ENSO and PDO cycles since Glacial times: a 55,000 year record of inter-annual and decadal variabilities from the Gulf of California

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Seasonnal shifts between terrigenous (riverine) and biogenic inputs to the sea bed associated to disoxic conditions at intermediate depth lead to the rapid deposition and unaltered preservation of annually varved sedimentary sequences in the Gulf of California. These annually resolved sequences document shifts in marine upwelling/ stratification and wet/dry conditions on land, which are both strongly controlled by El Niño Southern Oscillations (ENSO) today.

Here we present a continuous 55,000 year long record of upwelling-induced biological productivity (biogenic silica and organic carbon) and water column deoxygenation (denitrification) in the Gulf of California at centennal timescales. Several (9) 200 year long, varved sections distributed from the Holocene to the last Glacial period and the millennial scale events of the deglaciation were selected from this long record, and both denitrification and productivity were measured with annual resolution.

Spectral and wavelet analyses of the annually resolved records reveal the permanence of ENSO- and PDO-like (Pacific Decadal Oscillation) variabilities throughout the record with only minor deviations in the length of the ENSO and PDO periodicities since the last glacial period. The relative amplitudes of the ENSO- and PDO-like cycles however vary greatly throughout the 55,000 year sequence and exhibit a negative relationship: strong PDO are associated with weak ENSO cycles

While denitrification and deoxygenation respond more prominently to PDO-like variabilities, upwelling-induced productivity is related to the amplitude of ENSO. This is in agreement with the recent observations that today's intermediate depth oxygen levels are influenced by North Pacific circulation changes (PDO paced) while upwelling-strength in the Pacific eastern boundary currents is strongly controlled by rapid atmospheric oscillations (ENSO).