

FINAL REPORT PROGRAM LEFE

Two pages to be written in English

Program LEFE/ IMAGO	Project Title	Years 2017-2019
	El Niño, seasonality and teleconnections during the Eemian warming.	
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Context (2-3 lignes)

El Niño Southern Oscillation (ENSO) is a major source of extreme climatic events at the interannual scale. Its response to anthropogenic climate change is not known, nor is the potential range of changes in its variability. The Eemian (MIS5e, ~129-116ka) offers an opportunity to observe ENSO under warmer global conditions.

Objectives / scientific questions (2-3 lignes)

Our aim has been to reconstruct the amplitude of the seasonal and interannual climate variability related to ENSO in during the MIS5e using (1) fossil mollusk shells from the Peruvian coast, (2) laminated marine sediments collected off Peru (ODP686), and (3) collect fossil giant clams from the Indo-Pacific warm pool.

Main results

The amplitude of ENSO variability (Standard deviation of ENSO anomalies) in Peru was twice larger in the MIS5e than in the Holocene or in the modern period. The potential climatic range of ENSO is dramatically increased. Seasonal variations of Ti and other terrigenous metals is recorded in laminated sediments from Peru yielding the possibility to estimate the relationship between ENSO-related variability and mean oceanographic conditions.

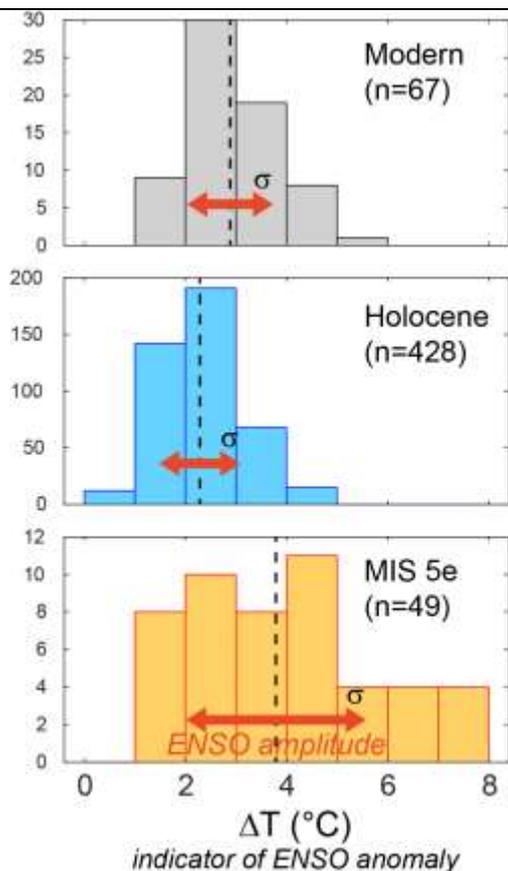


Figure 1. Distribution of ENSO anomalies in southern Peru reconstructed from *M. donacium* isotopic records

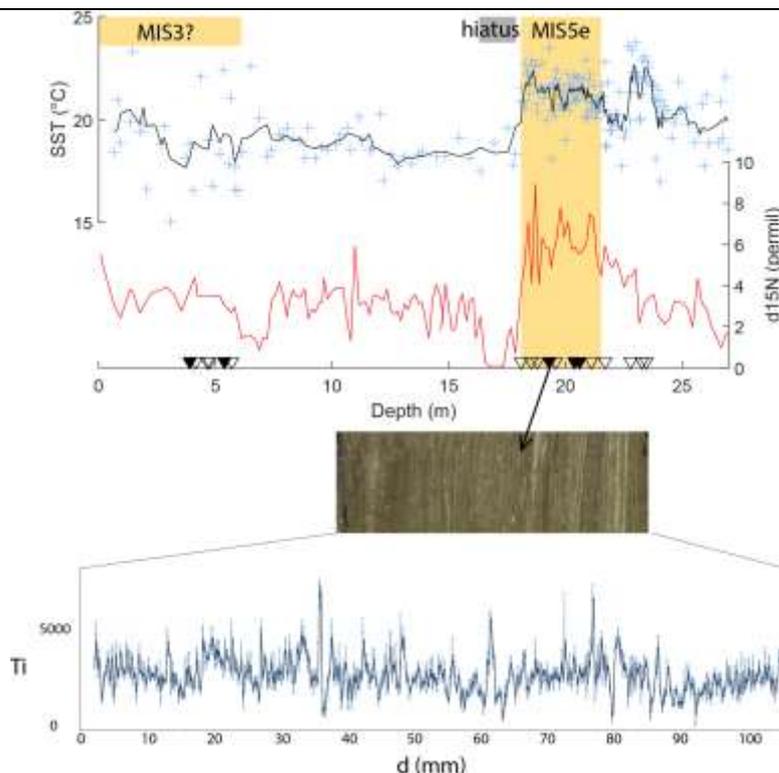


Figure 2. Top: alkenon-derived SST (black) and nitrogen isotopes in ODP686 sediment core. Bottom: High resolution (0.1mm) XRF record of Ti in a laminated section. Seasonal to interannual variability of fluvial input is recorded.

Fossil bivalves record monthly scale variations of SST in the Peruvian coast. The statistics of ENSO anomalies was obtained from a sample of 10 fossil *M. donacium* shells from an uplifted marine terrace (~130-120ka based on isotopic stratigraphy) in southern Peru. The comparison with the distribution obtained from the same species and the same area for the modern period and the Holocene indicates a larger seasonal variability of SST in the MIS5e and a variance that was 4 times higher than in the modern sample and 5 times higher than in the Holocene sample (Figure 1). The large seasonality shows that the upwelling seasonality in Peru is largely driven by the circulation in the northern hemisphere where the seasonal insolation contrast was much higher than today. We confirm the positive relationship between ENSO and seasonality observed in Holocene records. This interannual variability, unprecedented in any instrumental or proxy record, indicates that ENSO has a much larger range of variability than previously thought.

This study is complemented by high resolution XRF records of laminated sediments from Peru. We show that, at a 0.1mm resolution, seasonal to interannual variability, related in Peru to ENSO, is recorded. 5 out of 18 laminated sections have been analyzed (the analyses were interrupted for technical reasons) (Figure 2). The relationship between the ENSO variability and mean oceanographic conditions (denitrification, Redox conditions, SST, primary productivity) are being reconstructed.

New samples of Giant clam shells of MIS5e reefs were sampled in Sumba Island during a field trip in 2017. These samples are undergoing preliminary analyses. We anticipate to submit an independent research proposal which will provide funding necessary for the analyses of these samples. Comparison of Giant clam shells from this locality will enable to test if ENSO variability was increased during this time interval with effects on surface hydrology across the Pacific Ocean and the Indian Ocean.

Future of the project :

- The unexpected results on ENSO in the MIS5e open new questions about the forcings of ENSO. When only forced with insolation, climate models simulate a reduction of ENSO amplitude in increased precession conditions such as those of 125ka, in opposition with our record. Other forcings must have influenced ENSO, possibly ice sheet melting (the sea level was 2-5m higher than today in the MIS5e), and should be better evaluated.
- The high-resolution analysis of laminated sediments opens also new possibilities to explore the link between high frequency variability and mean conditions at a broad range of time scales.
- Giant clam shells collected within the scope of this and previous projects in sites across Indonesia (Sumba and Sulawesi) will also provide a test for increase interannual variability during this period.

Nombre de publications, de communications et de thèses

- 2 peer-reviewed publications
Emile-Geay, J.; K. Cobb; J. Cole, M. **Elliot** and F. Zhu, Past ENSO variability: reconstructions, models, and implications. 2020 AGU monograph on "ENSO in a Changing Climate" (editors: Mike McPhaden, Agus Santoso, and Wenju Cai). ISBN: 978-1-119-54812-6.
- Elliot, Mary**, Cahyarini Sri Yudawati, Abram Nerelie, Felis Thomas, McGregor Helen. Is the El Niño-Southern Oscillation changing? Lessons from the past. Past Global Changes Magazine, vol. 28(1), 28, 2020.
<https://doi.org/10.22498/pages.28.1.28>
- 2 Articles in preparation
- 2 Conference Presentations
Carré M., Rivas R., Cordova K., Fernández E., Chiessi C.M., Ochoa D., Salas-Gismondi R., Cardich J., Pérez A., Gutiérrez D., Extreme ENSO variability during MIS5e evidenced by fossil mollusk isotopic records from Peru. *AGU Fall meeting*, 1-17 December 2020
Cardich J., Salvattecí R., Bouloubassi I., Boucher H., Mandeng-Yogo M., Salas-Gismondi R., Pérez A., Ochoa D., Romero P., Pérez J., Carré M. ENSO variability in the last interglacial estimated from high resolution XRF records of laminated marine sediments from Peru. *AGU Fall meeting*, 1-17 December 2020
- 1 Thesis
Rivas Blas R., El ENSO durante el último interglacial (130-116 KA AP) registrado por fósiles de *Mesodesma donacium* (Bivalvia: Mesodesmatidae) en el Perú. Tesis de Maestría de Ciencias del mar. Universidad Peruana Cayetano Heredia. 2021.