



Climate Variability
and Predictability

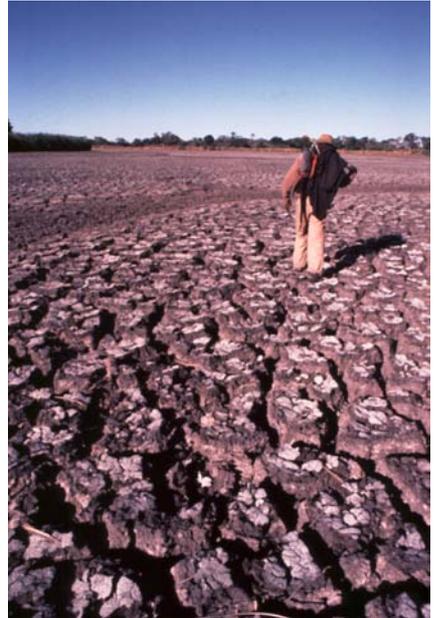
CLIVAR



THE CONTEXT OF CLIVAR

The impacts of climate variability and the threat of future climate change are issues that are brought to our attention in one form or another almost daily. News items, articles and TV and radio programmes on these topics have been appearing in the media with increasing frequency over the past decade or more. As a result, some of the key aspects of climate variability such as El Niño and the North Atlantic Oscillation are becoming household words. People want to know

We hear a lot about rising global temperatures, but what we really want to know is how this might affect our daily lives. Some places might get colder, others much warmer. Rainfall could be more frequent, or associated with increased storminess, with resultant floods. Heat waves could become regular events, bringing drought. Snow might disappear from the ski slopes and low lying communities could disappear into the sea. A first step in knowing what will happen and how to



scientific basis for making climate forecasts based on modern techniques and global observations. However, much remains to be done to realize reliable and accurate climate forecasts on seasonal and longer time scales. Meeting this challenge is the primary motivation for the Climate Variability and Predictability project, CLIVAR.

CLIVAR seeks to improve the climate information available to the public, to industry, to governments and especially to the policy and decision makers who must judge how best to manage this planet we call home.



not just what the weather will be like on the weekend, but what will happen next season, next year, in ten years. Farmers want to know when and what to plant; dam operators, how much water to store; electric companies, how much power to generate; health workers, the likelihood of epidemics. In order to answer these questions we need to determine how much of climate variability is predictable and then develop systems that can make reliable forecasts.

react will be to understand how much of the observed climate changes can be attributed to natural variability and which are due to human activities.

In the past, people observed nature and consulted the farmer's almanac to get information about future climate, with little reliability. Now, due to the efforts of the World Climate Research Programme, and most notably the results of the WCRP Tropical Ocean Global Atmosphere Project (TOGA), we now have the



WHAT IS CLIVAR?

CLIVAR is the World Climate Research Programme (WCRP) project that addresses Climate Variability and Predictability, with a particular focus on the role of ocean-atmosphere interactions in climate. It works closely with its companion WCRP projects on issues such as the role of the land surface, snow and ice and the role of stratospheric processes in climate.

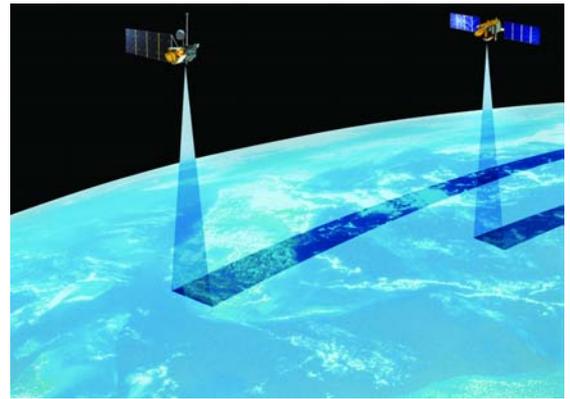
The challenges for CLIVAR are to develop our understanding of climate variability, to apply this to provide useful prediction of climate variability and change through the use of improved climate models, and to monitor and detect changes in our climate system.

As CLIVAR science advances, it becomes increasingly important and possible to address all aspects of the climate system, including the role of biogeochemical cycles, and to build the application of CLIVAR science to societal applications and impacts. To enable the necessary scientific interactions, CLIVAR looks to part-

nership with other international programmes, especially the International Biosphere-Geosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the International Programme of Biodiversity Science (DIVERSITAS).

THE ROLE OF CLIVAR

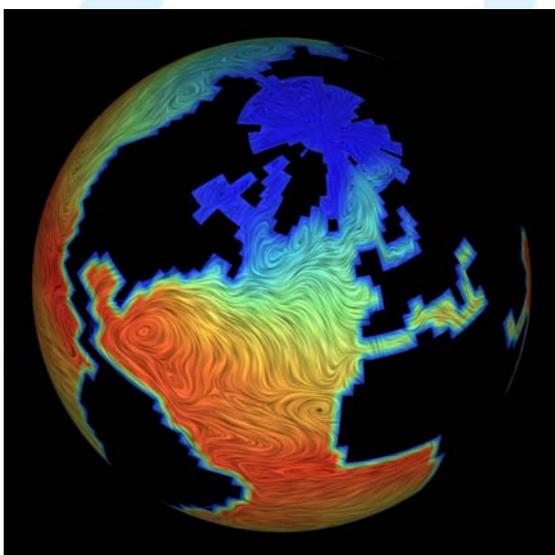
CLIVAR has been established to provide international coordination of research on climate varia-



observations of the climate system, field and modelling studies which help our understanding of climate processes and how they can be represented in models, analytical studies to assist our understanding of climate



Photo Courtesy FAO/I. de Borhegyi



bility and predictability. In doing so CLIVAR acts to encourage and facilitate national and international activities which contribute to our understanding of climate variability and our ability to provide improved predictions on seasonal, interannual, decadal and centennial timescales. It seeks, amongst other things, to encourage the development of systems of sustained

variability and coordinated modelling experiments aimed at improving our abilities for climate prediction. To achieve CLIVAR objectives requires the use of research-related observations of the atmosphere and oceans, operational observations, datasets and analysis products, paleoclimatic data and reconstructions of past climate and climate models run on the world's most powerful computers.

THE NATURAL VARIABILITY OF CLIMATE

Many aspects of our lives are bound up by the regularity of the cycle of the seasons. Crops are planted, water resources are managed and our periods of work and leisure are largely dictated by the seasons of the year.

To some extent we expect regularity in these patterns but for many of the populations of the world, there are also marked consequences in the fact that there is variation in the climate from year

more widely across the globe.

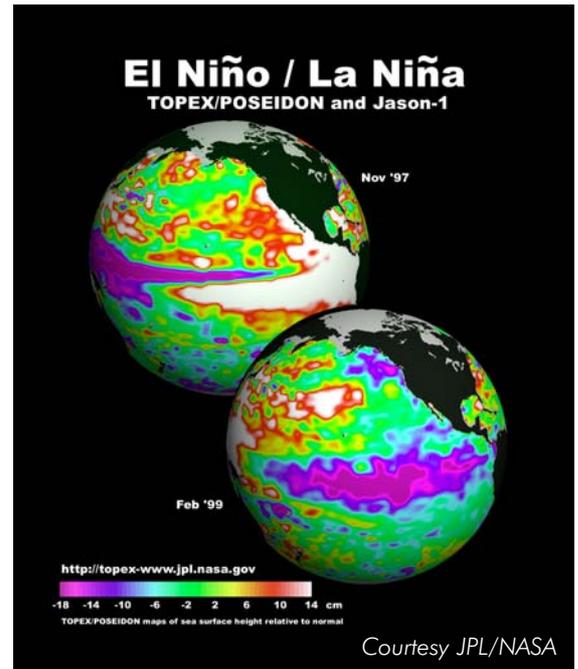
Over half the world's population lives within the influence of the Asian monsoon and a further large fraction live within the monsoon areas of Africa and the Americas. In these areas, the advent of the summer rains is the very basis of life and failure

or extended delay of the monsoon can mean the difference between survival and famine. In some years in regions elsewhere over the globe, crops must be planted in soil that is too dry, winter and spring rains

are excessive sometimes bringing devastating floods (or fail to come at all with promise of summer drought and restrictions on water supplies), or abnormal snow causes cities to grind to a halt.

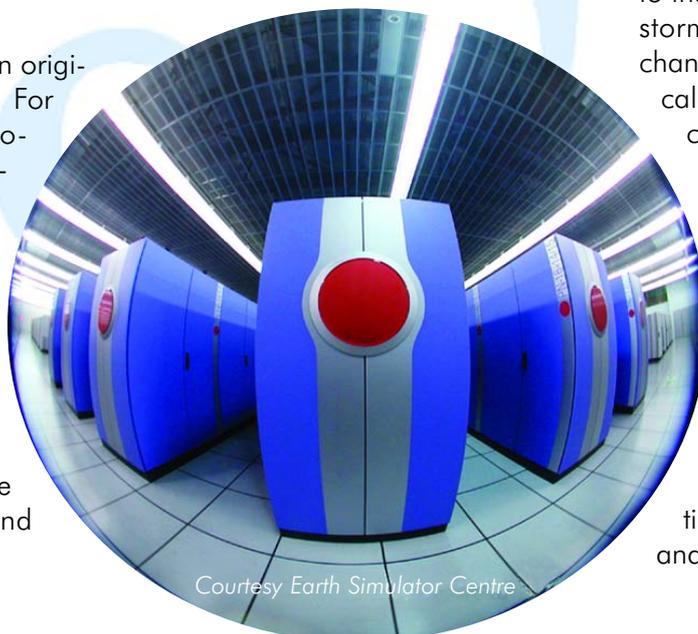
to year and even from one decade to another. Stories of famine and plenty abound in our heritage and demonstrate the dependence of whole populations on the variability that lies in our climate.

Modulation of climate can originate in various ways. For example the El Niño-Southern Oscillation phenomenon brings alternating periods of warmer (El Niño) and cooler (La Niña) sea surface temperatures in the central and eastern Pacific and corresponding changes in the patterns of rainfall and drought both over the Pacific region itself and



Such events all contribute to a heightened awareness that in reality, climate can vary dramatically from year to year and that these variations can have consequences which impact on so many of us, to an extent that affects both our livelihood and sometimes our very lives.

Climate variability is not just restricted to differences from one year to the next. We are now able to detect patterns of change on decadal to centennial timescales. In the North Atlantic, the changes to the patterns and intensity of the storm tracks associated with changes in the strength of the so-called North Atlantic Oscillation can result in periods of severe winter storminess with damage to property and loss of life. The changes in annual rainfall in the African Sahel on decadal and longer timescales and the dust bowl years of the 1930s in the United States are other examples of how longer term variations of climate can affect us and our prosperity. On much



Courtesy Earth Simulator Centre



programmes. A key activity is to seek to extend the range and accuracy of predictions on seasonal to yearly (and, if possible, longer) timescales to provide forecasts, for example, of the future state of ENSO, the monsoons or winter storminess to help planners, policy makers and others to make informed decisions affecting, economic, agricultural, health and other items of societal importance.

longer timescales, the cycles of glacial (ice age) and interglacial periods (such as we are in now) demonstrate the very long-term variability of climate.

A wider-reaching and longer-term threat is the undisputed rise in the concentration of greenhouse gases in our atmosphere. Associated with this are predictions of associated increased temperatures, changes in the patterns of rainfall and changes in other aspects of global and regional climate in the future. Such increases in the concentrations of greenhouse gases are likely to cause

significant changes in the patterns and intensity of the natural variability of climate. The need to reduce the uncertainties associated with such changes underlines the requirement for developing a coherent and rational approach to understanding the climate system, its natural variability and how humankind's activities may change climate.

The key role for CLIVAR is to describe and understand the physical processes responsible for climate variability and prediction on seasonal, interannual, decadal and centennial timescales. It does this through the collection and analysis of observations and the development and application of models of the coupled climate system, in cooperation with other relevant climate research and observing



Courtesy O. Boebel



ANTHROPOGENIC CLIMATE CHANGE

Human activities, through burning of fossil fuels and other activities such as large-scale deforestation are threatening to change the very nature of our climate system. There is widespread concern and clear evidence that anthropogenic emissions of greenhouse gases are resulting in global warming, local climate and environmental changes and sea level rise. Use of fossil fuels for energy generation and transport currently lies at the very foundation of our modern society and can be expected to increase substantially in developing countries. Understanding the effects on future climate and their societal and environmental impacts is of key importance if we are to seek ways to reduce fossil fuel consumption and plan for mitigation of impacts. The need to form national and international policy on matters related to anthropogenic climate change has emphasised the need for a better understanding of, and ability to model, the climate system. It also calls for effective detection and attribution of climate change.

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CLIVAR is working, together with other projects and programmes both within WCRP and more widely, towards the development of improved climate models and datasets to help in prediction, detection and attribution of climate change. The outcomes of these CLIVAR activities form the scientific basis for input to policy-makers through the activities of the Intergovernmental Panel on Climate Change in particular.

Detection of climate change is the process of demonstrating that an observed variation in climate is larger than would be expected to occur by natural internal fluctuations alone. Attribution of change to human activity entails showing that the observed change cannot be explained by natural causes.

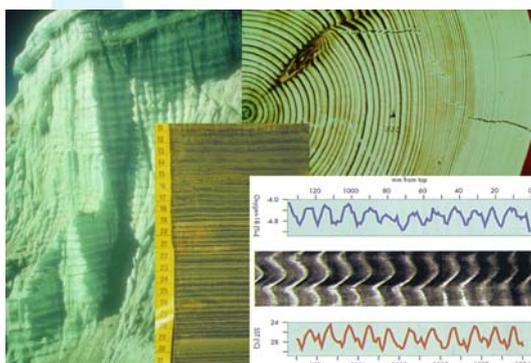
Both require interplay between relevant observations of our climate system and climate models. Systematic and long observational time series characterising climate variability and change are key inputs.



THE TOOLS FOR CLIVAR RESEARCH

Observations and datasets

CLIVAR requires a range of observations of the various components of the climate system. Given the important role of the ocean in the coupled climate system, a major challenge is to develop and implement an ocean observing system to meet climate research needs. CLIVAR is working with operational and research entities to further develop the ocean observing system for climate. CLIVAR also requires observations of the atmosphere, the land surface and biosphere, and snow and ice cover together with analysis products derived from them. Global observations are essential in support of advancing our understanding of atmosphere-ocean-land interactions. In this regard, the global perspective of remotely-sensed observations is particularly valuable. Indices based on in situ observations such as the number of days with frost or length of the growing season also provide measures of climate variability and change.



Some of CLIVAR's data needs are met in partnership through the activities of its companion WCRP projects (GEWEX, CliC and SPARC).



Another challenge is to extend the climate record through data rescue activities and other means. Proxy indicators (tree rings, sediments, ice cores etc.)

are the sole means of documenting climate prior to the instrumental record. CLIVAR cooperates closely with the IGBP Past Global Changes (PAGES) to learn more about past climate and its natural variability.

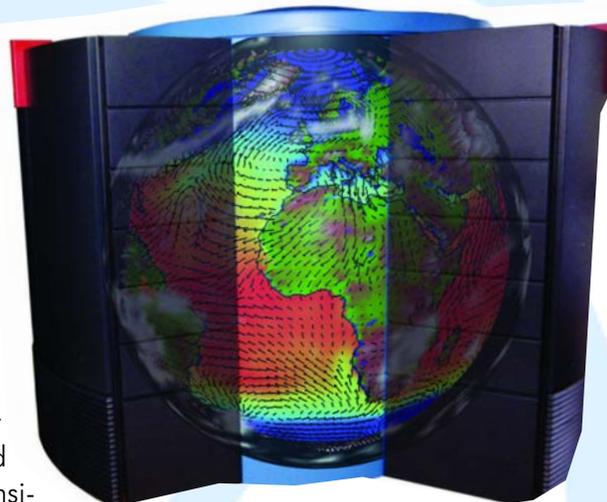
Process studies

Process studies are key to help our understanding of the mechanisms important for climate and how to best represent them in models.

They employ a variety of observing systems from ships, buoys, aircraft and land-based systems to make intensive observations of key atmospheric, oceanic and land surface processes. CLIVAR seeks to actively stimulate and sponsor such studies.

Climate modelling

Climate models are key tools by which future changes can be predicted. They also enable us to explore both the sensitivity of our climate system to changes in the factors affecting it such as greenhouse gas concentrations and the mechanisms for climate variability and change. They take into account the various processes important for the coupled climate system of atmosphere, oceans, land surface and the cryosphere and the interactions between them. In doing so they must also represent key atmosphere, ocean and land surface processes such as the interactions between clouds and radiation, the mechanisms which produce rain, atmospheric and oceanic mixing, transfer of heat and heat and moisture through the soil and freezing of water on sea, land and in the atmosphere. Climate models are now being developed into fuller



Earth System models that take into account the effects of biology and atmospheric and oceanic chemistry of our climate system. This is another area where CLIVAR interacts with IGBP.



How CLIVAR operates

CLIVAR's mission is to observe, simulate and predict changes in the 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 has published planning documents that highlight the science issues and challenges within its remit. They document a consensus of what research activities need to be undertaken and which can benefit most from international coordination. Under the guidance of CLIVAR's Scientific Steering Group, CLIVAR's panels and working groups, made up of experts from a variety of institutes around the globe, are implementing a range of activities including a modelling experiments, coordinated data analysis activities and field projects.

The contributions to CLIVAR are made up of activities funded by national research programmes and those funded through international organisations such as the European Union. Combining these contributions in such a way that they will enable CLIVAR to obtain its objectives is a main task for the science panels and working groups and the International CLIVAR Project Office (ICPO).

Information about CLIVAR, its plans, its organisation, its publications and its research can be found on the CLIVAR web site (<http://www.clivar.org>). Enquiries should be made to the ICPO at icpo@soc.soton.ac.uk

CLIVAR was established in 1995 by the World Climate Research Programme (WCRP) as its major focus for the study of climate variability and predictability on timescales from months to centuries.

WCRP is sponsored by the World Meteorological Organization, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO.

