

Observed Tropical Expansion: Impact on the Hydrological and Energy Cycles

New Investigator Research Summary

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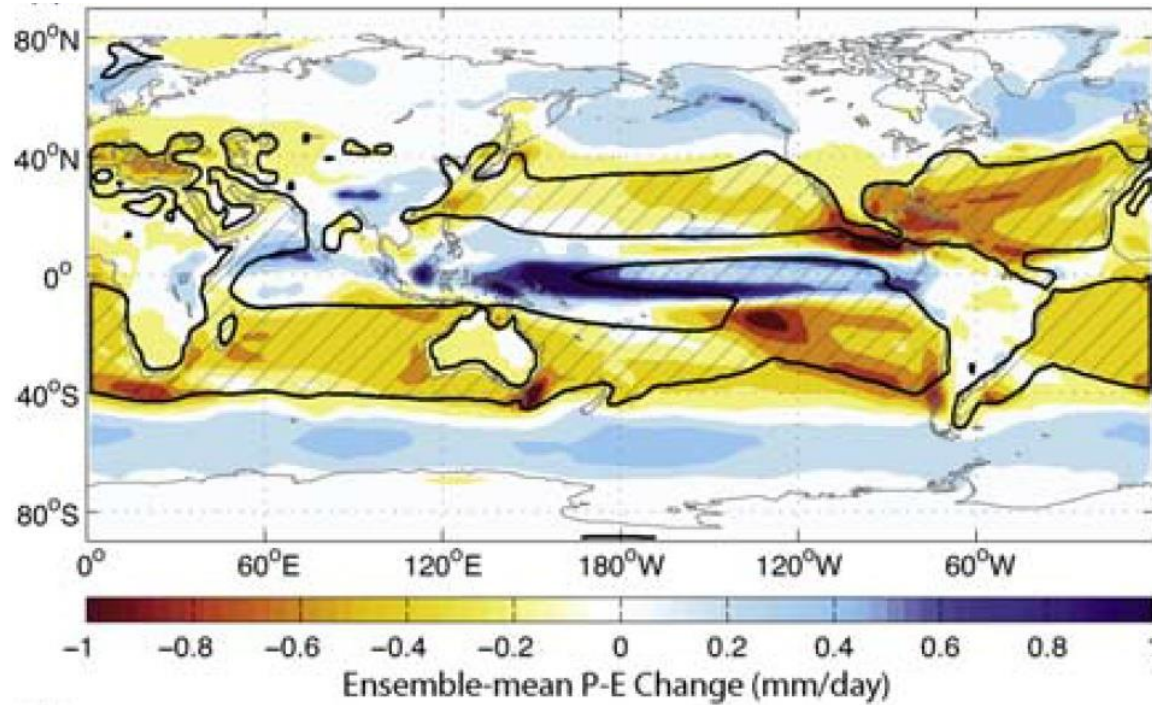
NEWS Science Team Meeting

Goddard Space Flight Center

May 1, 2013

Motivation/Background

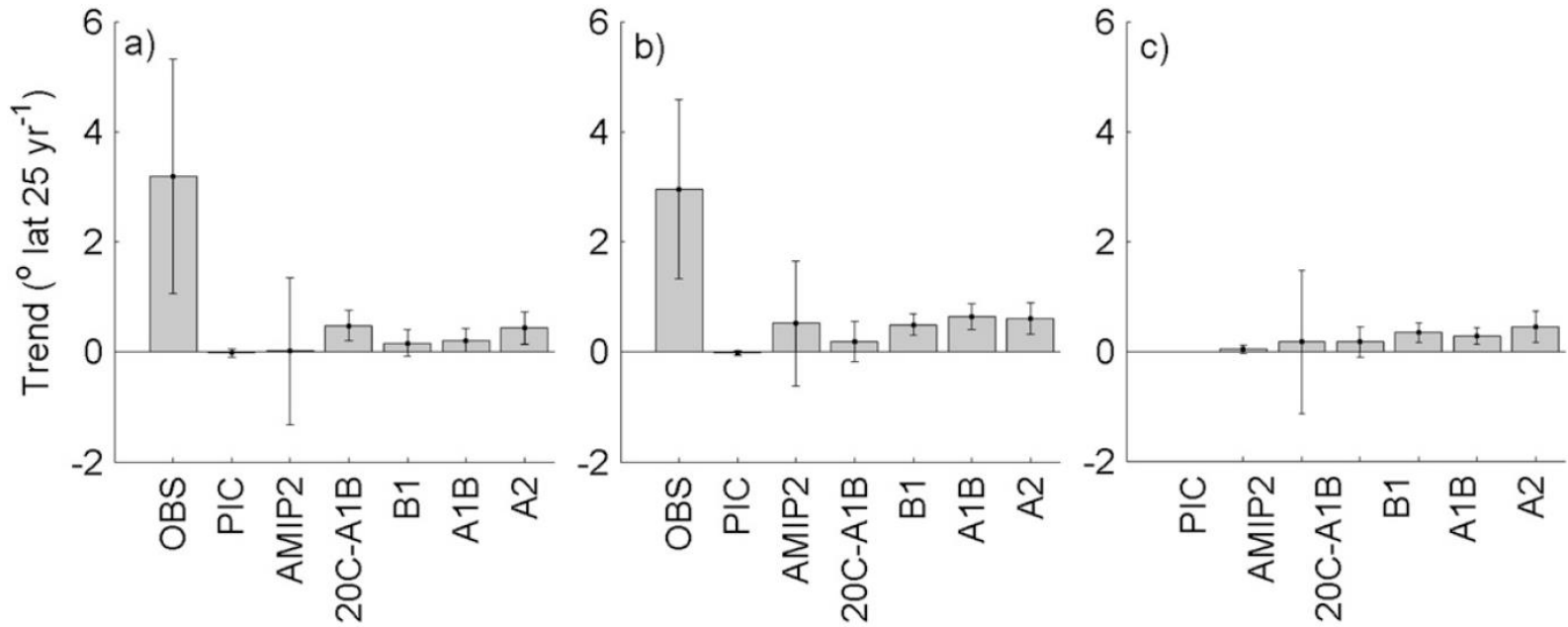
CMIP3 Ensemble Mean Projections



From
Lu et al.
(2007)

Climate models project expansion of subtropical dry zone

CMIP3 vs. Observed Tropical Expansion

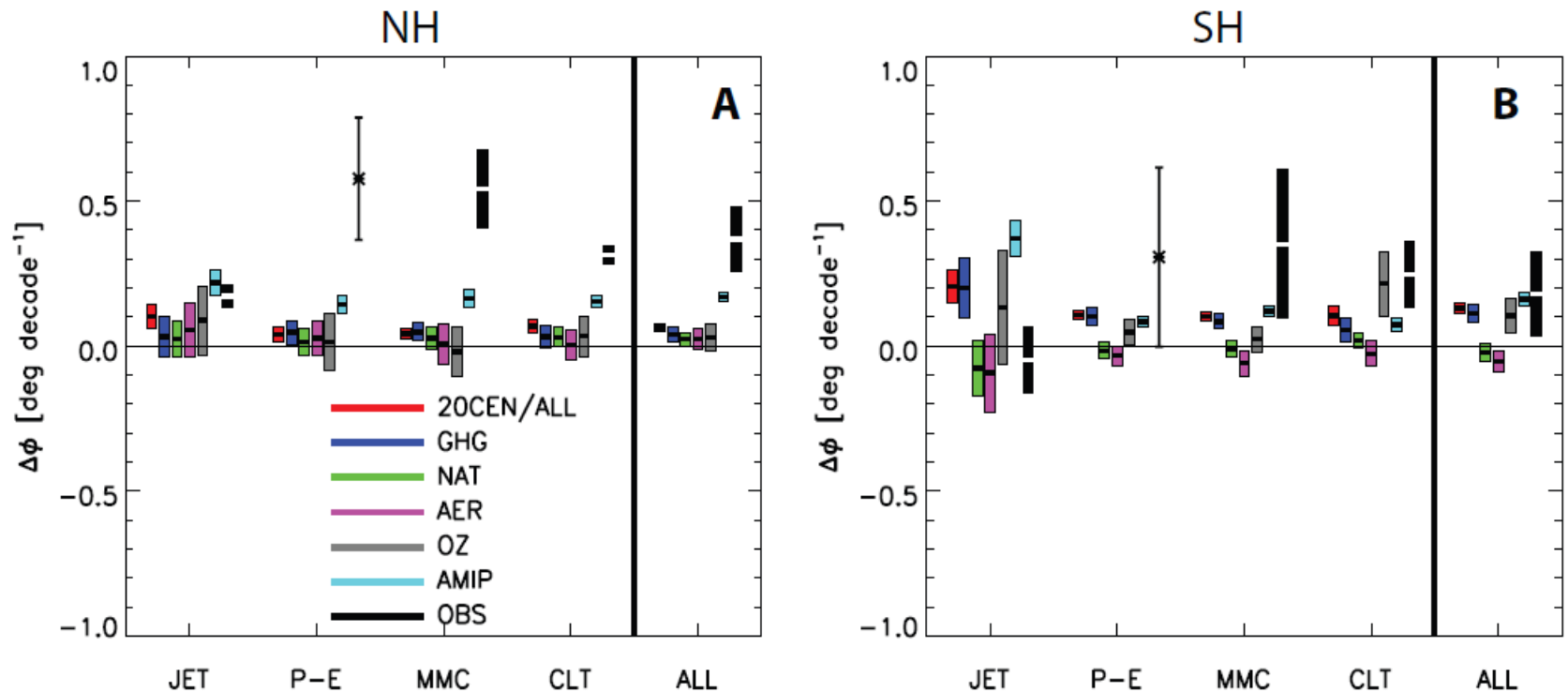


from Johanson and Fu (2009)

Observed tropical expansion greatly exceeds that for prescribed SST simulations (up to 1999) and CO₂ warming projections

Results So Far

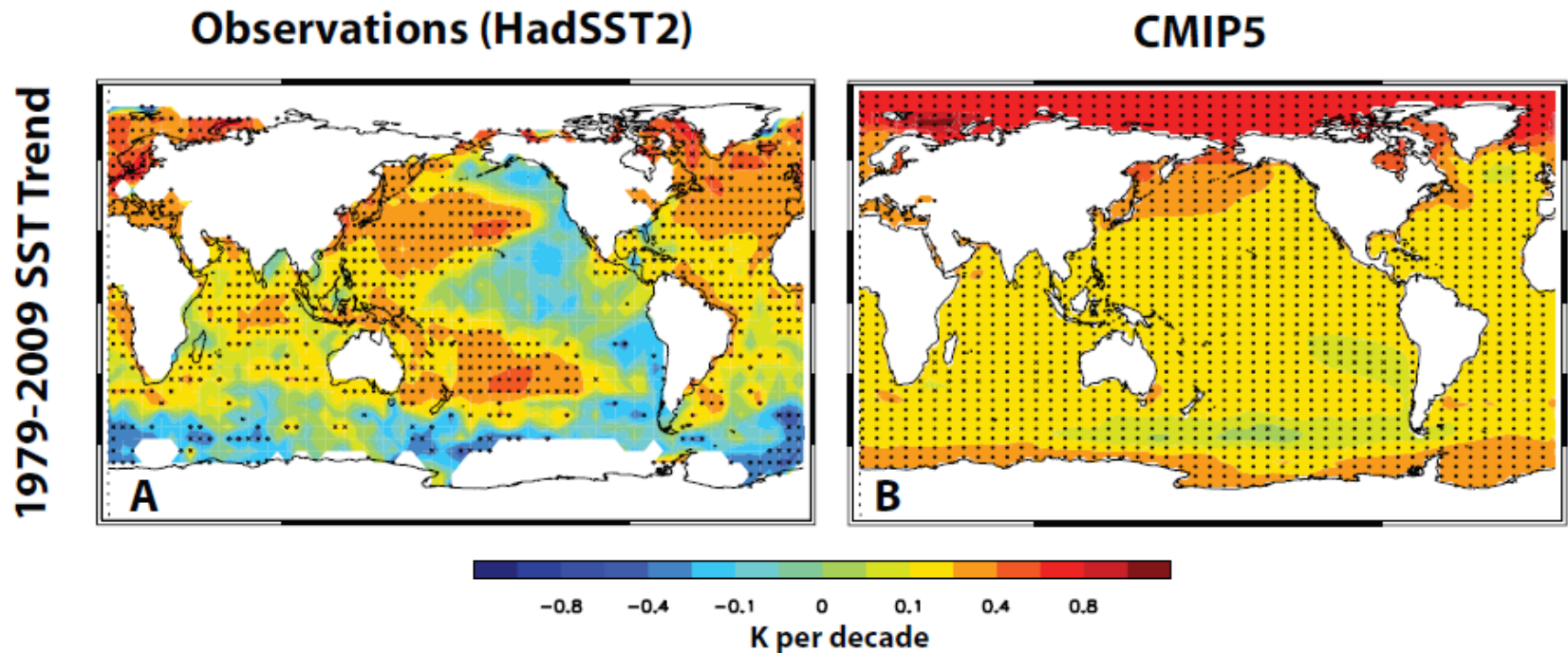
CMIP5 vs. Observed Tropical Expansion



Observed tropical expansion greatly exceeds that for CMIP5 coupled simulations of 1979-2009

Prescribed SST simulations (up to 2009) projections come closest

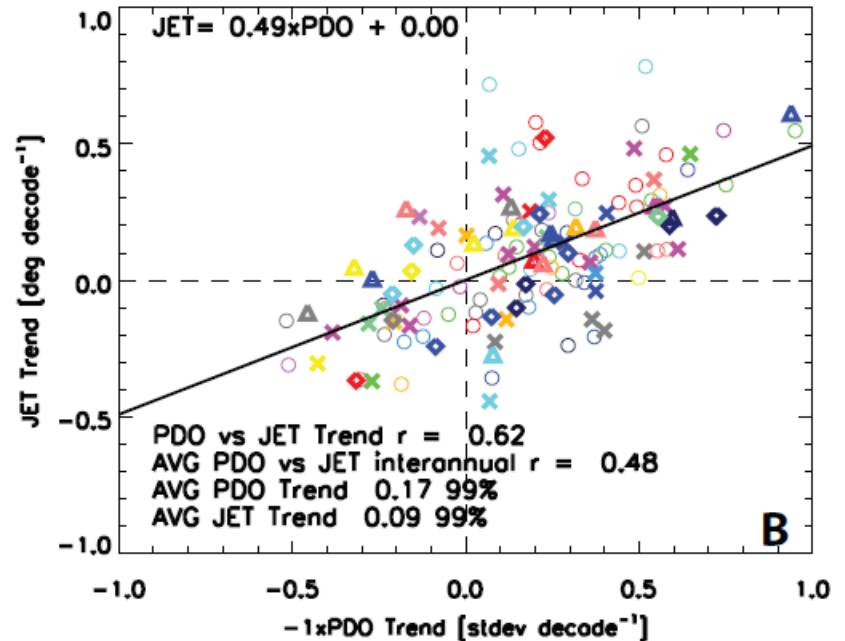
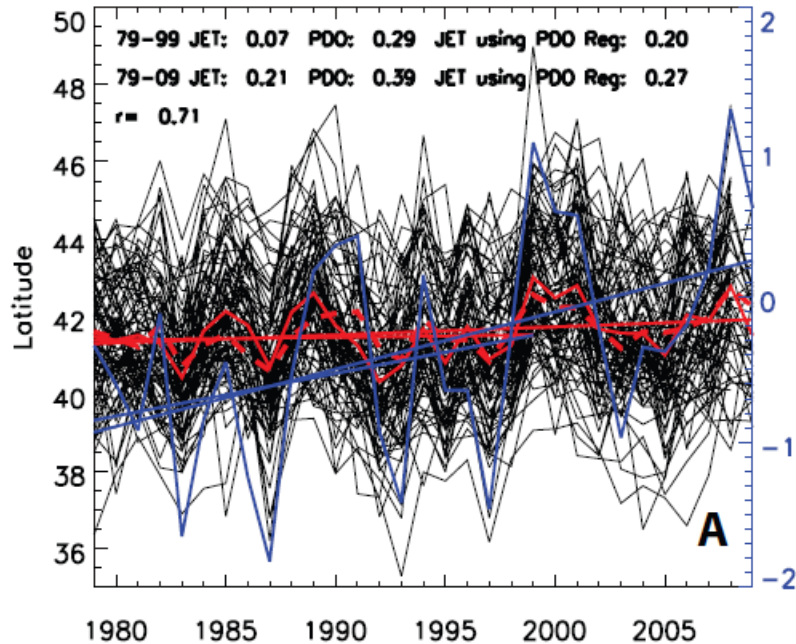
CMIP5 vs. Observed SST Trends



Observed SST trend pattern for 1979-2009 resembles the negative phase of the Pacific Decadal Oscillation (PDO)

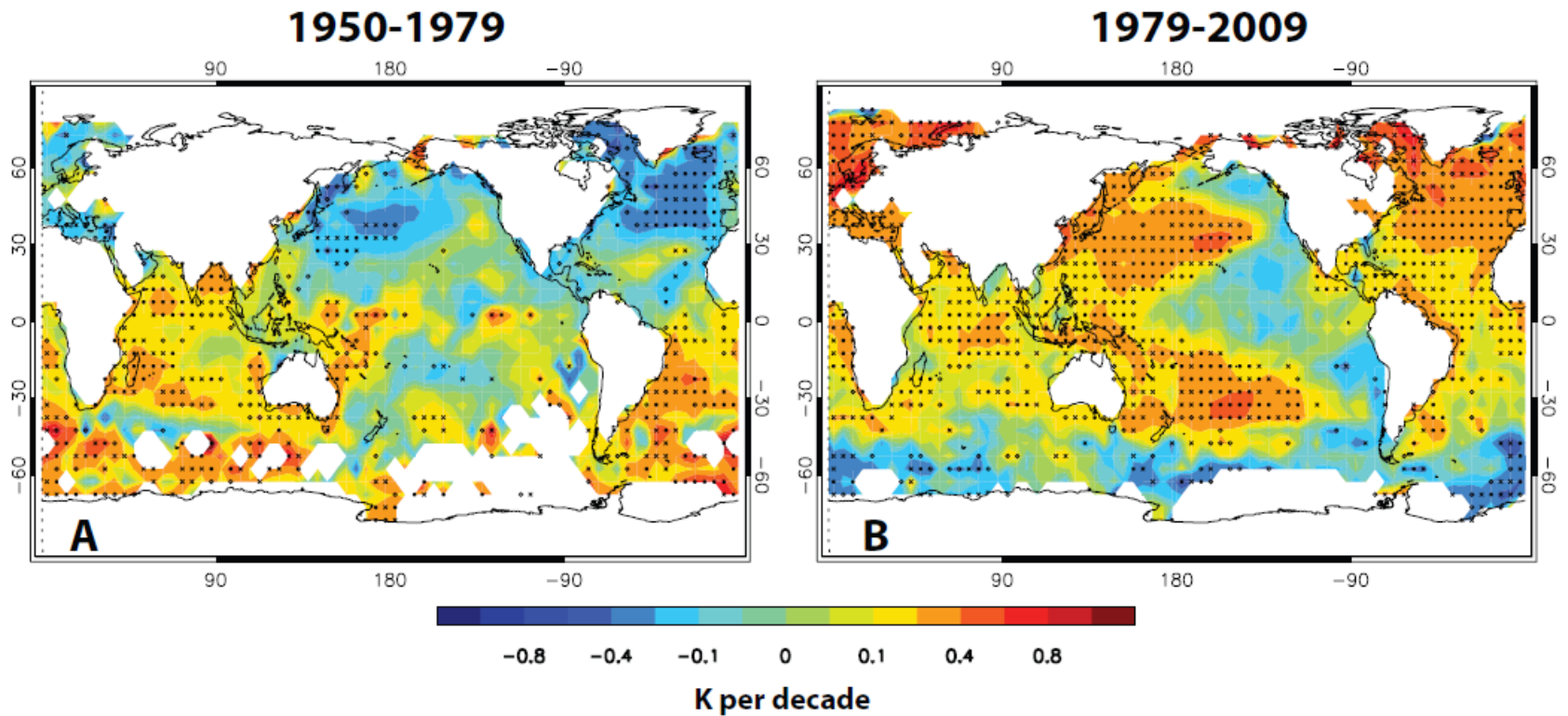
Ensemble mean CMIP5 coupled SST trend pattern for 1979-2009 is much more spatially uniform

Tropical Expansion and PDO



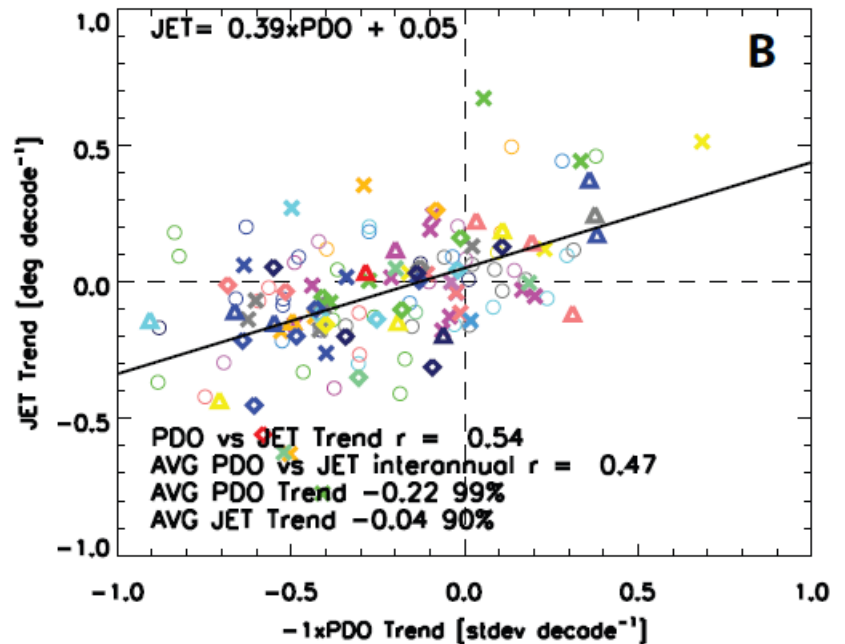
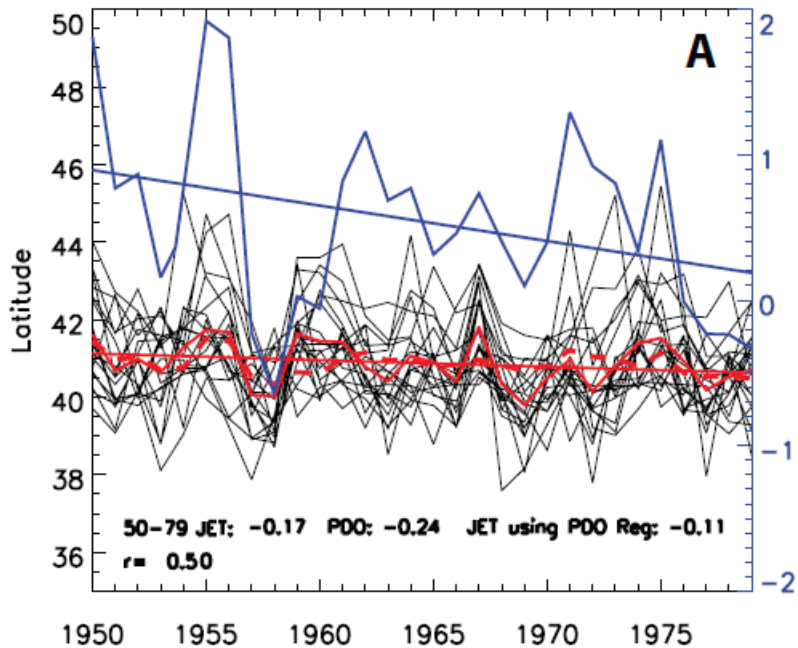
Jet latitude variations from prescribed SST runs resemble observed -PDO
-PDO is a good predictor of variability in JET latitude
Jet latitude trends are correlated with PDO trends in 20th century coupled simulations

1950-1979 vs. 1979-2009 SST Trends



1950-1979 and 1979-2009 SST trends have opposite sign in many regions

1950-1979 Tropical Contraction and PDO

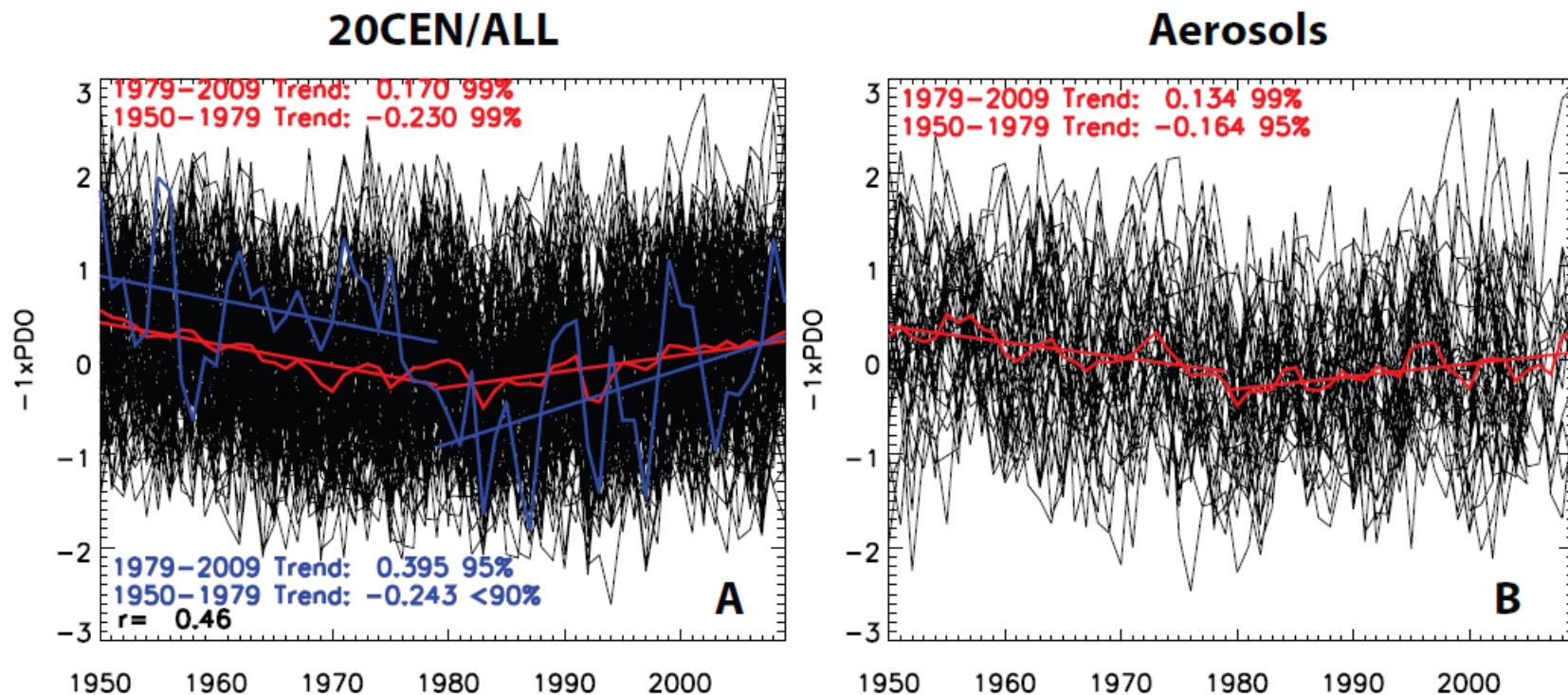


Jet latitude variations from prescribed SST runs resemble observed $- \text{PDO}$

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1950-1979 vs. 1979-2009 PDO Index



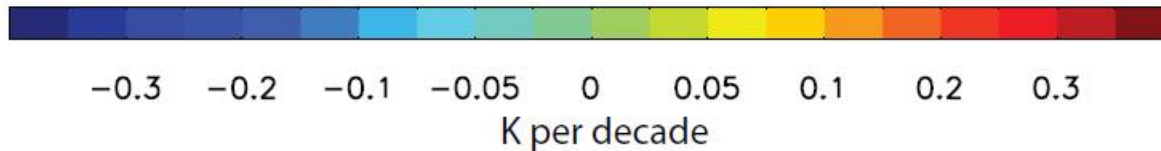
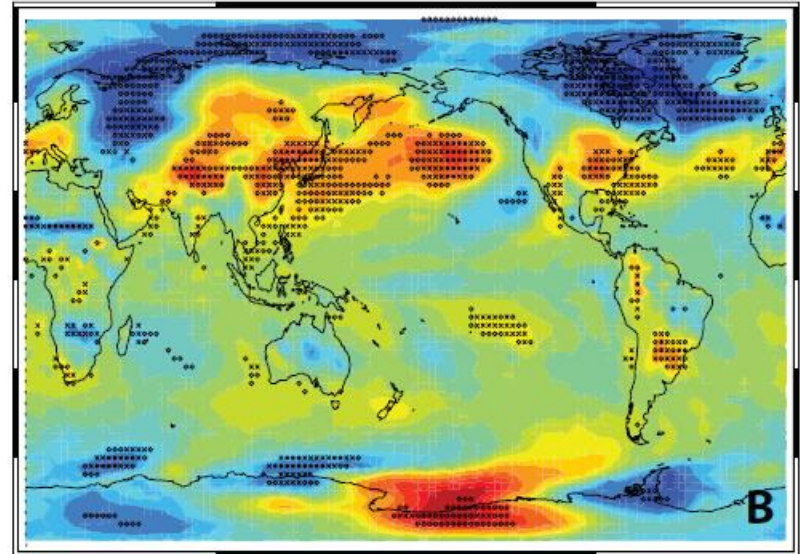
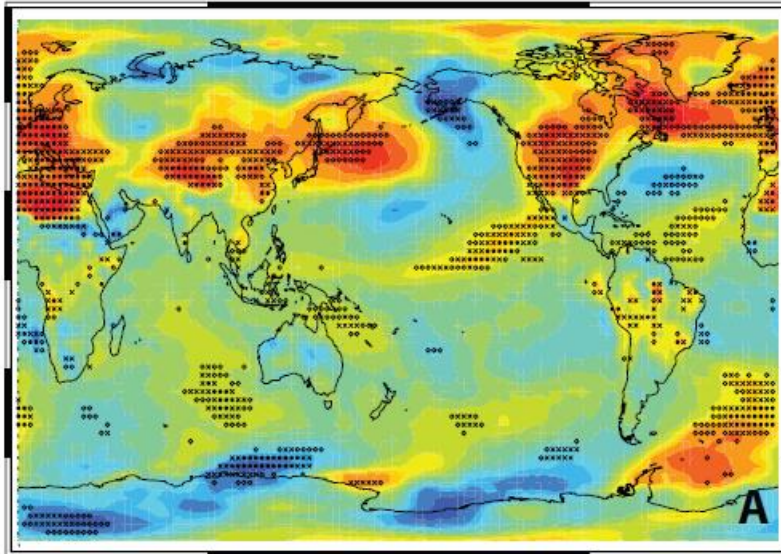
PDO trend has opposite sign in 1950-1979 from 1979-2009 in 20th century coupled simulations with all forcings

Trend sign reversal also occurs in 20th century simulations with only aerosol forcings

SST Response to Aerosol Radiative Forcing

BC+OC+S02

BC



Simulated 1979-2005 surface temperature trends in response to historical aerosol radiative heating

Summary

- Subtropical dry zone expanded during 1979-2009
- Greatly underestimated by coupled model ensemble mean
- Strong association between expansion and -PDO
- Could have substantial natural variability component
- Could have substantial contribution from aerosol radiative forcing

Implications for NEWS

- Does regional aerosol radiative forcing drive circulation, SST, and precipitation patterns on decadal time scales?
- Can we project aerosol radiative forcing changes in coming decades and likely circulation, SST, and precipitation response?