Climate and Ocean: Variability, predictability and change

“To improve understanding and prediction of the ocean-atmosphere system and its influence on climate variability and change, to the benefit of society and the environment.”
CLIVAR – the context

Climate and Ocean

The ocean, which covers 70% of the Earth’s surface, dominates the global climate system. The ocean waters have a large heat capacity meaning that they absorb vast quantities of incoming solar radiation and release heat only slowly back to the atmosphere.

Ocean heat capacity, ocean circulation and mixing shape the global heat and water budgets. Thus the ocean has a strong influence on global and regional climate. Changes in the atmospheric forcing of heat and momentum are immediately felt in the ocean. This interaction gives rise to climate predictability on interannual to multidecadal time scales.

The ocean has responded to climate change and taken up about 90% of the extra heat. It is the largest sink of anthropogenic carbon dioxide and host the largest ecosystem on Earth.

Variability, predictability and change

Much remains to be done to realize reliable and accurate climate forecasts on seasonal and longer time scales. Meeting this challenge is a primary motivation for the WCRP CLIVAR "Climate and

Ocean: variability, predictability and change" project.

The impacts of climate variability and the additional challenge of future climate change are important issues for our societies. Climate information is needed to inform development pathways towards more climate resilient societies.

Improved climate information depends on an in-depth understanding of the climate system, with particular emphasis placed on the identification and realization of climate predictability.

Furthermore there is increased demand to attribute climate change to possible causes. We need to understand the processes that determine the interplay of climate variability and change, improve our ability to simulate and monitor those processes, and then develop systems that represent them to make useful climate forecasts.

The World Climate Research Programme (WCRP) and its partners within the Global Framework for Climate Services (GFCS) have joined forces to develop and deliver climate information products to society. The research within CLIVAR will provide the scientific basis for improving climate information, based on modern climate prediction and analysis systems and climate observations.
What is CLIVAR?

CLIVAR is the World Climate Research Programme (WCRP) project that addresses Climate and Ocean variability, predictability and change.

Primary challenges for CLIVAR are to further develop our understanding of the climate system, and to undertake research to improve prediction and monitoring of climate variability and change through the use of improved climate models and observations.

In order to address all aspects of the climate system including land, cryosphere, atmosphere and the role of biogeochemistry and ecology in climate science CLIVAR works closely with the other WCRP projects: GEWEX (Global Energy and Water Exchanges project), SPARC (Stratosphere-troposphere Processes And their Role in Climate project) and CliC (Climate and Cryosphere project). CLIVAR also partners with other international climate and environmental change programmes including those in the Future Earth initiative (IGBP, IHDP and DIVERSITAS).

CLIVAR works closely with the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS) efforts to design and implement sustained observing systems. Its research is directly relevant for the delivery of regional and sectorial climate information by the GFCS.

The role of CLIVAR

CLIVAR provides international coordination of research on the climate and ocean, variability, predictability and change. In doing so CLIVAR acts to encourage and harmonize national and international activities, which contribute to our understanding of climate variability and our ability to provide improved predictions on seasonal, interannual, decadal and longer timescales.

CLIVAR supports scientific capacity building with a particular emphasis on the next generation of researchers, including early career scientists, and the scientific capacity of developing nations.

CLIVAR objectives

CLIVAR seeks, among other things, to:

• Understand the causes of climate variability on intra-seasonal to centennial timescales through observations, analysis, and modeling.
• Improve predictions of climate variability and change associated with both internal and external processes.
• Support the development and implementation of sustained climate and ocean observing systems.
• Improve the atmosphere and ocean components of Earth-System Models.

The achievement of the CLIVAR objectives requires free and open access to observations of the atmosphere and ocean, and the associated datasets and analysis products, paleoclimatic data and reconstructions of past climate, and data from climate models.
CLIVAR - the legacy

CLIVAR builds on the success of the Tropical Ocean Global Atmosphere (TOGA) and World Ocean Circulation Experiment (WOCE) core projects. Following on from these programmes it was suggested that the next step in climate research would require a unified effort, cutting across disciplinary boundaries, which could be implemented by a new, internationally coordinated research programme on climate variability and predictability.

In 1993 the WCRP Joint Scientific Committee (JSC) formally decided to establish CLIVAR as a major new activity. The aim was to establish a sound scientific framework for the continuing study of ocean dynamics and the coupled ocean-atmosphere systems related to climate variability and predictability.

The scientific work undertaken through CLIVAR has been organized around a series of panels and working groups with international scientists guiding work and research of a broad range of nations and institutions. The first CLIVAR Implementation Plan was published in 1997.

CLIVAR has now been operating for almost two decades, continually building on successful scientific endeavors and breakthroughs. CLIVAR science has revolutionized ocean observations, analysis and modelling, and has contributed to advancing our understanding of, and ability to predict, monsoons, ENSO, and other climate phenomena in all regions of the world. Scientific success stories of the CLIVAR legacy include:

• Implementing and supporting major multinational observational networks in all the ocean basins.
• Improved seasonal to inter-annual climate prediction systems.
• Contributed significantly to the scientific foundation of the assessment process of the Intergovernmental Panel on Climate Change (IPCC).
In response to the rapid pace of scientific advances and recognizing the need for the CLIVAR project to be flexible and responsive to new ideas and challenges, the CLIVAR SSG has initiated the concept of "research foci". These are focused research topics identified by members of the CLIVAR community, as being ripe for progress in the next 5-10 years and that would significantly benefit from enhanced international coordination.

Seven such "research foci" have been identified to date and are outlined in the next section of this brochure. Teams of experts are being formed to further develop these ideas, keeping in mind the users of the information and knowledge that will be generated. These teams have been asked by the SSG to develop initial implementation plans that involve specific activities to address focused science questions whose outcomes are likely to be realized in the next 2-5 years.

Details of these plans will be discussed in various science fora and will be posted on the CLIVAR website as they become available.

The core activities of CLIVAR will continue and will be facilitated through the work of core CLIVAR panels, which include:
- Ocean Model Development Panel
- Global Synthesis and Observations Panel
- CLIVAR/GEWEX Monsoons Panel
- Climate Dynamics Panel
- Atlantic Region Panel
- CLIVAR/ CliC/SCAR Southern Ocean Region Panel

- CLIVAR/IOC-GOOS Indian Ocean Region Panel
- Pacific Region Panel
- CCI/CLIVAR/COMM/GEWEX Expert Team on Climate Change Detection Indices

CLIVAR – the future

CLIVAR core capabilities

The work of the CLIVAR panels, and research foci working groups will enhance the overarching capabilities of the project to:

1. Improve the atmosphere and ocean component of Earth System Models.
2. Implement innovative process studies and sustained ocean observations.
3. Facilitate free and open access to climate and ocean data, synthesis and information.
4. Support regional and global networks of climate and ocean scientists.
5. Facilitate knowledge exchange and user feedback.

CLIVAR will continue to find new and innovative ways to involve new communities of scientists and practitioners in its work. Accordingly, CLIVAR has established an Early Career Scientist network as well as an Africa network, to enhance its connections between CLIVAR scientists and developing nations and to build the global climate workforce of the future.
CLIVAR - Research Foci

Tractably achievable scientific priorities over 5-10 year timescales

Understanding and predicting weather and climate extremes
In recent years the damage caused to human and natural systems by extreme events has increased. Extreme events can be wide ranging in nature, from heat waves (see the image to the left of the 2003 European heat wave) and droughts, to flooding and storm surges. Natural climatic variations such as El Niño-Southern Oscillation and the North Atlantic Oscillation affect the frequency and intensity of extreme events at regional level on seasonal to interannual timescales. There is therefore a need to identify the key modes of ocean-atmosphere variability, impacting the magnitude and frequency extreme events, both now and in the future.

Decadal variability and predictability of ocean and climate variability
There is a need to better understand decadal natural variability in the ocean and climate system and to explore the predictability of decadal changes and their interaction with long-term climate change. This is increasingly important, as it is the timescale over which developed societies base significant decisions. Better understanding of decadal variability, such as variations of the Meridional Overturning Circulation (left) and its potential predictability can be achieved though improved understanding of the driving mechanisms, monitoring, observation and modeling studies of ocean-climate system variability.

Sea Level rise and regional impacts
Global sea level rise is forecast to rise by more than 50 cm by 2100, with significant regional variations and with impacts for coastal cities, which currently are home to 40% of the global population. Accurate predictions of regional sea level change on decadal to centennial time scales are required for impact, adaptation and vulnerability assessments, especially for the coastal communities and ecosystems. Observations are key to our understanding of past and present sea-level changes. Models are essential to obtain best projections of change in the future. Understanding these changes in terms of underlying physical and dynamical processes is essential for providing information about regional sea level change.

Consistency between planetary energy balance and ocean heat storage
Improving the accuracy of our estimates of Earth’s climate state and variability is critical for advancing our understanding and prediction of the evolution of our climate. Determining exact values for energy flows in the Earth system is an area of ongoing climate research. There are independent measurement approaches based on remote sensing and in situ measurements and each approach has problems. Reconciling the different approaches remains a challenge. While deriving budgets of the Earth’s Climate, errors in determining the individual components can accumulate and have major impacts on the accuracy of climate indicators, leading to large imbalances in the global energy budget. There is merit in pursuing all methods, because confidence in the result will be increased when they agree or at least the reasons that they differ are understood.
Intraseasonal, seasonal & interannual variability & predictability of monsoon systems

Monsoon systems are a major mode of seasonal climate variability driven by variations in temperature between the land and the ocean, determining the wet and dry seasons for much of the tropics. Ocean atmosphere coupling (e.g. El Niño / La Niña events) and associated variations in sea surface temperature affects the occurrence of monsoons. Monsoonal variability, from complete failure to greater than average rainfall over seasonal and inter-annual timescales, can have profound impacts on food security, water supplies and national economics. Consequently, it is important to accurately simulate and predict monsoon onset, intensity and decay.

CLIVAR welcomes comments, feedback and suggestions on the topics proposed as Research Foci. CLIVAR actively promotes the proposal of topics, which could become new research foci. It is anticipated that proposals for new topics will be regularly reviewed by the CLIVAR SSG and existing panels, thereby increasing the access to the CLIVAR community to a wider audience.

For more information see www.clivar.org/about/research-foci
CLIVAR governance

CLIVAR is one of four core projects of the World Climate Research Programme (WCRP), which is sponsored by the Intergovernmental Oceanographic Commission of UNESCO (IOC), the International Council for Science (ICSU) and the World Meteorological Organization (WMO).

International CLIVAR is a network of scientists and activities around the world that contribute to meeting the CLIVAR objectives. A subset of these scientists are members, on a rotating basis, of committees that facilitate coordination and cooperation amongst national and multinational efforts. The CLIVAR Scientific Steering Group (SSG) is appointed by the WCRP Joint Scientific Committee. The SSG provides overall guidance for CLIVAR activities, in concert with the goals of the WCRP, and establishes CLIVAR Panels and Working Groups and their terms of reference to ensure that the key objectives of the programme are met.

CLIVAR Panels and Working Groups meet regularly to review scientific progress, address research priorities, coordinate activities, develop best practices, guidelines and recommendations for the community as a whole and promote scientific capacity development. An open call for nominations to the various CLIVAR committees is announced annually via the CLIVAR newsletter. When considering nominations, the SSG aims for geographic and gender balance, as well as providing opportunities for early career scientists and researchers from developing countries to participate.

The International CLIVAR Project Office (ICPO) provides secretariat support to the SSG and the various panels and groups and is responsible for the project’s outreach activities. It also serves as the point of contact for the CLIVAR scientific community as a whole, and for other relevant activities.