Climate Information Across Timescales

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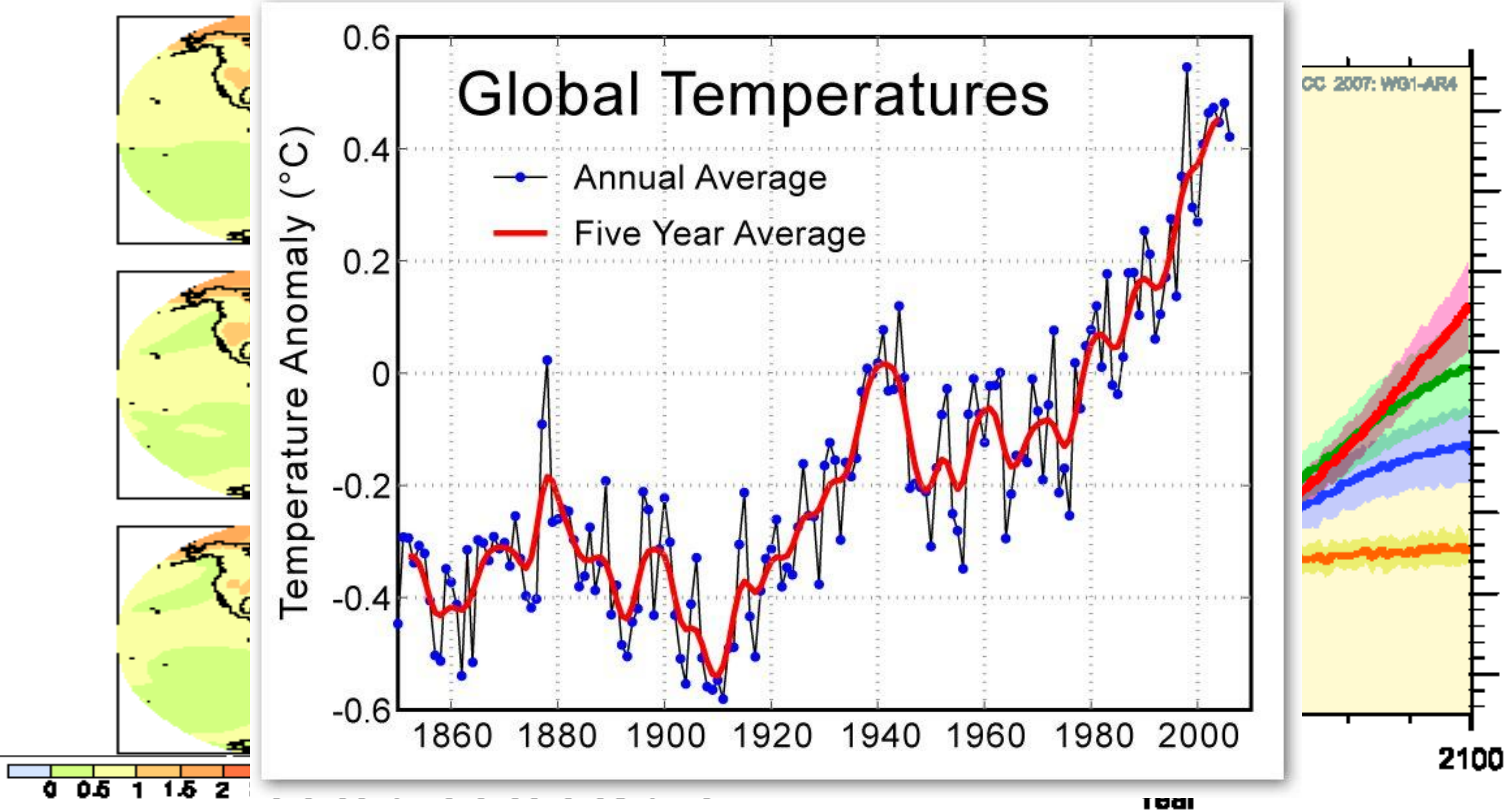
Global Climate Change



Source: IPCC 4th Assessment Report, Working Group 1: The Physical Science Basis for Climate Change
http://ipcc-wg1.ucar.edu/wg1/wg1-report.html

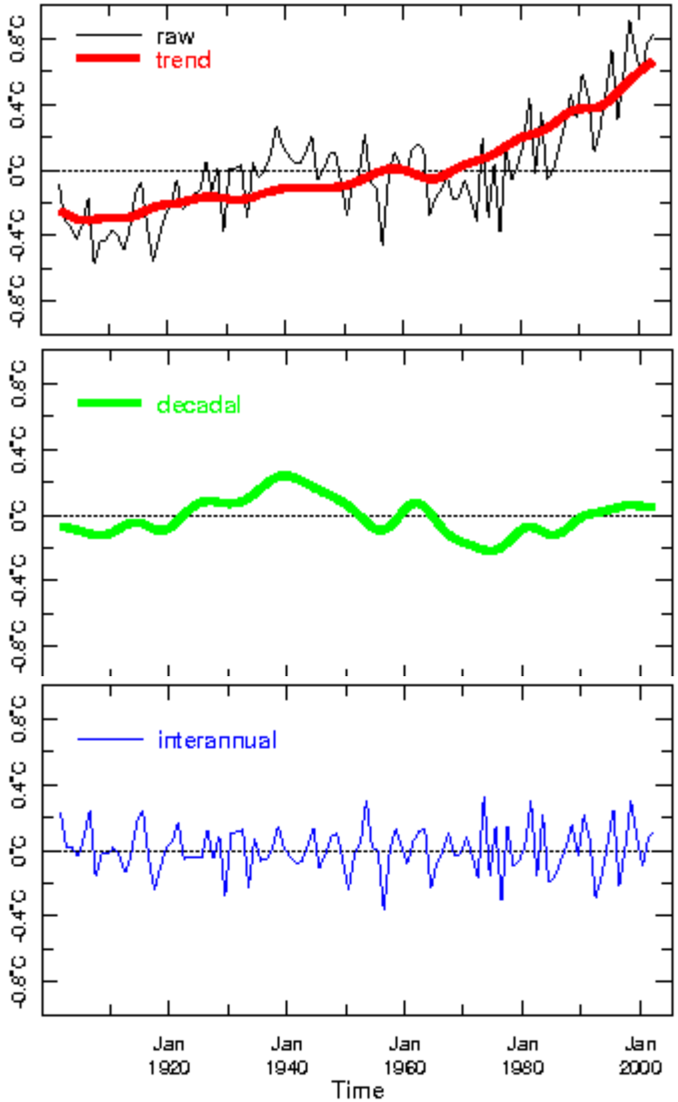
Climate Variability & Change Globally

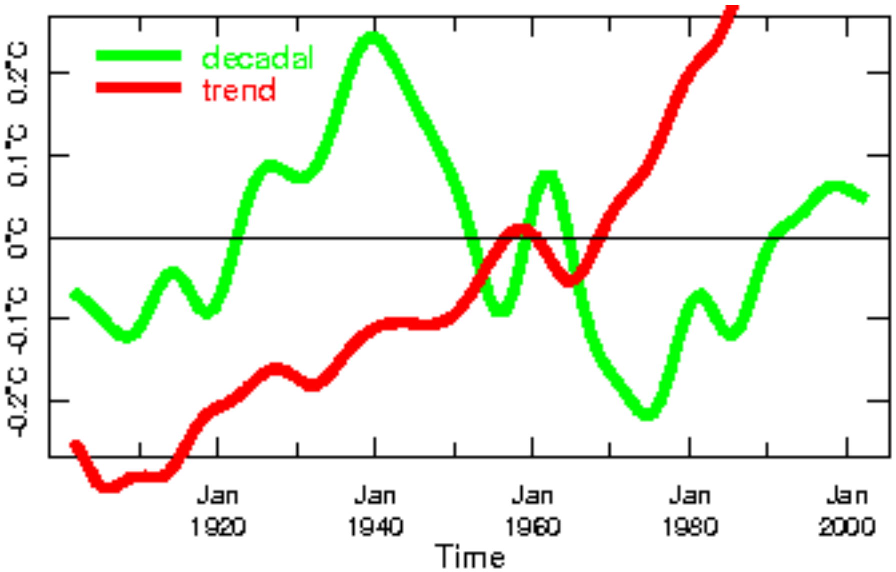
Annual Mean Temperature

65%

13%

21%





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

Climate Variability & Change Locally

e.g. Climate Variability & Change in Colorado, USA - DJF

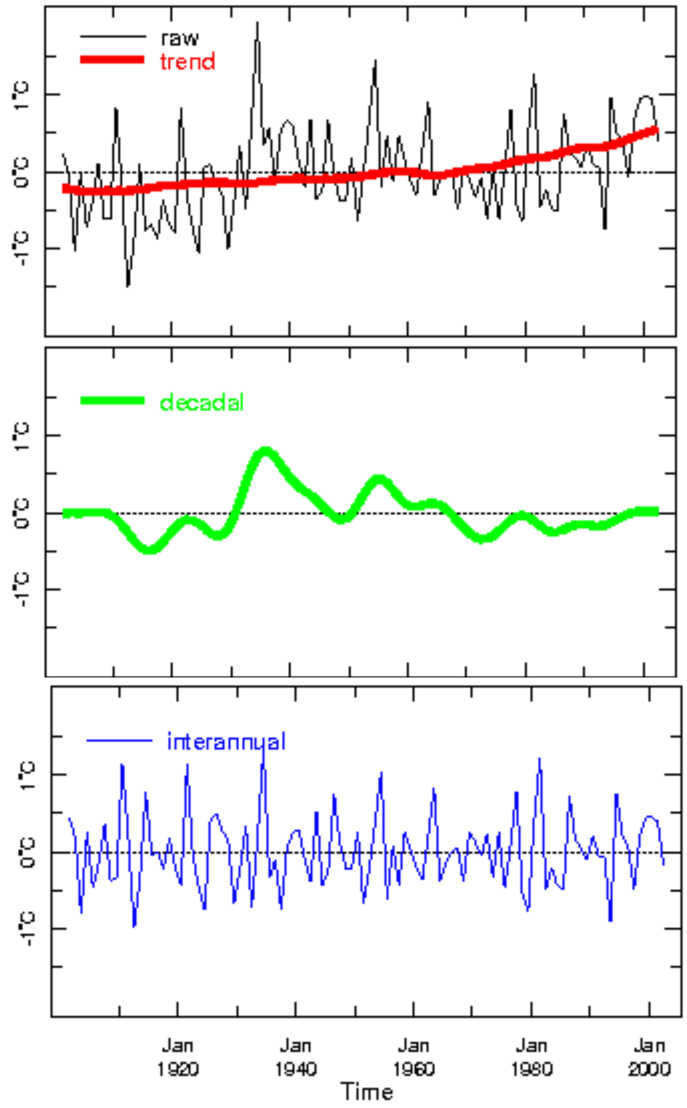
Temperature

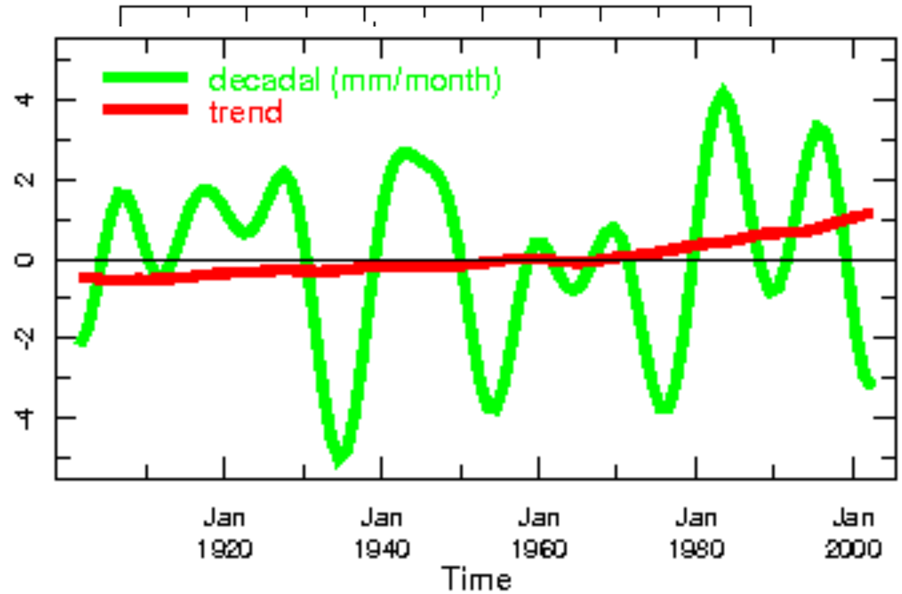
Precipitation

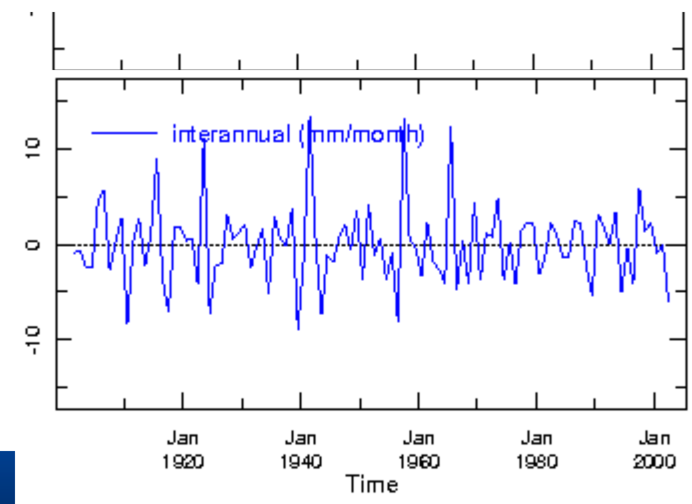
12%

21%

65%







75%

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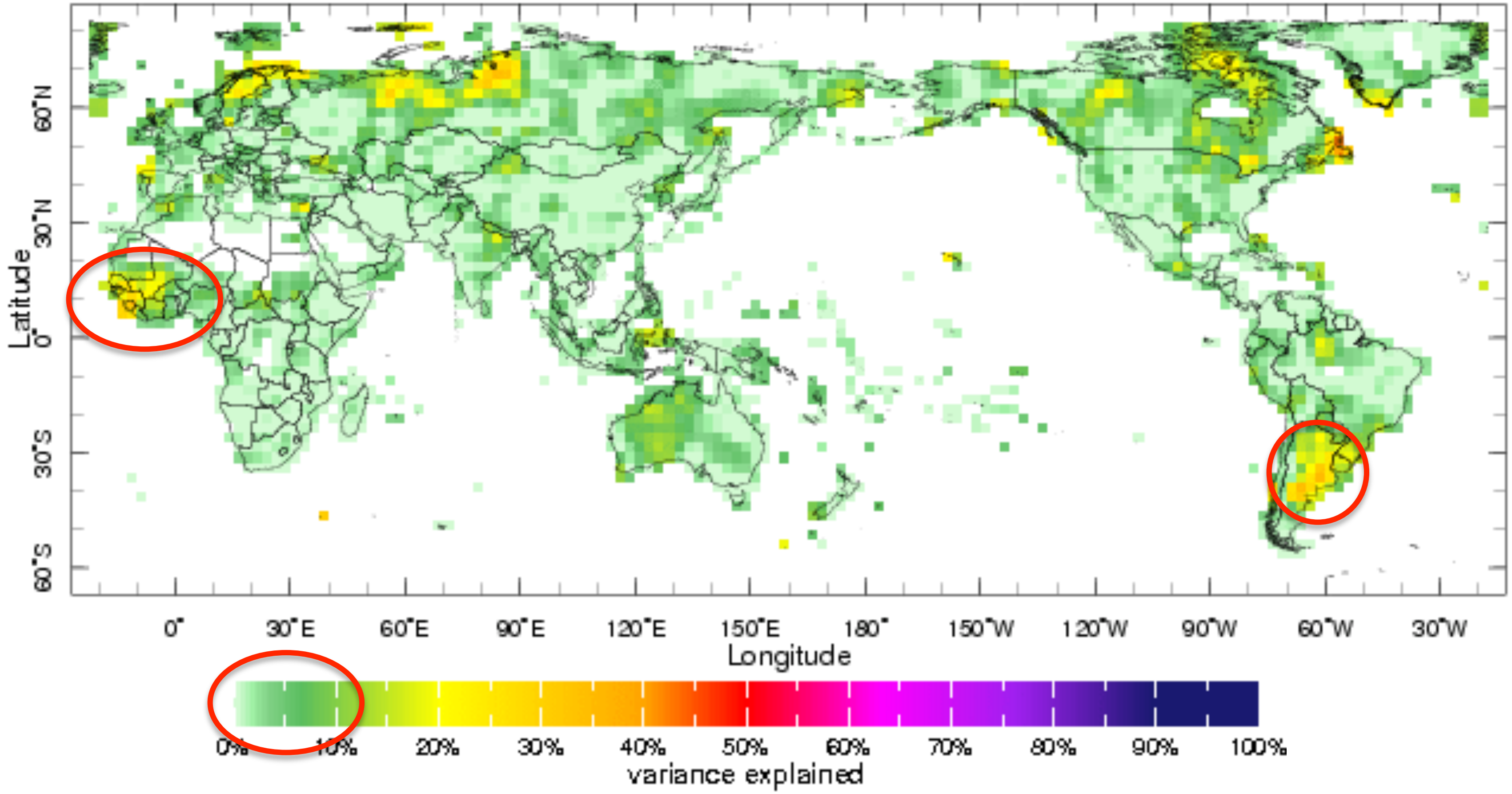
Earth Institute | Columbia University

Precipitation Trends: % of total variance

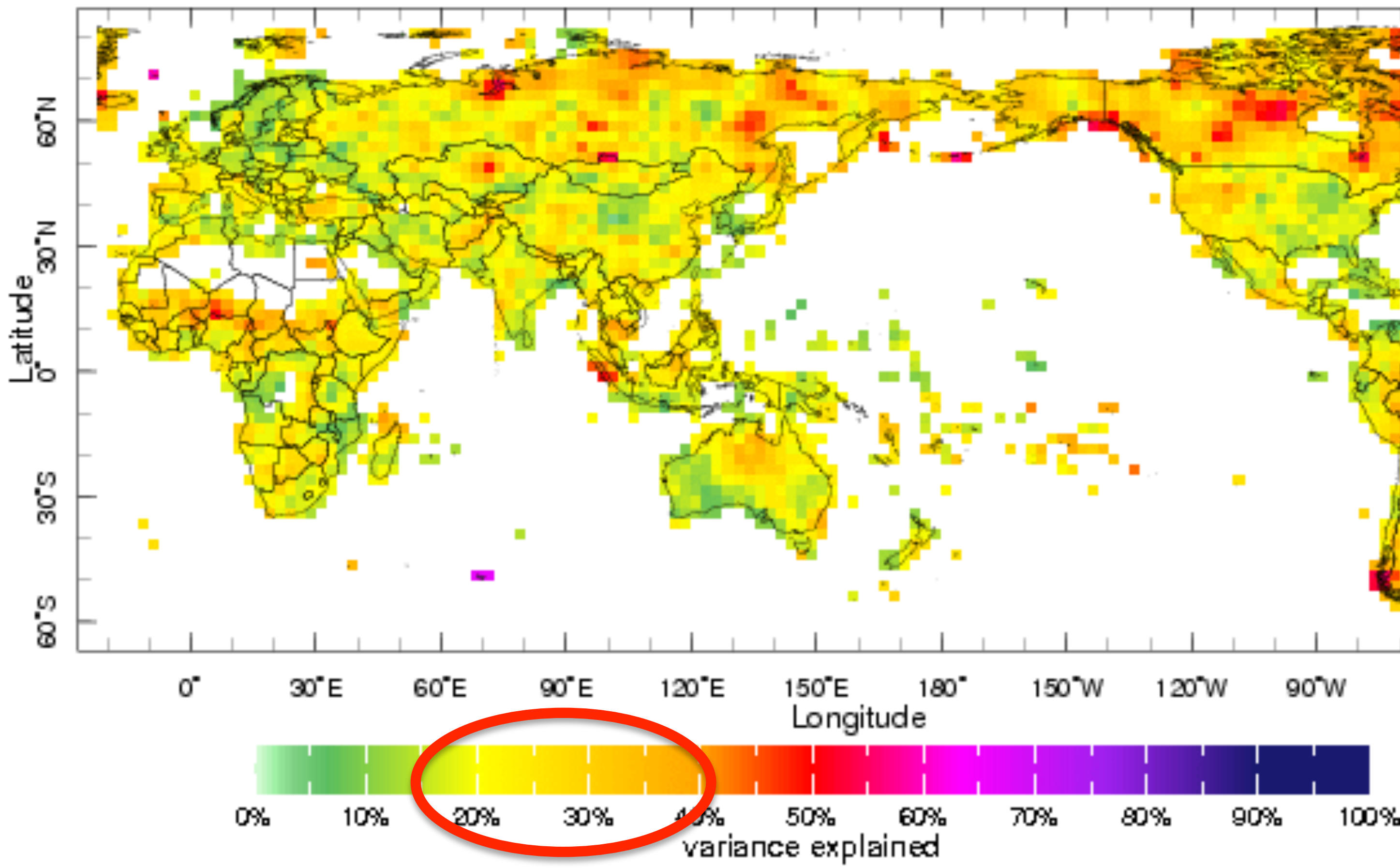
20th Century Observations -- Annual Means



http://iridl.ldeo.columbia.edu/maproom/Global/Time_Scales/

Precipitation Decadal Variability: % of variance

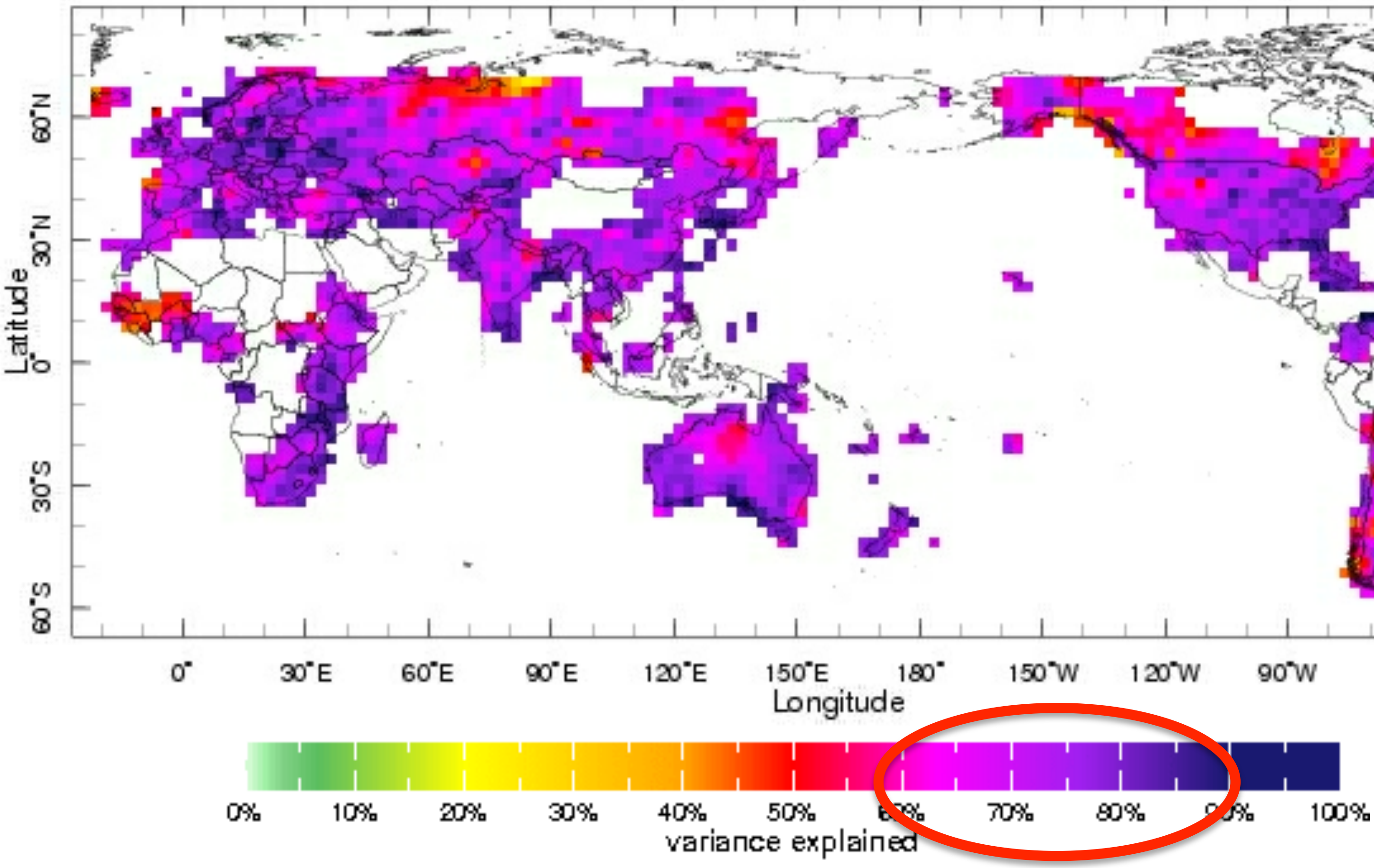
20th Century Observations -- Annual Means



http://iridl.ldeo.columbia.edu/maproom/Global/Time_Scales/

Precipitation Decadal Variability: % of variance

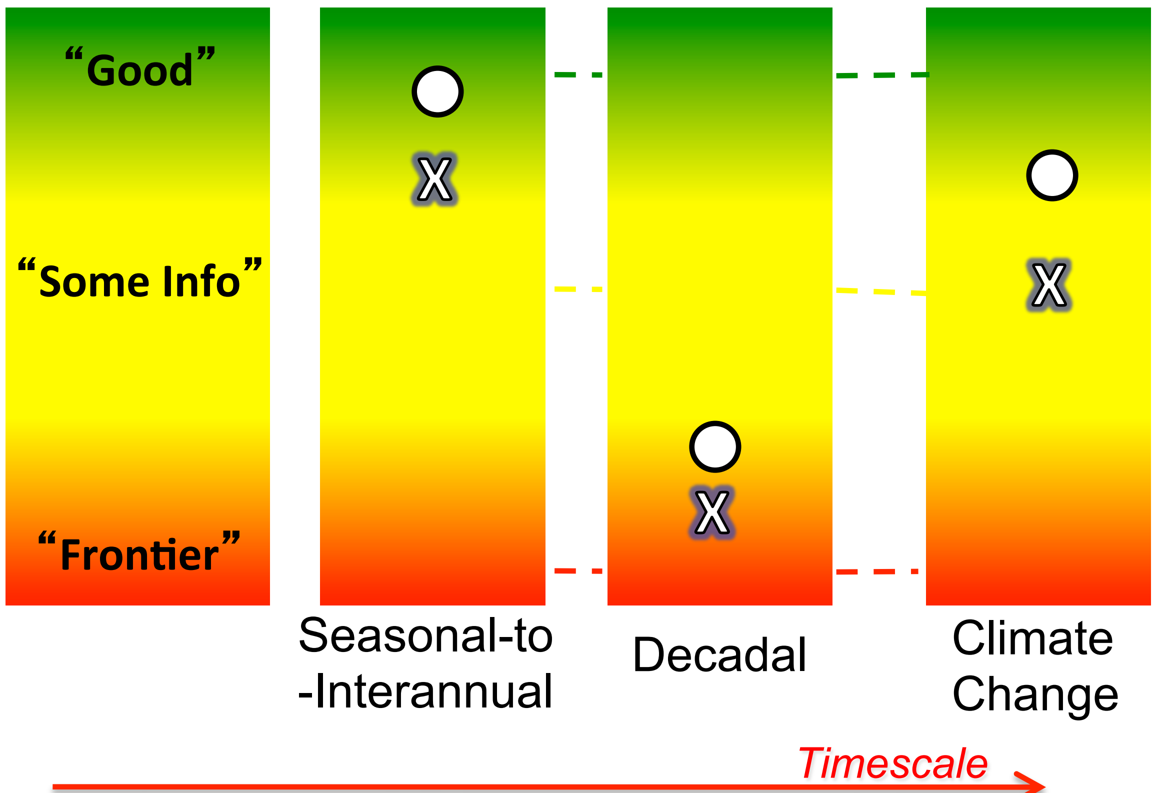
20th Century Observations -- Annual Means



Typically 60 – 80% of Total Variance

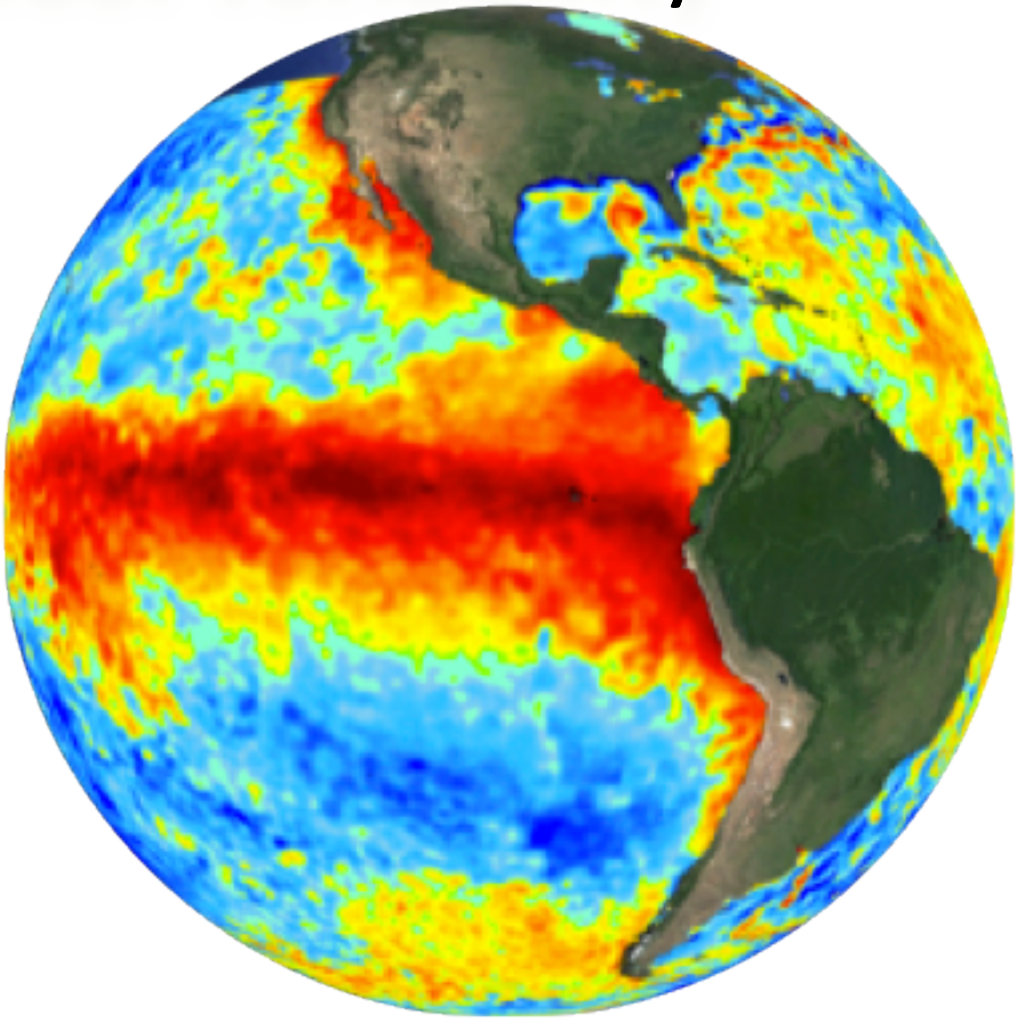
Planning for the Future …

Where are we?



Our understanding of climate variability and our ability to predict it is not constant across timescales.

ENSO is the dominant driver of interannual variability



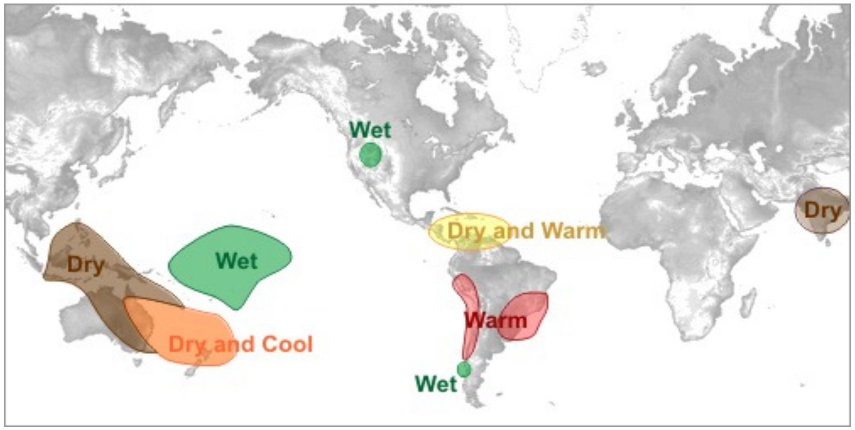
Making seasonal forecasts

Statistical expectation – association

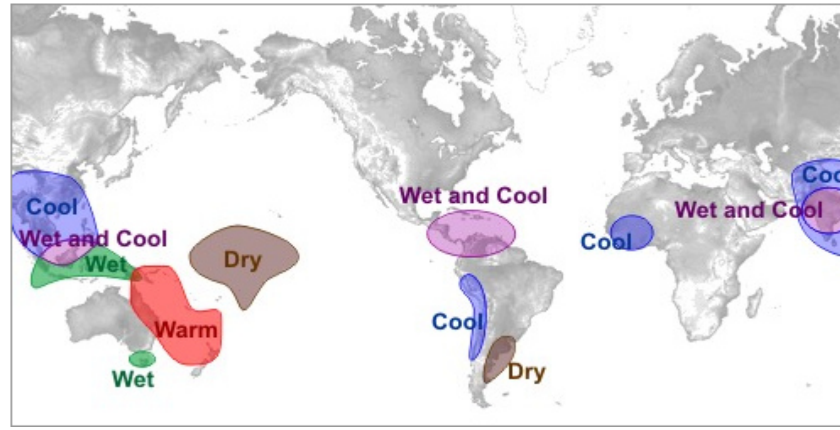
El Niño

La Niña

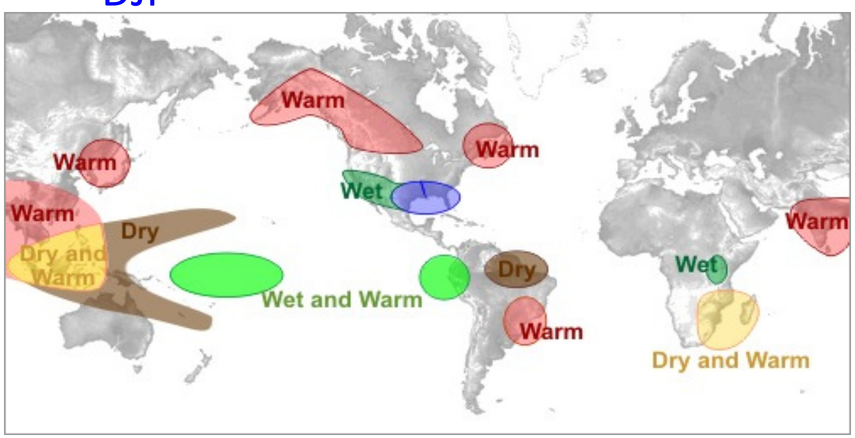
El Niño JJA



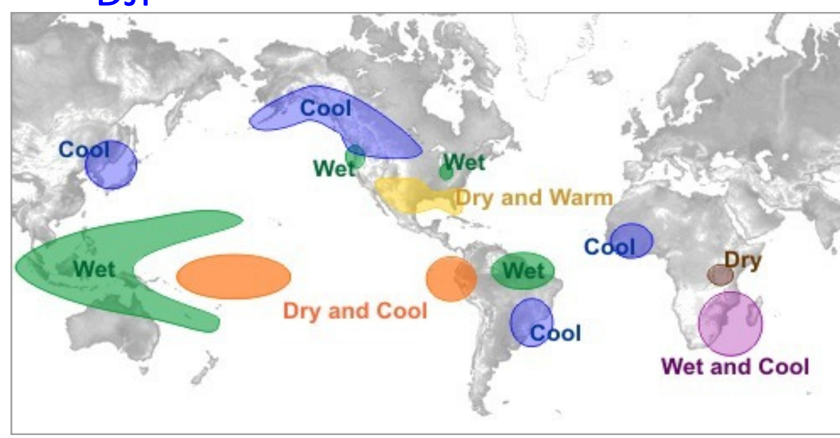
La Niña JJA



El Niño DJF

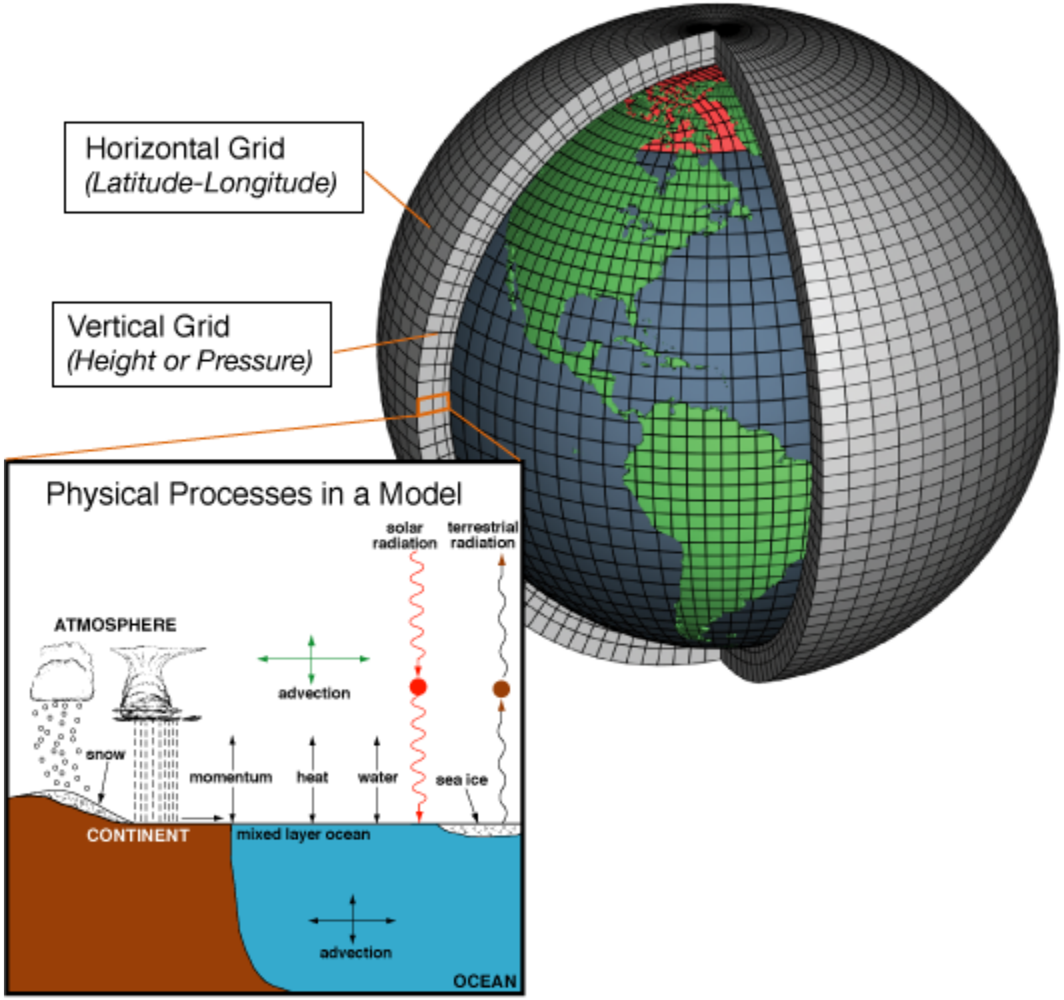


La Niña DJF



Making seasonal forecasts

Models of the physics – causation

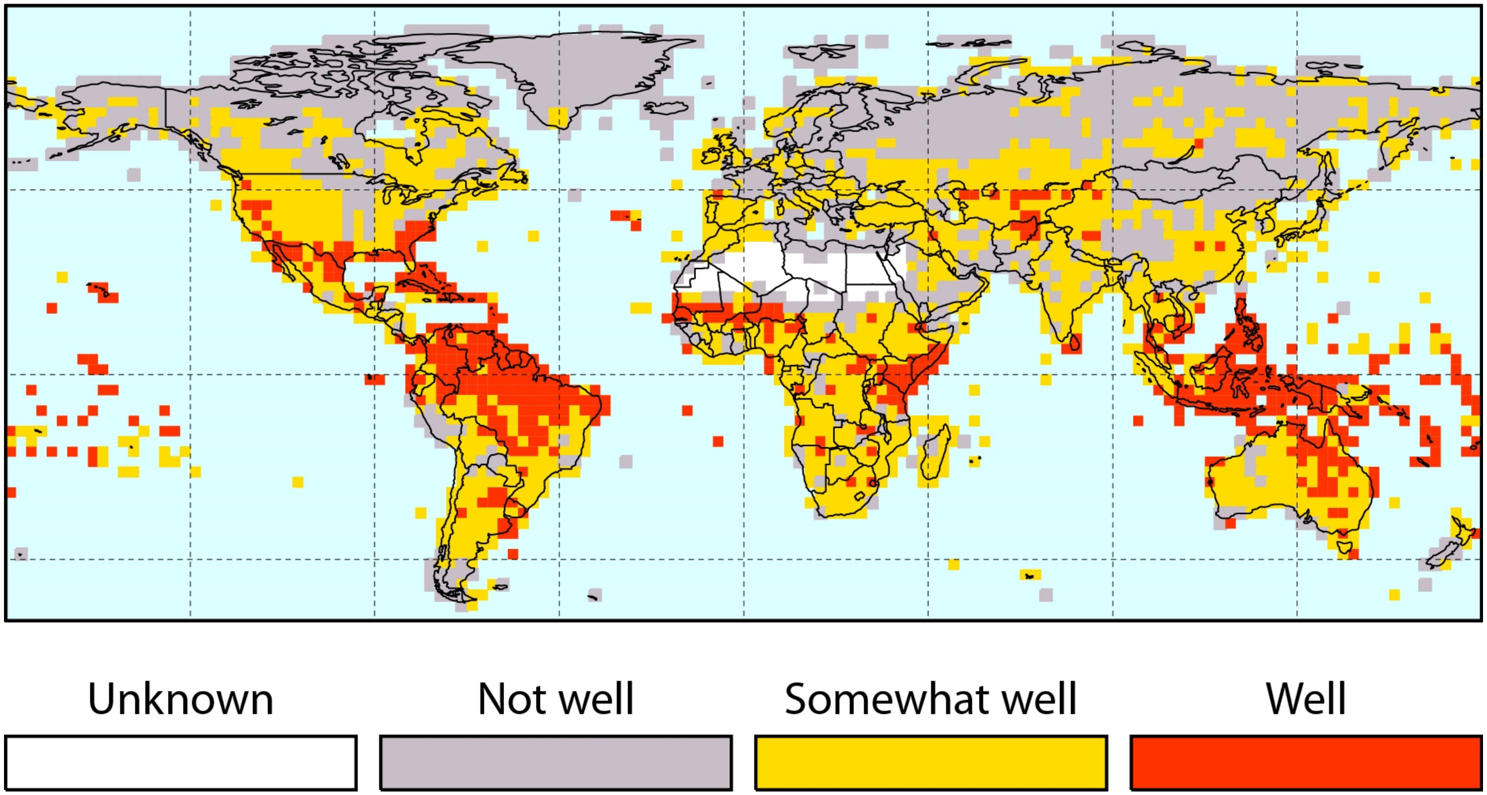


How might *this* El Niño affect weather?

Run lots of forecasts, ideally using a selection of models. Do many of the forecasts agree?

Do seasonal forecasts work?

How well can we predict seasonal rainfall totals?



Climate **Forecasts** | Flexible Forecasts: Precipitation Flexible Seasonal Forecast | Region: Asia | Model: Forecast | Target Time: Dec 2013 - Feb 2014 | Climatology (1979 to 2011): 1981 to 2010

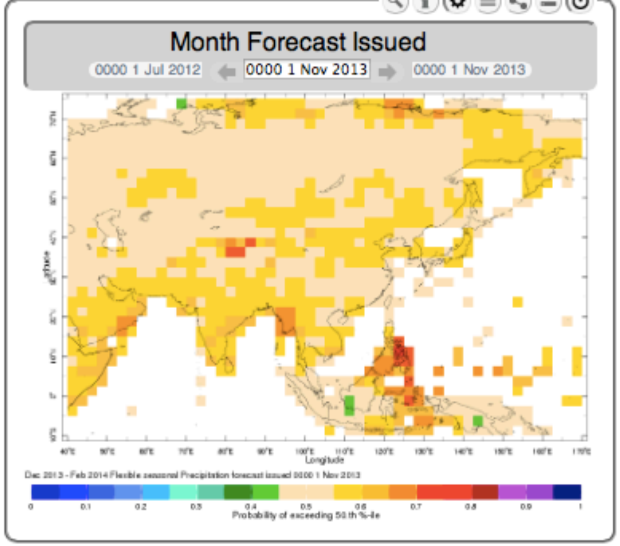
Probability: exceeding | Percentile | %-ile

Description | Dataset Documentation | More Information | Contact Us

Precipitation Flexible Seasonal Forecast

This seasonal forecasting system consists of probabilistic precipitation seasonal forecasts based on the full estimate of the probability distribution.

Probabilistic seasonal forecasts from multi-model ensembles through the use of statistical recalibration, based on the historical performance of those models, provide reliable information to a wide range of climate risk and decision making communities, as well as the forecast community. The flexibility of the full probability distributions allows to deliver interactive maps and point-wise distributions that become relevant to user-determined needs.

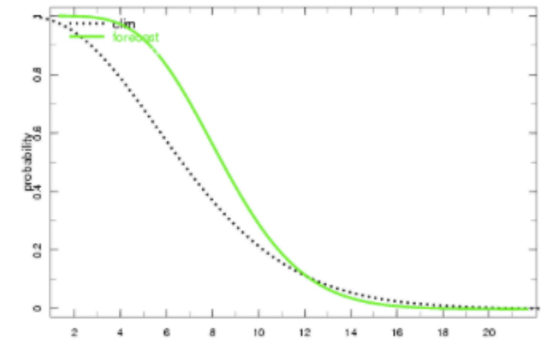


The default map shows globally the seasonal precipitation forecast probability (colors between 0 and 1) of exceeding the 50th percentile of the distribution from historical 1981-2010 climatology. The quantitative value (in mm/day) of that percentile is indicated by the contours. The forecast shown is the latest forecast made (e.g. Sep 2012) for the next season to come (e.g. Oct-Dec 2012). Five different seasons are forecasted and it is also possible to consult forecasts made previously. What makes the forecast flexible is that underlying the default map is the full probability distribution for the forecast and climatology. Therefore, the user can specify the historical percentile or a quantitative value (here precipitation in mm/day) for probability of exceedance or non-exceedance. The climatological reference on which the forecast probability of (non-)exceeding is computed can be tailored by defining its starting and ending years.

Clicking on a point on the map will show the local culmulative distribution and probability distribution fucntions of the forecast (green) together with the climatological distribution (black).

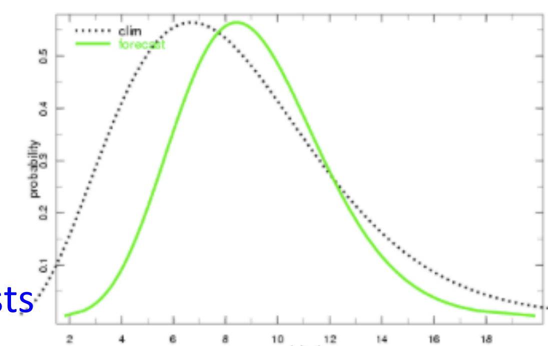
Target Date	Issue Date	Lead Time
Dec 2013 - Feb 2014	0000 1 Nov 2013	2.5

Probability of Exceedance



Dec 2013 - Feb 2014 issued 0000 1 Nov 2013 at (126.25E,11.25N)

Probability Distribution

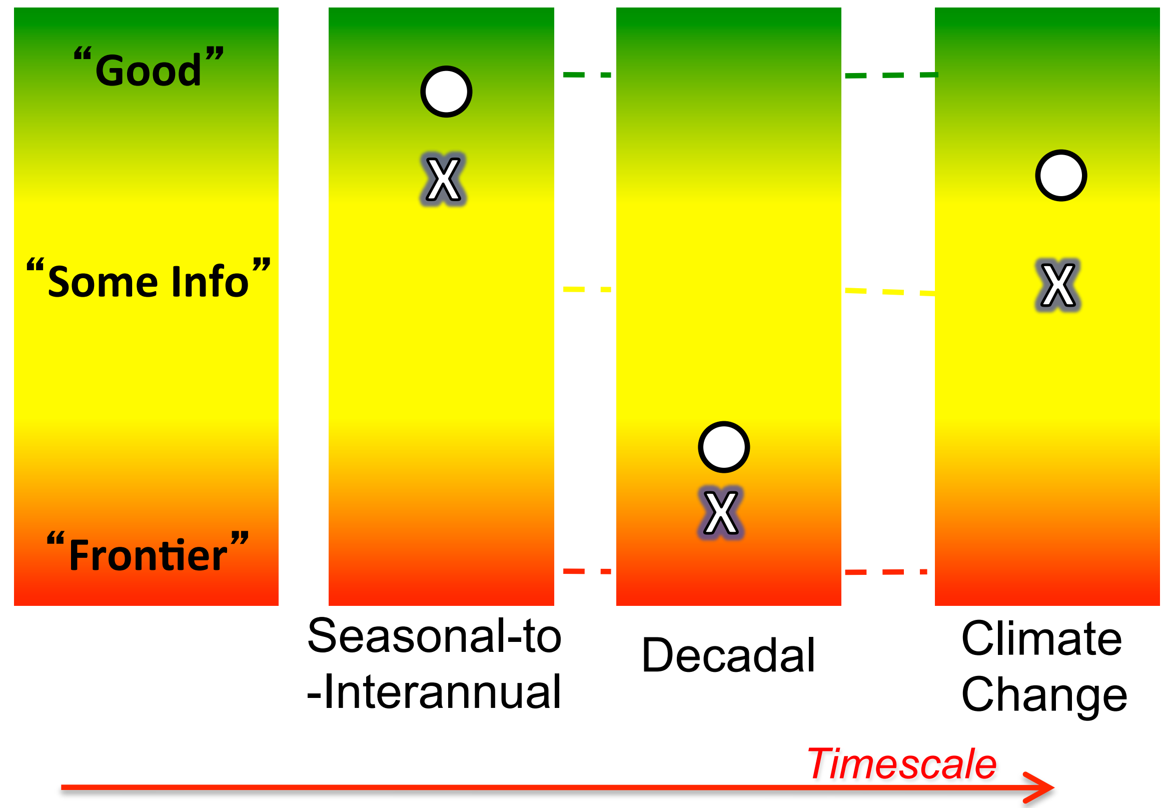


http://iridl.ldeo.columbia.edu/maproom/Global/Forecasts/Flexible_Forecasts

Planning for the Future …

Where are we?

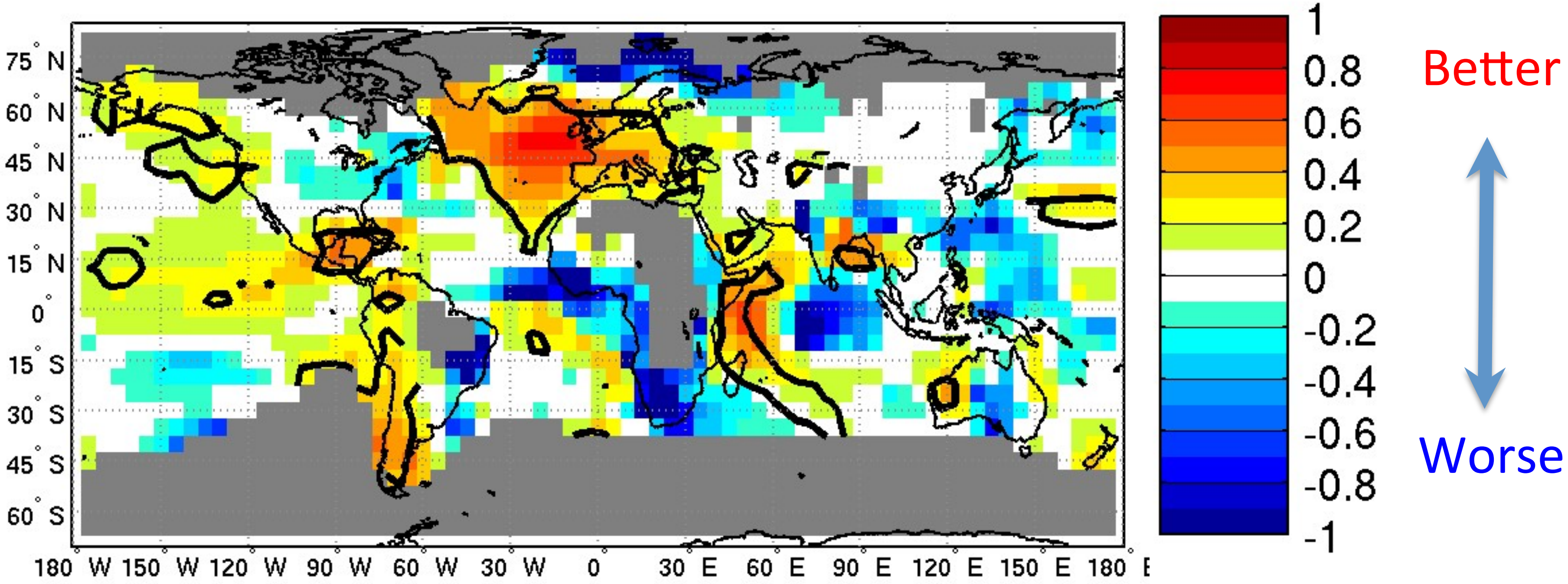
UNDERSTANDING ○
and
PREDICTABILITY X



Our understanding of climate variability and our ability to predict it is not constant across timescales.

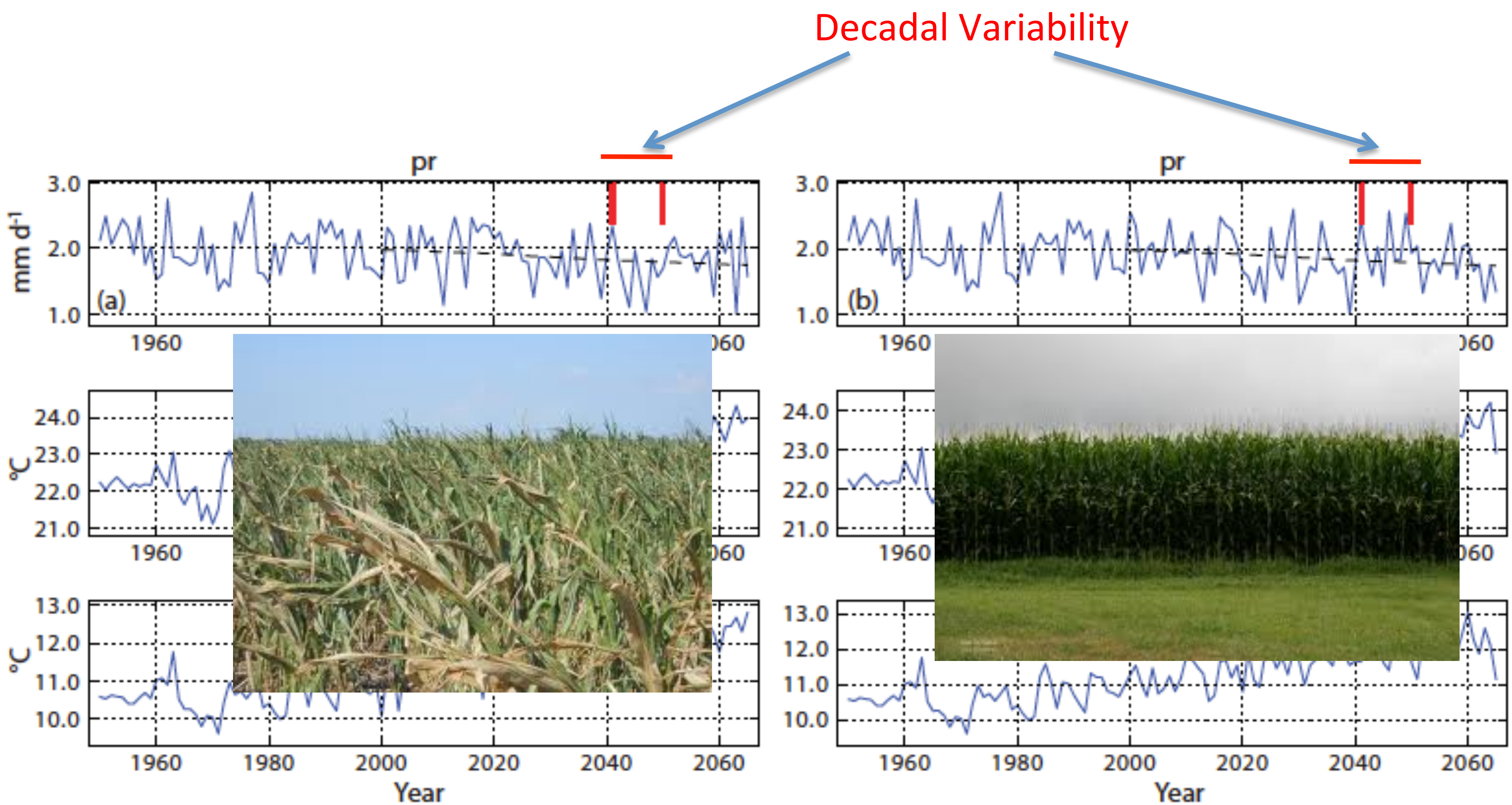
Decadal Predictions: Annual Temperature

Do Initial Ocean Conditions Make More Accurate Predictions Than Just Knowing the Greenhouse Gasses ??



(*based on Goddard et al. 2012, Climate Dynamics; See also http://clivar-dpwg.iri.columbia.edu)*

SAMPLING PAST OBSERVED CLIMATE: *2 Cases*



① Climate varies on all timescales.

② Our ability to predict the climate on different timescales is different

③ Climate information is more than just predictions

http://iri.columbia.edu

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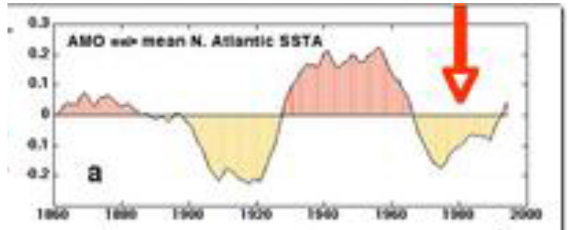
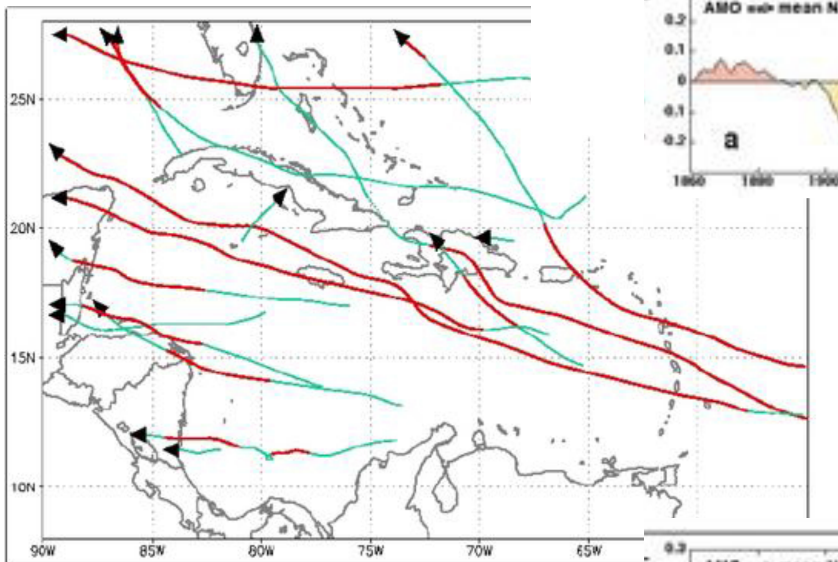
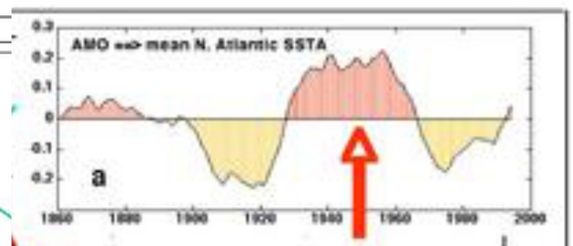
Extra slides …

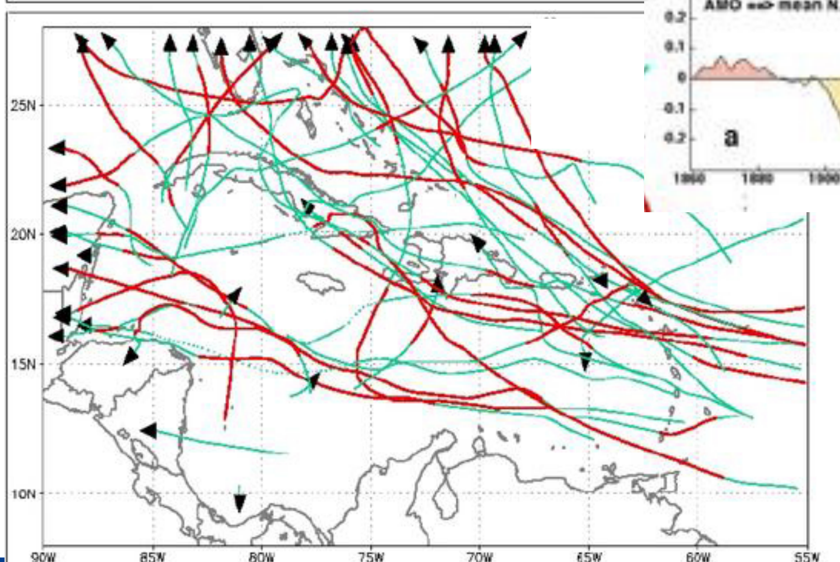
AMO effects on Atlantic hurricanes





"During warm phases of the AMO, the numbers of tropical storms that mature into severe hurricanes is much greater than during cool phases, **at least twice as many**."





Source:
http://www.aoml.noaa.gov/phod/d2m_shift/amo_faq.php

Take Away Points

1 – Consider BOTH climate variability and climate change
… for establishing resilience, for informing management, and for planning

2 – Decadal predictions from climate models are ***not*** yet ready for use

3 – But we can provide useful indications of decadal-scale risk by analyzing past observations

Spot the Ball Competition

Where is the ball now?

Where will it be in 20 seconds?

Who will win the match?

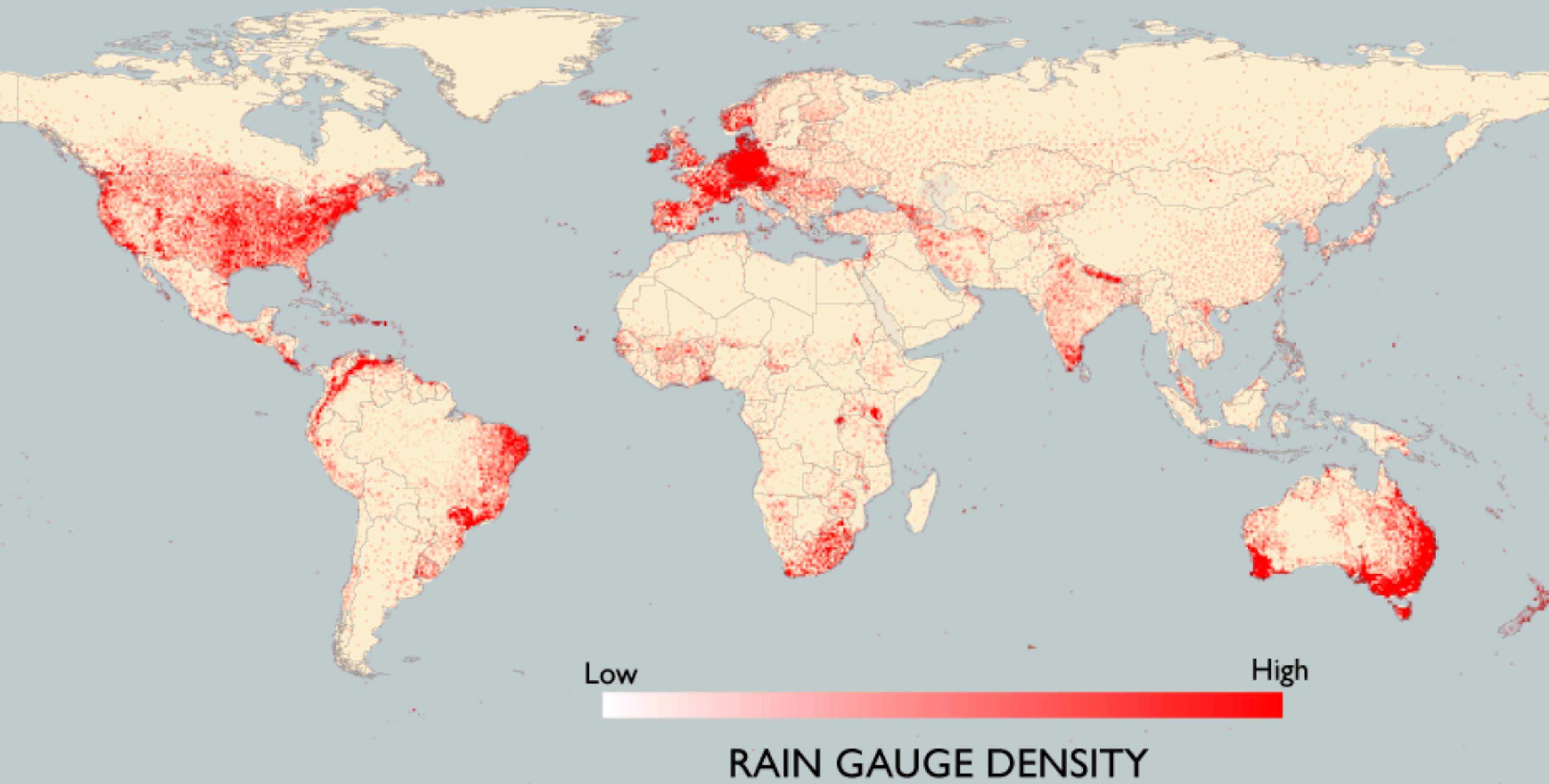
What is the current weather?

What will it be on Saturday?

Will winter be unusually wet?

Sources of Predictability

- We can make forecasts at different timescales because there are different reasons why the predictions can work:
  - *days*: current weather
  - *months*: sea-surface temperatures
  - *years*: sub-surface ocean temperatures
  - *decades*: atmospheric composition


Low
High
RAIN GAUGE DENSITY

Rain Gauges

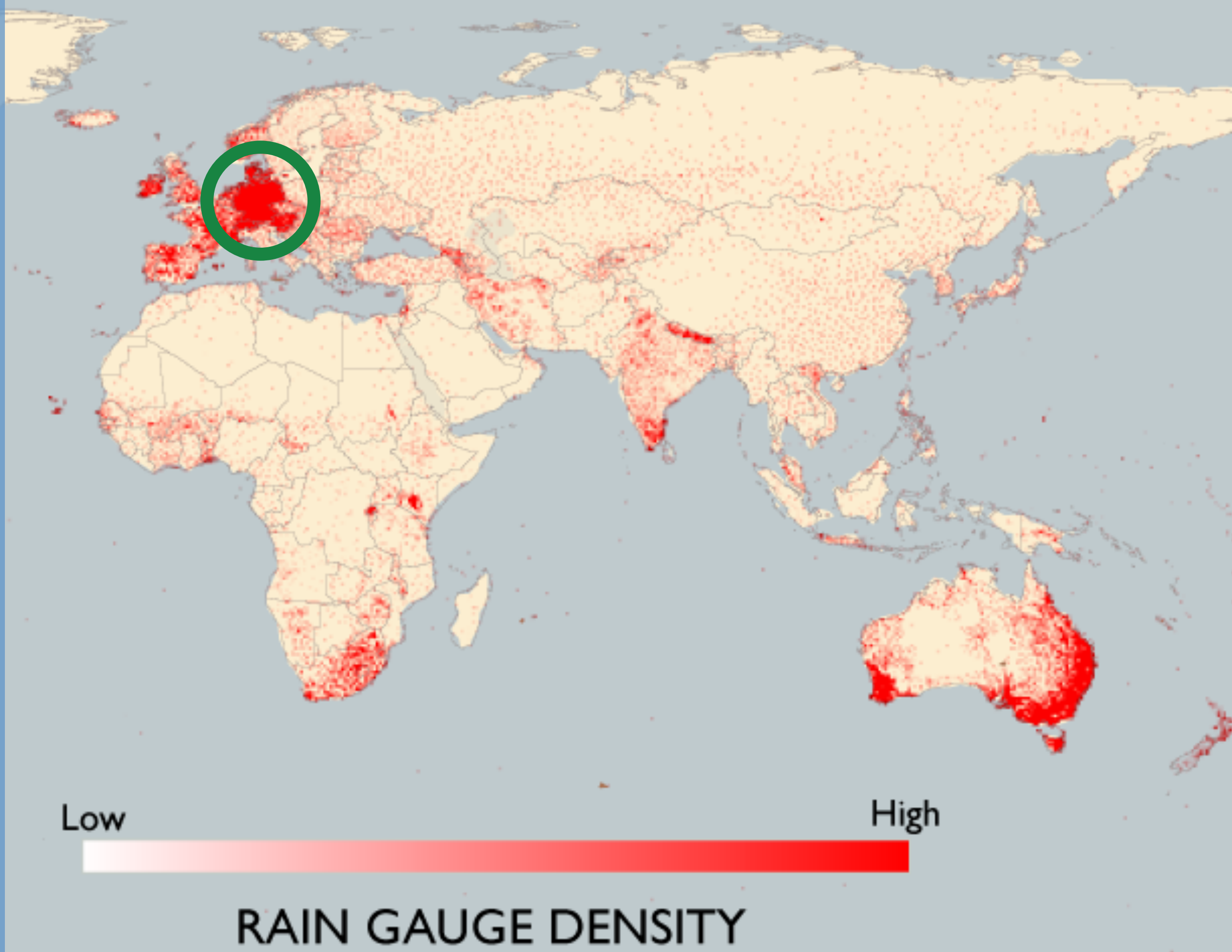
Africa: 2,967

Germany: 4,133

Land Area

Africa **11.7** million sq. miles

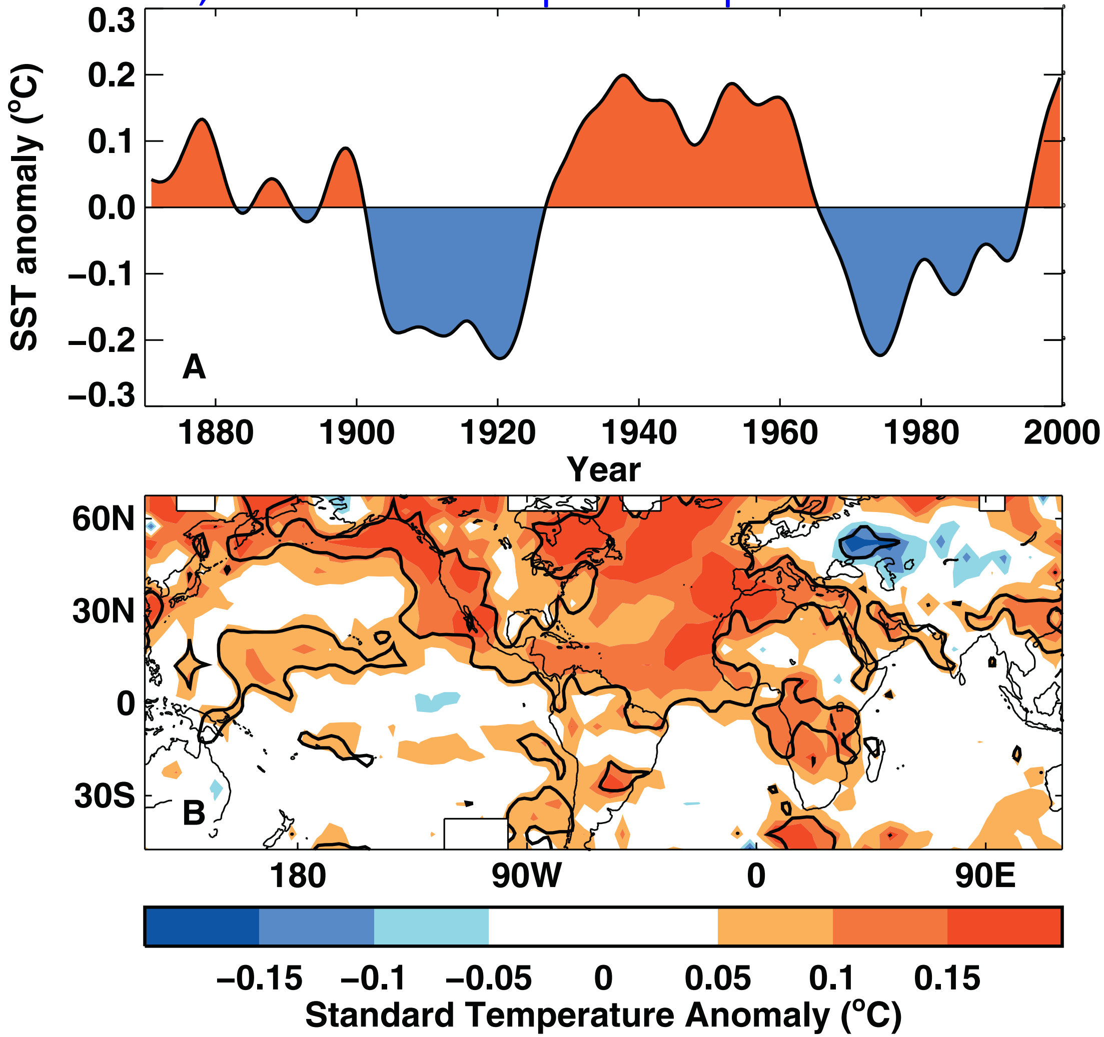
Germany **0.14**



AMO (Atlantic Multi-decadal Oscillation)

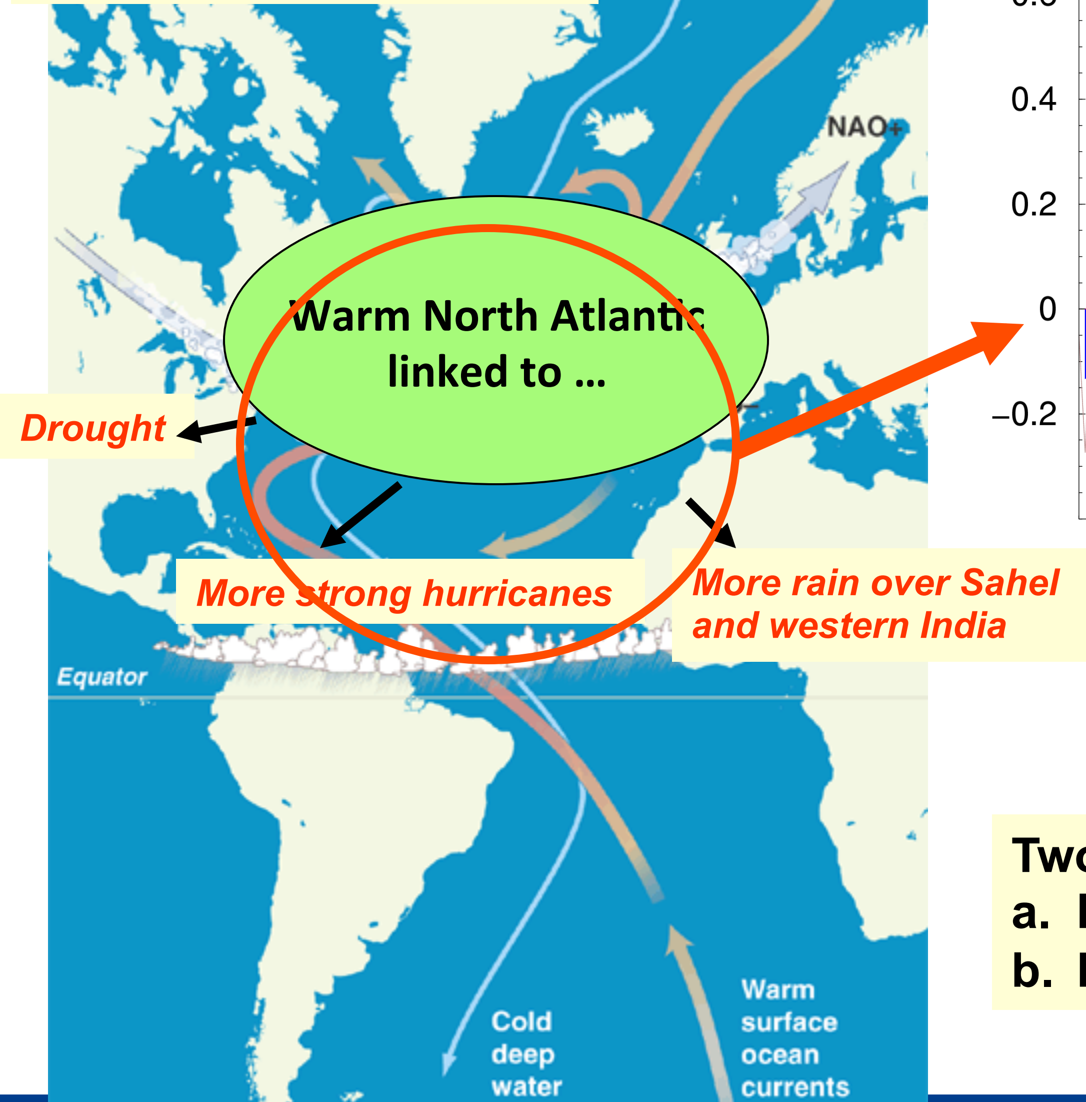
The principal mode in the Atlantic

Detrended AMO Index, and Surface temperature pattern associated with the AMO

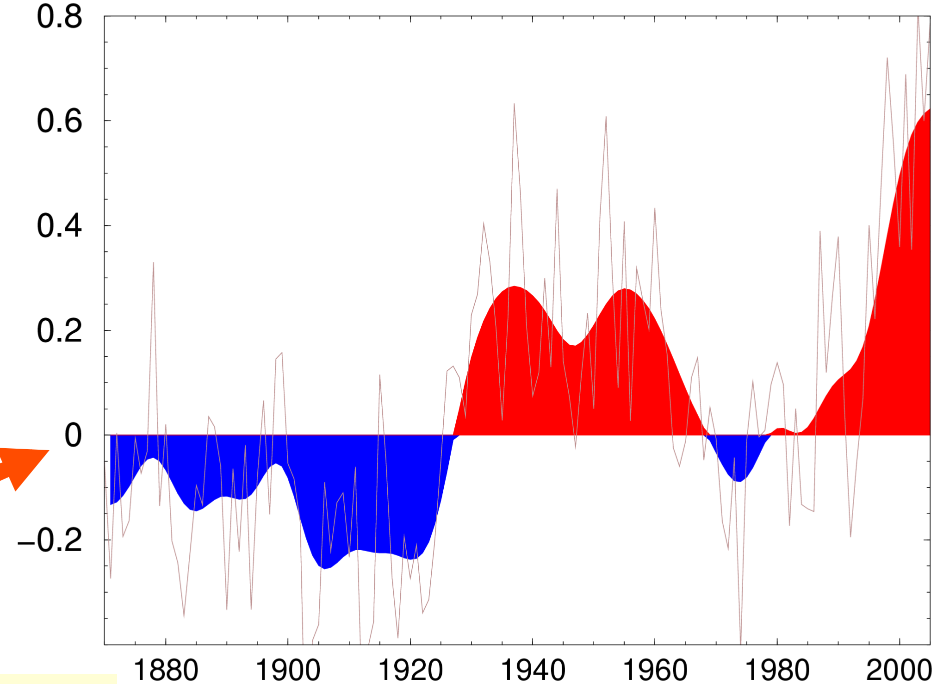


Knight et al. 2005, Geophys. Res. Lett.

Atlantic Meridional Overturning Circulation (AMOC)



North Atlantic Temperature



Two important aspects:

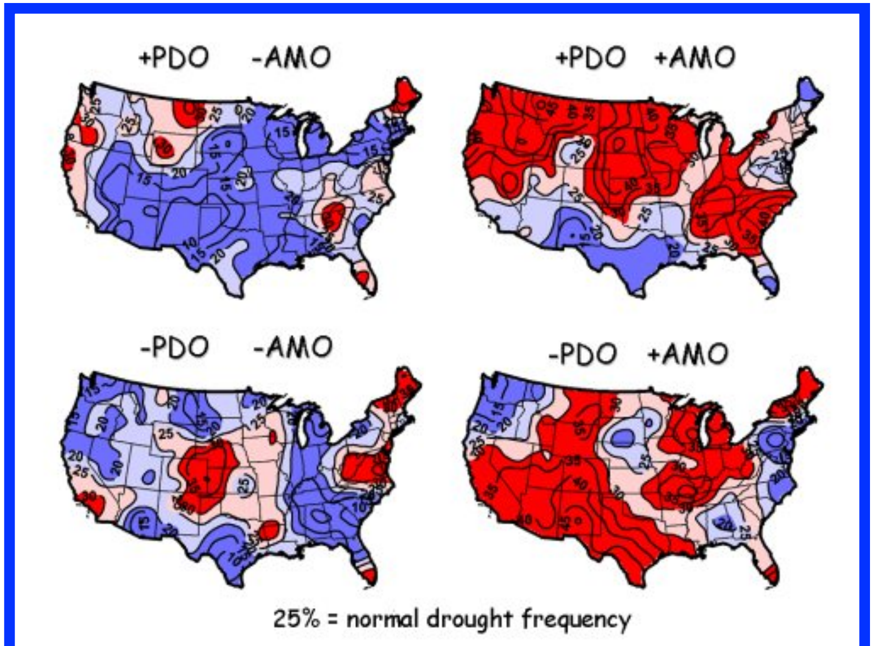
a. **Decadal-multidecadal fluctuations**

b. **Long-term trend**

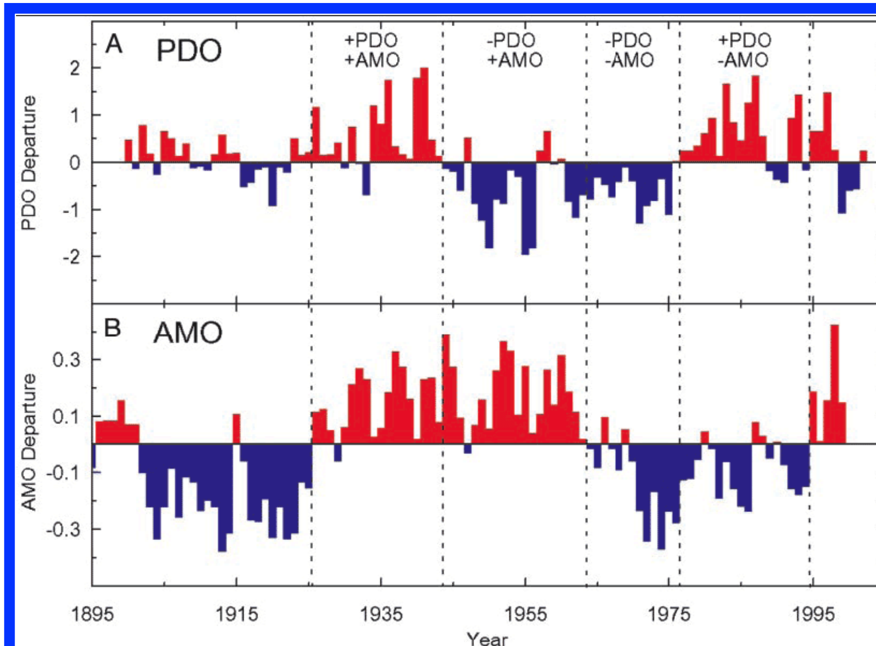
Atlantic & Pacific Decadal Variability ***both*** impact U.S. Climate

… such as risk of drought

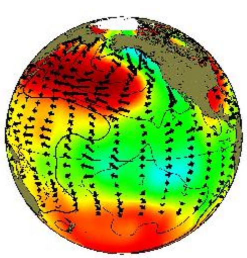
AMO/PDO combined effects on drought



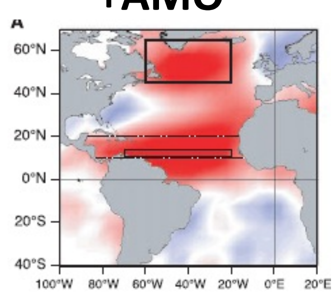
Periods when these conditions applied



- PDO



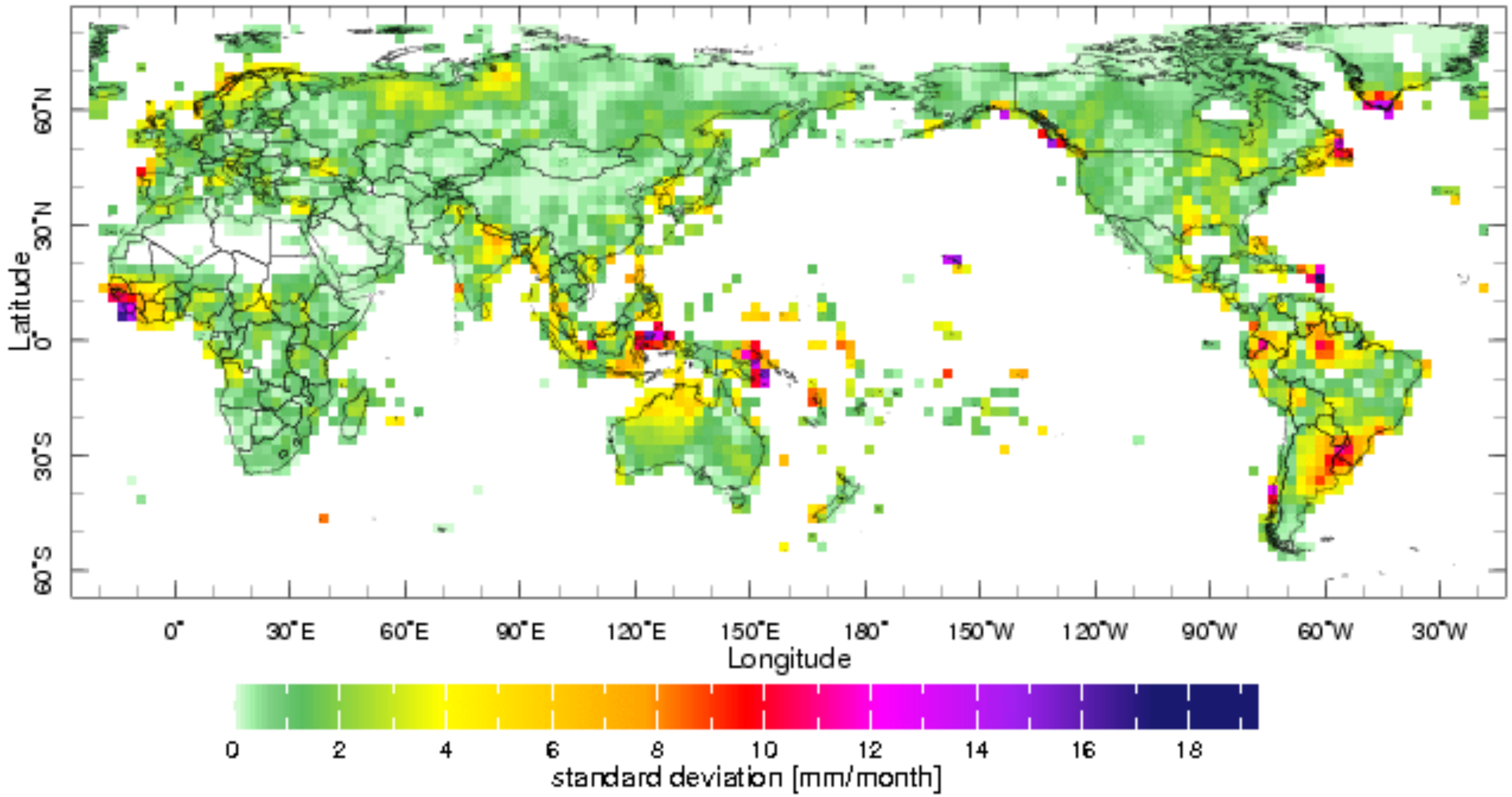
+AMO



(Source: McCabe et al, 2004)

Precipitation Trends: Magnitude of variance

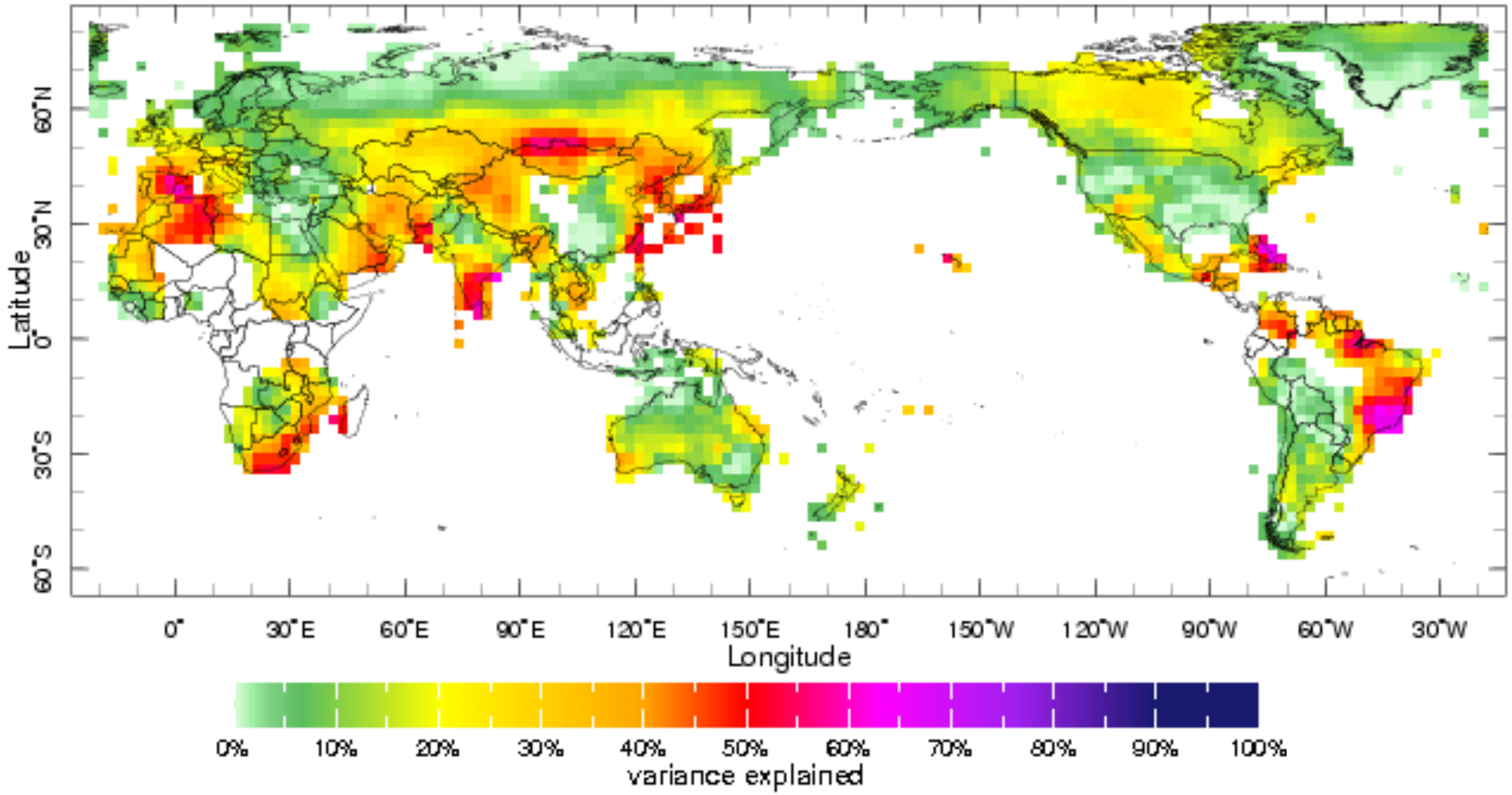
20th Century Gridded Observations -- Annual Means



http://iridl.ldeo.columbia.edu/maproom/.Global/.Time_Scales/

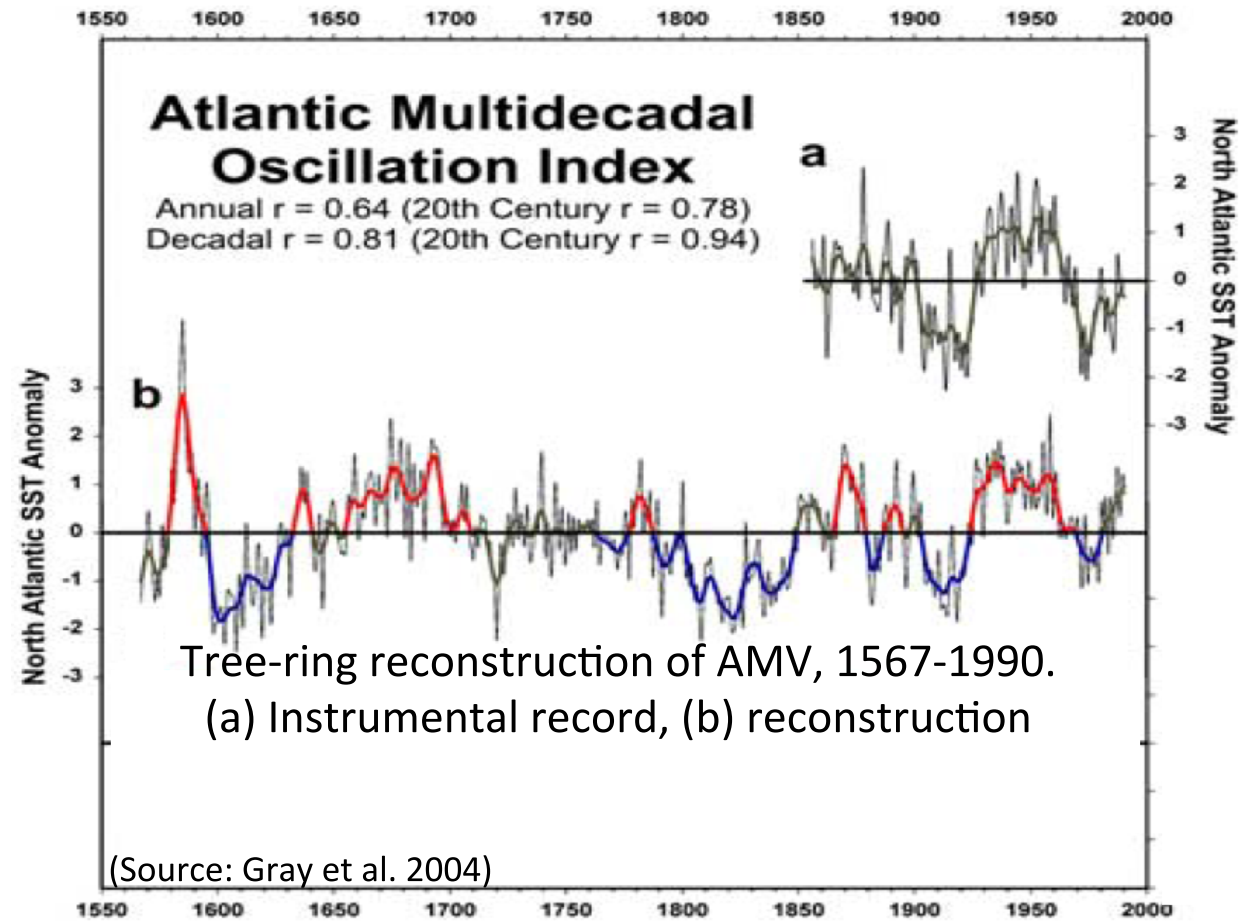
Temperature Trends: Percent of total variance

20th Century Gridded Observations -- Annual Means



Atlantic Multi-decadal Oscillation (AMO)

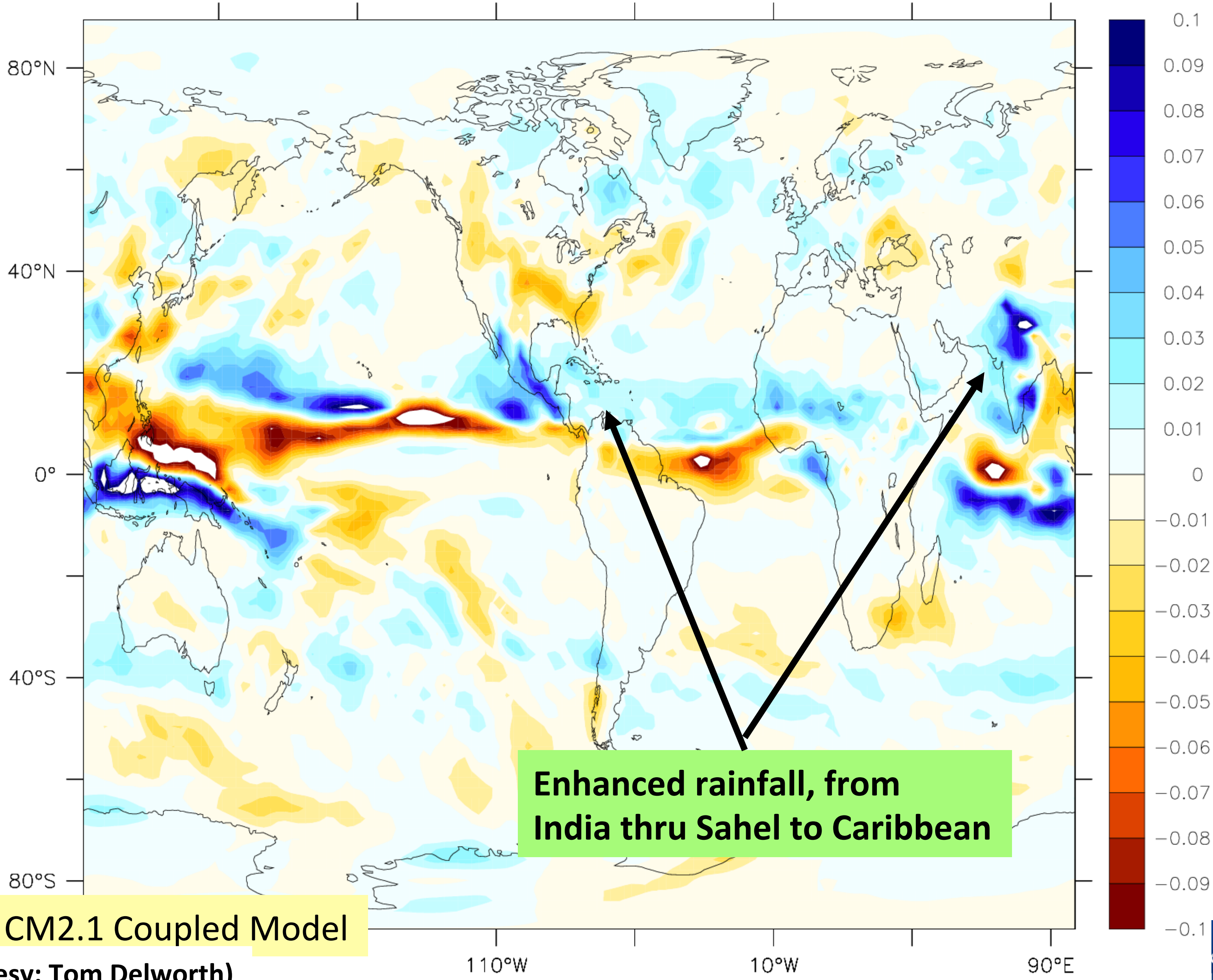
Has Existed for Centuries… at least



Tree-ring reconstruction of AMV, 1567-1990.
(a) Instrumental record, (b) reconstruction

(Source: Gray et al. 2004)

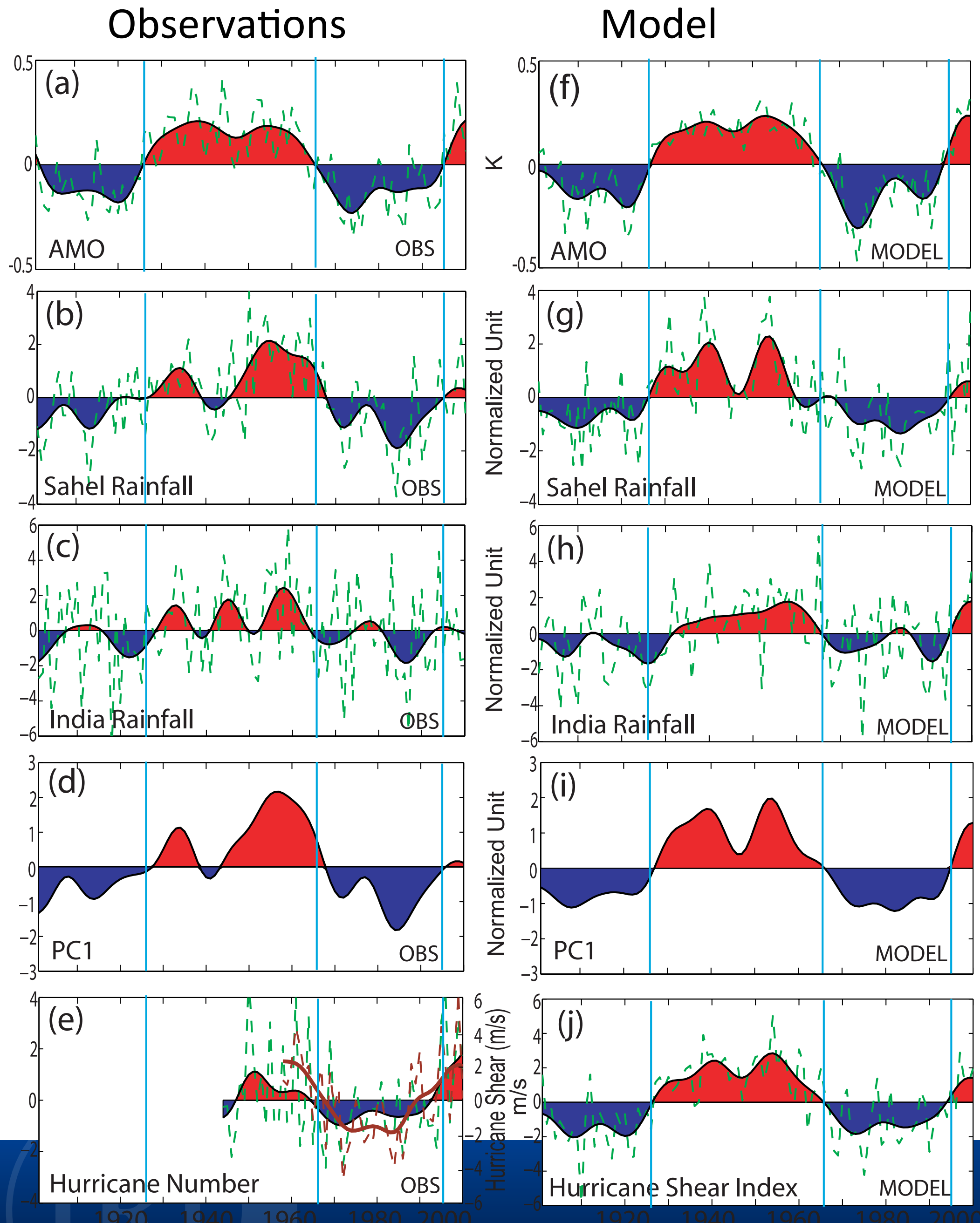
JJA Precipitation Anomalies Associated with Warm North Atlantic (+ AMO)



GFDL CM2.1 Coupled Model

(Courtesy: Tom Delworth)

Units: cm/day



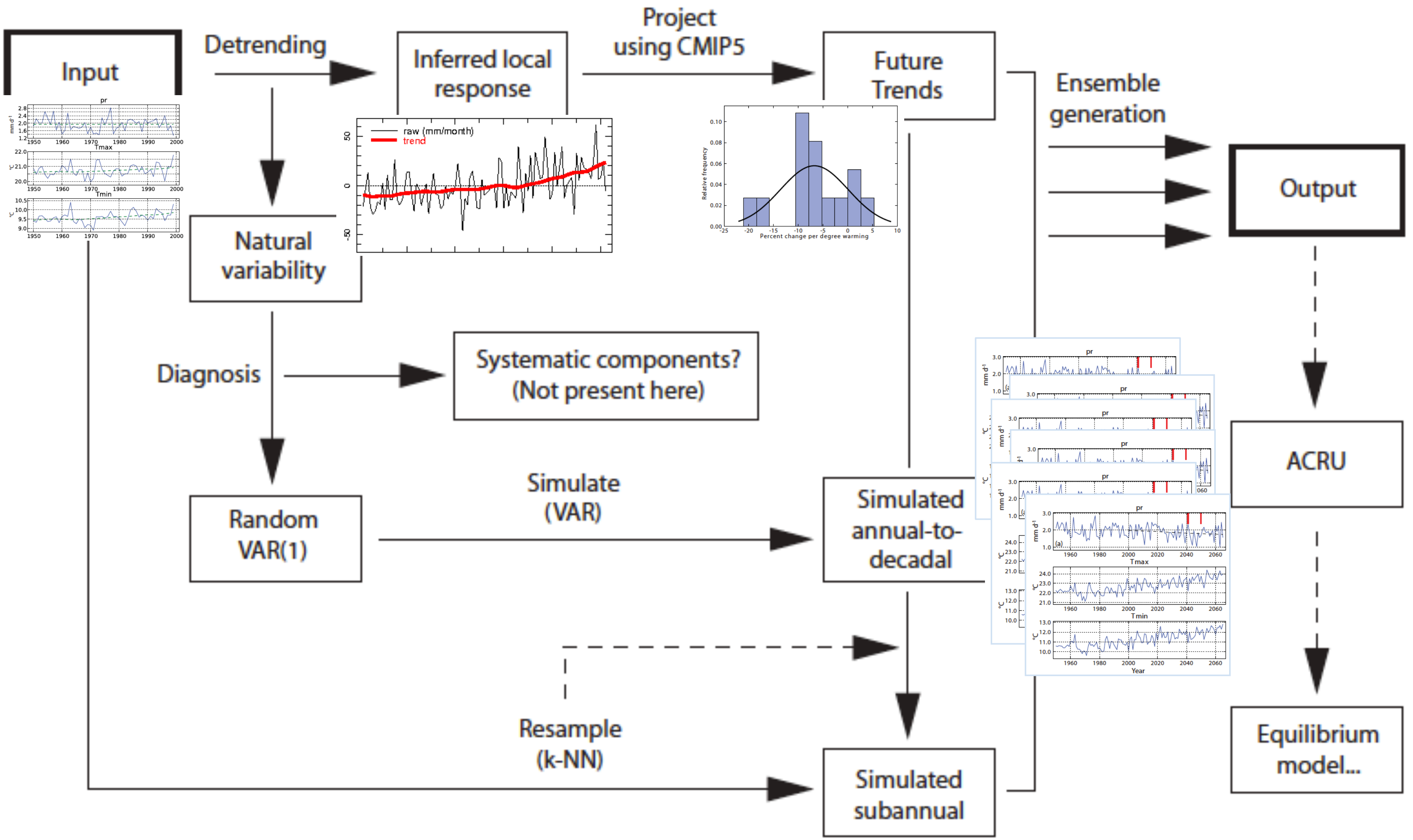
AMO and associated impacts

Model result obtained by forcing AGCM with observed heat fluxes

Zhang and Delworth 2006, Geophys. Res. Lett.

STOCHASTIC SIMULATION FRAMEWORK: *Example for South Africa*

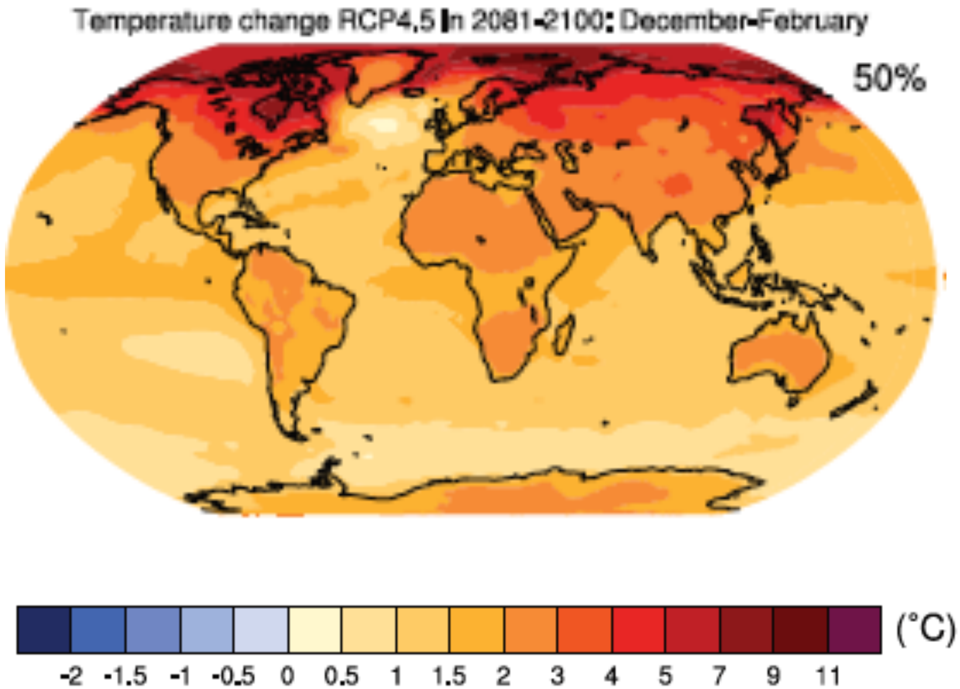
(Greene, et al. 2012)



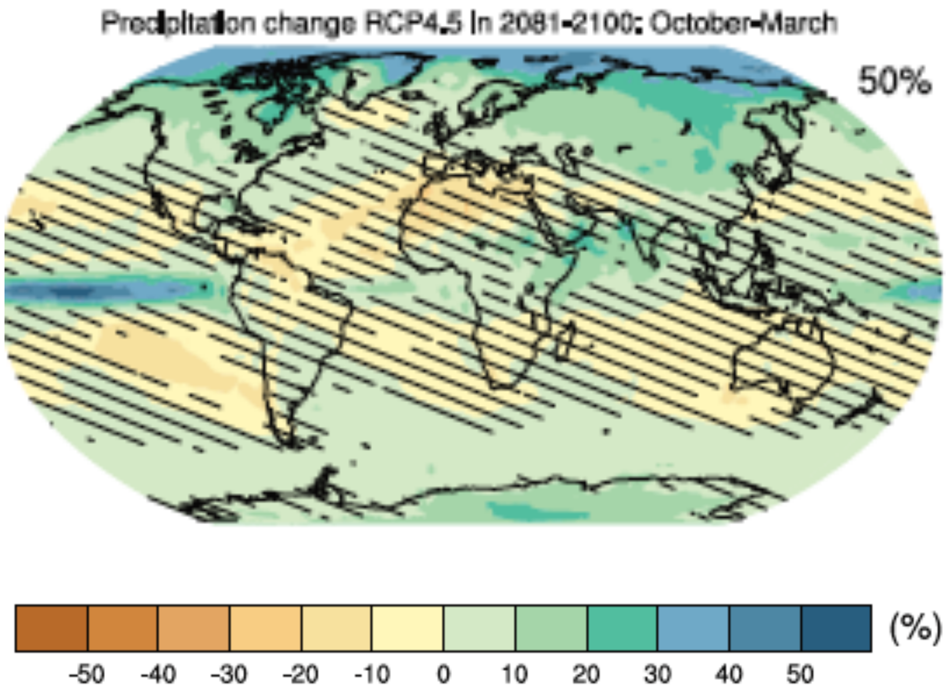
Is this what we are adapting to?

Multi-Model Mean Changes: (2081-2100)-(1986-2005)

Temperature



Precipitation



How much confidence can we have in these projections?

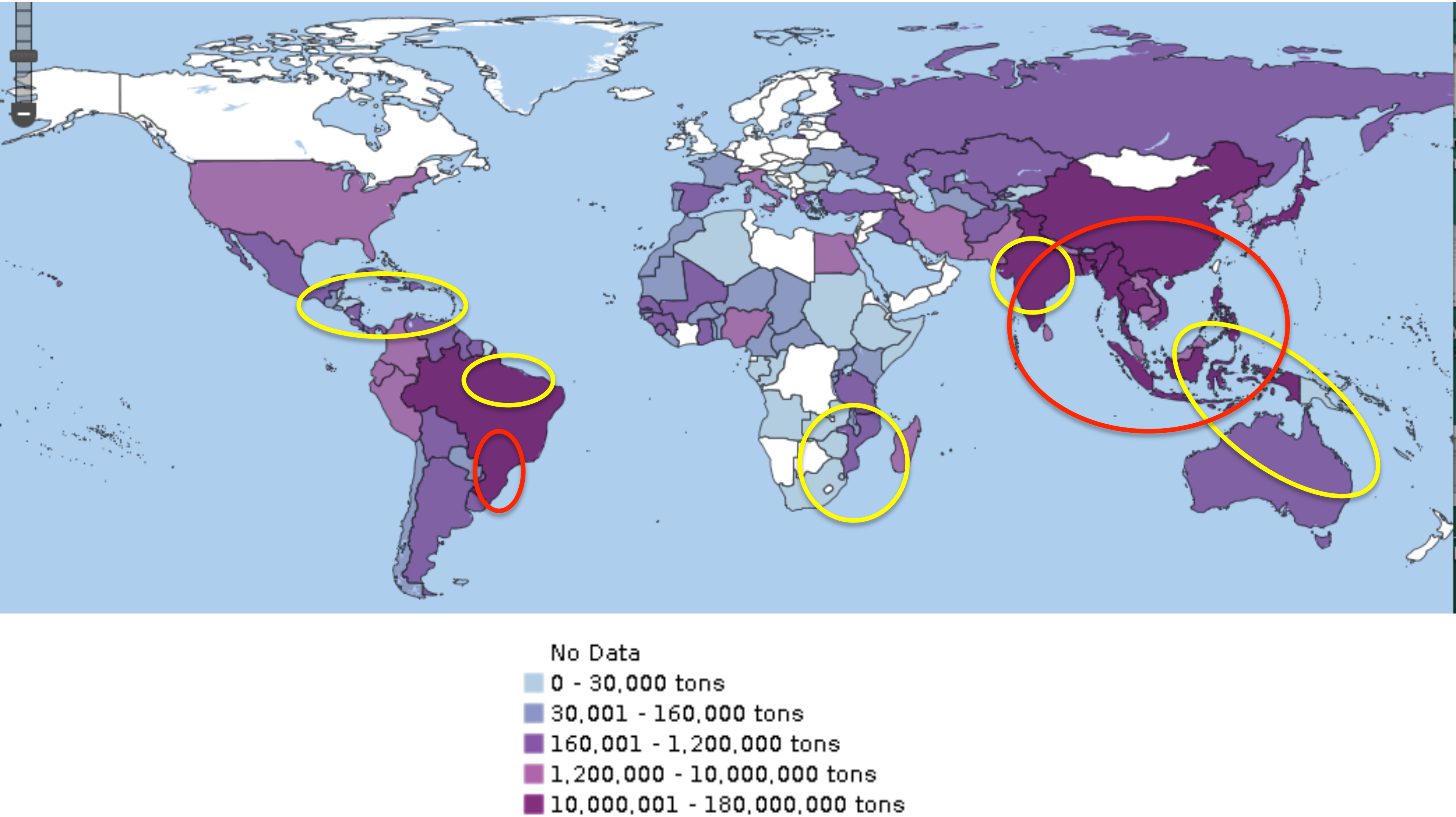
You are going away for 2 days this evening.

Do you start the roof repairs this morning, or might the house get wet?

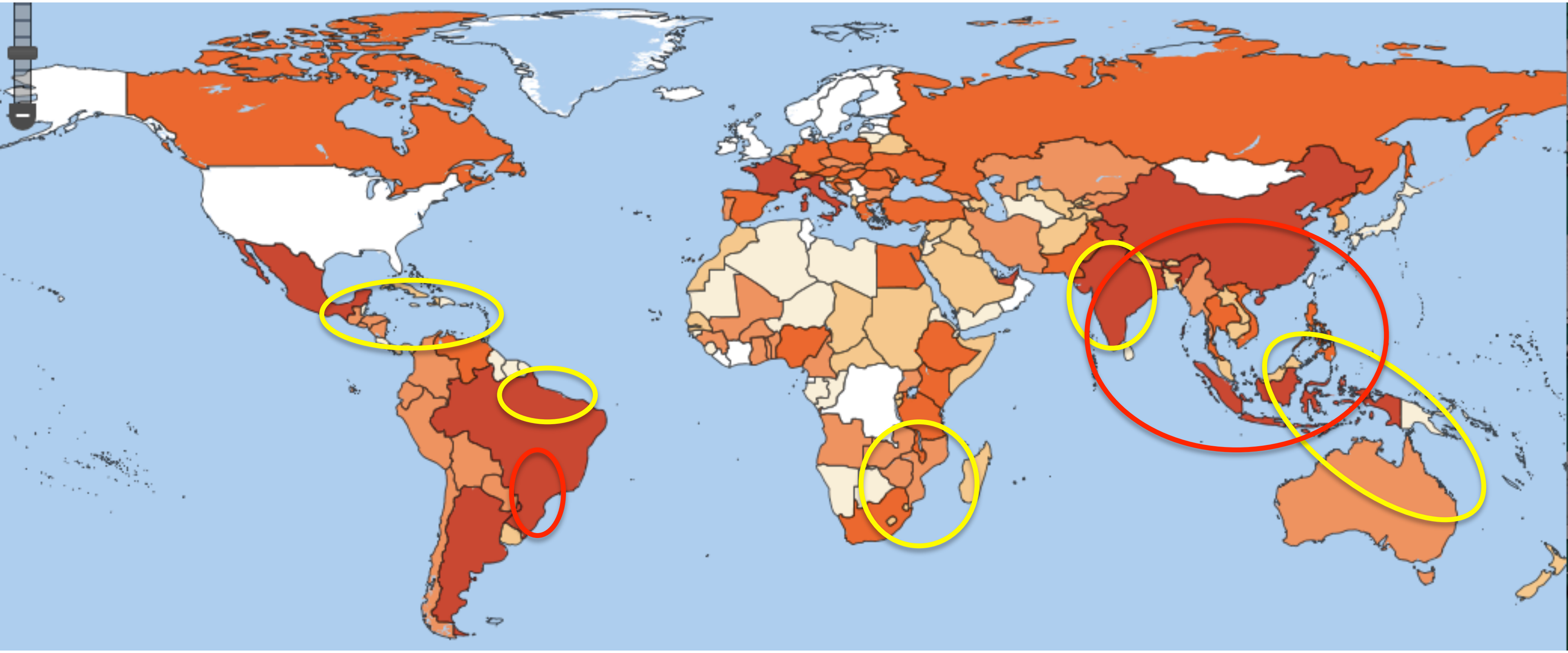
Would you look at the forecast for Saturday?

What if you only had the forecast for Saturday?

Rice Production + El Niño Impacts

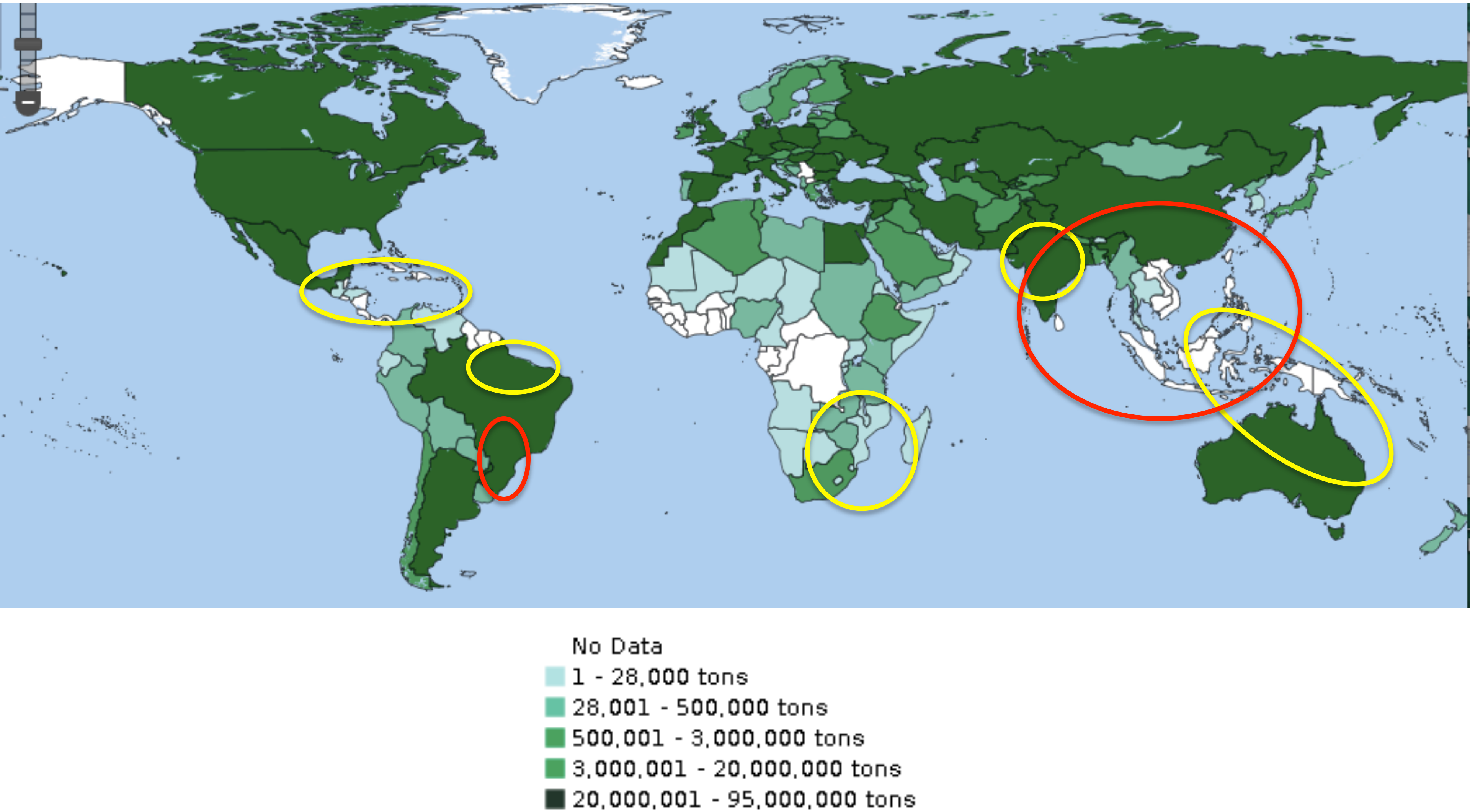


Maize Production + El Niño Impacts



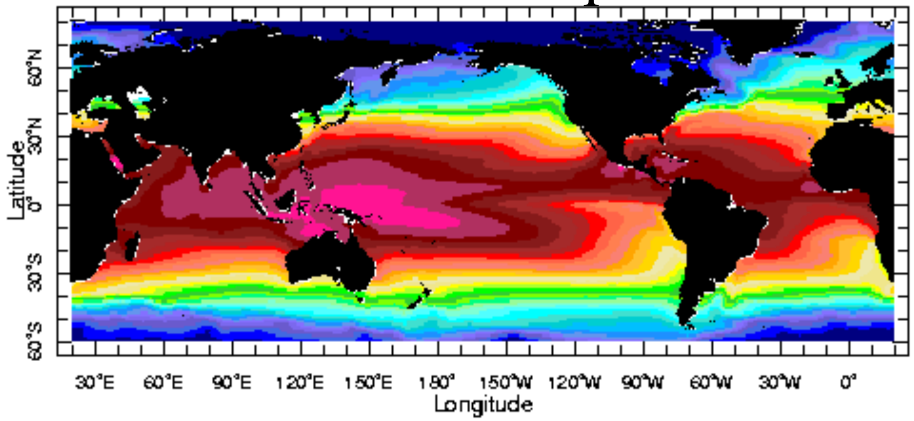
No Data
1 - 50,000 tons
50,001 - 350,000 tons
350,001 - 1,600,000 tons
1,600,001 - 10,000,000 tons
10,000,001- 270,000,000 tons

Wheat Production + El Niño Impacts

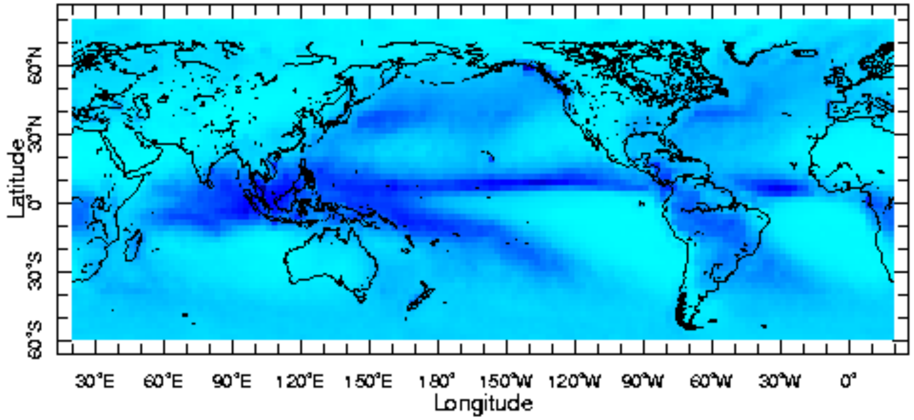


Average Conditions during Oct-Nov-Dec (OND)

Sea Surface Temperature

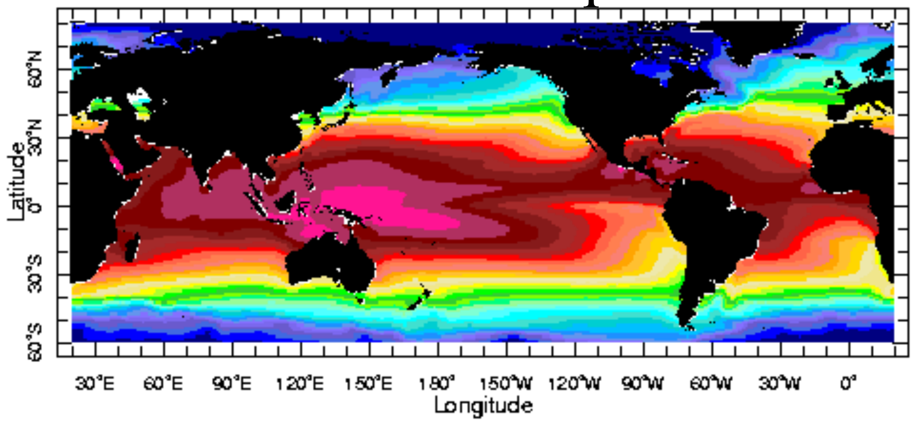


Precipitation

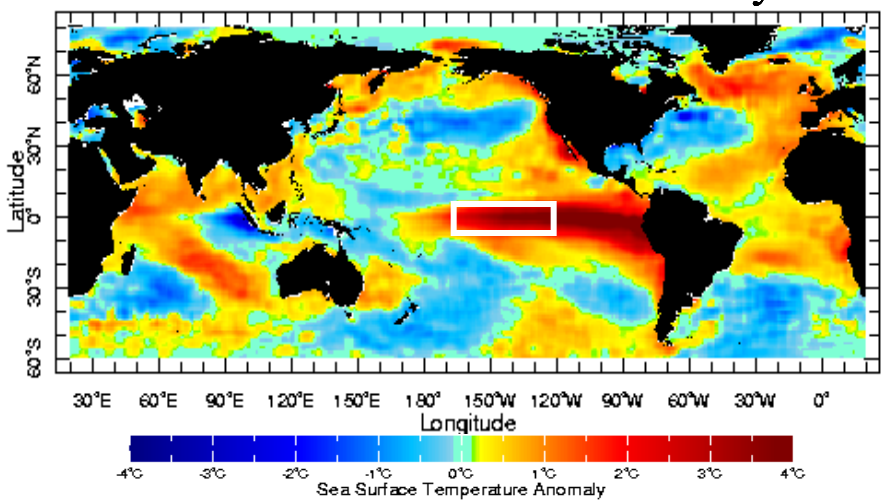


Interannual Variability:
Conditions during Oct-Nov-Dec (OND)

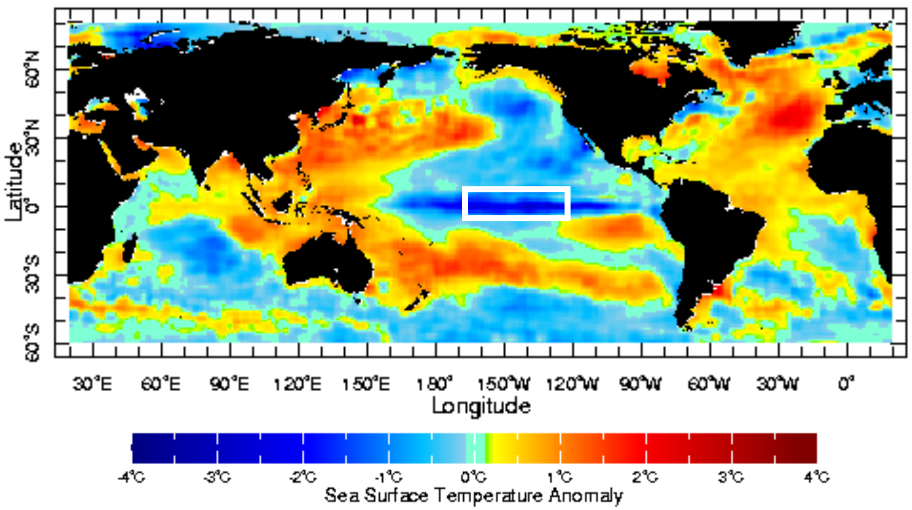
Sea Surface Temperature



El Niño SST Anomaly



La Niña SST Anomaly



Climate is changing on all timescales

- Need to address the time horizon of relevant decisions
- Some may actually involve information across timescales (Ready-Set-Go)

e.g. Seasonal forecast: start and evolution of rainy season; dry spells

e.g. Decade+ planning, but consider risk of year-to-year shocks and possible persistence

e.g. Climate change, but consider possible magnitude of decade-scale variability, and preparedness/resilience to year-to-year shocks

- i.e. longer timescale decisions may need to prepare or evaluate on shorter timescales

Our ability to predict the climate on different timescales is different

- predictability of drivers
- understanding of the processes of the drivers and how they affect regional climate
- ability of models to simulate these processes

Information is more than just predictions

- characterization of the climate (or weather within climate) is important too