

MioOcean Temperature Synthesis Meeting 2

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Arguably, the most important existential crisis facing modern society is that of climate change, caused by anthropogenic greenhouse gas emission. One way to understand how Earth's climate responds to changes in greenhouse gas concentrations, and thus how to predict, plan, and guide society through such a crisis, is to study past climate change. During the Miocene Epoch (~23 to 5.3 million years ago), Earth's climate experienced significant temperature and ice-volume fluctuations, which were coupled to marked changes in atmospheric carbon dioxide (CO₂) concentrations. In fact, the Miocene represents the most recent period in geologic history when Earth's climate experienced CO₂ concentrations equal to those predicted for the coming decades by the Intergovernmental Panel on Climate Change (e.g. Fig. 10.20 in Meehl et al. 2007). This, in conjunction with a similar continental configuration, makes the Miocene a crucial and relevant analog to better understand modern climate change.

A large number of studies have published estimates of Miocene ocean temperatures. These studies determined past temperatures using a variety of compounds, known as geochemical proxies (e.g. organic molecule thermometers like U^k₃₇ or TEX₈₆, or inorganic elemental or isotopic thermometers such as Mg/Ca, clumped isotopes (Δ₄₇), and stable isotopes). Usually, such studies only focused on one or a few specific location(s) in the ocean(s) (e.g. Modestou et al. 2020; Sosdian et al. 2020). There is currently an urgent need from several communities, mainly the climate modeling, paleoclimate, and policy-making communities, to summarize and synthesize data in order to make it more accessible to advance our understanding of modern climate change. The MioOcean Temperature Synthesis working

group (a subgroup of PAGES' PlioMioVar working group [pastglobalchanges.org/pliomiovar]) aims to update and synthesize existing ocean-temperature proxy data, compile them all into a databank for open access, and ultimately generate a global temperature atlas for specific Miocene time slices relevant to modern climate change.

The second workshop to date, MioOcean 2 (pastglobalchanges.org/calendar/137169), aimed to bring our large group of researchers together to provide updates on synthesis progress, discuss ongoing issues, find solutions, and specify how the group's outputs will take shape. One major hurdle for each proxy is to update the method used to translate raw data into temperature. Part of the meeting was dedicated to determining the most state-of-the-art methods of temperature calculation for each proxy, in order to begin recalculating temperature from raw data. Another major hurdle is to consider how to make data from different locations comparable in the time domain, which is solved by the stratigraphers and geochronologists comprising the group who specialize in generating age models for the Miocene sediments and rocks the proxy data are derived from. This group also presented their vision for moving the synthesis forward, and what that might entail. Finally, MioOcean is working in close partnership with a climate modeling initiative, MioMIP (Miocene Model Intercomparison Project). Climate modelers use paleoclimate data to validate and compare model outputs. However, if data are conflicting or have poorly defined uncertainties, that critical comparison and validation work becomes very difficult. To this end, MioOcean hosted several MioMIP participants to receive their feedback and guidance on how best to compile ocean temperature data to ensure that the

new compilations are as useful as possible for the modeling community.

The workshop followed another conference (MioMEET; Utrecht, 5–7 June 2023) for reasons of sustainability; since the two communities overlap, most participants were already gathered in the beautiful Dutch city. An international group of 32 scientists met in Utrecht on 8 June (MioOcean 2), and 15 participants who were unable to travel also joined online. The workshop was a success in many ways, but most importantly, it was the first time the group was able to gather in person. Online meetings are convenient (assuming one wins the timezone lottery), and much more environmentally friendly, but getting to know one another in real life adds to the energy and motivation of a scientific working group.

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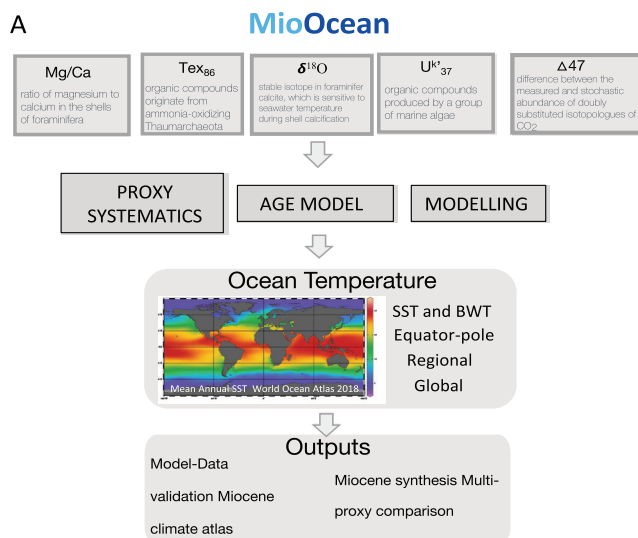


Figure 1: (A) Workflow of the MioOcean Temperature Synthesis. **(B)** Sindia Sosdian, of the MioOcean Steering Committee, facilitating discussion during the meeting.