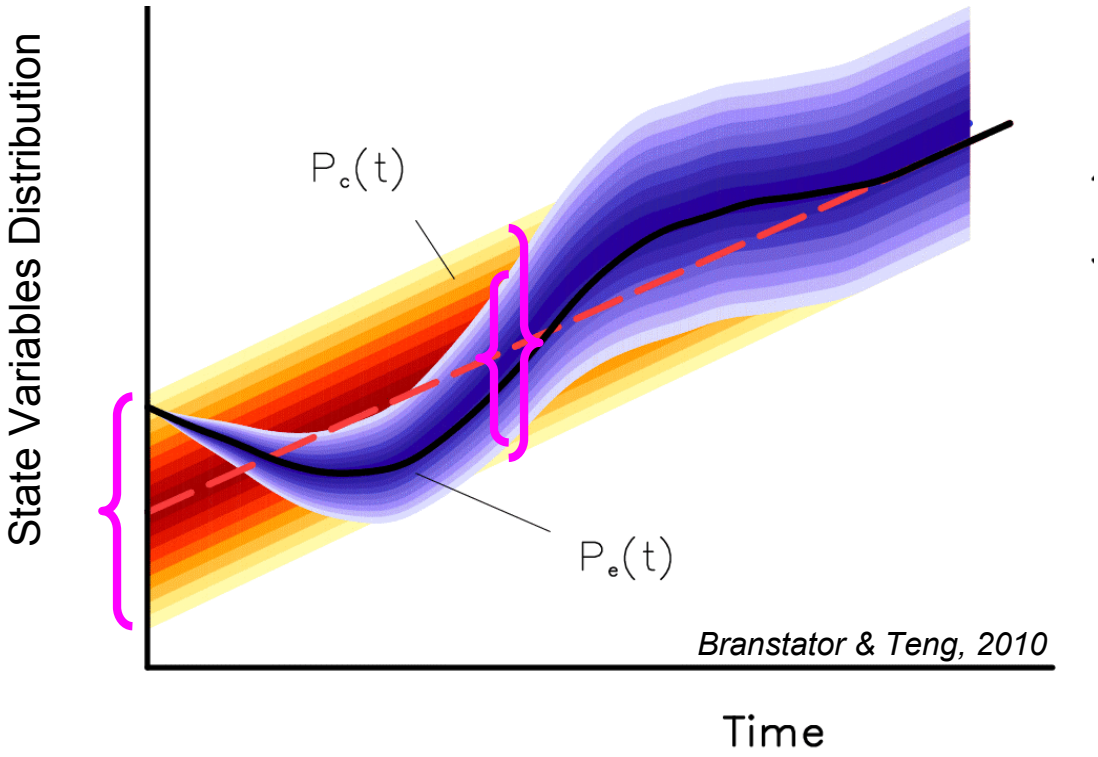
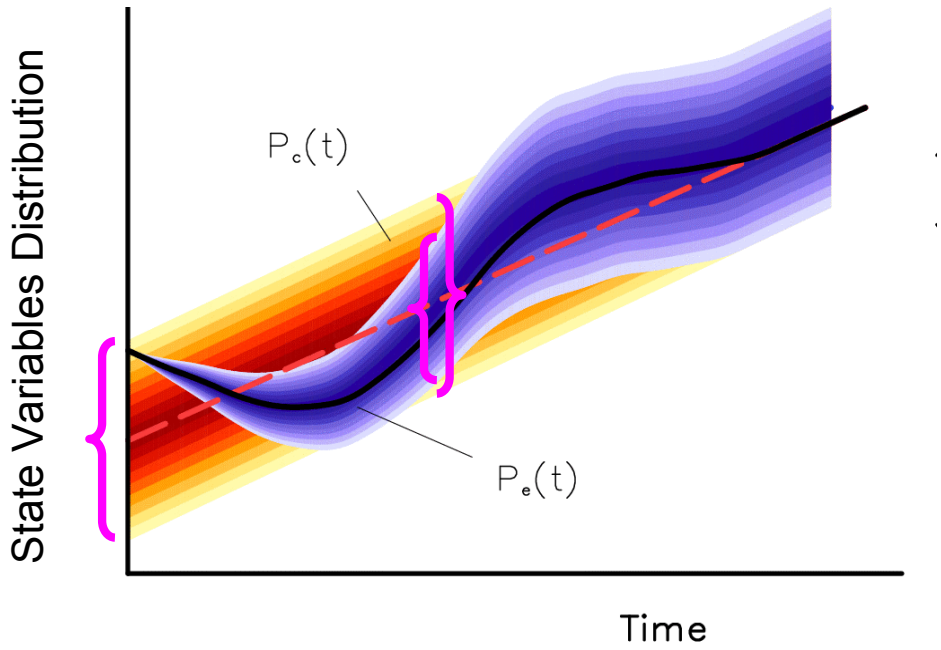
# Initial Value Predictability

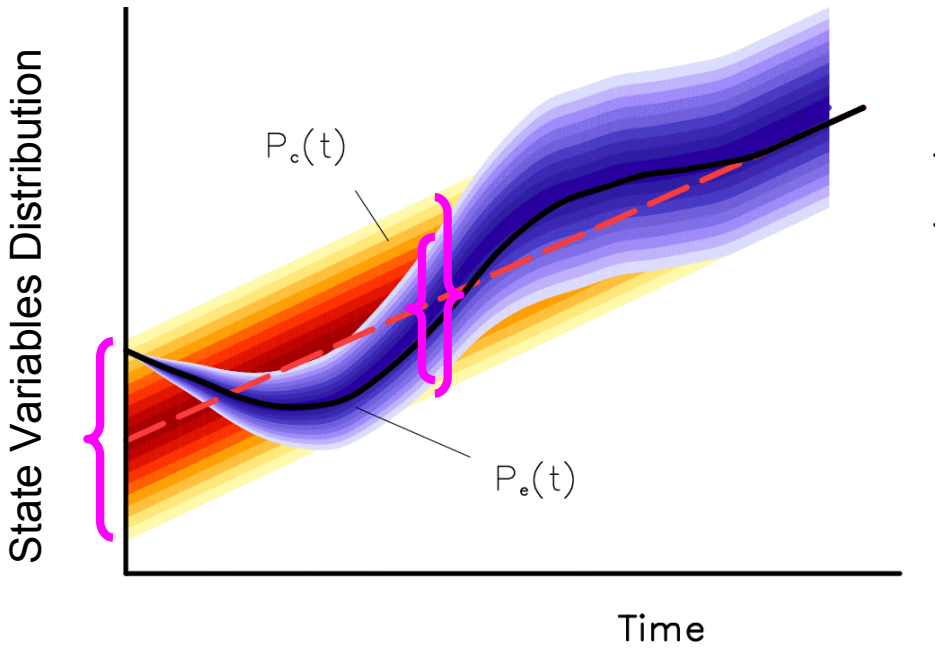


# The Reliability of AOGCM Decadal Predictability Properties

**Grant Branstator & Haiyan Teng**

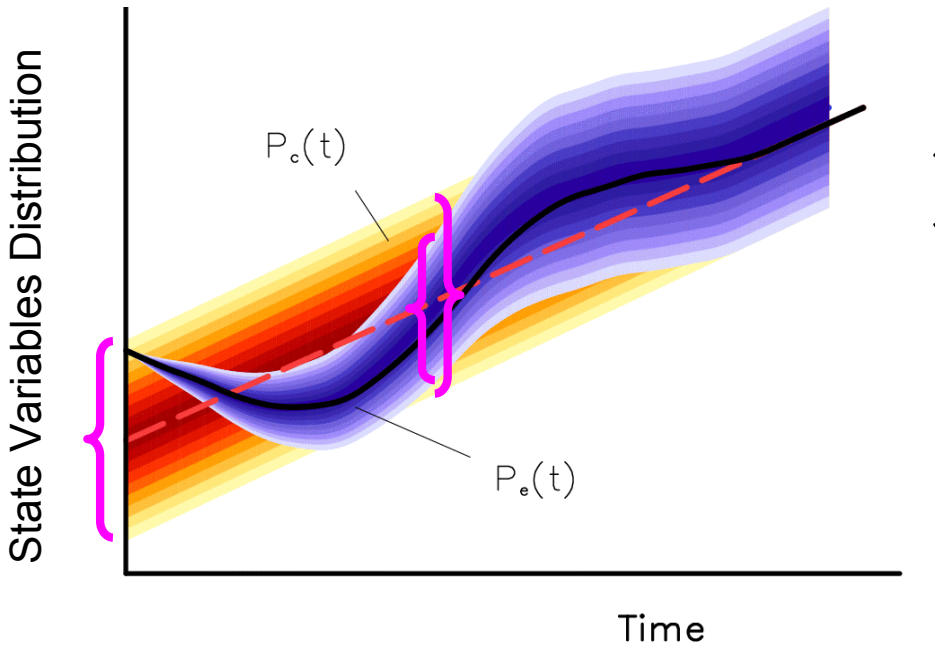
**G. Meehl, M. Kimoto, J. Knight, M. Latif, A. Rosati**


State Variables Distribution
$P_c(t)$
$P_e(t)$
Time

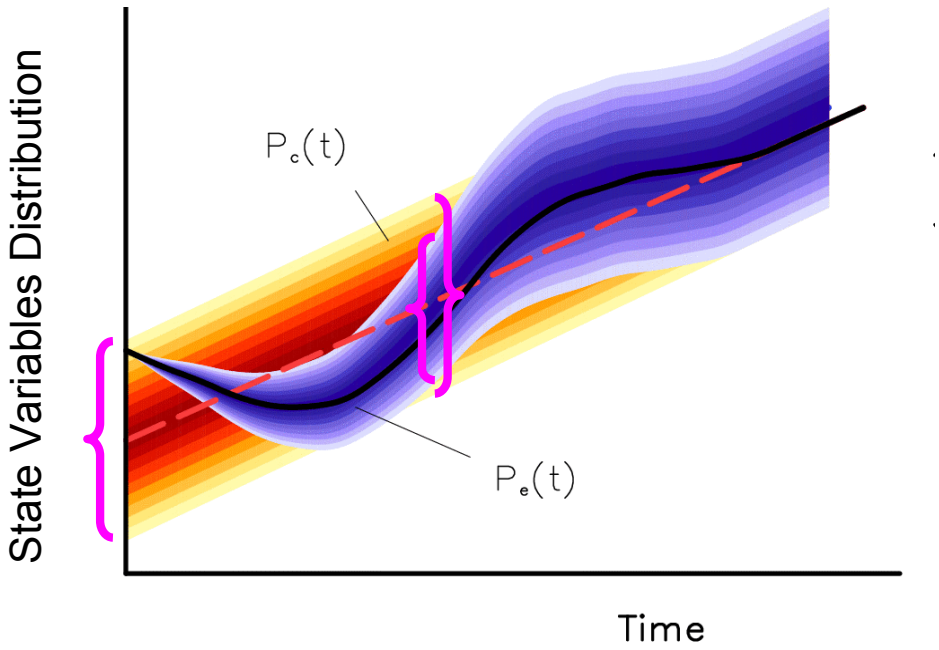



## ✓ Control Runs

- CCSM3, NCAR ……700yr
- CCSM4, NCAR ……700yr
- KCM, University of Kiel ……..4200yr
- CM2.1, GFDL……..2500yr
- MIROC3.2, CCSR & JAMSTEC …...3600yr
- HadCM3, Hadley Centre ……...5400yr



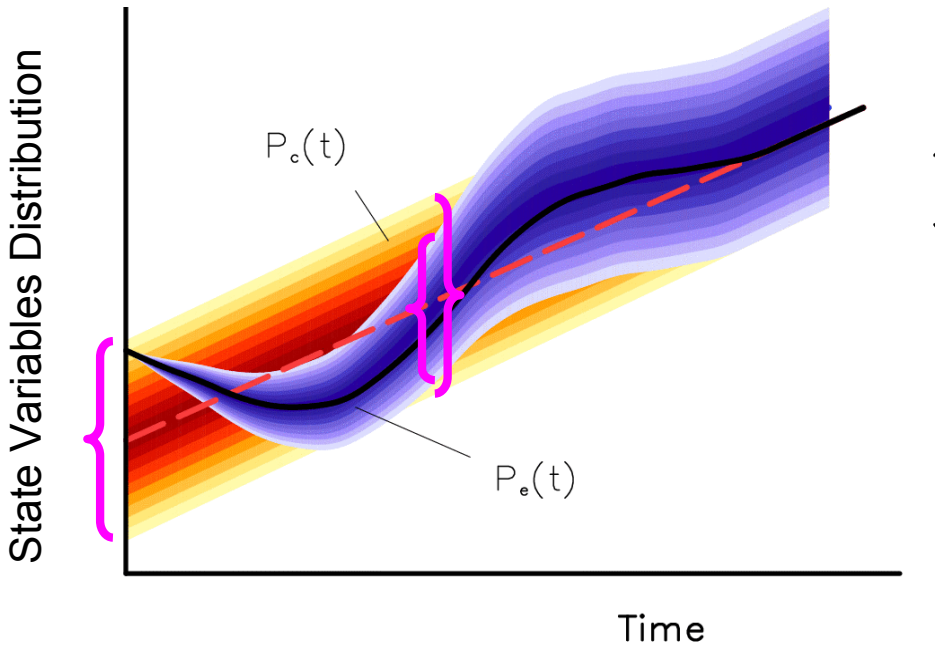

- ✓ Control Runs
- ✓ Attractor averages




- ✓ Control Runs
- ✓ Attractor averages
- ✓ Relative entropy

$$R = \int_S P_e(s) \ln\left[\frac{P_e(s)}{P_c(s)}\right] ds =_G \frac{1}{2}\left[\ln\left(\frac{\sigma_c^2}{\sigma_e^2}\right) + tr\,\frac{\sigma_e^2}{\sigma_c^2} + (\mu^e - \mu^c)^T \sigma_c^{-2} (\mu^e - \mu^c) - n\right]$$

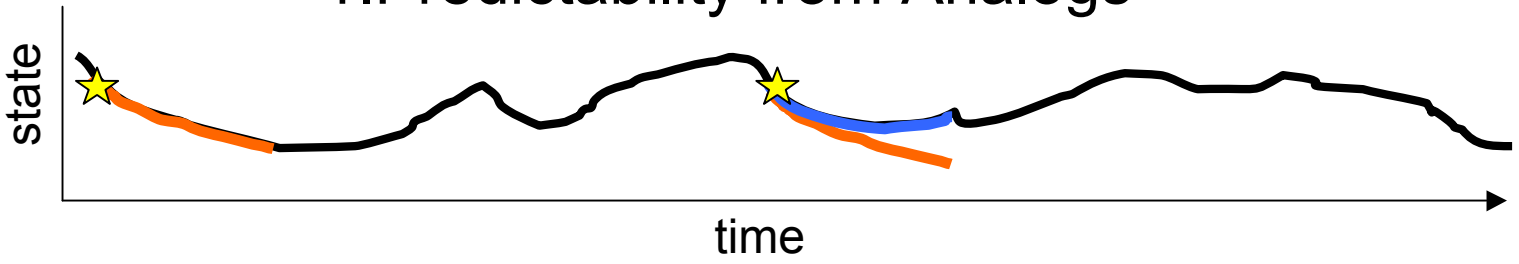
*dispersion* *signal*



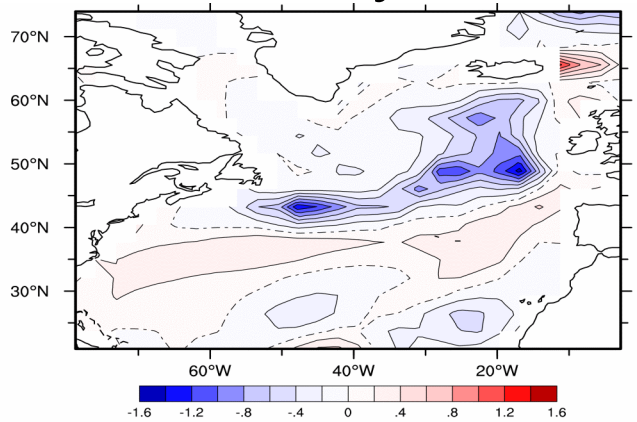

- ✓ Control Runs
- ✓ Attractor averages
- ✓ Relative entropy
- ✓ Annual mean upper 300m temperature

# Methods

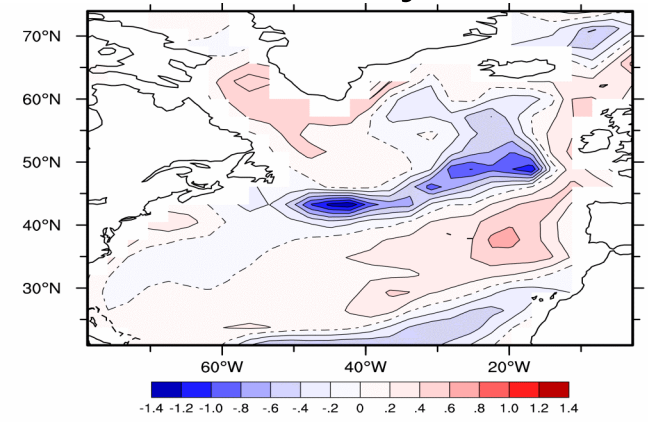
## 1.Predictability from Analogs




CCSM3 yr 236

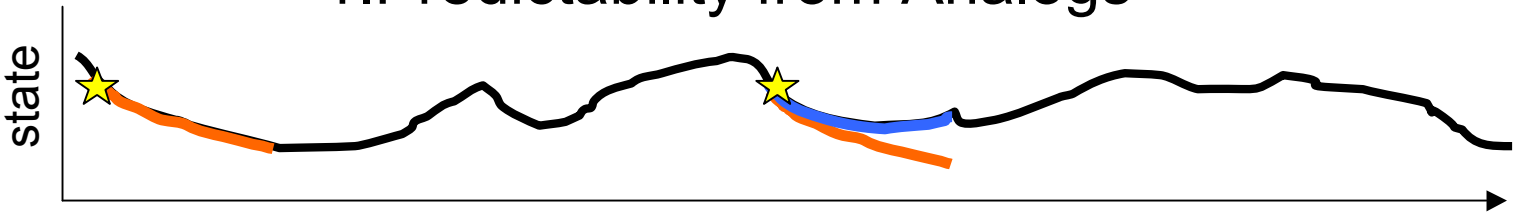



CCSM3 yr 337

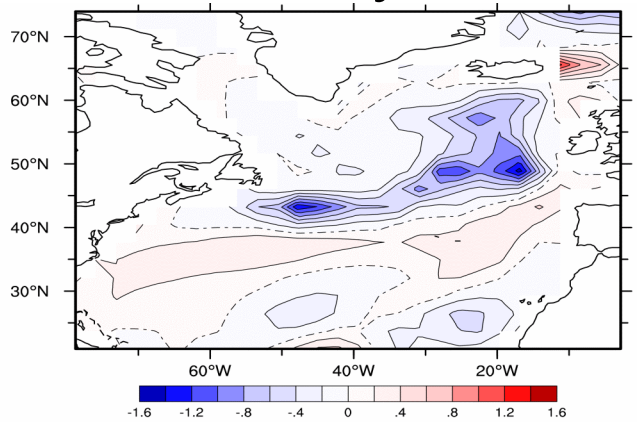


# Methods

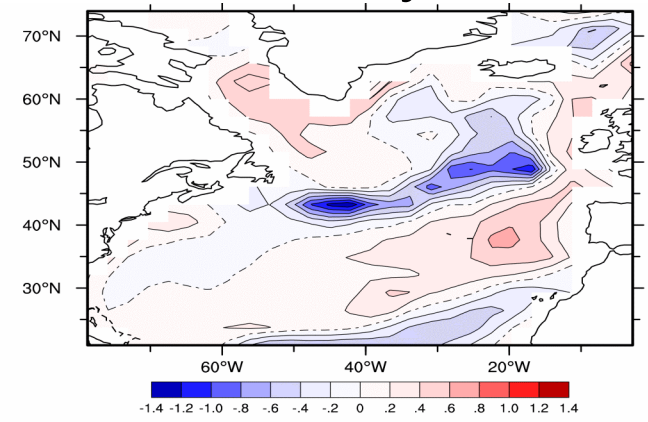
## 1.Predictability from Analogs




CCSM3 yr 236




CCSM3 yr 337

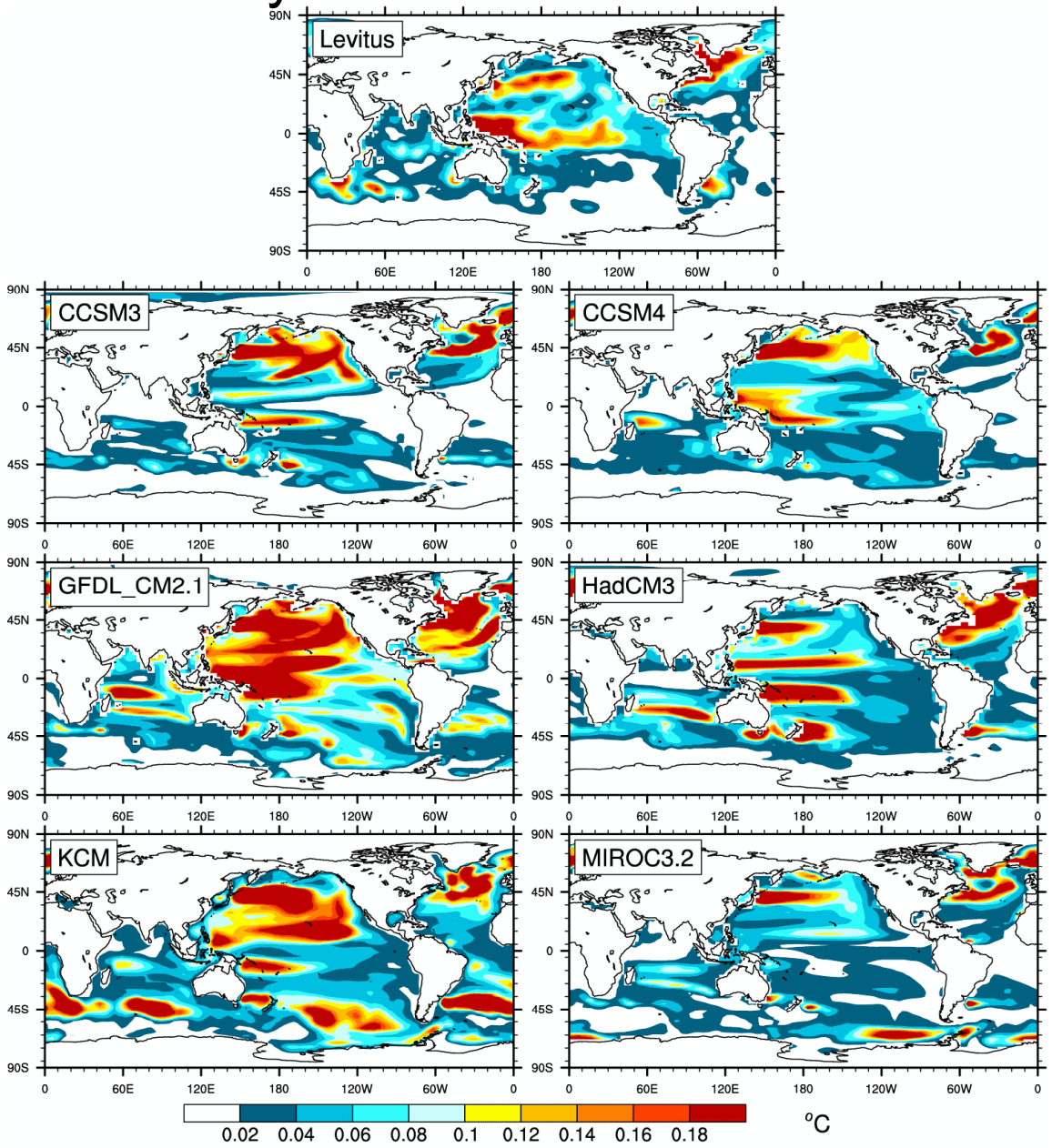



## 2.Predictability from Multivariate Regression Propagators

$$x(t) = \mathbf{C}(t - t_0)\mathbf{C}^{-1}(0)x(t_0), \quad \text{for } \mathbf{C}(\tau) = \text{lag cov matrix}$$

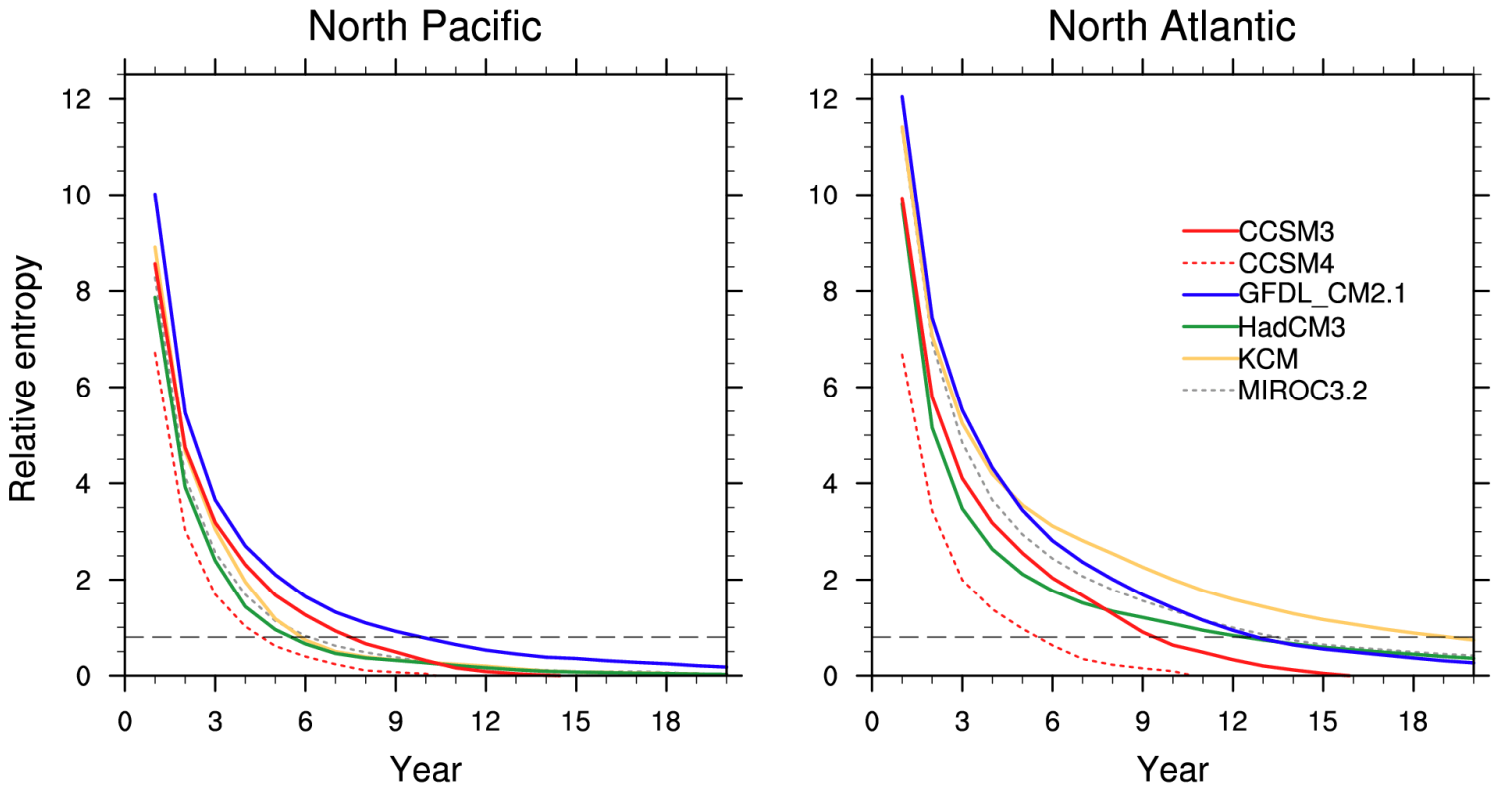
- DelSole & Tippet (2009)
- Lorenz (1969)

# T0-300 5yr Low-Pass Standard Deviation



# Basin Total Relative Entropy

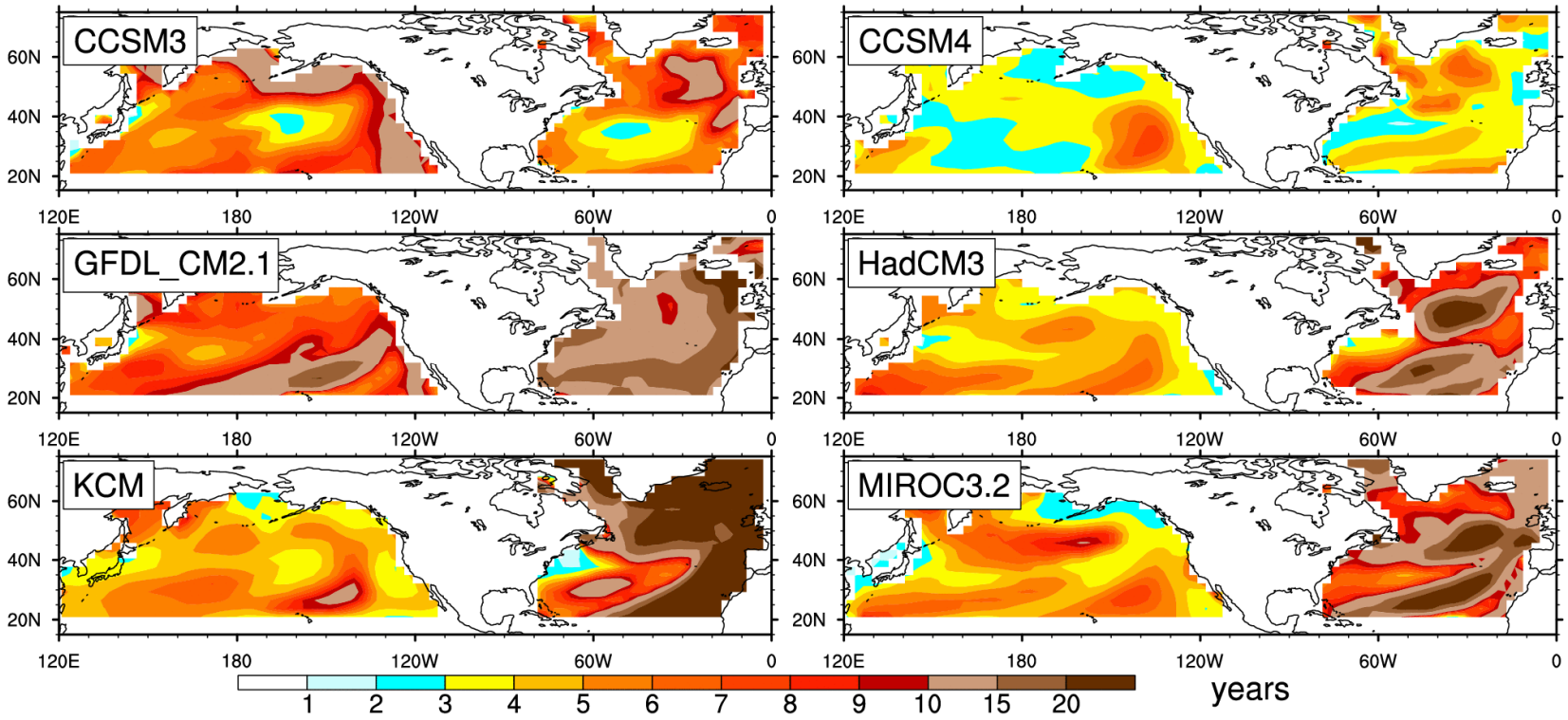
*multivariate regression method*




*10 PCs*

# Year of Nominal Predictability Limit

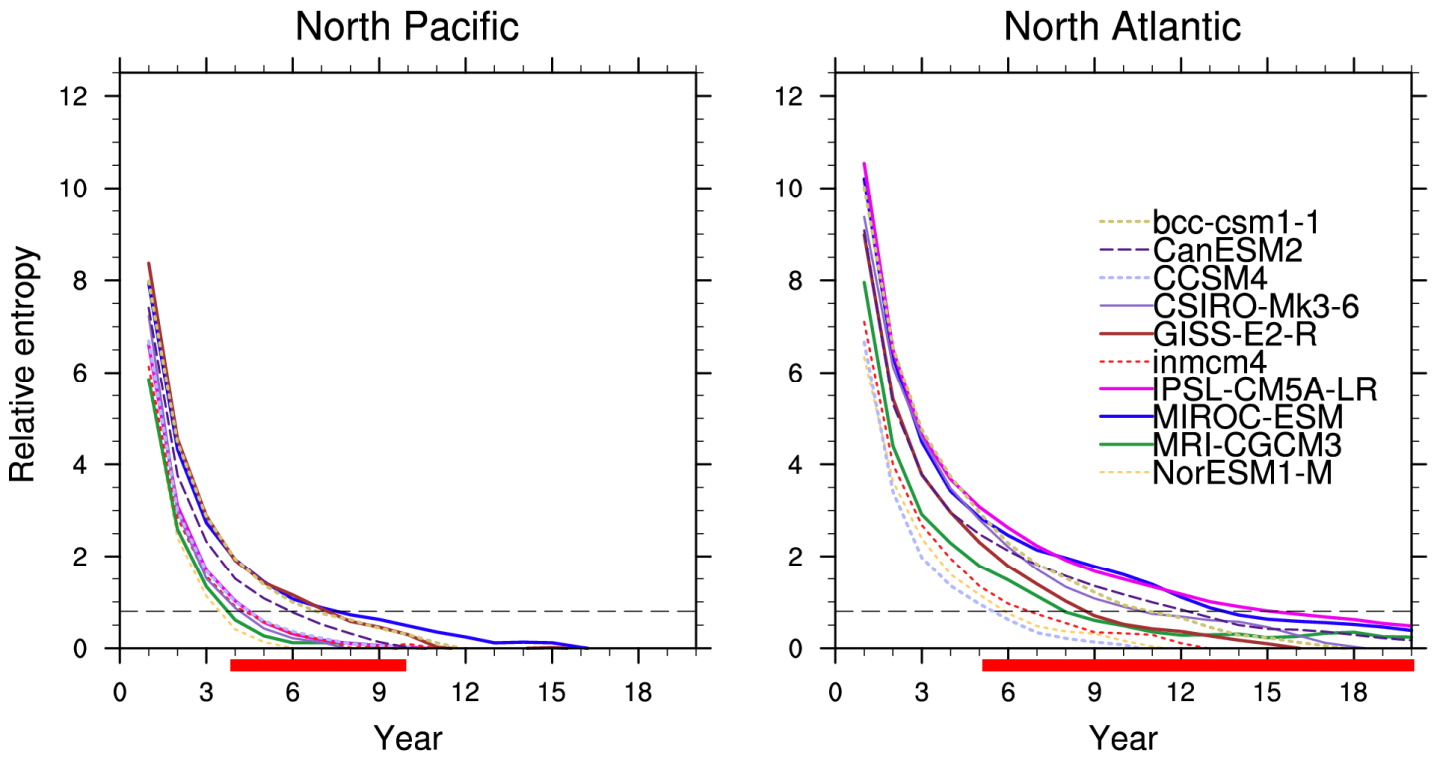
*multivariate regression method*



# CMIP5 Models

## Basin Total Relative Entropy

*multivariate regression method*

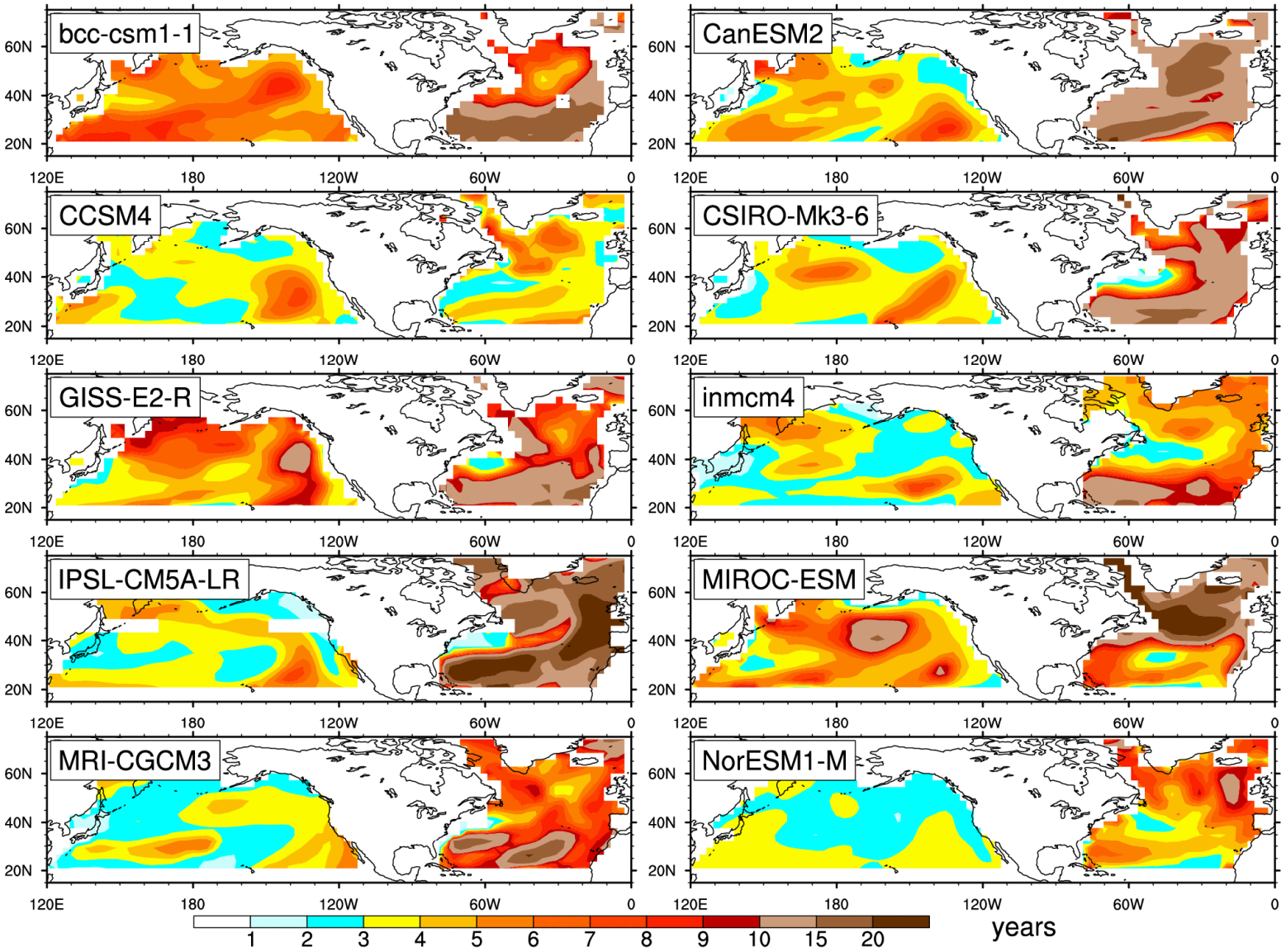



*10 PCs*

# CMIP5 Models

## Year of Nominal Predictability Limit

*multivariate regression method*



## Summary

** For basins, T0-300 initial value predictability limit is roughly a **decade***

** Predictability limits vary substantially from model to model and from region to region*

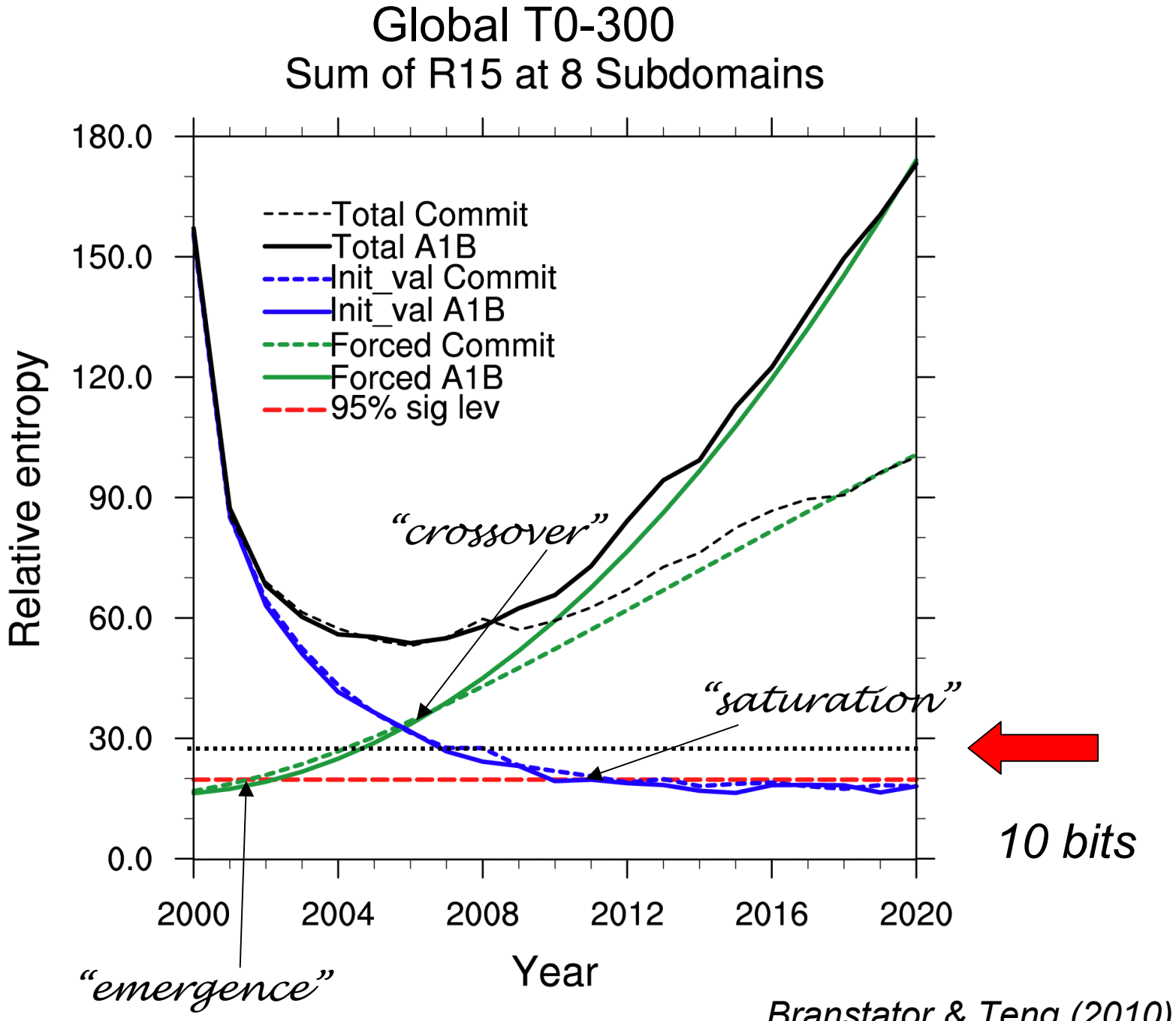
## Ergo

** Many, and possibly all, AOGCMs misrepresent nature's initial value decadal predictability*

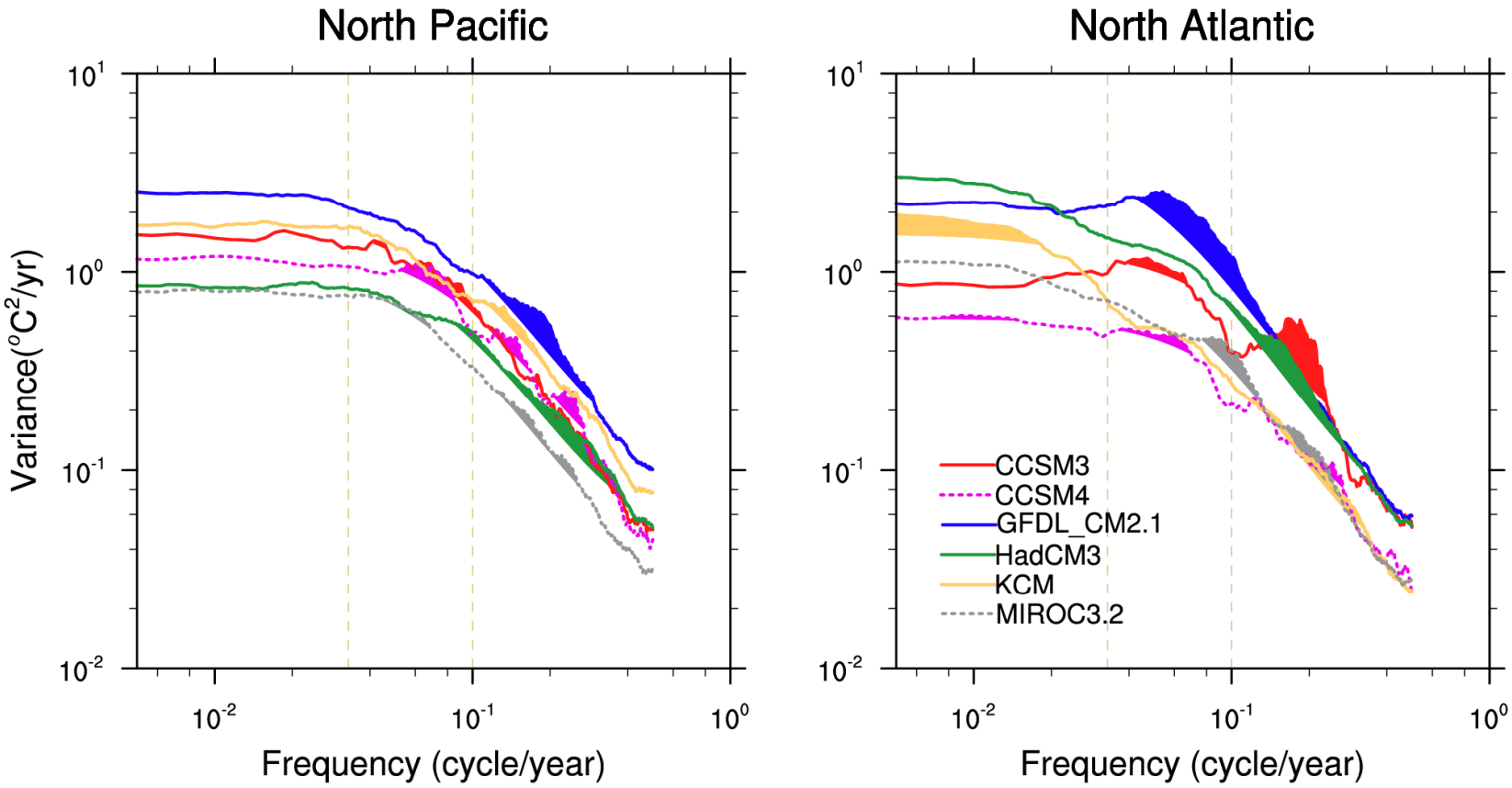
** An essential component of any decadal prediction effort is quantification of the predictability of the forecast model*

## More

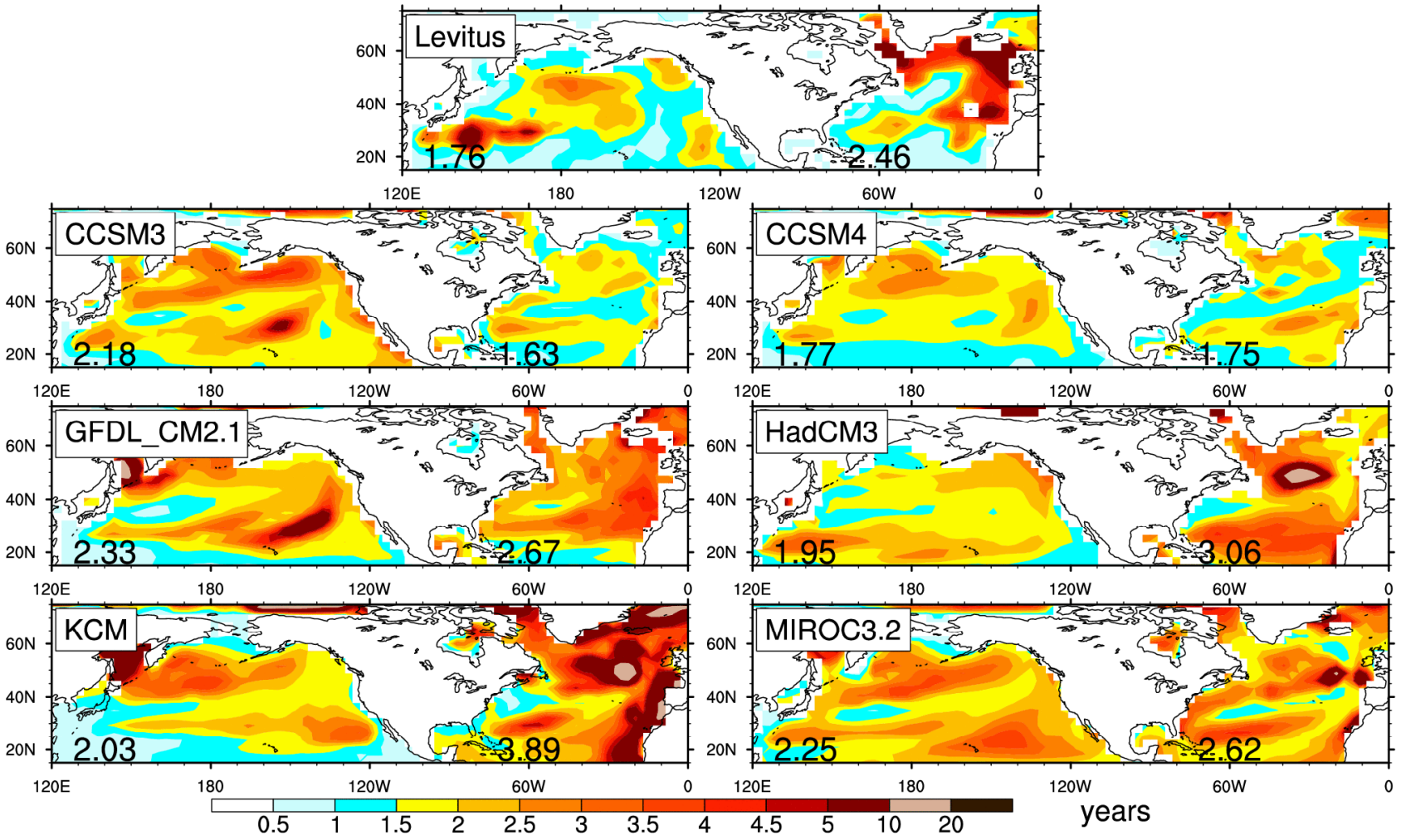

** Branstator & Teng, 2010, JCLIM*
** Teng & Branstator, 2011, Clim Dyn*
** Teng et al., in press, JCLIM*
** Branstator et al., in press, JCLIM*


Global T0-300
Sum of R15 at 8 Subdomains
Relative entropy
180.0
150.0
120.0
90.0
60.0
30.0
0.0
2000
2004
2008
2012
2016
2020
Year
Total Commit
Total A1B
Init_val Commit
Init_val A1B
Forced Commit
Forced A1B
95% sig lev
"crossover"
"saturation"
"emergence"
10 bits
Branstator & Teng (2010)

# Average Spectrum



# e-damping time

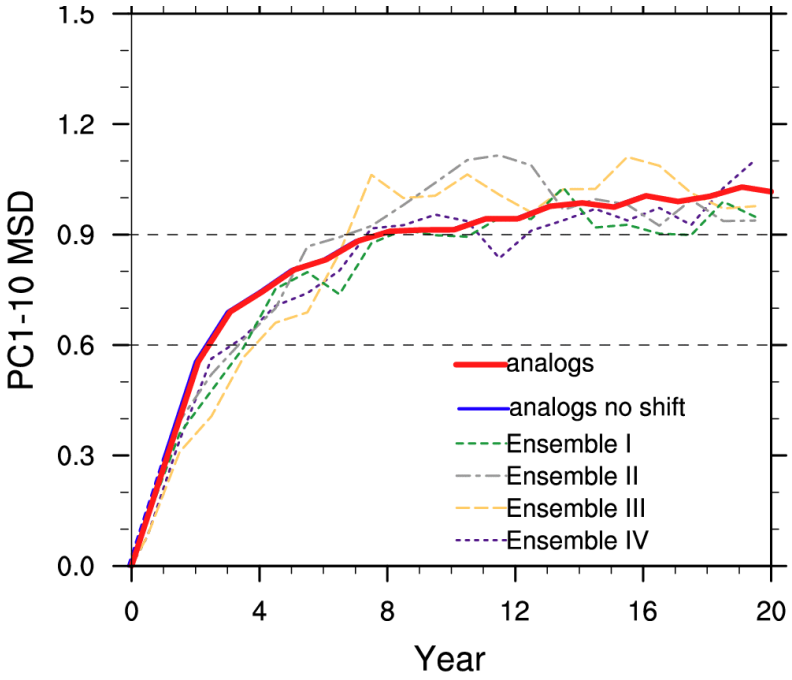


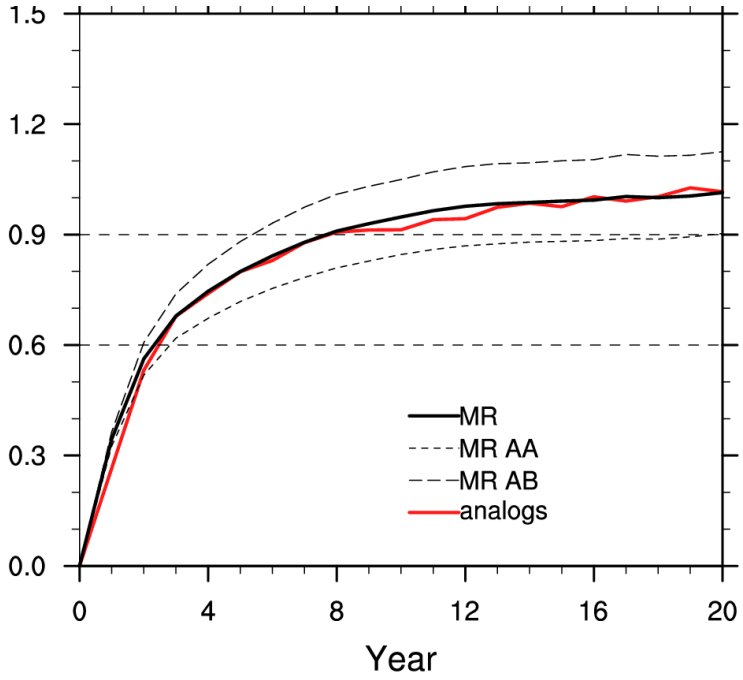
# Predictability from Ensembles, Analogs & Regression

## Attractor averages

CCSM3

North Pacific

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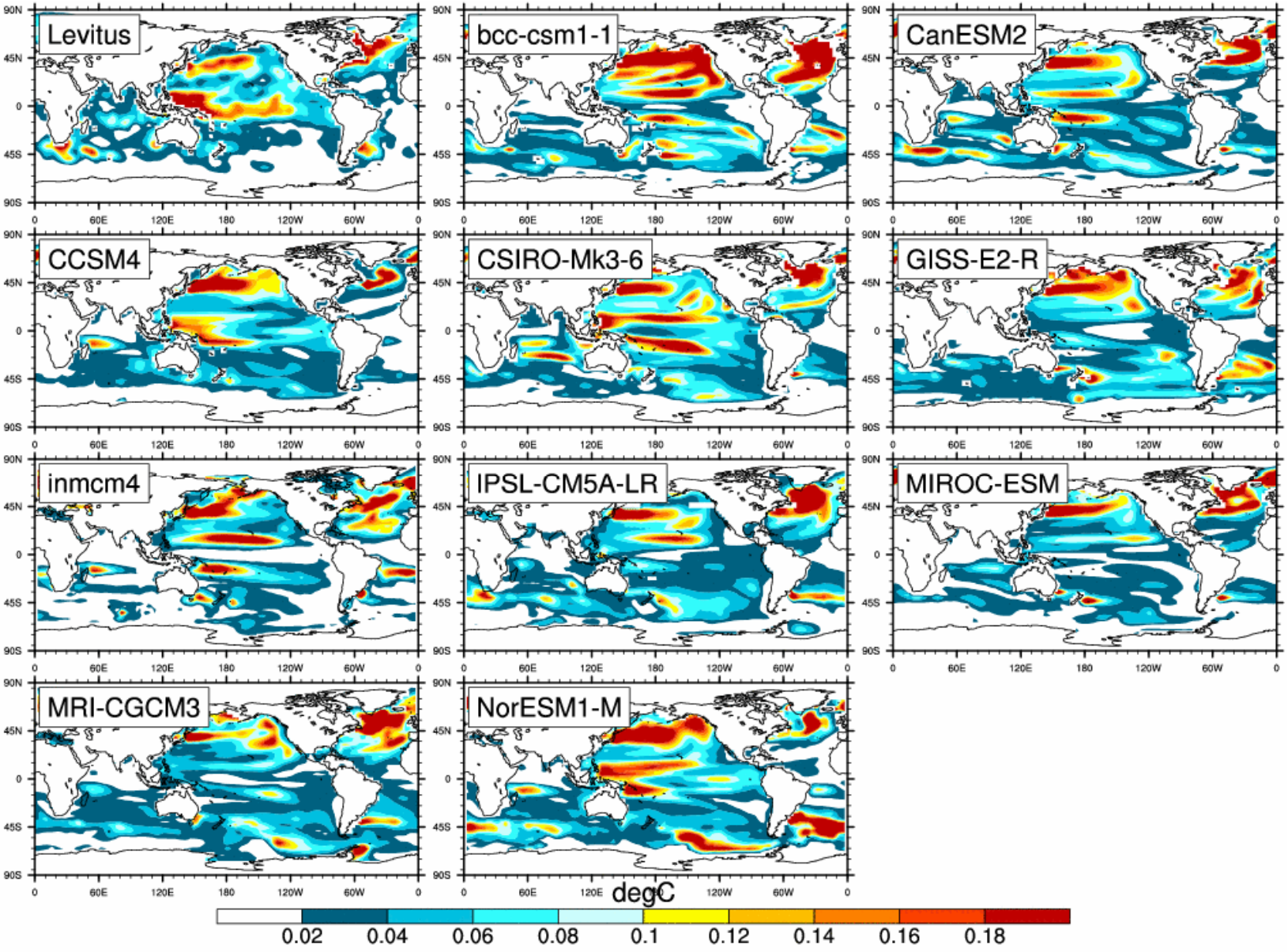
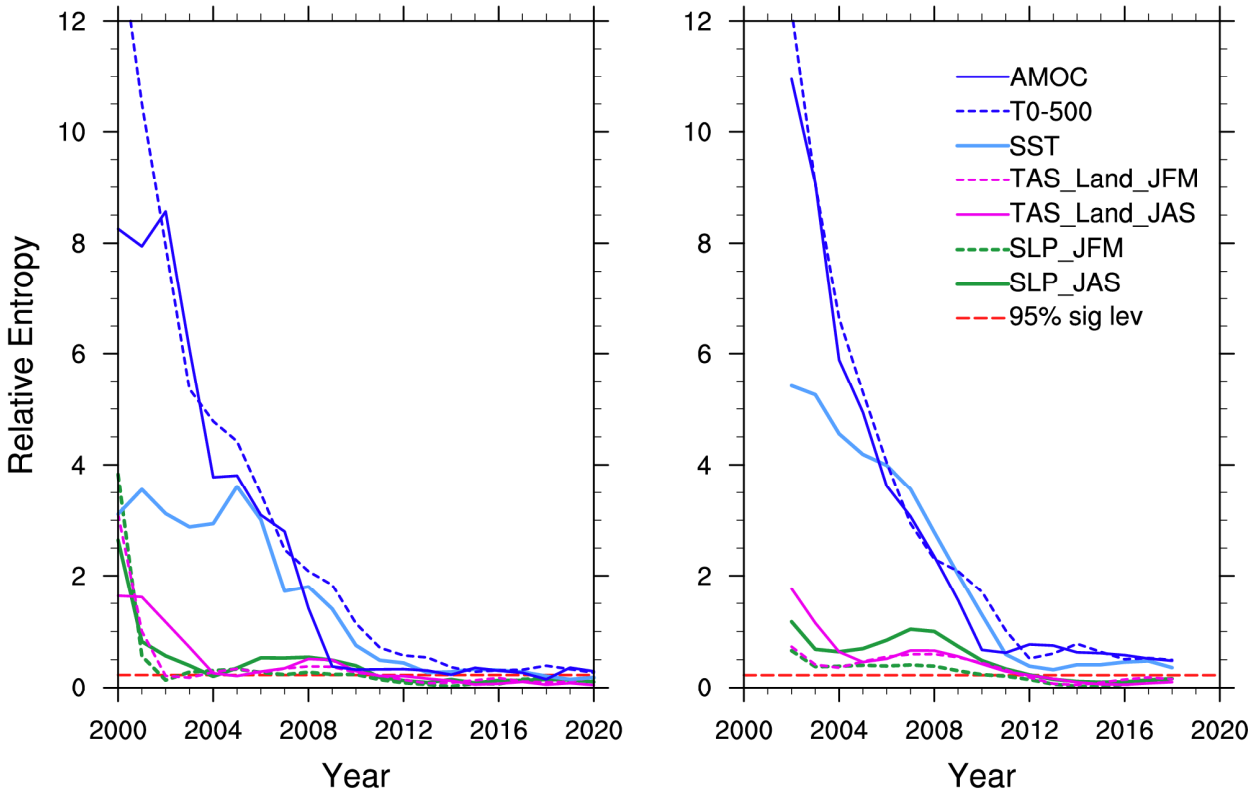
# CMIP5 Models
## T0-300 5yr Low-Pass Standard Deviation



# Predictability in 40 member ensemble



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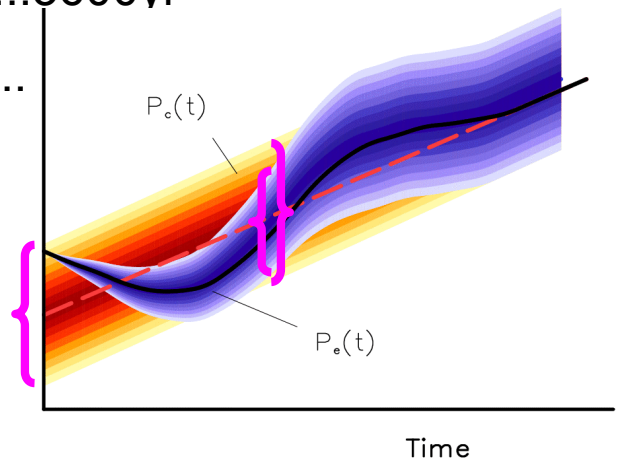


✓ Attractor averages

✓ Mean square difference

✓ Relative entropy

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*dispersion* *signal*

# Mean Square Difference

*analog method*