NSF funded project

Upwelling and regional response to embedding ROMS in CCSM3 at an eastern boundary

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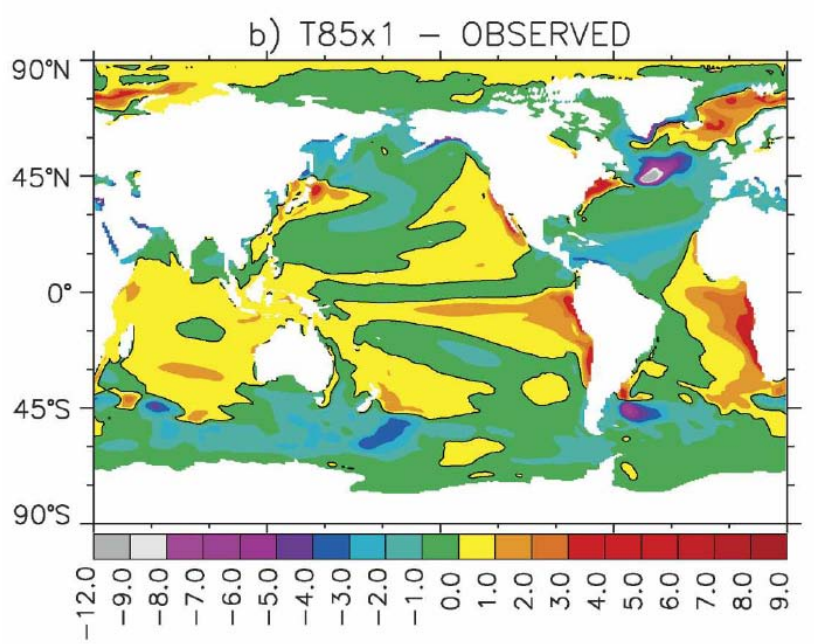
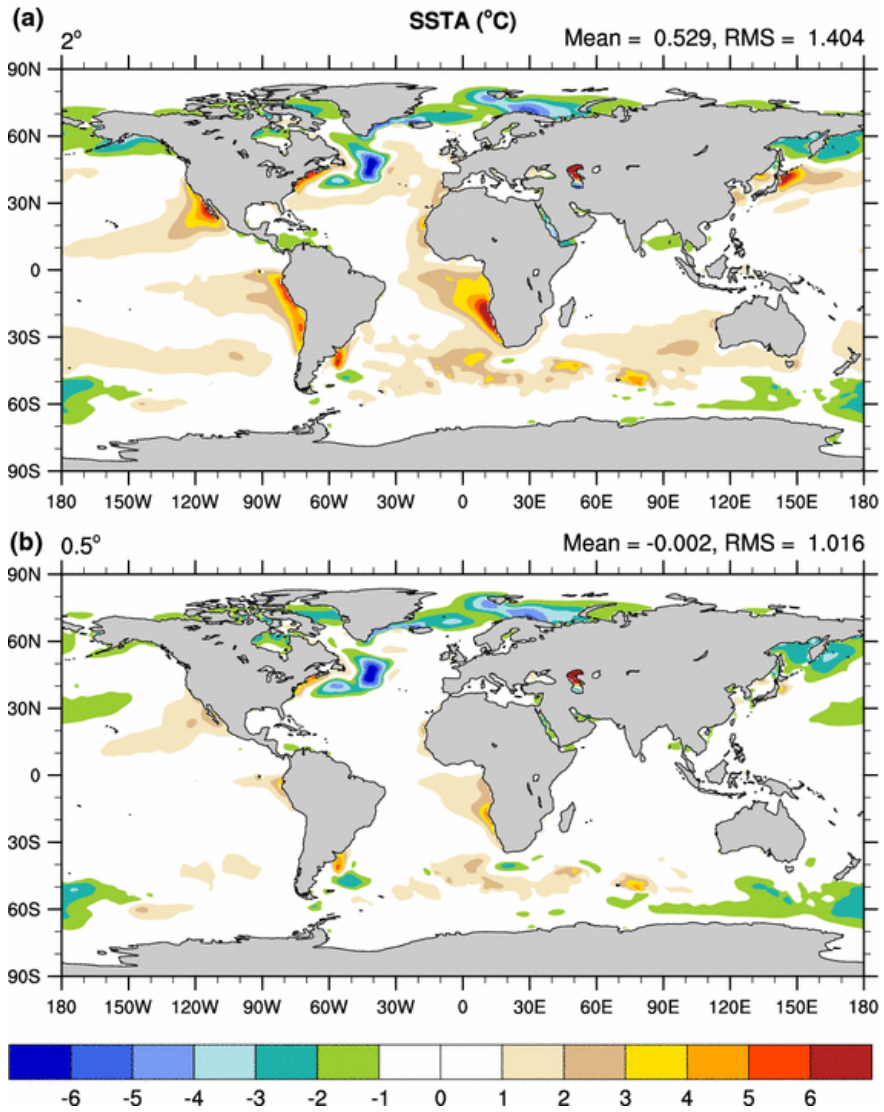
Thanks also to Frank Bryan, Zack Powell and others

Eastern boundary current biases in CCSM3



CCSM3.0 at T85_gx1v3 Resolution
Large and Danabasoglo 2006

Increasing atmospheric resolution fixes some but not all of the bias problem

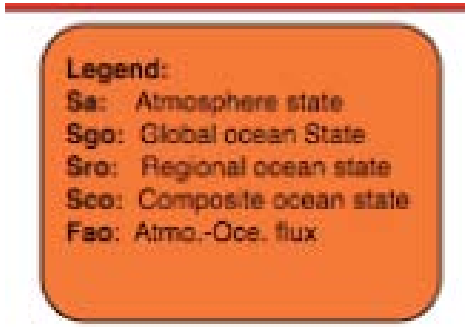


CCSM3.5 finite volume atmosphere (Gent et al. 2010)

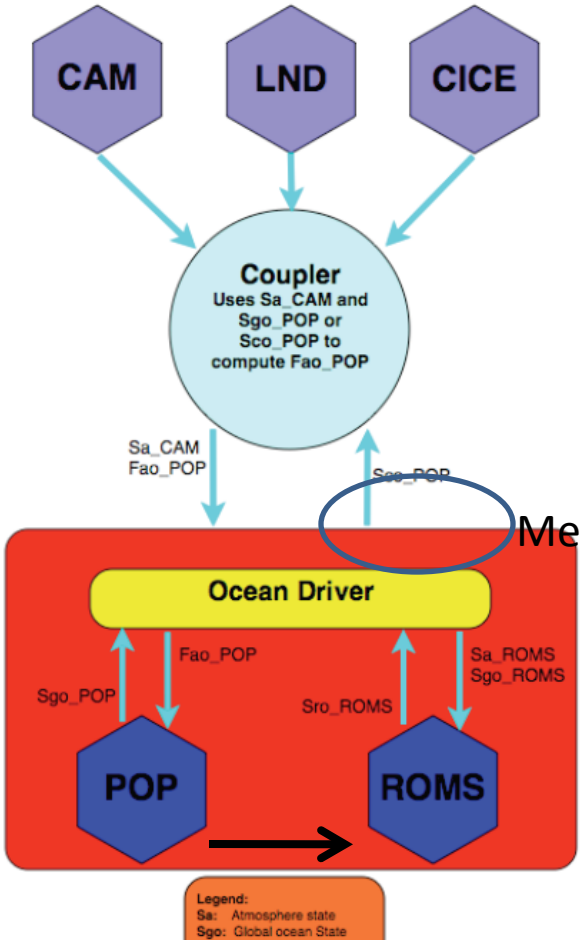
Complementary approach: What if ocean resolution is improved?

- Increase resolution at eastern boundaries to better resolve upwelling, coastal currents, and mesoscale fronts, eddies and filaments.
- As an interim step before unstructured grids, *(or as an alternative, Enrique pers. comm.)* use a **nested, regional** model
- Regional Oceanic Modeling System (ROMS: Shchepetkin and McWilliams 2005 etc.)
- Preliminary coupled simulation:
  - use one way nesting of ROMS within POP
  - merge ROMS SST with POP SST to pass to atmosphere via coupler

CCSM3-ROMS design



Over the ROMS domain ROMS and POP receive the same bulk fluxes, based on ROMS SST. This is a design limitation that affects the underlying POP and leads to a boundary condition problem (next)



One way boundary conditions Marchesiello et al. 2001.

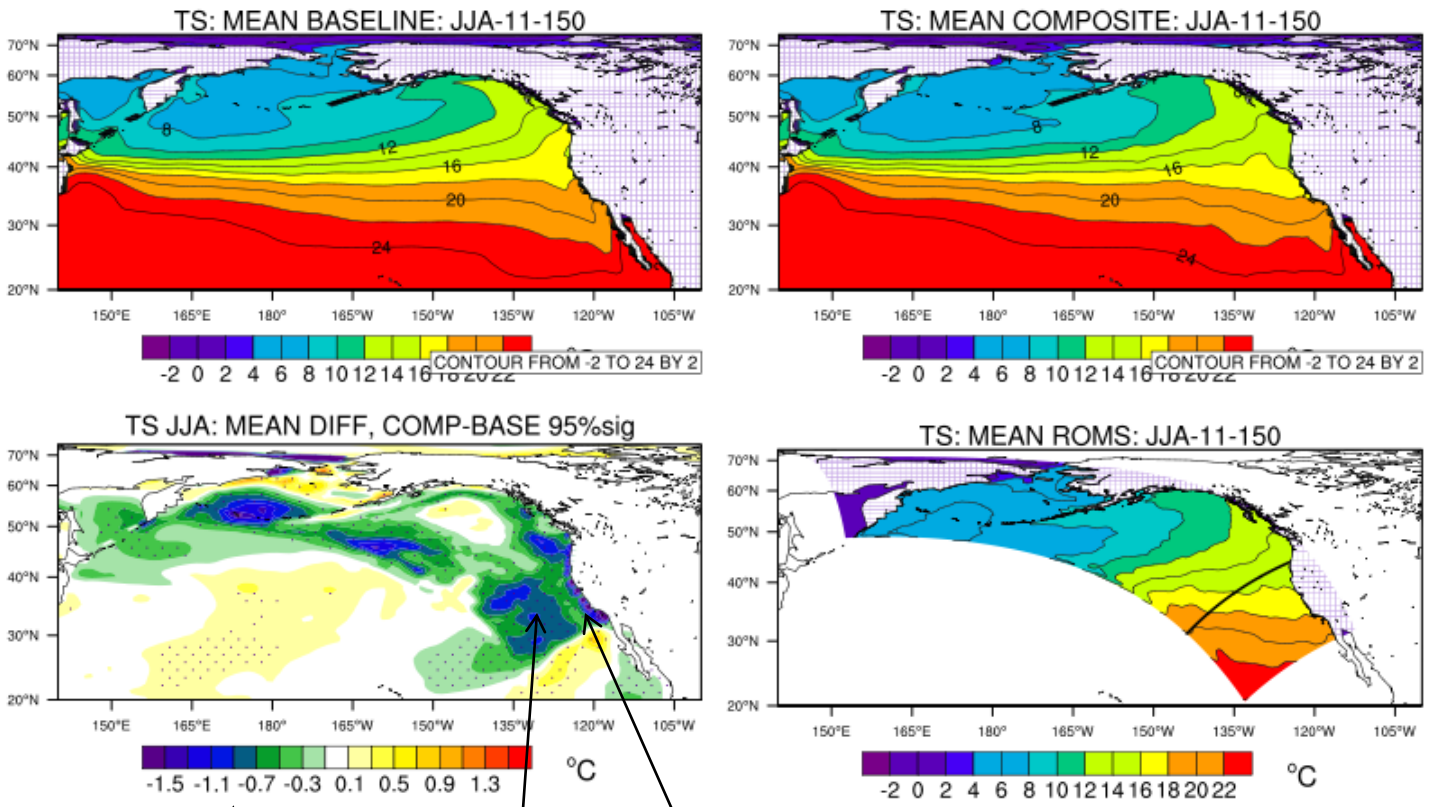
POP is only influenced by ROMS indirectly, via the atmosphere.

Figure 5. Schematic of the multi-scale CCSM. The original ocean module (POP) has been replaced by a composite POP/ROMS module that is controlled by a newly designed ocean driver. The Ocean driver passes fluxes and state variables to the respective oceans, controls the communications between the global and regional oceans (boundary conditions) and also assembles the output of the two oceans (e.g., SST's) that are then passed to the coupler for the computation of the fluxes to the atmosphere (CAM), Land (LND/CLM) and sea ice (CICE/CSIM) modules.

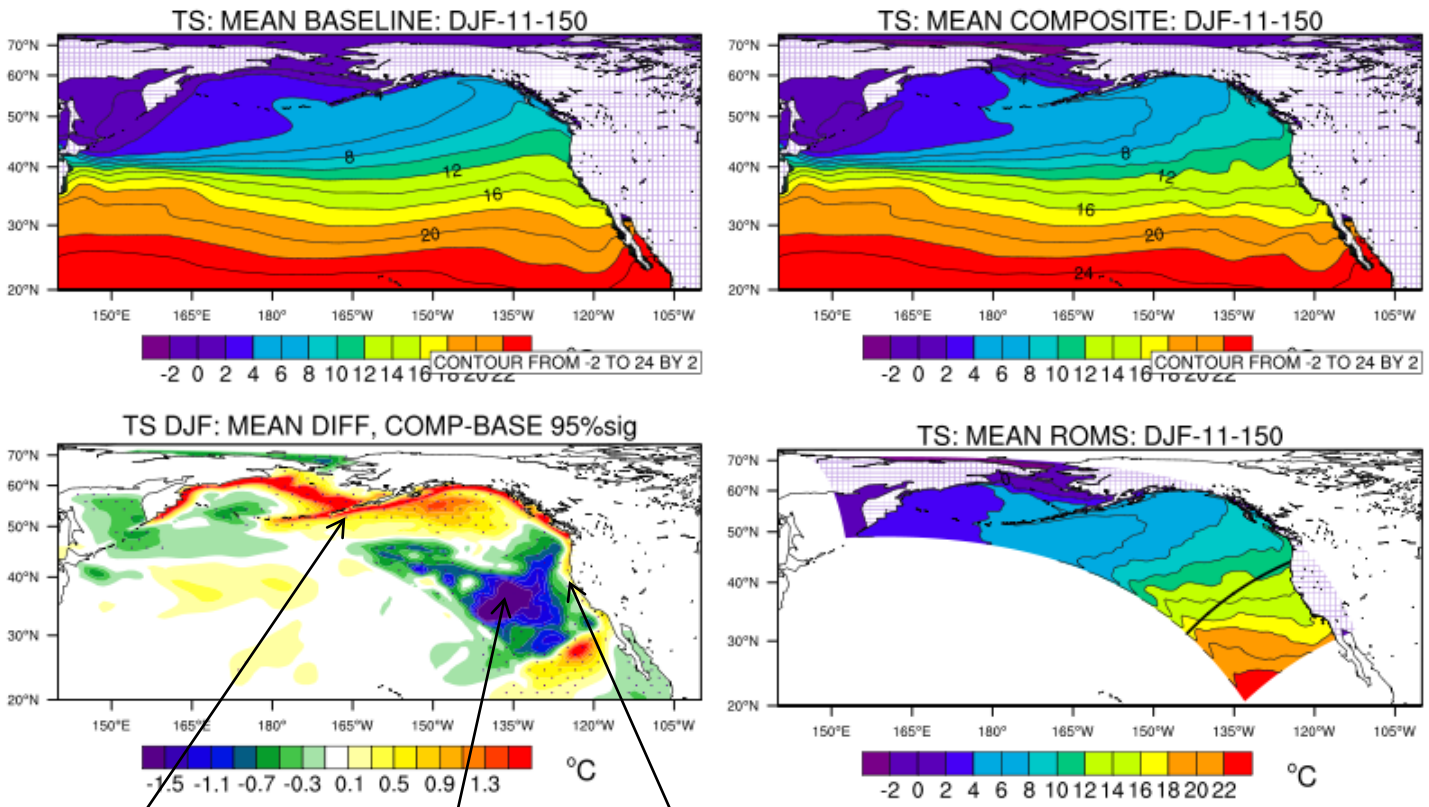
Experiments

- **Baseline**: 150 year run of CCSM3.1, T85, g1v4, branched from 1870 control run.
- **Composite**: 150 year run of CCSM3.1-ROMS, same initial conditions.
- Ocean
  - POP - ~1degree, 40 levels
  - ROMS ~10km, 42 stretched sigma levels
- Atmosphere CAM 3.3 – T85, 26 levels
- Land-CLM 3
- Sea ice-CSIM 5

North Pacific SST, **summer**



North Pacific SST, **winter**

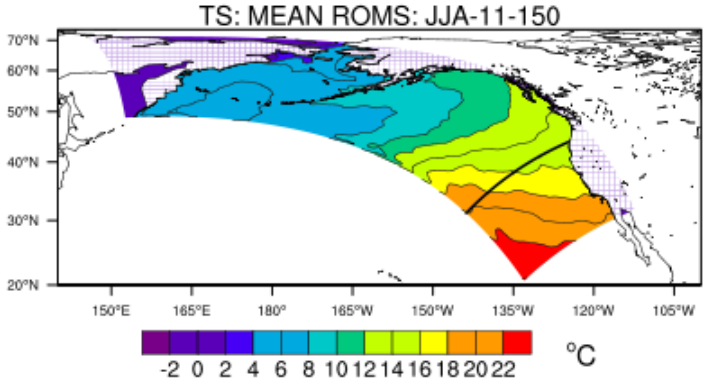


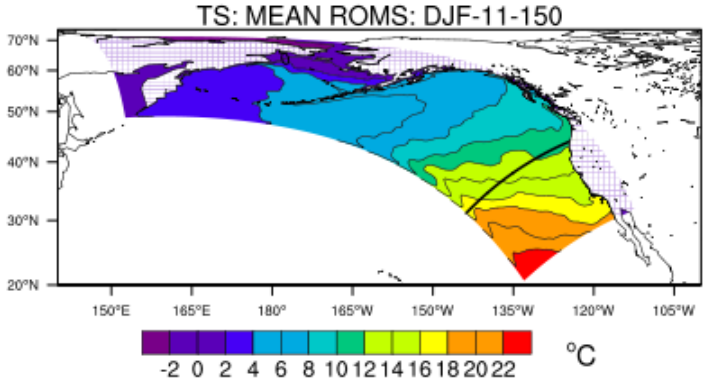
Warm coastal currents

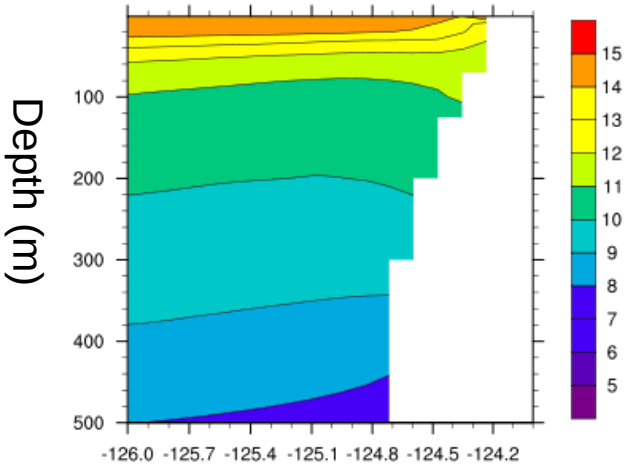
Offshore cooling persists

More coastal downwelling?

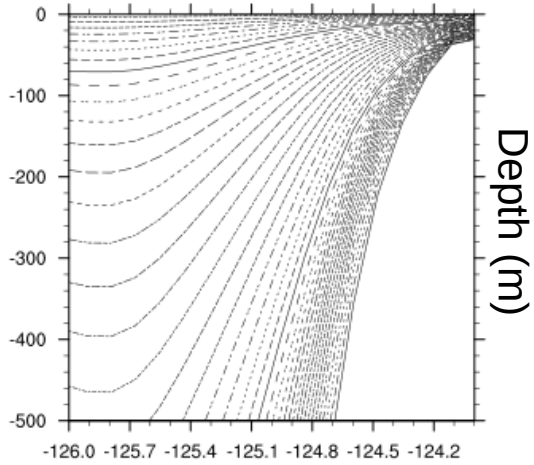
Upwelling vertical sections -ROMS

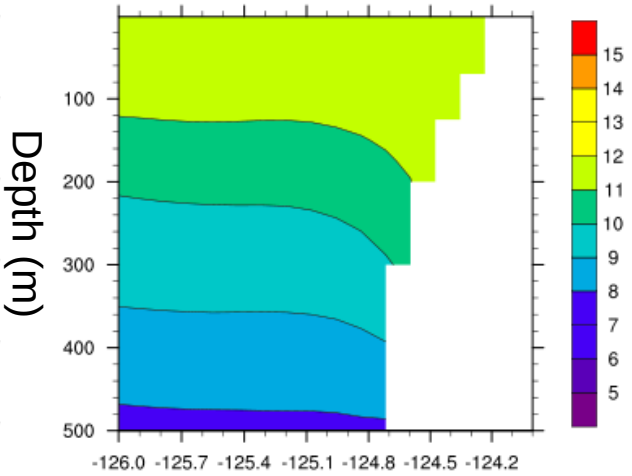






SUMMER

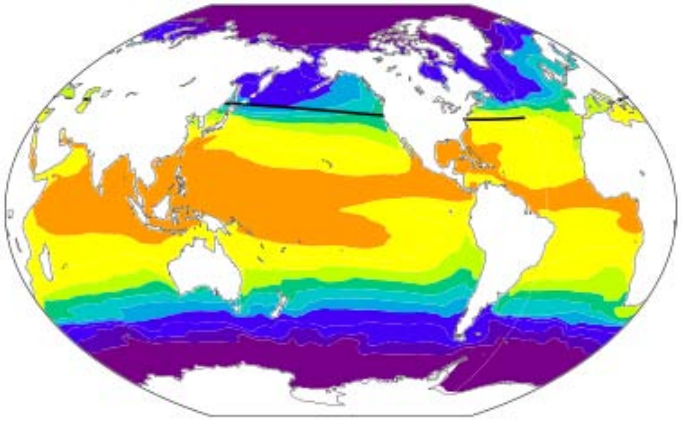




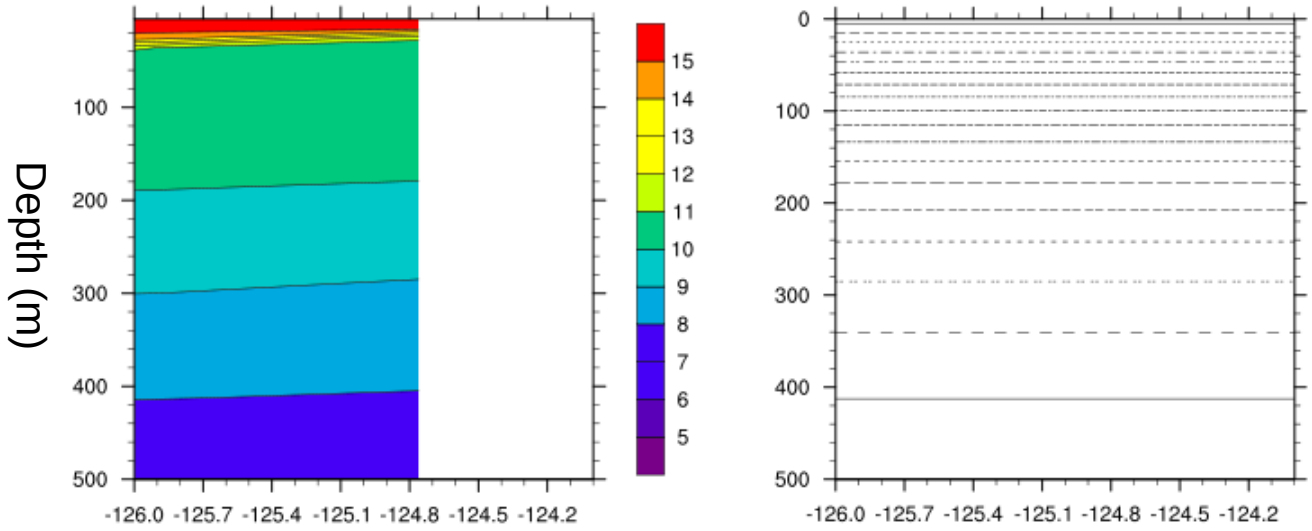
WINTER

Upwelling vertical sections -POP

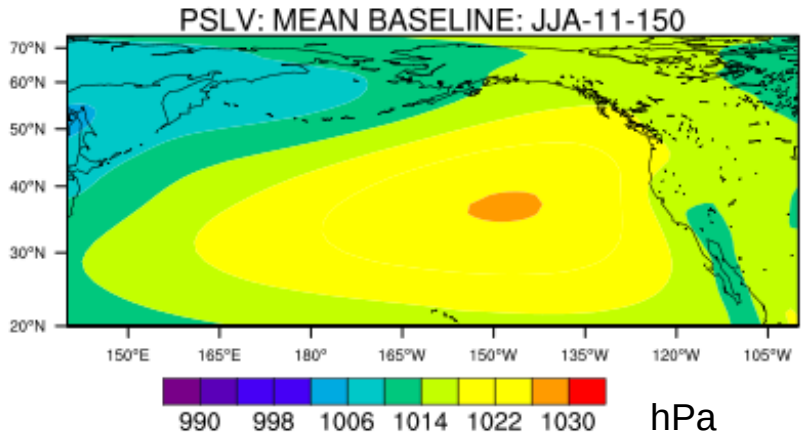
Summer JJA

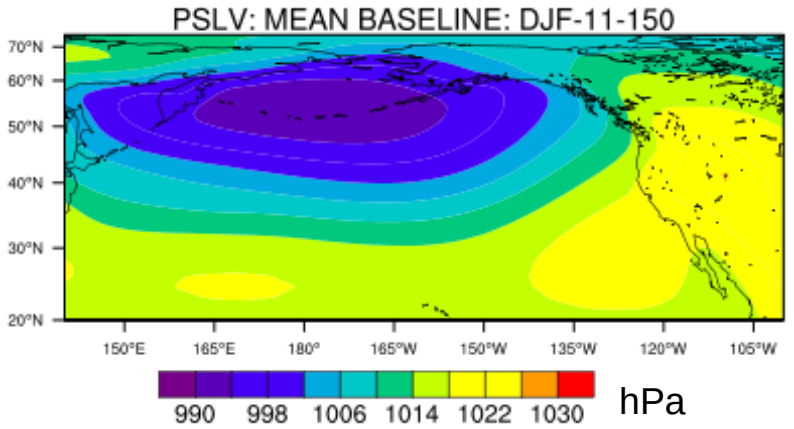


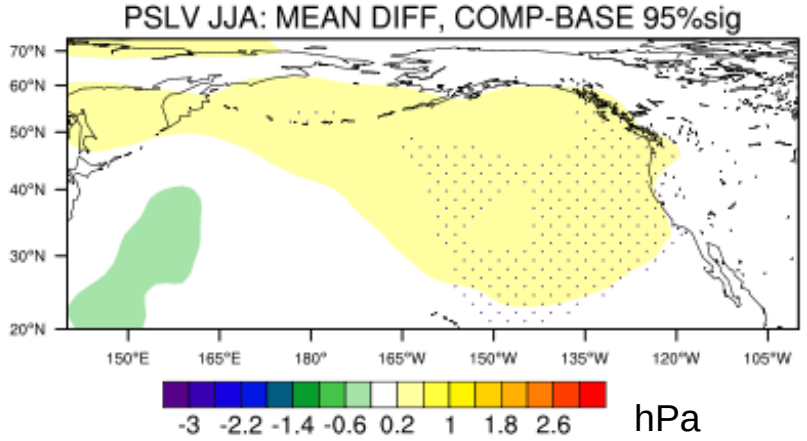
Caution – based on just a few years model data.

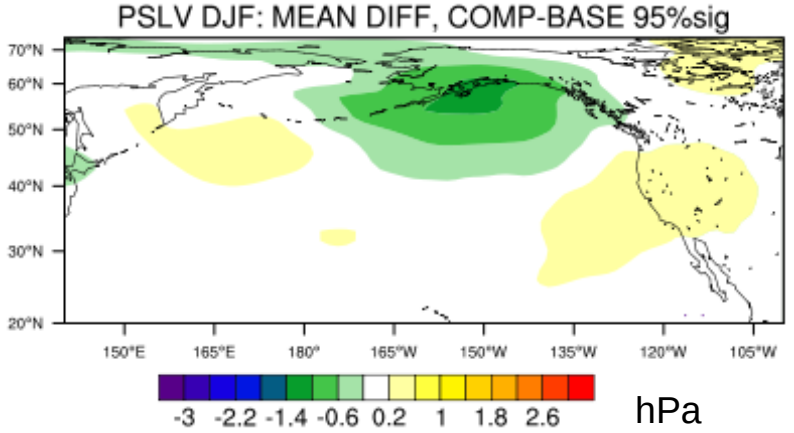


Sea level pressure and difference





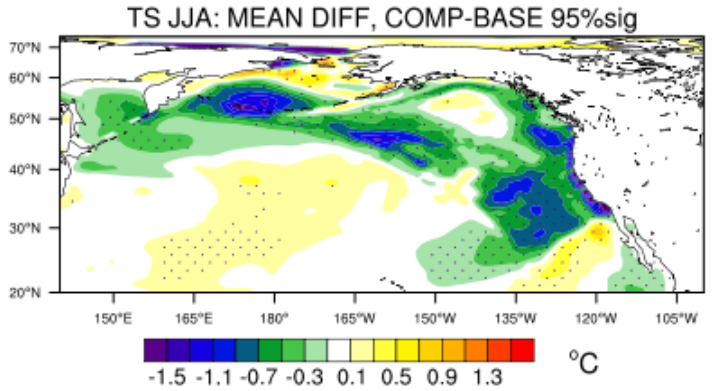


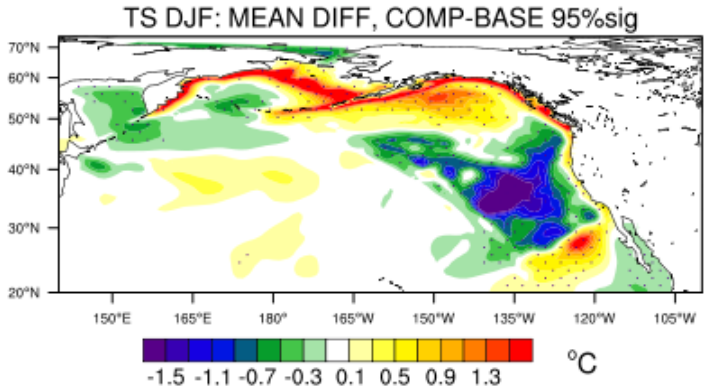


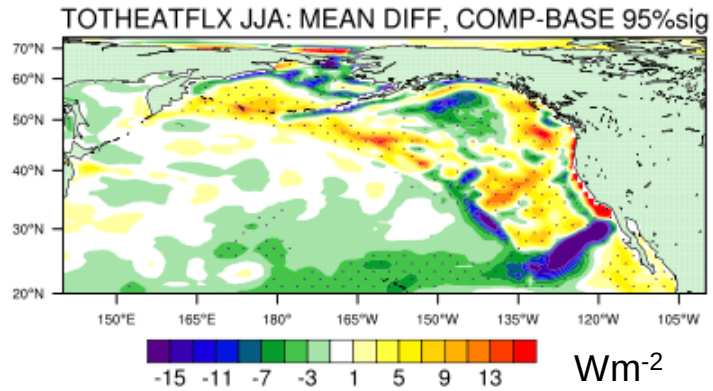
SUMMER –statistically significant enhancement of seasonal high

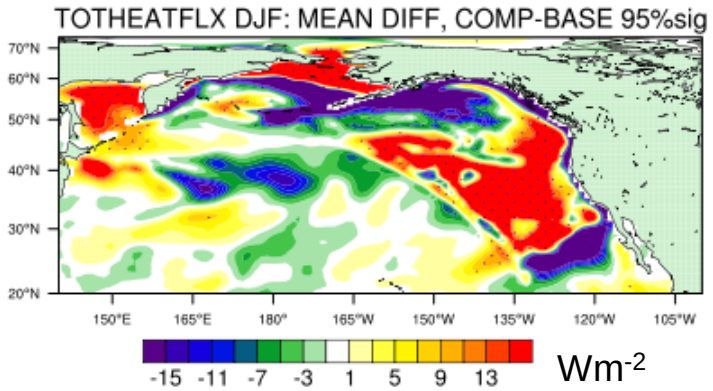
WINTER–low pressure enhanced in Gulf of Alaska, but not statistically significant

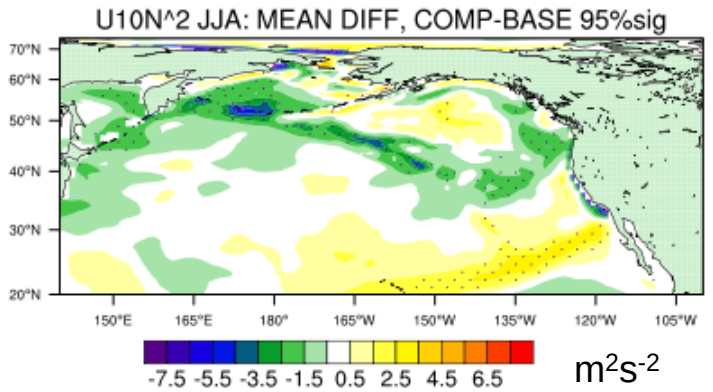
Changes in wind stress (+heat flux)

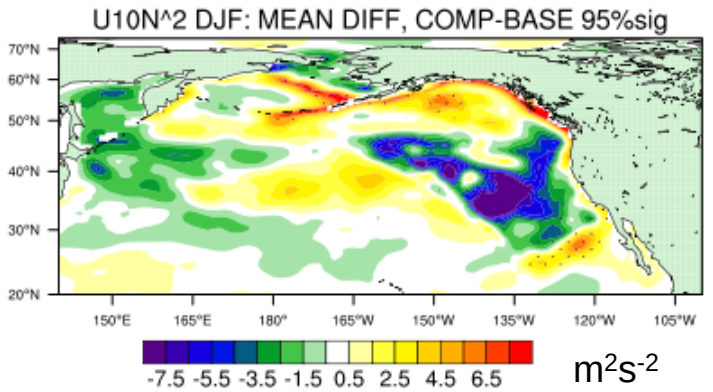






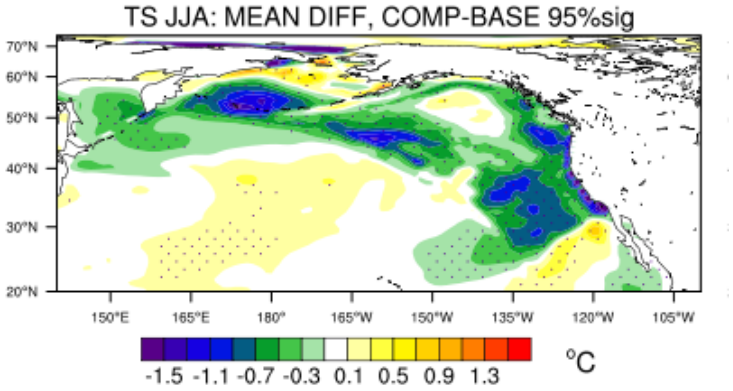


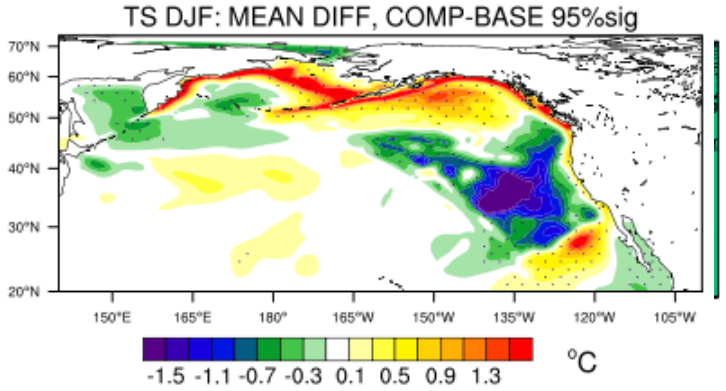


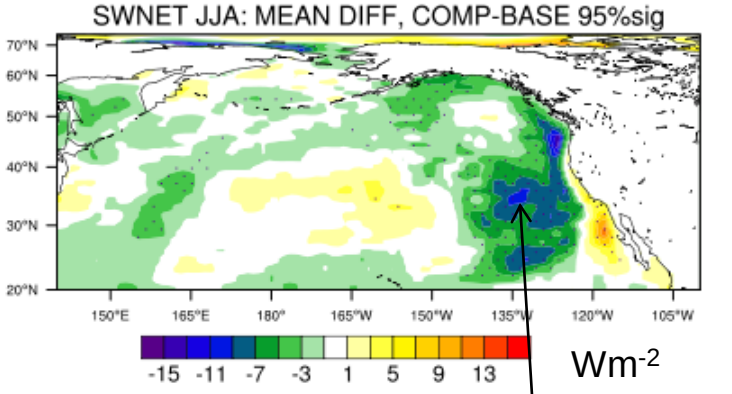


SUMMER **WINTER**

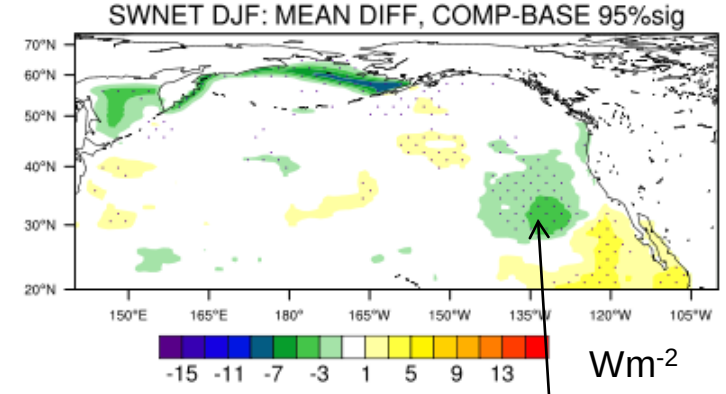
Net shortwave flux (any increase of stratus clouds when SST cools?)





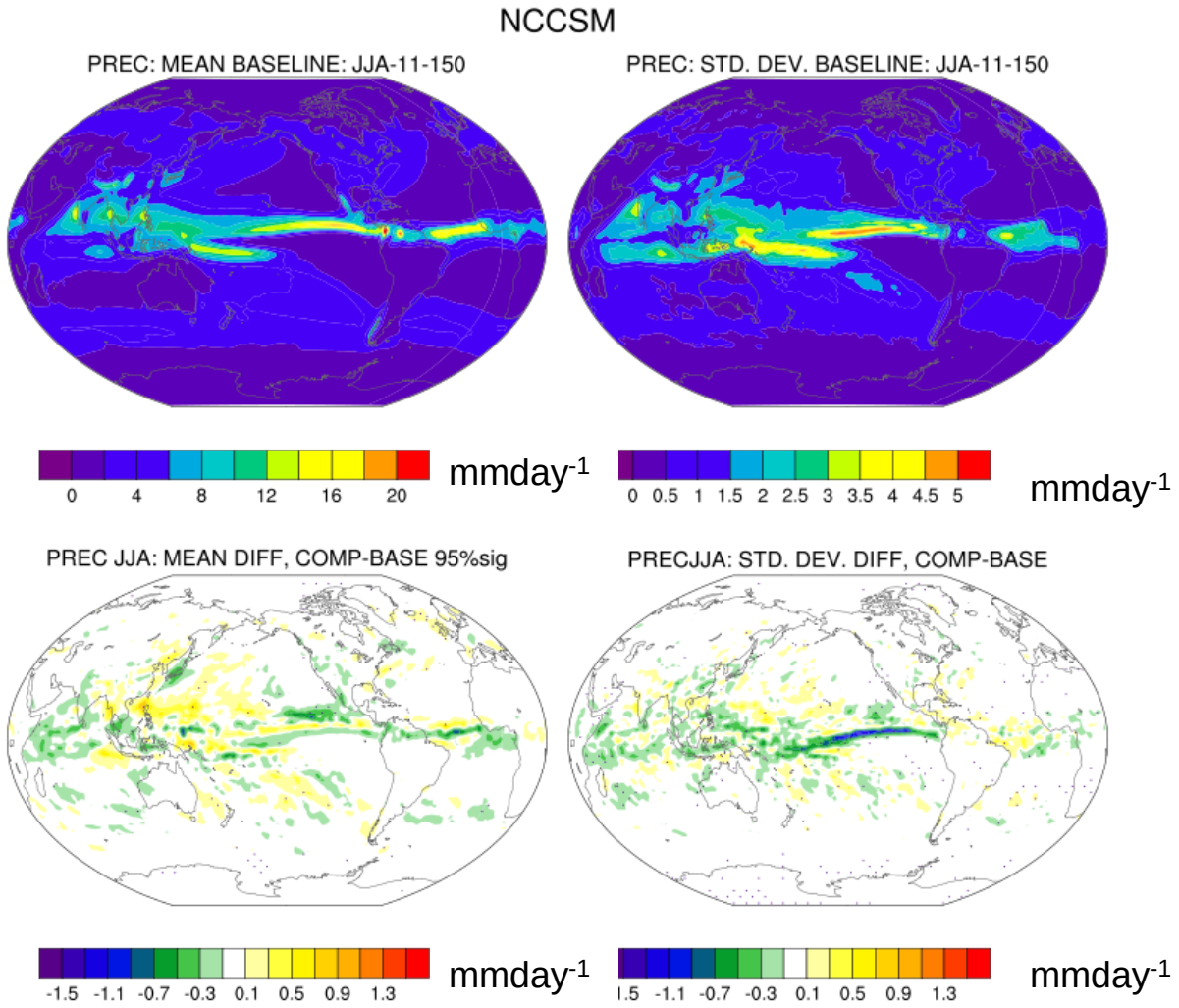


SUMMER

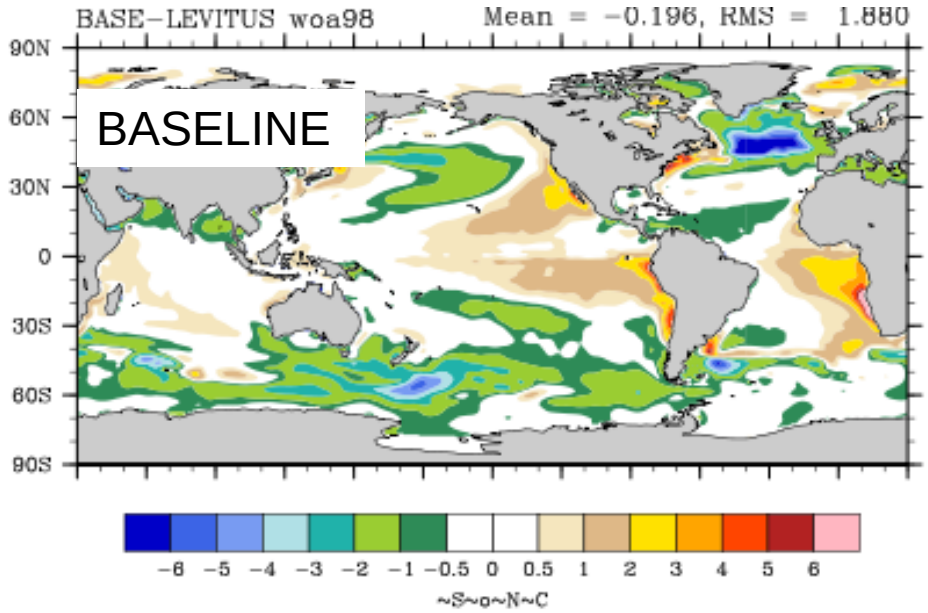


WINTER

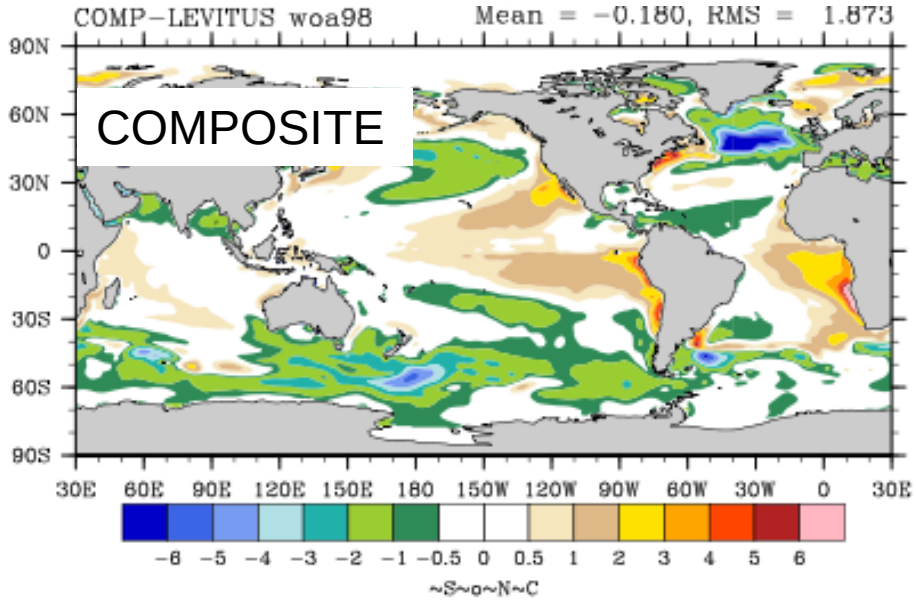
Remote influence
Global maps of Precipitation,



The moment you've all been waiting for…



BASELINE

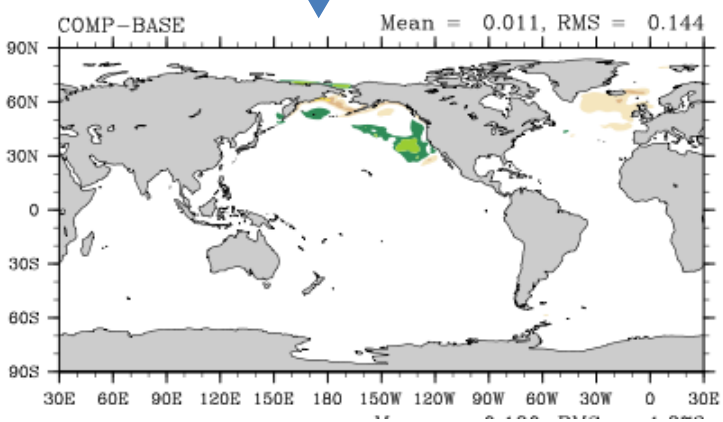


COMPOSITE

Annual averages of SST, comparison vs Levitus WOA98.

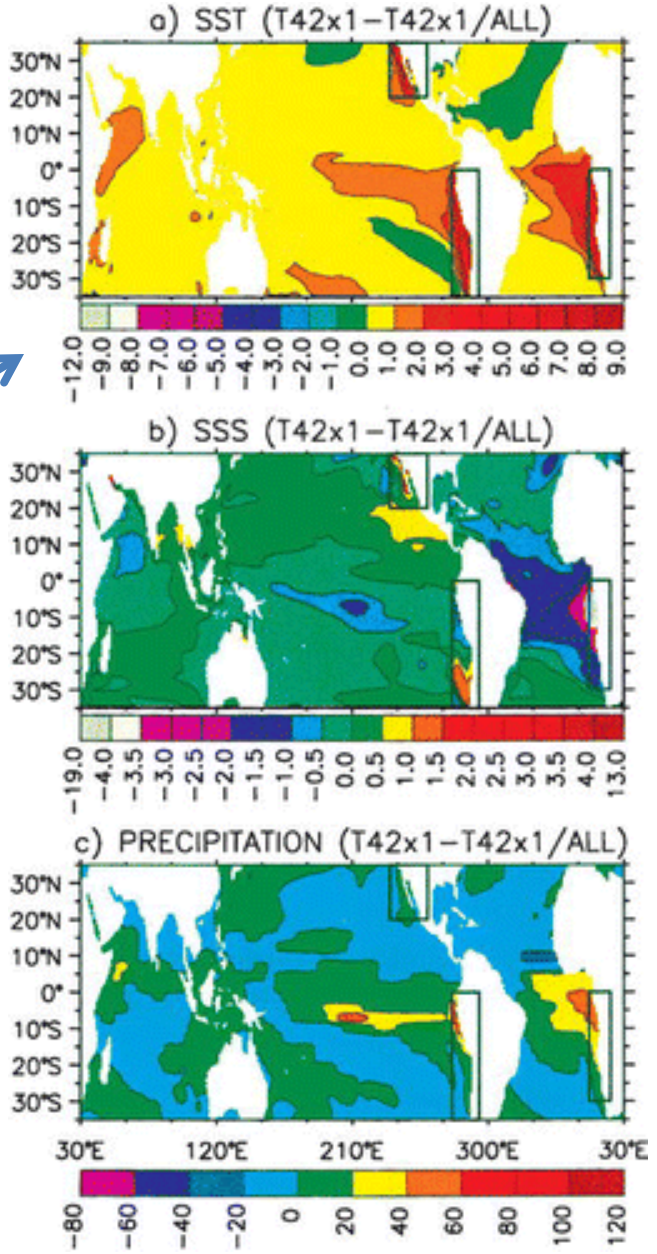
Improvement is spatially limited, partly because of boundary condition

Composite – baseline SST



Way ahead

- Move to CCSM4 (CESM?)
- Test 2-way ocean boundary conditions and/or restoring techniques
- Look at other eastern boundary regions
- *and western boundary (new NSF grant for Enrique et al)*
- Add bio-geochemistry and couple between ROMS and POP



Large and Danabasoglu 1996