# Defining a Framework to Verify Initialized Decadal Predictions


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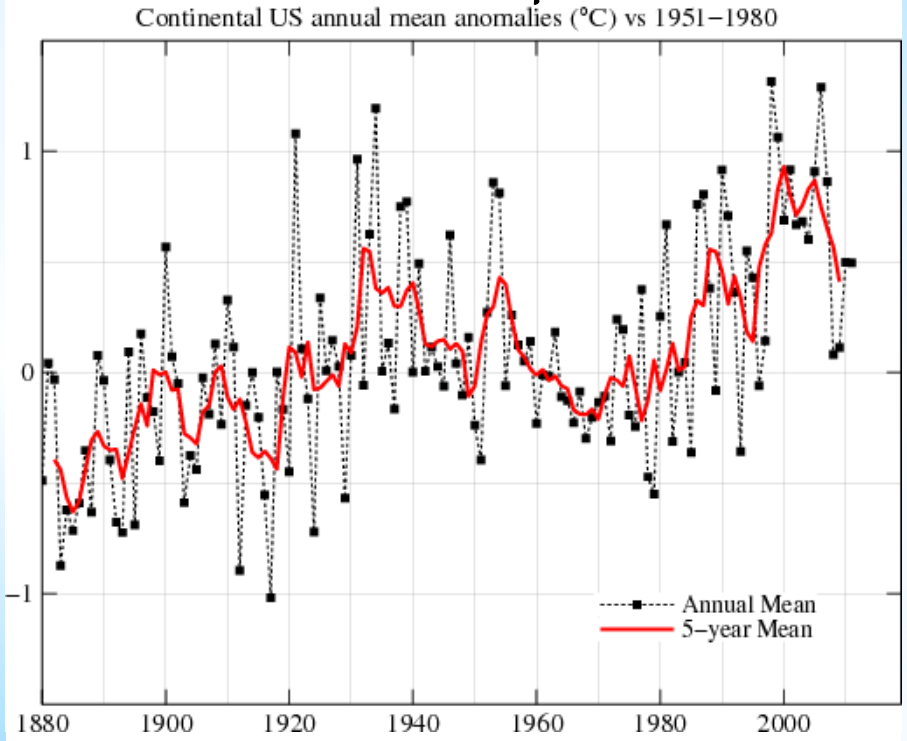
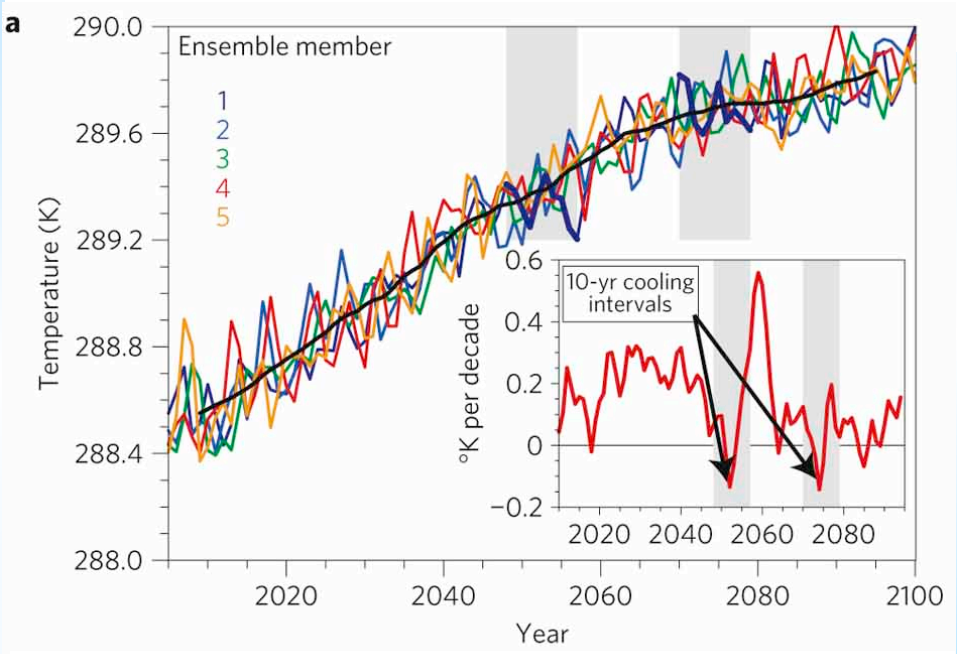
*…Untangling the natural and forced components of the climate is necessary since the response to external forcing may project onto or comingle with natural climate variability.*
*(DPWG White Paper, BAMS 2011)*

## Annual and 5-year Running Mean U.S. Surface Air Temperature



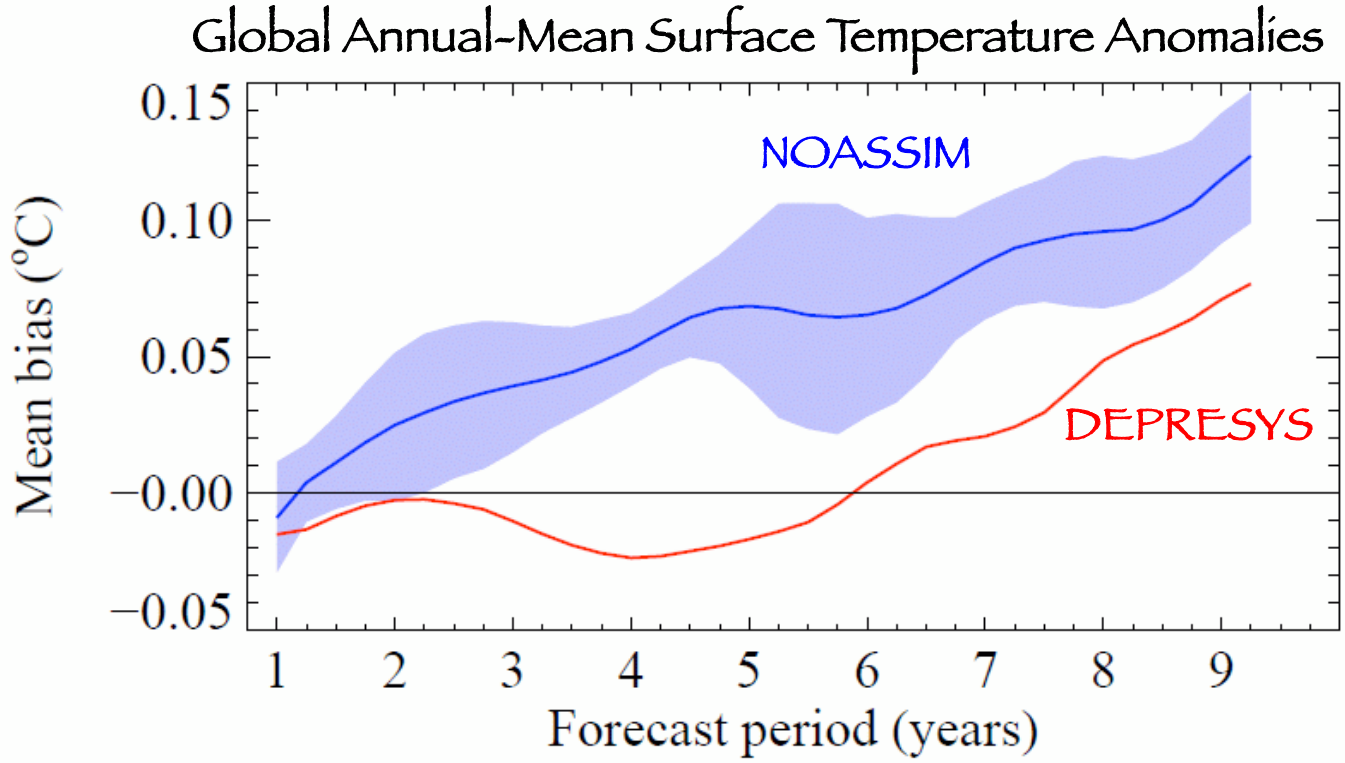

(http://data.giss.nasa.gov/gistemp)

## CCSM4 Annual Mean Globally Averaged Surface Temperature



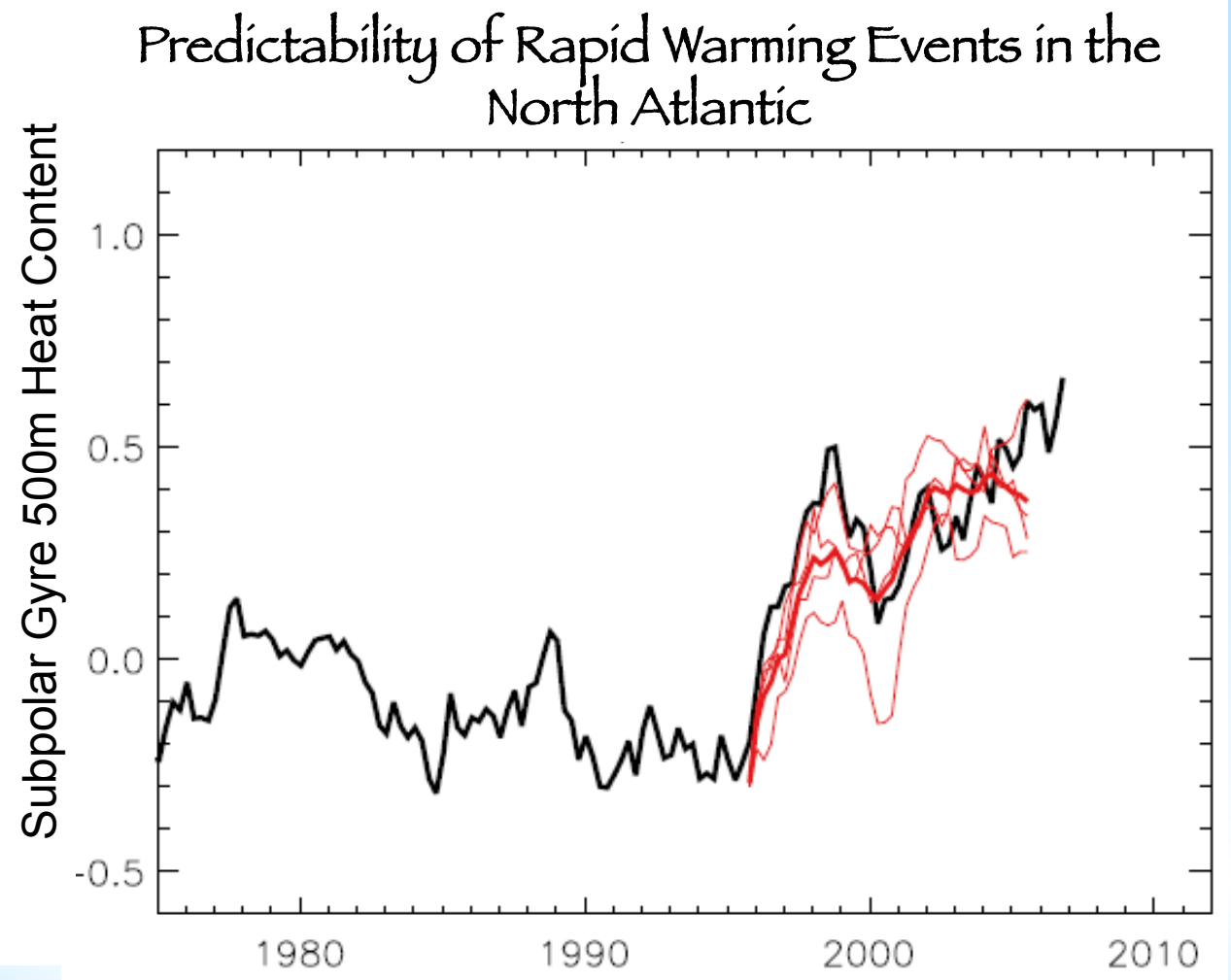

(Meehl et al. 2011)

# Motivation For Initialized DecPred Experiments: Improving Forecast Skill




"Improved Surface Temperature Prediction for the Coming Decade from a Global Climate Model" Smith et al. (2007)

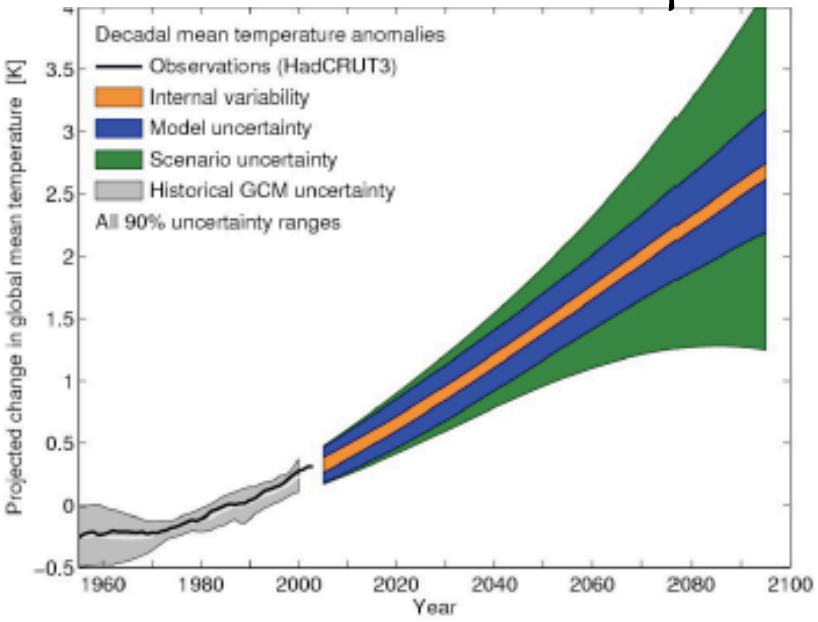
# Motivation For Initialized DecPred Experiments: Predicting Natural Decadal Variability

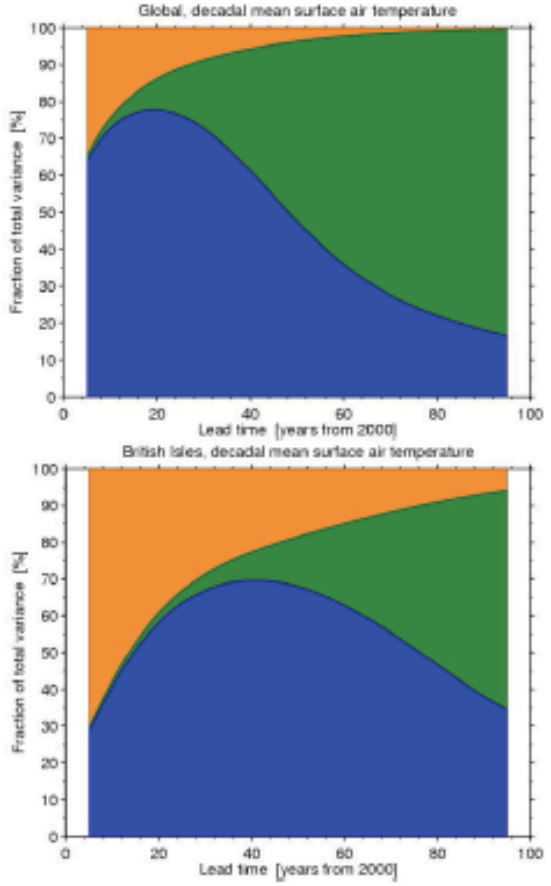


# Motivation For Initialized DecPred Experiments: Understanding Sources of Model Uncertainty

## Estimates of Uncertainty from CMIP3 Ensembles

### Decadal Mean Surface Air Temperature




Hawkins and Sutton (2009,2010)

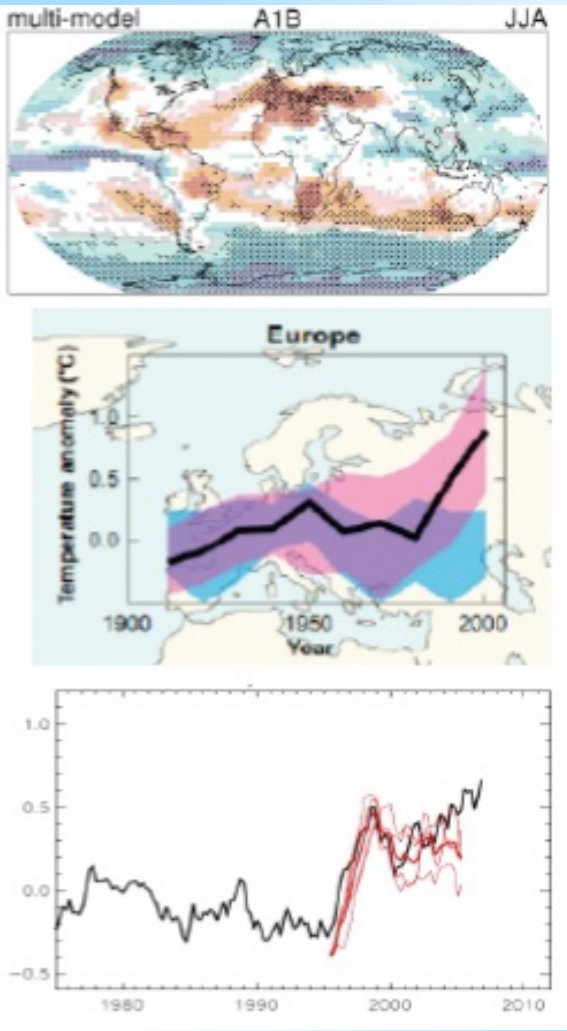
# Motivation For Initialized DecPred Experiments: Building Trust in Climate Projections

Increasing Trust in Decadal Predictions

Multi-Model Ensembles
-- Limited role for observations

Detection and Attribution
-- Isolate response to specific forcings
--Model errors may lead to false attribution

Initialized Decadal Hindcasts
-- Ability to use observations to test the fidelity of models over different time-scales and to verify simulations of different weather and climate phenomenon



# CMIP5 Initialized Decadal Prediction Experiments

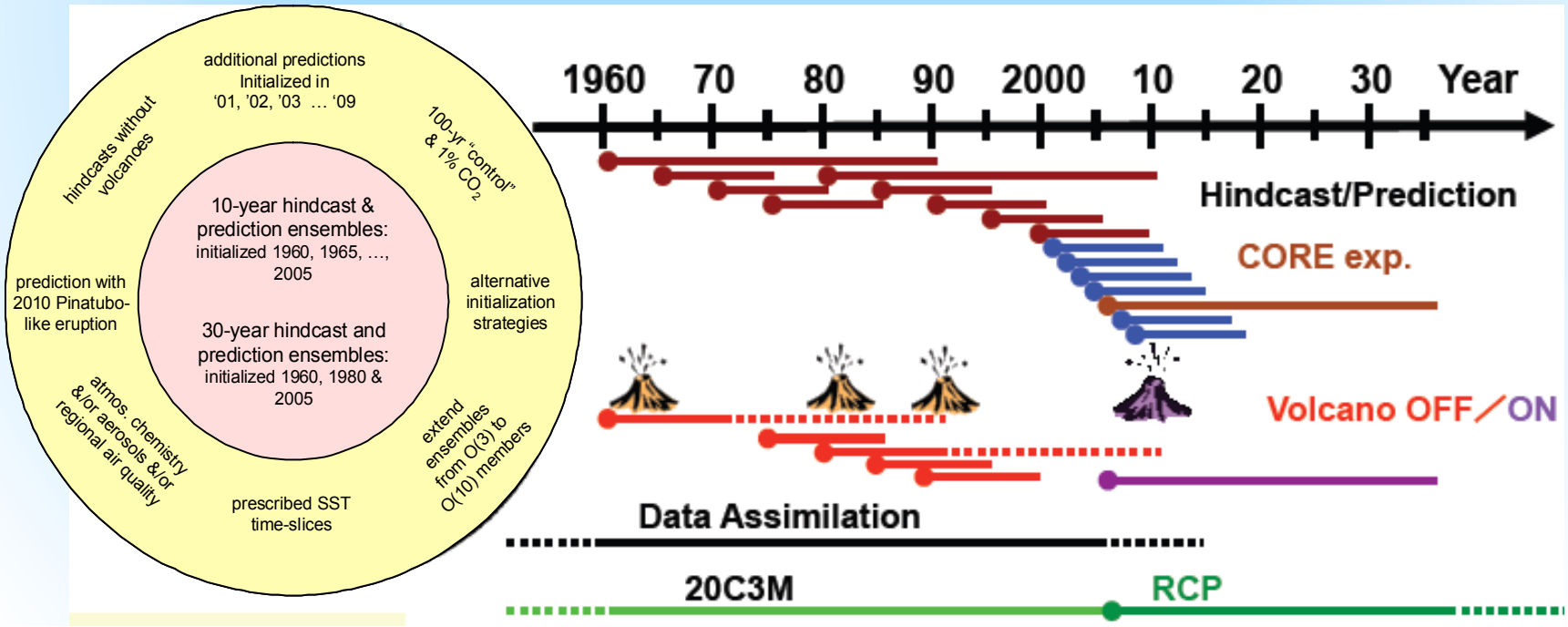



Figure 2. Schematic summary of CMIP5 decadal prediction experiments.

Taylor et al. (2008)

… There will be a new chapter in AR5 on Near-Term Climate Projections

# Challenges: Initialization Strategies

1) Full field initialization:
Forecast initial conditions are created by constraining model values to be close to observed values.

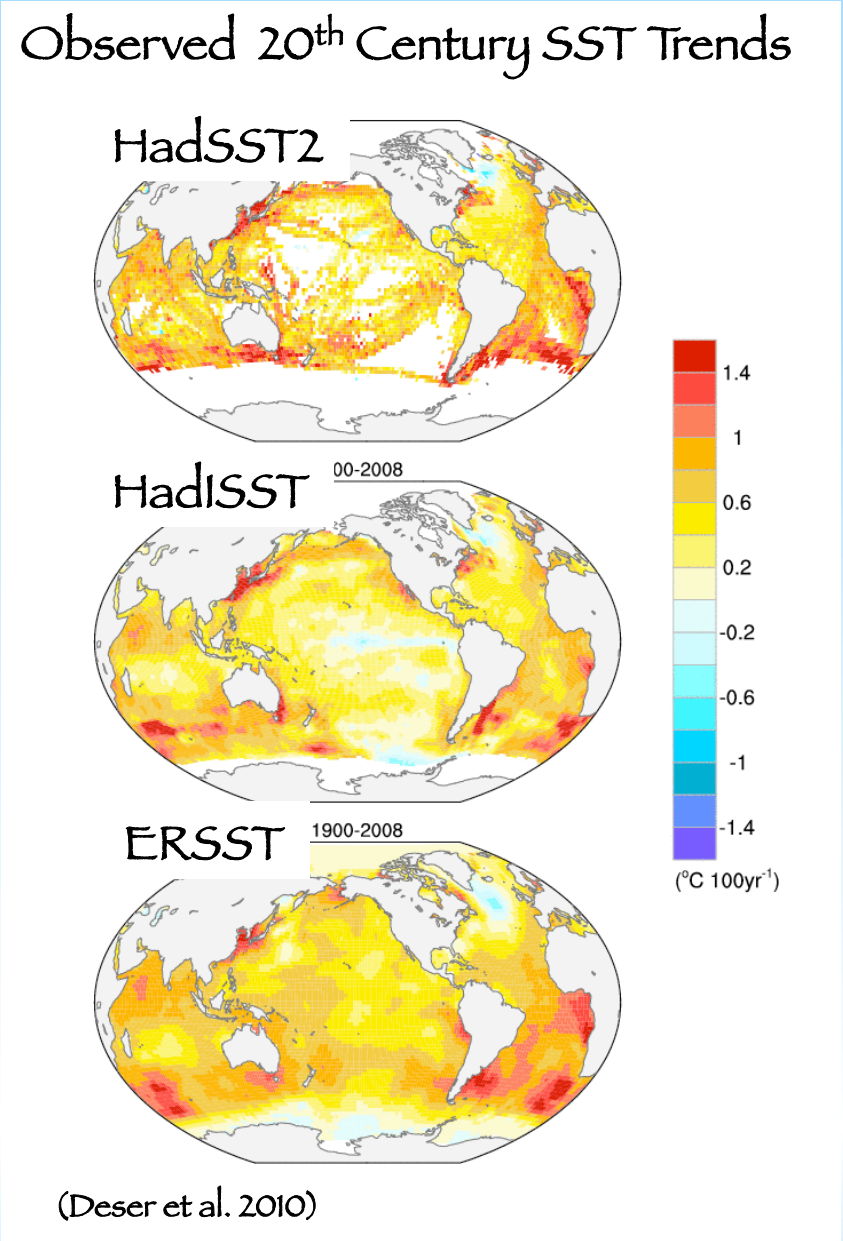
…Suffers from model drift and initial shocks

2) Anomaly initialization:
Models are initialized with observed anomalies rather than with observed total values (e.g. Pierce *et al.*, 2004, Smith *et al.*, 2007).

Overcomes drifts,
However observed anomalies might not be assimilated at optimal locations relative to features such as the Gulf Stream

Also, Initialize Full Ocean? Ocean+Atmos? just SSTs?

# Challenges: Validating Forced Variability

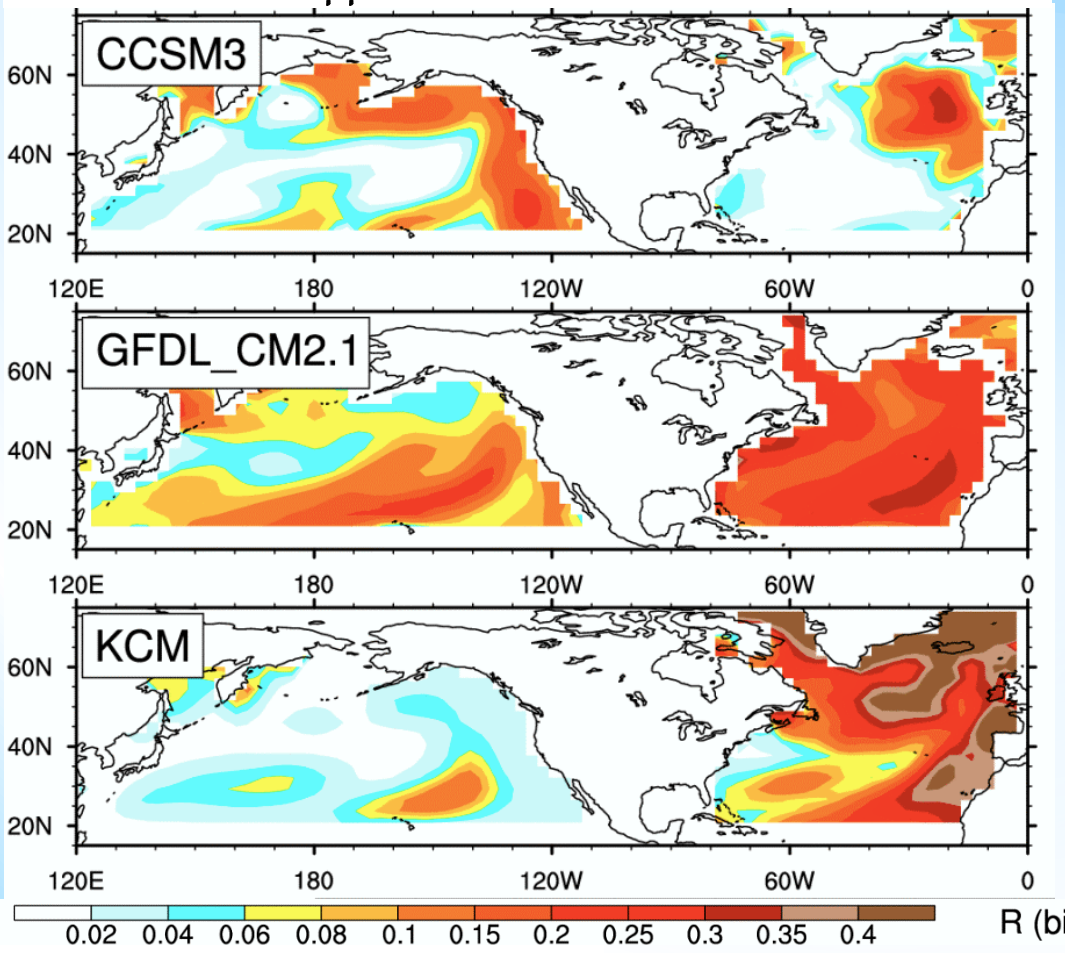



(Deser et al. 2010)

# Challenges: Predictability of Natural Variability

## Model-Dependent Regional Structure

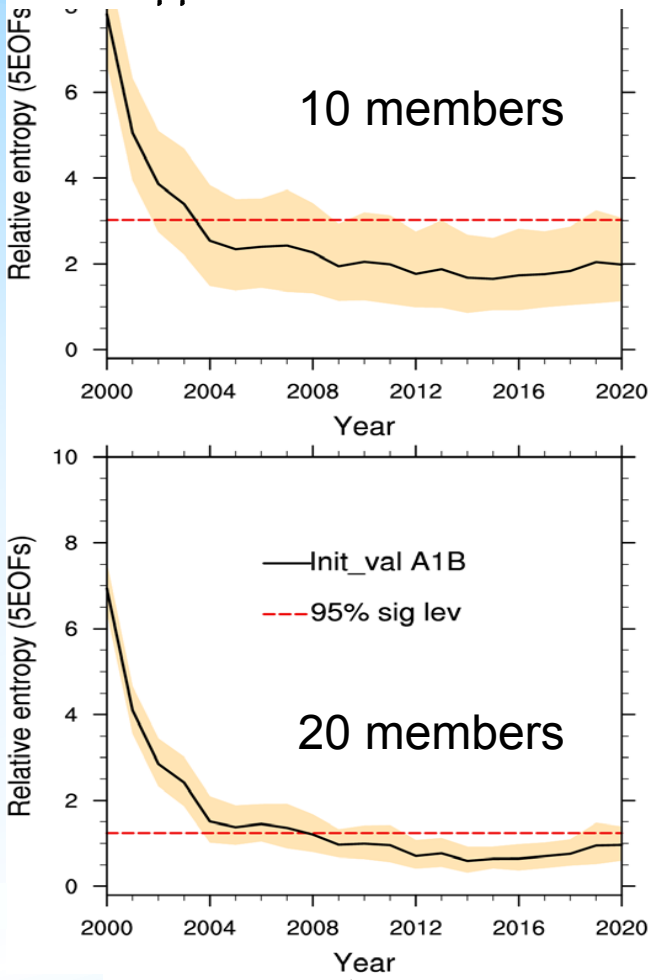
Relative Entropy for years 6-10 of
Upper Ocean Heat Content




(Branstator et al. 2011)

## Estimating Predictability Requires Large Ensembles

Relative Entropy of
Upper Ocean Heat Content




(Branstator and Teng 2010)

# Need for Coordinated Verification

In order to:

1) Compare forecast systems across modeling centers

2) Evaluate successive generations of the same forecast system and document improvements over time

3) Provide feedback to the modelers regarding model biases

4) Manage user expectations in terms of the utility of the forecast information based on hindcast skill

# Need for Coordinated Verification

A verification framework has been developed by the US CLIVAR Decadal Predictability Working Group…

**A Verification Framework for Interannual-to-Decadal Predictions Experiments**

By L. Goddard[1]*, A. Kumar[2], A. Solomon[3], D. Smith[4], G. Boer[5], P. Gonzalez[1], C. Deser[6], S. Mason[1], B. Kirtman[7], R. Msadek[8], R. Sutton[9], E. Hawkins[9], T. Fricker[10], S. Kharin[5], W. Merryfield[5], G. Hegerl[11], C. Ferro[10], D. Stephenson[10], G.A. Meehl[6], T. Stockdale[12], R. Burgman[7], A. Greene[1], Y. Kushnir, M. Newman[3], J. Carton[13], I. Fukumori[14], D. Vimont[15], T. Delworth[8]

Submitted to Climate Dynamics

The framework will provide information on forecast quality across prediction systems, such that relative comparisons can be made, and provides a baseline against which future improvements can be quantified.

# Asking Questions of the DecPred Experiments

Question 1: Do the initial conditions in the hindcasts lead to more accurate predictions of the climate?

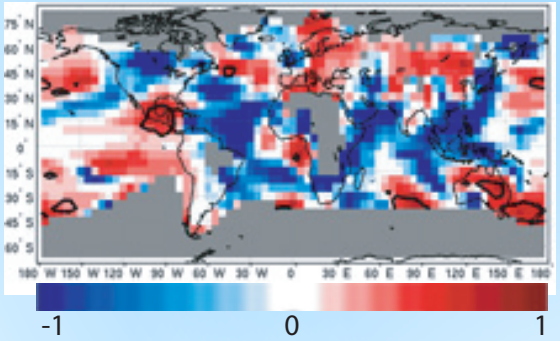
Question 2: Is the model's ensemble spread an appropriate representation of forecast uncertainty on average?

Question 3: In the case that the forecast ensemble does offer information on overall forecast uncertainty, does the forecast-to-forecast variability of the ensemble spread carry meaningful information?

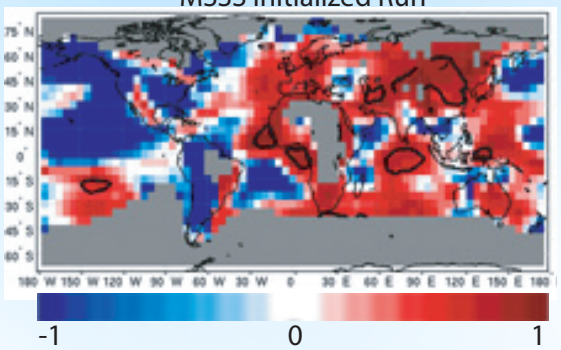
# Deterministic Metrics: Mean Squared Skill Score (MSSS)

## DePreSys: Years 2-9

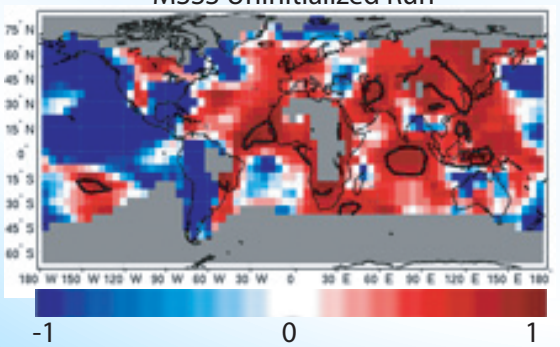
Initialized vs Uninitialized




MSSS Initialized Run

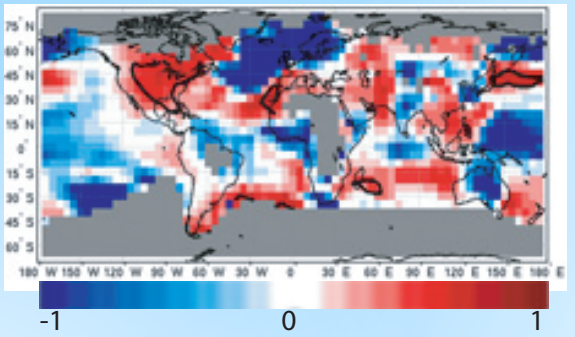



MSSS Uninitialized Run

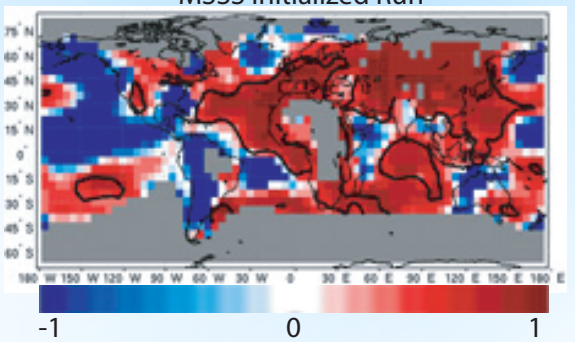



## CanCM4: Years 2-9

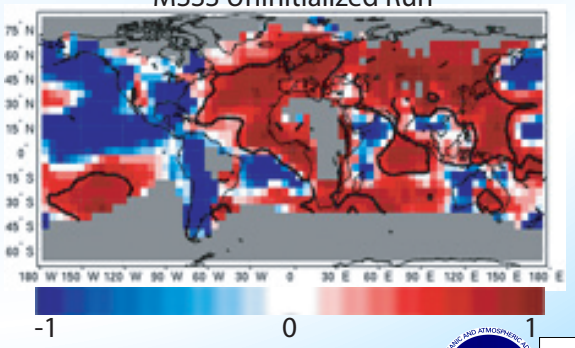
Initialized vs Uninitialized




MSSS Initialized Run




MSSS Uninitialized Run

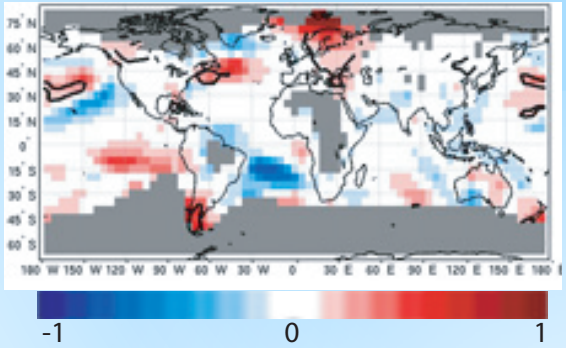


# Deterministic Metrics: Mean Squared Skill Score (MSSS)

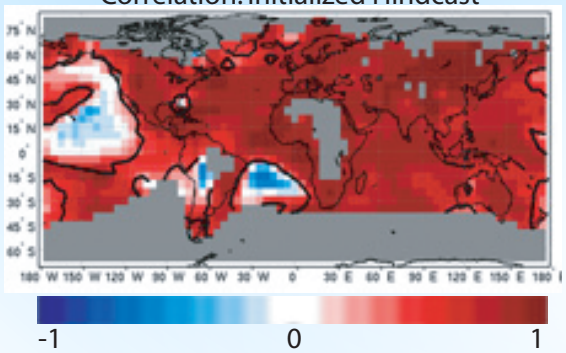
## Hadley Centre DePreSys Years 2-9

### Anomaly Correlation

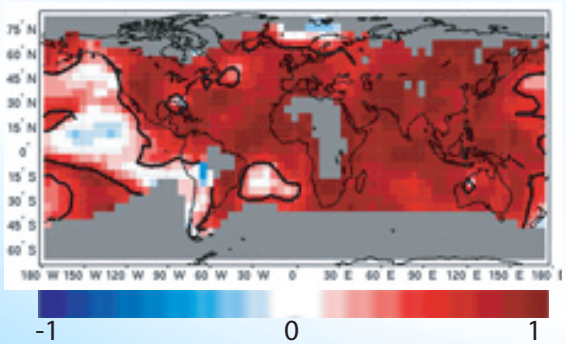
Correlation: Initialized - Uninitialized




Correlation: Initialized Hindcast

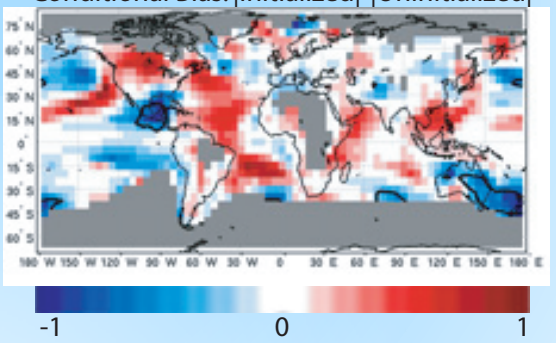



Correlation: Uninitialized Hindcast

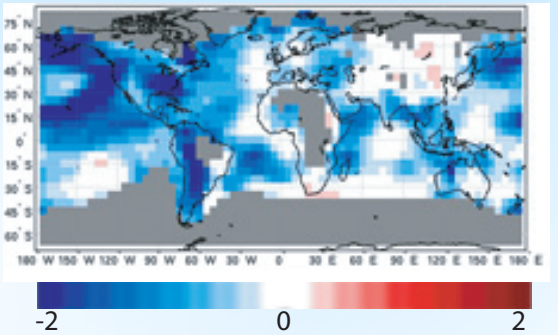



### Conditional Bias

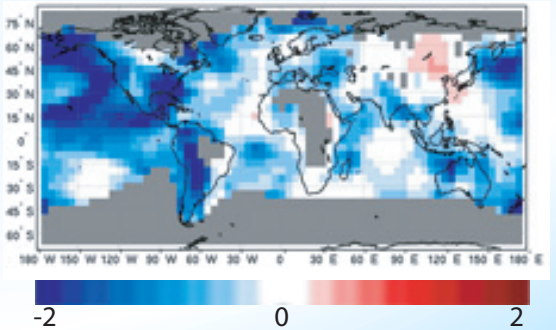
Conditional Bias: |Initialized|-|Uninitialized|



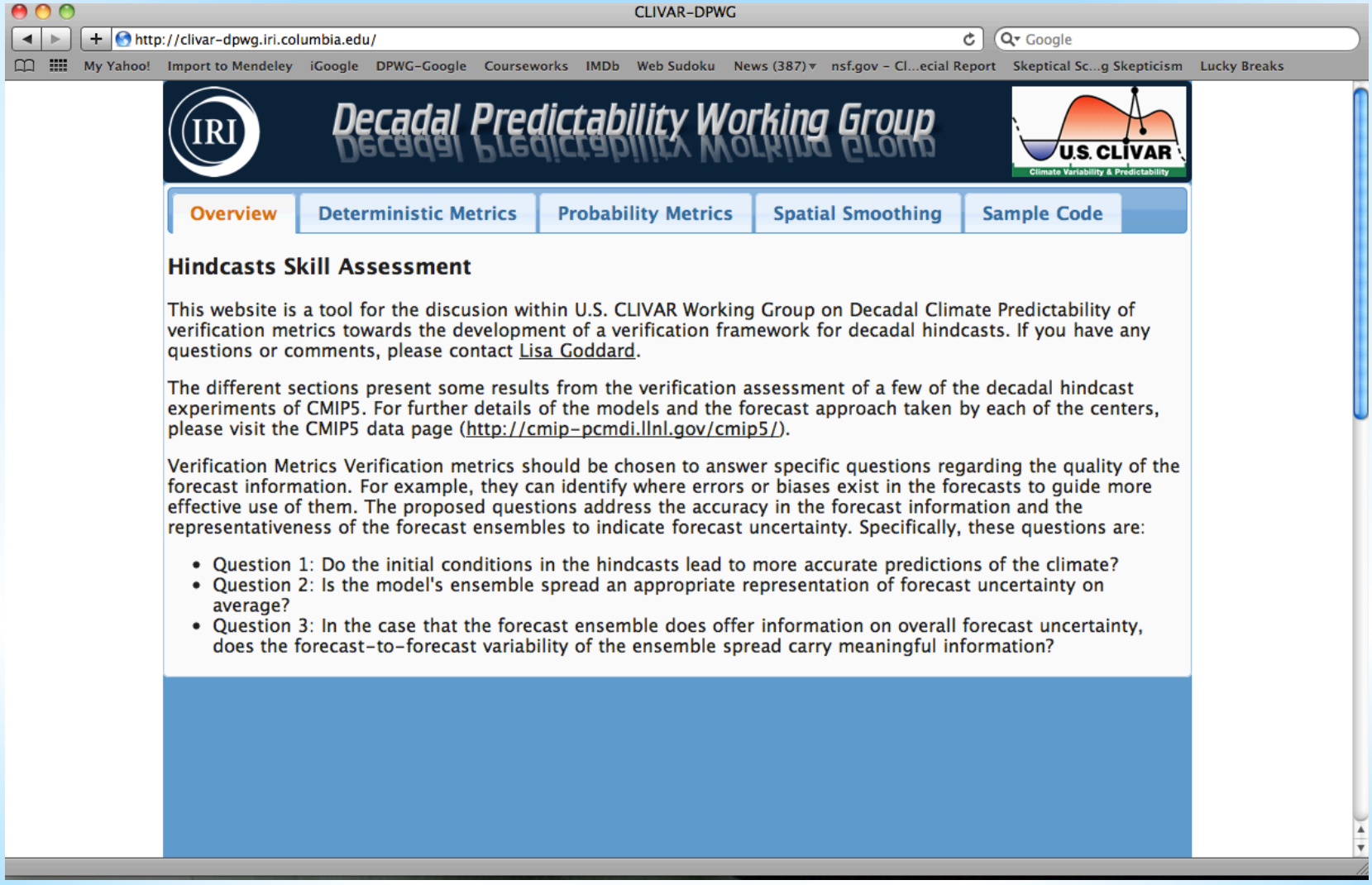

Conditional Bias: Initialized Hindcast




Conditional Bias: Uninitialized Hindcast



# DPWG Metrics Website: http://clivar-dpwg.iri.columbia.edu



To Modeling Centers and Users of Decadal Forecasts:

Coordinate with the scientific community by

----Posting results of diagnostic studies on the IRI DecPred website

----Proposing additional metrics to validate the forecasts