Tropical Climate Variability of the Past

Earth-System Modelling of Tropical Climate Variability During the Last Interglacial and the Holocene

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In Short

- High-resolution simulations using the water isotope-enabled Community Earth System Model (iCESM1.2) will be performed for the Holocene and the Last Interglacial.
- The project aims at insights into the tropical hydrological cycle on interannual-to-multidecadal timescales and atmospheric teleconnections.
- The planned simulations will help to interpret signals of variability recorded by tropical corals during warm periods in the past.

It is still under debate how climate in the tropics will change in a warmer climate state in response to anthropogenic climate change. Insights can be achieved from fossil shallow-water corals, which represent one of the most valuable climate archives due to their high temporal resolution and which allow to reconstruct climate variability beyond the instrumental record and during various climatic periods in the past.

In particular, a recent synthesis by Felis (2020) of coral proxy records for several warm periods in the past (130-118 and 6-2 kiloyears before present), i.e. from the Last Interglacial and from the Mid-to-Late Holocene, suggests different characteristics of seasonality and interannual-to-multidecadal variability during the course of these two warm episodes. Sea-surface temperature as well as sea-water salinity information derived from fossil corals might arise from a superposition of local-to-regional processes and tropical climate modes connecting the Atlantic, Pacific and Indian Ocean basins. Therefore, the mechanisms shaping the signals shown by the corals are only partially understood so far. Furthermore, the limited length of coral records is often restricted to only a few decades and may lead to misinterpretations of coral-derived shorter-term variability (e.g. on interannual timescales) given the possibility of a superposition by low-frequent variability operating on inter-decadal to centennial timescales.

In order to put the local coral signals into a larger-scale perspective of tropical climate dynamics, global earth-system model simulations will be conducted with the aim of providing a more detailed picture of the response to paleoclimatic boundary conditions, such as greenhouse-gas concentrations and orbital settings. Furthermore, the model simulations will shed light on tropical climate variability, in particular the hydrologic cycle, and contribute to the understanding of climate modes, such as the El Niño/Southern Oscillation phenomenon (ENSO) in the tropical Pacific, for selected periods of the past. This is of particular relevance since previous modelling efforts have shown ambiguous results with respect to the strength and frequency of ENSO under future climate conditions. The planned experiments of this HLRN project are expected to disentangle aspects of the ENSO sensitivity from a paleoclimatic perspective through the focus on past warm periods.

To this end, the stable water isotope-enabled Community Earth System Model (iCESM), version 1.2, will be used. A specific characteristic of iCESM1.2 consists in tracking stable water isotope ratios through all the components of the hydrologic cycle, thereby taking into account the physics of fractionation during condensation and evaporation processes.

The planned experiments will be conducted at a comparatively high resolution in the paleoclimate modelling context. A horizontal resolution of 1° in the atmosphere and land components, and nominally 1° in the ocean (0.5° and 1.125° in the latitudinal and longitudinal directions, respectively) will be used. The vertical discretization is configured to 30 levels in the atmosphere and 60 levels in the ocean model component. For the high-resolution simulations, a timeslice approach is applied instead of long transient simulations at coarser resolution. This allows to better resolve the spatio-temporal scales recorded in the fossil coral material against which the model results will be compared.

The expected outcome of the project is two-fold. On the one hand, characteristics of tropical mean climate and variability will be studied through appropriately designed sensitivity experiments with iCESM1.2. On the other hand, the proxy-forward modelling by stable water-isotope enabling in

the model has the potential of allowing a direct comparison to hydroclimate information provided by the fossil coral records. In the framework of the DFG Priority Program SPP 2299, this will bear the opportunity for proxy-model intercomparison and collaboration with the coral experts within SPP 2299.

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http://www.marum.de

More Information

[1] More information on the DFG SPP 2299: https://www.spp2299.tropicalclimatecorals.de

[2] T. Felis, *Oceanography* **33**, 2, (2020). doi: 10.5670/oceanog.2020.209

Project Partners

AWI Potsdam; GEOMAR Kiel; GFZ Potsdam; MPI for Chemistry, Mainz; Univ. Frankfurt; Univ. Gießen; Univ. Heidelberg; Univ. Kiel; Univ. Leipzig; Univ. Konstanz; ZMT Bremen; Advanced Climate Risk Education gUG (ACRE), Bad Gandersheim

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