Decadal Climate Variability & Predictability (DCVP):

a CLIVAR crosscutting research focus

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DCVP Objectives

- Advance the study of decadal climate variability and predictability by focusing on key phenomena with significant impact on near-term climate evolution and potential for rapid progress.
- Review the state of understanding of the governing mechanisms and predictability of these phenomena, and of their impact on regional and global climate variability – including their attribution to internal interactions and external forcing.
- Identify gaps in knowledge and recommend observations, analysis and model experiments to address these gaps.
- Facilitate interaction between scientists to discuss the results of these studies and communicate conclusions and remaining challenges to the scientific community and beyond.

Networks of Teleconnectivity

- Observations and models indicate that decadal variability is characterized by a few global-scale patterns representing three teleconnection networks in the coupled climate system:
  - **Tropical-extratropical teleconnections within the large Ocean basins**
  - **Inter-basin teleconnections suggesting the presence of (tropical) interactions among the Atlantic, Pacific, and Indian Oceans, as well as interactions between these basins and the Arctic and Southern Oceans**
  - **Ocean-land teleconnections: primarily atmospheric teleconnections that bridge between ocean variability and climate variability over land.**
- DCVP research grand objective is to advance the predictive, dynamical and phenomenological understanding and drivers of these networks of teleconnectivity.

Drivers of Teleconnectivity

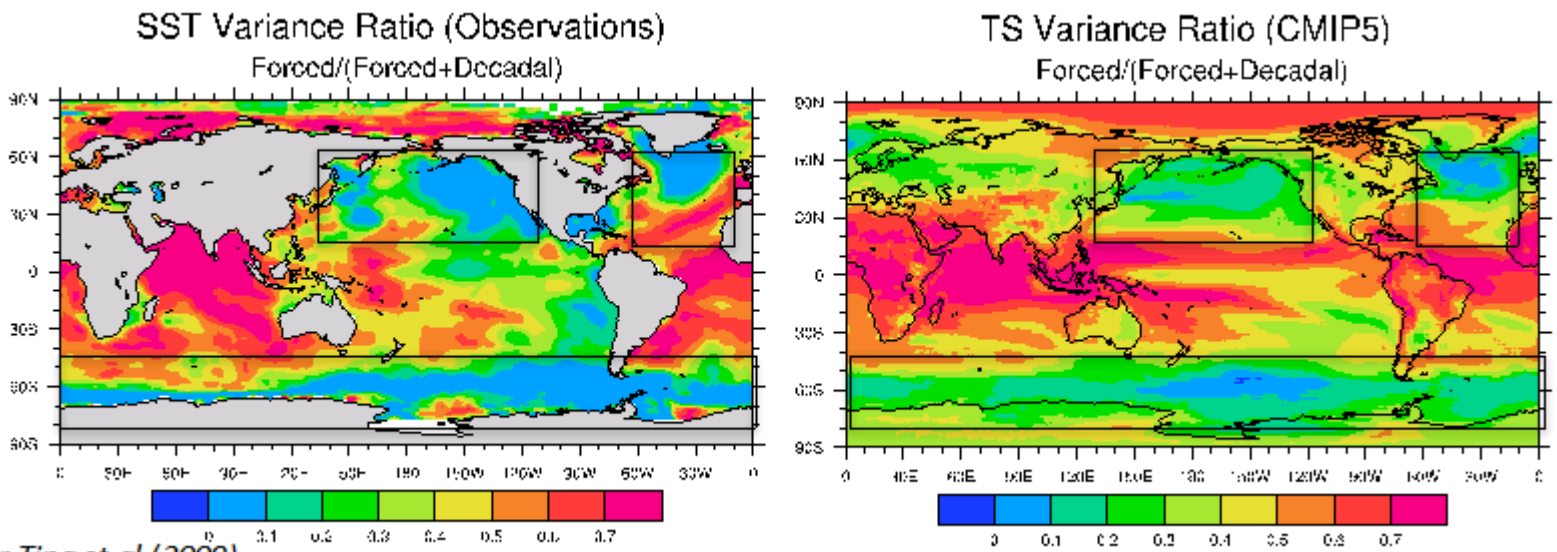

Figure after Ting et al.(2009)

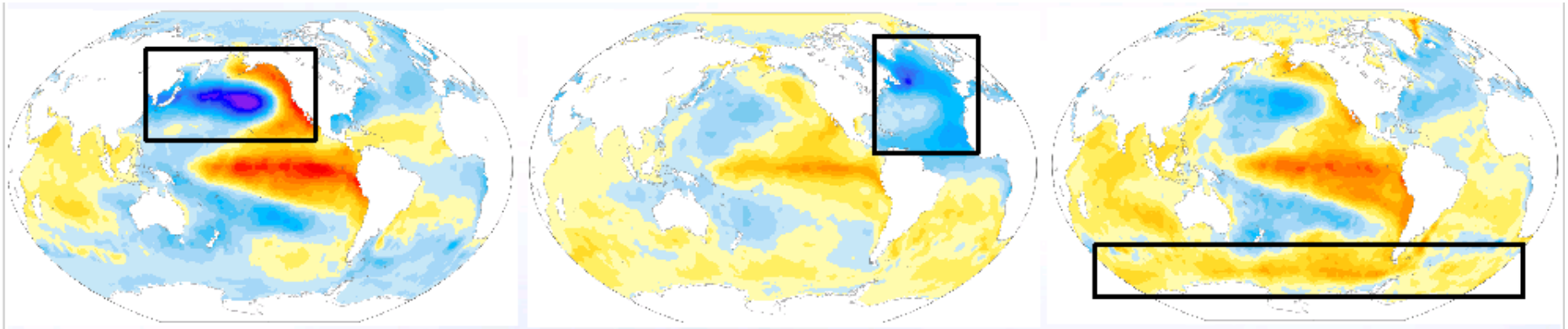

Figure courtesy C. Deser (presented at the CLIVAR-ICTP InternaOonal Workshop on Decadal Climate Variability and Predictability: Challenge and Opportunity Trieste, Italy 16-20 November 2015)

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°C

Broad Science Questions

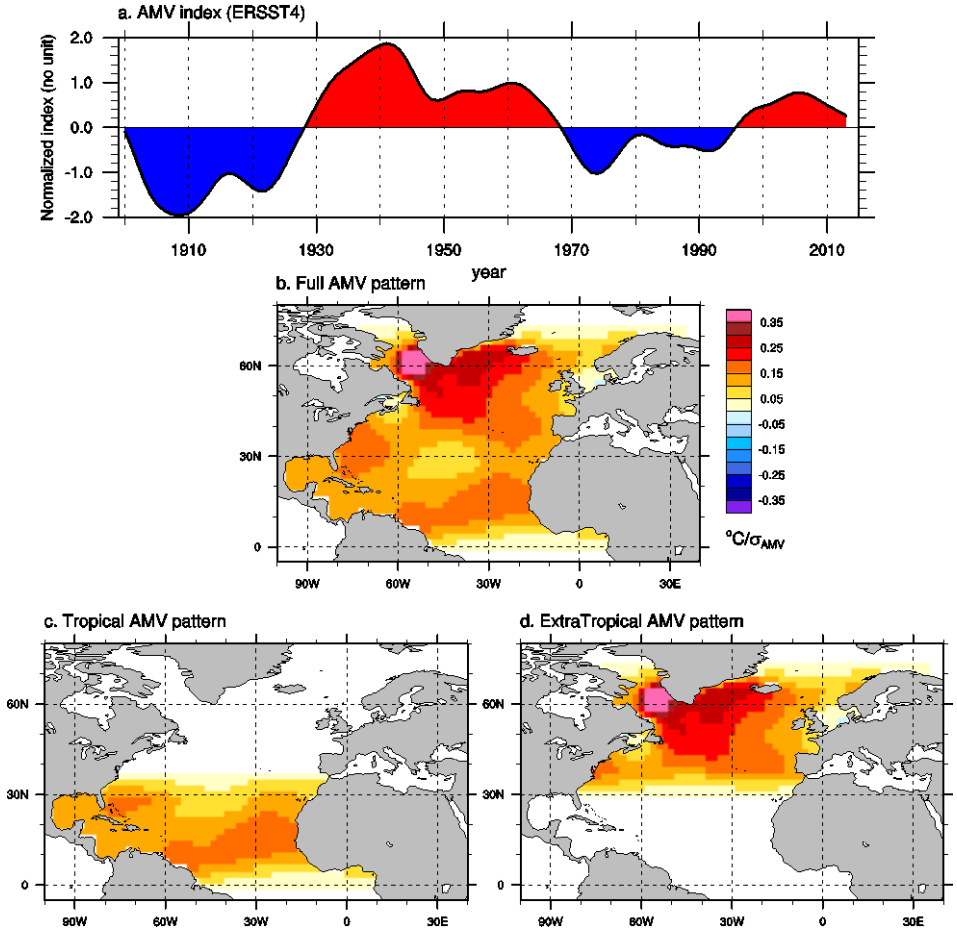
- *Characteristics*: What are the characteristics of decadal climate variability (DCV) in space and time?
- *Dynamics*: What are the climate mechanisms that give rise to and govern DCV? In what way does DCV display distinct dynamical behavior (i.e., different from ”red noise”)?
- *Forcing*: What is the role of external forcing in DCV and to what extent does this forcing interact or resonate with internal variability?
- *Observations*: What observations are available to determine these DCVP phenomena and mechanisms? Are they current sufficient for DCV research and comparison with models? Do they allow reliable monitoring of DCV? Can the paleo-data (e.g. PAGES 2k) help inform on these issues?
- *Modeling*: Do models capture the observed DCV? What are their limitations? How can these limitations be addressed and reduced?
- *Predictability/prediction*: Is DCV predictable? How is this predictability expressed?
- *Impact*: How do we discern and quantify DCV impact on climate in general and climate extremes in particular?

DCPP Component C: Predictability, Mechanisms and Case Studies

The DCPP and DCVP are proposing coordinated multi-model investigations believed to be of broad interest to the community.

Two research areas are the current foci of Component C of the CMIP6 experimental design:

- Hiatus+: this is used as shorthand to indicate investigations into the origins, mechanisms and predictability of long timescale variations in both global mean surface temperature (and other variables) and regional imprints including periods of both enhanced global warming and cooling with a focus on the most recent slowdown that began in the late 1990s.
- Volcanoes in a prediction context: an investigation of the influence and consequences of volcanic eruptions on decadal prediction and predictability.



Future Activities (*& timeline*)

- Prepare and publish a CLIVAR Exchanges issue dedicated to DCVP topics, jointly with PAGES (*winter 2017*).
- Prepare and publish a DCVP "white paper" (*winter 2017*).
- Participate in analysis of DCPP experiments, particularly component C results and contribute to publications of the results (*2017 – 2018*)
- Plan and execute a joint DCPP-DCVP workshop on CMIP6 results and prepare a joint DCPP-DCVP white paper/perspective on the results of DCPP component C experiment (*2018*).
- Present DCVP science in the 2019 Ocean Observations Conference.
- Plan and execute a final DCVP Science Symposium and Summer School and publish outcome (*Summer 2020*).

DCVP Research Foci

- Two topics have been identified:
  - *Advance the predictive understanding of **Atlantic Decadal Climate Variability**, i.e.*, the variations of ocean circulation systems in the North Atlantic (AMOC, gyres), their related SST variability (AMV/AMO, extratropical and tropical SST) and association/impact on atmospheric variability (NAO/AO, blocking, etc.). Determine the governing mechanisms - internal and external - and their interactions and impact on climate variability over land and over other ocean basins and on the GMST.
  - *Advance the predictive understanding of **Pacific Decadal Climate Variability**, i.e.*, the decadal variability of tropical Pacific SST (IPO), its links to North Pacific ocean SST and circulation (PDV) and to the atmosphere and stratosphere (PNA, NAO). Determine the governing internal and external mechanisms and the impact and interactions with climate variability over land, other ocean basins and on the GMST.
- The CLIVAR Panels and other WCRP Projects and Themes are already engaged in intense observational, analysis and modeling research on these foci.
- DCVP will review and draw on these activities, produce statements of progress, identify remaining issues and suggest/initiate additional research to address its objectives.

Opportunties for Progress

- Existing and upcoming results from observational campaigns (in situ obs. From ARGO, RAPID, OSNAP, SAMOC, TPOS-2020 & space observations of land and ocean surface conditions); advances in assimilation products.
- Large ensemble of century-long control and historical experiments under CMIP5/6, as well as detection-attribution dedicated experiments.
- Production of initialized decadal coupled model hindcasts and predictions under CMIP5 and CMIP6 continuation (DCPP) and the planned activities of WCRP Grand Challenge on Near Term Climate Prediction (NTCP).
- PAGES 2K reconstructions of pre-industrial climate variability from high-resolution, single and multiple proxy datasets and CMIP5 “climate of last millennium” simulations (to be covered in upcoming US-CLIVAR Paleo-AMOC meeting)
- Flurry of new research to understand the uneven rate of the global response to anthropogenic GHG increase and aerosol emission, in particular the slowdown in GMST warming since the late 1990s.

Recent DCVP activities

- Established RF Working Group (currently with 15 members and co-chaired by C. Cassou – CERFACS, France and Y. Kushnir – LDEO, USA).
- Contributed to planning and execution of the CLIVAR-ICTP "International Workshop on Decadal Climate Variability and Predictability".
- Contributed to framing the objectives and determining the protocols of the WCRP/WGSIP/DCPP component C.
- Contributed to the proposal (Concept Paper) and "White Paper" of WCRP Grand Challenge on Near Term Climate Prediction.
- Participate in DCPP ad hoc Panel Meeting and in the SPECS/PREFACE/WCRP "Workshop on Initial Shock, Drift, and Bias Adjustment in Climate Prediction" (*May 2016*).
- Contributed to planning the session on Decadal Climate Variability in the CLIVAR OSC 2016.
- Prepared a CLIVAR-ICTP DCVP workshop report (*submitted to BAMS*).

Specific Science Issues (from Cassou et al.)

- Use of multivariate metrics ('fingerprints') to identify and discriminate between processes involved, especially when comparing model simulations to observations.
- Facilitate multi-model comparisons and analyses of dedicated internationally coordinated sensitivity experiments aimed at: (i) understanding the internal processes and assessing the respective roles of internal variability and external forcing in AMV and PDV; (ii) better characterizing and understanding the observed and simulated spatial responses to external forcing and to how these forcing affect circulation change in the ocean and the atmosphere, specifically, the role of anthropogenic aerosols and of volcanic eruptions; (iii) to have any confidence in decadal prediction, one must demonstrate a capability to robustly attribute decadal events to specific causes at a process level within the constraints of observational and model uncertainty.
- strengthened links across international community programs, such as CLIVAR DCVP and PAGES2K, is needed to improve integration across climate modeling, modern observations, and paleoclimate proxy identification and reconstruction initiatives.
- Determination of the physical origin of model drift and systematic errors provides a pathway toward to their improvement in simulating and predicting DCV.
- The recent 2000's slowdown in the rate of global warming highlights the importance of investigating: (i) the seasonal characteristics of the ocean-land connections (e.g., strong cooling over North America an Eurasia during wintertime as an important contributor to the slower rise in global temperature); and (ii) the changes in the entire probability density function of the key parameters such as surface air temperature and precipitation