

# GFDL Activities in Decadal Forecasts

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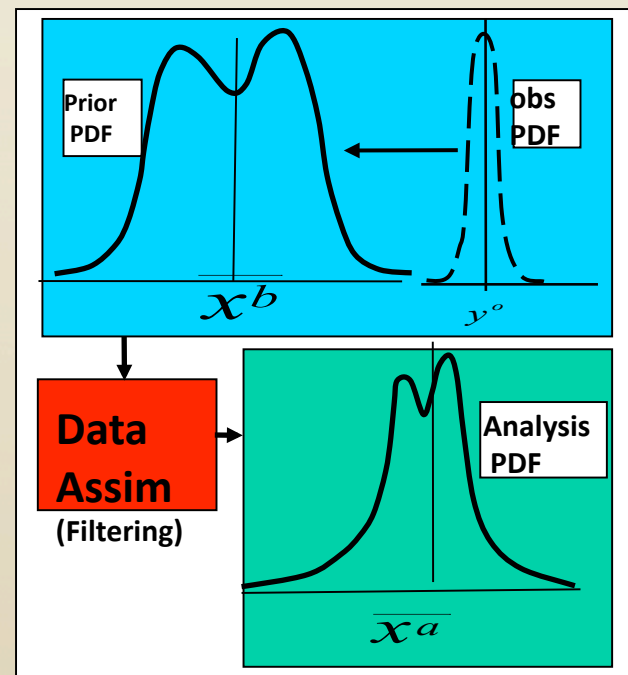
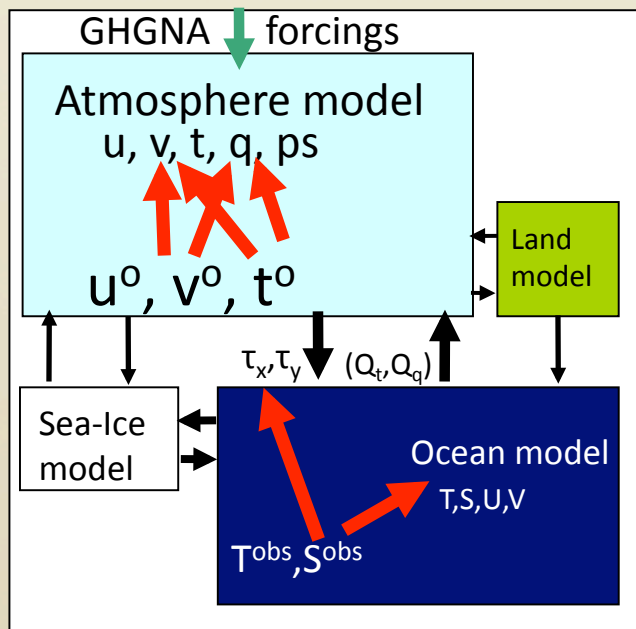
# Key Questions

- **What seasonal-decadal predictability exists in the climate system, and what are the mechanisms responsible for that predictability?**
- **To what degree is the identified predictability (and associated climatic impacts) dependent on model formulation?**
- **Are current and planned initialization and observing systems adequate to initialize models for decadal prediction?**
- **Is the identified decadal predictability of societal relevance?**

# Pioneering development of coupled data assimilation system

Ensemble Coupled Data Assimilation estimates the **temporally-evolving probability distribution** of climate states under observational data constraint:

- Multi-variate analysis maintains physical balances between state variables such as T-S relationship – primarily geostrophic balance
- Ensemble filter maintains the nonlinearity of climate evolution
- All coupled components adjusted by observed data through instantaneously-exchanged fluxes
- Optimal ensemble initialization of coupled model with minimum initialization shocks



S. Zhang, M. J. Harrison,  
A. Rosati, and A.  
Wittenberg  
MWR 2007

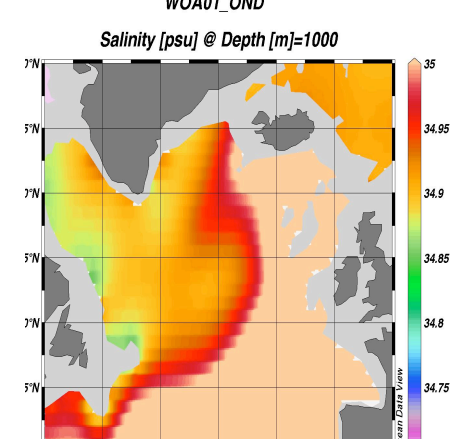
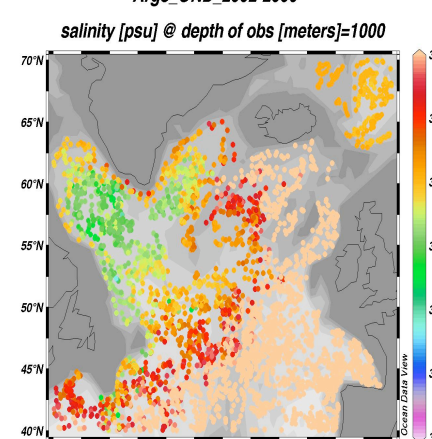
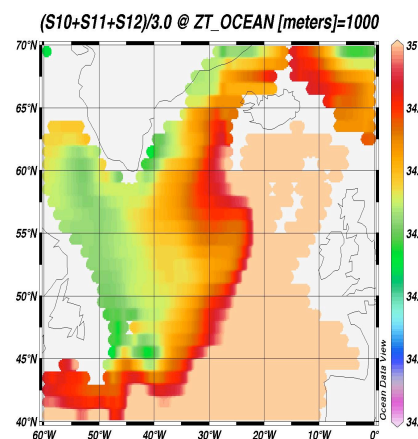
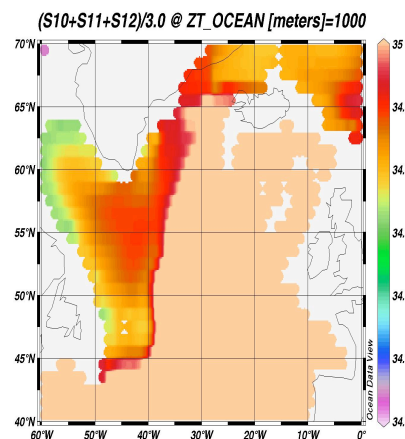
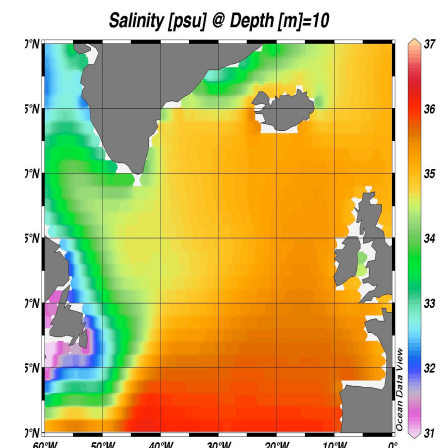
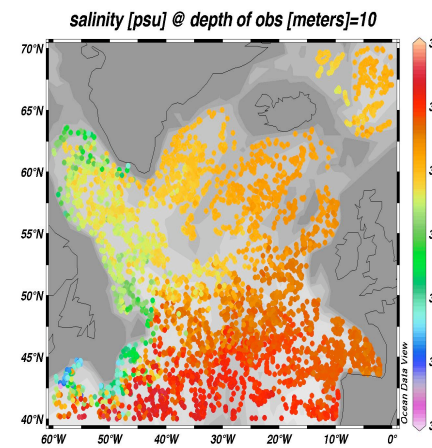
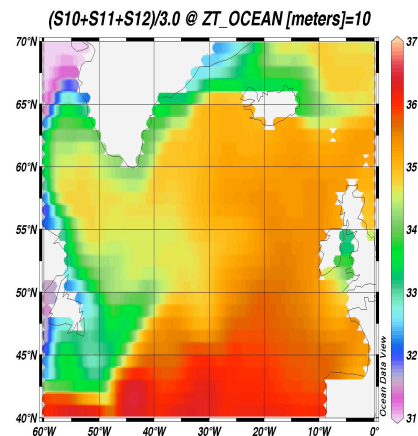
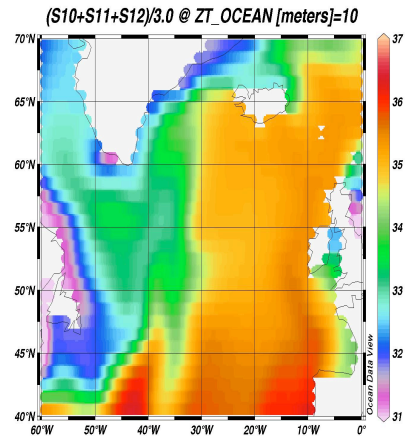
# OND N.A. - SALINITY

NO-ASSIM

ASSIM(ECDA)

Argo

WOA01

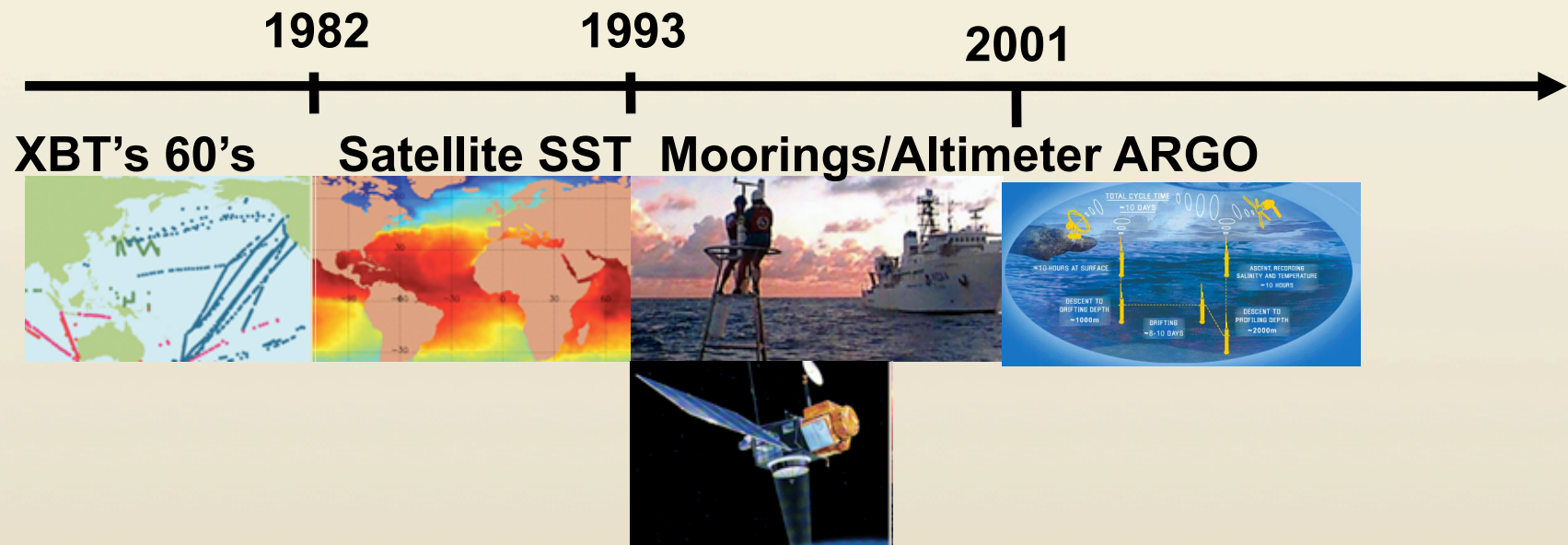




# ECDA activities to improve Initialization

- **Multi-model ECDA to help mitigate bias**
- **Fully coupled model parameter estimation within ECDA**
- **ECDA in high resolution CGCM**
- **Assess additional predictability from full depth ARGO profilers**
- **Produce Pseudo Salinity profile - 1993-2002**

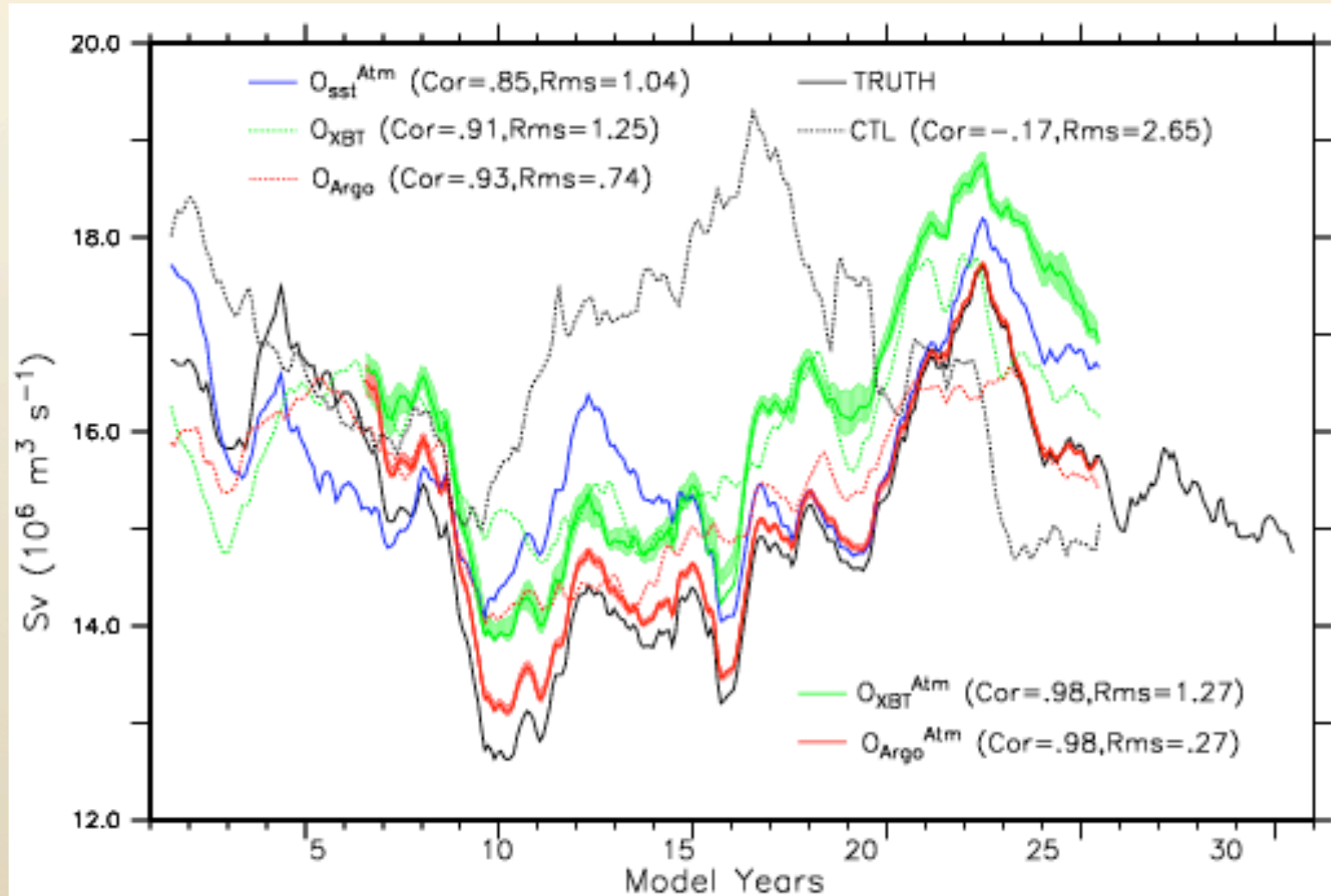
# Ocean observations assimilated



The ocean observing system has slowly been building up...  
Its non-stationary nature is a challenge for the estimation of decadal variability

# Ability to represent AMOC in models is a function of observing system

- Use of ARGO plus atmospheric temperature and winds performs best



# GFDL Decadal Prediction Research in support of IPCC AR5

**Key goal: assess whether climate projections for the next several decades can be enhanced when the models are initialized from observed state of the climate system.**

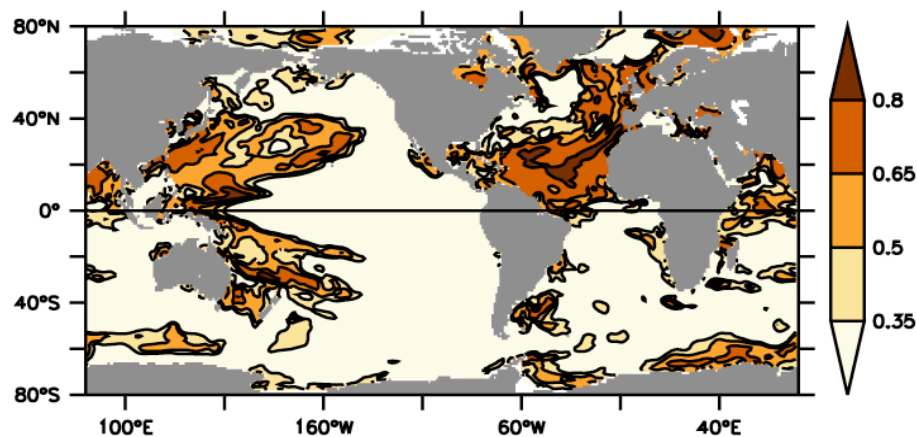
- **Historic Runs - CM2.1 600 yr spin up 1860 forcing - 10 ensemble**
- **Use ECDA\_ver3.1 for initial conditions from “observed state”**  
**Produce ocean reanalysis 1960-2011**
- **Use “workhorse” CM2.1 model from IPCC AR4**  
**Decadal hindcasts from 1960 - 2001 every year starting in JAN**  
**Decadal forecasts starting from 2001 - 2011 RCP-4.5 forcing**
- **Use experimental high resolution model CM2.5 (.5° atm x .25° ocn )**  
**Decadal forecasts starting from 2003 - 2011**



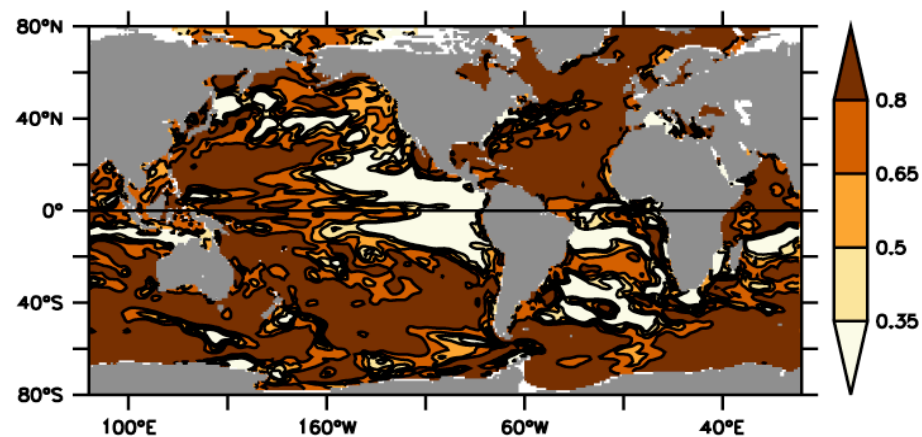
# CMIP5 EXPERIMENTAL DESIGN

- Initialization- from Ensemble Coupled Data Assimilation (ECDA\_ver2.0) Reanalysis
  - Atmosphere - NCEP Reanalysis2 (T,u,v,ps)
  - Ocean - xbt,mbt,ctd,sst,ssh,ARGO
  - Radiative Forcing - GHG, Solar, Volcano, Aerosol
- Hindcasts - 10 member ensembles, starting Jan every year from 1960-2011 for 10 years (total of 5k years)
- Forecasts - RCP-4.5 scenario

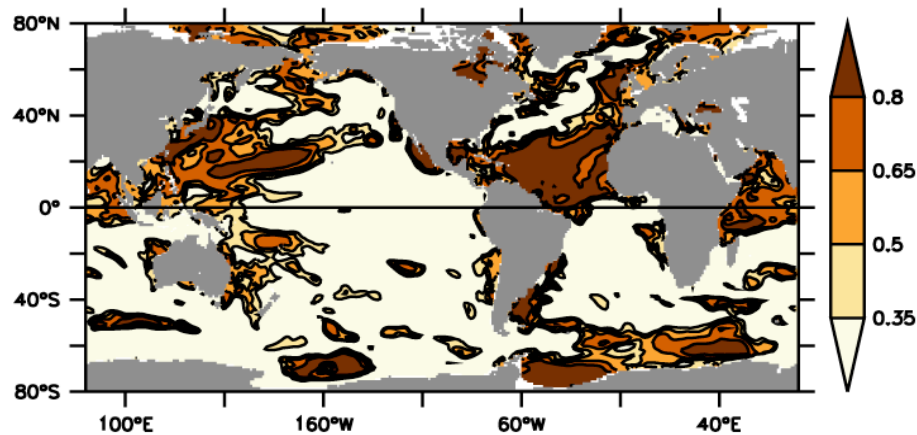
# SST CORR between OBS and Hindcasts



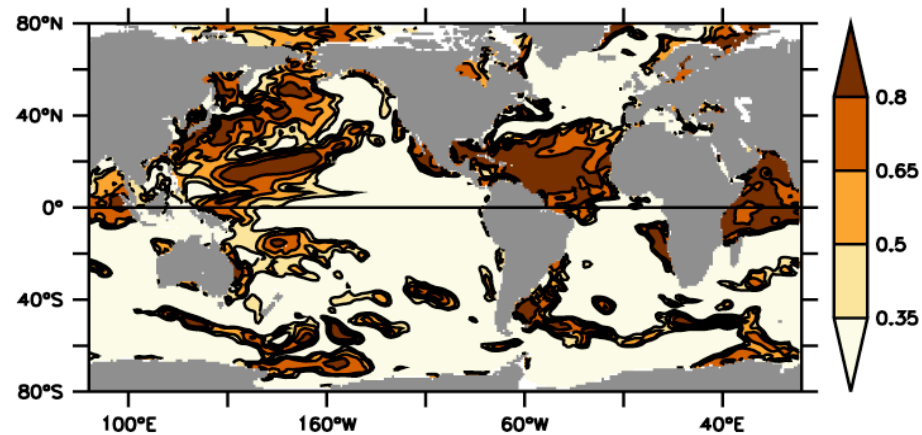
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**YR1**

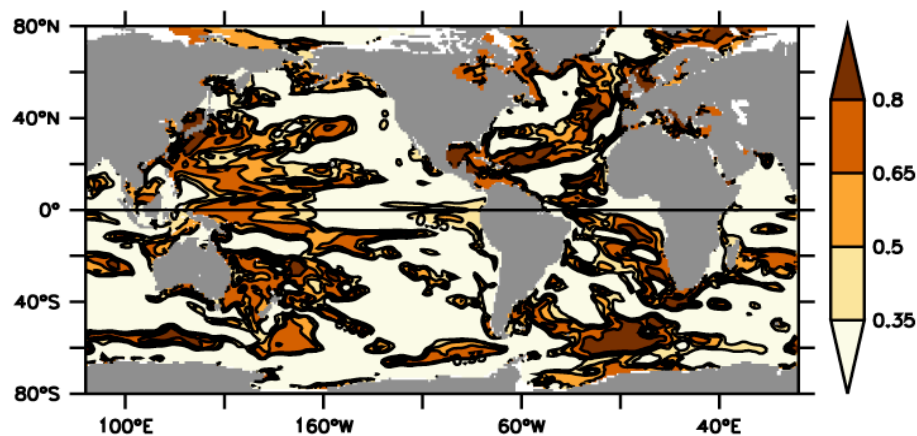


**YR5**

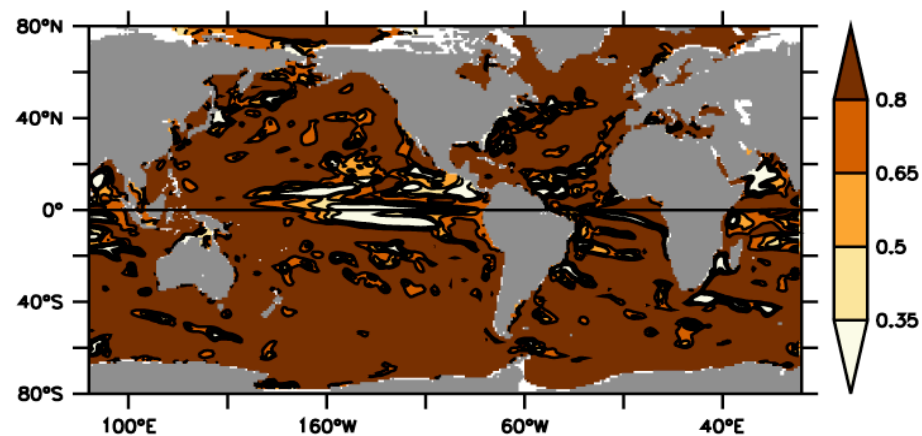


**YR10**

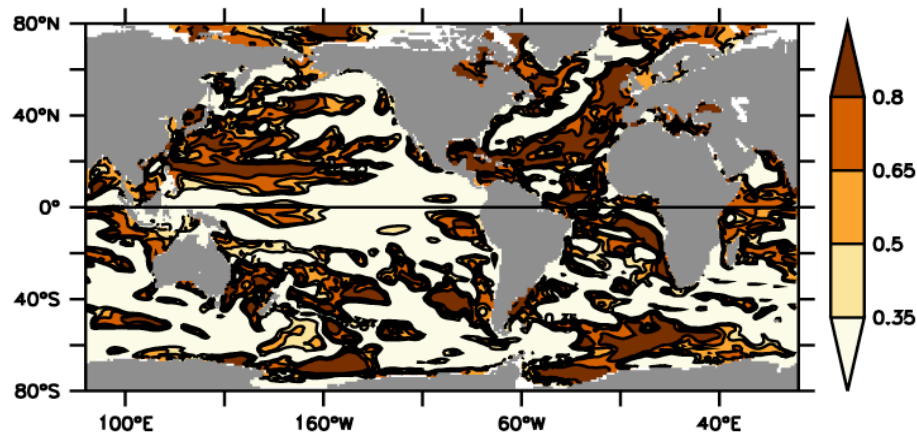
# Tav300 CORR between OBS and Hindcasts



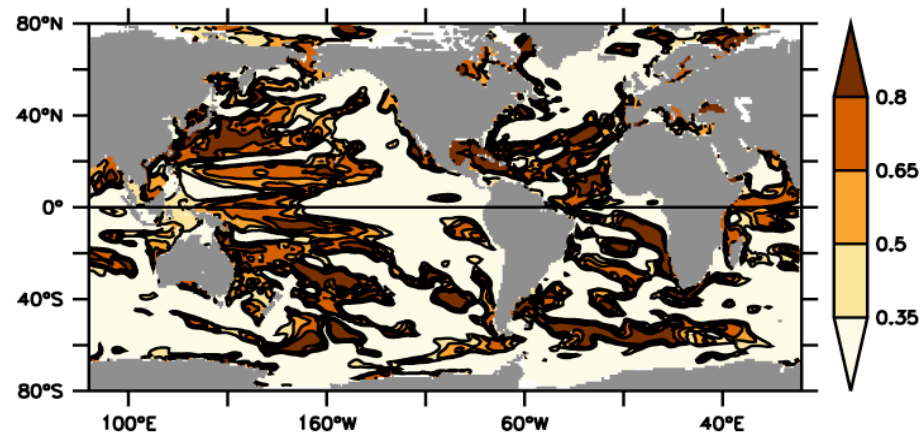
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**YR1**



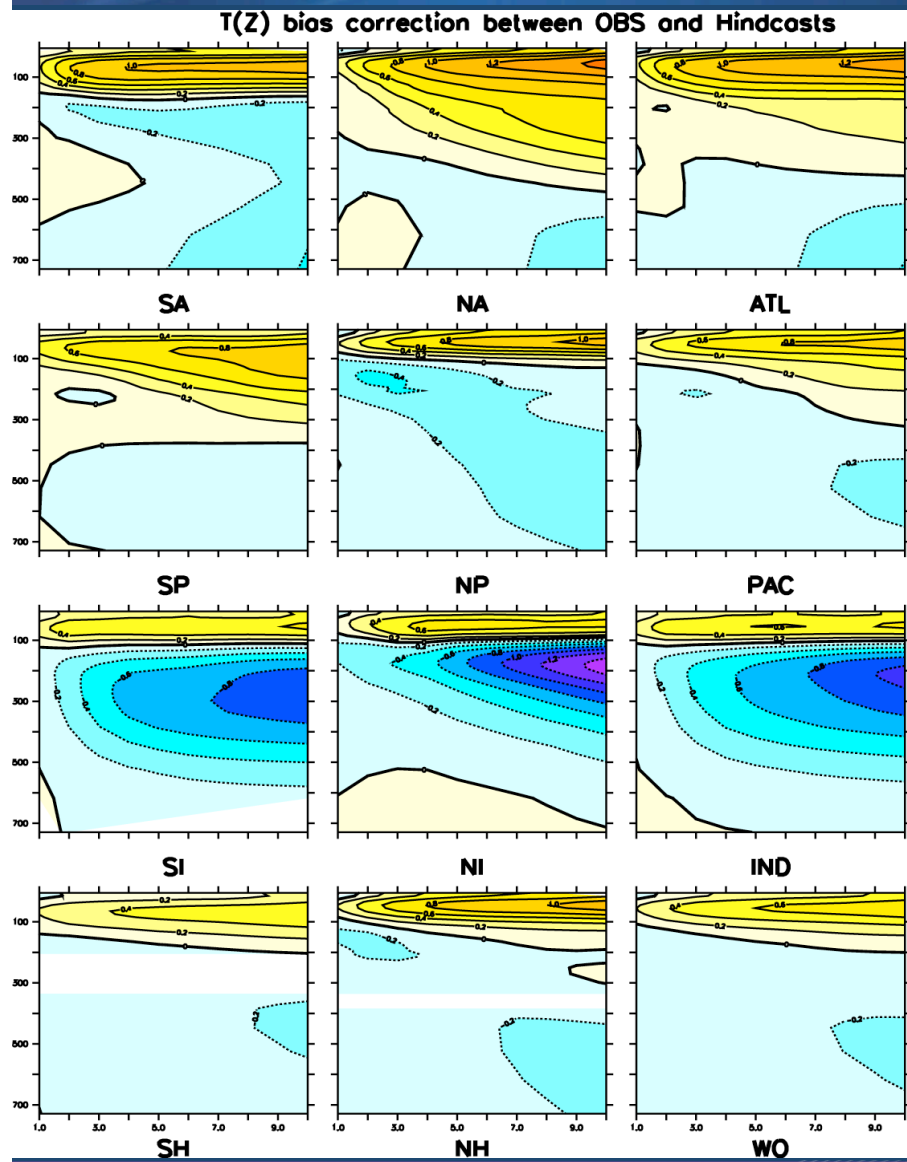
**YR5**



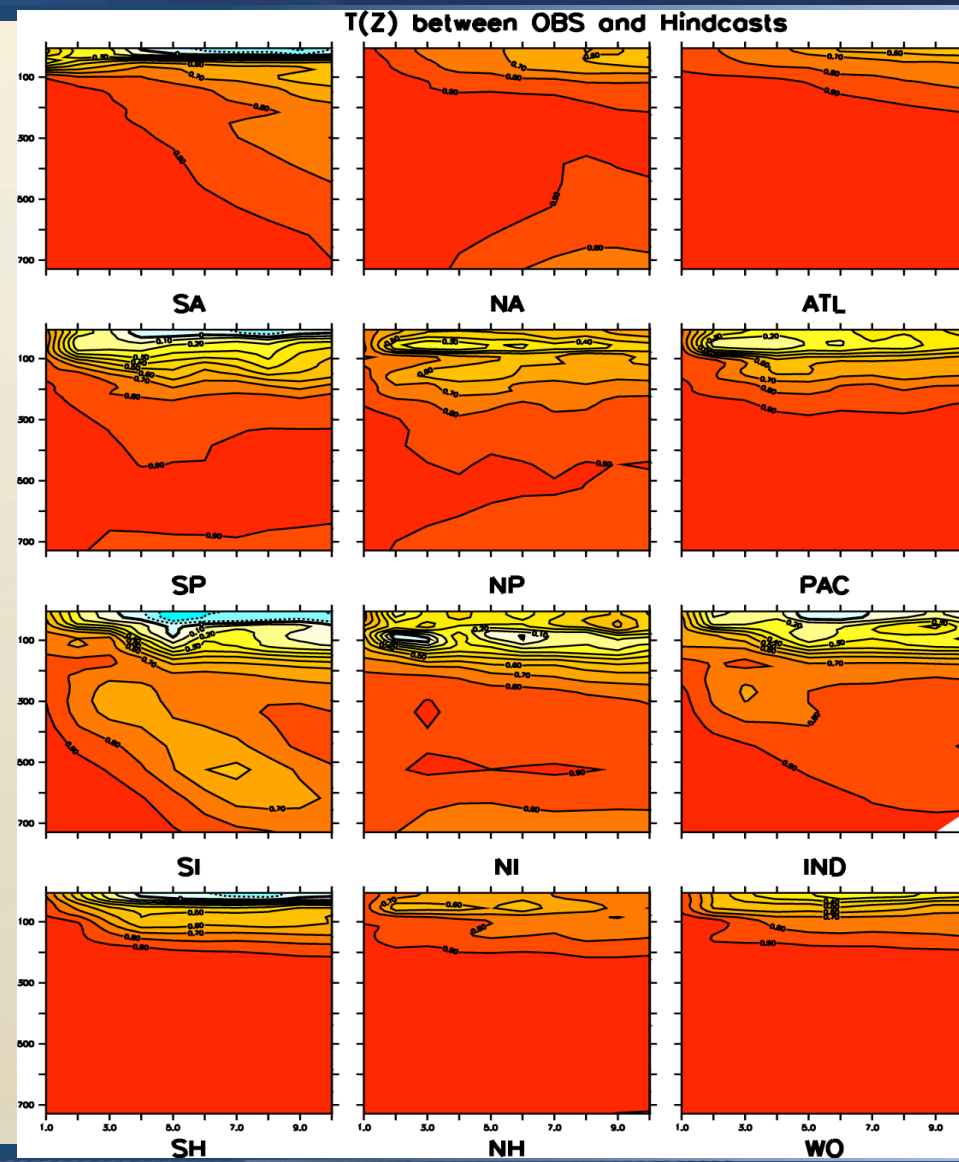
**YR10**



# T(Z) bias correction

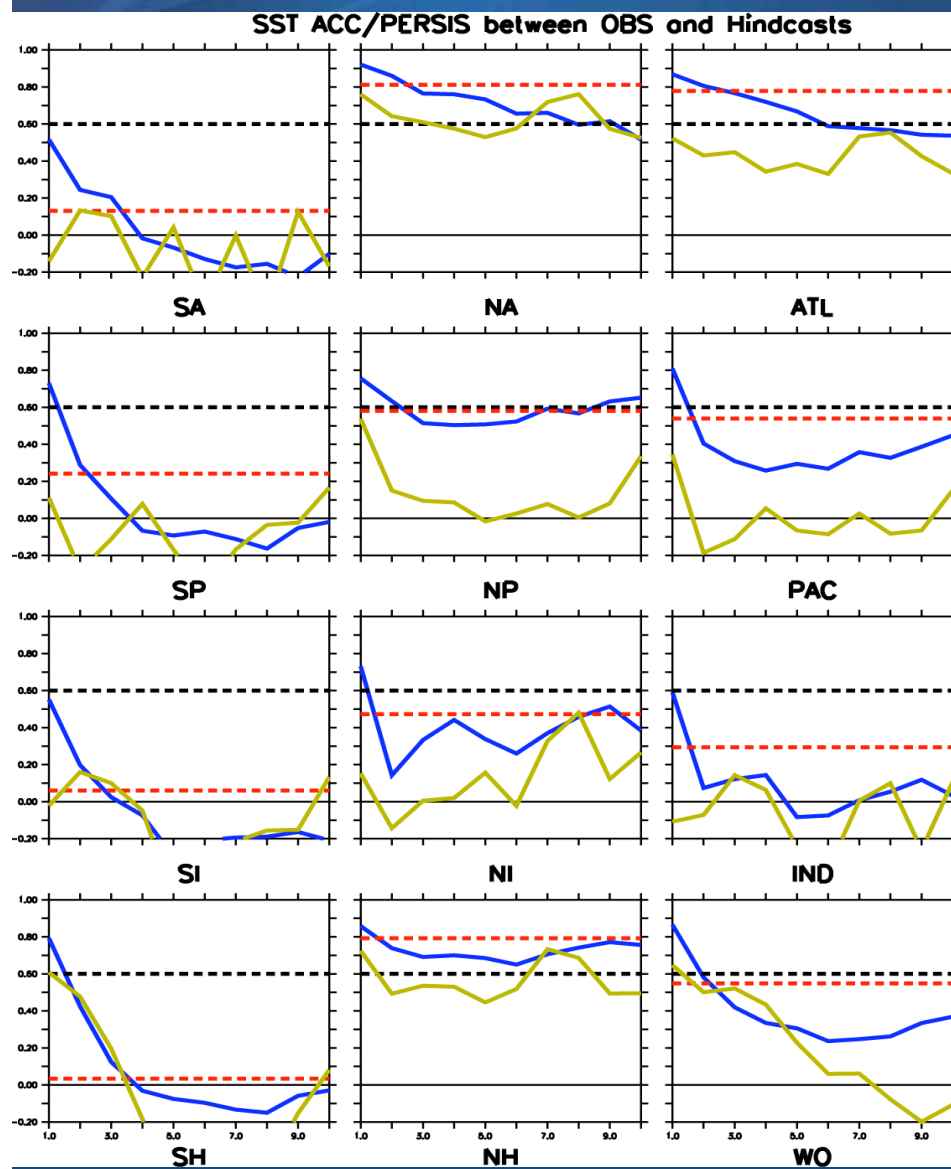


# T(Z) ACC





# SST Hindcast ACC

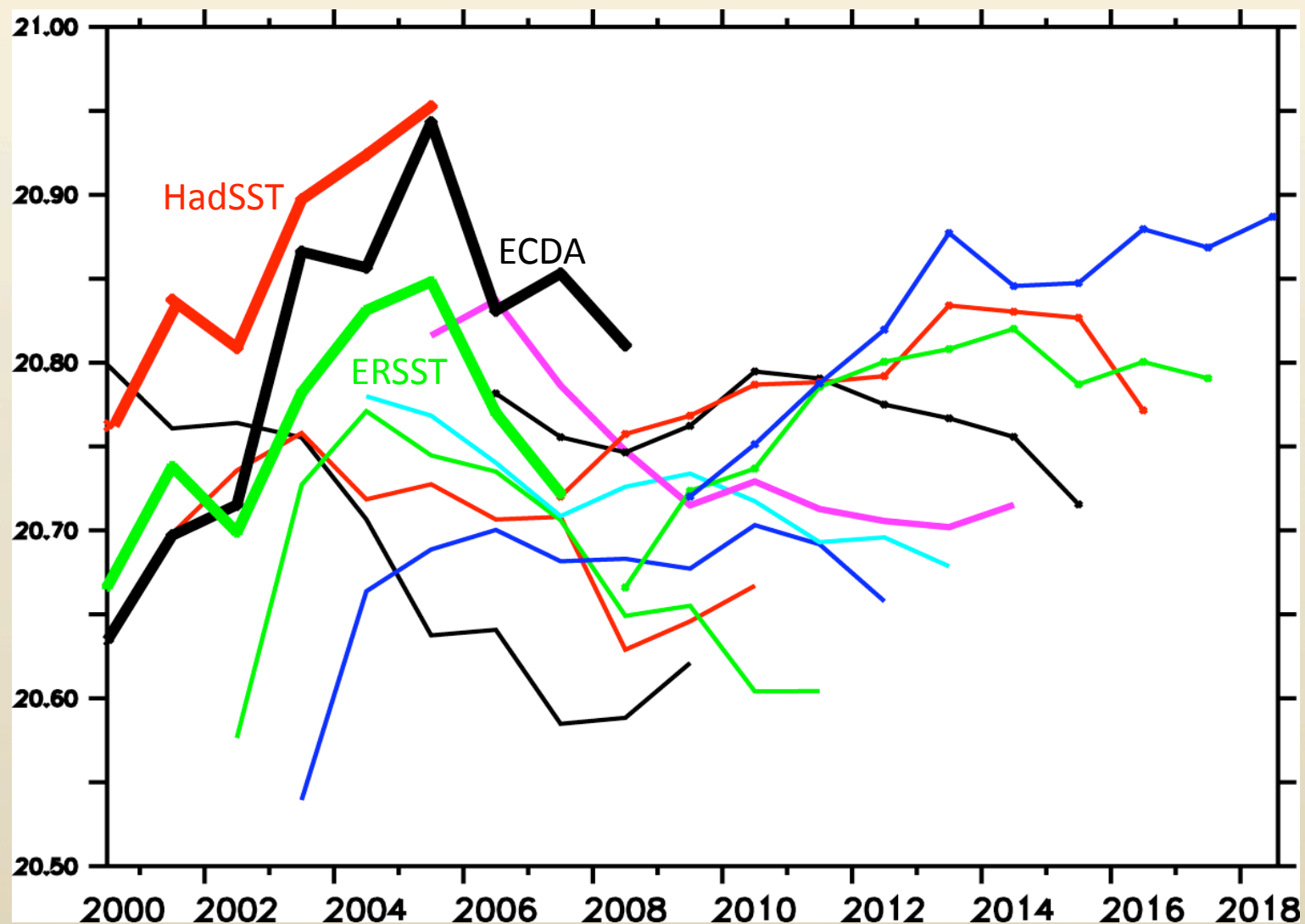


hindcast

noassim

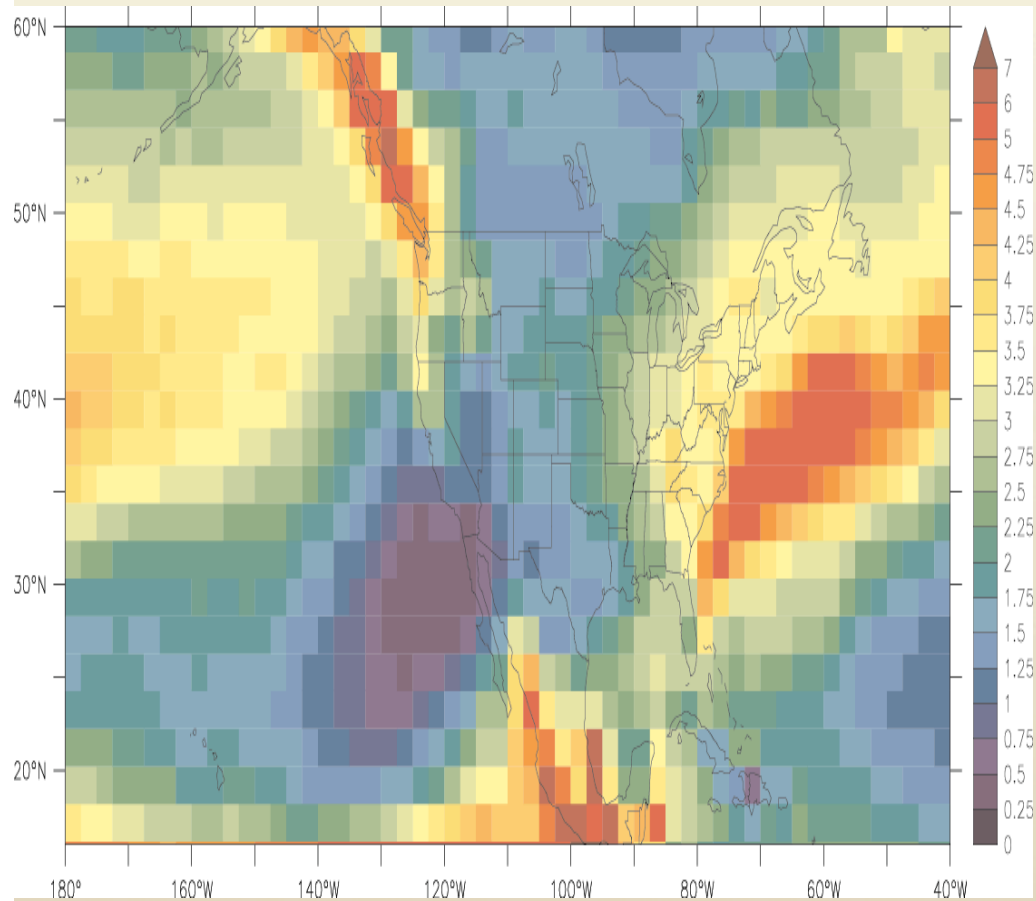
persistence

# N.H. SST Predictions



# PRECIPITATION (mm/day)

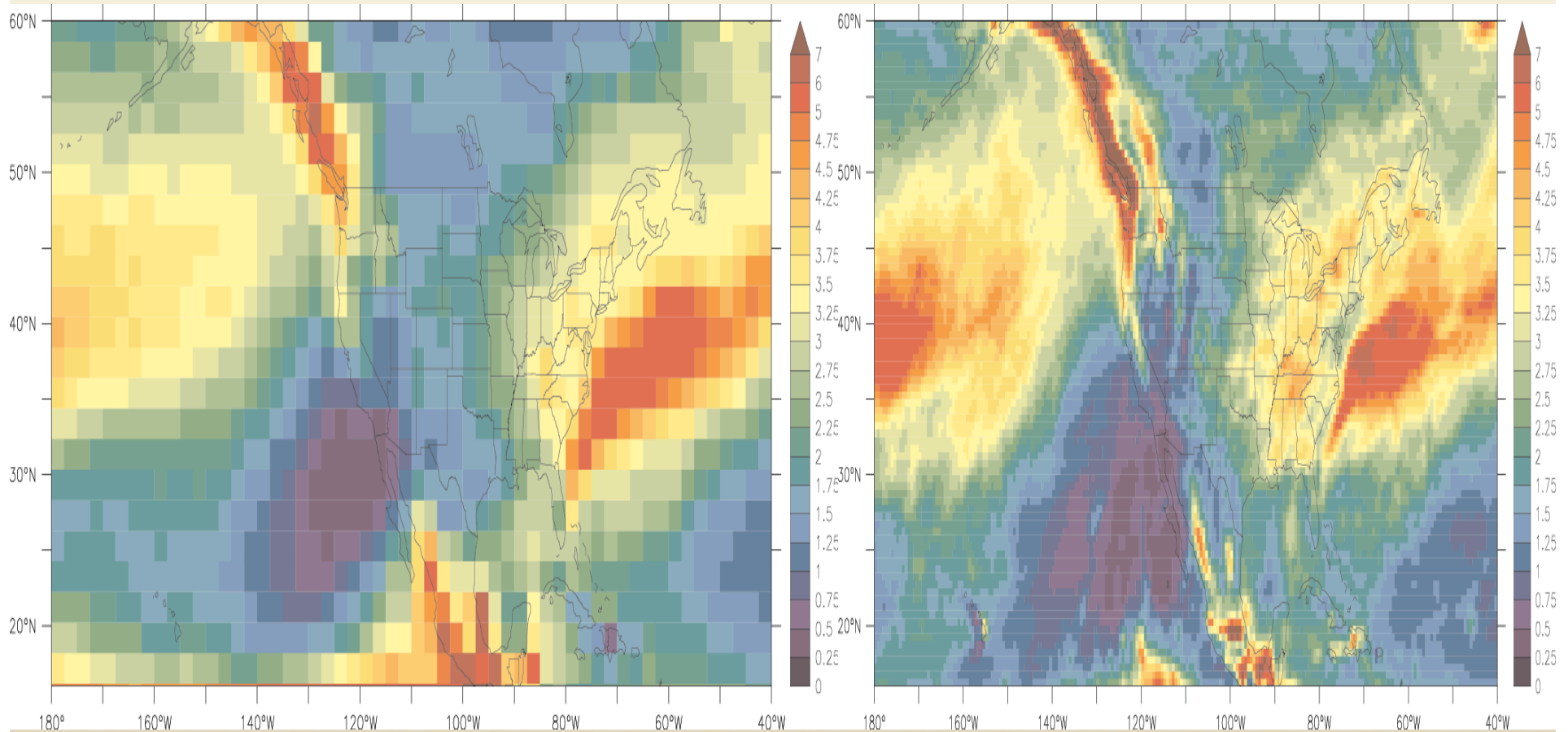
CM2.1



# PRECIPITATION (mm/day)

CM2.1

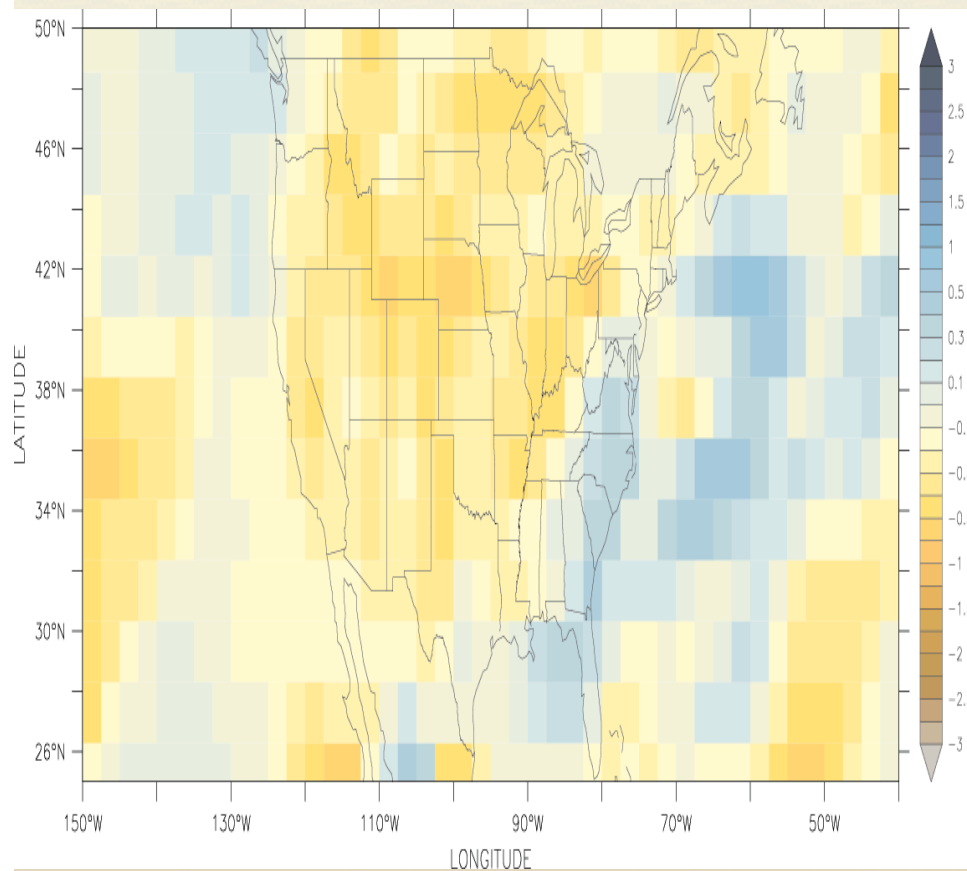
CM2.5





# DELTA PRECIPITATION (mm/day)

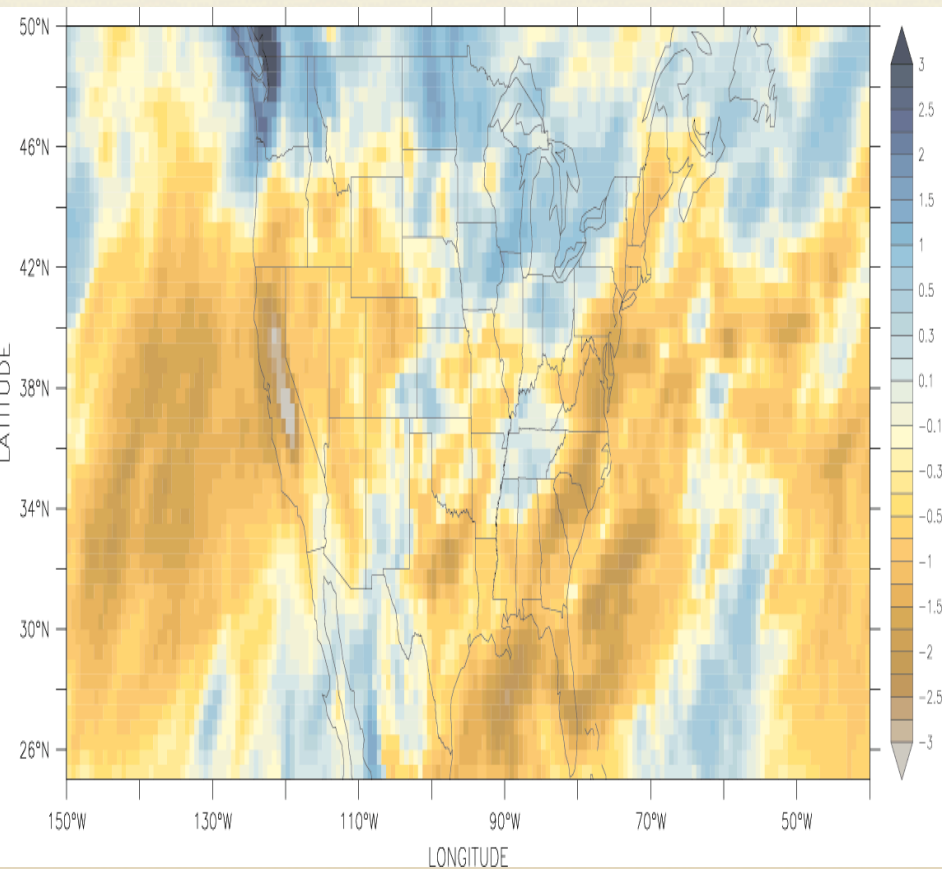
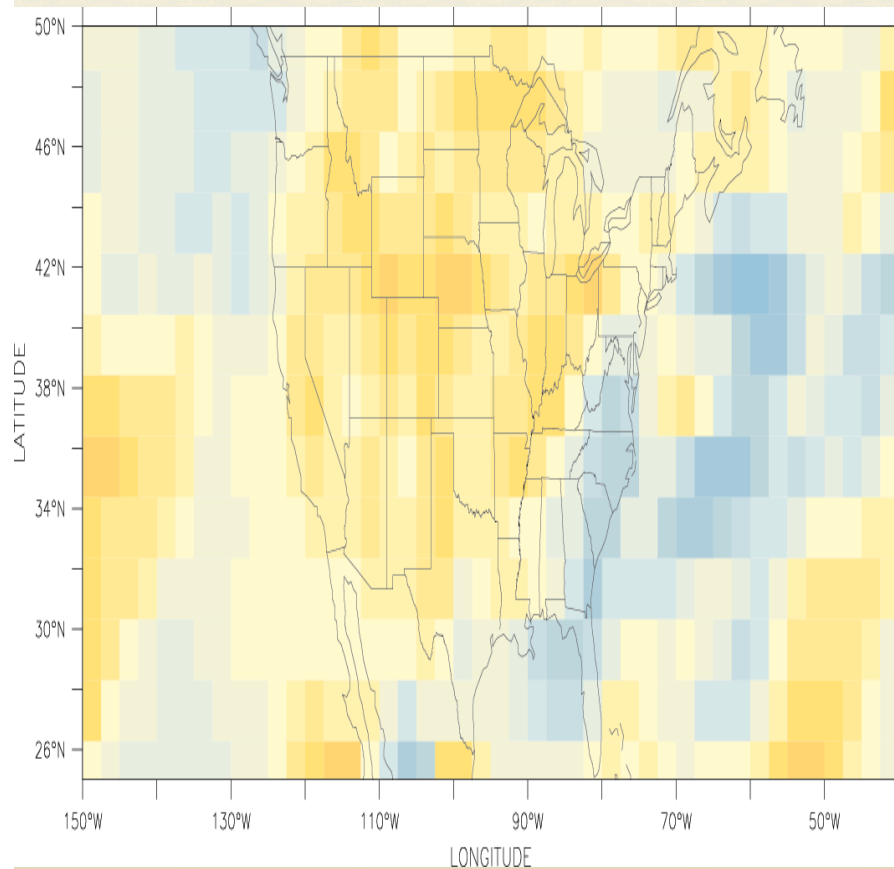
CM2.1



# DELTA PRECIPITATION (mm/day)

CM2.1

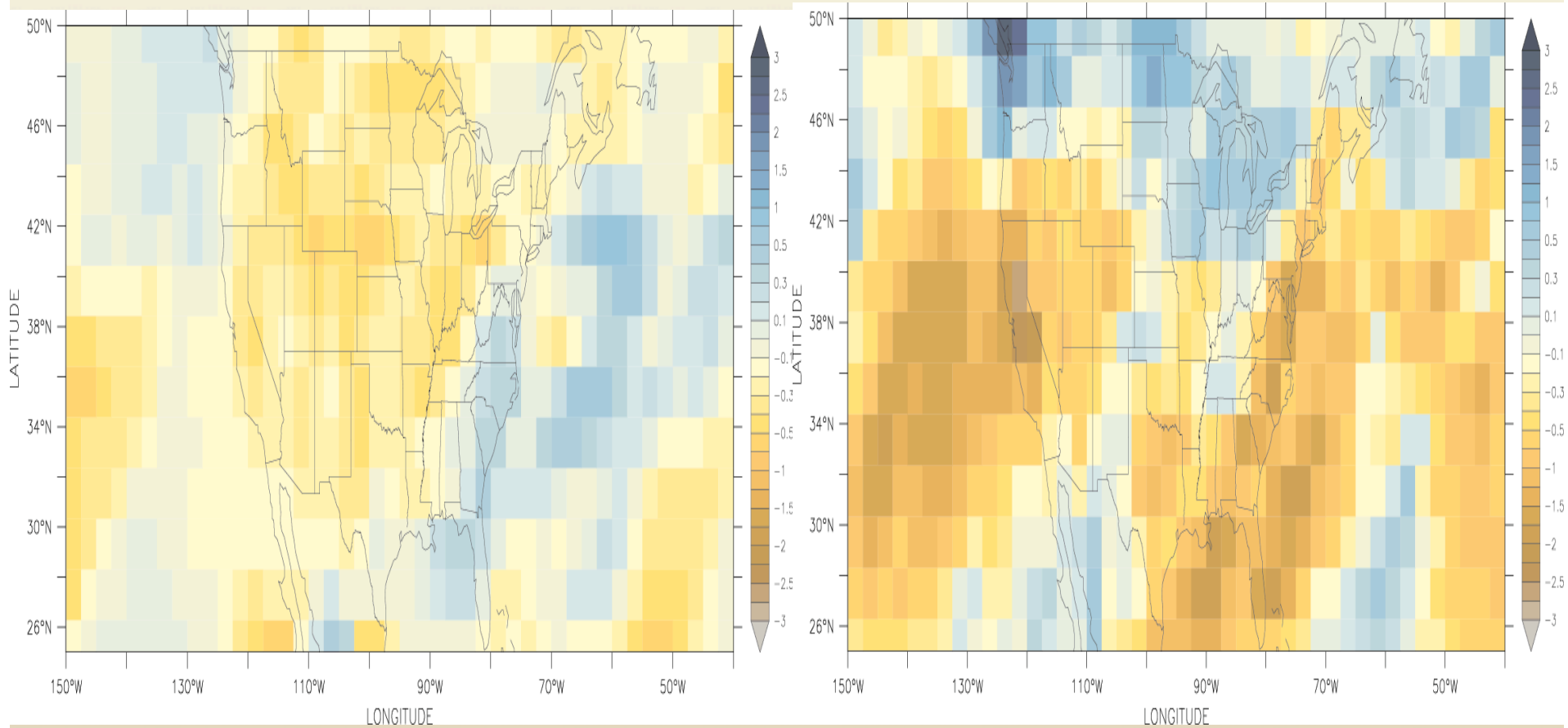
CM2.5



# DELTA PRECIPITATION (mm/day)

CM2.1

CM2.5@cm2.1



**Complicating factor:** Changing radiative forcing alters not only the thermal structure of the ocean, but its circulation as well. This complicates attribution.

Simulated North Atlantic AMOC Index

$10^6 \text{ m}^3 \text{ s}^{-1}$  (Sverdrups)

