CLIVAR: CLIMATE & OCEAN
variability, predictability and change

WCRP Core Project on the
Ocean-Atmosphere System

Detlef Stammer & Annalisa Bracco (SSG co-chairs)

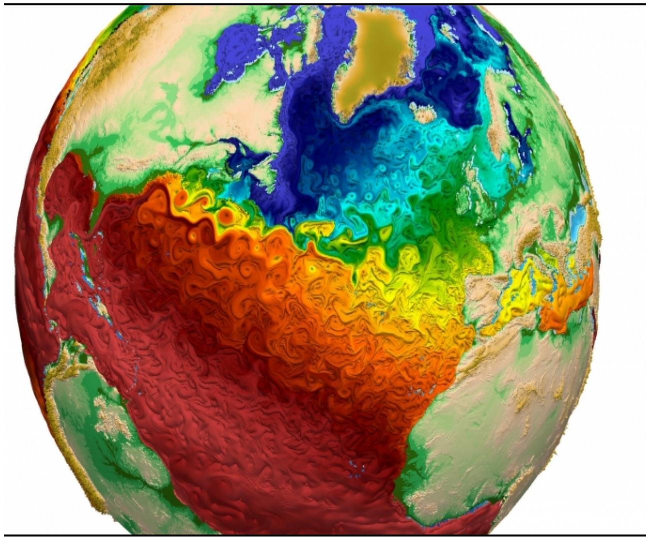
JSC-37 / Geneva / 25-27 April 2016

CLIVAR

WCRP
World Climate Research Programme

CLIVAR: CLIMATE & OCEAN
variability, predictability and change

- Describe and understand the dynamics of the coupled ocean-atmosphere system,
- Identify processes responsible for climate variability, change and predictability,
- Develop - through the collection and analysis of observations - and apply models of the coupled climate system.



Credit: Los Alamos National Laboratory

- **CLIVAR was established 20 years ago** as one of the core-projects of the World Climate Research Programme, building on WOCE and TOGA,
- The CLIVAR legacy includes the
  – **implementation and development of major multinational observing networks** in all the ocean basins;
  – development of **ocean and climate re-analyses**, bridging observations and modeling through data assimilation
  – development of **ocean-climate models, initialized decadal climate predictions building on o&c reanalyses.**

New CLIVAR Science

Long term objectives:

- Identify ocean and coupled **climate processes** that are critical for global and regional climate variability and change
- Identify temporal and spatial scales of **climate predictability**
- Quantify constraints on **climate sensitivity**, air-sea exchange and Earth's energy budget / ocean heat content
- Quantify **regional impacts** of climate change in **sea level, cryosphere and water cycle**
- Quantify past/present/future **ocean role in CO_2 uptake** and links between **climate and ocean ecosystems**

New CLIVAR Science Plan will be released in 2016

Science Plan

TIMELINE

MAY 2016 - Draft posted on CLIVAR website and widely distributed (including WCRP, sister programmes) for comment/input

MAY/JUNE, 2016 - further refinement of Plan

MID/END JULY, 2016 - new draft (ICPO w/ editorial team) prepared and published on CLIVAR website and advertised on CLIVAR OSC website

SEPTEMBER 2016- OSC - town hall for community input, comment

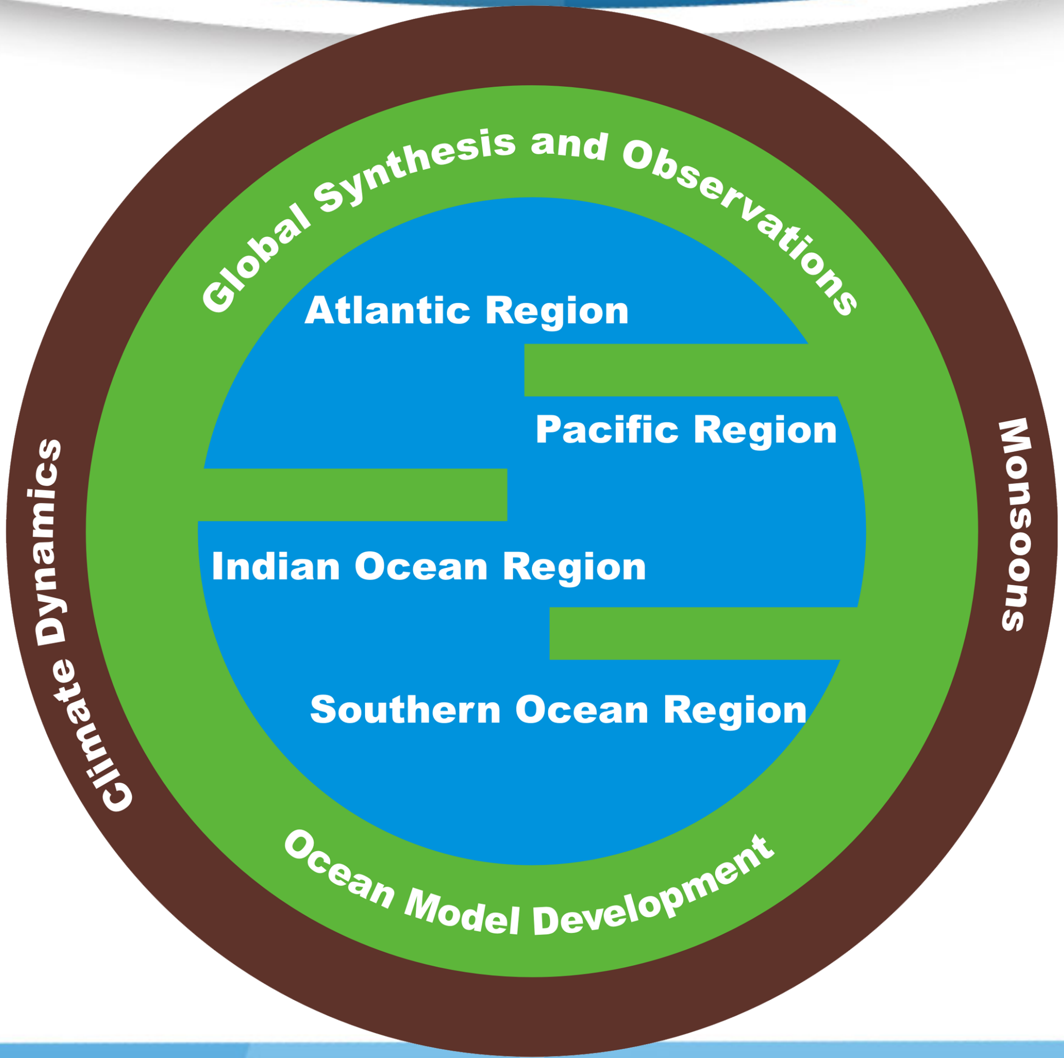
OCT/NOV- revisions to Plan based on OSC, produce camera-ready copy

DECEMBER 2016 - "final" Plan published

How CLIVAR works

CLIVAR Panels

CLIVAR Panels



WCRP
World Climate Research Programme
CLIVAR

Research Foci

Research Foci (RF): launched in 2015; focused limited-lifetime initiatives (5 years or less); topics of high priority in the climate research community that would benefit from enhanced international coordination.

- Decadal Climate Variability & Predictability
- Planetary Heat Balance & Ocean Heat Storage (with GEWEX participation)
- ENSO in a Changing Climate
- Eastern Boundary Upwelling Systems
- Regional Sea Level Change & Coastal Impacts (with CliC participation)

CLIVAR Enabling Capabilities

International cooperation is critical to grow the infrastructure that underpins all CLIVAR science:

- Climate and Ocean Process and Sustained Observations
- Global, Regionally Enhanced and Process Models
- Ocean Data, Synthesis and Assessment
- Capacity Development and Knowledge Exchange

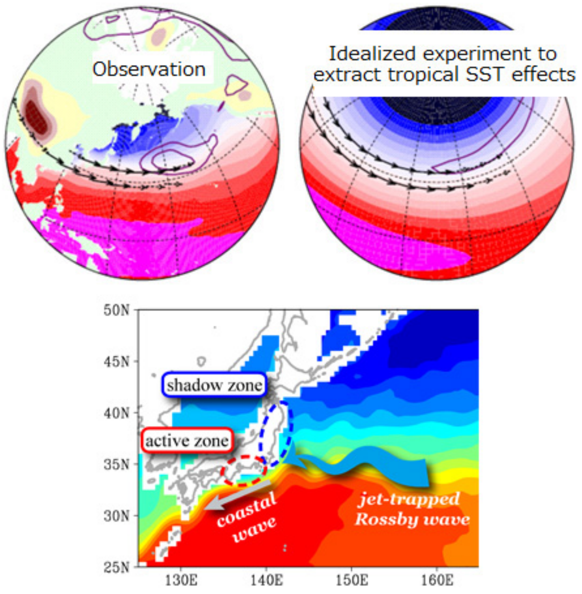
Scientific progress

Organized around WCRP objectives

- Climate processes
- Climate predictability
- Climate sensitivity
- Regional impacts
- Ocean CO_2 uptake

CLIMATE PROCESSES

- Climate feedbacks and modes of coupled variability
- Model representation of climate modes
- The ocean's role in climate variability at different timescales
- Ocean energetic and mixing



Source: Minobe

World Climate Research Programme

CLIMATE PROCESSES
Climate Dynamics Panel

Key Themes

- Storm tracks, jet streams and weather systems
- Tropical-extratropical interactions
- Coupled atmosphere-ocean feedbacks

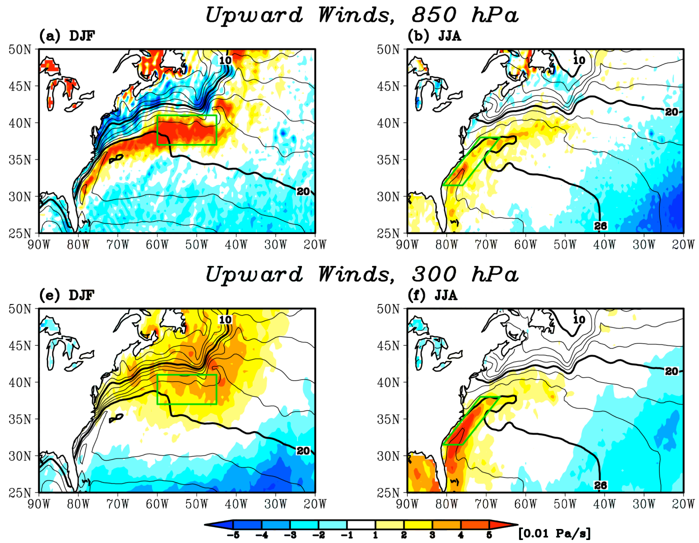
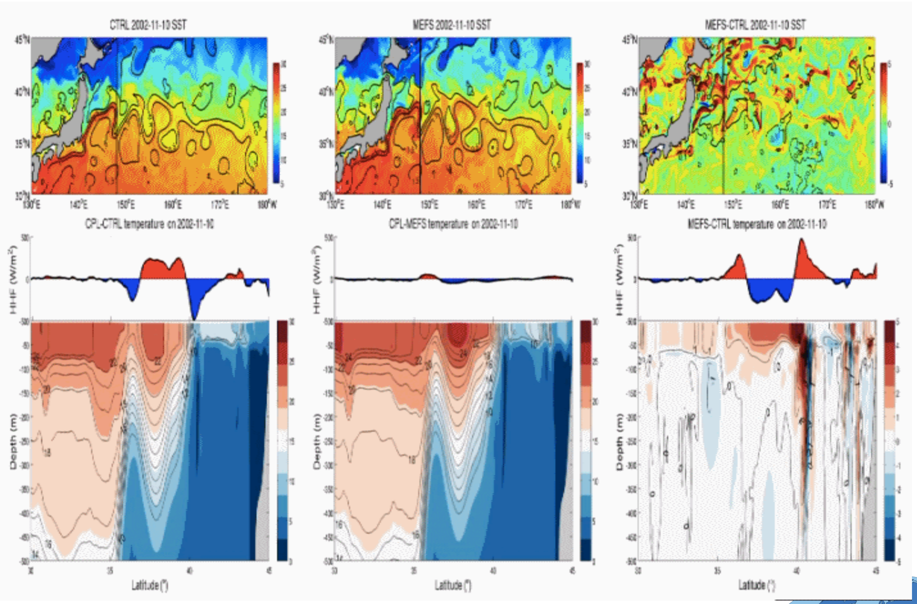


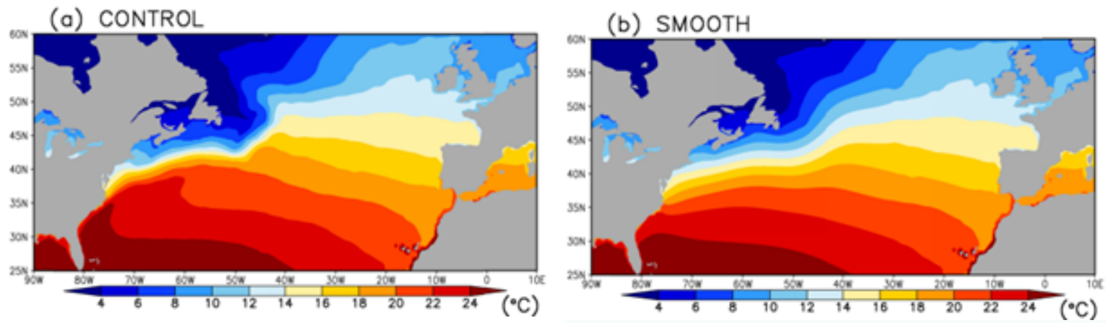
Figure from Minobe et al. (2010) showing vertical velocity response in the Gulf Stream region.



Mesoscale eddy role in air-sea interactions
Ma et al., Scientific Reports, 2015

Impact of sharp SST front on European Blocking

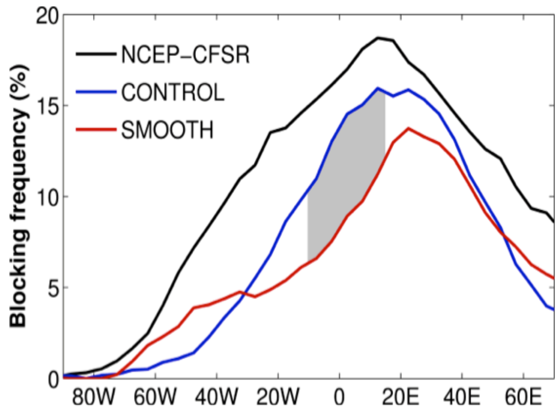
20-year 0.5-degree resolution AGCM experiments.



Smoothing is just over the Gulf Stream region.

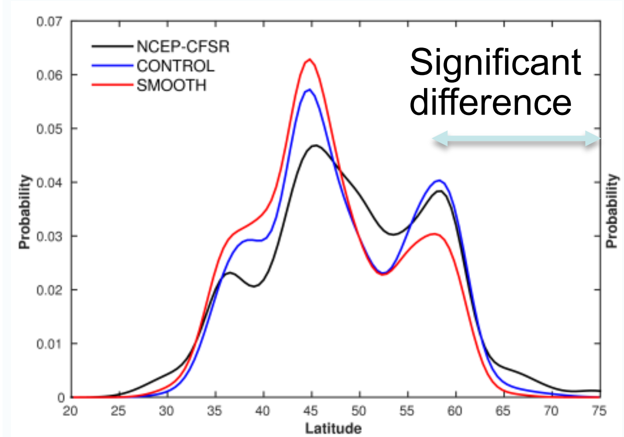
Sharp SST front (CONTROL): more frequent blocking than smoothed SST (SMOOTH)

Frequency of European Blocking



O'Reilly, Minobe & Kuwano-Yoshida (2015 Clim Dyn)

PDFs of eddy-driven jet latitude



O'Reilly, Minobe, Kuwano-Yoshida & Woolings (in prep)

Sharp SST front causes larger probability of northern path of eddy driven jet

- High-res SST is important for high-res AGCM .
- Hires-MIP in CMIP6 is great resource for studies of mid-latitude air-sea interaction.

WCRP World Climate Research Programme

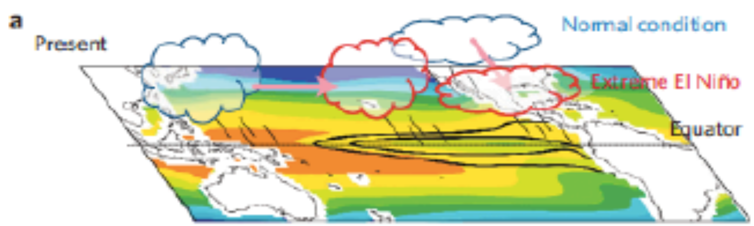
CLIVAR

CLIMATE PROCESSES
RF ENSO in a changing climate

nature climate change
LETTERS
PUBLISHED ONLINE: 19 JANUARY 2014 | DOI: 10.1038/NCLIMATE2100

Increasing frequency of extreme El Niño events due to greenhouse warming

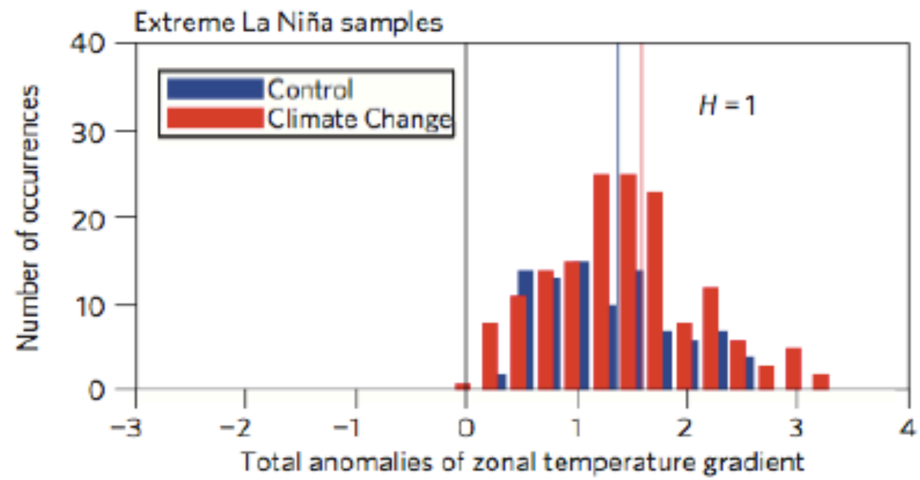
Wenju Cai[1,2]*, Simon Borlace[1], Matthieu Lengaigne[3], Peter van Rensch[1], Mat Collins[4], Gabriel Vecchi[5], Axel Timmermann[6], Agus Santoso[7], Michael J. McPhaden[8], Lixin Wu[2], Matthew H. England[7], Guojian Wang[1,2], Eric Guilyardi[3,9] and Fei-Fei Jin[10]



LETTERS
PUBLISHED ONLINE: 26 JANUARY 2015 | DOI: 10.1038/NCLIMATE2492
nature climate change

Increased frequency of extreme La Niña events under greenhouse warming

Wenju Cai[1,2]*, Guojian Wang[1,2], Agus Santoso[3], Michael J. McPhaden[4], Lixin Wu[2], Fei-Fei Jin[5], Axel Timmermann[6], Mat Collins[7], Gabriel Vecchi[8], Matthieu Lengaigne[9], Matthew H. England[3], Dietmar Dommenget[10], Ken Takahashi[11] and Eric Guilyardi[9,12]

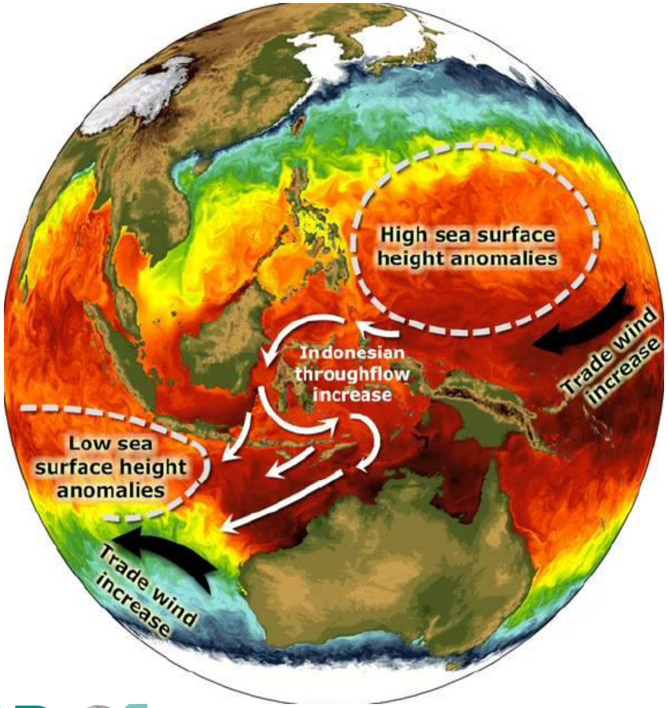


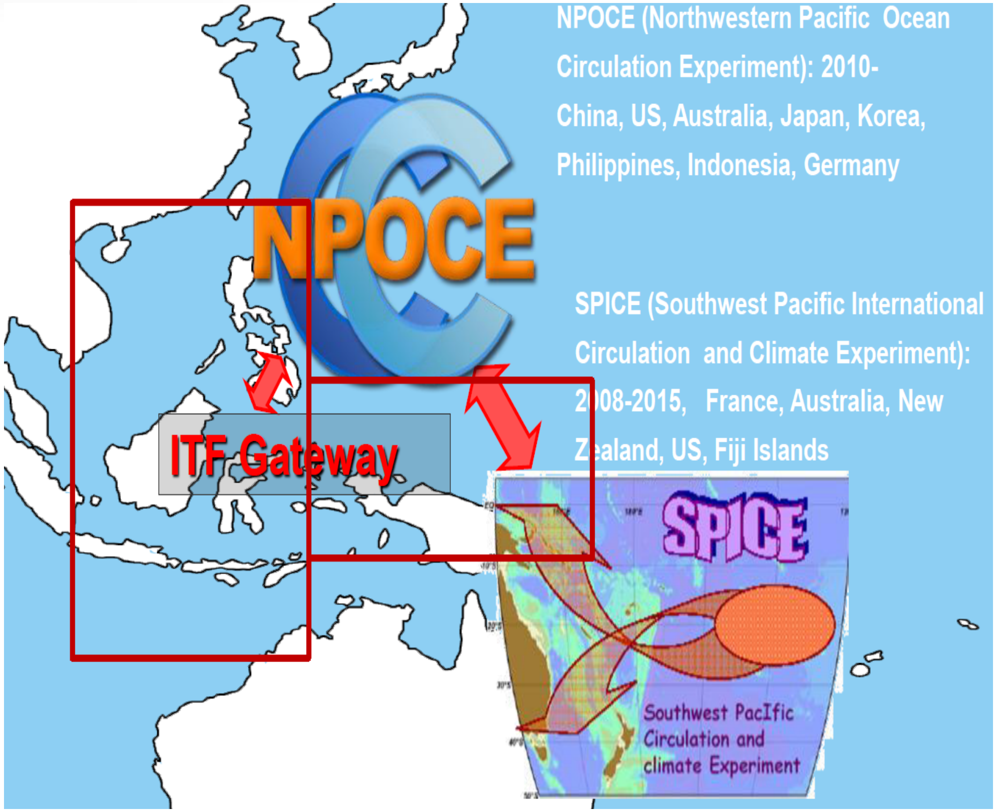
Need for:

- TPOS-type observations
- Continued/enhanced record
- Enhanced obs of Equatorial currents
- Equatorial atmospheric data

CLIMATE PROCESSES
Pacific and IO Region Panels: Plans for new experiment in the Indo-Pacific and Indonesian Throughflow (ITF)

- ✓ Large transports
- ✓ Complex pathways
- ✓ Modulation by ENSO/SPCZ
- ✓ Warm Pool Maintenance
- ✓ WBC

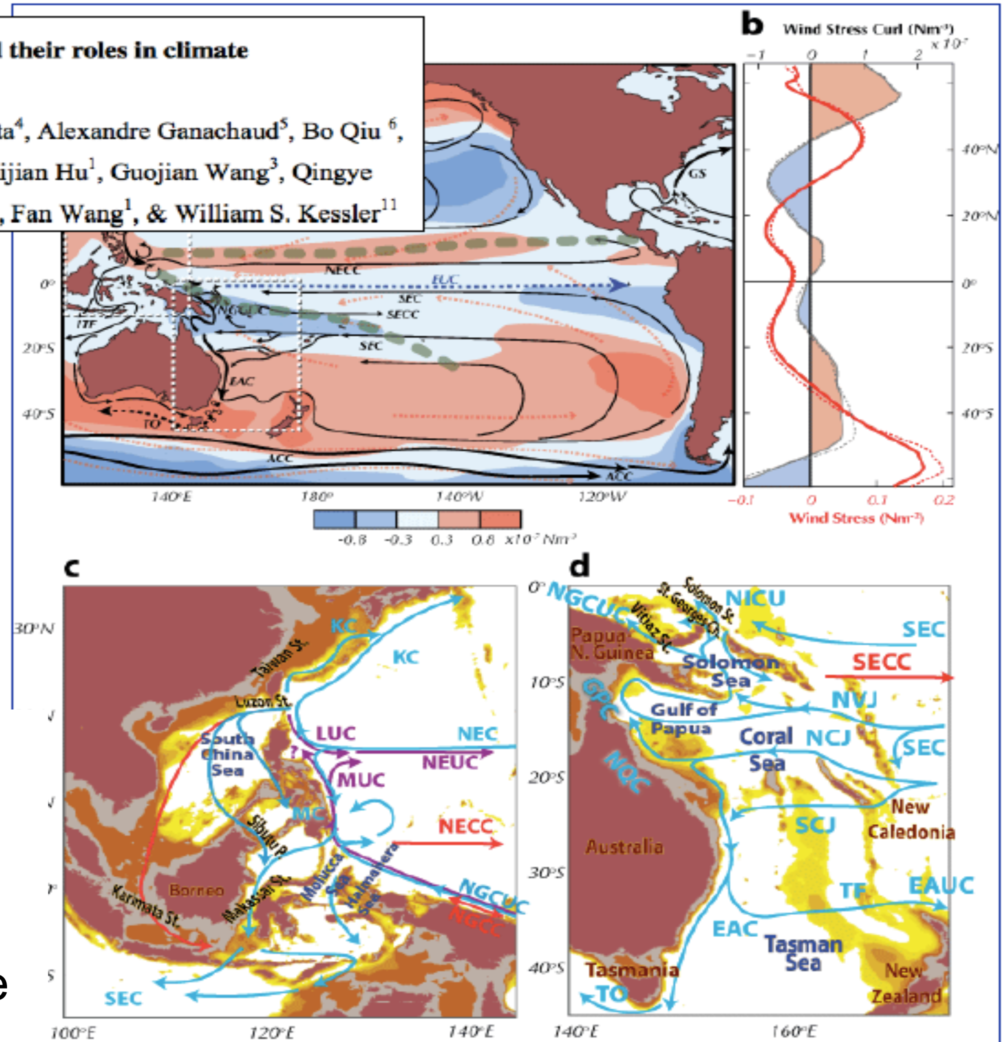




CLIMATE PROCESSES
Western Boundary Currents

Pacific western boundary currents and their roles in climate

Dunxin Hu[1], Lixin Wu[2,*], Wenju Cai[3,2,*], Alex Sen Gupta[4], Alexandre Ganachaud[5], Bo Qiu[6], Arnold L. Gordon[7], Xiaopei Lin[2], Zhaohui Chen[2], Shijian Hu[1], Guojian Wang[3], Qingye Wang[1], Janet Sprintall[8], Tangdong Qu[9], Yuji Kashino[10], Fan Wang[1], & William S. Kessler[11]

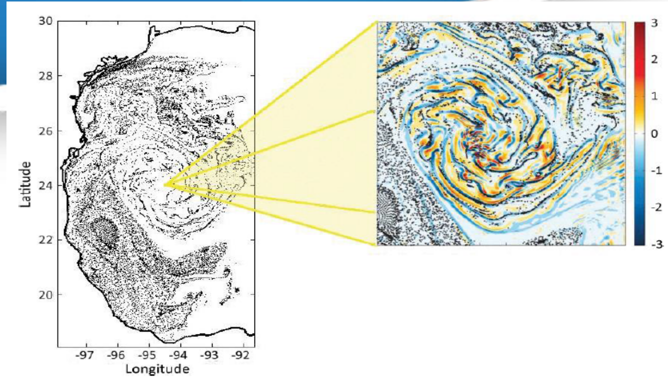


Nature review, 2015
Outcome of SPICE, NPOCE &ITF

CLIVAR Pacific Region Panel working in coordination with TPOS2020 Western Boundary Task Team to determine the observational requirements, strategies and design plan for the region

World Climate Research Programme

CLIMATE PROCESSES
Ocean Model Development Panel



- Ocean energetics, waves, mixing and parameterizations

- Coordinate Ocean-Ice Reference experiments
  - Evaluation, understanding, and improvement of ocean models
  - Investigation of mechanisms for seasonal, interannual, and decadal variability
  - Evaluation of robustness of physical mechanisms across models
  - Complements data assimilation / state estimation
    - bridges observations and modelling
    - ocean initial conditions for climate (decadal) prediction simulations.

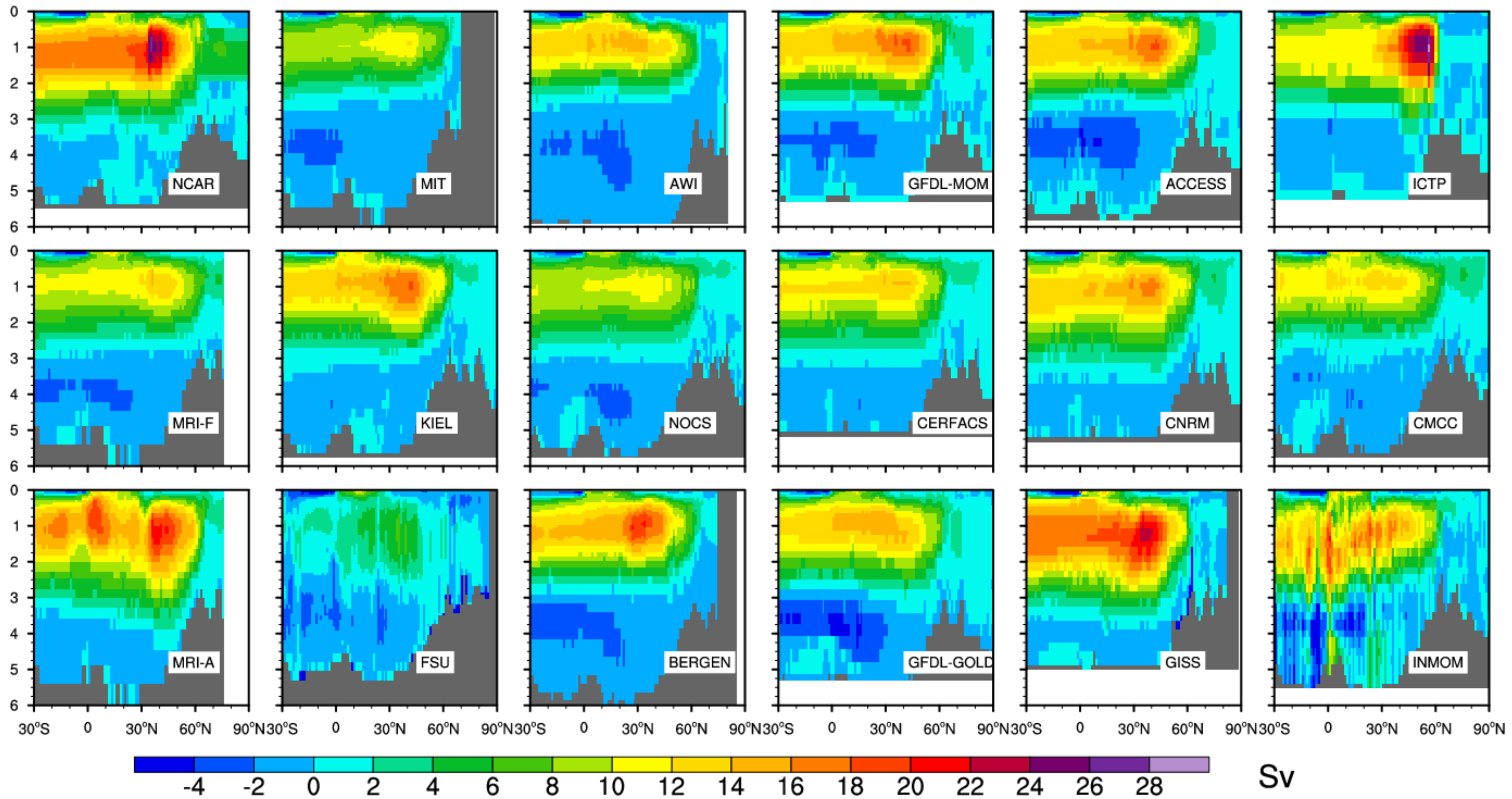
WCRP World Climate Research Programme

CLIVAR

Coordinated Ocean-ice Reference Experiments

CORE phase II (CORE-II) represents an experimental protocol for coupled ocean – sea-ice simulations forced with inter-annually varying prescribed atmospheric data.

CORE is recognized as the community standard for coordination of global ocean – sea-ice simulations.



Danabasoglu et al. (2014, Ocean Modellling)

WCRP World Climate Research Programme

Ocean Reanalysis Intercomparison Project (ORA-IP)
AMOC Intercomparison

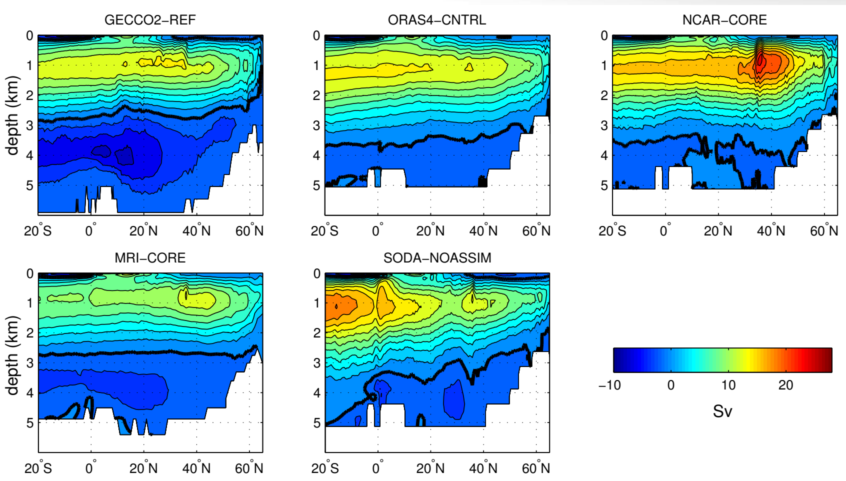


Fig. 2 The time-mean AMOC stream function from 1960-2007 in depth/latitude space for the No Assimilation set of forced ocean model simulations. The NCAR-CORE forced ocean model simulation is included for comparison. Positive (negative) contours indicate clockwise (counter-clockwise) circulations, respectively. Bold line is the zero contour. Contour interval is 2 Sv.

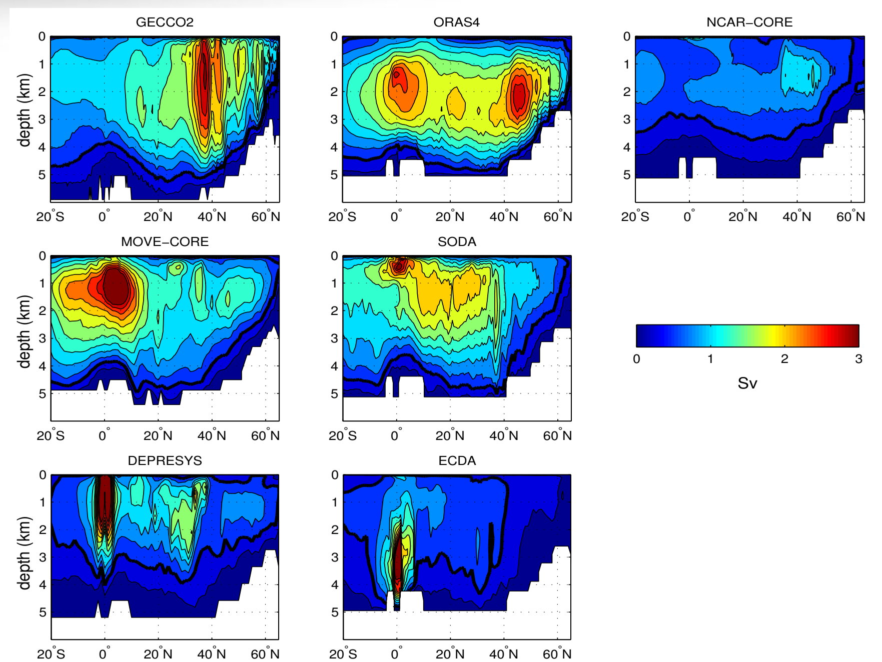


Fig. 4 The standard deviation of the annual-mean, detrended stream function from 1960-2007 in depth/latitud space for the set of ocean reanalysis products. The NCAR-CORE forced ocean model simulation is include for comparison. Bold line corresponds to the 0.5 Sv contour. Contour interval is 0.25 Sv.

Karspeck et al., 2015

World Climate Research Programme

CLIVAR

Ocean Reanalysis Intercomparison Project (ORA-IP)

coordinated effort between CLIVAR/GSOP & GODAE OceanView with interaction with OMDP

Goal:

- To evaluate the consistency among and strength/weakness of different ocean synthesis products
- To explore merit of ensemble ocean synthesis products
- To assess observational impacts

Examples of recent progress/applications:

- Initializations of S-I & decadal forecasts.
- Near realtime monitoring of ocean state (e.g., NOAA's monthly Ocean Briefings).
- Improvement of data assimilation methods & practices.
- Utility of related tools for OSE & OSSE (e.g., TPOS2020)
- Ocean heat content & sea level changes (related to WCRP Grand Challenges)

Overview articles: **Balmaseda et al. 2015, J. Oper. Oceanogr.** + several articles in the same issue; **Fujii et al. 2015, QJRM.**

CORE-II Special Issue of Ocean Modelling

- North Atlantic and Atlantic meridional overturning circulation (AMOC)
  Part I: Mean states (Danabasoglu, Yeager, & Bailey),
  Part II: Interannual to decadal variability (Danabasoglu, Yeager, & Kim),
- Global and regional sea level (Griffies, Yin, Durack, & Goddard),
- Southern Ocean water masses, ventilation, and sea-ice (Downes, Farneti, Griffies, Marsland, & Uotila),
- Antarctic Circumpolar Current and Southern Ocean overturning circulation (Farneti, Downes, Griffies, & Marsland),
- Arctic Ocean and sea-ice (Wang, Ilicak, Gerdes, & Drange),
  Part I: Sea-ice and solid freshwater
  Part II: Liquid freshwater
- Arctic Ocean and sea-ice (Ilicak, Wang, Gerdes, & Drange),
  Part III: Hydrography and fluxes
- Pacific Ocean circulation and its variability (Tseng)

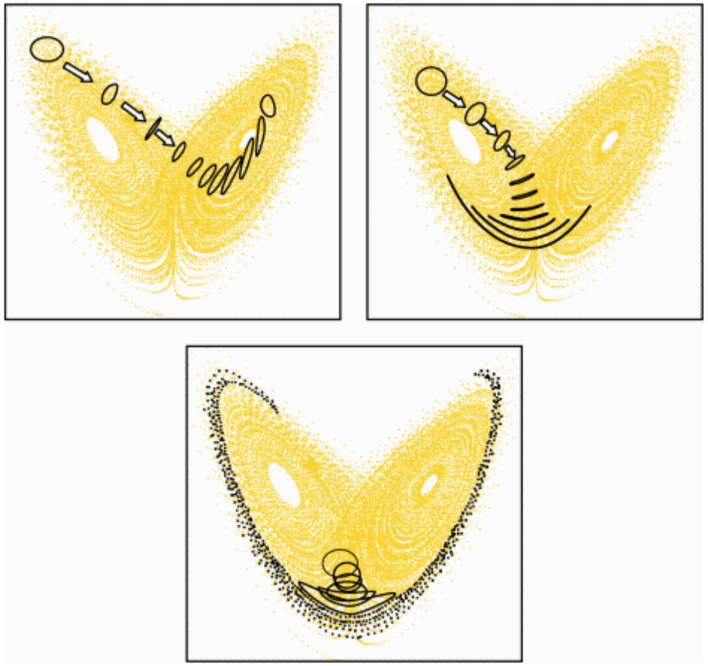
Annual Reviews, 2016

- Changes in Ocean Heat, Carbon Content, and Ventilation: A Review of the First Decade of GO-SHIP Global Repeat Hydrography, L.D. Talley, R.A. Feely, B.M. Sloyan, R. Wanninkhof, M.O. Baringer, J.L. Bullister, C.A. Carlson, S.C. Doney, R.A. Fine, E. Firing, N. Gruber, D.A. Hansell, M. Ishii, G.C. Johnson, K. Katsumata, R.M. Key, M. Kramp, C. Langdon, A.M. Macdonald, J.T. Mathis, E.L. McDonagh, S. Mecking, F.J. Millero, C.W. Mordy, T. Nakano, C.L. Sabine, W.M. Smethie, J.H. Swift, T. Tanhua, A.M. Thurnherr, M.J. Warner, and J.-Z. Zhang

- Ocean Data Assimilation in Support of Climate Applications: Status and Perspectives, D. Stammer, M. Balmaseda, P. Heimbach, A. Köhl, and A. Weaver

CLIMATE PREDICTABILITY

- Intra-seasonal to Interannual Variability, Predictability and Prediction
- Decadal Variability, Predictability and Prediction (multi-decadal variability and detection/attribution of changes)
- Extreme Weather and Climate and Ocean Extremes



Decadal Climate Variability and Predictability DCVP RF

- Two focus areas:
  - **Atlantic Decadal Climate Variability and Predictability**: variations of ocean circulation systems (AMOC, gyres), related SST (AMV/AMO extratropical and tropical) and atmospheric (NAO/AO, blocking) variability; their interactions with land areas and other ocean basins.
  - **Pacific Decadal Climate Variability and Predictability**: decadal tropical SST variability (IPO); links to North Pacific ocean circulation and SST

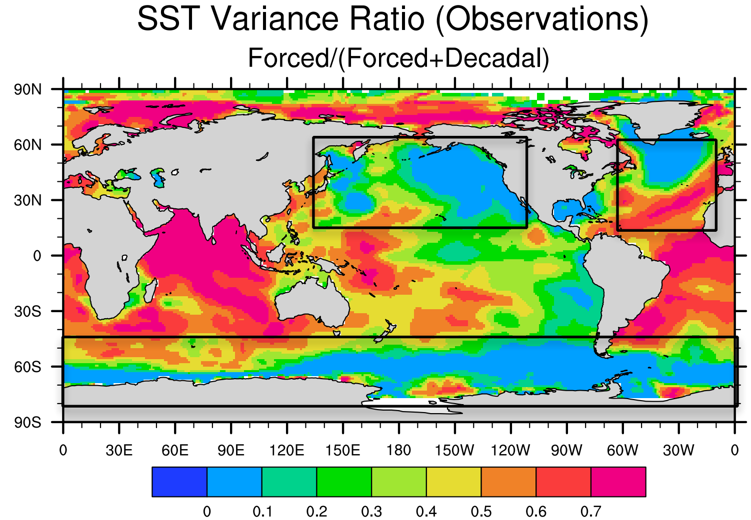
- CLIVAR and WCRP are already engaged in observational, analysis and modeling research on these subjects.
- DCVP RF will draw on these activities but focusing on **process understanding**

WCRP World Climate Research Programme

CLIVAR

"Drivers of Teleconnectivity" – Motivation

Regions where DCV is prominent (top figs) are globally teleconnected (bottom)



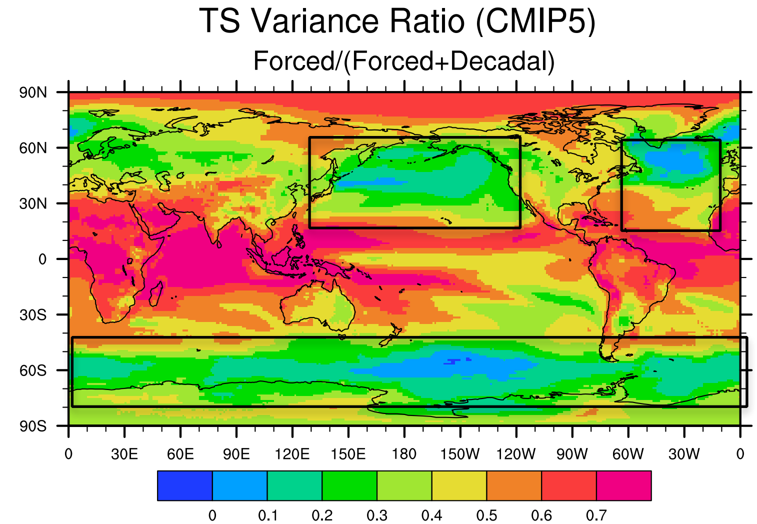


Figure after Ting et al.(2009)

Pacific

Atlantic

Southern Ocean

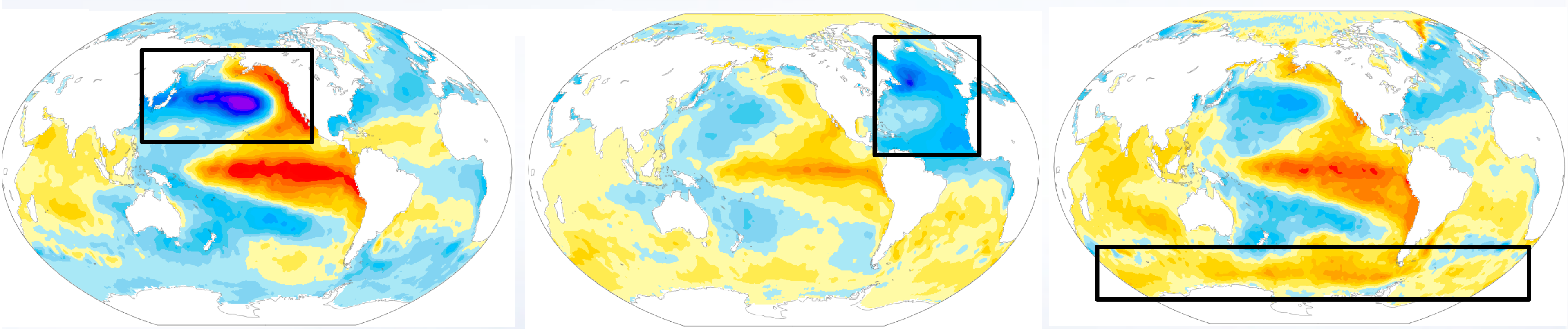
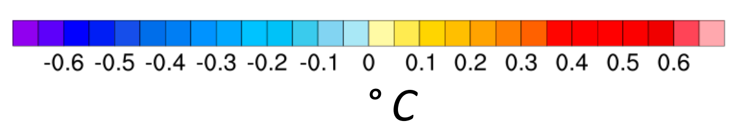


Figure courtesy C. Deser (presented at the CLIVAR-ICTP Interna0onal Workshop on Decadal Climate Variability and Predictability: Challenge and Opportunity Trieste, It aly 16-20 November 2015)

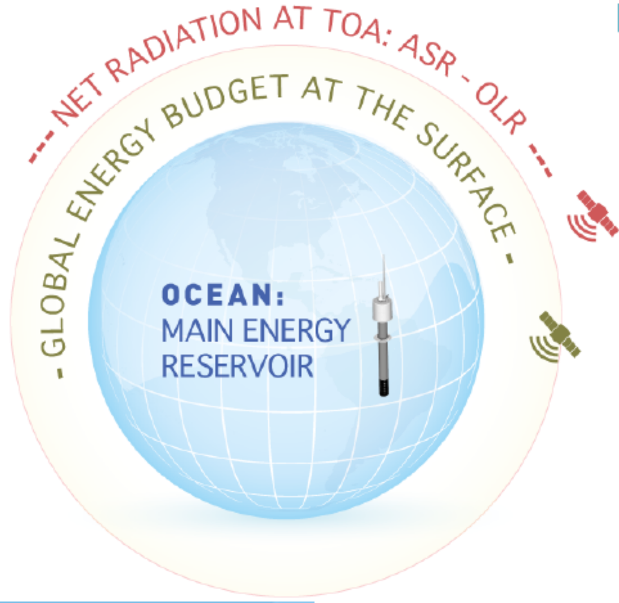


CLIMATE SENSITIVITY
RF CONCEPT-HEAT
Consistency between planetary energy balance and ocean heat storage

- K. von Schuckmann, K. Trenberth; joint with GEWEX

- **Bringing together different climate research communities** concerned with the energy flows in the Earth's System to advance on the **understanding of the uncertainties through budget constraints**:

➢ **Atmospheric radiation**
➢ **Ocean Heat Content**
➢ **Earth's surface fluxes (when, where, how much)**
➢ **Climate variability and change**
➢ **Data assimilation & operational services**
➢ **Climate projection**
➢ **Sea level**

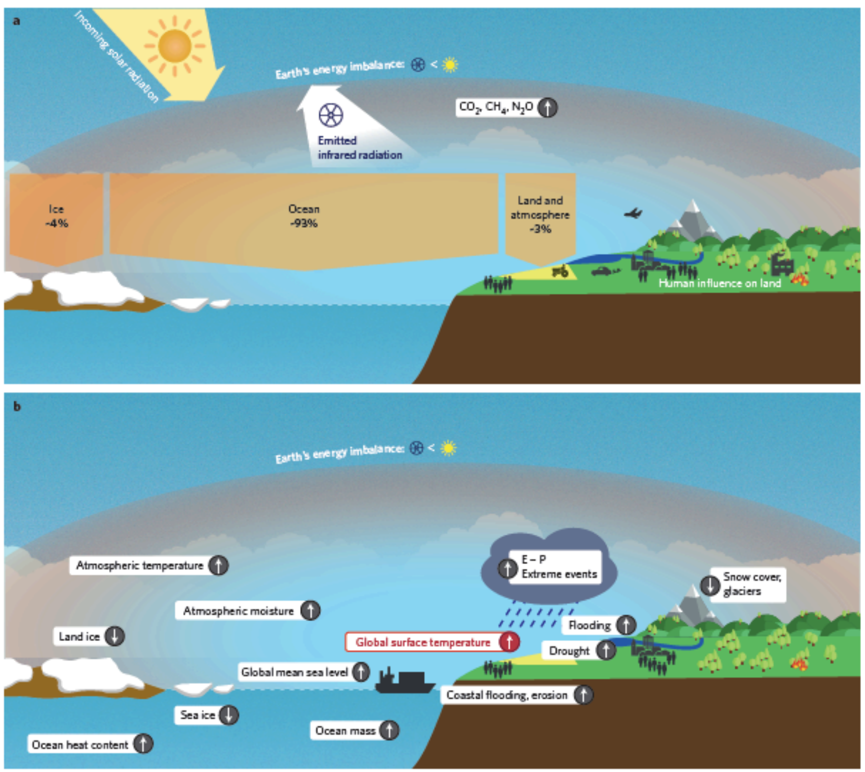


WCRP World Climate Research Programme

PERSPECTIVE
PUBLISHED ONLINE: 27 JANUARY 2016 | DOI: 10.1038/NCLIMATE2876
nature climate change

An imperative to monitor Earth's energy imbalance

K. von Schuckmann[1,2*], M.D. Palmer[3], K.E. Trenberth[4], A. Cazenave[5,6], D. Chambers[7], N. Champollion[6], J. Hansen[8], S.A. Josey[9], N. Loeb[10], P.-P. Mathieu[11], B. Meyssignac[5] and M. Wild[12]



Earth's Energy Imbalance Currently +0.5 to 1 Wm^{-2}

Schematic representations of the flow and storage of energy in the Earth's climate system and related consequences. a, EEI as a result of human activities. The global ocean is the major heat reservoir, with about 90% of EEI stored there. The rest goes into warming the land and atmosphere, as well as melting ice (as indicated). b, 'Symptoms' of positive EEI, including rises in Earth's surface temperature, ocean heat content, ocean mass, global mean sea level, atmospheric temperature and moisture, drought, flooding and erosion, increased extreme events, and evaporation − precipitation (E−P), as well as a decrease in land and sea ice, snow cover and glaciers.

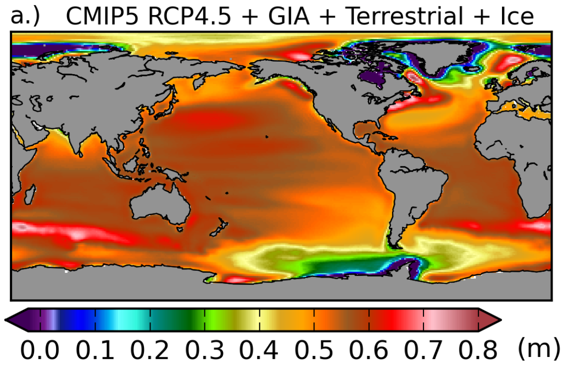
World Climate Research Programme

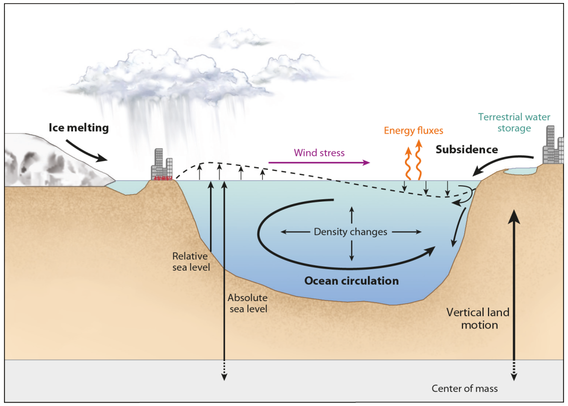
REGIONAL IMPACTS
GC Regional Sea Level Change and Coastal Impacts

Five parallel, but interconnected, working groups:

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**

International Conference on Sea Level Change: New York University, July. 10 – 15, 2017

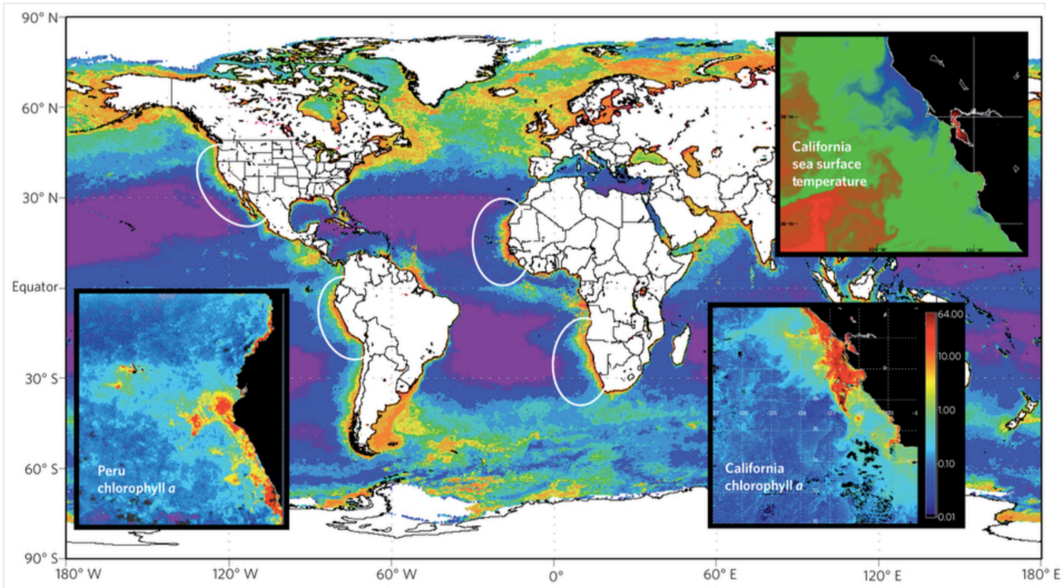




World Climate Research Programme

REGIONAL IMPACTS / CO_2 UPTAKE
RF on Eastern Boundary Upwelling Systems

- Identifying key **physical processes, similarities and differences** between EBUS
- Improving **model representation** of EBUS.
- **Examining biogeochemical interactions** and role in carbon and nutrient cycling
- **Understanding future variability**



In collaboration with IMBER and SOLAS

WCRP World Climate Research Programme

CLIVAR

REGIONAL IMPACTS / CO_2 UPTAKE EBUS RF

Challenge

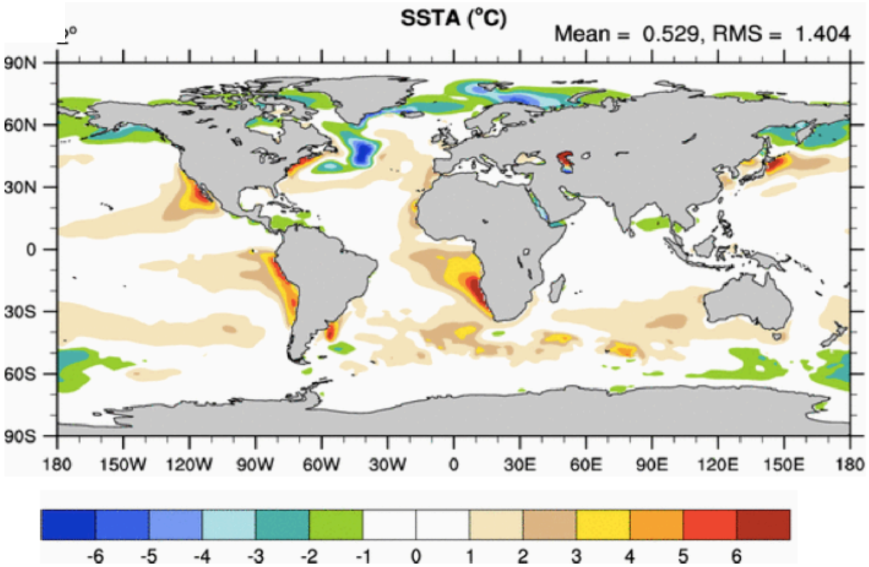


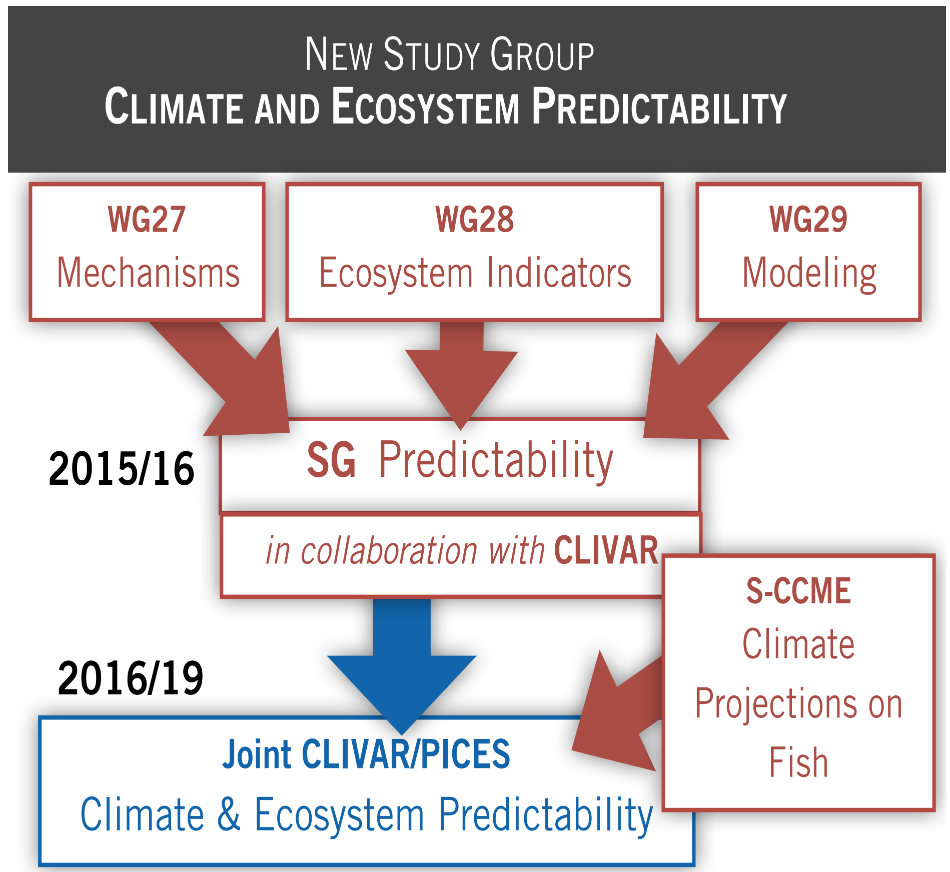
Figure 1: Sea surface temperature anomalies between an NCAR-CESM simulation and WOA data.

Proposed activities

- Analysis of downscaled climate models and reanalysis products
- Design of upwelling metrics
- Synthesis of existing physical and biogeochemical data
- Design of process-oriented numerical experiments for sensitivity study
- Exploration of EBUS water sources and their climate-scale variability
- Identification of nutrient and carbon sources in EBUS

Climate and Ecosystem Predictability in the North Pacific
PICES Study Group in collaboration with CLIVAR

Study Group on *Climate and Ecosystem Predictability* (SG-CEP)♪



PICES

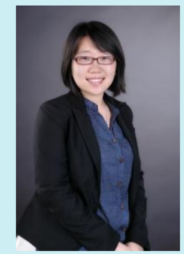
CLIVAR 20 Years of Progress

WCRP World Climate Research Programme

CLIVAR

ICPO – Who are we?

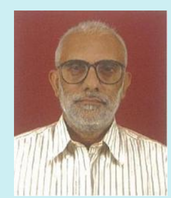
ICPO Executive Director
ICGPO Director
Valery Detemmerman



Scientists: Dr Lei Han and Jing Li

Assistant: Lina Kang

ICPO Deputy Director
Dr. Nico Caltabiano



ICMPO Director
Dr. Rokkam R. Rao

Dr. Ramesh Kripalani
Senior Scientist

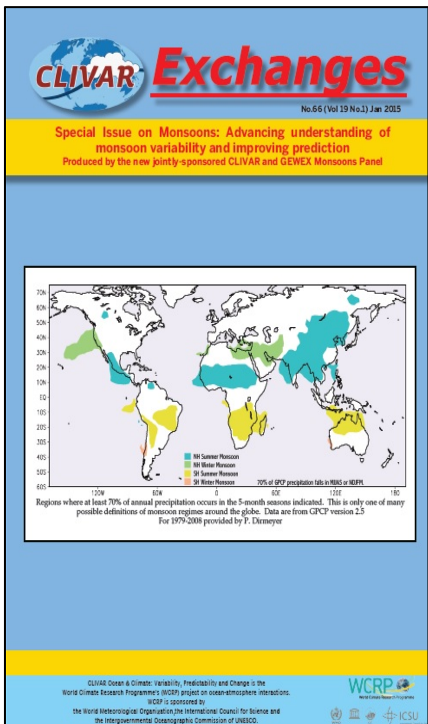
Harish Borse
D.T.P. Operator

Publications

CLIVAR Exchanges issues in 2015

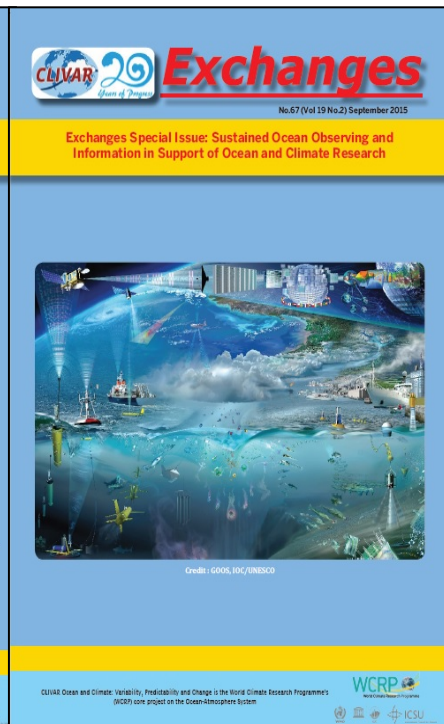
CLIVAR Exchanges issue No. 66

Monsoons



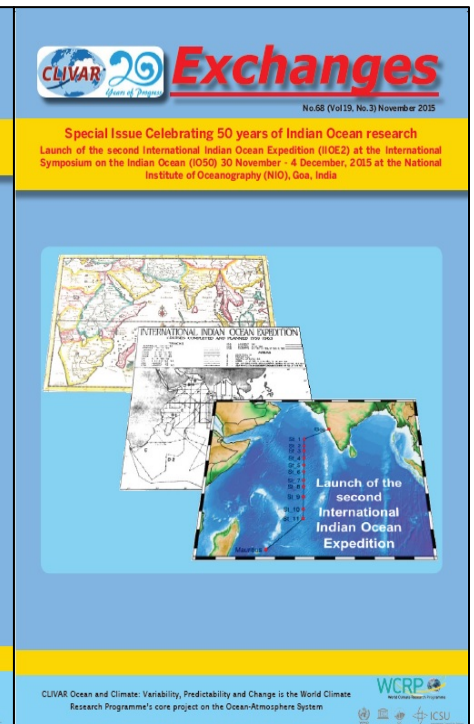
CLIVAR Exchanges issue No. 67

Ocean Observations



CLIVAR Exchanges issue No. 68

Indian Ocean



CLIVAR Exchanges issue No. 69

Kuroshio Current System

CLIVAR Exchanges issue No. 70

DCVP

Dissemination

- ✓ Town halls: AGU Fall Meeting, Ocean sciences
- ✓ Session at major conferences
- ✓ Themed workshops (DCVP; Kuroshio, CLIVAR/ WESTPAC)
- ✓ Training Schools
- ✓ Exchanges

WCRP World Climate Research Programme

CLIVAR

CLIVAR Open Science Conference

"Charting the course for climate and ocean research"

18-25 September 2016, Qingdao, China

http://www.clivar2016.org/

...

Programme Overview

Charting the course for climate & ocean research
CLIVAR
Open Science Conference
Qingdao, 2016

September 2016

17^{th} -18^{th}, 24^{th} : **CLIVAR Panel Meetings**

18^{th}, 24^{th}-25^{th} : **Early Career Scientists Symposium**

19^{th}-23^{rd} : **Open Science Conference**

$23^{rd, PM}$ -24^{th} : **CLIVAR SSG Meeting**

750 scientists from 66 countries submitted 936 abstracts

280 ECS applied for a place in the ECS Symposium

Sep 19th – OSC

(in the Qingdao National Laboratory for Marine Science and Technology (QNLM))

	CLIVAR 2016 Main Open Science Conference	
	Monday , Sep 19th	
AM	**7:30** Registration & **9:00** Transport to QNLM	Shuttle bus from hotel to QNLM
	10:00 **Opening Session**	Speech from Mayor of Qingdao,
	11:00 **Photo and Coffee/tea break**	provided by QNLM
	11:30 **Keynote 1**	**Speaker**: *Thomas Stocker*
	12:15 Lunch	in QNLM cafeteria
PM	**14:00** **Plenary Session 1**-Ocean Role in Climate	**Speakers and topics**: Monika Rhein: Energy Laurent Bopp: Carbon Ray Schmitt: Water
	15:30 Coffee/tea	provided by QNLM
	16:00 **Parallel 1.1- Energy**	*Chairs: Karina von Schuckman, Matthew Palmer*
	16:00 **Parallel 1.2 - Carbon**	*Chairs: Pedro Monteiro, Curtis Deutsch*
	16:00 **Parallel 1.3 - Water**	*Chairs: Paul Durack, Sonia Seneviratne*
	17:30 Transport to hotel	Shuttle bus from QNLM to hotel
Evenin g	**19:00-21:00** **Icebreaker Reception**	in Hyatt

World Climate Research Programme

CLIVAR 2016 Main Open Science Conference (20-23 Sep, 2016)

	DAY 2 Tuesday 20-Sep	DAY 3 Wednesday 21-Sept	DAY 4 Thursday 22-Sept	DAY 5 Friday 23-Sept
	9:00 Plenary Session 2	**9:00 Plenary Session 3**	**9:00 Plenary Session 4**	**9:00 Plenary Session 5**
AM	Climate Variability and Predictability *Harry Hendon: Intraseasonal to Interannual* *Rowan Sutton: Decadal* *Kim Cobb: Centennial to Millennial*	Understanding Ocean and Climate Processes *Raffaele Ferrari: Mixing and Stirring* *Rym Msadek: Ocean and Climate Dynamics* *Weidong Yu: Upwelling and Frontal Zones*	The Ocean in a Warmer World *Clara Deser: Climate Modes* *Anny Cazenave: Sea Level* *Fan Wang: Boundary Currents*	**Climate Information and Sustainable Development** *Chair: Martin Visbeck* *Keynotes: Jane Lubchenco* *Tbc* *Arame Tall*
	10:30 Coffee/tea break	**10:30 Coffee/tea break**	**10:30 Coffee/tea break**	**10:30 Coffee/tea break**
	11:00 **Poster Session 1**	**11:00** **Poster Session 3**	**11:00** **Poster Session 5**	**11:00 Plenary Session 6-** **Future of Climate and Ocean Science** *Chair: Annalisa Bracco* *Keynotes: Valerie Masson- Delmotte, Matt Collins, Nicolas Gruber*
	12:00 Lunch	**12:00 Lunch**	**12:00 Lunch**	**12:30-13:00 Closing Ceremony**
PM	**14:00** **Parallel 2.1 - Intraseasonal to Interannual** *Chairs: Aida Diongue, Rodney G. Martinez*	**14:00** **Parallel 3.1- Mixing& Stirring** *Chairs: Marina Levy, Baylor Fox Kemper*	**14:00** **Parallel 4.1 – Modes** *Chairs: Krishna AchutaRao, Eric Guilyardi*	Marine Network Meeting, Panel meetings *In-Sik Kang, Lynne Talley, Gavin Schmidt,* *Lixin Wu*
	14:00 **Parallel 2.2 – Decadal** *Chairs: Paco Doblas Reyes, Yochanan Kushnir*	**14:00** **Parallel 3.2 - Ocean and Climate Dynamics** *Chairs: Shoshiro Minobe, Matthew England*	**14:00** **Parallel 4.2 - Sea Level** *Chairs: Aimee Slangen, Benoit Meyssignac*	
	14:00 **Parallel 2.3 – Centennial** *Chairs: Pascale Braconnot, Axel Timmermann*	**14:00** **Parallel 3.3 – Upwelling** *Chairs: Enrique Curchitser, Mauricio Mata*	**14:00** **Parallel 4.3 - Boundary Current Systems** *Chairs: Sabrina Speich, Toshio Suga*	
	15:30 Coffee/tea	**15:30 Coffee/tea**	**15:30 Coffee/tea**	
	16:00 Poster Session 2	**16:00 Poster Session 4**	**16:00 Poster Session 6**	**SSG and Panel /RF meetings (Fri, Sat and Sun)**
	17:00-17:40 **Keynote 2** *Magdalena Balmaseda*	**17:00-17:40** **Keynote 3** *Jennifer MacKinnon*	**17:00-17:40** **Keynote 4** *Wenju Cai*	
Evening	**19:30-20:30** **Or 18:00-19:00** **Townhalls 1,2,3**	**19:30-20:30** **Or 18:00-19:00** **Townhalls 1,2,3**	**19:00-21:00** **Banquet**	

WCRP
World Climate Research Programme

Early Career Scientist Symposium (ECSS)

The Early Career Scientists Symposium (ECSS) is a 3-day programme designed by, and for, early career scientists.

A unique opportunity for young scientists to interact and exchange ideas with their peers and senior scientists.

The ECSS will include career development workshops, while building lasting relationships and collaborations with colleagues from different countries.

	CLIVAR2016 Early Career Scientist Symposium	CLIVAR2016 Early Career Scientist Symposium	CLIVAR2016 Early Career Scientist Symposium
	DAY 1	**DAY 2**	**DAY 3**
	Sunday	**Saturday**	**Sunday**
	18-Sep	**24-Sep**	**25-Sep**
	FIO Registration	FIO	FIO
	Opening session	Plenary session: Science Frontiers	YESS and the foundation of ECS organizations in climate science Speaker: Gaby Langendijk
AM	**Introduction to the OSC**		
	Coffee/tea	**Coffee/tea**	**Coffee/tea**
	CLIVAR in the context of Major Climate Programmes Speaker: Martin Visbeck	Working Groups on "Science Frontiers"	Science topics panel discussion
	Lunch	**Lunch**	**Closure**
PM	Introduction to Working groups with short talks by Senior Scientists on OSC Daily themes Speakers: Pedro Monteiro; Pascale Bracconot; Mat England; Eric Guilyard	Working Groups on "Science Frontiers"	
	Coffee/tea	**Coffee/tea**	
	Working Groups / PICO sessions	Working Groups presentations and plenary discussion	
Evening			

WCRP World Climate Research Programme

CLIVAR

Early Career Scientists Symposium

- Hosted by FIO: 18, 23-24 Sept
- Unique opportunity for young scientists to interact and exchange ideas with their peers and senior scientists.
- Designed by and for the CLIVAR ECS community, jointly with YESS

Opportunities at the OSC

- Career development workshops
- Mentoring

Recent and planned CLIVAR capacity development activities

2015:

- CLIVAR- ICTP School on Ocean Climate Modelling: Physical and Biogeochemical Dynamics of Semi- Enclosed Seas" Ankara, Turkey, OMDP, EBUS , Sept 2015
- CLIVAR-ICTP Workshop on Decadal Climate Variability and Predictability, DCVP, ICTP, Nov 2015

Activities planned for 2016:

- CLIVAR-ICTP Advanced School on Earth System Modelling, IITM, Pune, India, July 2016
- ECSS, Qingdao, China, September 2016
- ICGPO summer intern from Kenya, August 2016

Challenges

- New ICPO director (ongoing search)
- Sustained funding for activities and Project Office

Modelling Challenges

- Improved representations of unresolved physics, e.g, mesoscale and submesoscale eddies
- Southern Ocean biases (e.g., heat and carbon uptake)
- Western boundary current separation
- Warm biases off the west coasts of continents (upwelling)
- Ocean physics and BGC interactions, e.g., Oxygen minimum zones

Observational Challenges

- Deep observations (e.g., deep-Argo),
- Continuous observations
- Full depth, basin-wide, AMOC and associated transports, including the Arctic Ocean
- Carefully-derived error estimates for observational data
- Expanded and improved paleo-climate data

New opportunities

IPCC Special Report on Oceans and Cryosphere

The End