CLIVAR climate variability and predictability

©martin visbeck
Evolution of CLIVAR

The World Climate Research Programme’s project on ocean-atmosphere interactions
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. Valere 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

Dr. Lisa Goddard (co-chair 2015)
Earth Institute at Columbia, USA
International CLIVAR Project Office (ICPO)

Roger Barry
Director

Nico Caltabiano
Staff Scientist

Carlos Ereño
Staff Scientist

Anna Pirani
Staff Scientist

Xiaohui Tang
Staff Scientist

Jennifer Riley
Staff Scientist

Valery Detemmerman
WCRP JPS

www.clivar.org
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<th>Meeting Title</th>
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<tr>
<td>15th VAMOS Panel Meeting</td>
<td>VAMOS</td>
<td>Brazil</td>
<td>June -12</td>
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<tr>
<td>CLIVAR VAMOS Workshop on Modeling and Predicting Climate in Americas</td>
<td>VAMOS</td>
<td>Brazil</td>
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<td>IMBER ClimECO3 Summer School</td>
<td>IMBER</td>
<td>Turkey</td>
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<td>12th Annual Meeting of the Asian-Australian Monsoon Panel</td>
<td>AAMP</td>
<td>China</td>
<td>September-12</td>
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<td>12th Session of the Implementation Panel</td>
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<td>Germany</td>
<td>September-12</td>
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<td>WCRP/CLIVAR Workshop on Decadal and Multi-decadal Variability in the Pacific and Indian Ocean</td>
<td>PP -IOP</td>
<td>China</td>
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<td>9th Session of the CLIVAR/IOC- GOOS Indian Ocean Panel</td>
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<td>Ocean Synthesis and Air- Sea flux evaluation Workshop</td>
<td>GSOP</td>
<td>USA</td>
<td>November -12</td>
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### Panel and Workshop Meeting held 2012 and planned for 2013

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<tr>
<td>GSOP 6 Workshop for Assembly of Observational Data for Climate and Decadal Prediction and Predictability</td>
<td>GSOP</td>
<td>USA</td>
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<tr>
<td>11th Session of WGOMD</td>
<td>WGOMD</td>
<td>Australia</td>
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<td>8th Session of the CLIVAR/CLiC/SCAR</td>
<td>SOP</td>
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<td>WGOMD/SOP Workshop on sea level rise, ocean/ice shelf interactions and ice sheets</td>
<td>WGOMD/SOP</td>
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<td>CLIVAR SSG-20</td>
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<td>Germany</td>
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<td>CLIVAR/GSOP Workshop on Global Ocean Sub-Surface Climate Data</td>
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<tr>
<td>WCRP/CLIVAR Second International Symposium on Boundary Current dynamics</td>
<td>CLIVAR/IOC-GOOS</td>
<td>China</td>
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Future Arrangements of (ICPO) to start early 2014

Global ICPO Management
(close collaboration with JPS)

IPO-China
(focus on ocean)

IPO-India
(focus on monsoon)

IPO-Italy
(focus on modelling)
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.
Evolution of CLIVAR – Main Directions

- CLIVAR remains the ocean-atmosphere program of the World Climate Research Program
- CLIVAR is in the process of formulating a new set of research opportunities that will contribute to the Grand Challenges of WCRP and the wider context of the oceans role in climate variability and change.
- CLIVAR will retain its global and balanced approach based on observations, models and theory and their joint exploitation for climate assessment and climate prediction.
- CLIVAR supports the development of sustained climate and ocean observations as well as targeted improvements to the climate and ocean components of earth system models.
- CLIVAR will intensify its partnerships with the marine biogeochemistry and eco-system community as well as with a selected spectrum of its information user community.
- CLIVAR support education, capacity building and outreach.
- Next Steps
  - AGU (December 2013) & AMS (February 2014) townhall discussion
  - OCEAN SCIENCE MEETING (March 2014) rollout of NEW CLIVAR strategy and plans
  - PAN-CLIVAR meeting in 16-18 July 2014
Mission
To observe, simulate and predict changes in Earth’s climate system with a focus on ocean-atmosphere interactions, enabling better understanding of climate variability, predictability and change, to the benefit of society and the environment in which we live.
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.

- Extend observational climate record through assembly of quality-controlled data sets.

- Improve the atmosphere and ocean components of Earth-System Models.
current CLIVAR Research

- **Anthropogenic Climate Change**
  - Natural variability versus forced change
  - Climate sensitivity and feedbacks
  - Regional phenomena (e.g., ENSO, AMOC, …)
  - Extremes
  - CMIP#
  - Climate Engineering (Geo-engineering)

- **Intra-to-Seasonal Variability, Predictability and Prediction**
  - Monsoons (and ENSO, TAV, …)
  - ISV/MJO
  - Quantifying prediction uncertainty
  - Building pan-WCRP and WWRP links
  - CHFP

- **Decadal Variability, Predictability and Prediction**
  - Determine predictability
  - Mechanisms of variability (AMO, PDV, …)
  - Role of oceans
  - Adequacy of observing system
  - Coupled Initialization
  - Quantifying prediction uncertainty
  - Building pan-WCRP links
current CLIVAR Imperatives

• Improved Atmosphere and Ocean Components of ESMs
  • Analysis and Evaluation
  • “Climate Process Teams” (process studies)
  • Building links pan-WCRP and IGBP
  • Model-Data comparisons

• Data Synthesis and Analysis
  • Ocean
  • Coupled Data Assimilation Systems
  • Links – carbon, biogeochemistry, marine-ecosystems

• Ocean Observing System
  • Development, implementation and system design
  • Advocacy for sustained observations
  • IGBP links for Carbon, Biogeochemistry, Ecosystems

• Capacity Building
  • Summer schools and topical workshops
  • Expert training
  • Call for panel membership
Current CLIVAR Research & Imperatives

• Anthropogenic Climate Change
• Intra-to-Seasonal Variability, Predictability and Prediction
• Decadal Variability, Predictability and Prediction
• Improved Atmosphere and Ocean Components of ESMs
• Data Synthesis and Analysis
• Ocean Observing System
• Capacity Building

All Must Remain WCRP Priorities
CLIVAR – A Global View

Regional implementation

Global Observations

Global Modelling

CLIVAR Atlantic

CLIVAR Pacific

CLIVAR VAMOS

CLIVAR African Monsoons

CLIVAR Asian Australian Monsoons

CLIVAR Indian Ocean

CLIVAR Southern Ocean

Paleo Data & Modelling

Anthropogenic Climate Change

27-31 May 2013

WCRP JSC-34
Brasilia, Brazil

Martin Visbeck and Lisa Goddard
Co-Chair CLIVAR SSG
Highlights against CLIVAR Objectives

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Process Experiments in the Pacific

Pacific climate change and Adaptation science Programme PACCSAP

NPOCE
OKMC
ITF GATEWAY
GAIA
TAO / TRITON
SPICE
IMOS

North Subtropical gyre
South Subtropical gyre
Climatological monsoon onset (pentad 31 ~June 1)

- Observed and simulated results include data from the CMIP5 MMM, and two CMIP5 models
  - Individual models outperform the multi-model mean (not shown)
  - Bias in the time of onset: too late over India (CMIP5 MMM and IPSL-CM5A-MR)
  - Spatial extent of monsoon not defined over: China (IPSL-CM5A-MR) and India (CSIRO-Mk3.6.0)

![Map of monsoon onset](attachment:image.png)
Warming across the ACC

No change in isopycnal slope despite increase in winds (SAM)
Overturning and ACC response

- Eddy compensation is not perfect.
- ACC response shows no resolution dependence.
- Eddy saturation (ACC) does not imply eddy compensation (overturning).
- Overturning changes larger than ACC changes.

Morrison & Hogg (2013)
There was interest expressed to propose a new CLIVAR research opportunity on Ocean Mixing.

The Southern Ocean FINEstructure project (SOFINE) 2008 - 2011

The first full-depth microstructure observations of the turbulent dissipation rate in the ACC

Confirms several of our expectations of the relation between the internal wave field and turbulent mixing and dissipation in the Southern Ocean interior ...

\[ \text{log}_{10}(\text{turbulent dissipation rate}) \] (Wkg\(^{-1}\))
Highlights against CLIVAR Objectives

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Warming event in the Southeast Indian Ocean

Alongshore wind

Shelf mooring

Argo profiles

Ming Feng, et. al., Nature
LETTER

More extreme swings of the South Pacific convergence zone due to greenhouse warming

Wenju Cai¹, Matthieu Lengaigne², Simon Borlace¹, Matthew Collins³,⁴, Tim Cowan¹, Michael J. McPhaden⁵, Axel Timmermann⁶, Scott Power⁷, Josephine Brown⁷, Christophe Menkes⁸, Arona Ngari⁹, Emmanuel M. Vincent² & Matthew J. Widlansky¹⁰

Changes in South Pacific rainfall bands in a warming climate

Matthew J. Widlansky¹, Axel Timmermann¹,², Karl Stein², Shayne McGregor³, Niklas Schneider¹,², Matthew H. England³, Matthieu Lengaigne⁴ and Wenju Cai⁵
Mixed responses of tropical Pacific fisheries and aquaculture to climate change

Johann D. Bell¹*, Alexandre Ganachaud²,³, Peter C. Gehrke⁴, Shane P. Griffiths⁵, Alistair J. Hobday⁶, Ove Hoegh-Guldberg⁷, Johanna E. Johnson⁸, Robert Le Borgne², Patrick Lehodey⁹, Janice M. Lough¹⁰, Richard J. Matear⁶, Timothy D. Pickering¹¹, Morgan S. Pratchett¹², Alex Sen Gupta¹³, Inna Senina⁹ and Michelle Waycott¹⁴,¹⁵

Cascade down climate information
Work with local organization (S. of the Pacific Communities)
80 authors; 900-p book; country reports;
Adaptation recommendations
CLIVAR AIP: Near-term issues and challenges

Seasonal to decadal prediction

• Some large projects addressing decadal predictions: US AMOC, German MiKlip, EU-COMBINE, EU-NACLIM, EU-SPECS
• AIP involvement in CMIP5 analyses

Ratio of forced to total decadal SST variance (Stippling: forced variance \(\approx 0\) at the 5% level). Estimated over 1850-1960; Decrease with increasing latitude; Decadal SST variance in mid to high latitude regions due to internal variability.

Terray (2012)
Highlights against CLIVAR Objectives

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• Improve the atmosphere and ocean components of Earth-System Models.
67% of sites occupied at present (31 of 46)

Resource Formula:

- NOAA provides most equipment (+JAMSTEC, NIO, FIO)
- Regional partners provide ship time

ORV Sagar Kanya deploys ATLAS mooring

Indian Ocean Panel
CLIVAR Indian and Pacific Panels: Including our moorings on your maps is important international recognition for regional funding agencies
Observing System Issues and Challenges and the development of the SOOS

The Southern Ocean Observing System

- Design and implementation of an observing system that encompasses physical, biogeochemical and ecological processes is therefore a formidable challenge.
- Requires multiple nation and agency involvement since the region is vast, remote and logistically difficult to access and thus is one of the least sampled regions on Earth.

Observing gaps?

- Ecosystem monitoring on Argo profiling (CSOBOM – application pending) aims to address this gap.
- CO2 gas fluxes.
- Need to expand ocean coverage under sea-ice zone (CSOBOM and Argo to implement more profiling floats, but other technologies should be under consideration).
- Need to include atmospheric boundary layer and better observe SO clouds.
- Must include ice interaction regions.
- Process studies.

International SOOS office to carry forward this work.

SSG20 Kiel May 6-9 2013
A Southern Ocean Observing System – SOOS
AMOC observing system including trans-basin, overflow & western boundary current observations.

EU-NAKLM exchange across Greenland-Scotland ridge, subpolar North Atlantic

BMBF RACE (different locations, overflow and western boundary)

OSNAP in the subpolar North Atlantic

WHOI Line W at 40°N

RAPID-WATCH/MOCHA/WBTS at 26°N

US MOVE at 16°N

SAMOC at 34.5°S
Objective: “To quantify the large-scale, low-frequency, full water-column net fluxes of mass, heat and fresh water associated with the meridional overturning circulation in the subpolar North Atlantic.”

OSNAP elements: (A) German 53°N western boundary array, supplemented by Canadian shelfbreak array; (B) US Lab Sea glider survey; (C) US West Greenland boundary array; (D) US/UK East Greenland boundary array; (E1 and E2) US float launch sites; (F) US OOI Irminger Sea global node; (G) Netherlands western Mid-Atlantic Ridge array; (H) US eastern Mid-Atlantic Ridge and Iceland Basin array; (I) UK glider survey (Rockall-Hatton Plateau); (J) UK glider survey (Rockall Trough); (K) UK Scottish Slope current array.
South AMOC (SAMOC) at 34.5°S

Current state and evolution of the Atlantic ocean observing system

- Boundary current measurement systems have been started on the western boundary (USA-NOAA, Argentina-SHN, Brazil-USP, Navy) and on the eastern boundary (France-Ifremer, South Africa-UCT) along 34.5°S.
- The funded and proposed field programs have initial durations of 3 to 5 years.
Upcoming augmentations/expansions of the existing SAM pilot array at 34.5°S

The first turn-around for the NOAA pilot array will be done in December 2012 as part of a joint Brazilian, Argentine, and US cruise.

In addition to the NOAA turn-arounds, this cruise represents a crucial expansion of the MOC observing system in the region, as Brazil will be deploying additional instruments to improve the existing western boundary array and to expand it up onto the continental shelf.

High resolution hydrographic/biogeochemical data will be collected during the cruise.

Tentative cruise track for the planned December 2012 joint cruise on the Brazilian research vessel Alpha Crusis. Three of the four existing NOAA instruments will be recovered and redeployed, while the new Brazilian moored instruments will be deployed for the first time. A joint Brazilian/Argentine science party will also collect a detailed hydrographic section.
SSS measurements from SMOS & Aquarius provide new view of the dynamic ocean, complement existing obs, bring new understanding

**SMOS SSS & alt. surface current, June 13-27, 2012**

- SMOS reveals the rich salinity structure of Gulf Stream meanders & rings.
- Give a great opportunity to study cross-frontal exchanges.

N. Reul et al. (2013)

**Aquarius SSS & Reynolds SST, Dec. 18 2011**

- Aquarius reveals SSS structure of tropical instability waves (TIWs) for the 1st time from space.
- Dominant TIW speed at equator is twice as fast as that off equator (not reported in the past 3.5 decades of literature).
- Implications to eddy-mean flow interaction & eddy mixing.

Lee et al. (2012)
ARGO profiling float network

3623 Floats, 14-Feb-2013

Temperature observations per month

Year

Depth

0

-1000

-2000

-3000

1880 1900 1920 1940 1960 1980 2000

Ner month

10 100 400 1000 3000
Global ocean heat content change and significant depth contribution (based on ECMWF ORAS4 ocean reanalysis)
Balmaseda, Trenberth, and Källén (2013)

Fig. 1. OHC integrated from 0 to 300m (grey), 700m (blue), and total depth (violet) from ORAS4, as represented by its 5 ensemble members. The time series show monthly anomalies smoothed with a 12 month running mean, with respect to the 1958-1965 base period. Hatching extends over the range of the ensemble members and hence the spread gives a measure of the uncertainty as represented by ORAS4 (which does not cover all sources of uncertainty). The vertical colored bars indicate a two year interval following the volcanic eruptions with a 6 month lead (owing to the 12 month running mean), and the 1997-98 El Niño event again with 6 months on either side. On lower right, the linear slope for a set of global heating rates (W m⁻²) is given.
ETCCDI

Observations: evaluation of Indices

HadEX2 released
Better coverage than HadEX
Regional ETCCDI workshop data is ingested
A separate dataset based on GHCN data offers near real time update for monitoring

(c) warm nights

(d) warm days

Figure 2.41: Maps show observed trends (days per decade) in the frequency of extreme temperatures, over the period 1951 to 2010, for: (a) cool nights (10th percentile), (b) cool days (10th percentile), (c) warm nights (90th percentile) and (d) warm days (90th percentile). Trends were calculated only for grid boxes that had at least 30 years of data during this period.

Donat et al. 2013
Capacity building, regional workshops

• Practice and goals:
  – Free software + hands-on training + post workshop follow-ups
  – build capacity to analyze observed changes in extremes
  – improve information services on extremes
  – publish peer-reviewed papers from each workshop
  – contribute to worldwide database of derived indices

ETCCDI Key science questions

• Detection and attribution of anthropogenic influence on weather and climate extremes at regional scale and attribution to causes of extreme climate events.
• Mechanisms by which modes of ocean-atmosphere variability affecting weather and climate extremes.
• If and how these modes of ocean-atmosphere variability may change under global warming and possible impacts on future weather and climate extremes.
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Eastern Tropical Atlantic SST Bias
Foster research to improve observational network, reduce systematic model errors, and improve tropical Atlantic predictability

AR5 (25 models): SST − HadISST [°C]
Annual mean 1960–2004

Mean SST error in the historical integrations of a set of 25 coupled GCMs in the CMIP5 ensemble. White hatching denotes areas where the sign of the error agrees in all models; black dots where all but one (CSIRO-Mk3.6.0) agree.

Toniazzo and Woolnough (2013)
EU-PREFACE (N. Keenlyside, Bergen)

Enhancing PREdiction of Tropical Atlantic ClimateE and its Impacts
- 27 partner institutes, 17 from Europe, 10 from Africa

**Observations**
- Enhanced observing system
  - PIRATA SE extension
  - Coastal wave guide
  - Targeted field campaigns in upwelling regions
- Data synthesis of
  - Underused ocean & fisheries data
  - Available in-situ and remote sensing data
  - New PREFACE data

**Modelling**
- **Ocean**
  - High resolution regional & basin
- **Climate**
  - 8 models
  - Medium & high resolution
  - Sensitivity experiments
- **Prediction**
  - 4 systems
  - Comprehensive data assimilation

**Available simulations**
- CMIP3 & 5
- ECMWF
- APCC
- ENSEMBLES, SPECS

**Improved Prediction of Tropical Atlantic Climate and its Impacts**
Coupled Ocean-ice Reference Experiments
Phase II - CORE-II
An experimental protocol for ocean – sea-ice coupled simulations forced with inter-annually varying atmospheric data sets for the 1948-2007 period (Large and Yeager 2009).

These hindcast simulations provide a framework for
- evaluating, understanding, and improving ocean models
- investigating mechanisms for seasonal, inter-annual, and decadal variability
- evaluating the robustness of mechanisms across models,
- complementing data assimilation in bridging observations and modeling and in providing ocean initial conditions for climate prediction simulations.

Participating Groups: 18 models
Level, isopycnal, hybrid, mass, and sigma coordinates; unstructured finite element ocean model; mostly nominal 1° resolution
CORE II Results

AMOC Mean (1988-2007) in Depth Space

Danabasoglu et al, submitted

Griffies et al, in prep.
CORE II Results

Griffies et al, in prep.
CORE II Results (more topics to come)

North Atlantic simulations with a focus on the Atlantic meridional overturning circulation, Part I: Mean states; Part II: Variability (Danabasoglu, Yeager, Bailey et al.)
  • Global and regional sea level (Griffies & Yin, et al.)
  • Arctic Ocean and sea-ice (Gerdes, Wang, Drange et al.)
  • The Antarctic Circumpolar Current and Southern Ocean overturning circulation with a focus on eddy compensation (Farneti & Downes, et al.)
  • Evolution of Southern Ocean water masses and ventilation (Downes & Farneti, et al.)
  • South Atlantic simulations (Treguier & Weiner, et al.)
  • Ocean circulation in temperature and salinity space (Nurser & Zika, et al.)

WGOMD Key Activities over next 1-10 years

• Model biases and improve model physics, considering biogeochemistry and ecosystems,

• High resolution modeling and regional/coastal modeling (scale aware parameterizations),

• Sea level and interactions with ice sheets,

• Role of ocean in decadal variability (e.g., AMOC),

• Operational oceanography and data assimilation.
Evolution of CLIVAR
The World Climate Research Programme’s project on ocean-atmosphere interactions
SSG20 Issues

- Finalize the words that go with the *NEW* CLIVAR
- Develop and agree on an action plan for the next 12-18 month to roll out the *NEW* CLIVAR
- Advance the concept of CLIVAR research opportunities and how to implement them in the context of WCRP-Grand Challenges
- Develop and hopefully agree on a revised CLIVAR governance model to be presented at the JSC end on May
- Broader science community engagement (ECS, national reports, communication)
- Engagement with other groups (WCRP family, Future Earth, IOC regions, GOOS, ...)
- Knowledge exchange with users of climate research (GFCS, IPCC, AoA, prediction centers, data centers, nations)
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.
WCRP Grand Challenges

Joint Scientific Committee

Modelling Advisory Council

Data Advisory Council

Working Groups on: Coupled Modelling (WGCM), Regional Climate (WGRC), Seasonal to Interannual Prediction (WGIIP), Numerical Experimentation (WGNE)

WCRP JSC-34
Brasilia, Brazil

27-31 May 2013

Co-Chair  CLIVAR SSG
new CLIVAR Capabilities

- Improving the atmosphere and ocean component of Earth System Models.
- Implementing innovative process and sustained ocean observations.
- Facilitate free and open access to climate and ocean data, synthesis and information.
- Support Regional and global networks of climate and ocean scientist.
- Facilitate knowledge exchange and user feedback.
- Support education, capacity building and outreach.
new 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
• Consistency between planetary heat balance and ocean heat storage
• ENSO in a warmer world
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
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.
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.
Proposed after SSG-20

Core Panels

- Ocean Model Development Panel
- Global Synthesis and Observations Panel
- Atlantic Region Panel
- Pacific Region Panel
- Indian Ocean Region Panel
- Southern Ocean Region Panel
- Monsoons Panel
- ETCCDI
- Knowledge Exchange and Capacity Building Panel

Focused & Integrated Res. Opportunities

- 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
- Ocean heat storage
- NEW

CLIVAR Organization

Scientific Steering Group

ICPO

Mar, n Visbeck and Lisa Goddard
Co-Chair CLIVAR SSG
SSG20 Follow up

- Pan CLIVAR meeting during July 16-18 2014 in The Hague, Netherlands jointly with GEWEX (all panels and WGs members meet at the same time)
- CLIVAR SSG meeting in the fall 2014 (Moscow)?
Issues for the JSC

• CLIVAR proposed to have a single Monsoons panel that should serve all of WCPR’s monsoon activities. Focused working groups under that are encouraged with the possibility to be regional.

• CLIVAR has no concrete plans to include the Arctic in its scope of activities. We defer to CLiC to take the initiative.

• CLIVAR will rework all the TORs for its panels. Plan to make the WGOMD a panel.

• CLIVAR will not support a separate panel of PAGES-CLIVAR. activities, but encourages all groups to liaise with PAGES where appropriate (like we do with CARBON and IMBER).

• CLIVAR will consult further with GEWEX on the ETCCDI member etc.

• ... wrestle with the connection to WGSIP and WGCM ...
Evolution of CLIVAR – Main Directions

• CLIVAR remains the ocean-atmosphere program of the World Climate Research Program

• CLIVAR is in the process of formulating a new set of research opportunities that will contribute to the Grand Challenges of WCRP and the wider context of the oceans role in climate variability and change.

• CLIVAR will retain its global and balanced approach based on observations, models and theory and their joint exploitation for climate assessment and climate prediction.

• CLIVAR supports the development of sustained climate and ocean observations as well as targeted improvements to the climate and ocean components of earth system models.

• CLIVAR will intensify its partnerships with the marine biogeochemistry and eco-system community as well as with a selected spectrum of its information user community.

• CLIVAR support education, capacity building and outreach.

• Next Steps
  - AGU (December 2013) & AMS (February 2014) townhall discussion
  - OCEAN SCIENCE MEETING (March 2014) rollout of NEW CLIVAR strategy and plans
  - PAN-CLIVAR meeting in 16-18 July 2014
Visualization of the Monsoons Panel

<table>
<thead>
<tr>
<th>WCRP CLIVAR/GEWEX</th>
<th>Monsoons Panel</th>
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<tbody>
<tr>
<td>WG Austral Asian Monsoon</td>
<td>WG American Monsoons</td>
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<td>WG African Monsoons</td>
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<td>WG Predictability ?</td>
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Build on existing activities