

Modelling El Niño

Dr Pascale Braconnot leads a consortium testing models to estimate the future impact of climate change on the El Niño event. To do so, the team is gathering insight from a range of datasets for climatic conditions during the Last Glacial Maximum and the Holocene



What is the aim of the ELPASO project? What brought about its inception?

In recent years, the understanding and forecasting of the El Niño Southern Oscillation (ENSO) has greatly improved. Despite this, current knowledge does not allow us to anticipate how it might change in future because each event is unique and climate models provide little consensus as to how climate change may affect this phenomenon.

The consortium emerged from the need to synthesise what we can learn from high resolution paleoclimate records and to combine this with lower frequency records from marine sediment cores, pollen and lake records. From this rich dataset we will develop methodologies to test the accuracy of climate models used for future climate projections.

Are the characteristics of ENSO altering in the face of global climate change?

The instrumental records of El Niño show different types of events. In the 1990s, these were strong and lengthy, while the peak of recent events has recently shifted further westwards into the centre of the Pacific with a concurrent decrease in amplitude.

It is currently unclear whether these changes in ENSO's characteristics are related to global warming. Long simulations representing the modern climate show significant internal variability, suggesting that the observed variability might simply be noise.

The El Niño events have a significant impact on global climate and food security, and there

is thus a need to better understand the link between mean climatic state and the characteristics of these El Niño events.

Can you outline the key objectives of the project?

The ultimate goal is to better understand the link between ENSO variability and mean state and to provide constraints to evaluate simulated change in climate variability. Since we are interested in climate change, we consider periods where the mean state is different from the modern one – the Holocene or the last glacial period – as this permits testing climate models without any man made climate footprint.

How are you collaborating with other researchers in the field? Could you expand on the various specialisations of consortium members?

We have specialists in a range of measurements and a number of modelling techniques, drawn from Edinburgh, Bordeaux, Paris, Aix, Montpellier and Nantes. In addition there is a close connection between ELPASO and the international Paleoclimate Modeling Intercomparison Project.

Why is it important to take a multidisciplinary approach to a project such as ELPASO?

Each specialist has only a partial view of the whole system and it is one of huge complexity. The use of various climate indicators allows the coherency of the different records to be tested at a large scale. This permits greater certainty in the dataset which is used to test and help develop ENSO models.

What have you achieved so far in your attempts to create successful climate models that will accurately simulate more detailed properties of El Niño?

A first important accomplishment was the data synthesis of high resolution proxy records throughout the Holocene. A further important reconstruction was the ocean sea-surface temperature during our two study periods.

The results produced by ELPASO are beginning to clarify how stable the connection between the variability in the South Pacific Convergence zone and overall ENSO variability. This is important because ample paleoclimatic records are available for this area.

Can you highlight the challenges faced in the development of these climate models?

One important challenge is to break down common ideas about ENSO. Future events should not be assumed to replicate the patterns of this century in a changing climate.

Another important challenge is to ensure that we can fully integrate all climatic records. They do not necessarily tell the same story, but complementary ones. It is challenging to draw meaningful constraints that can inform future models.

Finally, what are your ultimate hopes for the impact of ELPASO?

I am hopeful that this project will contribute to the ongoing revival of interest in the El Niño event's importance in climate change and shed light on how best to analyse ENSO. The way the system will behave in the future will not be a simple replication of what happened in the preceding century.



CORAL CORING OPERATIONS IN FIJI © JOEL OREMPULLER (IRD)

El Niño and climate change

El Niño events have a significant impact upon the global climate and food security. The **ELPASO** project is addressing El Niño characteristics in periods when the global climate differed from the present day, offering an opportunity to better anticipate future changes in El Niño events within a context of climate change

THE EL NIÑO SOUTHERN OSCILLATION (ENSO) is a climatic phenomenon whereby the surface temperature of a band of the Pacific Ocean off the coast of South America varies significantly from average temperatures for several months. Warming events are referred to as El Niño and cooling events are known as La Niña.

These occur on a semi-regular basis, lasting between two to five years. When the band is at either extreme, the effect upon climatic phenomena across the Pacific Ocean and surrounding coasts can be significant. These climatic effects can lead to increased or decreased precipitation, increased frequency and severity of hurricanes and tropical storms, and alterations of global weather.

These changes impact upon food security throughout Pacific Rim countries. A sustained El Niño event can result in failure of the American coast fisheries due to an altered ocean circulation, while ENSO-related droughts cause failures of harvests or decreased crop yields in South America, India and Southeast Asia. The climatic changes associated with El Niño have also been associated with coral reef bleaching, incidence of

civil strife and warfare and outbreaks of (insect-borne) epidemic diseases like dengue fever or West Nile encephalitis.

Since ocean surface temperature is at the heart of El Niño, it is strongly believed that changes in the climate, including manmade climate change, will have an effect on the occurrence and magnitude of ENSO. At present, there is no consensus as to the effect of oceanic warming upon ENSO according to future climate model projections.

ELPASO

Within this context of ENSO, the El Niño: Lessons from the Past using Simulations and Observations (ELPASO) project aims to synthesise data from a range of climate records to build a comprehensive picture of the Oscillation during key periods, such as the Last Glacial Maximum (21 ka) and the Holocene (6 ka), in order to test how models reproduce ENSO events in a different climate. This study includes specialists in various fields ranging from climate modelling, to bivalve and shell data analysis or sediment and ice core analysis. Project Coordinator Dr Pascale Braconnot explains further: "The ultimate goal of the project is to better

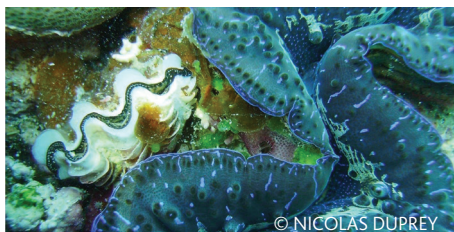
understand the link between variability and mean state of ENSO and provide constraints to evaluate simulated change in climate variability that can be used to assess climate feedbacks at play in future climate projections".

A number of research groups have attempted to model changes that will occur to the amplitude and frequency of the El Niño cycle as a response to climate change. However, to date these have not produced consistent results, as they still exhibit a large degree of uncertainty with respect to ENSO changes, ranging from enhancement of ENSO's amplitude to strong suppression of variability.

Braconnot and her colleagues believe that testing their models against past climate reconstructions at the scale of the Indo-Pacific sector will permit effective evaluation. If observed changes in the past climate can be replicated in the model, this will provide evidence that the model has predictive utility and relies on the right processes and mechanisms characterised by, for example, temperature, humidity, air pressure. As Braconnot makes clear, checking predictions against previous eras will be particularly important: "The way the system will behave in the future will not be a

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Archaeological shell midden located near the mouth of Ica River, Peru. Shells of marine molluscs were harvested over centuries by Inca and pre-Inca fishermen, and were accumulated around their settlement. © Matthieu Carré





LIVING *TRIDACNA MAXIMA* GIANT CLAMS (BIVALVIA) FROM NEW CALEDONIA, SOUTHWEST PACIFIC

simple replication of what happened in the recent past. The recent period of intense observation is affected by climate change”.

A NEW METHODOLOGY

ELPASO will involve the integration of high and low resolution proxy records. The first category will be the high resolution archives, which allow variation in conditions to be inferred on an interannual to multidecadal timescale. This permits information about the cyclic variation in El Niño periodicity and magnitude to be obtained for the periods when these records were laid down. These records will include corals, molluscs, speleotherms and laminated sediments.

The lower resolution category of archives is also as important as the high-resolution records as they allow determination of the mean climate state at a number of locations. These characteristics of the climate are important for setting the simulated variables to test against the high resolution archives. Lower resolution records comprise marine and lake sediments, ice cores and moraines.

Marine data for both categories of archives will be obtained in a number of locations in the Pacific and Indian Ocean, while continental records will be obtained in a wide range of areas climatically affected by ENSO.

After obtaining data multiproxy syntheses will be performed. The multimodel, multiproxy and multi-era analysis will provide better insight into the relationship between climate variability and the mean climate state. The multiproxy analysis will have the particular effect of clarifying both seasonal and interannual to multidecadal variability.

Following the multiproxy syntheses new metrics will be developed to assess model results. These metrics will be aimed to accurately reflect real processes and variables in the changing climate so that beyond prediction we better understand the way these processes are affected by climate change.

INFORMING CLIMATE CHANGE MODELLING

The project has been running since 2010 and has already started to produce some useful results. Sensitivity tests have involved imposing different starting conditions or changes upon different modelled climates (eg. different ice sheet sizes at the Last Glacial Maximum, or an Atlantic fresh water flux). The outcomes of this range of simulations have made clear that perturbations outside of the tropical pacific have a role in determining the amplitude and frequency of

ENSO. They also have helped researchers to understand these perturbations’ teleconnections – through remote atmospheric or oceanic circulation changes – with the Indian monsoon and ENSO.

After early success, the future looks bright for ELPASO. A first important achievement of the project will be this data synthesis of high resolution proxy records throughout the Holocene in collaboration with the Paleoclimate Modelling Intercomparison Project (PMIP) activity. “Other important reconstructions [will] concern the ocean sea-surface temperature with lots of discussion on the uncertainties linked to different proxy records and the use of models to understand these uncertainties,” Braconnot highlights. It is hoped that the project will succeed in isolating these uncertainties and clarifying the most effective models to be used in the prediction of the effects of future climate changes on the El Niño/ La Niña Southern Oscillation. “The recent period of intense observation is affected by climate change. It is thus critical that in addition to more recent periods we consider all the information we can obtain from past archives,” Braconnot concludes.



SEDIMENT CORE EXTRACTED FROM A BOG IN ECUADOR

INTELLIGENCE

ELPASO

EL NIÑO: LESSONS LEARNED FROM SIMULATIONS AND OBSERVATIONS

OBJECTIVES

- To better understand the relationship between ENSO and its mean state by exploring its characteristics and teleconnections in different climatic contexts
- To develop a set of metrics on the mechanisms involved in ENSO and paleoclimatic data to test the ability of climate models to reproduce the ENSO variability and teleconnections with the monsoon in a different climate from the current climate

PARTNERS

Centre de Recherche et d’Enseignement de Géosciences de l’Environnement (CEREGE) • Environments and Paléoenvironnements Oceanic and Continental (EPOC), Université Bordeaux 1 • Institut des Sciences de l’Evolution de Montpellier (ISEM) • Laboratoire d’Oceanographie et du Climat (LOCEAN) • Laboratoire des Sciences du Climat et l’Environnement (LSCE – coordinator)

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CONTACT

Pascale Braconnot
Project Coordinator

IPSL/ Laboratoire des Sciences du Climat et de l’Environnement
Unité mixte CEA-CNRS-UVSQ
CEA-Orme des Merisiers, bat 712
91191 Gif sur Yvette
F-91191 GIF-Sur-Yvette Cedex
France

T +33 1 69 08 77 21
E pascale.braconnot@lsce.ipsl.fr

<https://elpaso.lsce.ipsl.fr/index.php/elpaso>

<http://pmip3.lsce.ipsl.fr>
(Paleoclimate Modelling Intercomparison Project – PMIP WG – PaleoVAR)

PASCALE BRACONNOT is head of the LSCE modelling department and develops climate models to study climate feedback. She co-coordinates the Paleoclimate Modelling Intercomparison Project. Braconnot was awarded the EGU Miluntin Milankovich Medal in 2009 in recognition of her work on paleoclimate. She contributed to the IPCC’s AR4 and AR5 as a lead author.

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