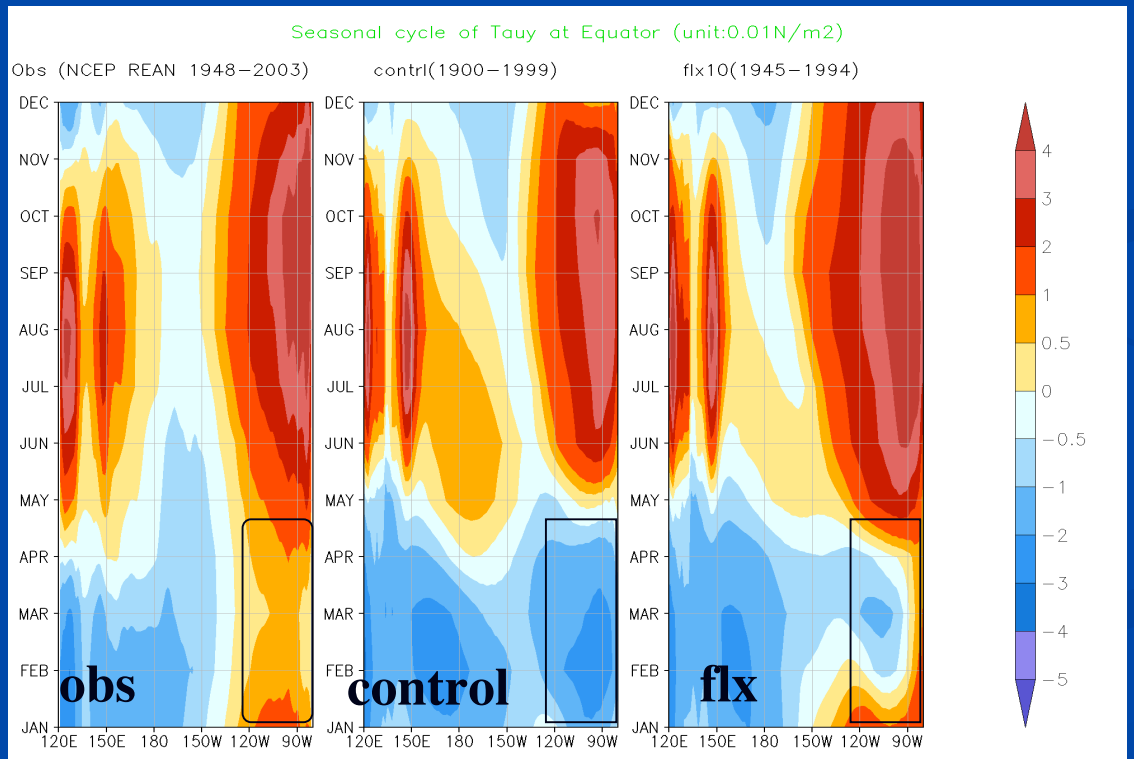
↓ Evaporation and upwelling

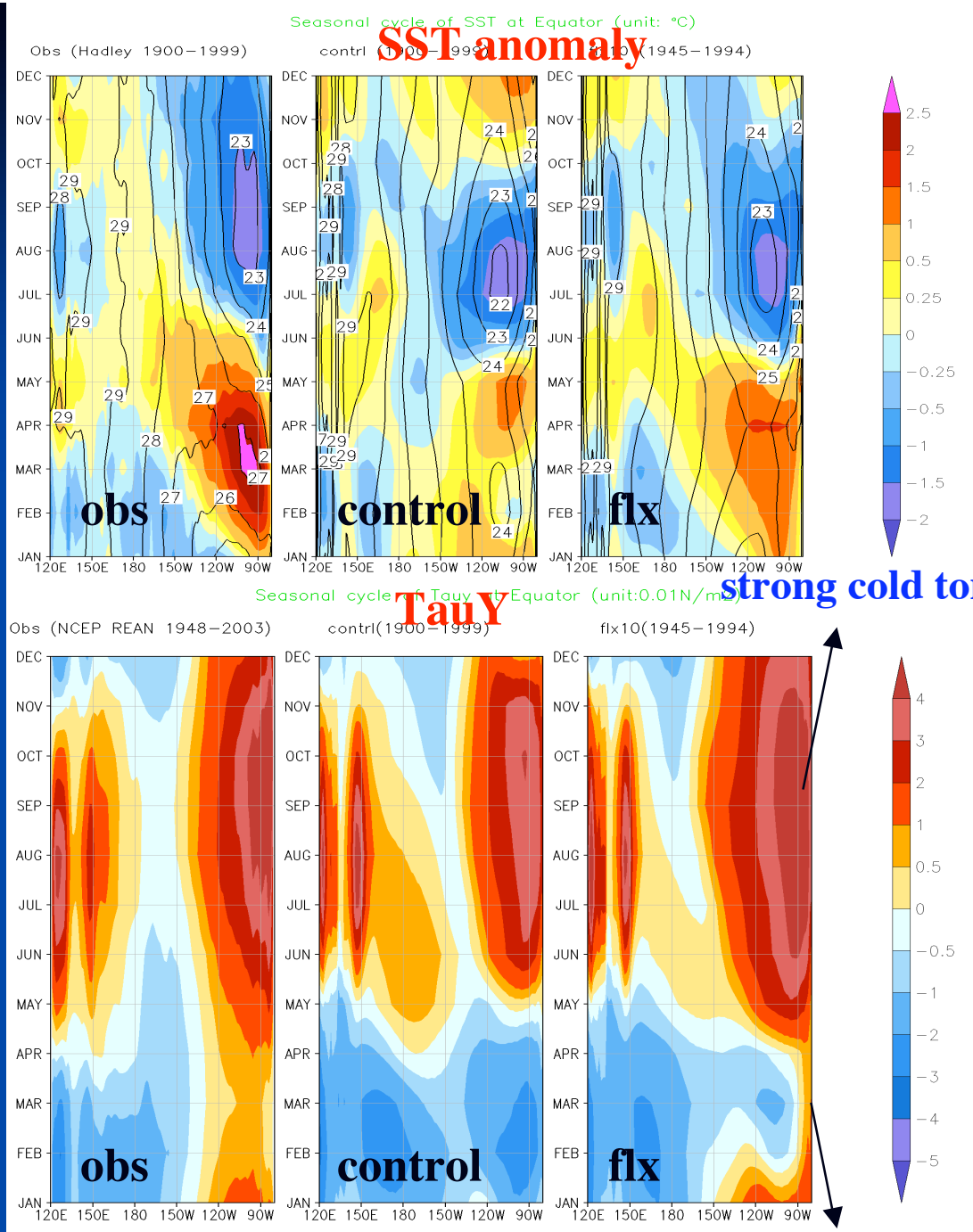
Sea water in the south cool down

↓

More realistic SST north-south asymmetry

The seasonal variation of the southerly (TauY) at Eqt





How is an annual cycle of SST Is generated? (dynamically)

Seasonal variation of southerly

↓ evaporation

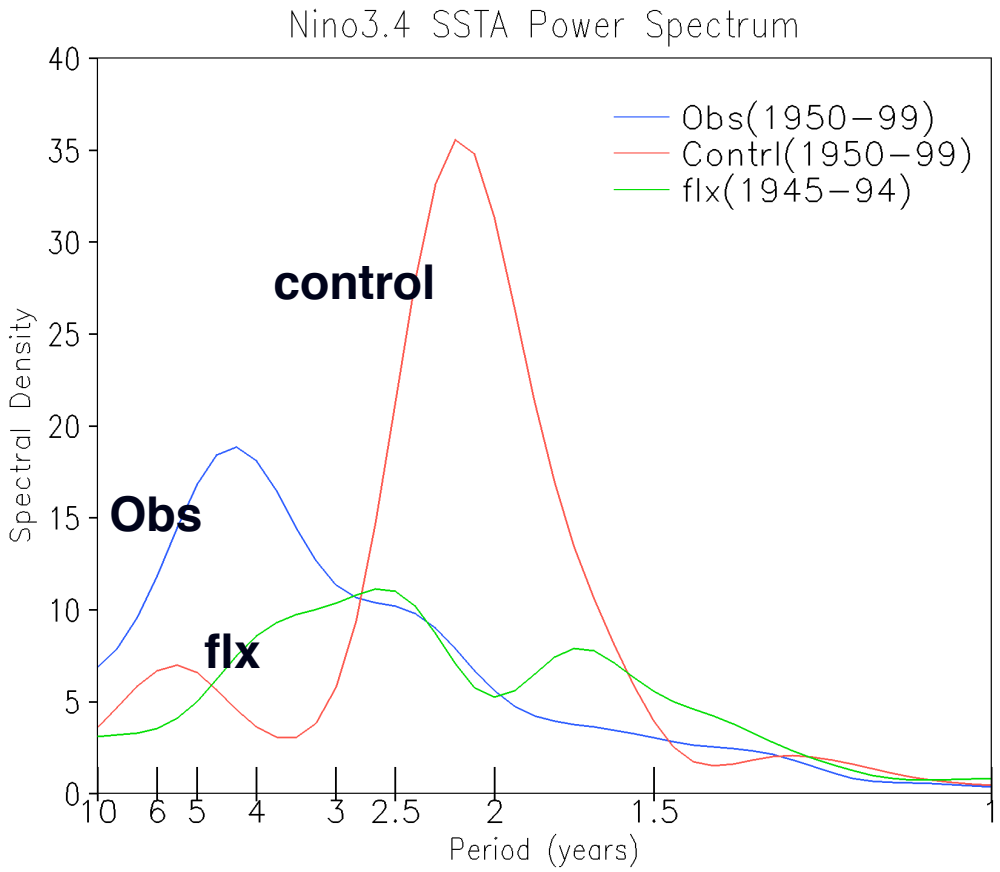
Seasonal variation of cold tongue

strong cold tongue

Weak cold tongue

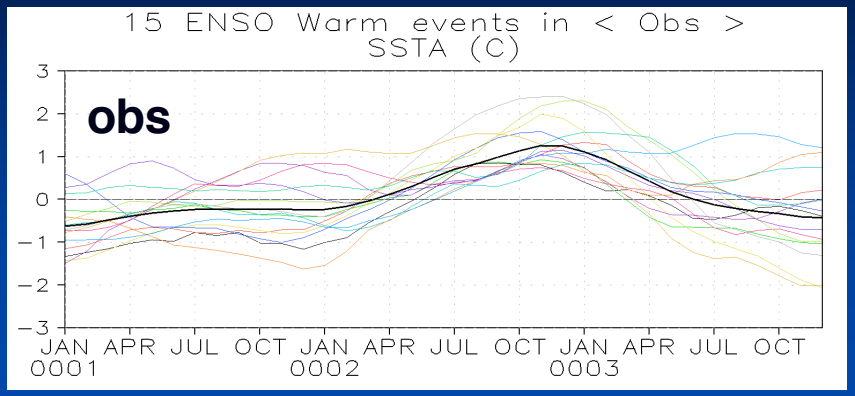
The impact on ENSO variability: Period

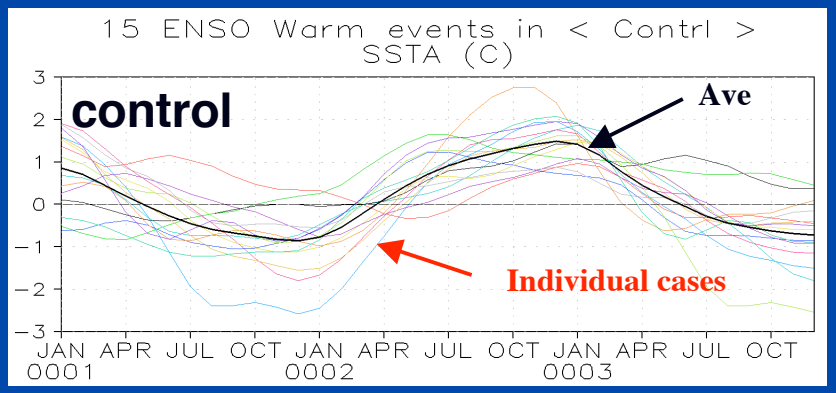
Nino3.4 SSTA Power Spectrum

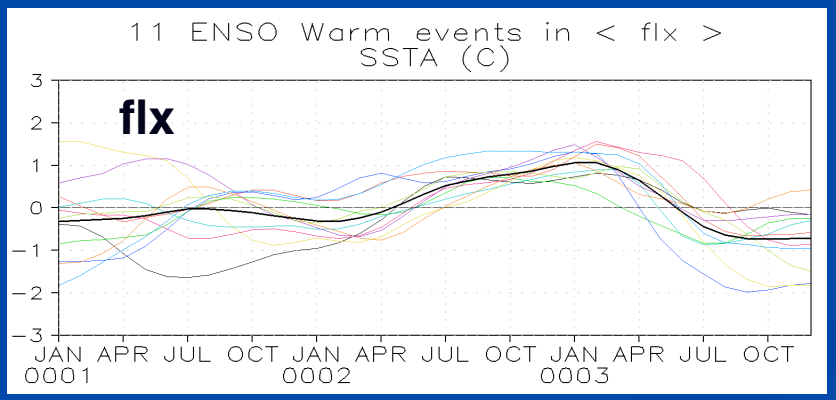


Evolution of Composite ENSO events (Nino3.4 SSTA)

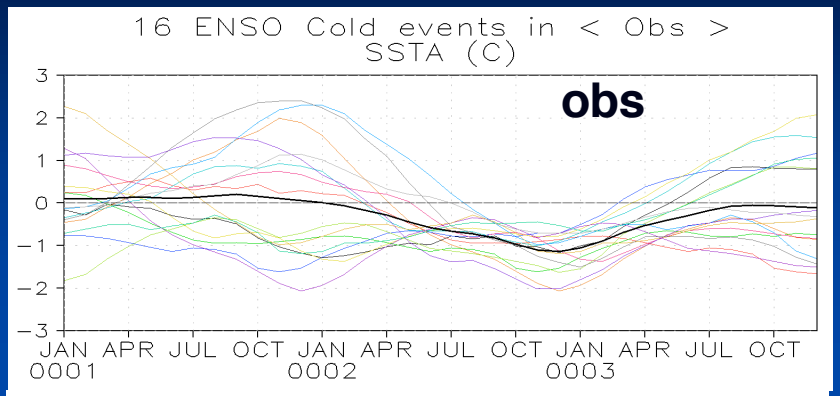
Warm

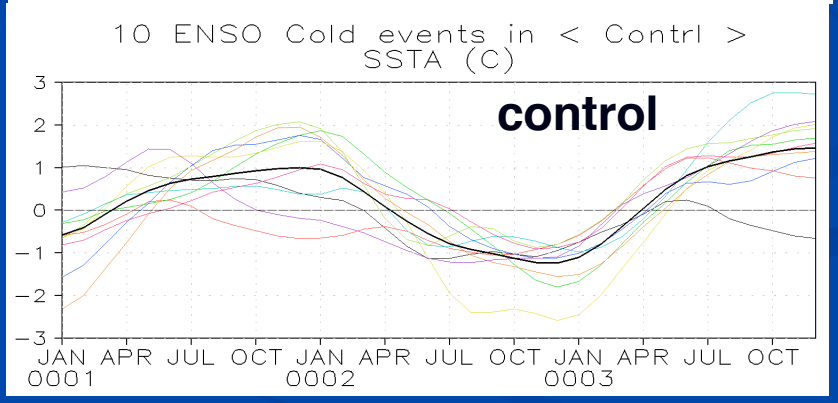


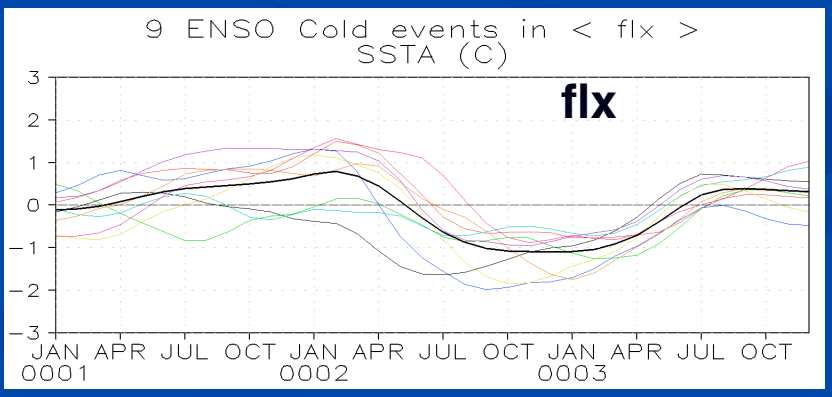




Cold







------>Time

The impact on ENSO Prediction

- With heat flux correction (flx) and without (control)
- Details about the hindcasts (take control as example)
  - **January** and **July** initial conditions
  - lead times of 12 months
  - 1982-1998
  - Initialization

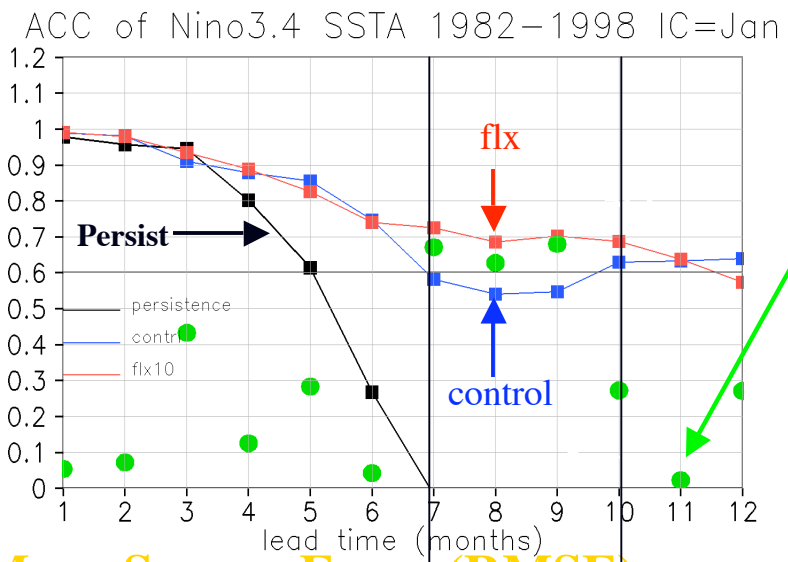
    Ocean: ODA from GFDL (follow Kirtman & Min, 2008)

    Other components: AMIP (No observations) ->

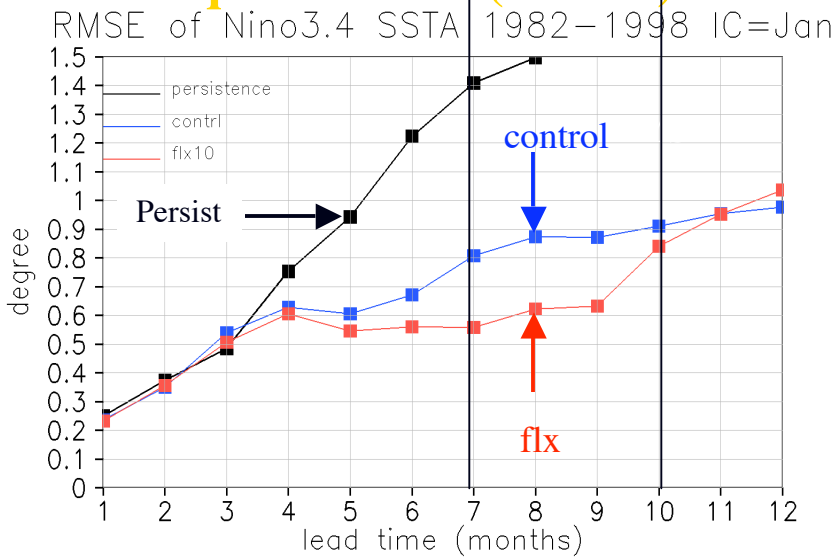
    3 ensembles

Prediction skill: Jan IC

Anomaly Correlation Coefficient (ACC)



Root Mean Square Error (RMSE)

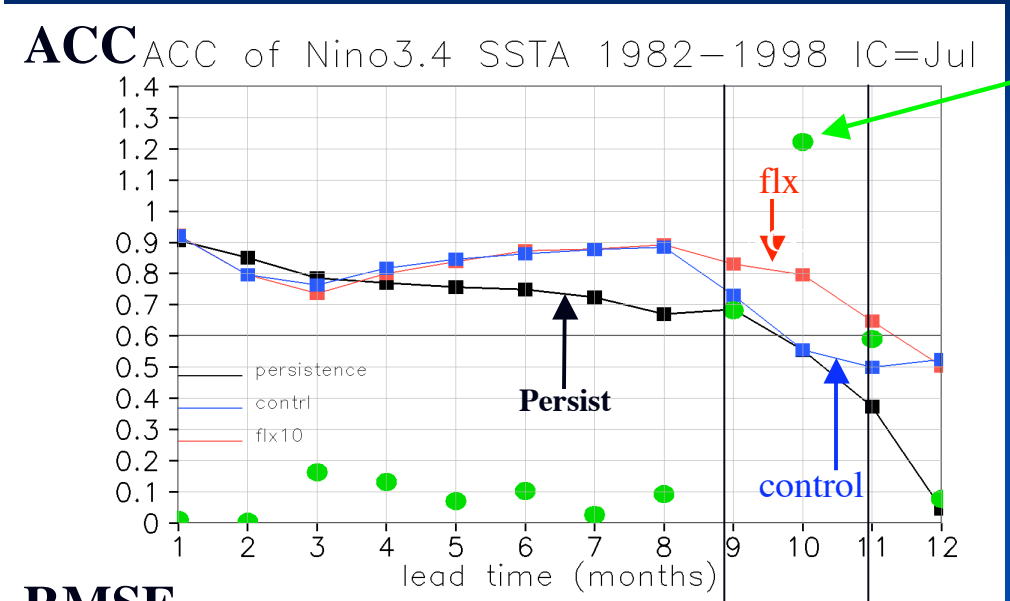


T-test of difference:
If >1.64
difference is significant
at 90% level

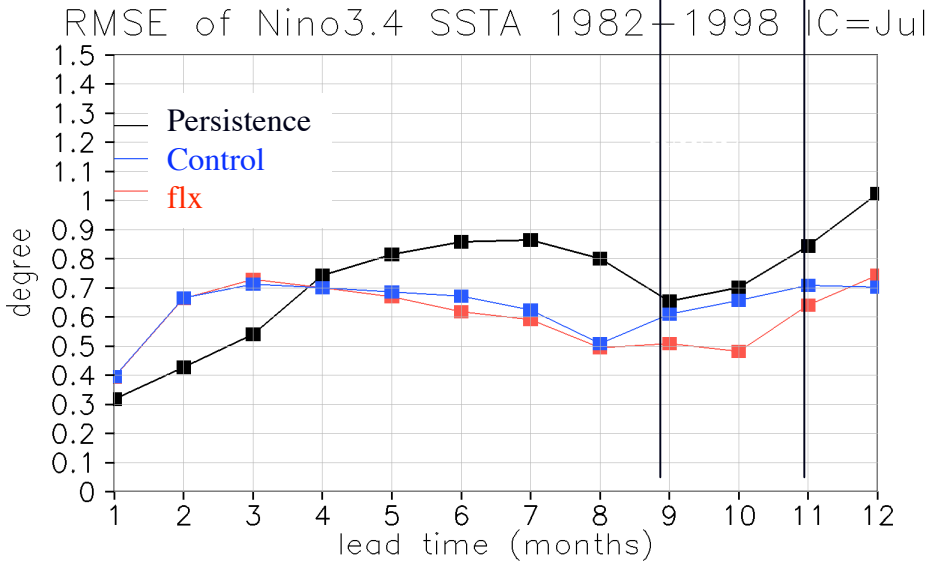
- First 6 months: comparable
- 7-10 months: slightly higher skill in heat flux corrected hindcasts, although insignificant
- CCSM3 is Skillful in forecasting ENSO (>persist and >0.6 for the first 6 months)

Prediction skill: July IC

ACC



RMSE



T-test of difference

If >1.64

Difference is significant at 90% level

- First 8 months: comparable
- 9-11 months: slightly higher skill in heat flux corrected hindcasts, although insignificant
- CCSM3 is Skillful in forecasting ENSO (>persist and >0.6 for the first 9 months)

Summary

1. **The mean climate** is improved in the heat flux corrected simulation with reduced warm biases in coast of Peru and a persistent southerly.
2. **An annual cycle of SST** in the eastern Pacific is generated because of the more realistic asymmetry in the mean climate there suggest…
3. **The ENSO** behavior is sensitive to the improvement of mean climate (irregular cycle, longer period);
4. There is a slightly higher **prediction skill of ENSO** by improving the mean climate, although its robustness needs verification.

References

- Bjerknes, J., 1969: Atmospheric teleconnections from the equatorial Pacific. Mon. Wea. Rev., 97, 163–172.
- Kirtman, B. P. and D. Min, 2008: Multi-Model Ensemble Prediction with CCSM and CFS. Mon. Wea. Rev. (in press).
- Manganello, Julia V.; Huang, Bohua, 2008: The influence of systematic errors in the Southeast Pacific on ENSO variability and prediction in a coupled GCM. Climate Dynamics, DOI:10.1007/s00382-008-0407-5.
- Xie, S.P., 1994: On the Genesis of the Equatorial Annual Cycle. J. Climate, 7, 2008–2013.