Do low clouds amplify internal fluctuations of the Pacific climate?

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Collaborators:

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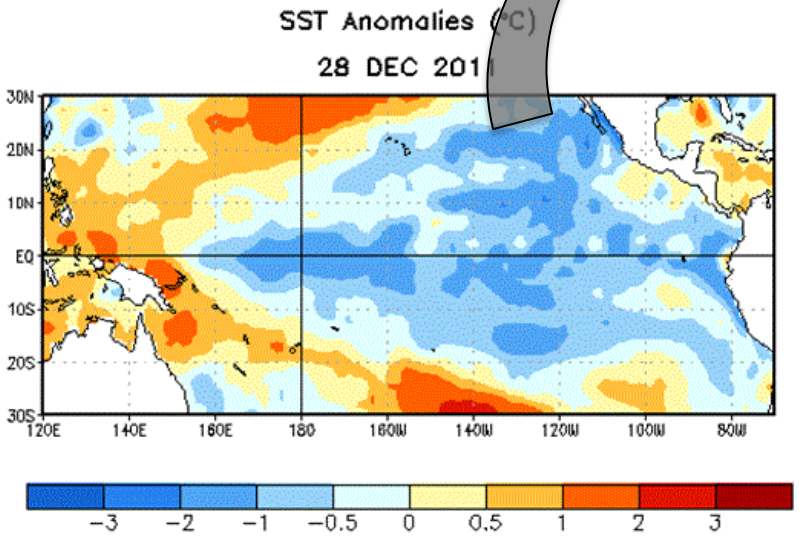
Drought in southern US is linked to Tropical Pacific Sea Surface Temperatures

Current La Nina pattern in the tropical Pacific



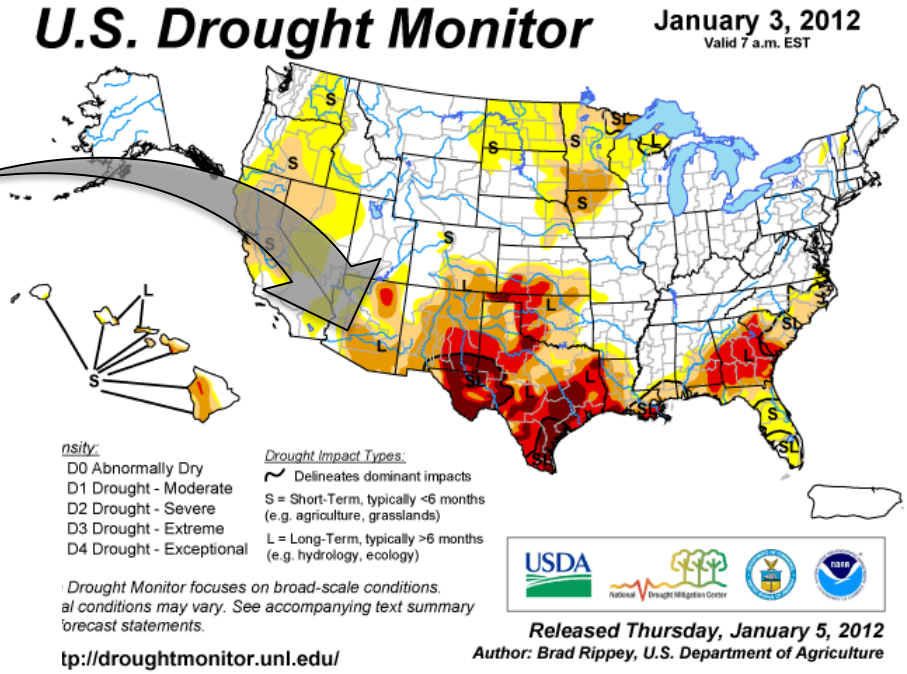
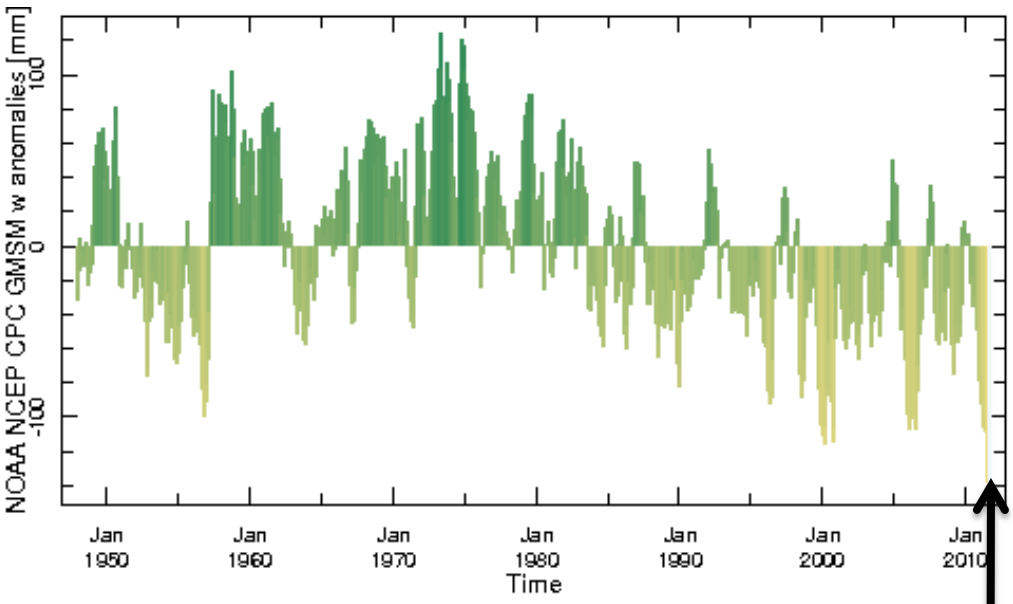


Figure 1. Average sea surface temperature (SST) anomalies (°C) for the week centered on 28 December 2011. Anomalies are computed with respect to the 1971-2000 base period weekly means (Xue et al. 2003, *J. Climate*, **16**, 1601-1612).

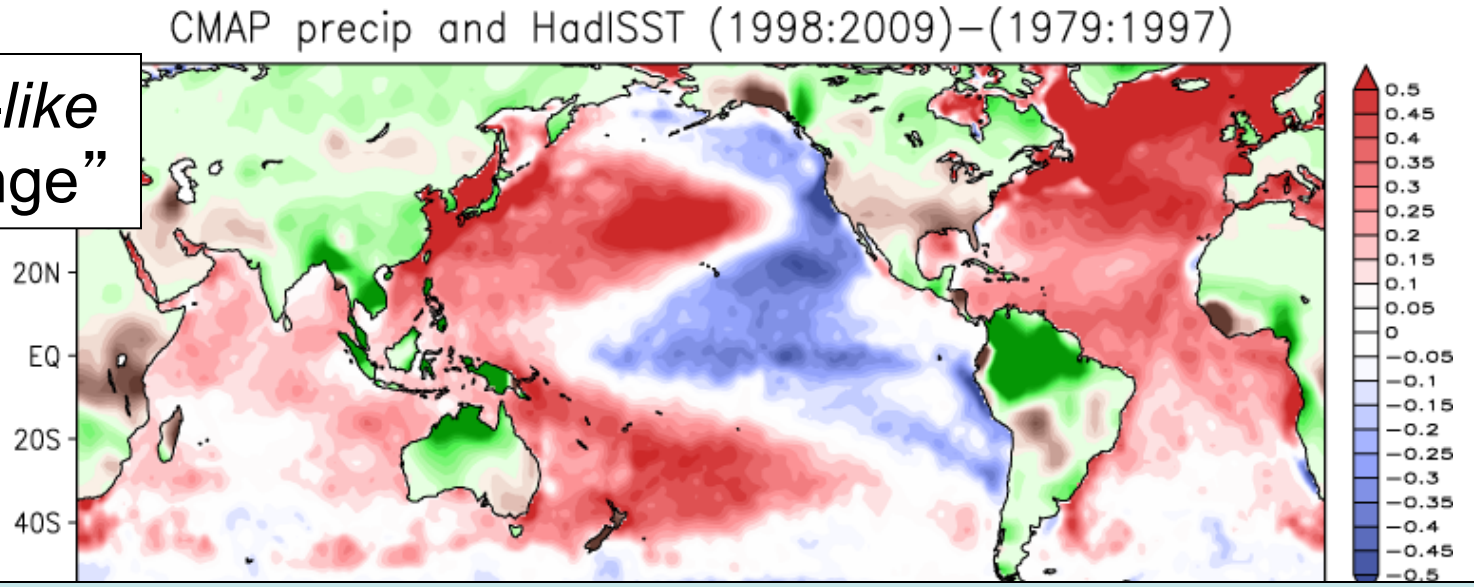
Meteorological drought can persist for decades

Soil moisture in Texas over the last 60 yrs

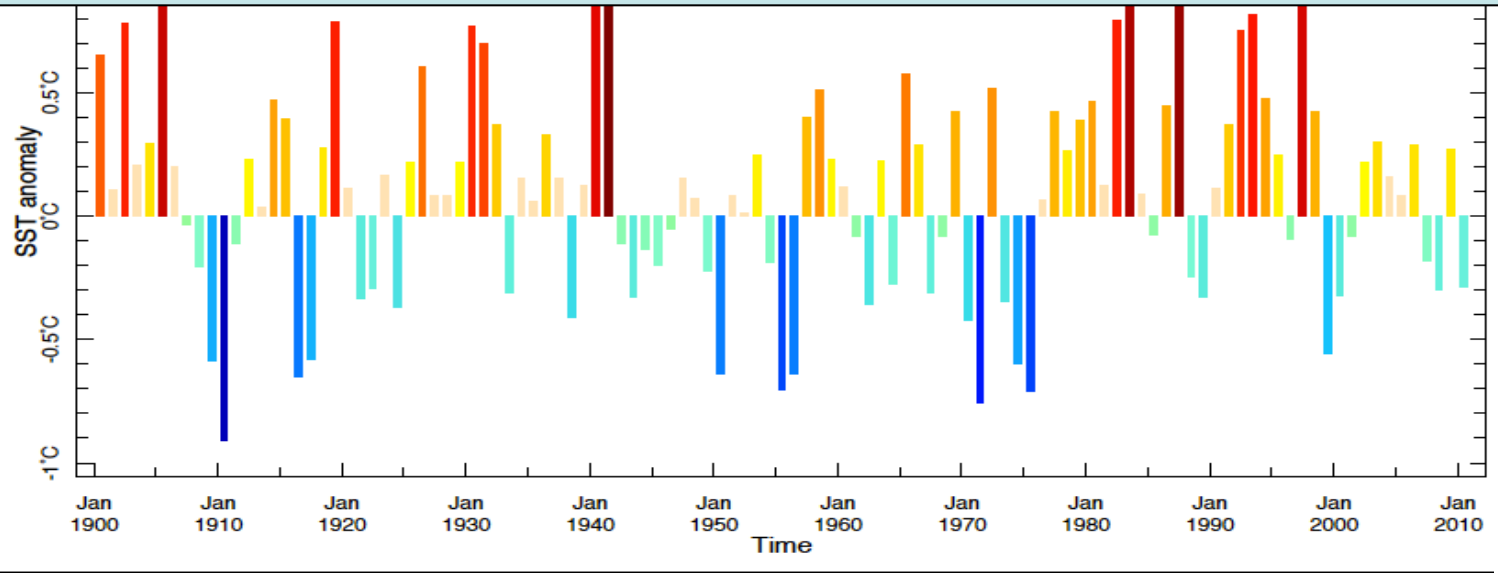


20th century and paleoclimate records provide ample evidence for decades-long, and even ‘Mega’ droughts

"La Nina-*like* SST change"



This is not the expected response of the Pacific to GHG forcing (DiNezio et al. 2009)



What caused the trend in Pacific SST in the last several decades? How long will this trend continue?

What do we need to understand, observe, model?

Our approach:

Decompose complex models into a set of relatively few processes

Methodology

- Climate models with different degrees of coupling with the ocean

  1. Forced with climatological SST

     Uncoupled

  2. Coupled to a SLAB ocean mixed layer (50 m)

     Thermodynamical coupling but
     No interactive ocean dynamics

  3. Coupled to a full ocean GCM

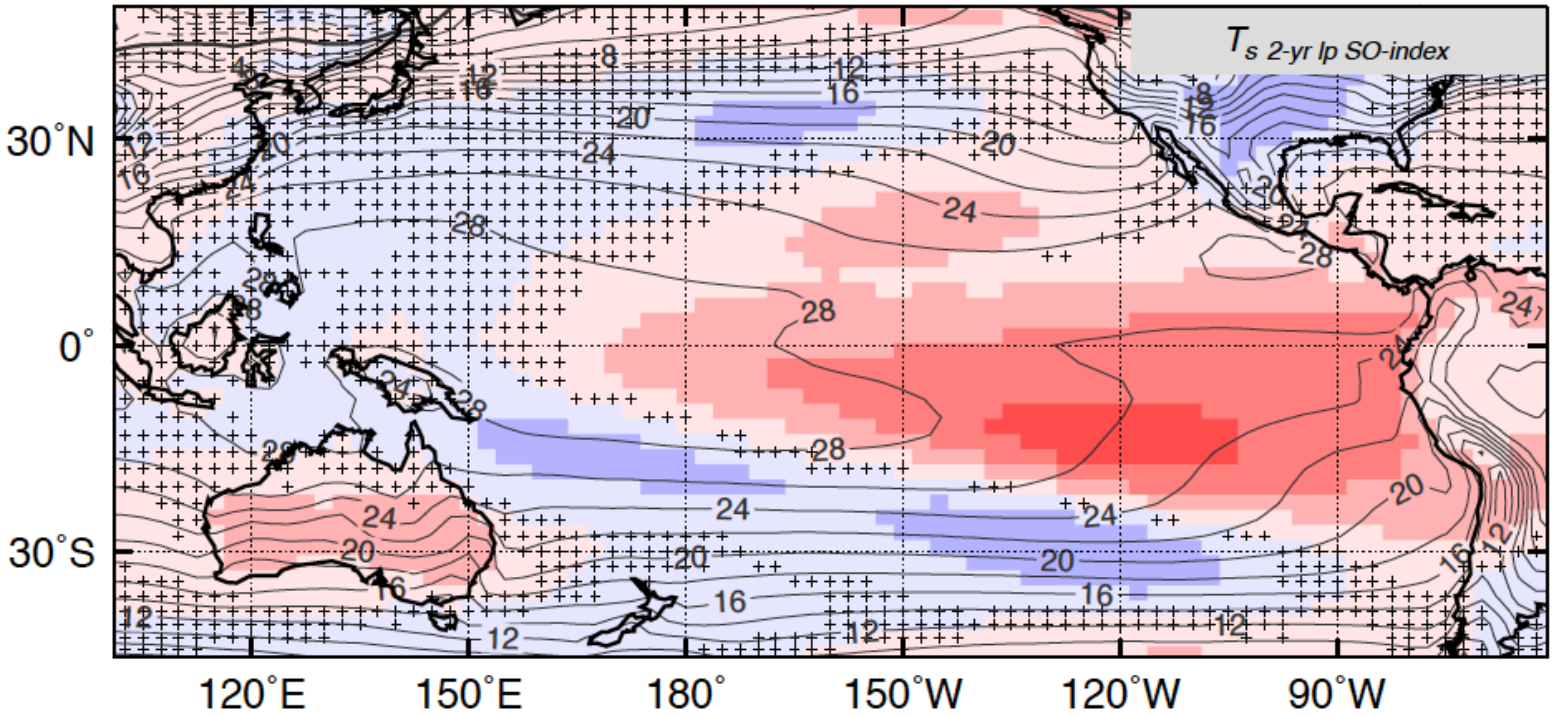
     Fully coupled

- 13 different AGCMs- multi-model mean fields show structures that are not sensitive to the details of parameterizations

Clement et al. (*J. Climate* 2011)

“El Nino-like” pattern is the dominant mode of variability without dynamical coupling to ocean

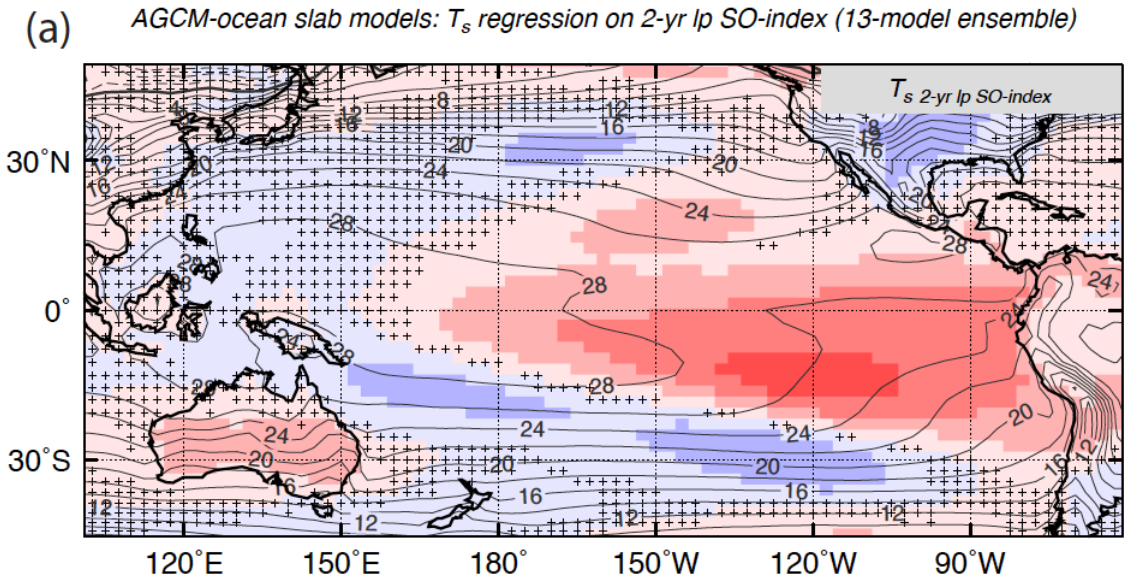
Multi-model mean regression of surface temperature on Walker Index**



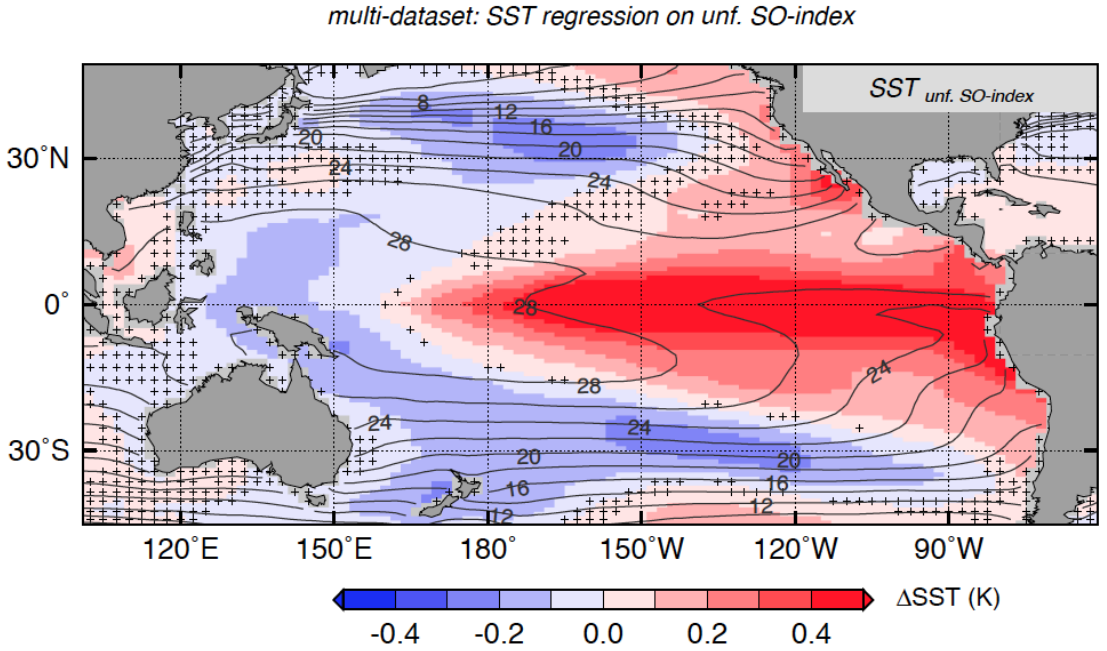
Note: Positive and negative fluctuations are equally likely

**stippling shows areas where < 10 out of 13 models agree in sign- i.e not robust

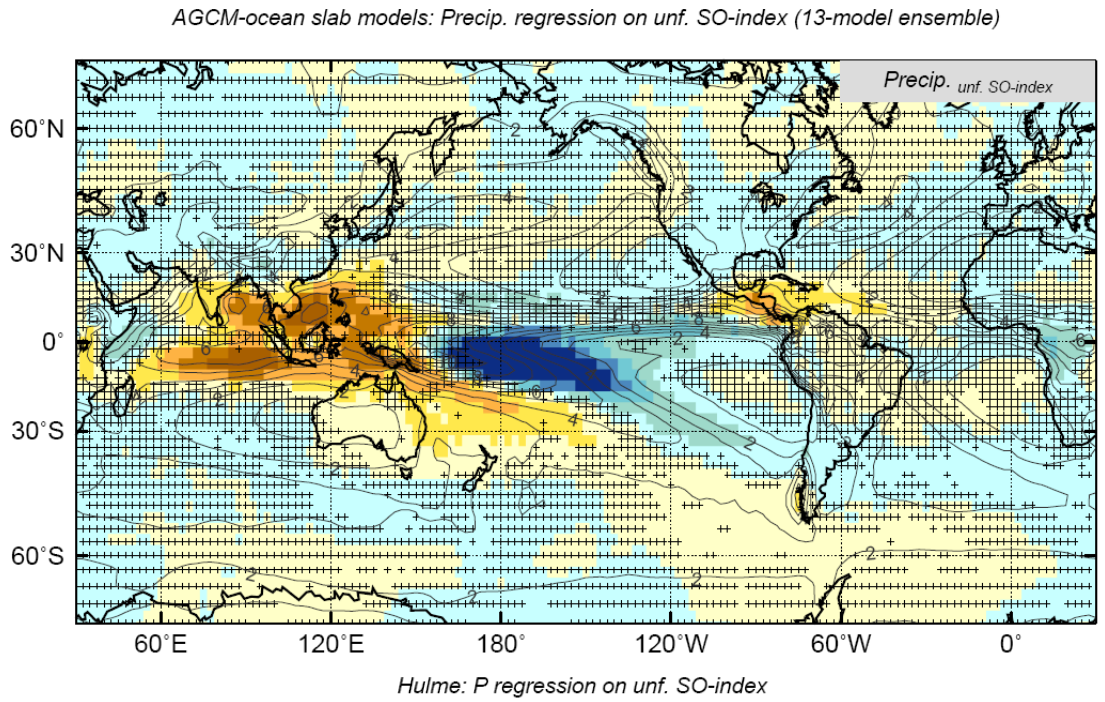
AGCM-slab multi-model mean (13 models) regression of SST on Walker index



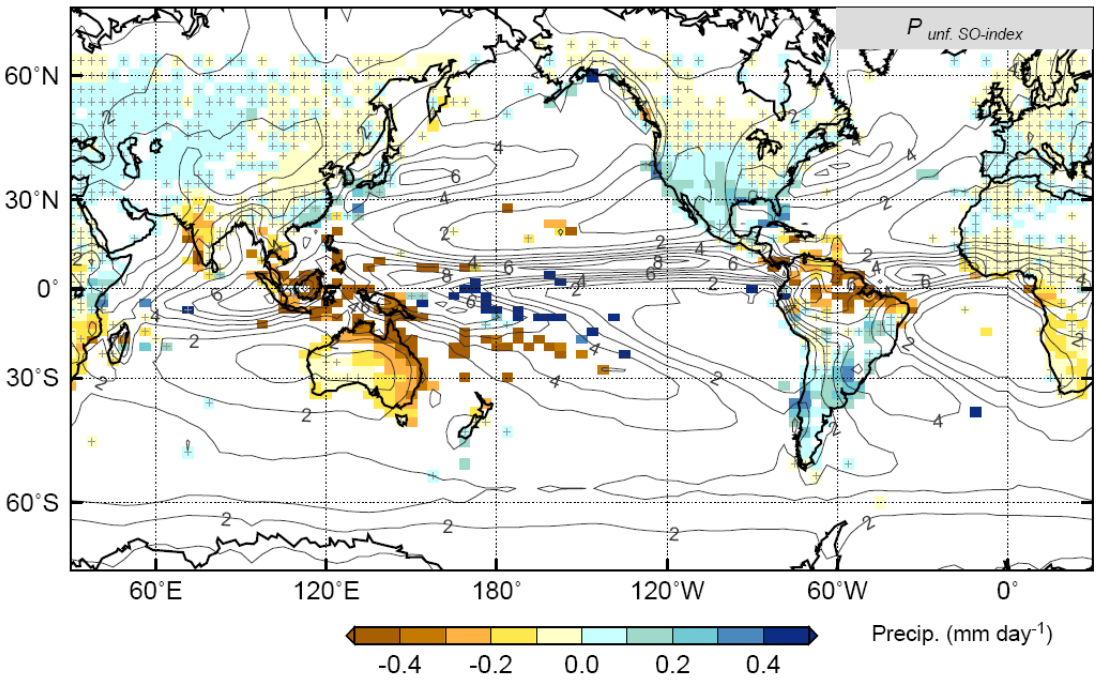
Observed regression of SST on normalized Walker index



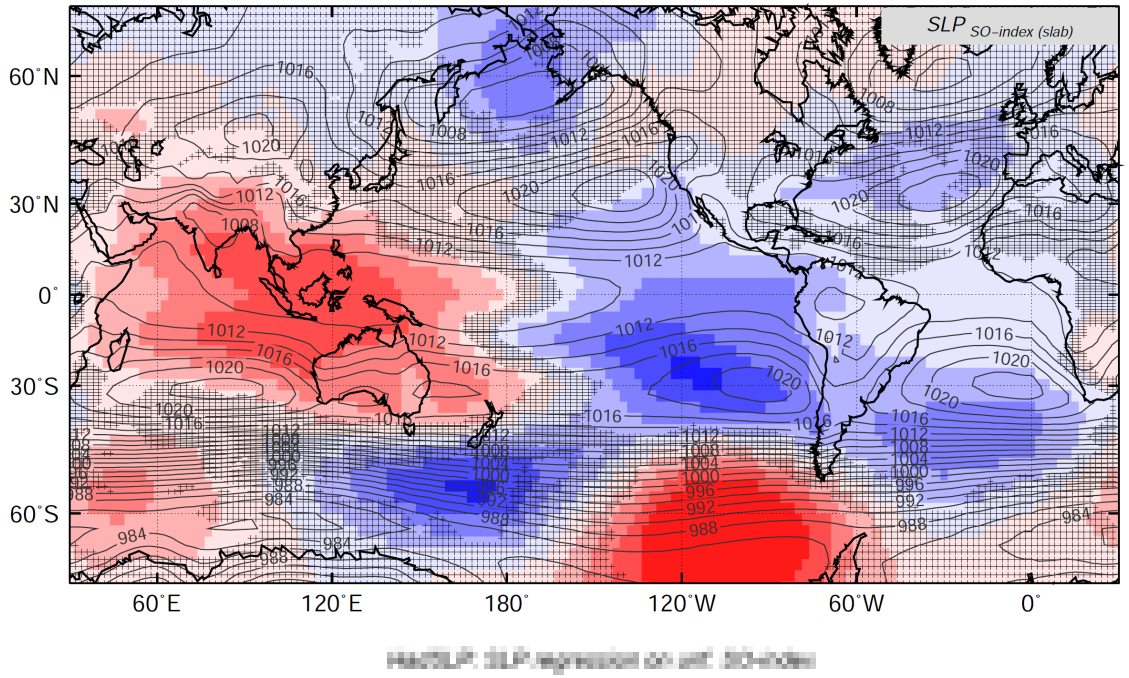
AGCM-slab multi-model mean (13 models) regression of precip on normalized Walker index



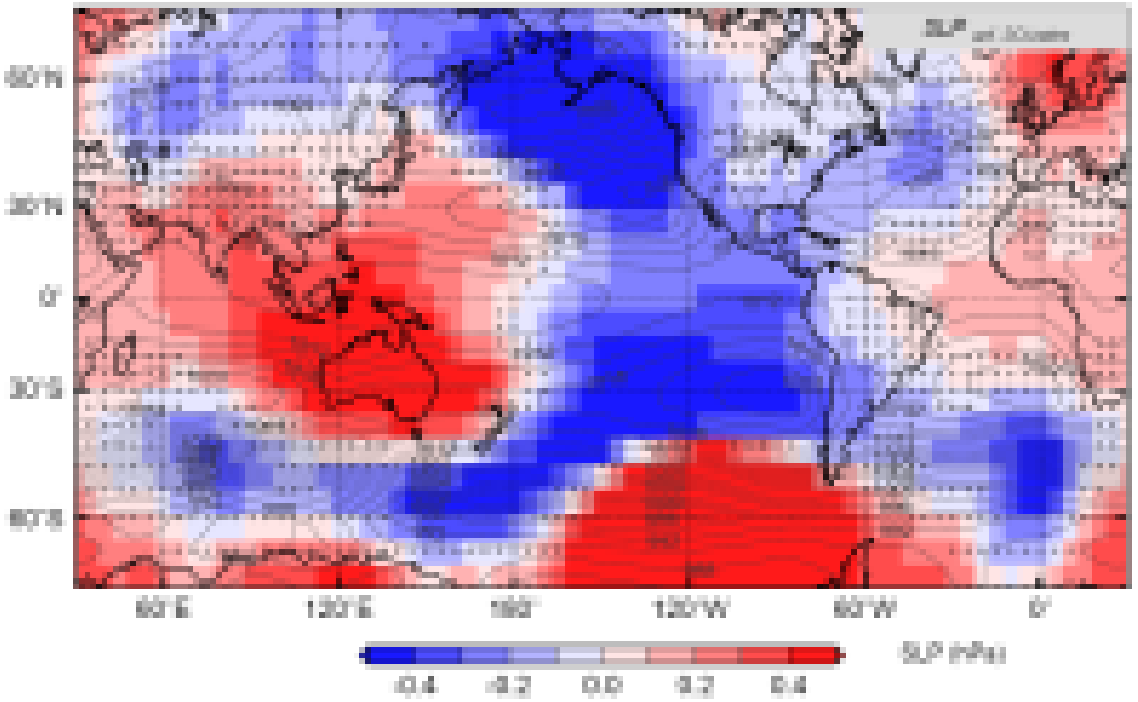
Observed regression of GPCP precip (Adler et al. 2003)



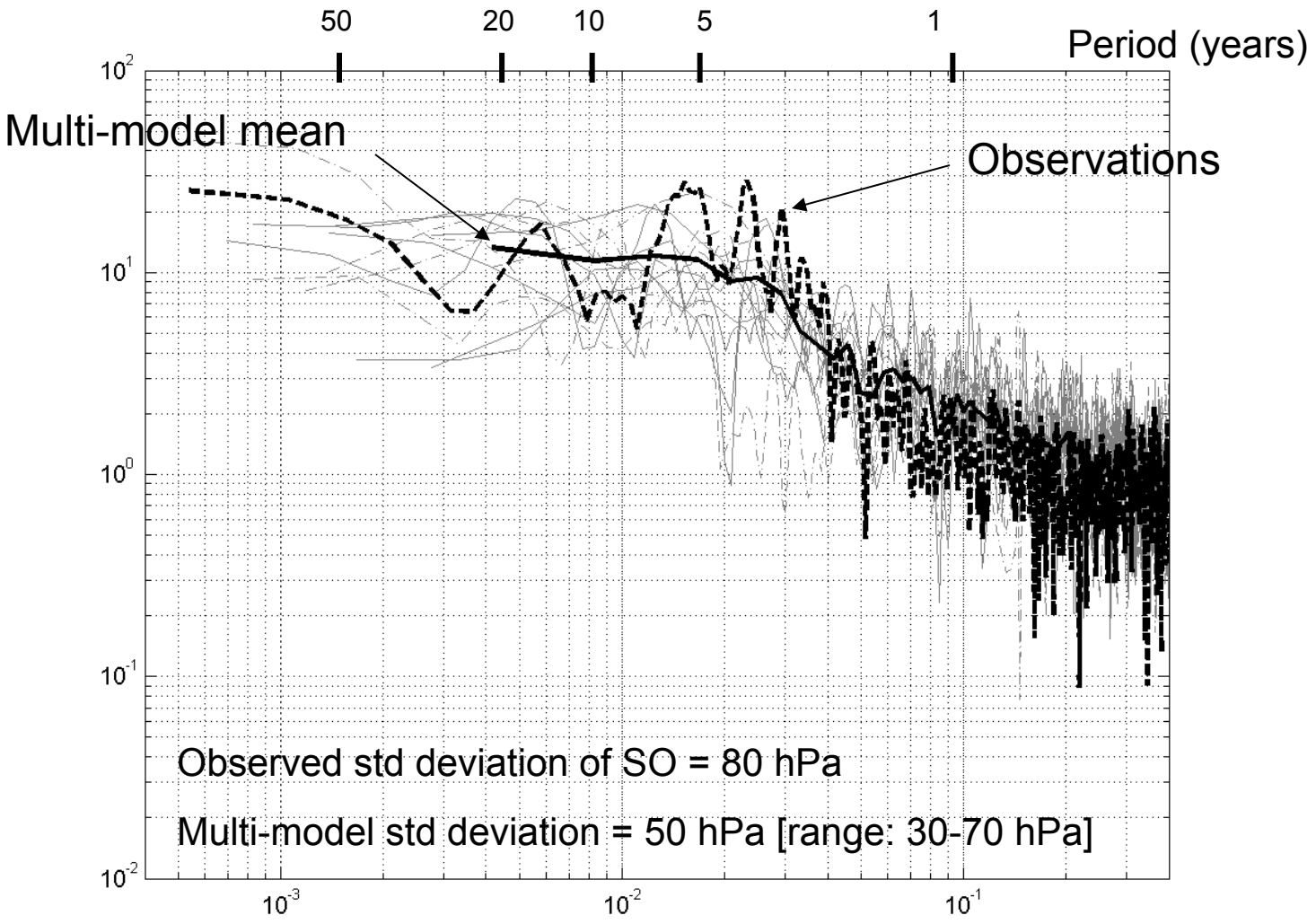
AGCM-slab multi-model mean (13 models) regression of SLP on Walker index

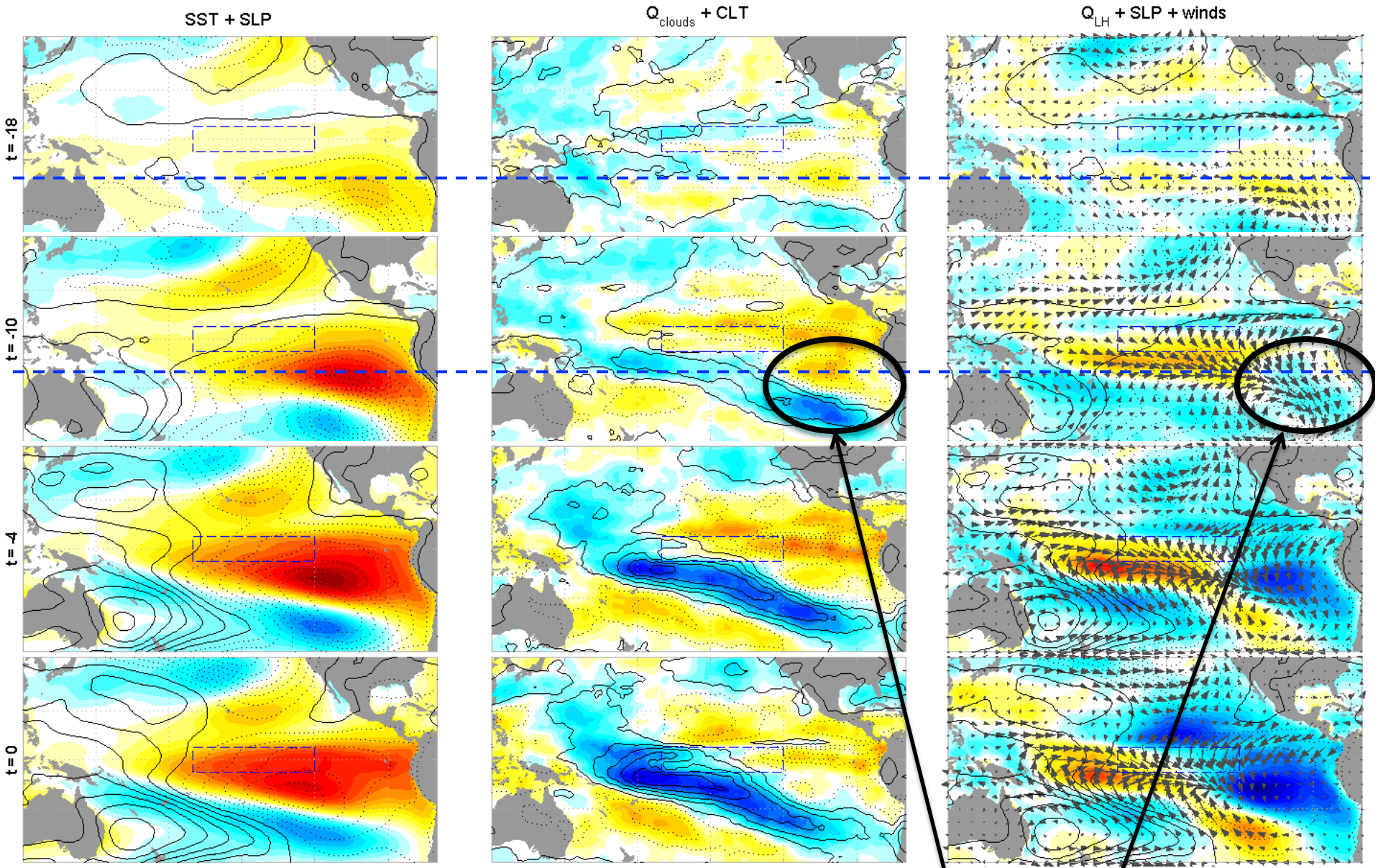


Observed regression of SLP on normalized Walker index



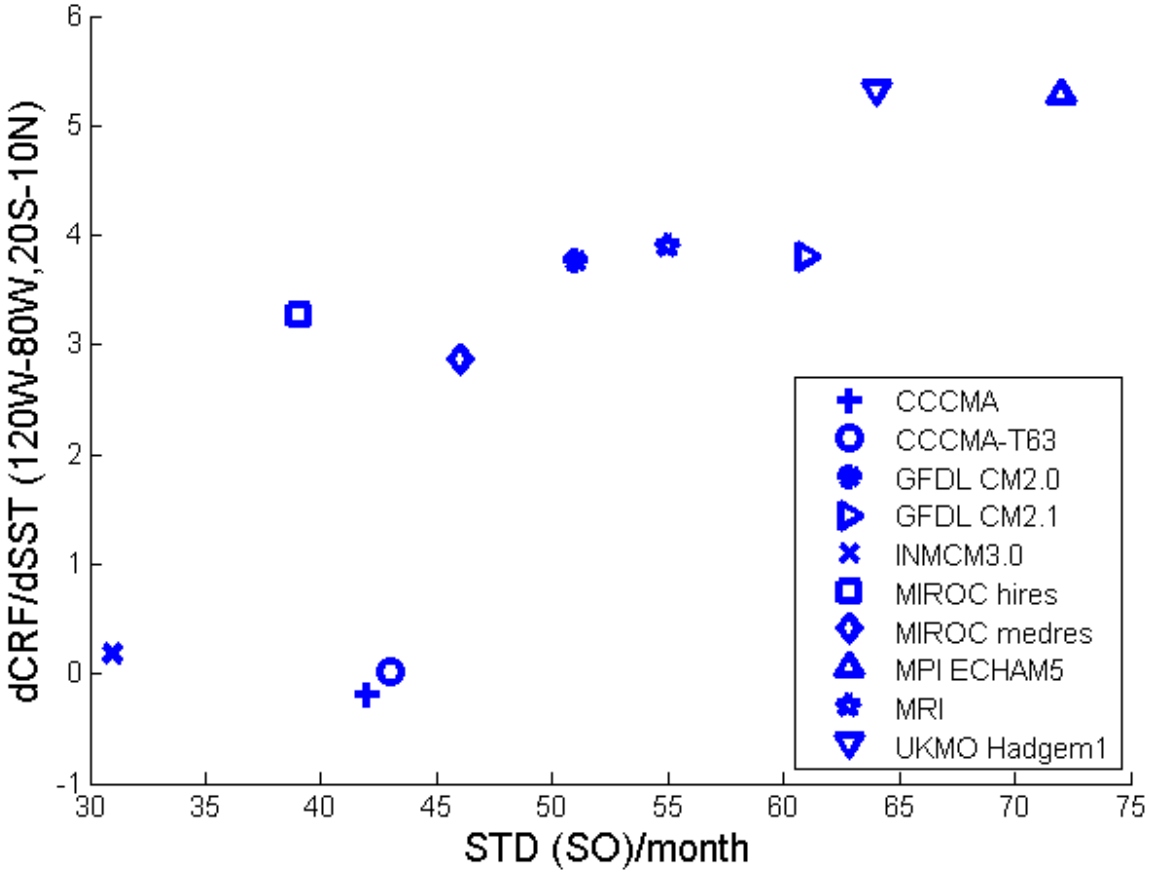
Walker index spectra from 13 AGCM-slab models





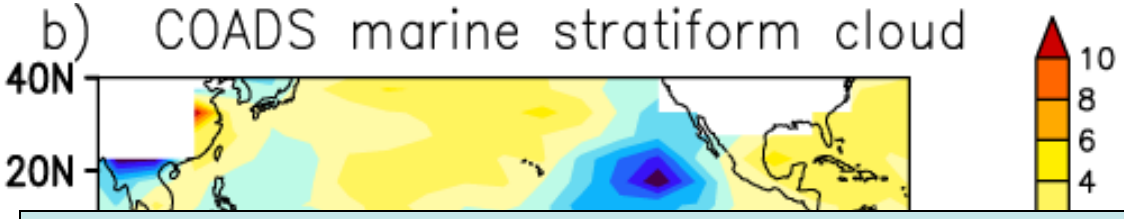
Latent heat flux damps SST, but clouds amplify so effective damping rate is small

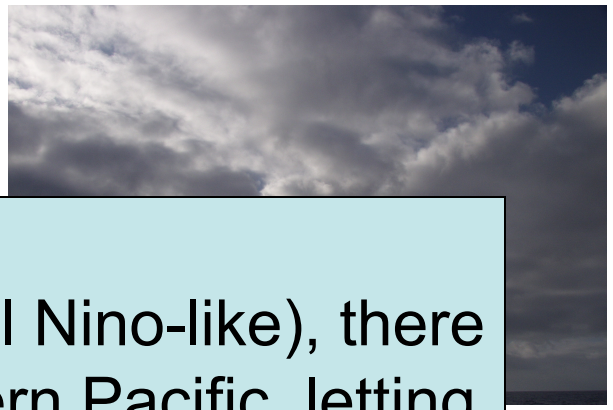
Models with strong cloud feedback have large SO variance



Zhang and Clement (*in prep*.)

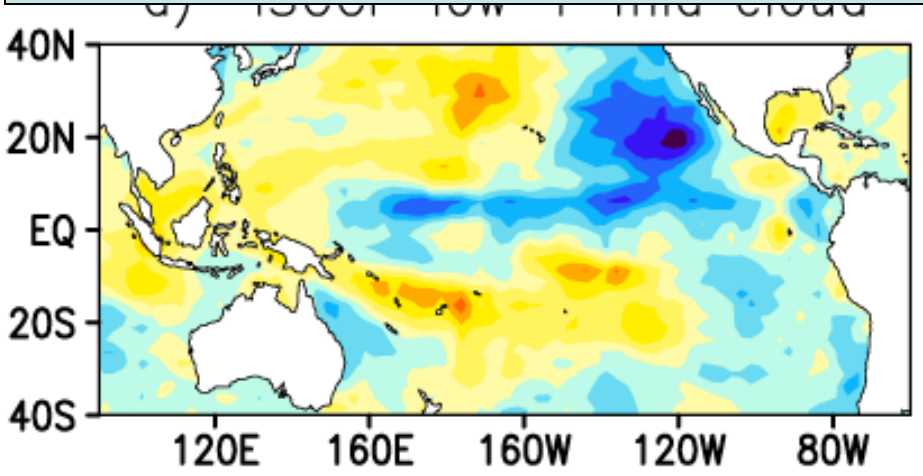
Observed decadal cloud changes that coincide with weaker Walker circulation

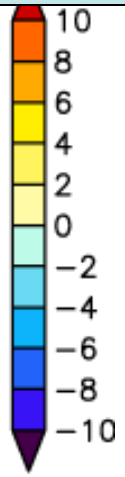




S. Yuter

When the Walker circulation is weak (El Nino-like), there is reduced low cloud cover in the eastern Pacific, letting in more sunlight and reinforcing the warming

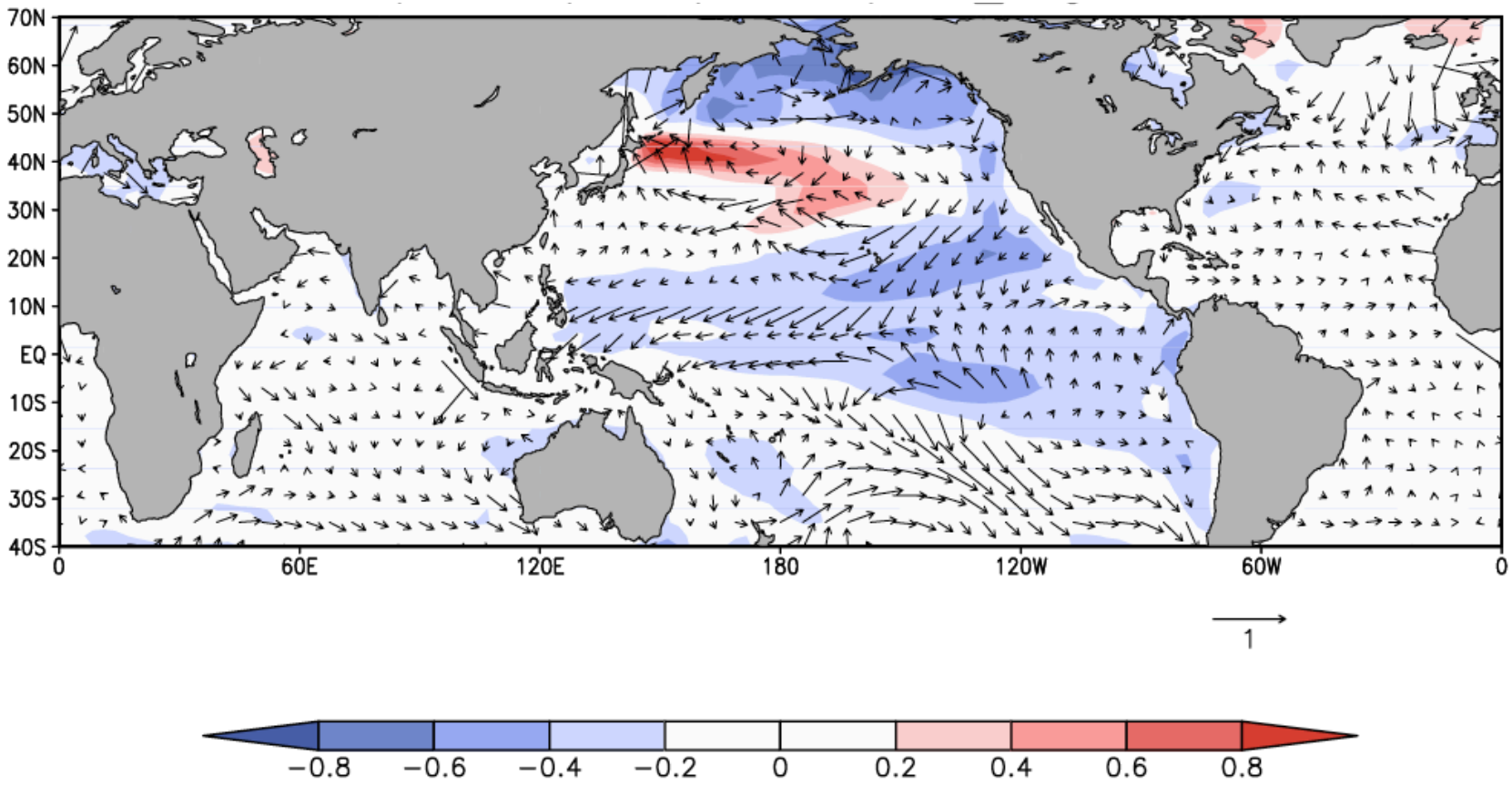




Clement, Burgman, Norris (2009)

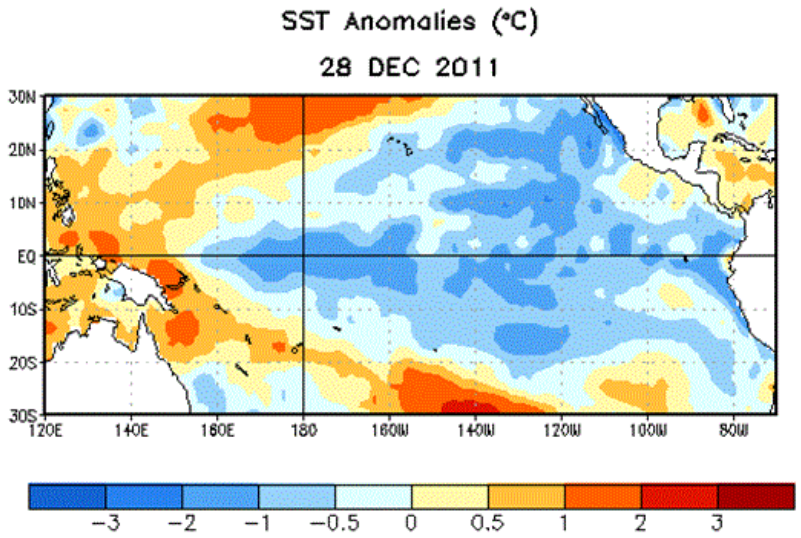
Low-level cloud forcing reinforces the pattern (i.e. causes it to persist)

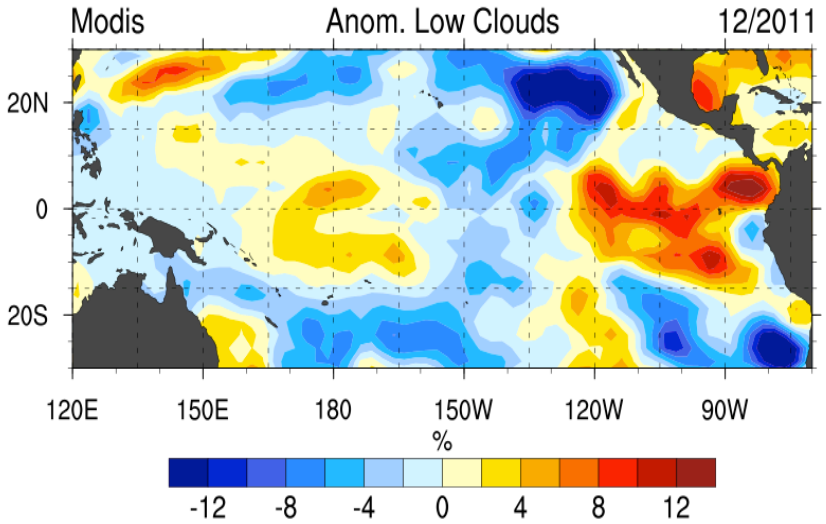
Coupled model response: SST (colors), SLP (contours), winds (vectors)



Burgman et al. (*in prep.)*

A developing warm event in the SE Pacific?





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Summary points

Realistic El Nino-like variability can arise on interannual to decadal timescales without coupled ocean dynamics.

Low-level clouds appear to play a role in the persistence of Pacific climate anomalies

Are climate models underestimating the persistence of Pacific climate anomalies and their associated impacts?