DCVP: a CLIVAR crosscutting activity on Decadal Climate Variability and Predictability

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Based on CLIVAR DCVP-RF prospectus drafted by the DCVP RF WG

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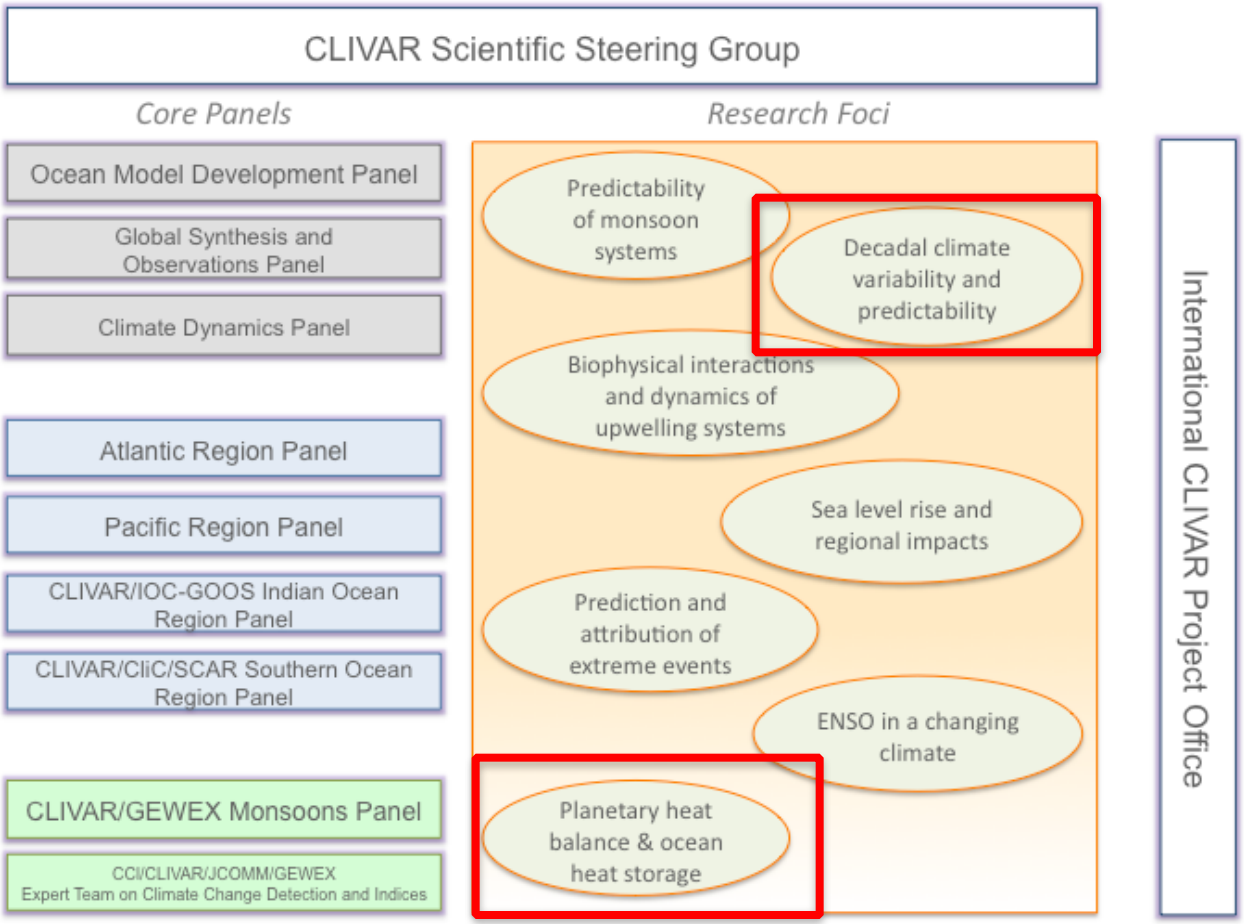
DCVP in CLIVAR Organizational Structure



The Research Foci are proposed as crosscutting activities

CLIVAR DCVP Objectives

- CLIVAR DCVP seeks to characterize the multi-year to multi-decadal variability of the climate system in response to internal processes and natural and anthropogenic forcing as well as their interaction
- to determine and understand the underlying phenomena, mechanisms, and impacts through diagnostic analysis and modeling
- to assess and subsequently harness the predictability of decadal climate variability for societal benefit.

Examples of DCVP concerns

DCVP is interested in the global and regional expression of the interaction between multi-year natural climate variations and anthropogenic climate change, i.e., phenomena such as:

- Sahel droughts of 1970s & 1980s [AMOC/AMV + ENSO + Indian Ocean SSTs + anthropogenic aerosols?]
- Decadal variations in Atlantic TC activity [AMOC/AMV + ENSO + GHGs?]
- 1960's-1990's Mediterranean drying trend [NAO trend + AMV?]
- Southwest US multi-year droughts [PDV + AMOC/AMV + GHGs?]
- Recent 'hiatus' – In the Pacific the east is cooling not warming and the trades are intensifying [ocean heat uptake + volcanic aerosols + solar changes + AMV + PDV + wind trends?]
- California is going through a protracted drought hitting water resources, hammering the agriculture enterprise, and leading to devastating forest fires + Collapse of civic order and bloody conflict in Syria [multi-year natural variability superimposed on a warming trend].

Why DCVP now?

- New instrumental observations (particularly of the ocean and from space and advanced in modeling) and advancement in reanalysis.
- CMIP5 experiments in coupled model initialized decadal prediction (and plans for CMIP6 continuation) provided material for an initial (encouraging) assessment but more work needs to be done.
- Reconstructions of past, pre-instrumental climate variability from high-resolution single and multiple proxy datasets provided new information on forced and free decadal variability during the pre-industrial era.
- CMIP 5 simulations of the climate of last millennium allow the study of the climate response to external forcing from solar variability, volcanic forcing, and changes in land use and to contrast this response with the response to anthropogenic greenhouse gas emission and industrial aerosols – but revealing model inconsistencies in response to forcing.
- The surprising “hiatus” and increase in damaging climate extremes invoke societal need for near-term knowledge for planning & preparedness.

DCVP RF

To advance CLIVAR DCVP objectives the Project sought to identify a limited number of research objectives that will be:

- Relevant & tractable and will benefit from international collaboration.
- Cuts across other CLIVAR (& WCRP) panels/programs agenda and timely (is already in consideration/implementation).
- Leads to widely appealing, actionable research activity resolvable within a finite time (2-5 years) and yielding broad scientific and social benefit.
- Be summarized in a prospectus for SSG decision.

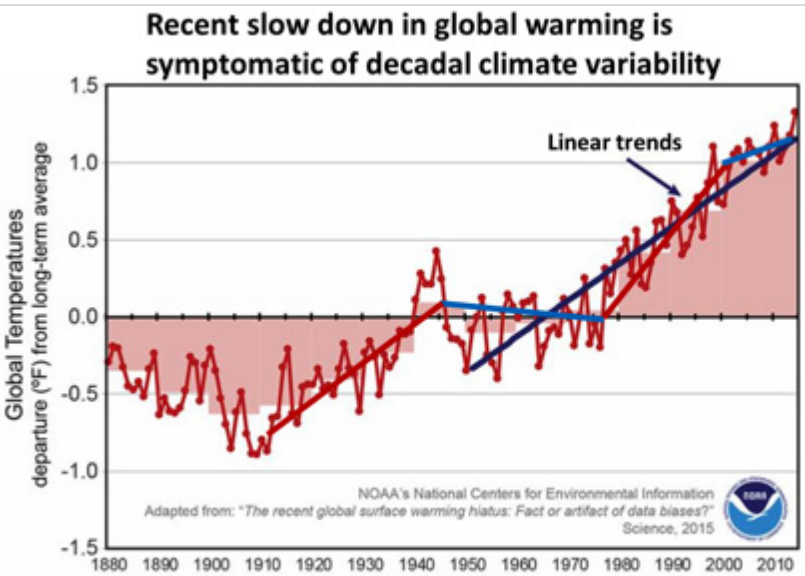
Community discussion yielded the following two foci that were endorsed by the SSG and are being developed further by the DCVP WG:

1. The decadal modulations – slowdowns and accelerations – of the long-term anthropogenic warming trend
2. The role of volcanic eruptions in decadal climate variability and their impact on decadal climate prediction

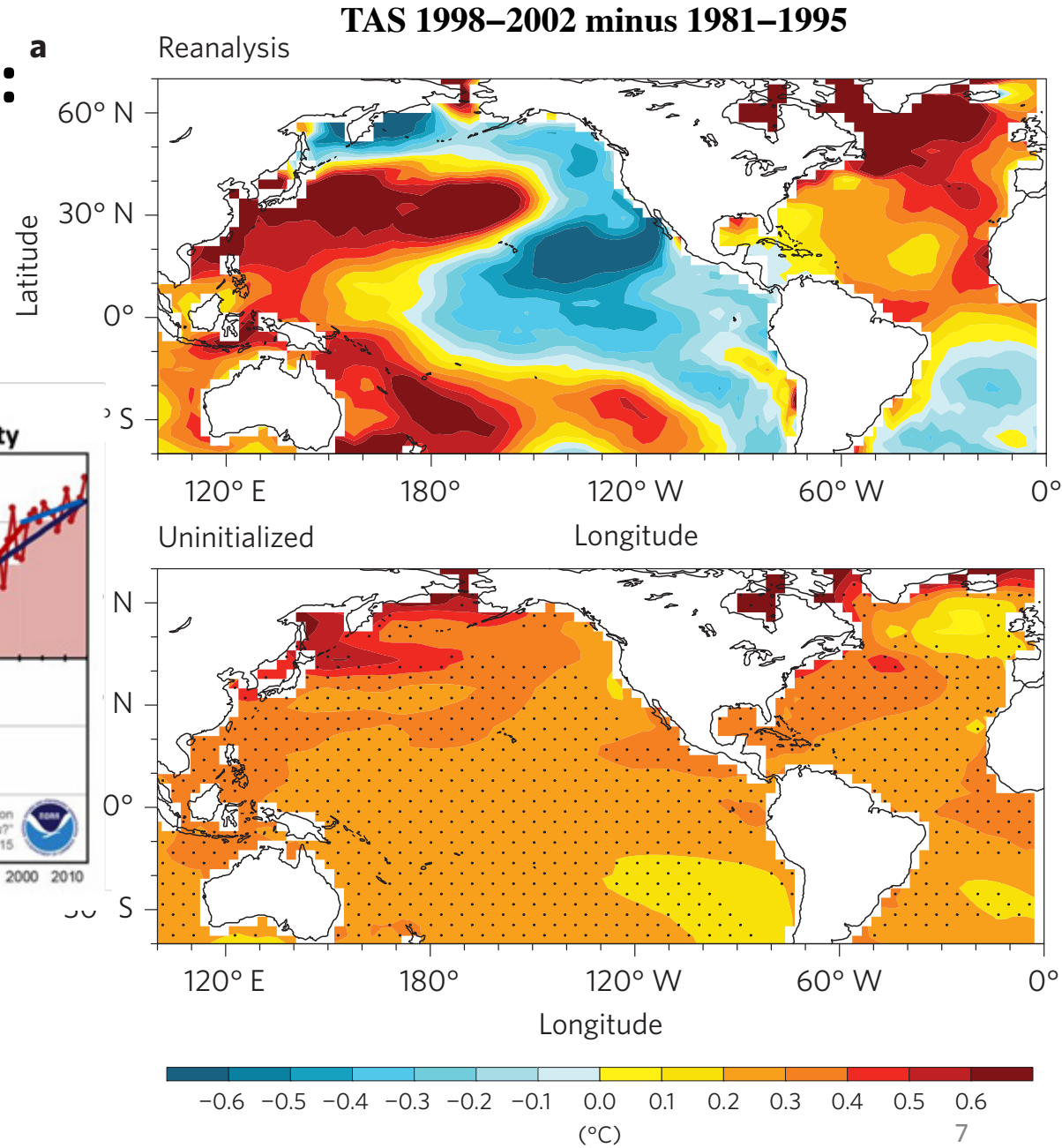
Hiatus expressions:

global mean vs.

the spatial pattern

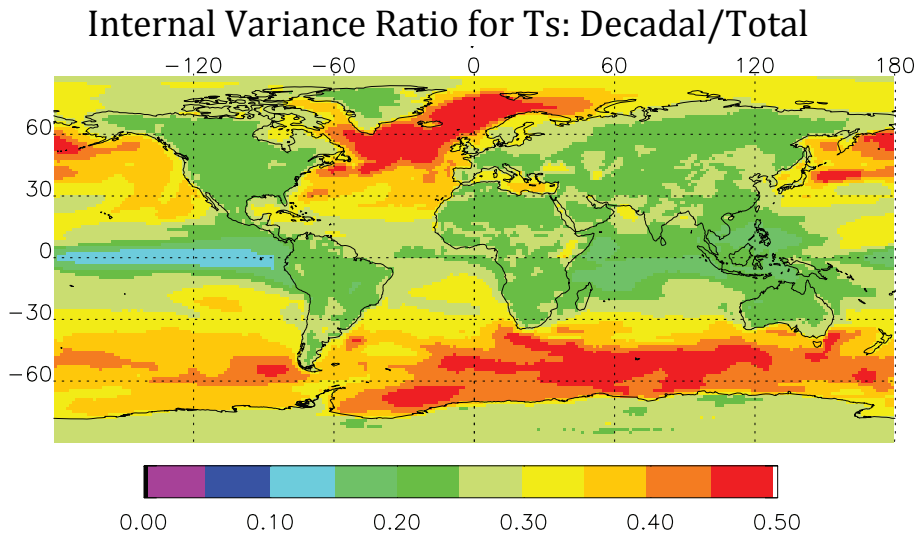


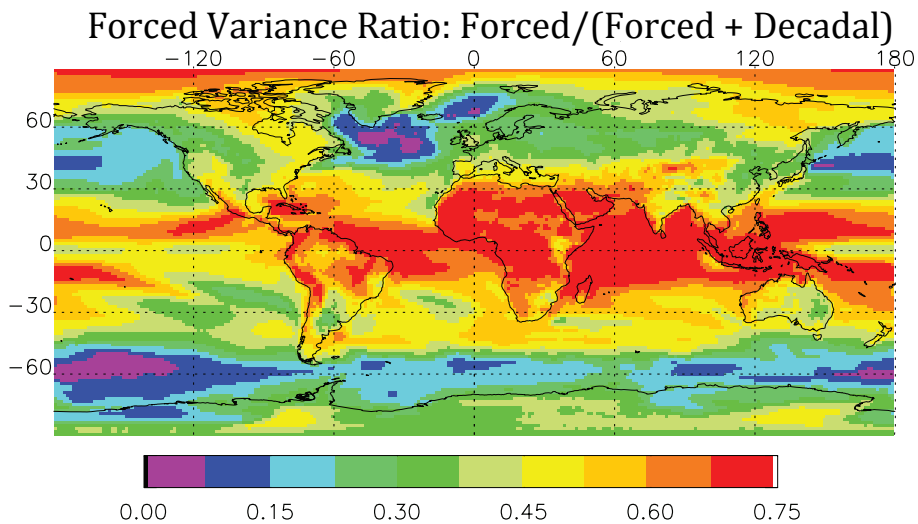
Karl et al. (2015)



Meehl et al. (2014)

Internal Decadal vs. Forced Variability





- The North Atlantic, North Pacific, and the Southern Oceans are regions of high internal decadal and longer time scale variability.
- Decadal and longer time scale variability is relatively weak over land.
- Externally forced variance to total variance ratio is low in regions of high decadal internal variability

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THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

Dynamical response to volcanic eruptions:

Large inter-model & model-obs. disagreements

Dynamical response averaged over first to large VEs, two winters after 20c volcanic eruptions. Top: Ts, bottom SLP. Note difference in color scale extent for obs. and models.

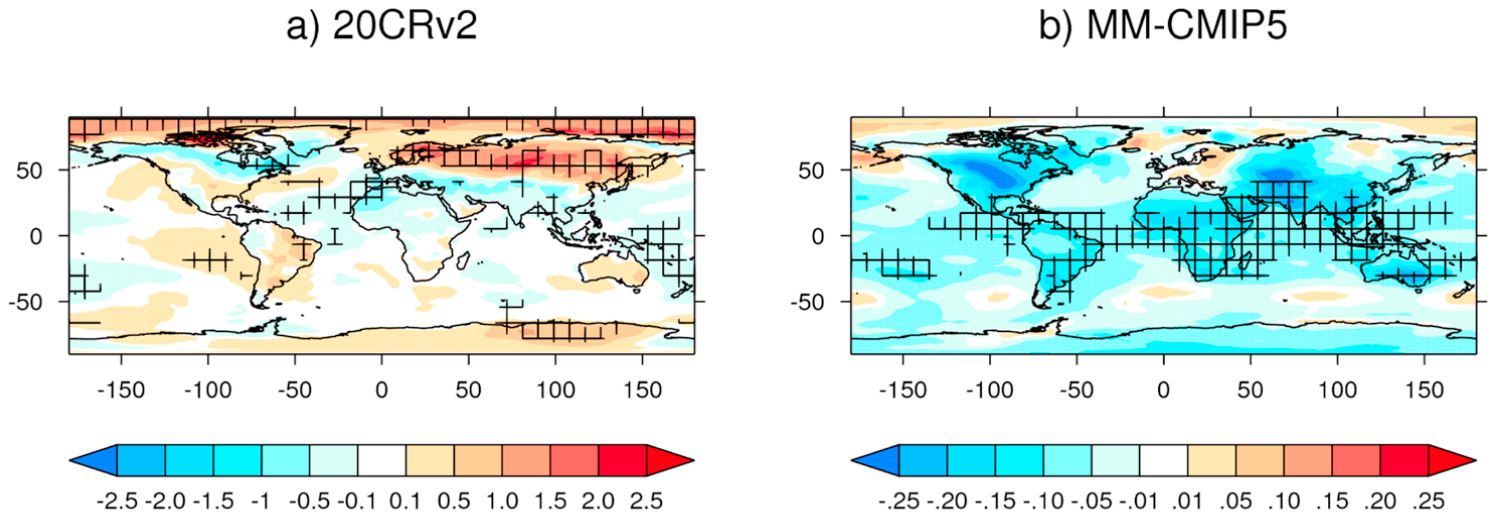
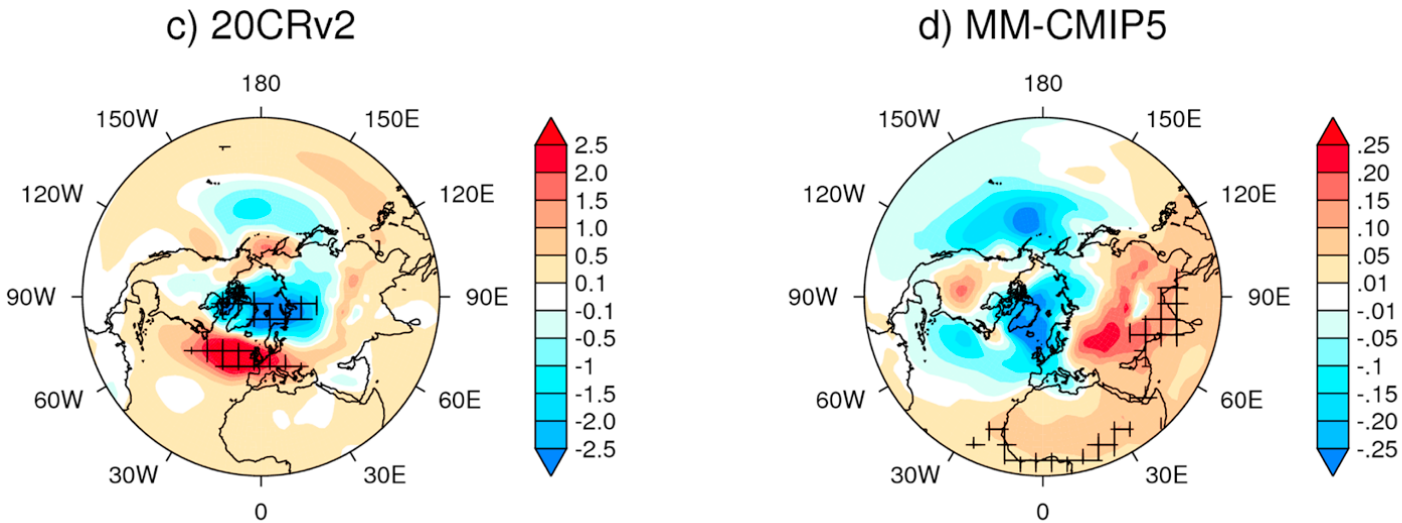


Figure from Driscoll et al. (2012),



DCVP Broad Objectives

- **Characterize and quantify**: Improve the physical space/time characterization of decadal climate variability (DCV), internal and forced and its impacts through the use of instrumental data and high-resolution paleoclimate proxies.
- **Observe**: Assess the observing systems effectiveness in measuring the state of the oceans, atmosphere, and land surface on space and time scales relevant to DCV, in order to support the study, modeling, prediction, and monitoring of DCV; Work to improve the DCVP serving observing system through judicious maintenance and enhancement;
- **Simulate and investigate**: Improve models' ability to capture and simulate the observed DCV phenomena, their time scales and regional impacts; Use models to test hypotheses regarding the cause and underlying mechanisms of forced and internal DCV.
- **Predict:** Use models of varying complexity, to determine the predictability of decadal climate variability and put them to task by performing hindcasts and forecasts. Develop methodologies to overcome data and physical uncertainties and model impediments such as drifts and biases.
- **Apply**: Contribute to the development of best practices for delivering decadal information to society by understanding the needs of users of decadal climate information; Support the development of appropriate information products geared to specific societal use, based on a probabilistic understanding of DCV, its physical underpinning and the inherent uncertainties.

DCVP RF scientific questions: Goal 1

Explaining, understanding and predicting the modulation -- accelerations and slowdowns -- of the global surface temperature average, emphasizing spatial patterns that affect regional climates:

- What is (are) their cause(s), the underlying mechanisms & the relationship to anthropogenic & other external forcing?
- What is their impact/expression in regional changes in surface temperature the hydrological cycle?
- How does the current change in the rate of planetary warming fit in the context of past extended periods of warming and cooling?
- What observations do we need to collect in order to improve our understanding and simulation of these phenomena?
- What model improvements are needed to better simulate and predict the spatial pattern, onset and termination of such modulations?

DCVP RF scientific questions: Goal 2

Determining the role of volcanic eruptions (VEs) in decadal climate variability, global and regional, and their impact on the decadal climate prediction, including:

- What processes and mechanisms determine the space-time characteristics of VE impacts?
- How do the global and regional impacts of VEs depend on their: strength, type & location? seasonality and the underlying climate system state? How do the impacts depend on prior VEs (VE clusters)?
- How does the prediction of VE depend on model resolution, model features, biases and method of forcing specification?
- What are the observational and modeling needs for correct simulation of the VE impacts?

DCVP RF Working Group

Title	Institute	Role	Year	Country
Cassou, Christophe	CERFACS Climate Modelling and Global Change	Co-Chair		France
Kushnir, Yochanan	LDEO Columbia University	Co-Chair		USA
Danabasoglu,Gokhan	NCAR, Climate and Global Dynamics Laboratory	Member		USA
Doblas-Reyes, Francisco	Institut Català de Ciències del Clima, SpainInstitut Català de Ciències del Clima	Member		Spain
Hawkins, Ed	University of Reading	Member		UK
Heimbach, Patrick	The University of Texas at Austin; Institute for Computational Engineering and Science (ICES); Jackson School for Geosciences (JSG), Institute for Geophysics (UTIG)	Member		USA
Von Schuckman, Karina	Mediterranean Institute of Oceanography, University of Toulon	Member		France
Masahide, Kimoto	Atmosphere and Ocean Research Institute, University of Tokyo	Member		Japan
Msadek, Rym	NOAA GFDL and UCAR	Member		USA
Mueller, Wolfgang	Max Planck Institute for Meterology	Member		Germany
Power, Scott	Bureau of Meteorology	Member		Australia
Zhou, Tianjun	LASG, Institute of Atmospheric Physics, Chinese Academy of Science	Member		China
Aldo Montesinos	University of Concepción	Member		Chile.
Amy Solomon	NOAA/ESRL	Member		USA

DCVP linkages to Concept HEAT

- Monitoring the imbalance of TOA radiation is important to understanding the climate response to external forcing: GHG, aerosols, and solar variability.
- The partition of heat between the ocean and atmosphere is an important factor in internal climate variability.
  - Heat can be stored in the ocean and released again after circulation within it leading to quasi-oscillatory variations in surface temperature and therefore in large-scale climate variability.
  - The pathways of such exchange within the ocean are not clear, particularly in the case of long-term, decadal and multidecadal variability.
  - The process of ocean-atmosphere heat exchange is key to understanding the observed low-frequency modulations of the global mean temperature and more importantly for impacts — the long-lasting anomalous state of the upper tropical Pacific ocean.

Ongoing DCVP Activities

- Established the DCVP WG that is updating and finalizing DCVP science and implementation plan to update the 2014 DCVP science and implementation plan and lays out governance and longer-term action for addressing and achieving program goals; Create mechanisms for communication and idea sharing between DCVP investigators.
- Support the creation of protocols for CMIP6 decadal predictions (in collaboration with the WCCRP Decadal Climate Prediction Project – DCPP):
  - Pacemaker experiments for understanding mechanisms of climate shifts, internal modes of variability and predictability
  - Perturbation experiments on the impact of volcanoes on predictability and predictions
- Prepared ICTP/CLIVAR International Workshop on Decadal Climate Variability and Predictability: Challenge and Opportunity, to be held on 16-20 November 2015, Trieste, Italy*.

* The Workshop addresses the relevant phenomena, their monitoring, modeling and predictability, presented by scientists from CLIVAR and other WCRP core projects. Agenda is available on the CLIVAR web site.

Ongoing DCVP Activities (cont.)

- Establish links to CLIVAR regional panels, other RF (CONCEPT-HEAT), and other related national and international CLIVAR activities (e.g., US AMOC, UK RAPID and CLIVAR Ocean observing activities) to identify common objectives and activities.
- Contribute (through shared membership) to the WCRP "Concept Team" on "Near-Term Climate Prediction" and work to:
  - Establish links to CMIP6 MIPS: DCPP, VOLMIP & RFMIP
  - Establish link to WGCRP projects: CLIC, GEWEX, and SPARC for more effective means to meet DCVP RF objective within CLIVAR and the broader WCRP community.
- Establish links to PAGES to expand the data window of DCVP RF beyond the instrumental period, in particular to resolve and understand better the nature and mechanisms of natural decadal climate variability.
- Prepare for the 2016 Annual CLIVAR meeting.

Summary

- The international community is moving intentionally towards operational decadal prediction
- This move requires international refocusing on the underlying science issues and investment in dedicated background research
- WCRP and CLIVAR are committed to support international activities towards this goal
- CMIP6 provides opportunities for organized international collaboration on modeling and analysis in support of such research