U.S. CLIVAR Research Challenges

U.S. CLIVAR supports all activities that **advance its Mission, address its fundamental science questions, and support its Goals**. As part of its research agenda, U.S. CLIVAR will also **highlight a small number of Research Challenges**.

Research Challenges are **broad areas of climate science that are timely, complex, societally relevant, and require coordinated research for a decade or longer**. They tend to expand U.S. CLIVAR into non-traditional research areas.

Four Research Challenges are identified in Science Plan:

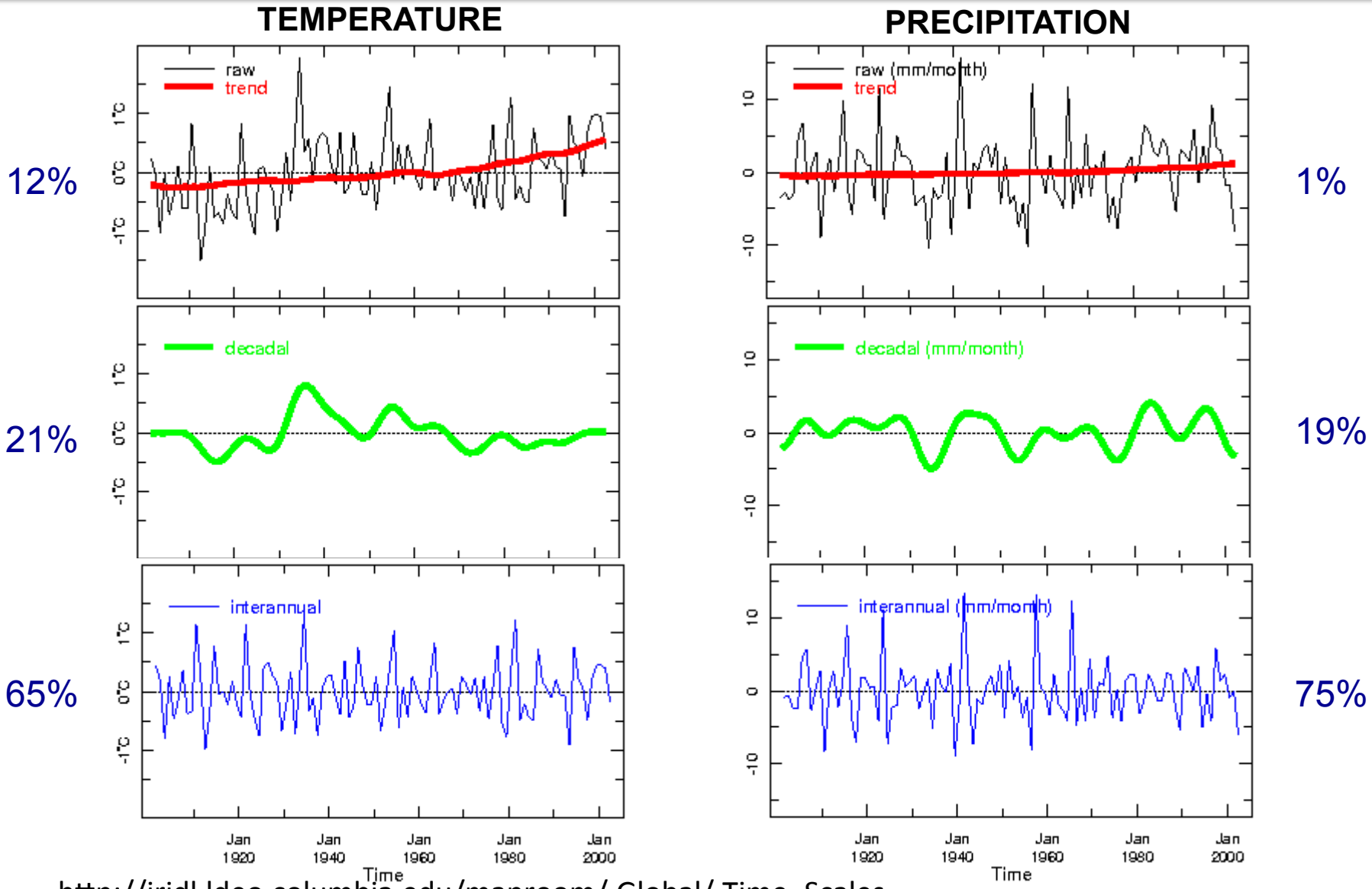
- **Decadal variability and predictability**
- **Climate extremes**
- **Polar climate**
- **Climate and carbon/biogeochemistry**

It is expected that additional Research Challenges will be added to the U.S. CLIVAR agenda as the need for them arises.

U.S. CLIVAR
Climate Variability & Predictability

Research Challenge: Decadal Variability

Climate Variability & Change in Colorado



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

Research Challenge: Decadal Variability

Context: The **amplitude of decadal variability is large enough to impact climate** in societally important ways. Thus, many scientific and development groups seeking decadal-scale climate information to help guide decisions for the future. Furthermore, **decadal variability can dominate regional and global anthropogenic trends**, thereby making it difficult to plan for future adaptation investments.

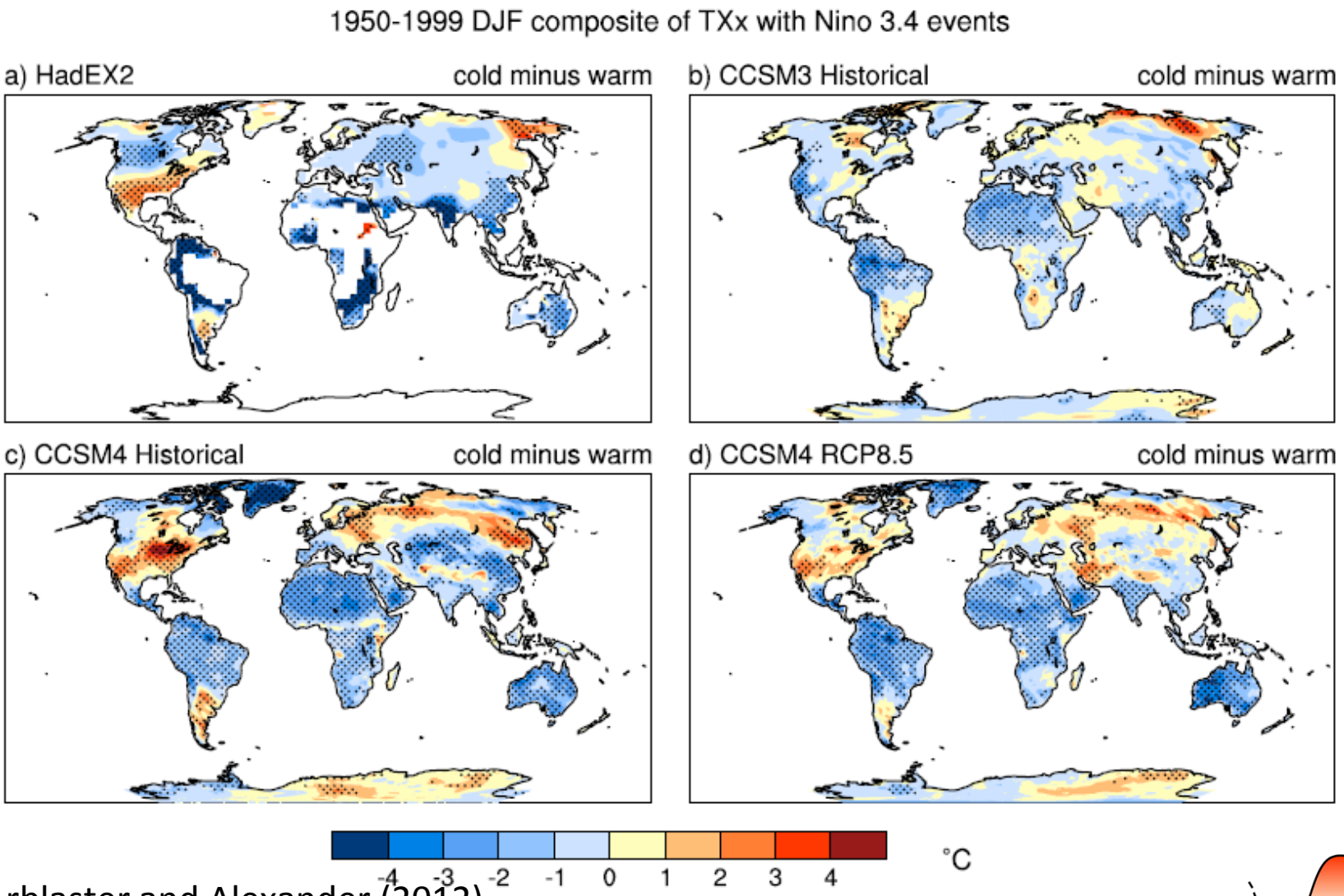
Research Questions:

- What are the **processes** that give rise to decadal variability, and which of them are **sources of predictability**?
- Given imperfect and incomplete observations and assimilation systems, what **predictions should be attempted**, and **how will they be verified**?
- What is the **best method of initialization** in climate predictions, and what is the **added skill with initialization** when compared to uninitialized predictions?

U.S. CLIVAR
Climate Variability & Predictability

Research Challenge: Climate Extremes

ENSO Impacts on Global Land Temperatures



Arblaster and Alexander (2012)

U.S. CLIVAR
Climate Variability & Predictability

Research Challenge: Climate Extremes

Context: Extreme meteorological and oceanographic events have major impacts on society. There are **clear relationships between some extreme events and climate variability and change**. For many, however, the **linkages are complex** and so not yet adequately understood, or still even a matter of debate. Furthermore, by definition **extremes in any location are rare**, making attribution of variability and change difficult.

Research Questions:

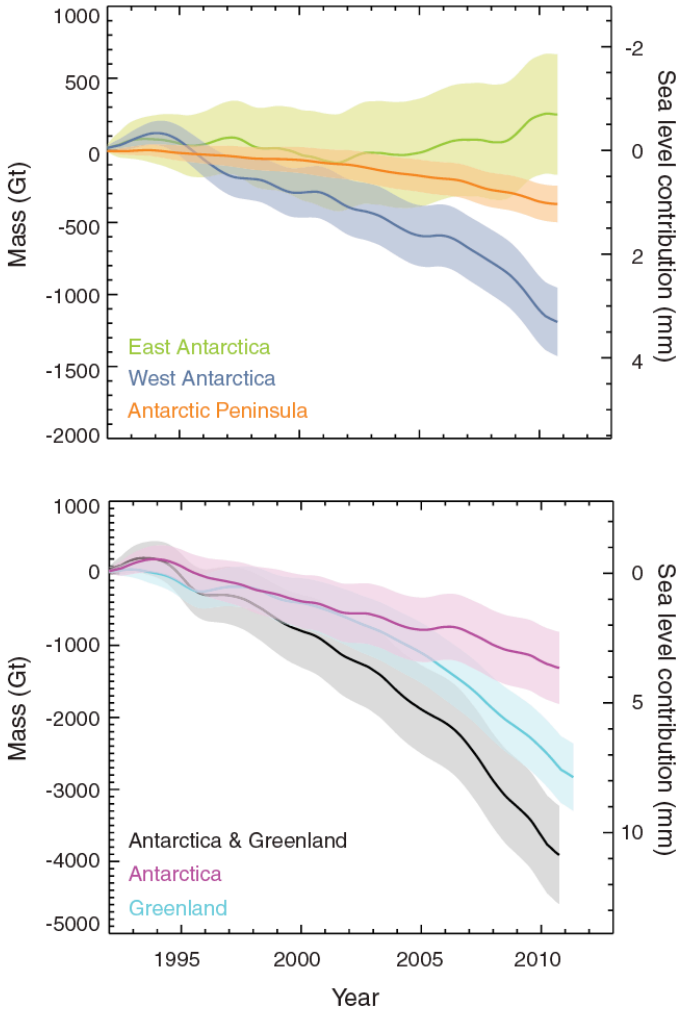
- What are the **important short-term processes** that underlie precipitation and temperature extremes?
- How do these **short-term processes interact with the larger-scale, slower and potentially-predictable climate fluctuations** linked to the ocean?
- What are **the timescales, metrics, statistics and analysis tools** that are most relevant for extremes?
- What **properties of extremes, if any, are changing under global warming**?

U.S. CLIVAR
Climate Variability & Predictability

Research Challenge: Polar Climate

Sea Level Contributions from Polar Ice Sheets

Fig. 5. Cumulative changes in the mass of (left axis) the EAIS, WAIS, and APIS (**top**) and GrIS and AIS and the combined change of the AIS and GrIS (**bottom**), determined from a reconciliation of measurements acquired by satellite RA, the IOM, satellite gravimetry, and satellite LA. Also shown is the equivalent global sea-level contribution (right axis), calculated assuming that 360 Gt of ice corresponds to 1 mm of sea-level rise. Temporal variations in the availability of the various satellite data sets (Fig. 4) means that the reconciled mass balance is weighted toward different techniques during certain periods.



Shepherd 2012, *Science*

U.S. CLIVAR
Climate Variability & Predictability

Research Challenge: Polar Climate

Context: The polar regions are historically not well observed, and therefore many physical processes are not well understood. We do know that **polar regions feel the greatest effects of climate change**, which impacts diverse ecosystems there, as well as greatly alters our planet's energy balance.

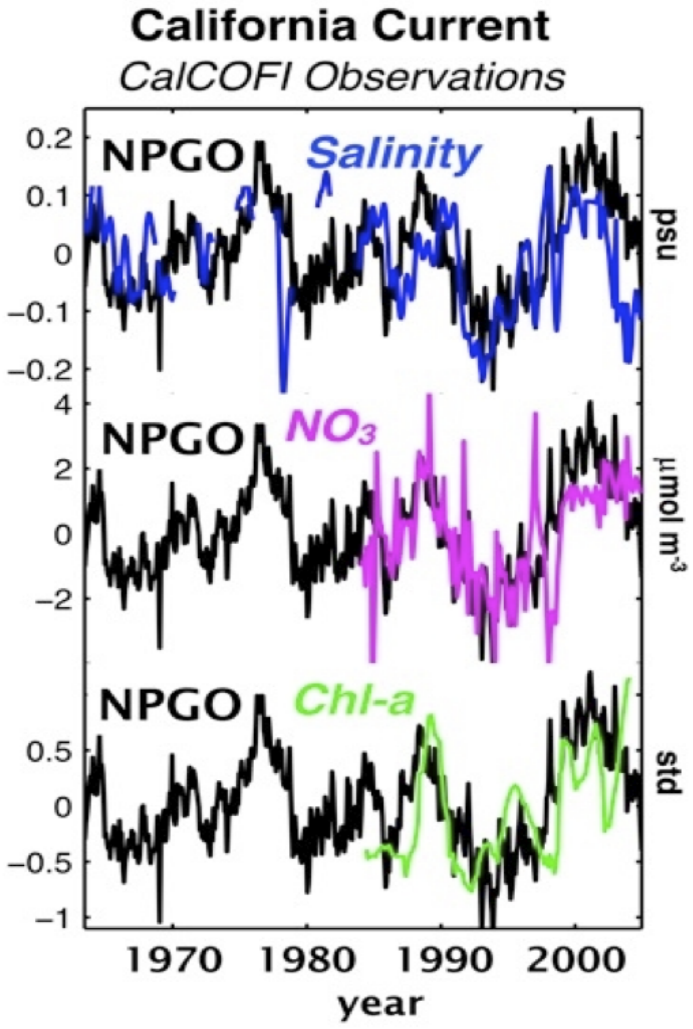
Research Questions:

- What are the **dominant oceanic factors affecting polar climate** variability and change?
- What **processes affect sea-ice conditions and ice-shelf stability**?
- What are the **large-scale polar/subpolar/subtropical interactions**?
- What processes are involved in the **exchange of polar (and subpolar) water masses with lower latitudes**?
- Do we have the **proper tools to simulate polar climate** and realize the predictability?

U.S. CLIVAR
Climate Variability & Predictability

Research Challenge: Climate & Marine Carbon / Biogeochemistry

Figure 5.2: Time series of the NPGO and anomalies in salinity (top), nitrate concentrations at 150 m (middle), and normalized chlorophyll a (bottom). The close connection between the NPGO index and biological variables is apparent. See Di Lorenzo et al. (2008) for details.



U.S. CLIVAR
Climate Variability & Predictability

Research Challenge: Climate & Marine Carbon / Biogeochemistry

Context: The ocean has historically been a net sink for CO_2. **Climate variability and change influence CO_2 sources and sinks**, which in turn feedback on climate. **Climate also impacts societally-important marine ecosystems**.

Research Questions:

- How will **marine carbon sources and sinks affect, and be affected by future atmospheric CO_2 concentrations**, and other carbon-containing greenhouse gases?
- How do **changes in ocean circulation and heat content affect the magnitudes and distributions of ocean carbon** sources and sinks on seasonal-to-centennial time scales?
- What are the **coupled physical/biogeochemical processes and feedbacks** that contribute to the heat and carbon sources and sinks, and to ecosystem structure?
- Do we have the **proper tools to simulate carbon-climate interaction**?
  - Multi-purpose and integrated ocean observing networks
  - Continued innovation of oceanographic instrumentation
  - Integrated ecosystem process studies (ala GLOBEC)
  - Coupled physical/biogeochemical modeling

U.S. CLIVAR
Climate Variability & Predictability

Research Challenge Implementation Activities

U.S. CLIVAR has already begun to address the above Research Challenges through the implementation of Science Teams (STs) and Working Groups (WGs):

- **AMOC ST** (2007-present)
- **Decadal Predictability WG** (2010-2012)
- **Hurricane WG** (2011-2013)
- **Extremes WG** (2012-2014)
- **High-Latitude Surface Flux WG** (2009-2013)
- **Greenland Ice Sheet-Ocean Interactions WG** (2011-2013)
- **Southern Ocean Heat and Carbon Uptake WG** (2012-2015)
- **Ocean Carbon Uptake in CMIP5 Models WG** (2012-2015)
- **ENSO Diversity WG** (2012-2014)
- **Eastern Tropical Ocean Synthesis WG** (2012-2014)

Question for Panels: What additional coordinated implementation activities would advance progress in addressing these research challenges?

U.S. CLIVAR
Climate Variability & Predictability