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Coupled simulations: Towards CCSM4

Rich Neale

with many thanks
Mariana Vertenstein, Mat Rothstein, Andy Mai, Tony Craig, Jon Wolfe and Cecile Hannay

Community Climate System Model

Development Aims

- Couple frequently to avoid surprises
- Perform present-day integrations sufficient to assess ENSO (20 years)
- Equal or improve on CCSM3.5
  - SST errors
  - El Nino (period, amplitude, correlation patterns)
  - Sea-ice thickness and extent
  - Southern ocean surface wind stress

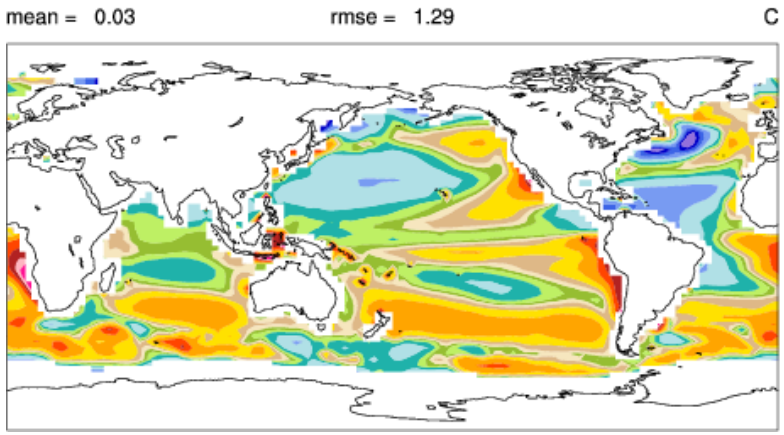
Candidate configurations

- Track II/IIb (‘fall back’)
  - CAM3.6 (CAM3.5+MG microphysics)
  - Prognostic BAM aerosols
  - Indirect effect
- Track V (all the new physics)
  - CAM3.5 +
  - MG microphysics
  - UW PBL+Sh. Conv.
  - RRTM radiation
  - MAM 3-mode prognostic aerosols
  - Indirect effect
- Both have modern surface components (ocean, land, ice, coupler)
- Contrast with ->
  - CCSM3.5 (CCSM3 + Neale-Richter Convection changes + freeze-drying)
  - CCSM3
  - No indirect effect

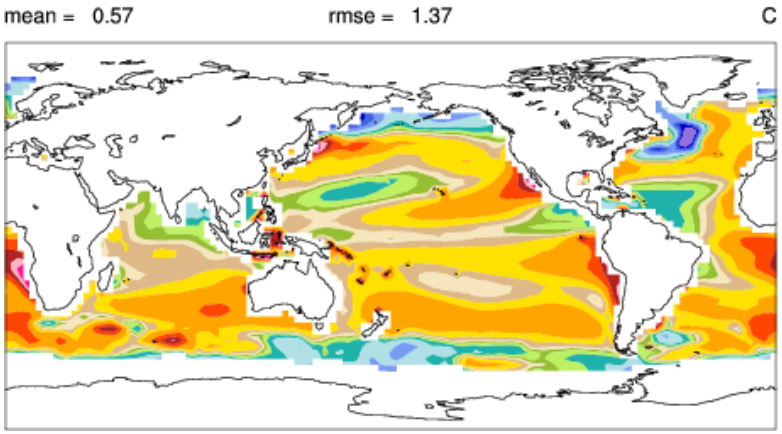
Starting Point

CCSM3/CCSM3.5 (finite volume 1.9x2.5)

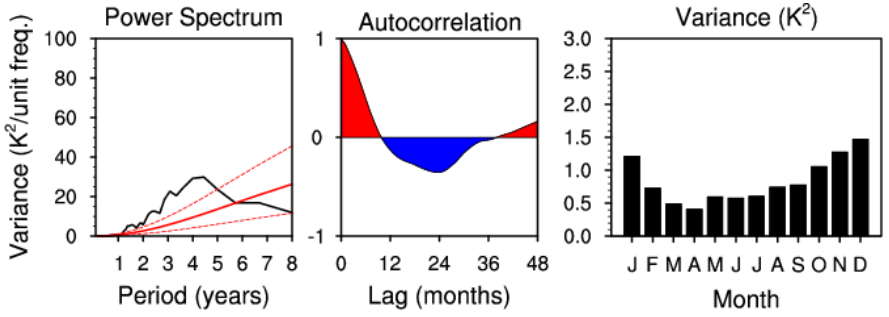
CCSM3



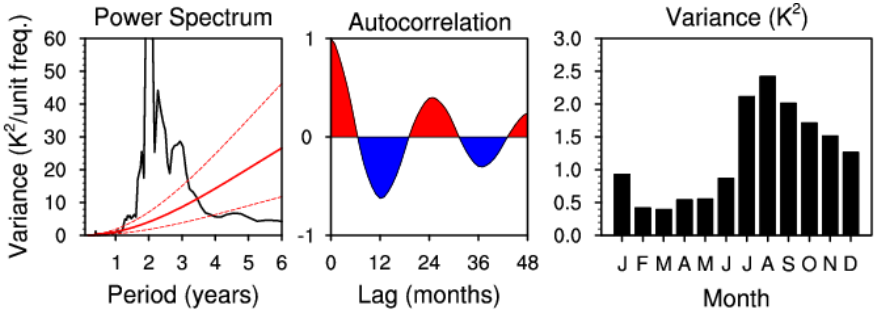
CCSM3.5



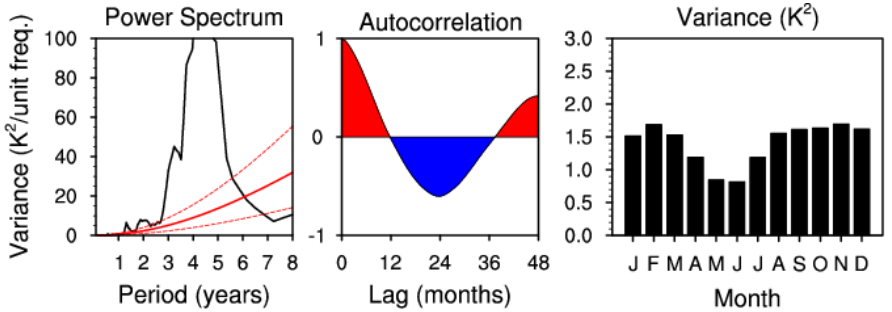
HadISST Nino3 SSTA (1966-2005)



CCSM3



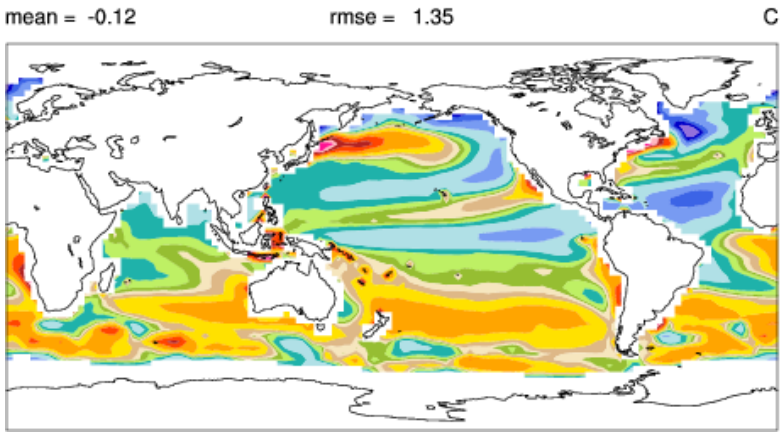
CCSM3.5



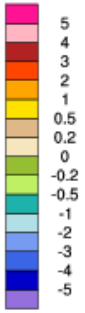
SST error

Track II largely untuned – Track V large sensitivities due to UW PBL

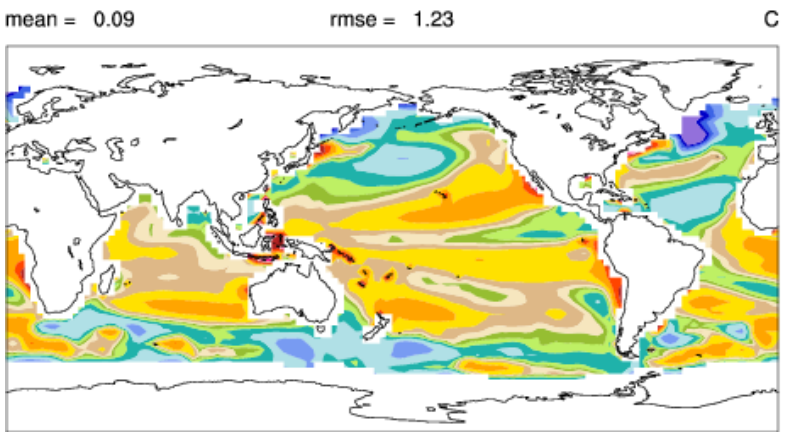
Track II



Min = -6.57 Max = 12.32



Track V



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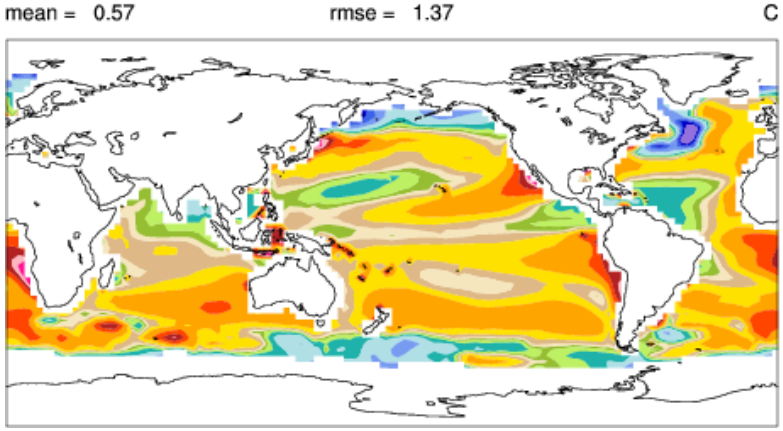
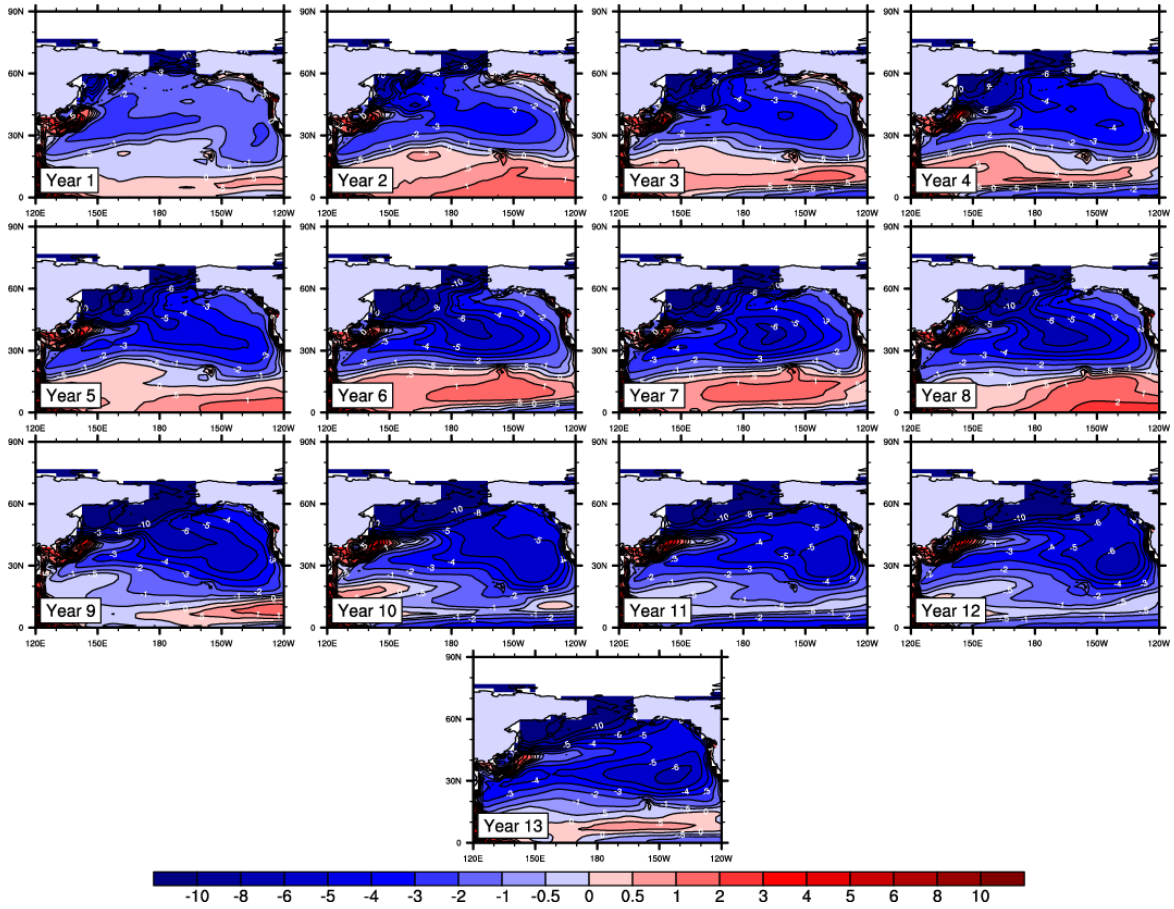


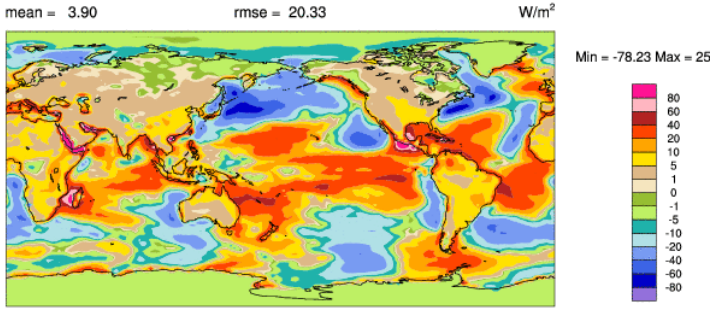
UW PBL coupling challenges

Boundary layer cloud responds to SST (cooling of > -5K)

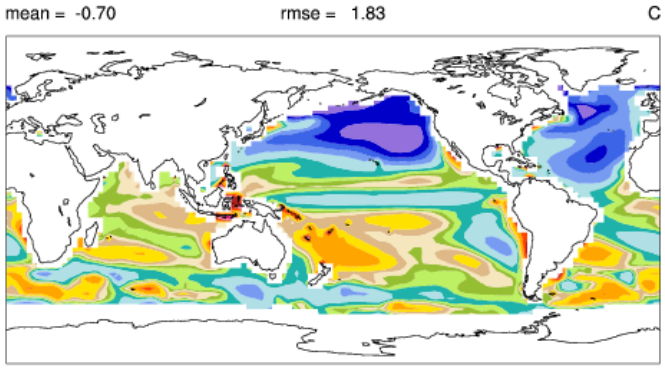
SST errors (K)



RESSURF difference from cam3.5



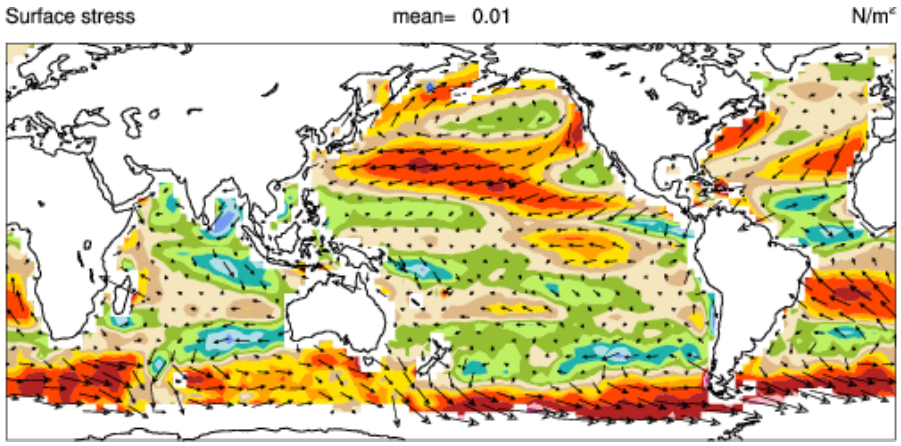
Mean SST errors (K)



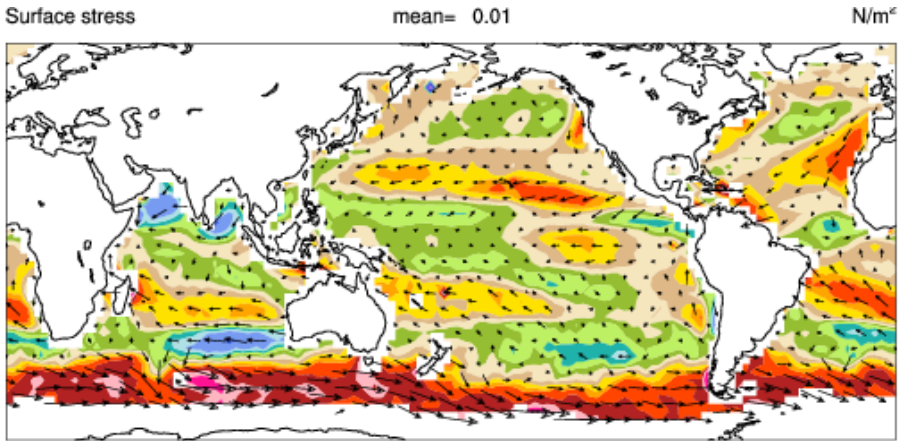
Surface Stress Error

Southern ocean errors remain

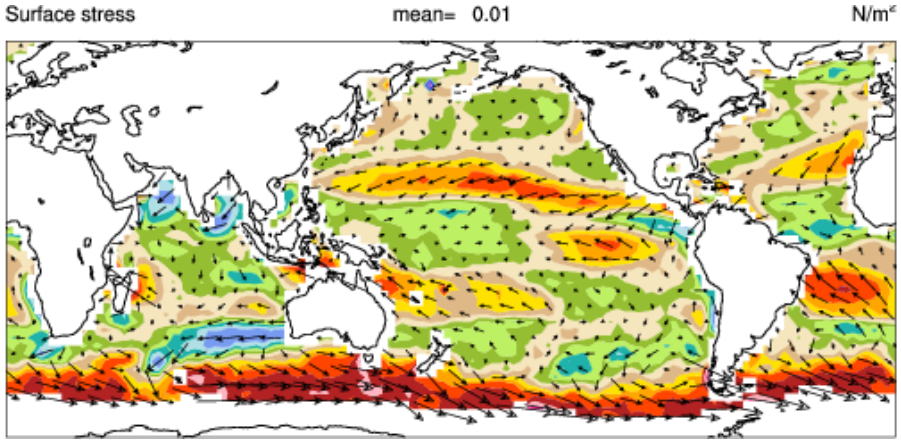
Track II

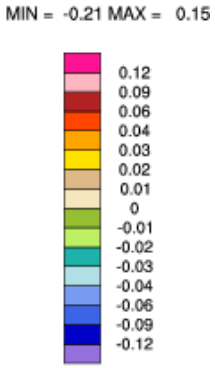


Track V



CCSM3.5



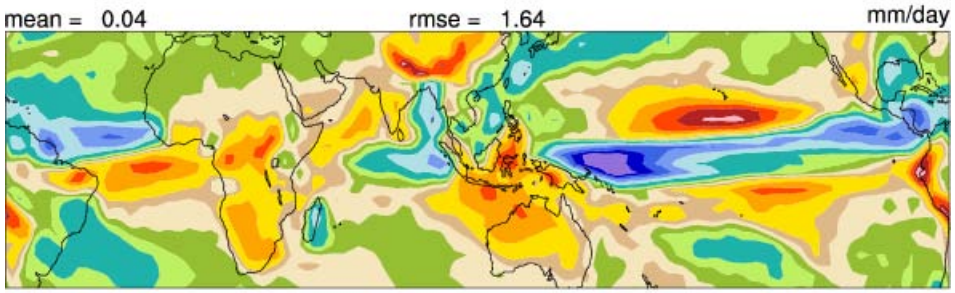


ERS

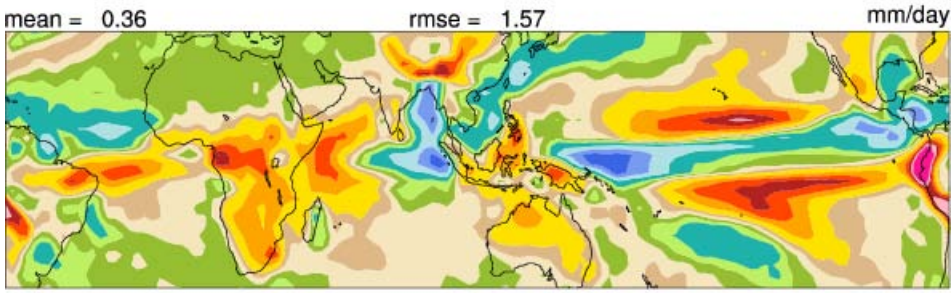
Rainfall Error

Track II poorer Pacific rainfall – Track V poorer land rainfall

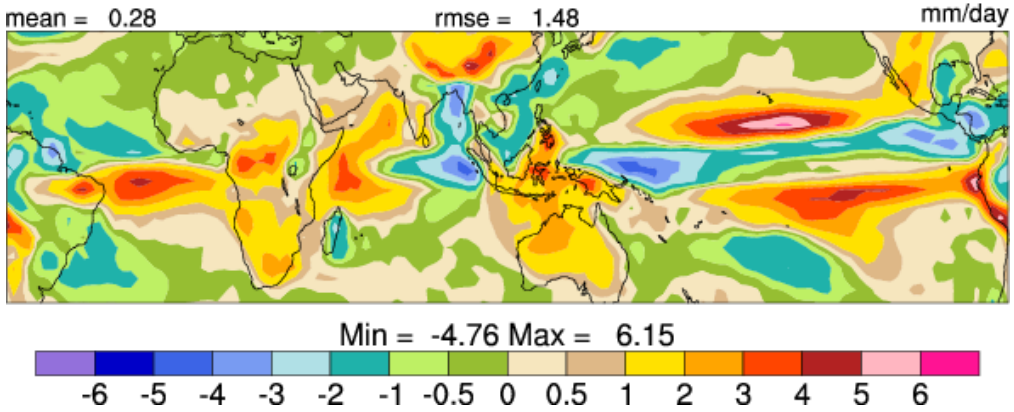
Track II



Track V



CCSM3.5

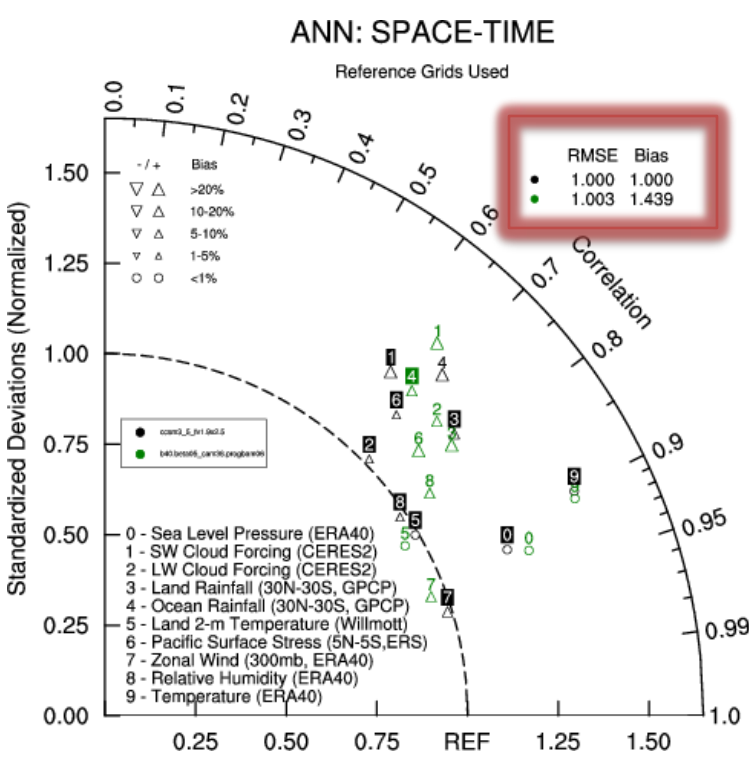


CMAP

Metrics

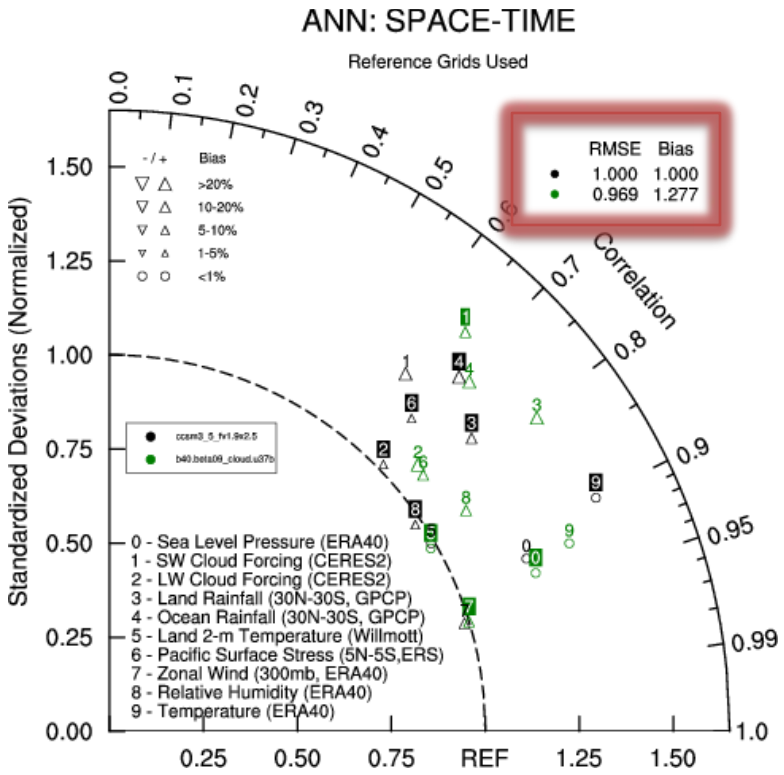
Competitive with CCSM3.5

Track II



2. LW cloud forcing
4. Ocean rainfall

Track V

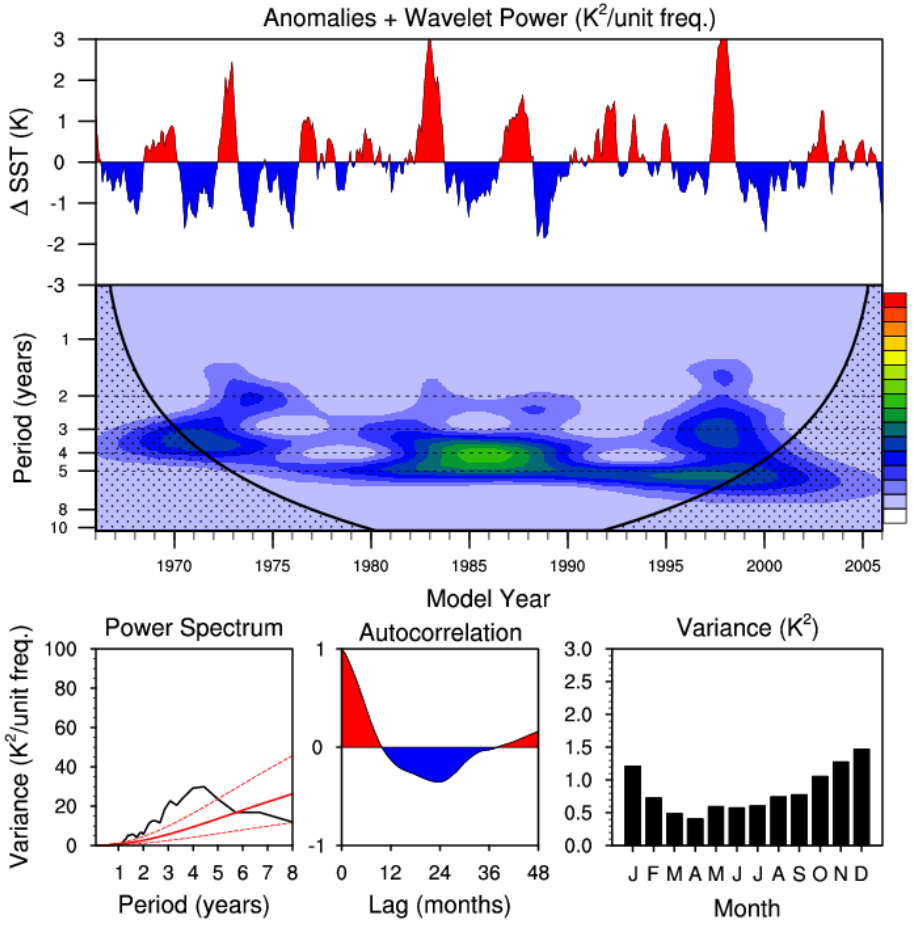


1. SW cloud forcing
3. Land rainfall

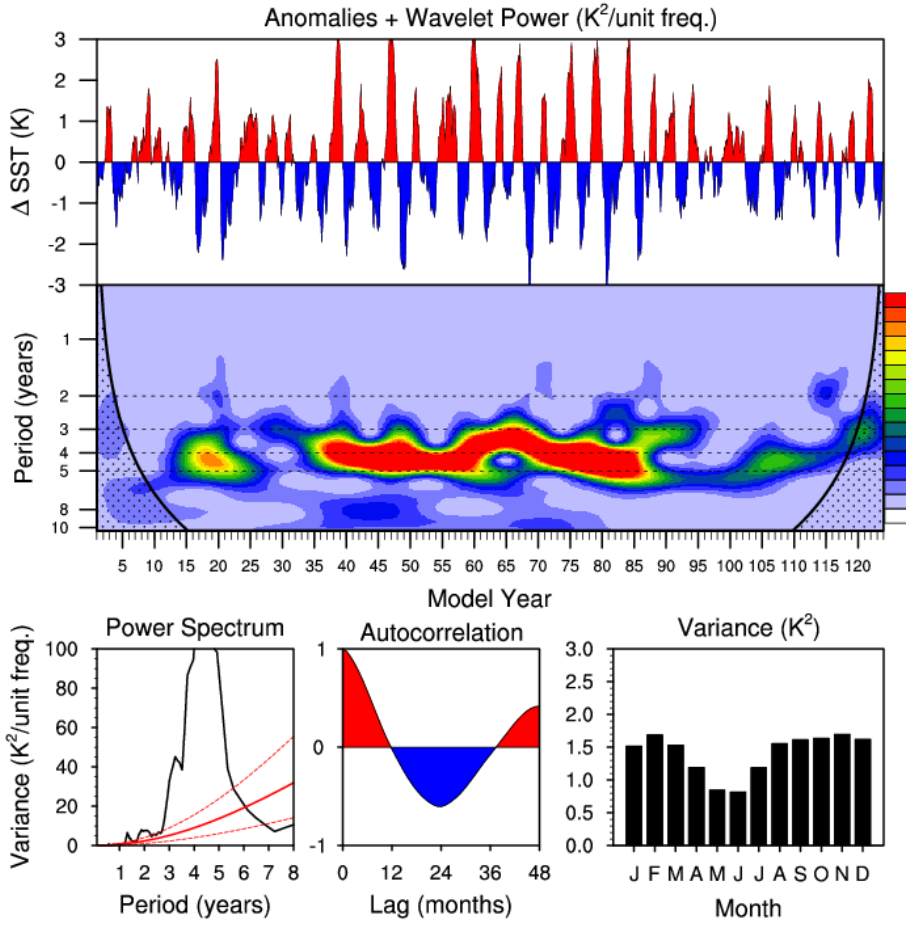
El Nino

Significant improvements in period

Obs. (1966-2005)



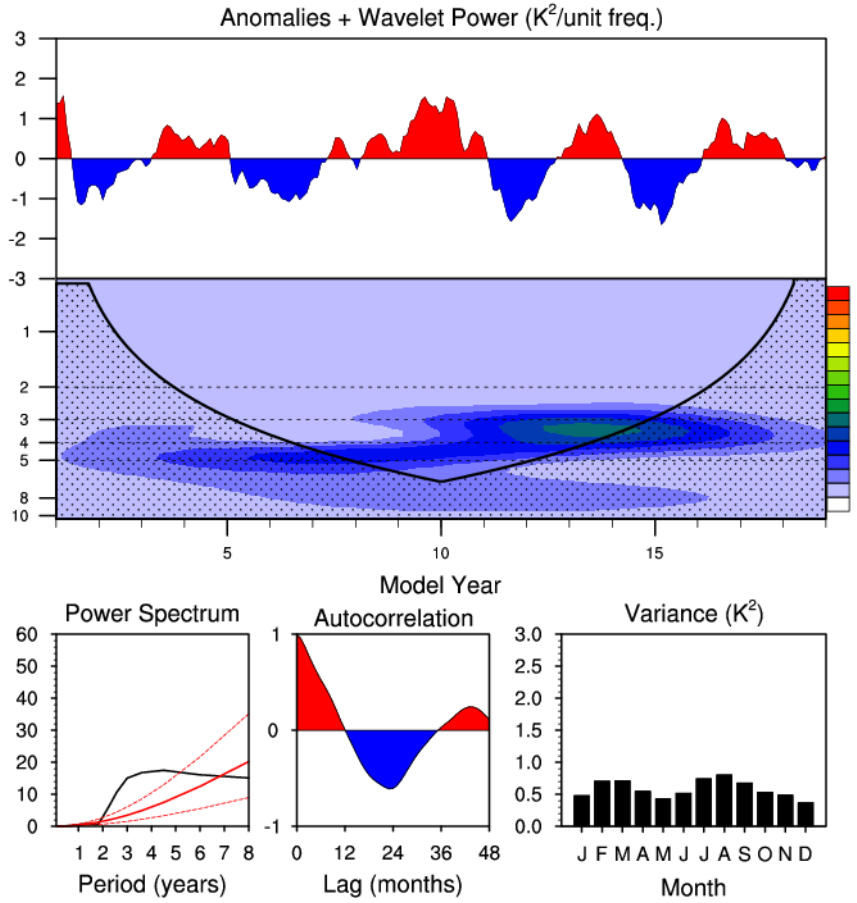
CCSM3.5



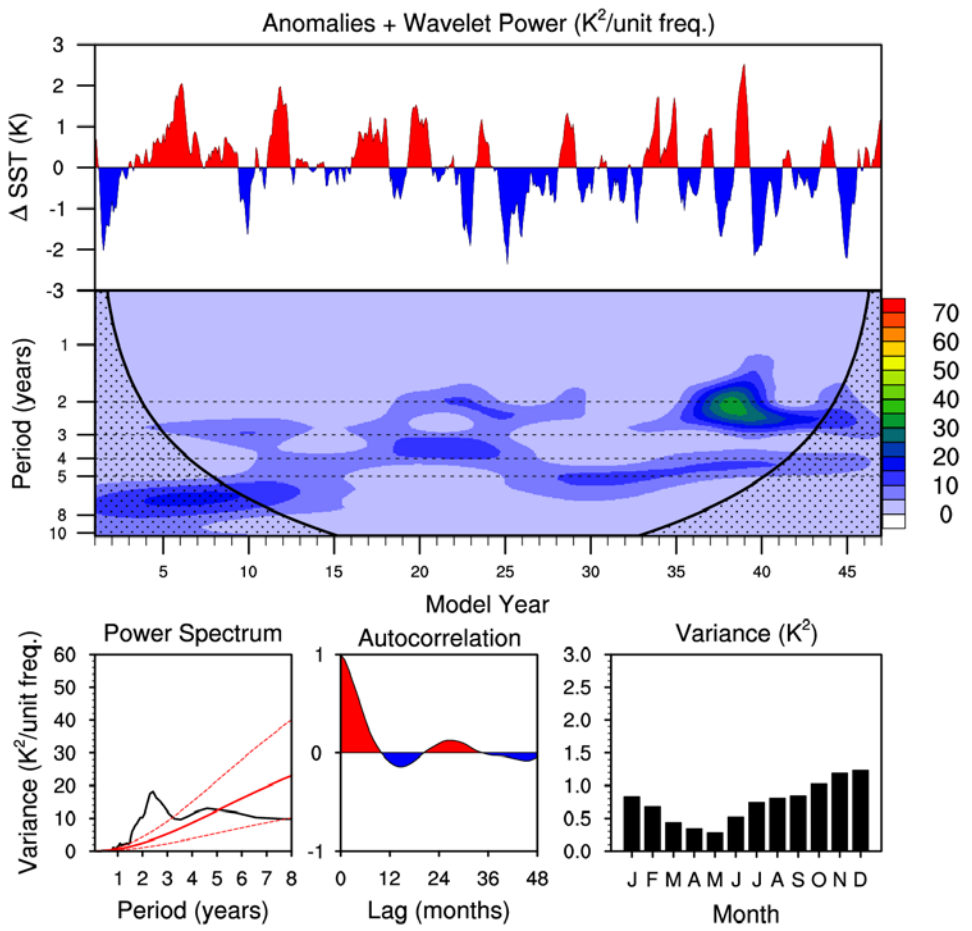
El Nino

Reduced amplitude / varying frequency

Track II



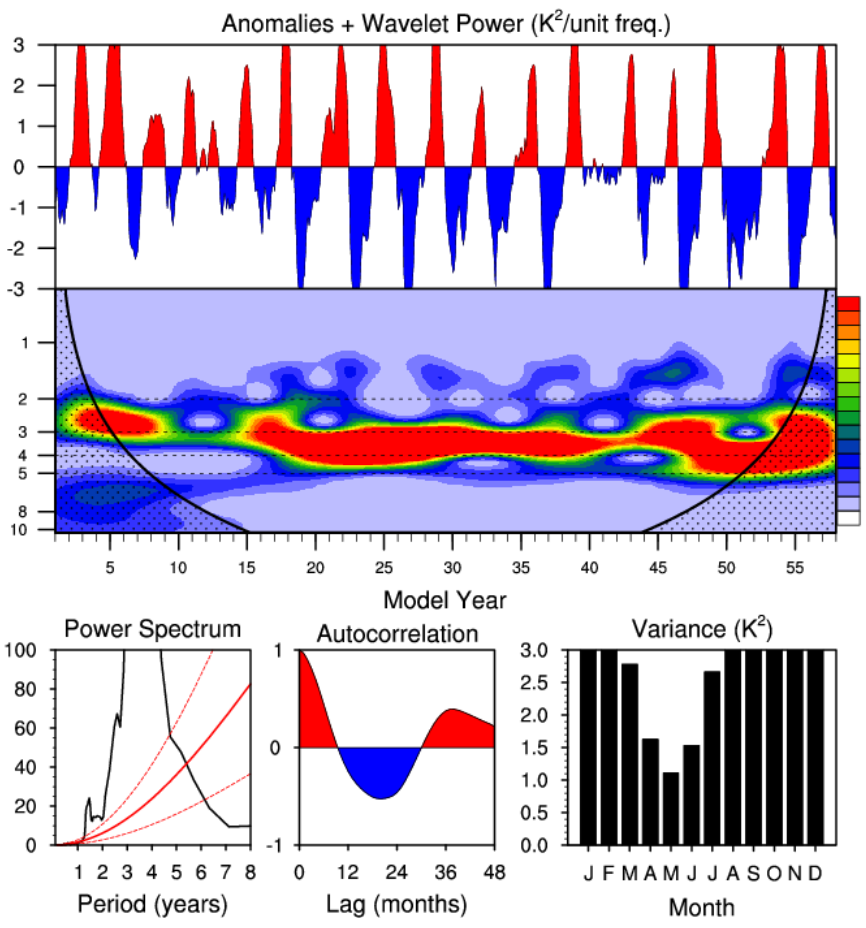
Track V



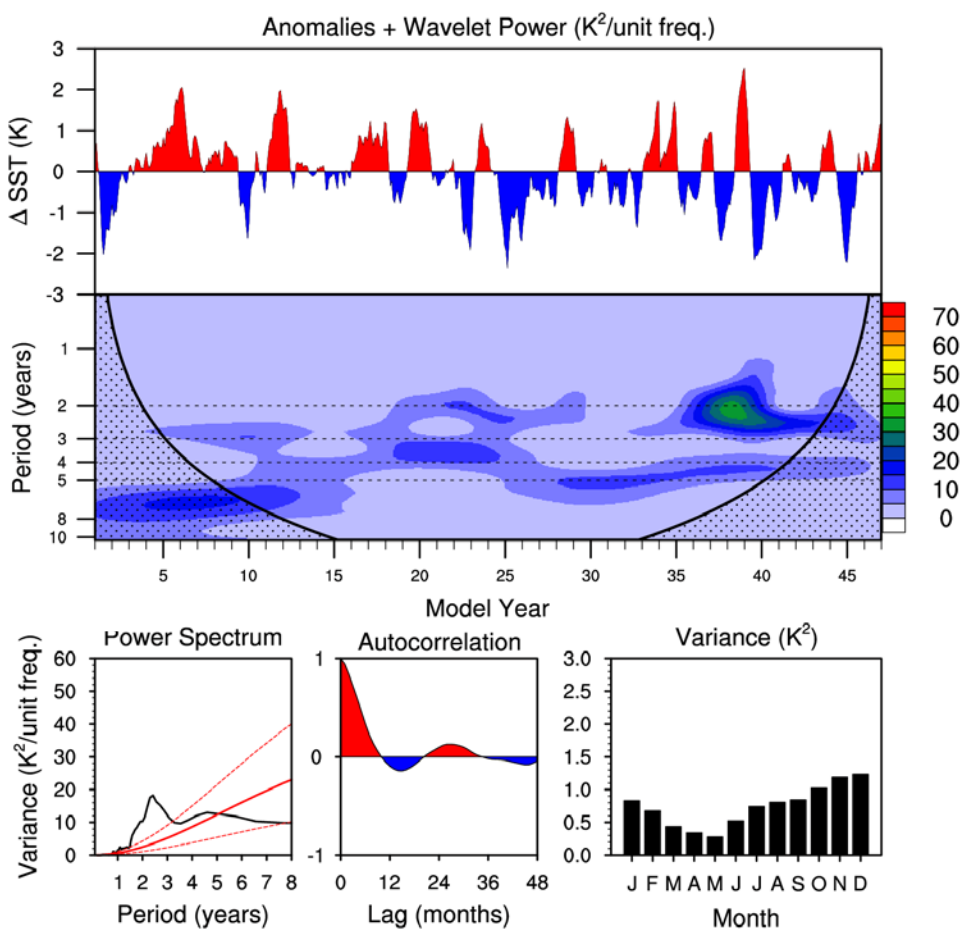
El Nino

Excessive amplitude with UW physics resolved

UW + macrophysics



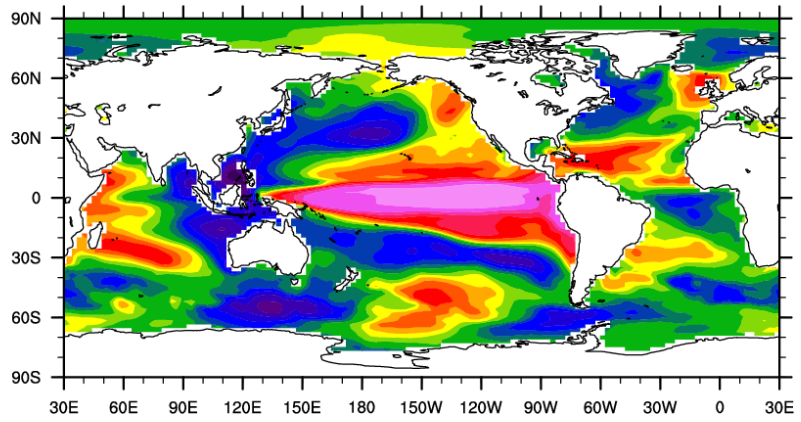
Track V



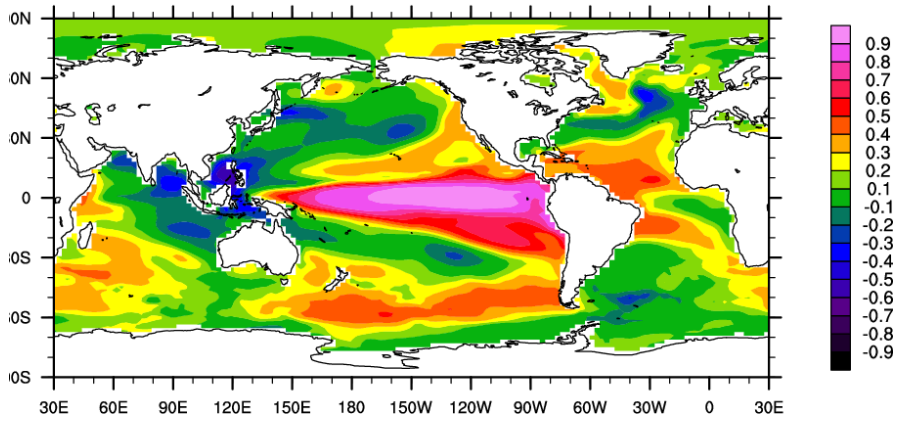
El Nino

Reduced remote correlation (nino3 SST' lag 0)

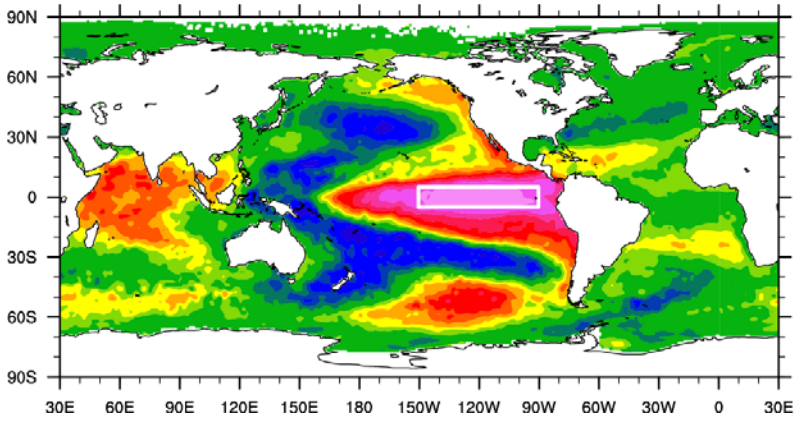
Track II



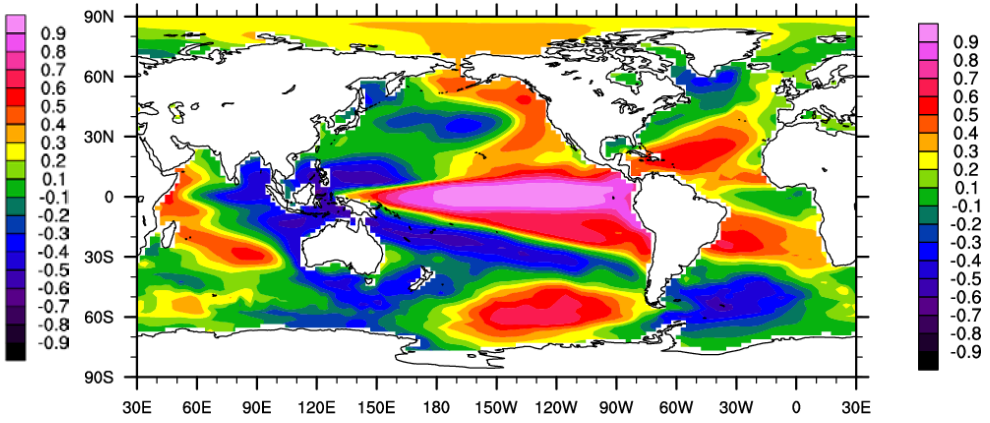
Track V



Obs.



CCSM3.5



Summary

- Frequent coupled simulations have revealed unforeseen problems
- Initial problems with AMWG development branch led to parallel development of alternative tracks
- Track II
  - Acceptable SST patterns and metrics
  - Sea-ice extent and thickness problems (low short-wave down)
  - El Nino acceptable – but sensitive to mean SST
  - Indirect effect 1.2W
- Track V
  - Acceptable SST patterns and metrics (larger biases)
  - Near observed sea ice extent and thickness
  - El Nino has low amplitude – low mean tropical SST
  - Strong indirect effect

- Ongoing simulations to determine climate sensitivity (1%/yr CO2)
- Efforts to reduce sea-ice in Track II (albedo, dust deposition)
- Land simulation is largely unknown - carbon cycle implications