CLIVAR: CLIMATE & OCEAN
variability, predictability and change

WCRP’s core project on the
Ocean-Atmosphere System

JSC36, 8-10 April 2015, Geneva
Lisa Goddard (SSG co-chair)
Outline

• CLIVAR priorities and opportunities
• Synergies and joint activities with US CLIVAR
• DCVP, CMIP6, and a new WCRP GC
• Upwelling and cooperations CLIVAR-IMBER
• IACS, WCRP, and CLIVAR-Arctic
• CLIVAR 2016 Open Science Conference
To observe, simulate and predict changes in Earth’s climate system with a focus on the **ocean-atmosphere system** as part of the climate system.

Enabling better understanding of climate variability, predictability and change.

To the benefit of society and the environment in which we live.
Truly International ICPO
CLIVAR: Basin panels
Int’l Coordination. Regional Implementation.

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

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

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

Figure 1. The latest RAPID time series including the AMOC (red), Gulf Stream (blue), Ekman (green) and upper mid-ocean (magenta) transports. Colored lines are ten-day values. Black lines are 90-day low-pass filtered values.

Figure 2. Time series of the MHT (black), and the contributions by the temperature transport of the ACT (red), Gulf Stream (blue), and the Ekman (green) transport is illustrated too (Smeed et al, 2014)

Figure 9. Observational network in the tropical Atlantic including the PIRATA network, the IBOP/MAKTA and its associated heat transport on seasonal and interannual time scales. Plans are for continued improvements to the network which is being used for seasonal and interannual variability. The year variability of the ACT sea surface temperature (SST) is a defining character of system's understanding of the eastern tropical Atlantic climate system. The regional focus of TACE during the past decade the tropical Atlantic observing system has been greatly developed. During the past decade the tropical Atlantic observing system has been greatly developed. On the basis of the PIRATA network, other multinational observing programs, such as the West African AWA and EU PREFACE programs, which are multidisciplinary studies linking regions of both hemispheres, particularly in the Southeast Atlantic. Different national and international programs are initiated, including German S

Figure 8. Schematic diagram illustrating the component parts of the AMOC observing system. Black arrows represent the Ekman transport (predominantly northward). Red arrows illustrate the circulation of warm waters in the upper 1100 m, and blue arrows indicate the main southward flow of colder deep waters. The array of moorings used to measure the interior geostrophic transports by various wind products. Figure 8 shows a schematic diagram of the components of the program (Smeed et al, 2014). The proj

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Argo and GO-SHIP

- Argo and repeat hydrography are of high priority to CLIVAR.
- GSOP is the liaison to both as well and is participating in meetings.
- Basin panels interact with resp. to regional observing components (see below).
- Like with other data sets responsible for the synthesis.
Main focus on Eastern Atlantic

• Panel played a key role in coordinating discussions on model biases in Eastern Atlantic Upwelling region, which led the creation of the US CLIVAR Eastern Tropical Oceans Synthesis WG

• Several members were essential in setting up the EU funded PREFACE (Enhancing PREdiction of Tropical Atlantic ClimatE & its impact) – 2012/2017
PREFACE: Enhancing PREdiction of Tropical Atlantic Climate & its impact

- 27 partners from 17 countries
  - 17 from 8 European countries
  - 10 from 9 African countries
- Coordinator: Noel Keenlyside

Associated projects/initiatives
- AWA (PI P. Brehmer)
- SACUS-SPACE (PI P. Brandt)
- US NSF (PI P. Chang)

Continuation of CLIVAR TACE program (2006-2011) with more emphasis on coastal upwelling regions
Some SORP members (Talley, Russell) instrumental in developing SOCCOM. Panel will foster further coordination of SOCCOM with other countries’ initiatives.

Development of proposal of SOMIP with wind perturbation protocols
- SOMIP metrics based on observations (with US CLIVAR Southern Ocean WG)
Observations
SORP advising GOOS on EOVs, working on list of most important, practical, near-term priorities (under-ice observations; surface fluxes)

Use of state estimates (ocean reanalysis) to aid with analysis of the broad-scale data

Use of state estimates and OSSEs to assist with optimizing sampling plans

Southern Ocean State Estimate (SOSE)

SOSE’s map of where pH measured on ~100 floats would influence pH field in SOSE
Observations
SORP working with SOOS on a strategy for an integrated under-ice observing system

Five domains in the sea ice zone, each with own sampling needs/opportunities:
1. Open ocean above 2000 m
2. Deep ocean
3. Continental shelf and slope
4. Ice shelf cavity
5. Sea ice and atmosphere
CLIVAR-Arctic

- An equivalent effort in the Arctic seems missing (my perspective).

- Discussion at the IACS meeting in Japan about the state of the observing systems.

- CLIC seems resistant to a joint Arctic panel

- AIP now puts a member on the IACS ocean panel to sort out what is there and what CLIVAR needs to take care of.
NPOCE program (Northwestern Pacific Ocean circulation and climate)

JGR special issue on Western Pacific Ocean Circulation and Climate

ENSO study: ENSO metrics to evaluate climate models (Guilyardi et al., 2009); ENSO-IOD relationship (Nagura and McPhaden, 2013); Extreme El Nino events (Cai et al., 2014)

SPICE (2008-2020) (Southeast Pacific Ocean Circulation and Climate Experiment)

SPCZ (South Pacific convergence zone) study
The Agulhas System Climate Array (ASCA) is located in South Africa, USA, and Netherlands. It is part of the CLIVAR/IOC-GOOS Indian Ocean Region Panel (IORP) with co-chairs Jerome Vialard (France) and M. Ravichandran (India). The IOD study includes MISMO (Yoneyama et al. 2008) and VASCO/CIRENE (Vialard et al. 2009a). There is a review paper on decadal variability in IO (Han et al., 2014), and a response to warming climate (Cai et al., 2013, nature).

Next Panel meeting:
Understanding the interaction of the surface and deep ocean with the climate system

Zhang et al., 2008

Hand et al., 2014

Gulev et al., 2013

Danabasoglu et al., 2014
Deep OHC (700-6000m) interannual variability

• Some Signal in N Atlantic and S Ocean
  - Check against Obs. only products ARMOUR3D, EN3

• High Noise (disagreement between products) in same regions so S/N < 1

• Planned to monitor OceanSITES locations to compare variability levels between sites

• Strategy for future deployment by investigating the consistency of temporal variability in ocean synthesis products in space

• Results preliminary: May be v. sensitive to outliers (models with strong drifts).
• Aim: To construct the most complete, consistent and high quality subsurface ocean temperature (EOV/ECV) long-term database, with intelligent metadata and assigned uncertainty to each observation,

• Future plans to expand IQuOD effort to other EOVs/ECVs such as subsurface salinity, oxygen, etc.

• globally-coordinated single best standard practice to avoid duplication.

• Deliverables will be tailored in close cooperation/collaboration with end-users (e.g., observational, reanalysis/modelling communities and ocean/climate services).
Climate Dynamics: Dynamical Processes and their Role in Climate Variability and Change

**Focus** on large-scale phenomena, processes, and mechanisms of coupled climate variability/modes, teleconnections and change on seasonal to centennial time-scales.

(i) **storm tracks, jet streams and weather systems**
- Extratropical Atmosphere-Ocean Coupling
- Remote Influences and External Forcing
- A Theoretical Challenge

(ii) **Tropical-Extratropical Interactions**
- Zonal Asymmetries in Tropical Convergence Zones
- Dynamical links Between the Tropics and Midlatitudes
- North-South Asymmetry in the Climate Change Signal

(ii) **Long-term Coupled Atmosphere-Ocean Circulation**
- Patterns of Future SST Change
- Precipitation Changes over Land
- Variability as an Analog for Forced Change
1st Meeting: 2-4 July 2015, Exeter, UK

- Overview of research and recent findings
- Open questions and challenges
- Forthcoming opportunities (workshops, meetings, funding calls)
- Suggestions for panel activities/deliverables e.g. coordinated meetings, model experiments/analyses, collaboration with other WCRP activities and projects
Given the widespread use of CORE-II, and the associated broad advances to ocean and climate science, there is an urgent need to advance the scientific and engineering foundations of CORE-II to serve model development, applications and mechanistic understanding needs, eg:

- High resolution modeling applications
- Upwelling
- Decadal Variability and Predictability

**OMDP priority**: to reignite both science and engineering efforts to advance the foundations of CORE-II, including the extension/update of forcing datasets for CORE-II
CMIP6 Ocean Model Intercomparison Project (OMIP)

- OMDP has developed the CORE-II protocol as an Ocean Model Intercomparison Project (OMIP) for inclusion in CMIP6
  - Includes the merger with the OCMIP ocean biogeochemistry effort.

Ocean-Ice Model Surface Forcing Function

- OMDP Mini-Workshop on Forcing Ocean-Ice Models - Grenoble, January 2015 ([report on OMDP webpage](#))
  - Major outcome: consideration of the new JRA-55 product – presented here for the first time - to provide the next generation of atmospheric forcing data sets for use in future CORE (OMIP) frameworks.
  - Exciting prospect for a new high resolution, near real-time forcing dataset for future COREs and potentially OMIP
  - JRA effort supported through a community evaluation effort by OMDP, the workshop participants and other members of the community over the course of 2015 and 2016.
Extended OMDP Session - Yokohama, Japan, 14-15 January 2016

The detailed evaluation of the new JRA-55 product, advancing the CORE-II framework and CMIP OMIP.

- **Specific topics:**
  - review of technical aspects of JRA-55; its on-going evaluation;
  - reviews of applied and / or additional corrections;
  - creation of a normal-year forcing data set;
  - presentations of preliminary scientific results, directly related to the development of the CORE-II framework and CMIP6 OMIP experiment.

- **Potential outcome:**
  - Evaluation and decision regarding the endorsement of the JRA-55 by OMDP (with input from the broader ocean and climate modelling communities) as the forcing for the future CORE-II efforts and OMIP ocean-ice climate model simulations.

- Another important goal of the meeting is to receive input from the wider ocean and climate modeling communities participating in the CORE-II and / or OMIP efforts on OMDP planning for these efforts.
Research Foci

- Timely, tractable and socially-relevant research challenges; limited life-time (2-5 yrs)
- Cross-cutting between CLIVAR & WCRP, modeling & obs.

**GCs**
- Regional sea-level change & coastal impacts
- Extremes

**Mature & Ongoing**
- Decadal climate variability and predictability
- Planetary energy balance & ocean heat storage
- ENSO in a changing climate

**Under Development**
- Predictability of monsoon systems
- Upwelling Systems
Decadal Climate Variability and Predictability (DCVP)

Objectives: Characterize, understand, attribute, and predict global and regional multi-year to multi-decade observed climate anomalies

Focus:
Explaining, understanding and predicting the modulation – accelerations and slowdowns – of the anthropogenic warming trend

Determining the role of volcanic eruptions in decadal climate variability and their impact on decadal climate prediction

Source: KNMI
<table>
<thead>
<tr>
<th><strong>DCVP RF Working Group membership</strong></th>
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<tbody>
<tr>
<td><strong>Cassou, Christophe</strong></td>
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<td><strong>Kushnir, Yochanan</strong></td>
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<td><strong>Danabasoglu, Gokhan</strong></td>
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<td><strong>Power, Scott</strong></td>
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<td><strong>Zhou, Tianjun</strong></td>
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Decadal Climate Variability and Predictability (DCVP)

- Improve the physical characterization and understanding of decadal variability, internal and forced, using instrumental and proxy records and models.

- Improve models ability to capture and simulate the observed phenomena, their time scales and regional impact, test hypotheses on cause and underlying mechanisms.

- Use models of varying complexity to determine the predictability of decadal climate (perform hindcasts and forecasts, address data and physical uncertainties and model drift and biases).

- Assess the observing systems and develop recommendations to sustain and enhance capabilities for model initialization and reliable monitoring of decadal climate variability.

- Develop best practices for delivering decadal predictions by understanding the needs users of decadal climate information - the development of appropriate information products geared to specific societal use based on probabilistic understanding of decadal climate variability.
Decadal Climate Variability and Predictability (DCVP)

Ongoing Activities

**Leading design of DCPP MIP Component C experiments**

Coordinated multi-model investigations of a restricted number of mechanism/predictability/case studies believed to be of broad interest to the community.

- Pace-maker experiments on understanding mechanisms of climate shifts, internal modes of variability and predictability
- Perturbation experiments on the impact of volcanoes on predictability and predictions
- Idealized Atlantic Multidecadal Variability (AMV) experiments to investigate the climate impacts of AMV variability due to its natural variability

**Coordination:**

Regional panels, other RF (e.g., CONCEPT-HEAT), & other related national CLIVAR activities (e.g., US AMOC, UK RAPID and CLIVAR ocean observing activities) WCRP (DCPP, GEWEX, SPARC, CliC), PAGES
Near-term DCVP Activities

- Establish links to CLIVAR regional panels, other RF (e.g., 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 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.
The state-of-the-art and perspectives from theory, simplified to fully coupled modelling, instrumental and paleoclimate research:

- General introduction to DCV
- The Atlantic DCV
- The Pacific DV
- Monsoons
- Recent hiatus and AMV/PDV connection
- Cryosphere: Arctic/Antarctic sea ice
- Predictability and Prediction
- DCVP Challenge and Opportunity
- Discussion and DCVP Working Group Meeting

Participants are asked to address:

What are major advances, what are the frontiers, where are there opportunities for significant progress. DCVP planning will integrate the community’s recommendations.
**Objectives:**

1. Better understand the role of different physical processes that influence ENSO characteristics.
2. Provide a synthesis of existing ENSO evaluation methods in GCMs.
3. Propose ENSO evaluation protocols and develop a strategy for coordinated ENSO analysis of CMIP models.
4. Identify new observations needed to better constrain ENSO processes, both for the current climate and for past climates (via paleo proxies).
5. Provide a better understanding of how ENSO might change in the future.
6. Promote and coordinate international collaboration between observationists and modelers for studies of ENSO.
7. Build research capacity by contributing to the development of the next generation of talent dealing with ENSO science.
Implementation Strategy

- Task 1. Processes responsible for ENSO characteristics
  **Deliverables**: a workshop report and a review paper about physical mechanisms responsible for ENSO characteristics

- Task 2. Model ENSO evaluation protocol
  **Deliverables**: a report/paper on the proposed ENSO evaluation protocol and a web site, including web services to compute the metrics/analysis required for the protocol.

- Task 3. ENSO in a changing climate
  **Deliverable**: peer-reviewed paper on ENSO in a changing climate providing latest estimates of likely ENSO changes over the next few decades.

Membership

<table>
<thead>
<tr>
<th>Name</th>
<th>Expertise</th>
<th>Affiliation, Country</th>
<th>Liaison for the group</th>
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<tbody>
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<td>Eric Guilyardi</td>
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Recent activity:
"4th CLIVAR ENSO workshop on the evaluation of ENSO in climate models: ENSO in a changing climate" in Paris, France, July 8-10 2015.
The workshop is co-sponsored by
The CLIVAR ENSO Paris workshop was a deliverable of Task 1. About 60 researchers, including 12 Early Career Scientists attended this workshop. A summary on the fruit of this workshop is anticipated to be published this fall.

Task 2: The model evaluation protocol was discussed in a dedicated session, including metrics and observations, in conjunction with TPOS.

There is a need for more diagnostics and metrics which help us to understand the role of atmospheric processes in the ENSO cycle. We have identified a few experts to be part of a metrics task team and the next call of the RF group will be to define in more detail its mission (metrics, observations, model evaluation software, with other related community activities). We may have identified some funding to help.
Task 3 is now in press in Nature Climate Change

There was some discussion about the role this RF should play in commenting on ENSO predictions. The consensus seemed to be that this is best left to operational centres.

There is significant interest in recent decadal variability in the tropical Pacific within the group. Hence some overlap or possible interaction with the new WCRP grand challenge on decadal.
Five parallel, but interconnected, working groups established:

1. An integrated approach to paleo time scale sea level estimates
2. Quantifying the contribution of land ice to near-future sea level rise
3. Causes for contemporary regional sea level variability and change
4. Predictability of regional sea level
5. Sea level science for coastal zone management
Ongoing work

- ISMIP
- FAFMIP
- New GIA model
- Climate modes and sea level
- Ocean-Ice interaction
- Coastal impact studies
- Review paper
Sea Level Conference „2016“

- Tentative location: New York University
- Possibly July 2017

Panel meeting during solar eclipse in Utrecht
Main objectives:

1) Quantify Earth’s energy imbalance, the ocean heat budget, and atmosphere-ocean turbulent and radiative heat fluxes,

2) Analyze the consistency between the satellite-based planetary heat balance and ocean heat storage estimates

29 Sep – 02 Oct 2015: Workshop on “Energy flows in the Earth’s climate system”
MetOffice (Exeter, UK)

Co-sponsored by CLIVAR, US CLIVAR, NOAA, EU-COST, ESA
Marine biophysical interactions and dynamics of upwelling systems

Activity leader:
Enrique Curchitser (Rutgers University, USA)

Recent activities:
- Pan-CLIVAR meeting, The Hague, The Netherlands
- Upwelling systems under future climate change workshop (Third International Symposium “Effects of Climate Change of the World’s Oceans, Santos, Brazil – 21-22 March 2015)

Planned activities:
- Planning workshop (Ankara, Turkey - 2-3 October 2015)
Marine biophysical interactions and dynamics of upwelling systems

Major research themes *

- Identifying the key physical and biogeochemical processes and impacts on ecosystem dynamics in upwelling regions and improving their representation in models
- Addressing upwelling related biases in climate models
- Exploring how upwelling systems will respond to change in climate

* These themes will be refined at the planning workshop in Oct 2015
NEW Collaborations

- Monsoons Panel with WCRP
- Climate Dynamics Panel
- Decadal Climate Variability
- Sea Level with PAGES and many others
- Upwelling RF with IMBER
- New GEC Ocean projects network,
  - CLIVAR, SOLAS, IMBER, OceanCarbon, PAGES, SCOR, WCRP, GOOS, Future Earth
- ECS network
- Strong links to national programs, e.g. USCLIVAR
US CLIVAR Research Challenges: Broad areas of climate science that are societally important, reflect the interests of the scientific community and funding agencies, concern most of the CLIVAR Panels, and typically extend US CLIVAR beyond its traditional research agenda.

US CLIVAR Research Challenges

• Decadal variability and predictability
• Climate and extreme events extremes
• Polar climate changes
• Climate and carbon/biogeochemistry

International CLIVAR Research Foci

Decadal variability and predictability
Understand & predict wx & climate
Regional sea-level change and Arctic
(Biophysical interactions & dynamics of upwelling systems)

Can we think of joint efforts, such as AGU or OSM sessions? Town hall meetings? Joint workshops? Joint experiments? Will highlight CLIVAR better.
CLIVAR Open Science Conference

15-23 September 2016
## Co-Chairs

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## Members

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<td>Krishna Achuta Rao</td>
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<td>Ken Drinkwater</td>
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<td>Virginie Guemas</td>
<td>Institut Català de Ciències del Clima</td>
<td>Spain</td>
</tr>
<tr>
<td>Ed Hawkins</td>
<td>University of Reading</td>
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</tr>
<tr>
<td>Dunxin Hu</td>
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<td>InSik Kang</td>
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<td>Arun Kumar</td>
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<td>Carlos Moffat</td>
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<td>Pedro Monteiro</td>
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<td>Bill Merryfield</td>
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<tr>
<td>James Renwick</td>
<td>Victoria University of Wellington</td>
<td>New Zealand</td>
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<td>Graeme Stephens</td>
<td>JPL, NASA</td>
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<td>Bjorn Stevens</td>
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<td>Toshio Suga</td>
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<td>Martin Visbeck</td>
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<td>Germany</td>
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<td>Anna Wahlin</td>
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<td>Jiang Zhu</td>
<td>IAP CAS</td>
<td>China</td>
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“The collective voice and expertise of the international climate community is essential to shaping the international research agenda on the coupled ocean-atmosphere system. The World Climate Research Programme’s (WCRP) core project on Climate and Ocean – CLIVAR – invites the international climate community to review the state of the science, to prioritize international research plans and to initiate new collaborations.”
CONFERENCE OBJECTIVES

• Review progress toward improved understanding of the dynamics, the interaction, and the predictability of the coupled ocean-atmosphere system
• Shape ideas to meet emerging ocean and climate science challenges
• Engage with the future generation of climate scientists
• Identify key climate research and stakeholder issues
• Develop and strengthen collaborations across nations, disciplines and age groups and promote integrative studies
CONFERENCE OUTCOMES

• High profile, peer-reviewed journal articles
• Perspective papers on daily themes
• Overview paper in open access journal
• Adjustments to Science Plan
• New activities
• New collaborations
Morning
- Plenaries
- Dedicated Poster Sessions

Afternoon
- 3 Parallel Sessions
- Dedicated Poster Sessions
- Keynote

Evening
- Town Hall sessions
- Reception/Banquet
PROGRAMME OUTLINE

Daily Themes

- The Ocean’s Role in the Climate System
- Climate Variability and Predictability
- Understanding Ocean Processes
- The Changing Ocean in a Warmer World
- Climate Information and Sustainable Development
- Future of Climate and Ocean Science
Parallel Session Themes

- The Ocean’s Role in the Climate System
  - Energy, Carbon, Water

- Climate Variability and Predictability
  - Interseasional to interannual, Decadal, Centennial

- Understanding Ocean Processes
  - Mixing, Dynamics, Upwelling

- The Changing Ocean in a Warmer World
  - Modes, Sea Level, Boundary current systems
Two and half-day event for up to 200 Students and Early Career Scientists; Local host: FIO

Career-enhancing event designed by and for the CLIVAR YESS ECS community

International ECS SOC
Noel Baker (USA, NASA) (Chair)
Sarah Perkins (Australia, U.New South Wales, Australia)
Debashis Nath (India, IAP, China)
Victor Dyke (Nigeria, IAP, China)
Ariane dos Santos (Brazil, CPTEC, Brazil)
Jonathan Durgadoo (Mauritius, GEOMAR, Germany)

Funding – support sought from national, regional and intl. sources; APN proposal submitted;
WCRP CLIVAR 2016 OSC
Early Career Scientist Symposium
A Career-Enhancing Opportunity
designed by and for ECS

Scientific Organizing Committee

- Noel Baker (USA, NOAA, USA)
- Sarah Perkins (Australia, University of New South Wales, Australia)
- Debasish Nath (India, IAP, China)
- Victor Dyke (Nigeria, IAP, China)
- Ariane dos Santos (Brazil, CPTEC, Brazil)
- Jonathan Durgadoo (Mauritius, GEOMAR, Germany)
- Fionna Tummon (SPARC IPO)
- Pascale Braconnot
- James Renwick
- Virginie Guemas
- Ed Hawkins,
- Steve Griffies
- Tianjin Zhou
One-day event for scientists, practitioners and policy makers

Providers and users of climate and ocean information

Discuss requirements and future collaborations

Particular focus on the Asia Pacific Region

Lead by regional institutions such as QNML, WESTPAC, PICES, SOA
WCRP CLIVAR 2016
Open Science Conference
Charting the Course for Climate & Ocean Research

KEY DATES

- September/October 2015 – Second Announcement
- December 2015 – Registration and Abstract submission opens
- March 2016 – Funding and Abstract deadline
- September 15-17, 2016 - Early Career Scientists Symposium
- September 18, 2016 - Regional Stakeholder Forum
- September 19-23, 2016 - Main Conference
Hosting agreement

Local Host: Qingdao National Laboratory for Marine Science and Technology

Local Organizers: ICPO, FIO, with help from OUC, IOCAS, USCLIVAR, WCRP JPS
### CONFERENCE BUDGET

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<tr>
<th>Item</th>
<th>Est cost (1K USD)</th>
<th>Funding source</th>
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<td>APN, WCRP, WESTPAC, etc</td>
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<td>Invited speakers (50x3000)</td>
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<td>National agencies</td>
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<td>Dev country participants (75 x 3000)</td>
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<td><strong>Total</strong></td>
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