CLIVAR OCEANS & CLIMATE

variability, predictability and change

The World Climate Research Programme's project on ocean-atmosphere interactions

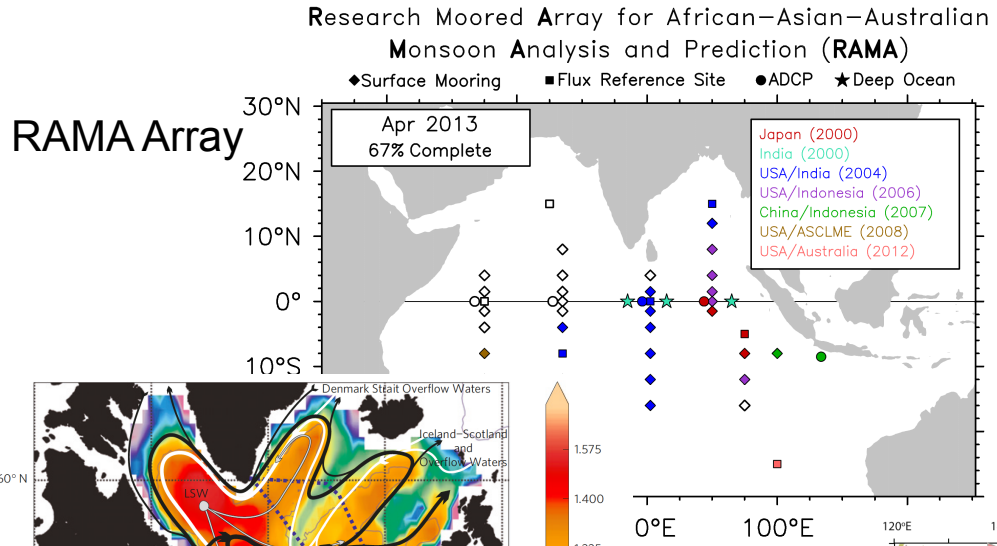
To improve understanding and prediction
of ocean-atmosphere interactions
and their influence on climate variability and change,
to the benefit of society and the environment.

Anna Pirani, Lisa Goddard

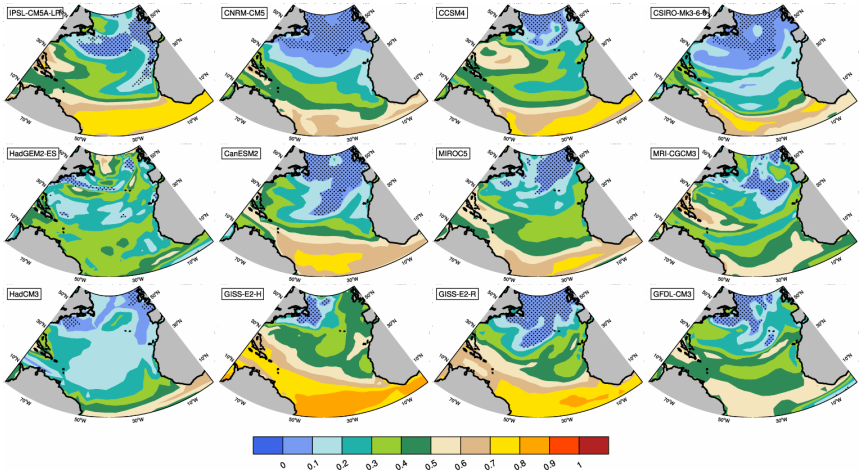
CLIVAR: International coordination, regional implementation

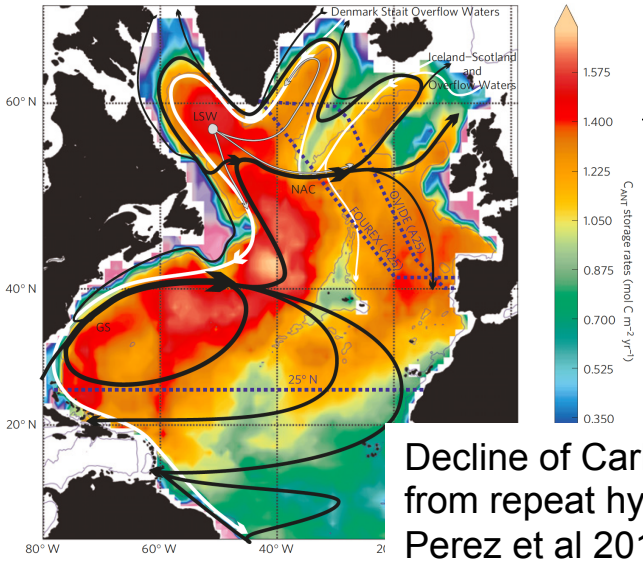
Regional and global studies - observations-process studies-modeling - of the variability and predictability of the climate system.

RAMA Array

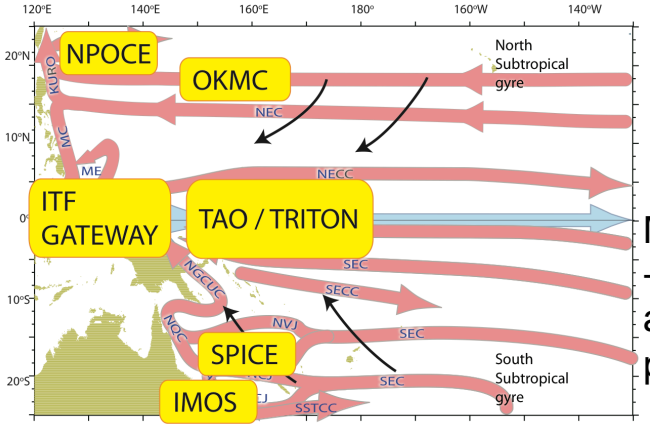


Forced variance versus internal variability, Terray 2012





Decline of Carbon uptake from repeat hydrography, Perez et al 2013



Multi-national, -institutional, and -investor process study programs

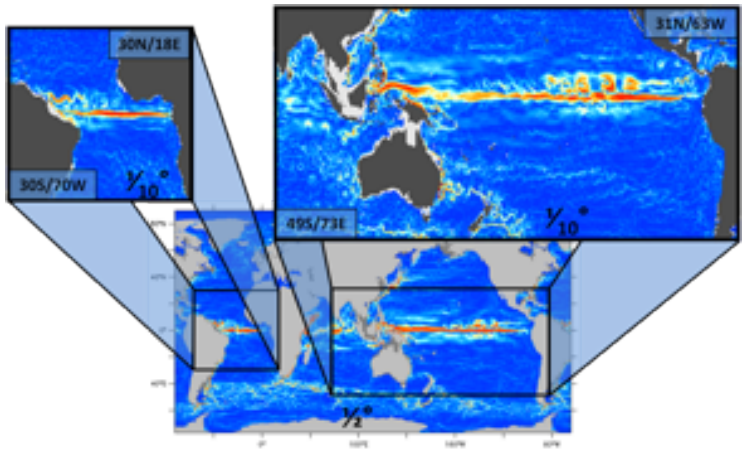
CLIVAR

Core Research Areas

- Anthropogenic Climate Change
- Decadal Variability, Predictability and Prediction
- Intra-to-Seasonal Variability, Predictability and Prediction

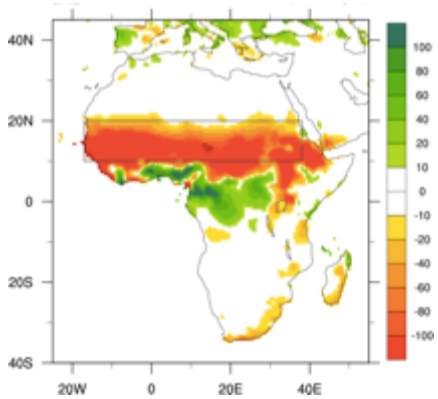
Core Capabilities

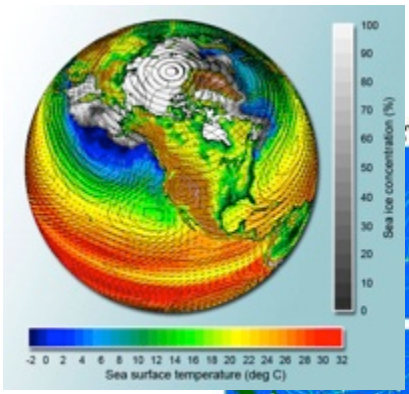
- Improved Atmosphere and Ocean Components of ESMs
- Data Synthesis and Analysis
- Ocean Observing System
- Knowledge Exchange
- Capacity Building

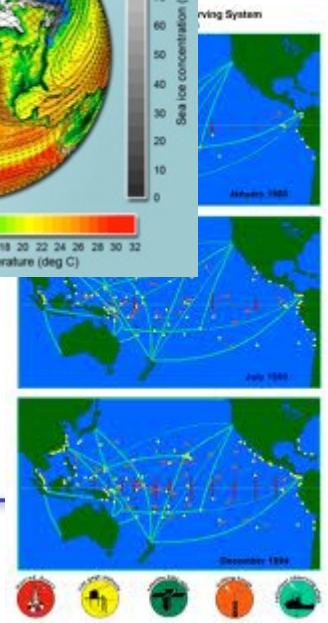


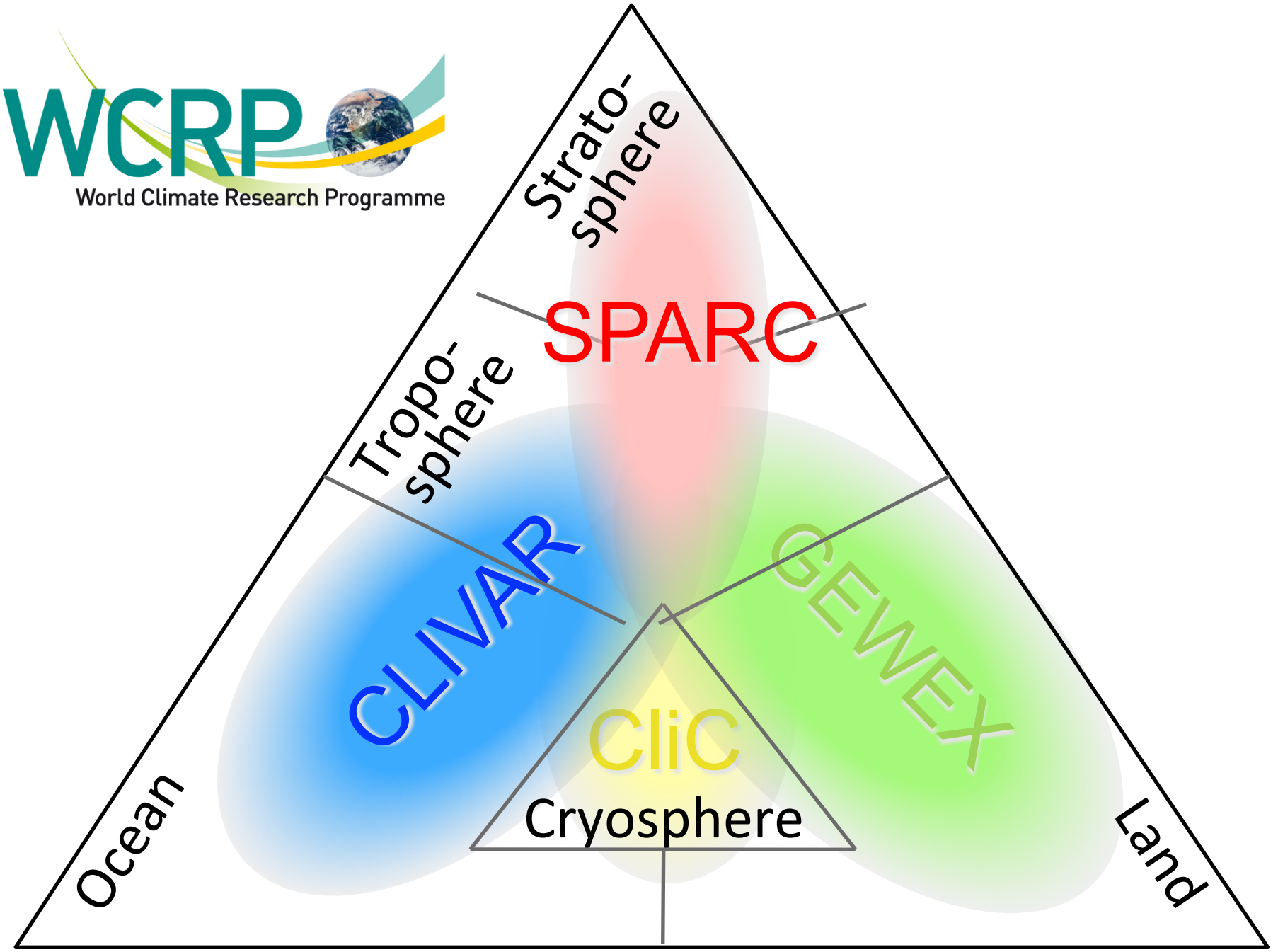
CLIVAR Objectives

- Understand the causes of climate variability on intra-seasonal to centennial time-scales through observations, analysis, and modeling.
- Improve predictions of climate variability and change associated with both internal and external processes.
- Improve the atmosphere and ocean components of Earth-System Models.
- Extend observational climate record through assembly of quality-controlled data sets.

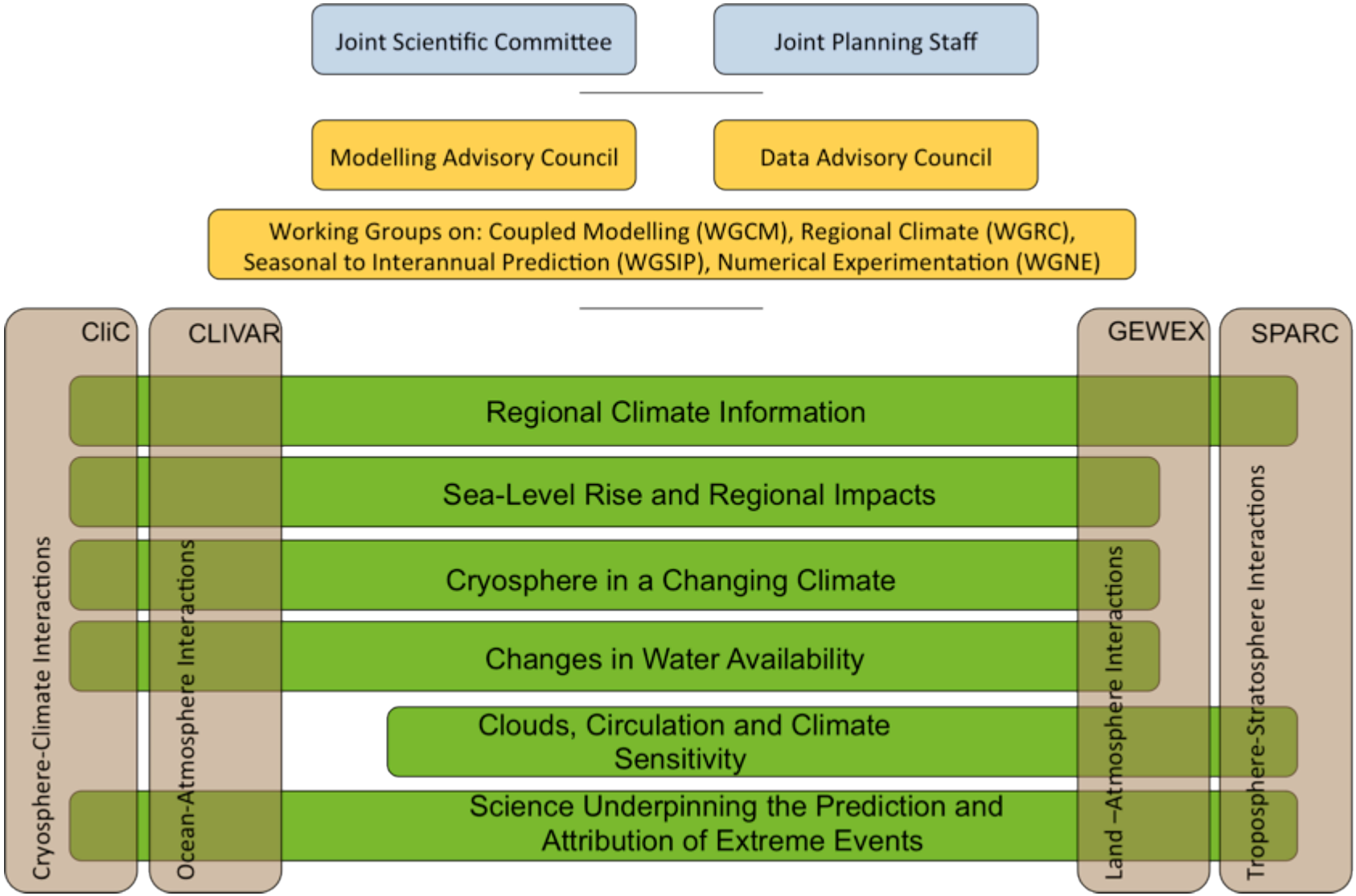






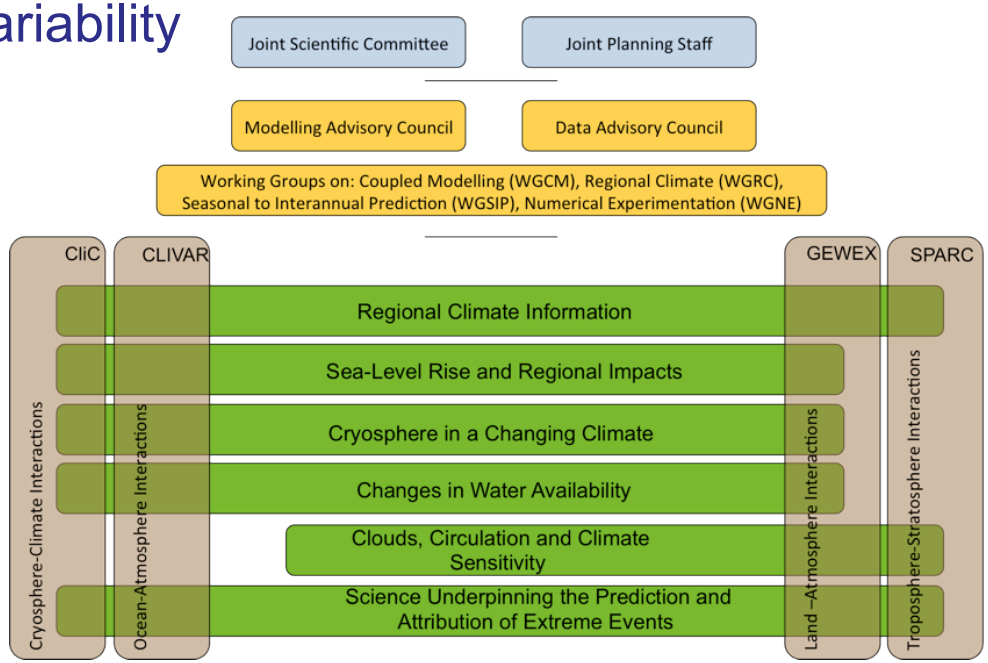

WCRP
World Climate Research Programme
Strato-sphere
Tropo-sphere
SPARC
CLIVAR
GEWEX
CliC
Cryosphere
Ocean
Land

WCRP Evolution



CLIVAR Research Opportunities

- Intraseasonal, seasonal and interannual variability and predictability of monsoon systems
- Decadal variability and predictability of ocean and climate variability
- Trends, nonlinearities and extreme events
- Marine biophysical interactions and dynamics of upwelling systems
- Dynamics of regional sea level variability
- …
- Planetary heat balance and ocean heat storage
- ENSO in a warmer world



WCRP Grand Challenges

Intraseasonal, seasonal and interannual variability and predictability of monsoons

Key areas for progress in the next 5-10 years:

- **Improved model constraint** on monsoon variability and change.
- **Better model representation** of the key processes involved in monsoon variability.
- **Improved prediction** of monsoon variability and change using land surface modelling and incorporation of land surface initialisation.
- **Enhanced understanding** of natural climate variability and anthropogenic change on monsoon systems.

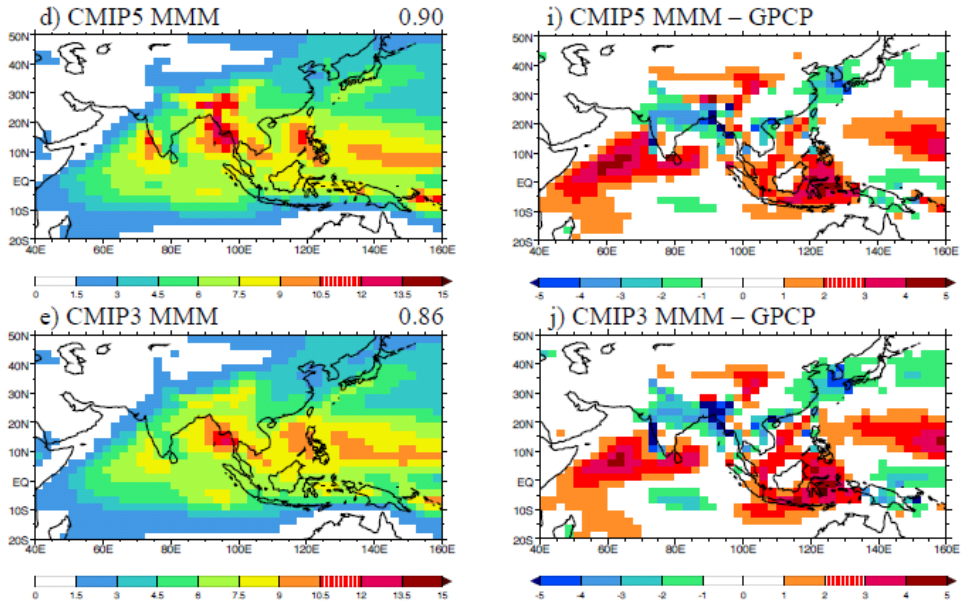
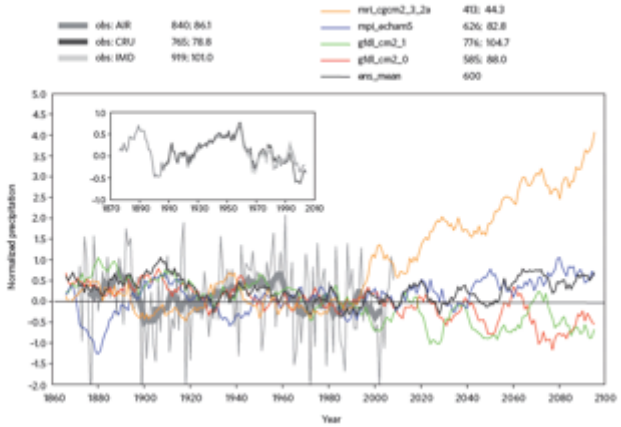


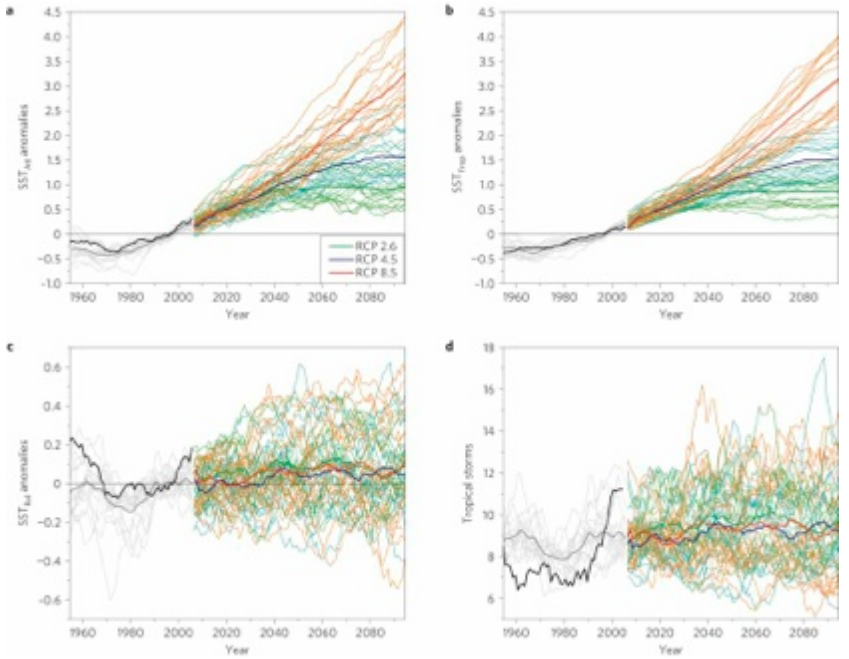
Figure shows large multi-model mean precipitation biases are present for the Asian summer monsoon in CMIP5 (from Sperber *et al*., 2012, *Clim. Dyn.*).

Figure demonstrates (for South Asian monsoon):
• Discrepancies between observed datasets.
• Apparent recent downward trend in monsoon rainfall
• Large decadal variability
• Uncertainty in future projections in SRES-A1B (from Turner & Annamalai, 2012, *Nature Climate Change*).



Decadal variability and predictability of ocean and climate variability

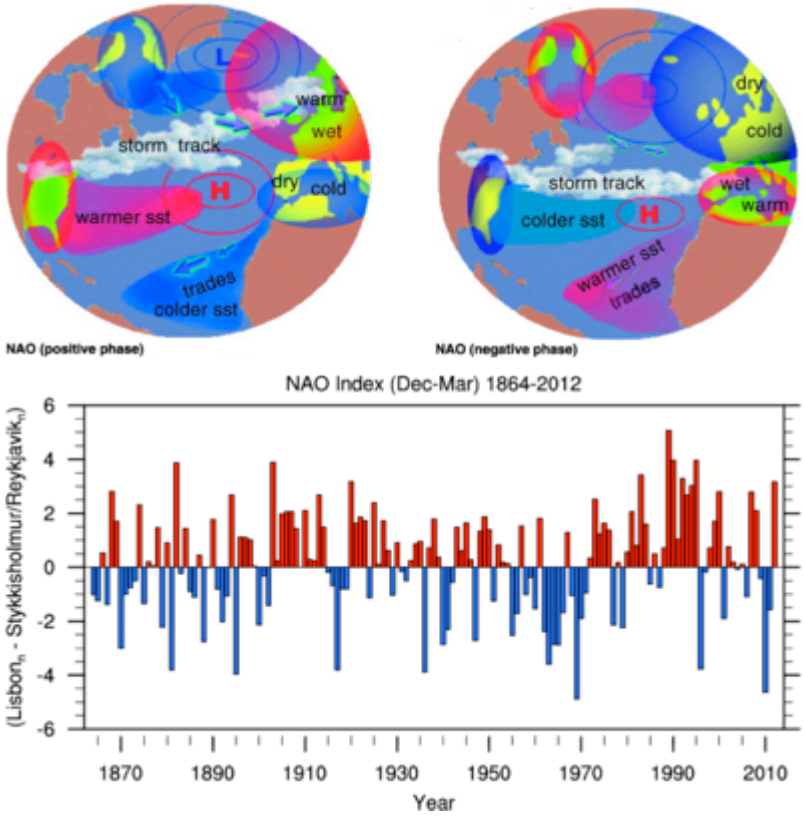
- **Improving understanding** of decadal variability and predictability.
- **Application of past data** sets including instrumental and proxy data.
- **Improving models** to better represent key processes associated with decadal variability.
- **Analysis and development** of current prediction potential of CMIP5 hindcasts.
- **Developing critical evaluations** of proposed climate/geo engineering methods.



Twenty-first-century projections of SST (top) and North Atlantic Tropical Storm frequency (bottom) using CMIP5 (Villarini and Vecchi 2012)

Trends, nonlinearities and extreme events

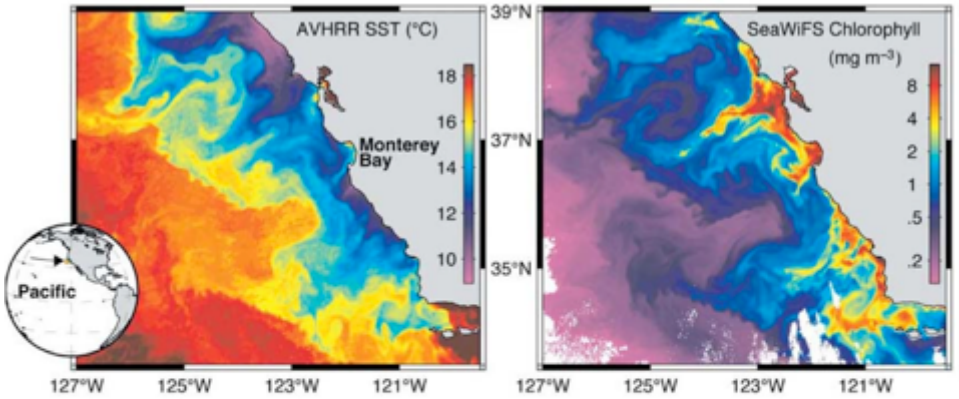
- **Ocean-atmosphere variations** influencing the magnitude and frequency extreme events, both now and in the future.
- **Increasing observational data sets**, providing higher temporal and spatial resolution for ocean-atmosphere processes.
- **Developing ocean-atmosphere models,** which simulate extreme events, focusing on observational approaches.
- **Investigating the physical mechanisms** leading to changes in high impact extreme events.



Top: The positive and the negative phases of the North Atlantic Oscillation (Bojariu and Gimeno 2003); Bottom, Hurrell North Atlantic Oscillation (NAO) Index (Hurrell 2012).

Marine biophysical interactions and dynamics of upwelling systems

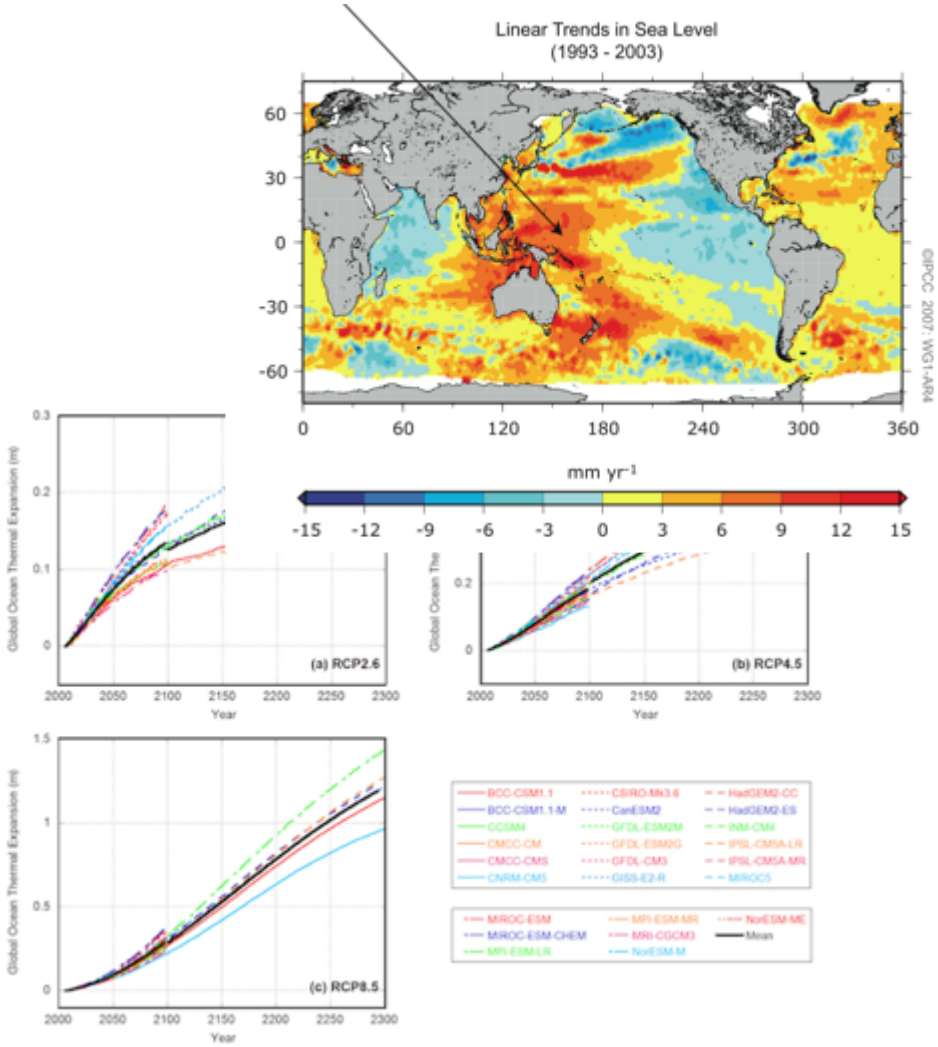
- **Identifying the key physical processes** that are responsible for upwelling.
- **Improving model representation** of upwelling processes.
- **Examining interactions** between the physical, biogeochemical and marine ecological systems.
- **Examining the cause of tropical bias** in climate models.
- **Understanding future variability** of upwelling systems, including changes in the biology and biogeochemistry associated with upwelling.



Satellite remote sensing imagery of the central California Current upwelling system. (a) Sea surface temperature (SST) from the Advanced Very High Resolution Radiometer (AVHRR) on August 14, 2000, and (b) surface chlorophyll from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on August 16, 2000. Source: Ryan et al. (2005). Marine Ecology Process Series. 287:23-32.

Dynamics of regional sea level variability

- **Examining wind-driven circulation** changes to sea level variability.
- **Regional distribution of ocean heat content changes** by ocean circulation and regional warming.
- **Understanding ocean-ice sheet** interactions in Southern Ocean and Greenland.
- **Representation of gravitational attraction** in climate models (with geodetic community).

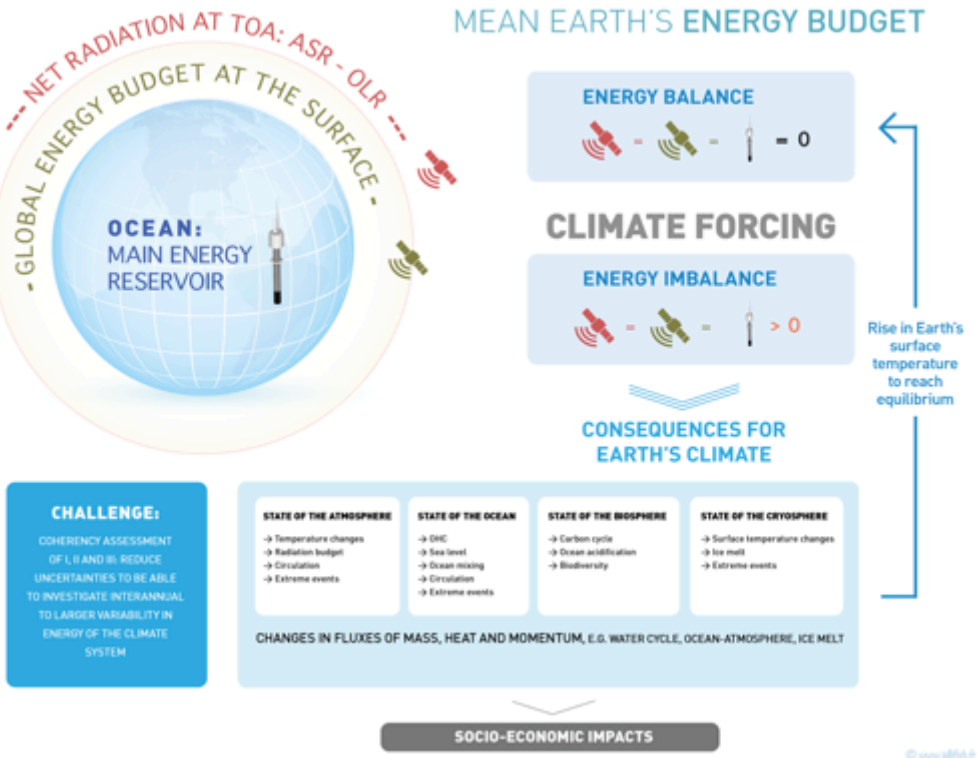


Projections of ocean global thermal expansion under low, medium and high representative concentration pathways, relative to 2006 (Yin 2012).

Consistency between planetary heat balance and ocean heat storage

Analyze the consistency between planetary heat balance and ocean heat storage estimates, data sets and information products based on different parts of the global observing systems and ocean reanalysis.

- **Earth Observation Measurement Constraints on Ocean Heat Budget**
- **In situ observations of ocean heat content changes**
- **Ocean reanalysis for atmosphere-ocean heat exchange and ocean heat content estimate**



ENSO in the climate system and how it may change in a warmer world

1. To better understand the role of different physical processes that influence ENSO characteristics.

2. To provide a synthesis of existing ENSO evaluation methods in GCMs.

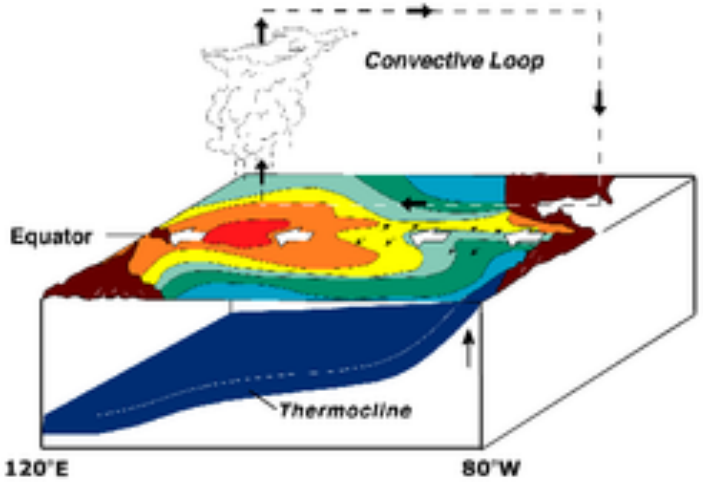
3. To propose ENSO evaluation protocols and develop a strategy for coordinated ENSO analysis of CMIP models, including development and maintenance of an interactive website, in coordination with the WGCM Metrics Panel.

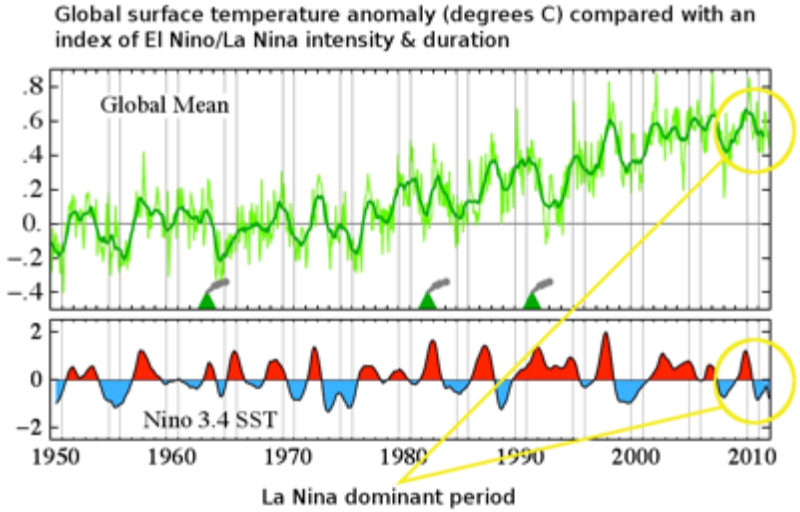
4. To identify new observations needed to better constrain ENSO processes, both for the current climate and for past climates (via paleo proxies).

5. To provide a better understanding of how ENSO might change in the future.

6. To promote and coordinate international collaboration between observationists and modelers for studies of ENSO

7. To build research capacity by contributing to the development of the next generation of talent dealing with ENSO science.





CLIVAR-U.S. CLIVAR Linkages

- Coordination of U.S. participation in process studies
  - **AMOC** – Atlantic, GSOP, WGOMD, PAGES
  - **DIMES** – Southern Ocean
  - **DYNAMO** – Indian Ocean, MJO Task Team
  - **SPURS** – Atlantic, GSOP
  - **IASCLIP** – VAMOS

- Implementation of Climate Process Teams (CPTs)
  - Internal-Wave Driven Mixing in Global Ocean Models – WGOMD
  - Ocean Mixing Processes Associated with High Spatial Heterogeneity in Sea Ice – WGOMD
  - Stratocumulus to Cumulus Transition – WGSIP & WGCM
  - Cloud Parameterization and Aerosol Indirect Effects – WGCM

International CLIVAR Linkages

International CLIVAR Research Challenges (U.S. CLIVAR)

- ISI variability and predictability of monsoon systems
- Decadal variability and prediction of ocean and climate variability **(decadal predictability)**
- Trends, nonlinearities and extreme events **(climate extremes)**
- Marine biophysical interactions and dynamics of upwelling systems **(climate & carbon-biogeochemistry contributions)**
- Dynamics of regional sea level variability **(polar climate, decadal predictability, climate extremes contributions)**

Enabling Capabilities (U.S. CLIVAR Cross-cutting Strategies)

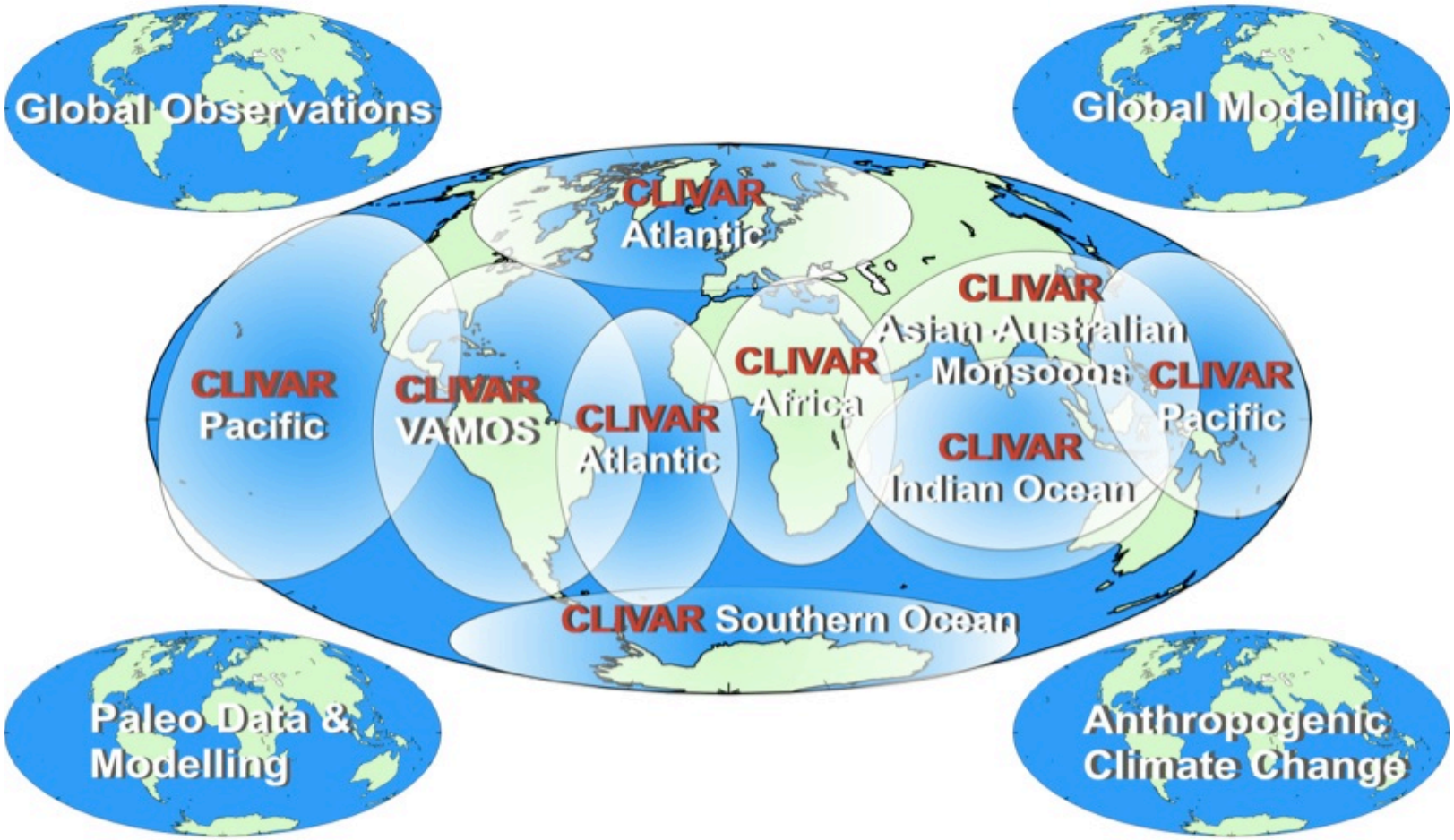
- improving ocean system models **(model development strategies; quantifying improvements)**
- implementing ocean observations **(sustained and new observations)**
- access to ocean data, synthesis and information **(sustained & new obs; communication)**
- knowledge transfer and stakeholder feedback **(communication of climate information)**
- education, capacity building and outreach

Evolution of CLIVAR

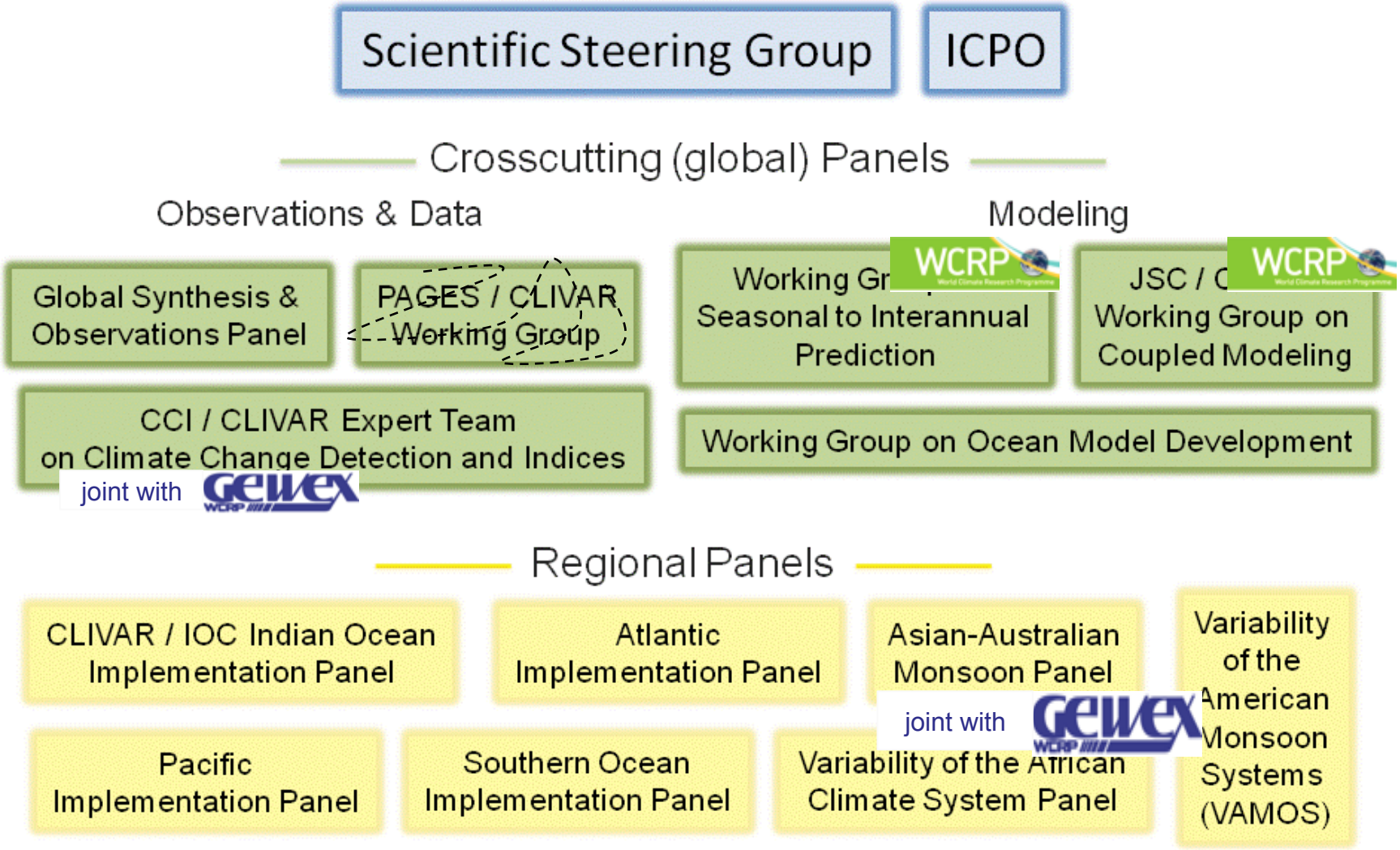
The World Climate Research Programme's project on ocean-atmosphere interactions

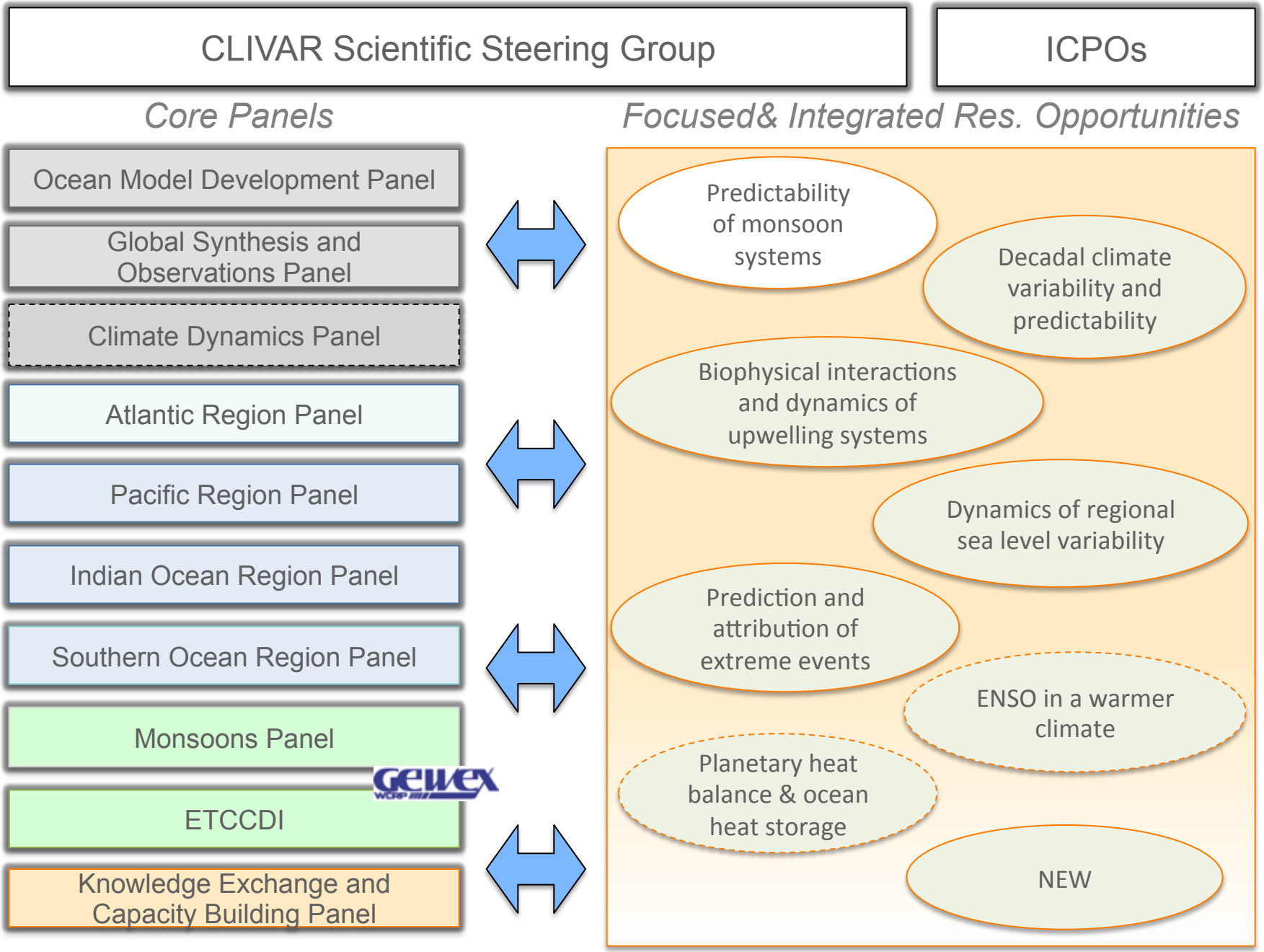
CLIVAR – A Global View

Regional implementation



current CLIVAR Organization




CLIVAR Scientific Steering Group
ICPOs
Core Panels
Focused& Integrated Res. Opportunities
Ocean Model Development Panel
Global Synthesis and Observations Panel
Climate Dynamics Panel
Atlantic Region Panel
Pacific Region Panel
Indian Ocean Region Panel
Southern Ocean Region Panel
Monsoons Panel
GEWEX
ETCCDI
Knowledge Exchange and Capacity Building Panel
Predictability of monsoon systems
Decadal climate variability and predictability
Biophysical interactions and dynamics of upwelling systems
Dynamics of regional sea level variability
Prediction and attribution of extreme events
ENSO in a warmer climate
Planetary heat balance & ocean heat storage
NEW

Pan CLIVAR meeting: July 16-18 2014 in The Hague, Netherlands, joint with GEWEX

(all panels and WGs members meet at the same time)

Opportunities exist

- Connecting to CLIVAR activities on global model development
- Exploiting CLIVAR-WCRP multi-model data sets
- Designing focused coordinated activities under the WCRP Grand Challenges/CLIVAR Research Opportunities

Scientific Steering Group Members

Professor Martin Visbeck (Co-chair 2014)
IGEOMAR, Kiel, Germany

Dr. Lisa Goddard (co-chair 2015)
Earth Institute at Columbia, USA

Dr. Annalisa Bracco (2015)
School of Earth & Atmospheric Sciences, Atlanta, USA

Dr. Ken Drinkwater (2014)
Institute of Marine Research, Bergen, Norway

Dr. Sergey Gulev (2014)
Russian Academy of Sciences, Moscow, Russian Federation

Dr. Ed Hawkins (2015)
Department of Meteorology, University of Reading, UK

Dr. Valerie Masson-Delmotte (2013)
Atomic Energy Commission & Energy Alternatives, France

Dr. Steve Rintoul (2013)
CSIRO, Australia

Dr. Pedro MS Monteiro (2015)
CSIR, South Africa

Dr. Sigfried Schubert (2014)
NASA Goddard Space Flight Centre

Dr. Lixin Wu (2015)
Ocean University of China, China

2014 Incoming.. S. Griffies, P. Braconnot,
D. Stammer - co-Chair

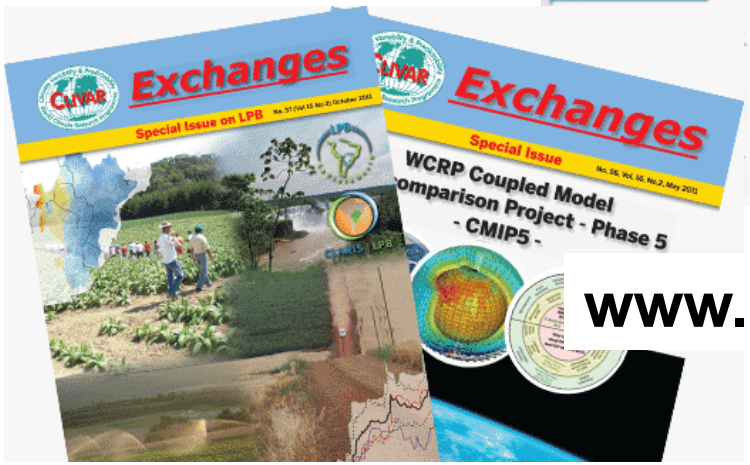
International CLIVAR Project Office (ICPO)

Roger Barry
Director

Jennifer Riley
Staff Scientist

NATURAL ENVIRONMENT RESEARCH COUNCIL

Tim Waterfield - Web developer
Jane Wilkinson - Admin support



www.clivar.org

Anna Pirani
Staff Scientist

Nico Caltabiano
Staff Scientist

Carlos Ereño
Staff Scientist

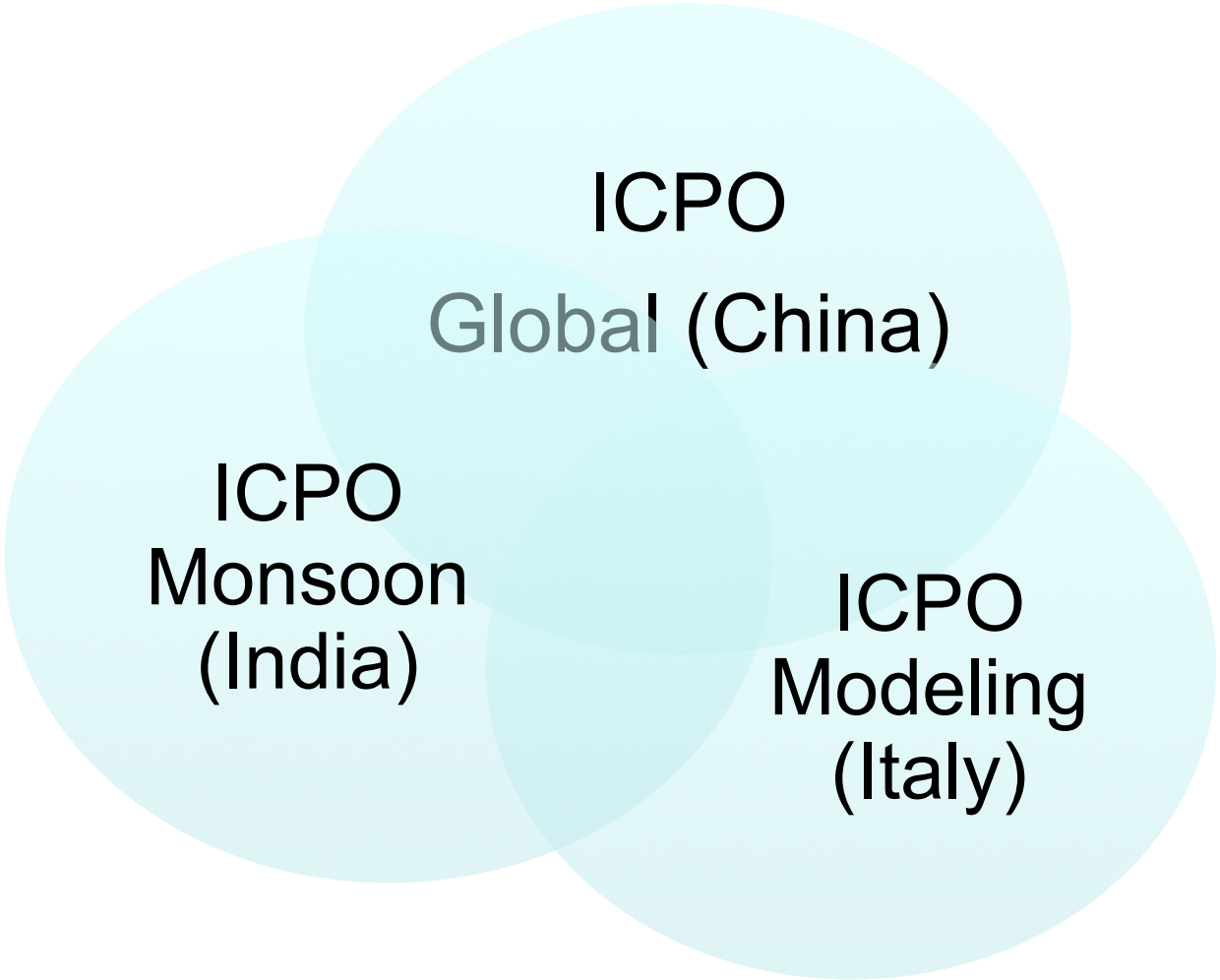
U.S. CLIVAR
Climate Variability & Predictability

Valery Detemmerman
WCRP JPS

International CLIVAR Project Office (ICPO)

- Support to CLIVAR panels, task forces and working groups;
- Support of SSG activities;
- CLIVAR communications and outreach including CLIVAR Exchanges;
- CLIVAR website development;
- Support to CLIVAR capacity development activities;
- Support for development and implementation of the CLIVAR Research Opportunities and relevant WCRP Grand Science Challenges;
- Representation of CLIVAR at international fora and to partner/sponsoring organizations;
- Development of CLIVAR panel and SSG membership proposals;
- Fund raising for CLIVAR activities and ICPO staff and operations

Future Arrangements of ICPO to start early 2014: Distributed Configuration



CLIVAR OCEANS & CLIMATE

variability, predictability and change

The World Climate Research Programme's project on ocean-atmosphere interactions

To improve understanding and prediction
of ocean-atmosphere interactions
and their influence on climate variability and change,
to the benefit of society and the environment.

Anna Pirani, Lisa Goddard