

Ten-Years Out:

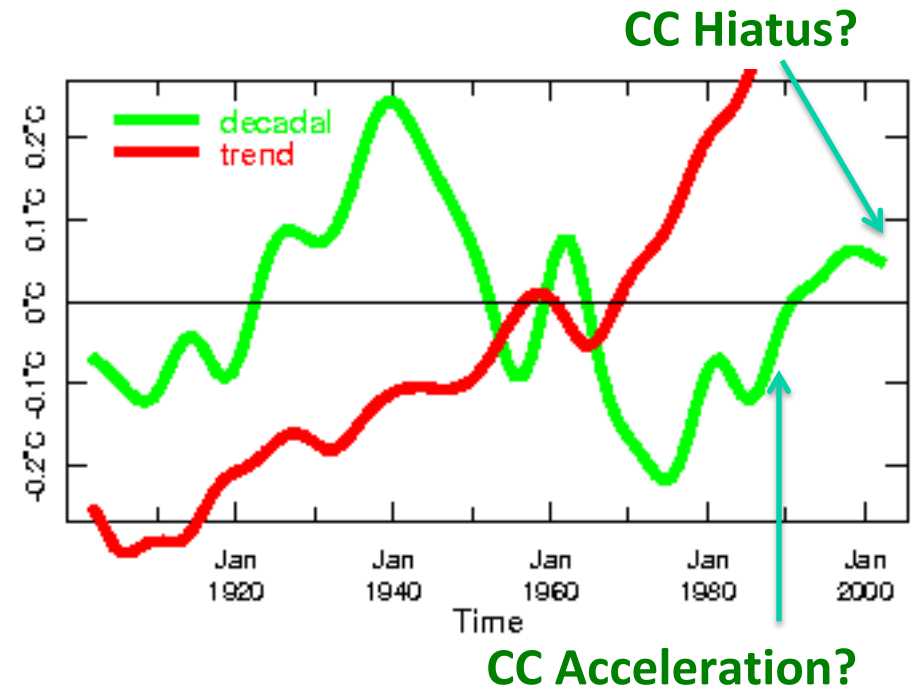
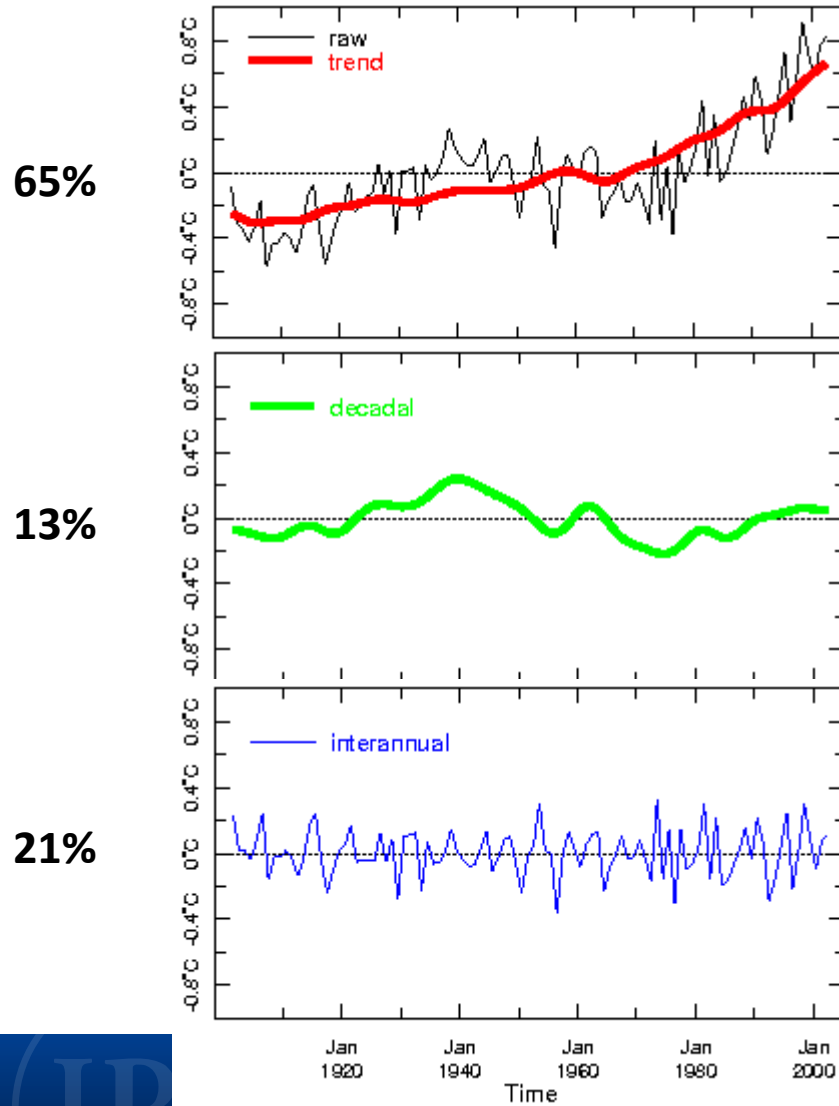
Navigating the Information Gap between El Niño & Climate Change

Lisa Goddard

International Research Institute
for Climate and Society
EARTH INSTITUTE | COLUMBIA UNIVERSITY

Climate Variability & Change Globally

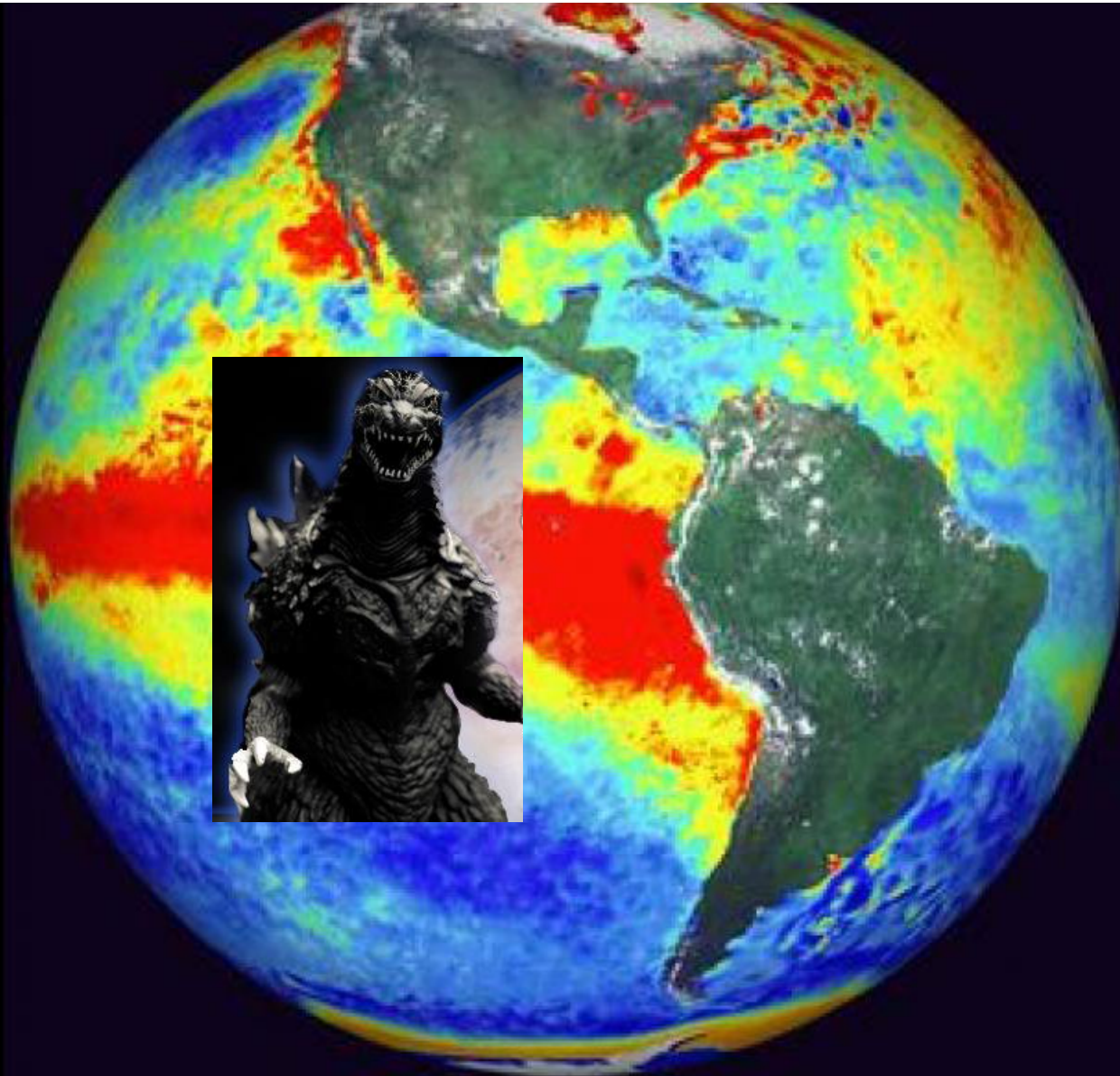
Annual Mean Temperature



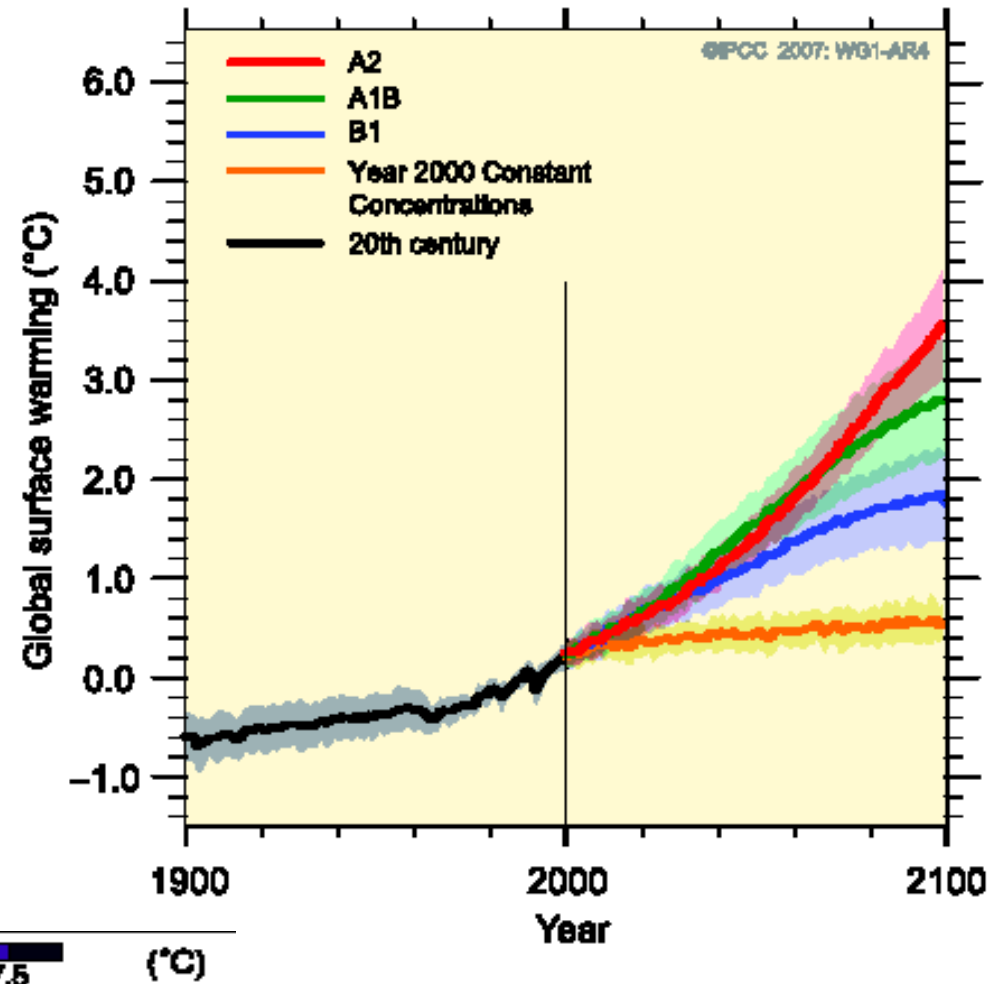
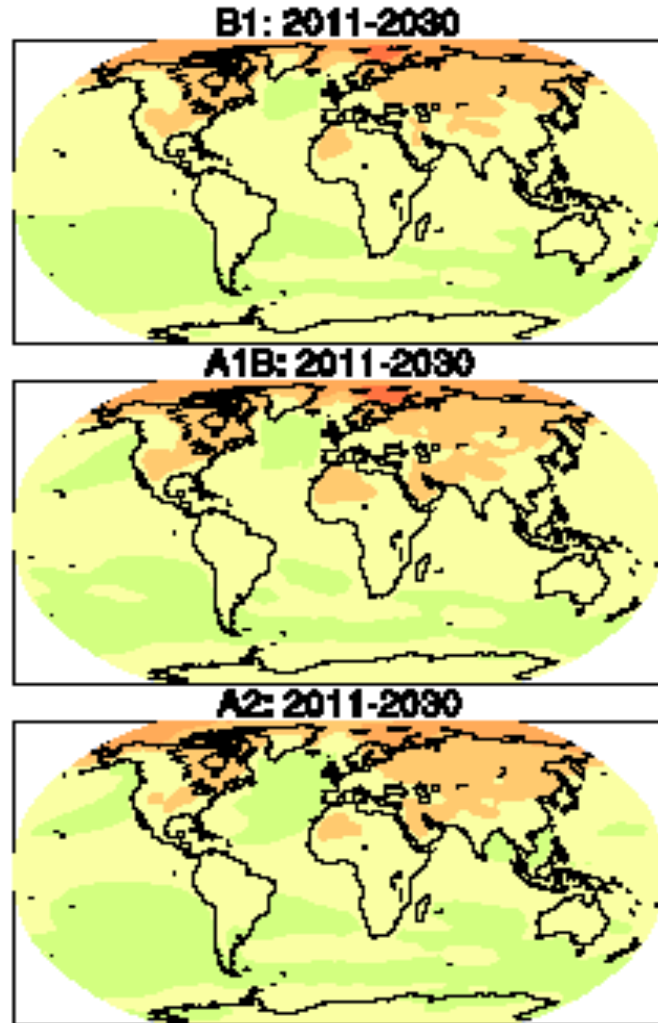
(Greene, Goddard & Cousin, *EOS*, 2010)



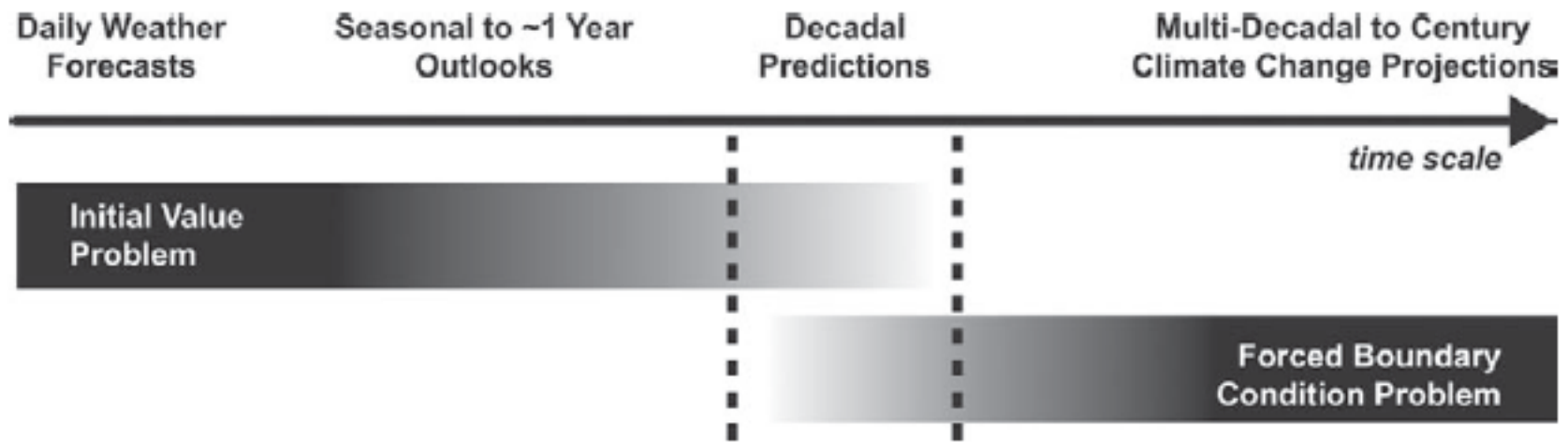
the 2015-16 El Niño was a monster!



Global Climate Change Projections



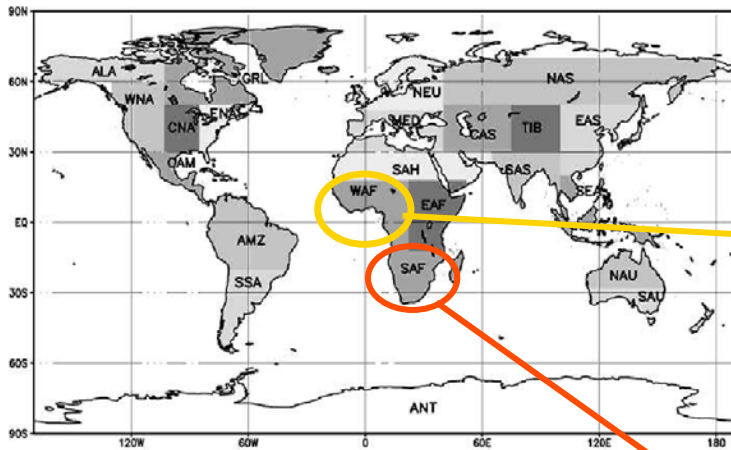
The Next Decade's Climate is influenced by Ocean State AND Atmospheric Composition



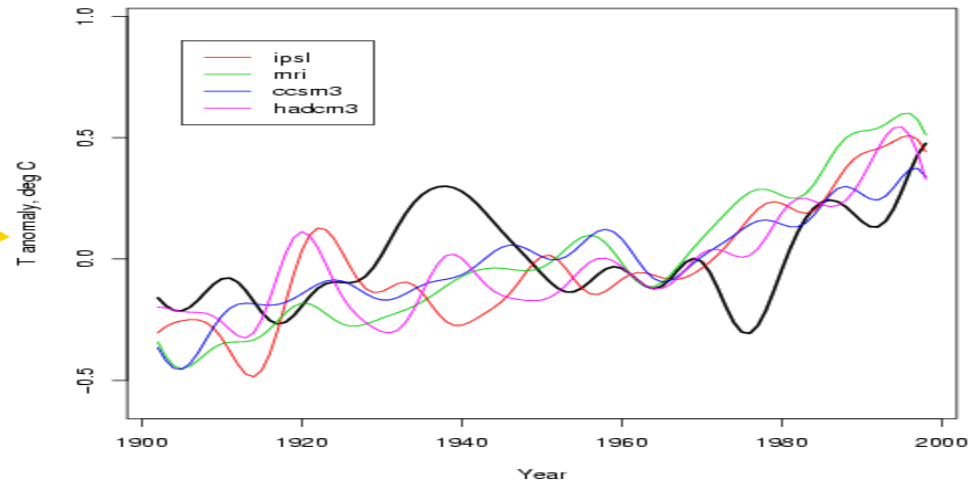
(Source: Meehl et al. 2009, BAMS)

Regional Scale Decadal Predictions from Climate Change Projections?

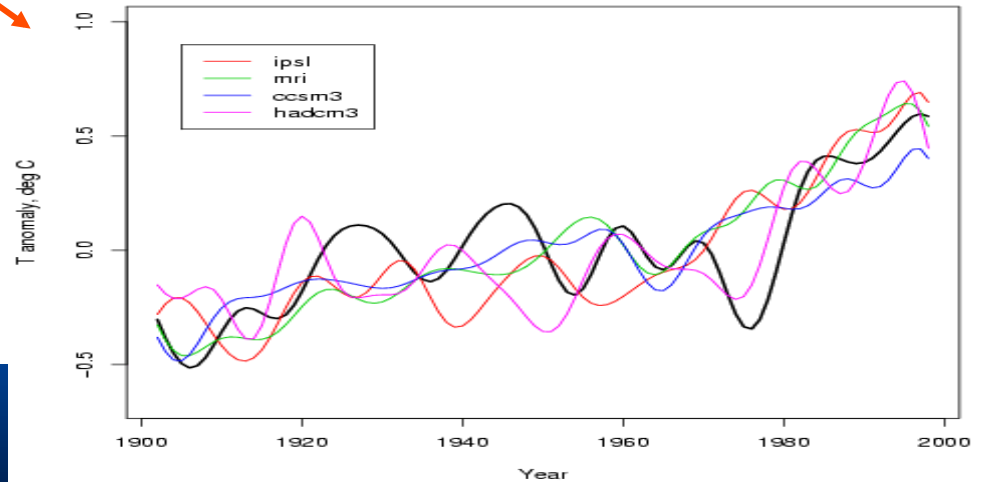
Western Africa : Annual-Mean Temperature



ALA	Alaska	NEU	Northern Europe	NAS	Northern Asia
WNA	Western North America	MED	Mediterranean	TIB	Tibet
CNA	Central North America	CAS	Central Asia	EAS	Eastern Asia
ENA	Eastern North America	SAH	Sahara	SAS	Southern Asia
GRL	Greenland	WAF	West Africa	SEA	South East Asia
CAM	Central America	EAF	East Africa	NAU	Northern Australia
AMZ	Amazonia	SAF	Southern Africa	SAU	Southern Australia
SSA	Southern South America	ANT	Antarctic		



Southern Africa : Annual-Mean Temperature



Climate Change Projections **cannot** deliver predictions of decadal variability

Decadal to Multi-decadal Climate Variability

“Natural” Slowly-Varying Climate

- * Atlantic Multi-decadal Oscillation (AMO or AMV)
- * Pacific Decadal Oscillation (PDO or PDV)

→ *What are these decadal phenomena?*

→ *How do they effect regional climate?*

→ *What is the basis for prediction?*

- * Experimental Prediction of Decadal Variability

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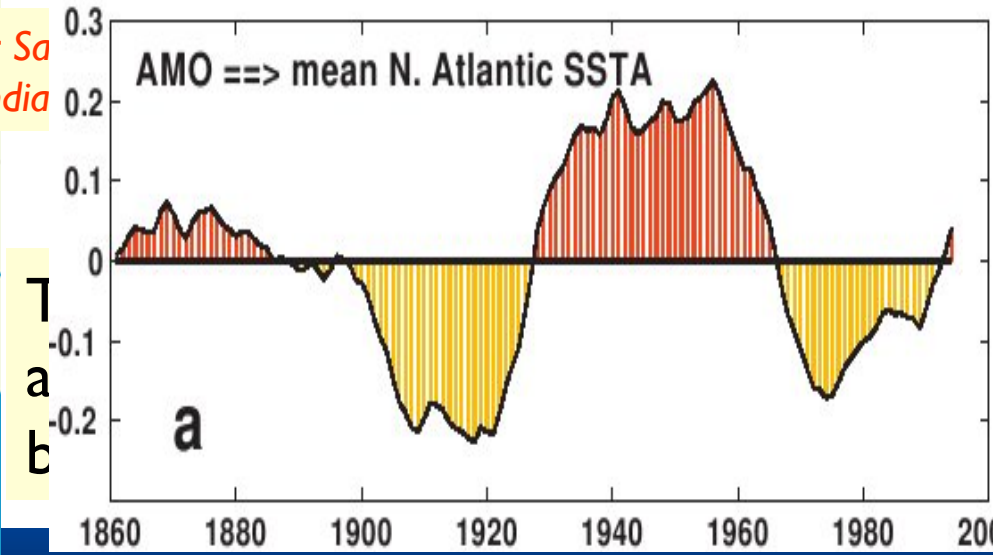
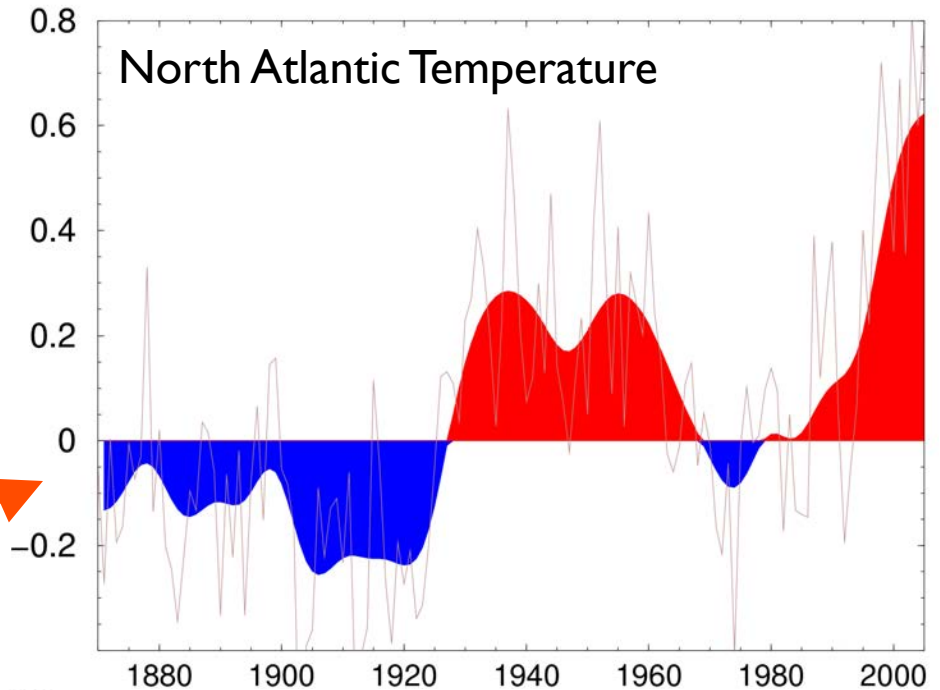
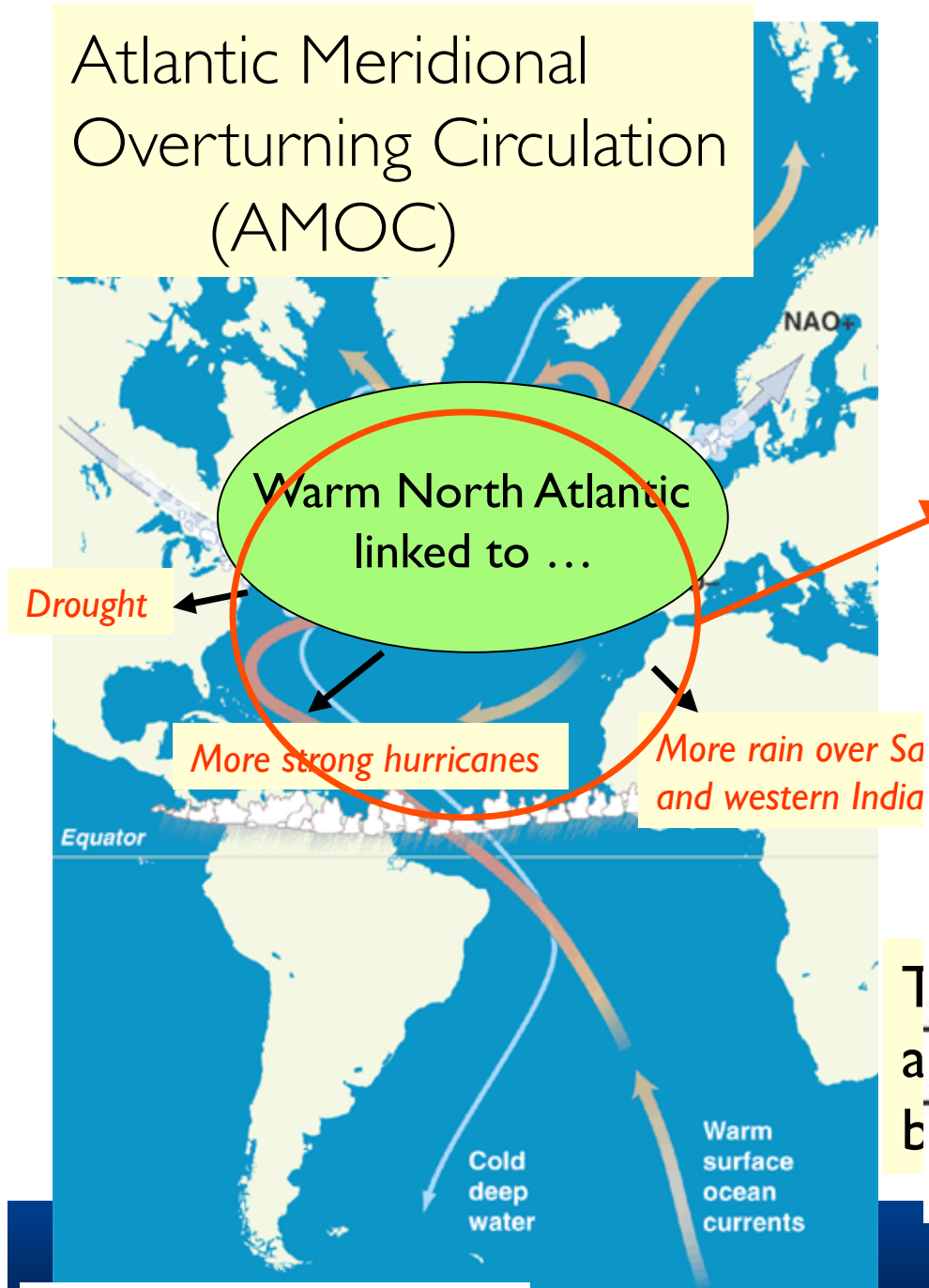
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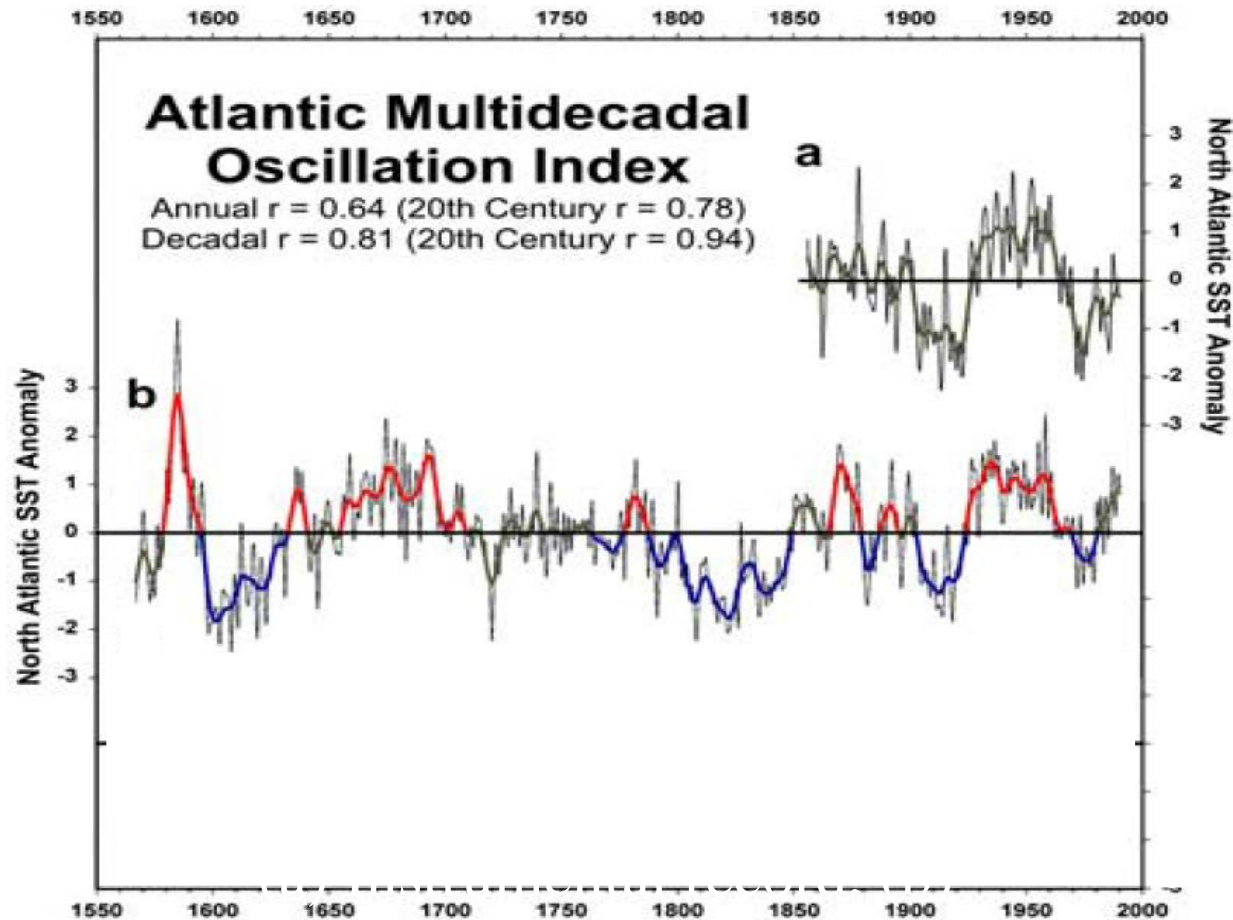
Atlantic Meridional Overturning Circulation (AMOC)



(Courtesy: Joe Tribbia, NCAR)

Atlantic Multi-decadal Oscillation (AMO)

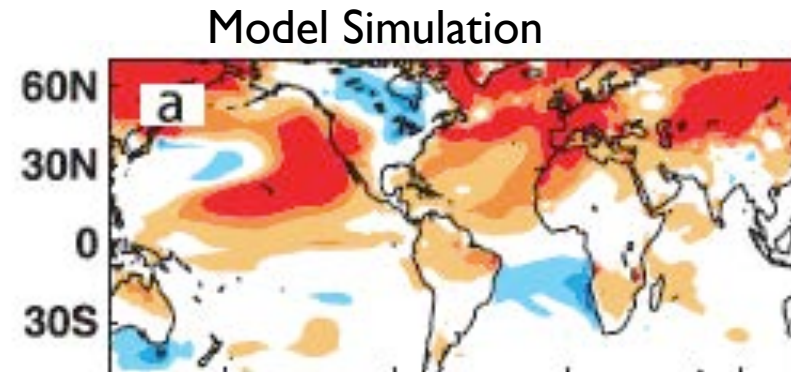
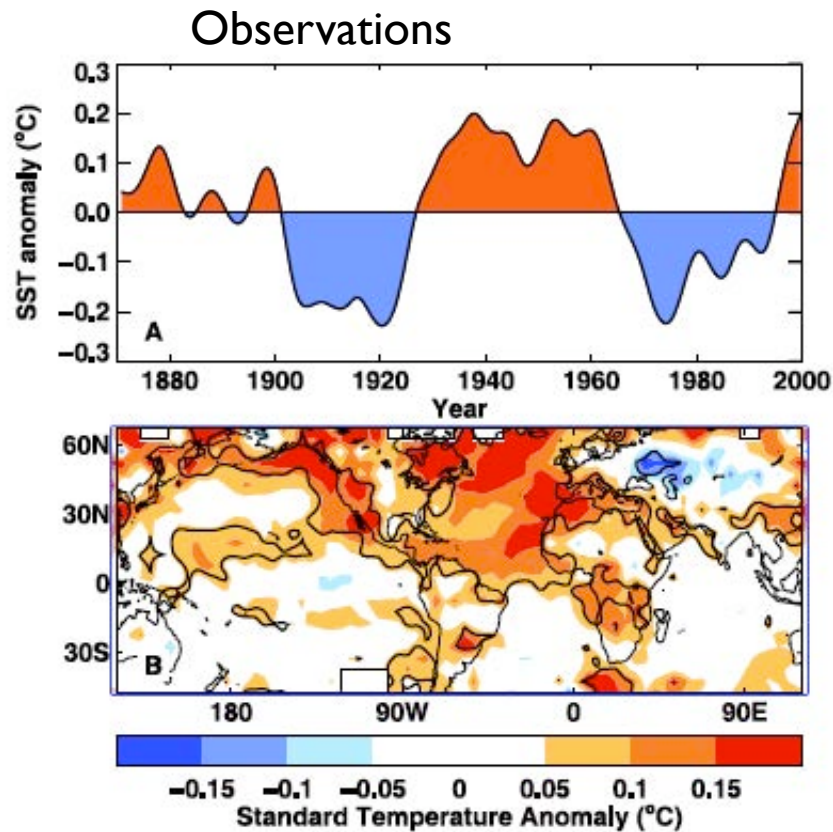
Has Existed for Centuries... at least



Other proxy data suggests its been around for >8,000 yrs

(Knudsen et al. 2011, DOI: 10.1038/ncomms1186)

Motivation for Prediction: Feasibility



(Knight et al. 2005, GRL)

Model variability, associated with AMOC variations, closely resembles observed variability associated with detrended and decadal-filtered AMV index.

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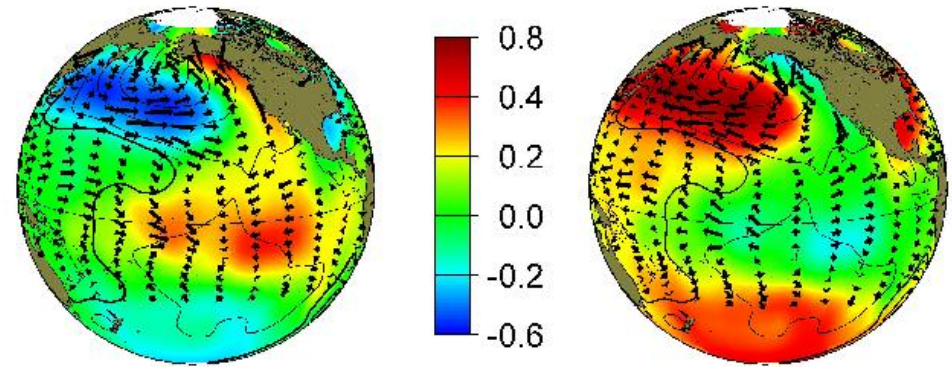
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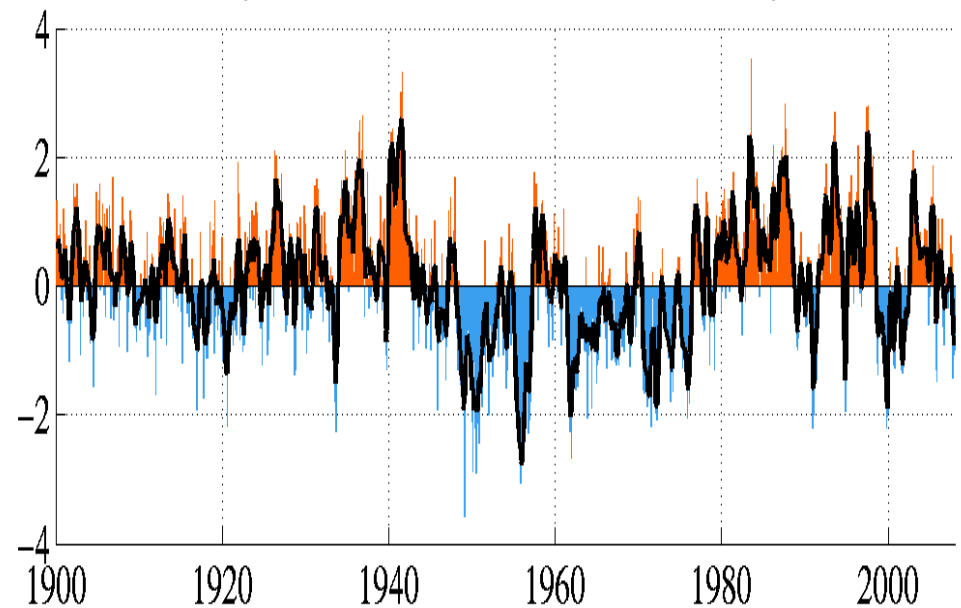
PDO (Pacific Decadal Oscillation)

The principal mode in the Pacific

- PDO refers mainly to N. Pacific sea surface temperatures (SSTs).
- The characteristic *pattern*, shows SSTs in the tropical Pacific and midlatitude Pacific are out of phase.

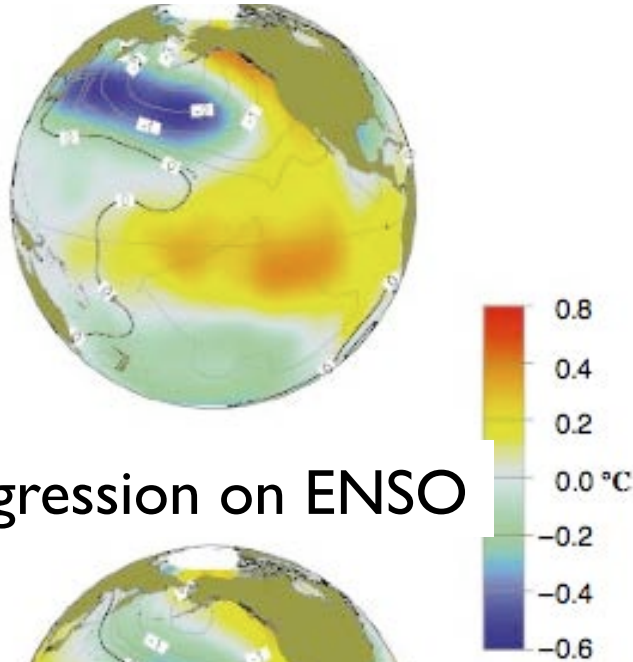


monthly values for the PDO index: 1900–January 2008



(Source: <http://jisao.washington.edu/pdo>)

SST & SLP Regression on PDO



... Regression on ENSO

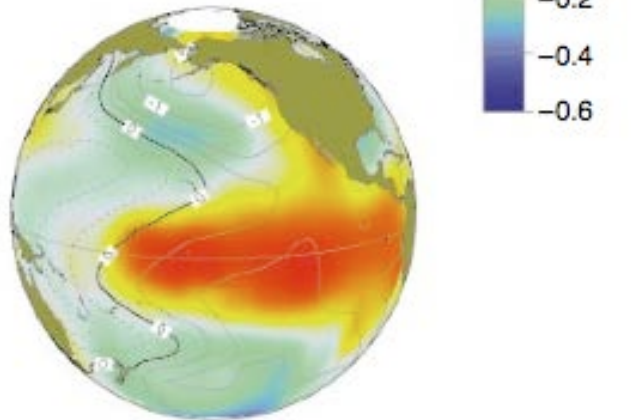
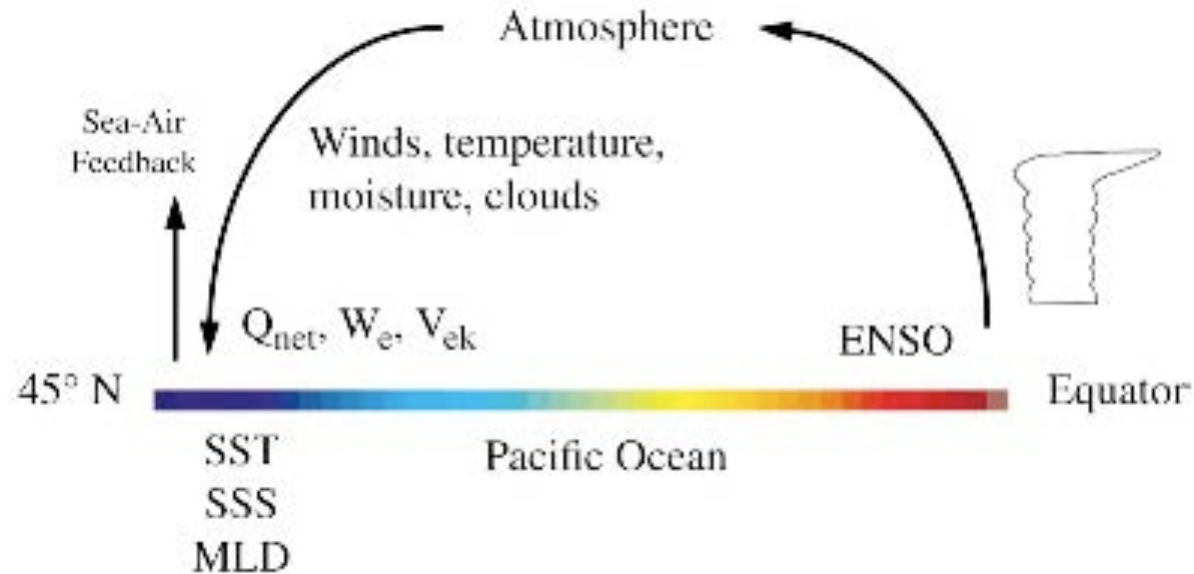


FIG. 2. COADS SST (color shaded) and SLP (contoured) regressed upon (a) the PDO index and (b) the CTI for the period of record 1900–92. Contour interval is 1 mb, with additional contours drawn for ± 0.25 and 0.50 mb. Positive (negative) contours are dashed (solid).

- the PDO has a similar structure to ENSO, but its amplitude is greatest over the North Pacific
- degree of equatorial symmetry suggests tropical forcing

Atmospheric Bridge



- tropical forcing generates atmospheric Rossby waves that propagate poleward
- surface winds create SST anomaly over North Pacific

Atmospheric response to tropical heating (due to tropical SST anomalies)

Note: This atmospheric SLP pattern, response to ENSO SST anomalies, is the Pacific North America (PNA) pattern.

Horel & Wallace (1981; MWR)

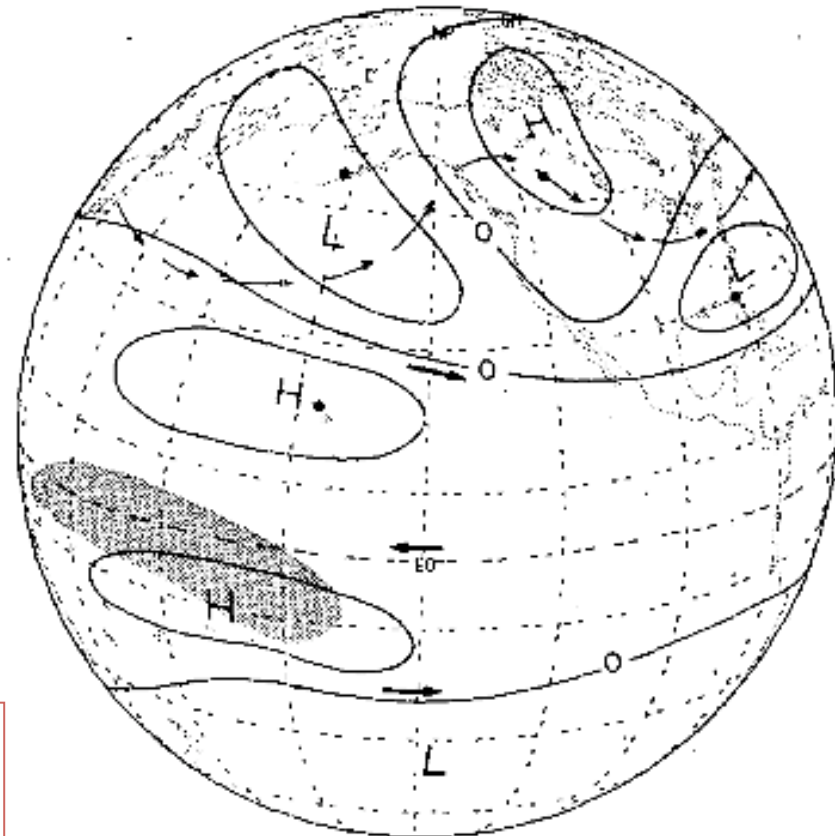
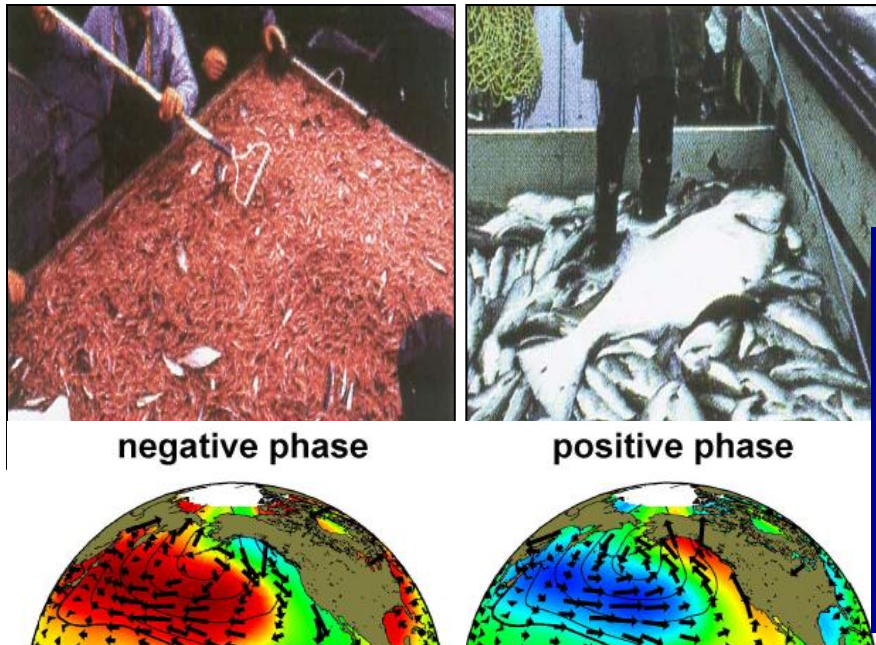


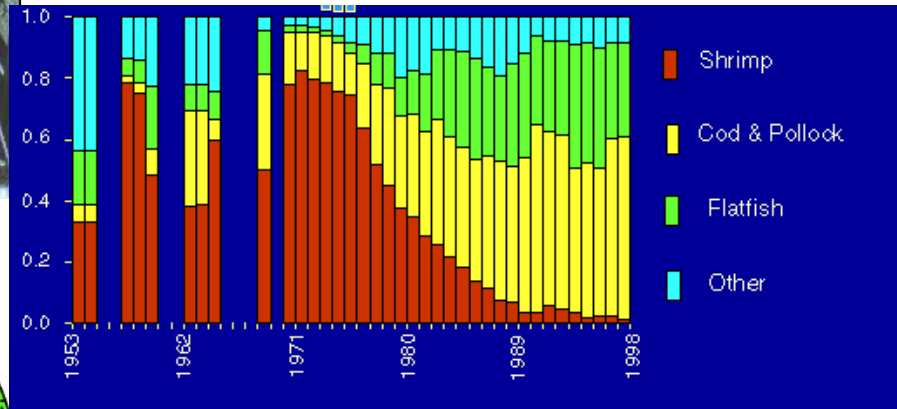
FIG. 11. Schematic illustration of the hypothesized global pattern of middle and upper tropospheric geopotential height anomalies (solid lines) during a Northern Hemisphere winter which falls within an episode of warm sea surface temperatures in the equatorial Pacific. The arrows in darker type reflect the strengthening of the subtropical jets in both hemispheres along with stronger easterlies near the equator during warm episodes. The arrows in lighter type depict a mid-tropospheric streamline as distorted by the anomaly pattern, with pronounced "troughing" over the central Pacific and "ridging" over western Canada. Shading indicates regions of enhanced cirriform cloudiness and rainfall. For further details see Section 7. The locations of the stations used in Table 4 are indicated by dots.

tute

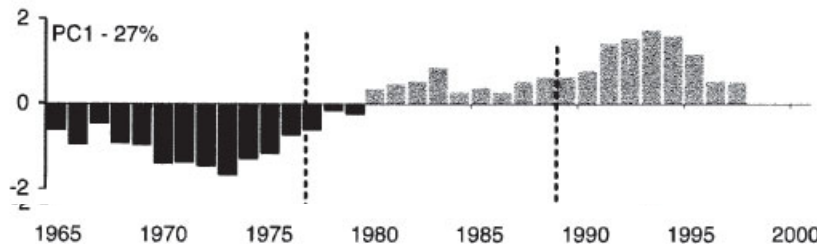
Link between PDO and ecosystems



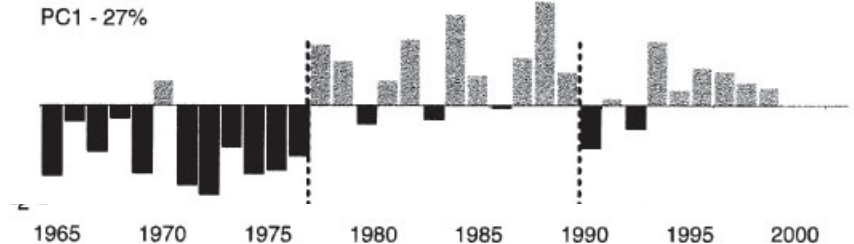
Gulf of Alaska – “climate change” and major shifts in marine ecosystems
Botsford et al 1997, Science; Anderson and Piat 2000, MEPS



PC Scores - biological indices



PC Scores - physical indices



Hare and Mantua, 2000, Prog. Oceanogr.

The main EOFs here represent a collection of several dozen biological and physical variables in the North Pacific. A regime shift is evident in the mid to late 1970s.

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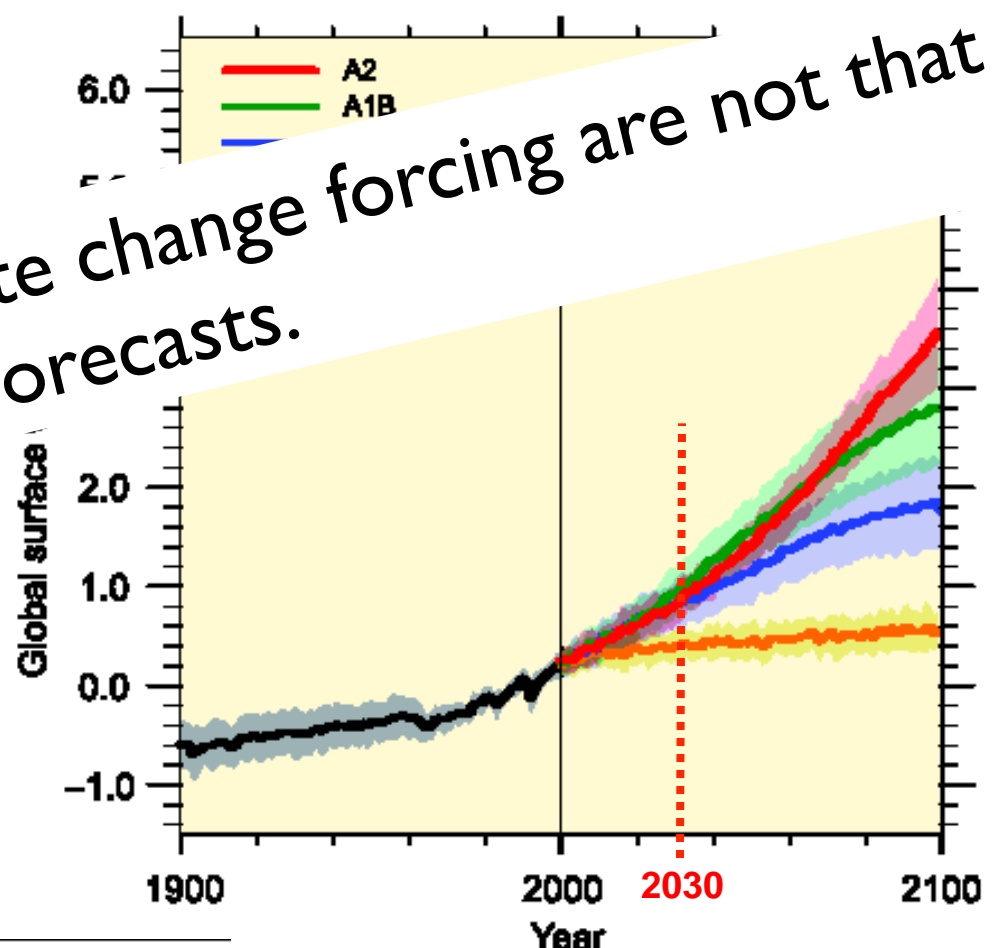
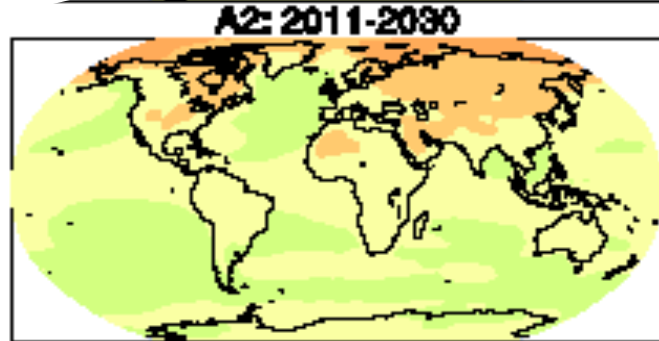
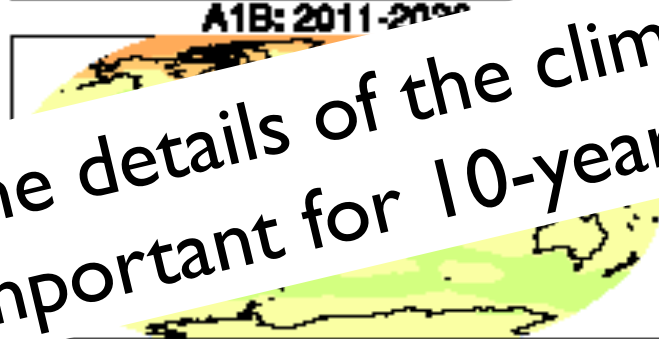
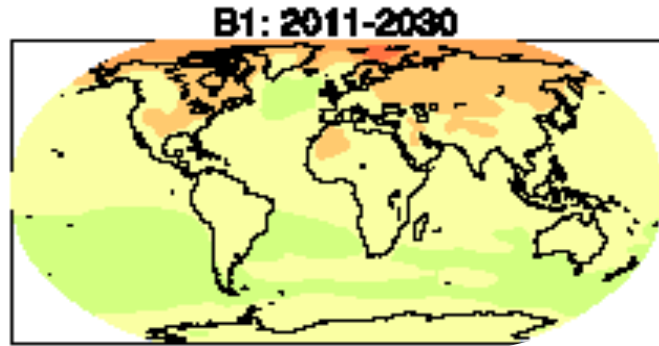
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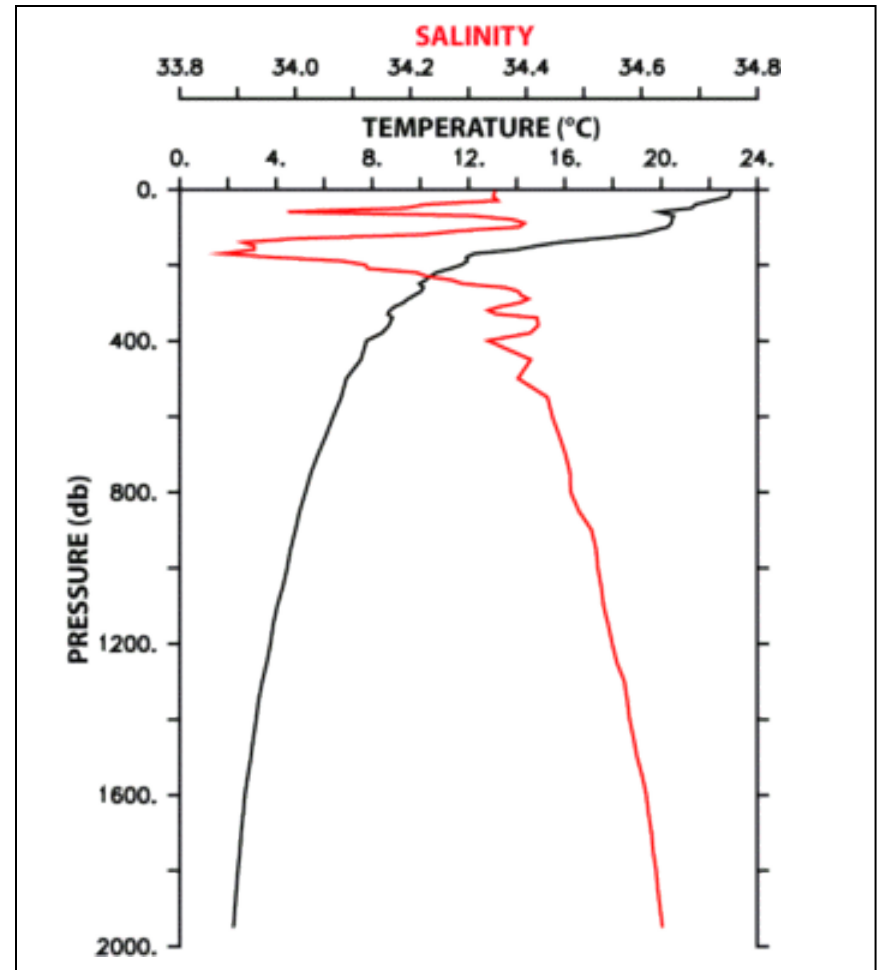
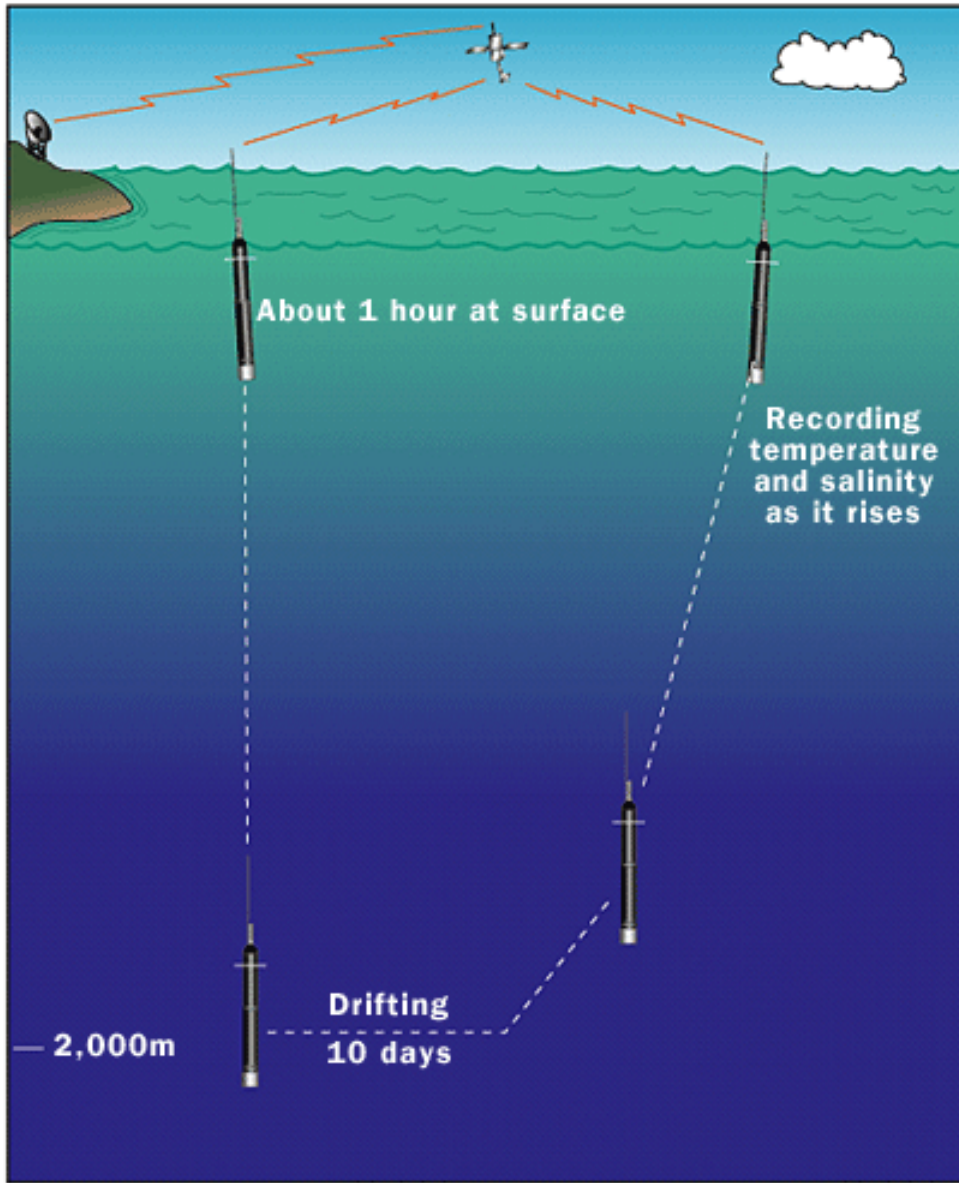
Global Climate Change Projections



The details of the climate change forcing are not that important for 10-year forecasts.



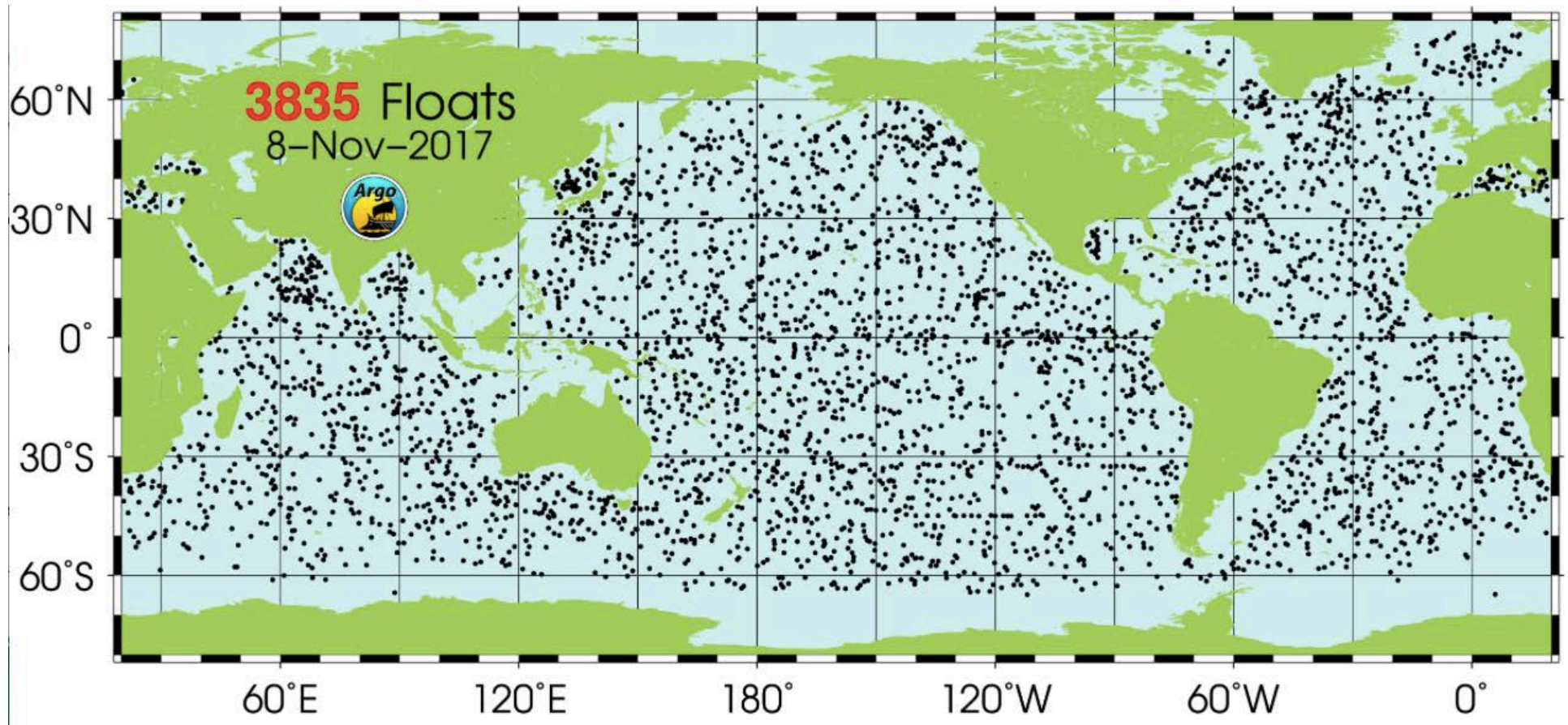
Ocean Observations: Argo Profiling Floats



Argo profile from the subtropical North Pacific (20.25N 121.4W, May 15 2004).

This shows interleaving in the salinity data.

Ocean Observations: Argo Profiling Floats



Decadal Predictions: Temperature

Multi-model Ensemble (12 models: Equal Weighting) – Decadal Average

Mean Error
Skill Score

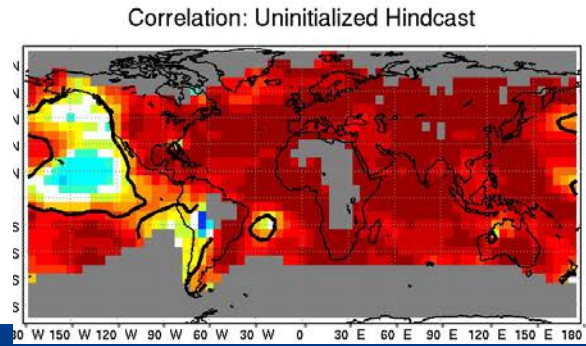
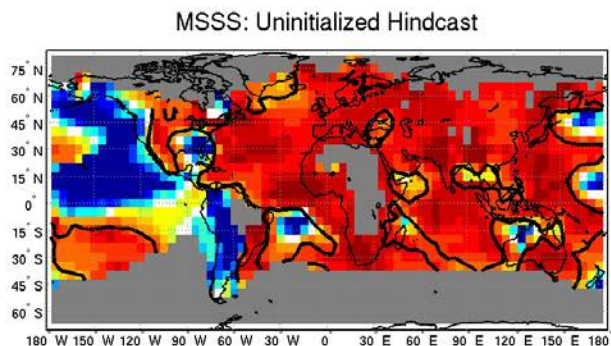
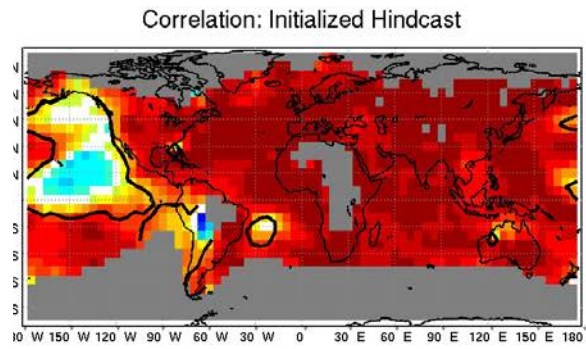
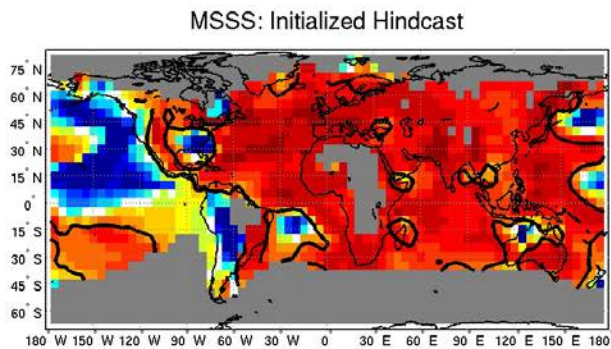
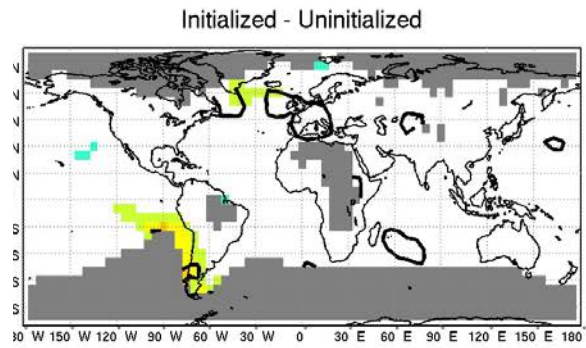
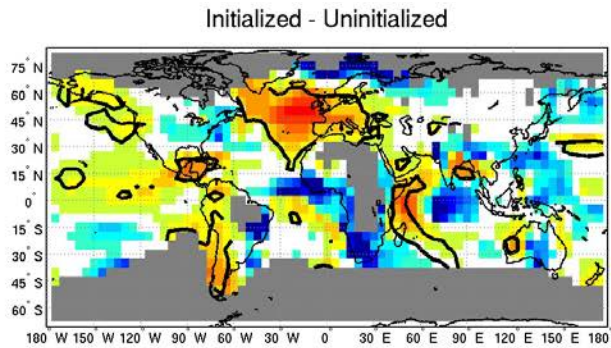
+1 (red):
Good

-1 (blue):
Bad

Correlation

+1 (red):
Good

-1 (blue):
Bad



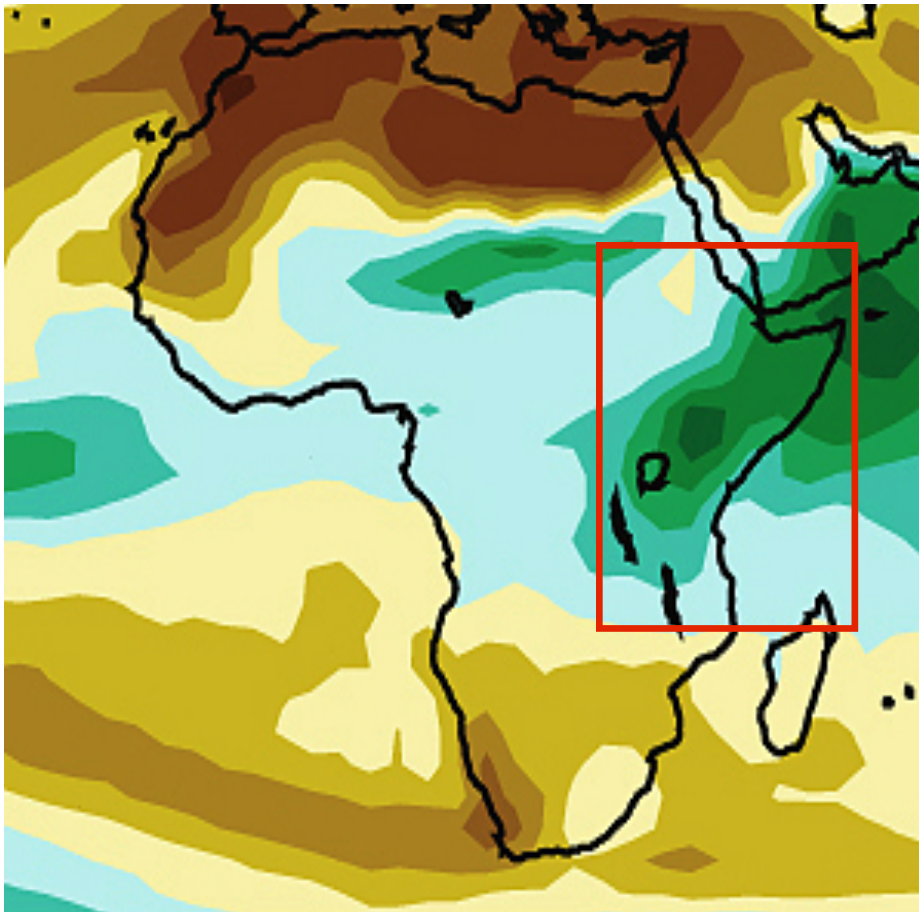
Consideration of Decadal Variability

EXAMPLE: East Africa

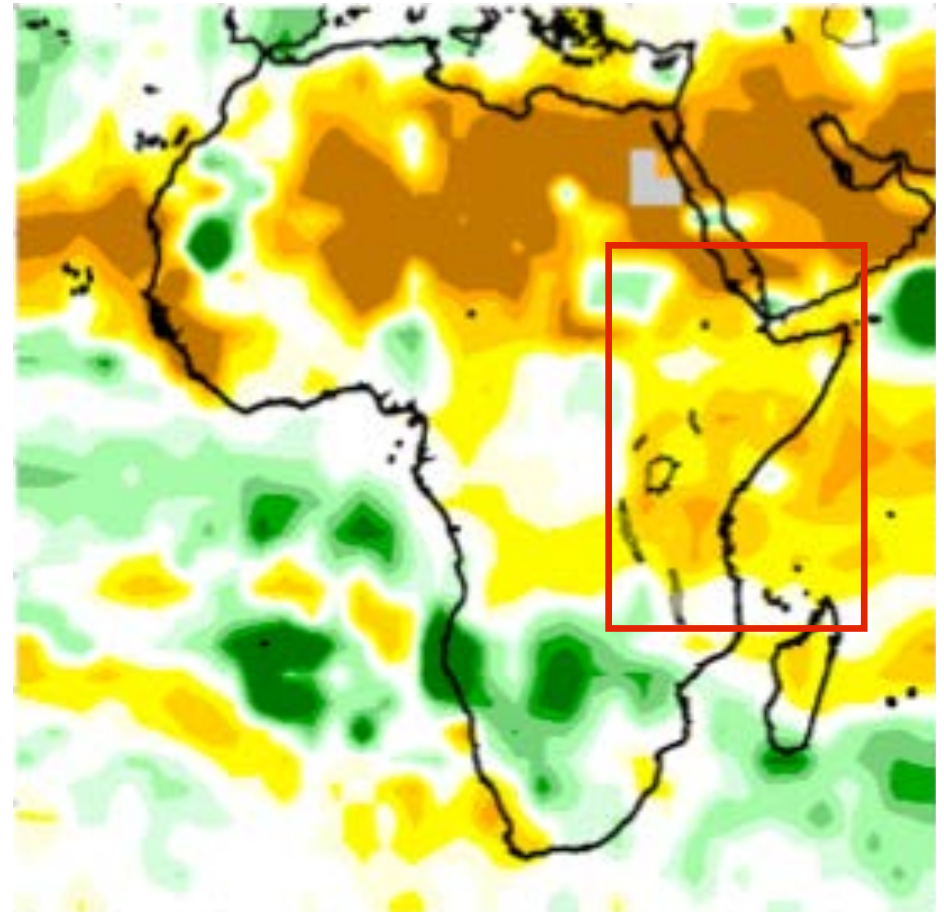


Evaluation of Malaria Interventions in East Africa

Climate Change Projections
(end of 21st century)

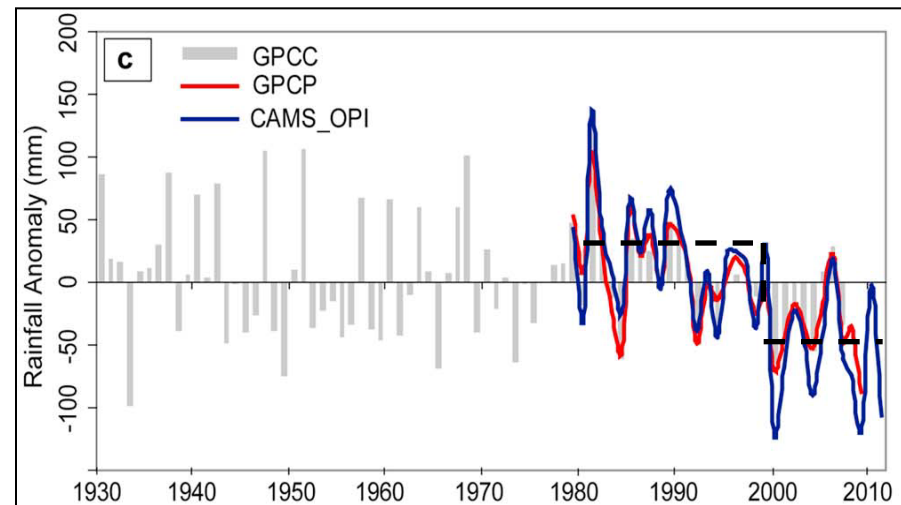
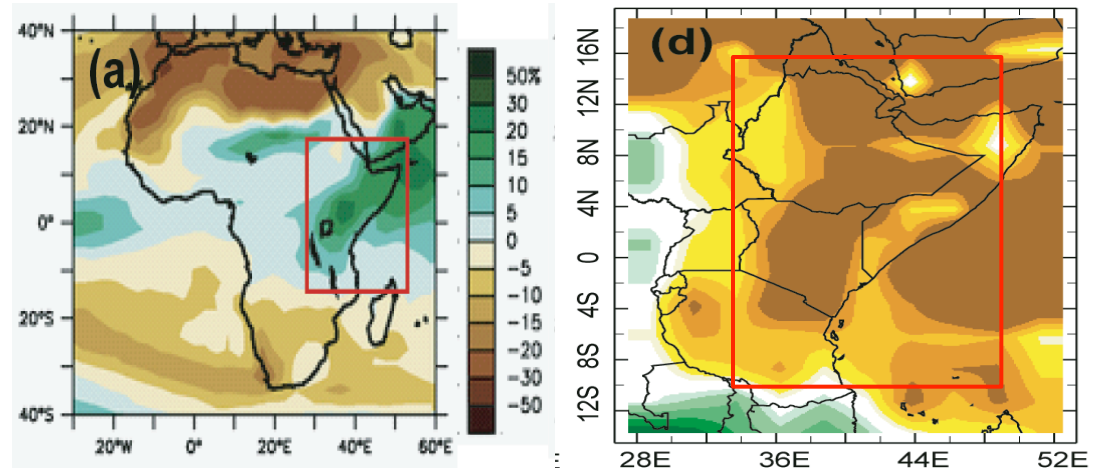


Observations
(last 15 years)



~~Evaluation of Malaria Interventions in East Africa~~ Increased Drought Frequency in East Africa

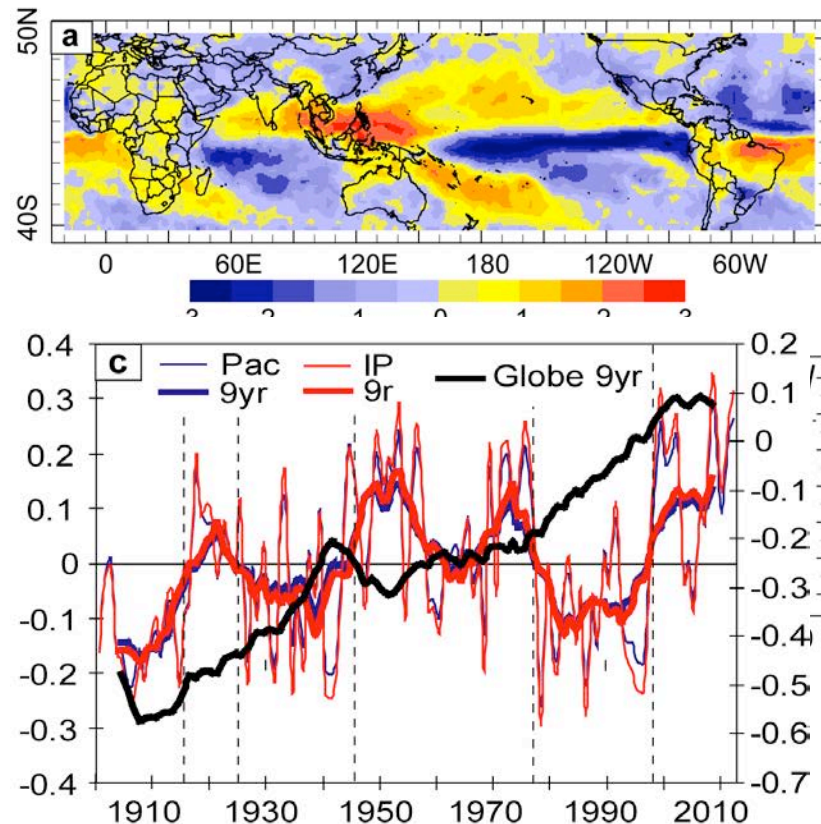
- Over the past ~15 years, drought has become much more frequent
- WHY?
- Is this climate change?



~~Evaluation of Malaria Interventions in East Africa~~ Increased Drought Frequency in East Africa

→ Increased frequency of drought in East Africa is **mainly the result of multi-decadal climate variability** in the Pacific

→ The recent shift in East African rainfall is part of a **global climate shift that occurred in 1998-99**

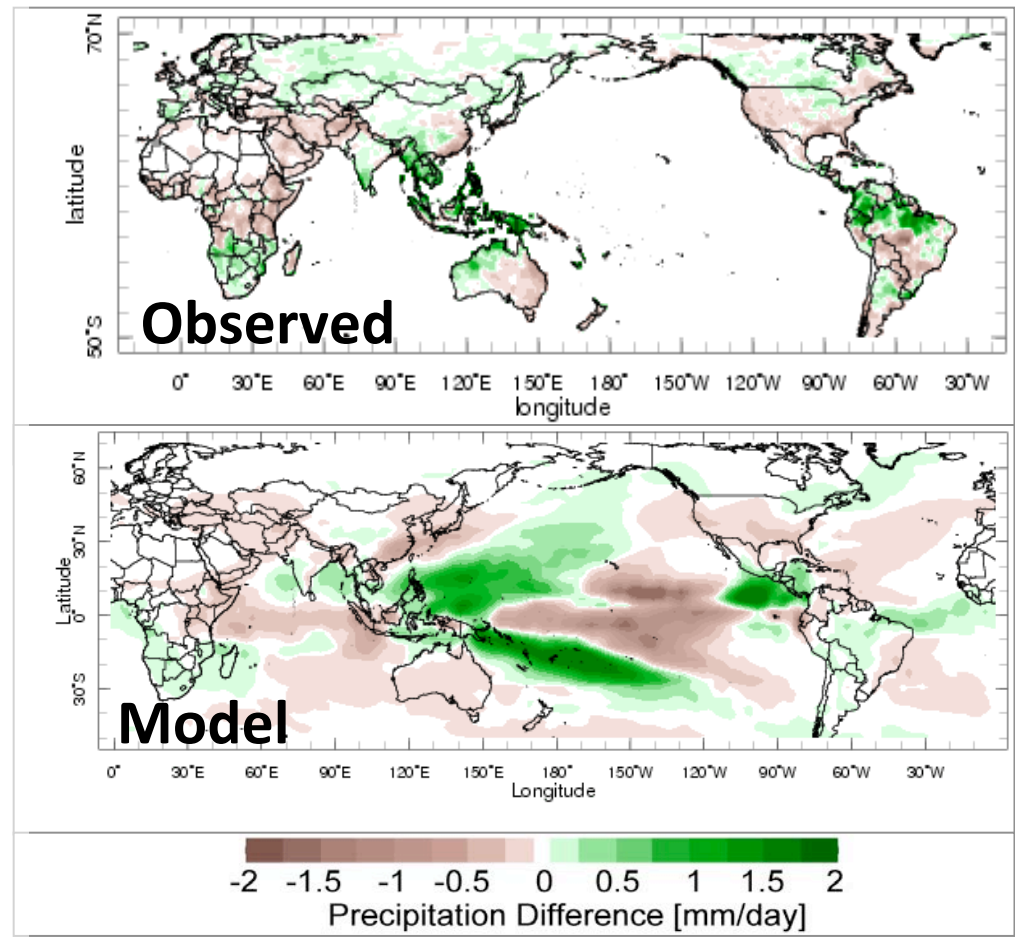


(Lyon et al. 2012, 2013, GRL, Clim. Dyn.)

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Summary

- Decadal variability and anthropogenic climate change are co-mingled.
- Both the Pacific and the Atlantic contain decadal/multi-decadal scale variability, with regional impacts to ocean and land ecosystems.
- The decadal predictions are still experimental.
- Some evidence exists that Atlantic decadal variability might be predictable if the ocean can be properly initialized (i.e. added skill over climate change projections)
 - Clear demonstration of predictability of natural decadal variability is still illusive.

Thank You



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goddard@iri.columbia.edu

info@iri.columbia.edu

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International Research Institute
for Climate and Society
EARTH INSTITUTE | COLUMBIA UNIVERSITY