Project: **1006**

Project title: **Simulations of the Mid-Piacenzian Warm Period (~3.3-3.0 Ma BP) in the framework of the Pliocene Model Intercomparison Project Phase 2 (PlioMIP2)**

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Report period: 01.07.2024 – 30.06.2025

In 2024/2025 we have successfully employed AWI-CM3 on DKRZ resources to compute the first batch of model spinups that is a key to our participiation in PlioMIP3. Recent developments also prompted us to invest additional resources (outside from ba1006) to create additional orbital and gateway sensitivity studies related to those applied for: An unexpected and time-critical opportunity to collaborate with paleoclimatologists who study the formation of sapropels in the Mediterranean prompted us to run orbital sensitivity studies with a different orbital configuration than planned for PlioMIP3 (as per necessity for the study of the evoluation of Mediterranean sapropels). The results are very promising and we indeed find a substantial effect of orbital forcing on precipitation, sea ice and temperature patterns (Figure 1). Additional freshwater discharge into the Mediterranean for different than modern orbits leads to a substantial freshening of the Mediterranean (not shown). Further analysis is currently underway in a collaboration with paleoclimatologists who specialize on the development of Mediterranean paleoceanography. This research will enable the study of mechanisms behind, and the origin of, sapropels in that basin. In order to open the door to AWI-CM3 taking part in PlioMIP3 research on orbital time-scales we request additional resources to also run the 100% PlioMIP3 conform orbital sensitivity simulations in the upcoming allocation period.

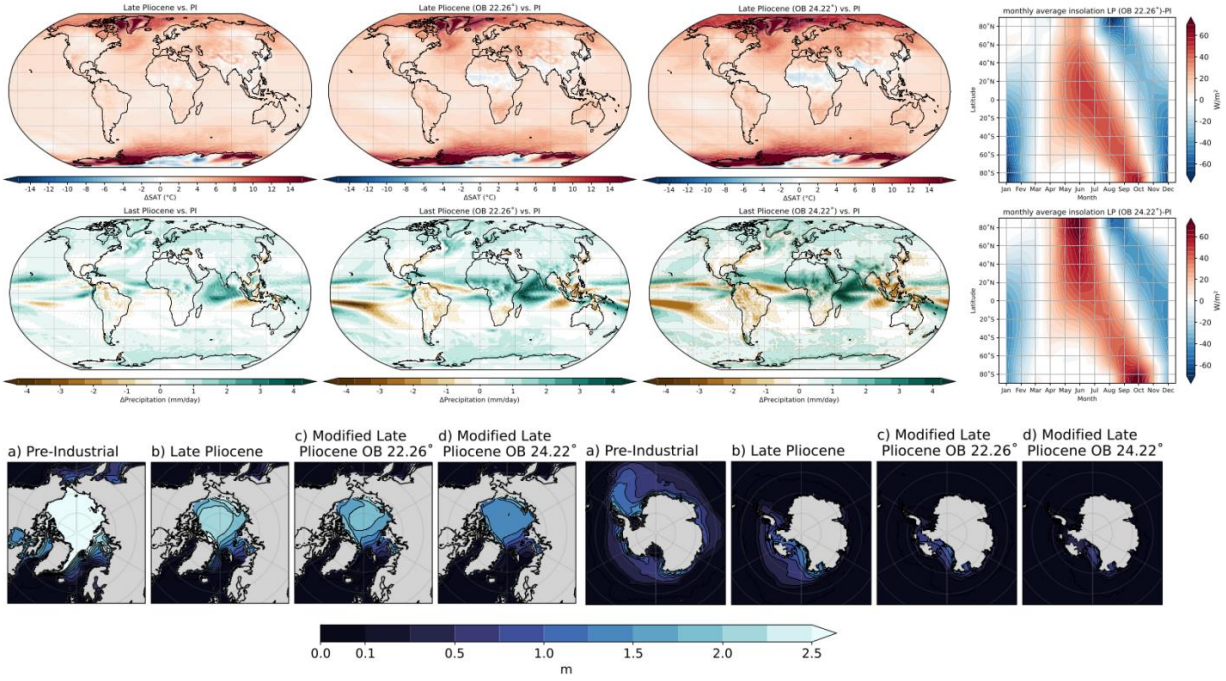

Figure 1: Late Pliocene climate in comparison to piControl (leftmost column) and influence of low obliquity (second column; top of the atmosphere insolation anomaly shown rightmost column, top) and high obliquity (third column; top of the atmosphere insolation anomaly shown in rightmost column, middle) on Late Pliocene climate. We show anomalies of annual mean near surface air temperature (uppermost row), precipitation (middle row), and sea ice thickness for the Northern Hemisphere (lower row, left) and Southern Hemisphere (lower row, right). We find a strong orbital impact on precipitation / monsoon and high latitude temperatures and sea ice. We also find a strong impact on the freshwater runoff into the Mediterranean (not shown). These results emphasize the scientific value of considering orbital sensitivity studies in PlioMIP3 towards researching urgent questions regarding development, stability, and impact of large-scale circulation systems like the African and Southern Asian monsoon systems.

We finished the spin up of the two core simulations that are a starting point for various other

PlioMIP3 simulations that we have proposed for the upcoming allocation period. Furthermore, based on a collaboration with an international project, we have studied the impact of alternative Pliocene continental geometries in the Arctic Ocean (see allocation request document for reference) on the amplitude of high latitude warmth (not shown). We note that, indeed, relative minor modifications of the gateways and continental configuration cause substantial anomalies in sea surface temperatures. The work of the coming months will be to study in how far these changes are mitigating known model biases in comparison to sea surface reconstructions for the Pliocene.

We note that the sensitivity of AWI-CM3 to Pliocene geography and greenhouse gas concentrations is very strong (Fig. 2) - much stronger than for the predecessor model AWI-ESM2 (not shown). This gives us hope that AWI-CM3 will in PlioMIP3 be among the best-performing models wrt. model bias at high boreal latitudes and with regard to polar amplification of the Pliocene large scale climate anomaly. It is noteworthy that the high resolution of the employed Pliocene FESOM2 mesh will facilitate high quality of ocean circulation through narrow gateways (Fig. 2). This is critical towards understanding the impact of narrow gateways on Pliocene and modern climate (in particular Bering Strait, Canadian Archipelago, West Antarctic, Strait of Gibraltar, North Atlantic / Arctic gateways).

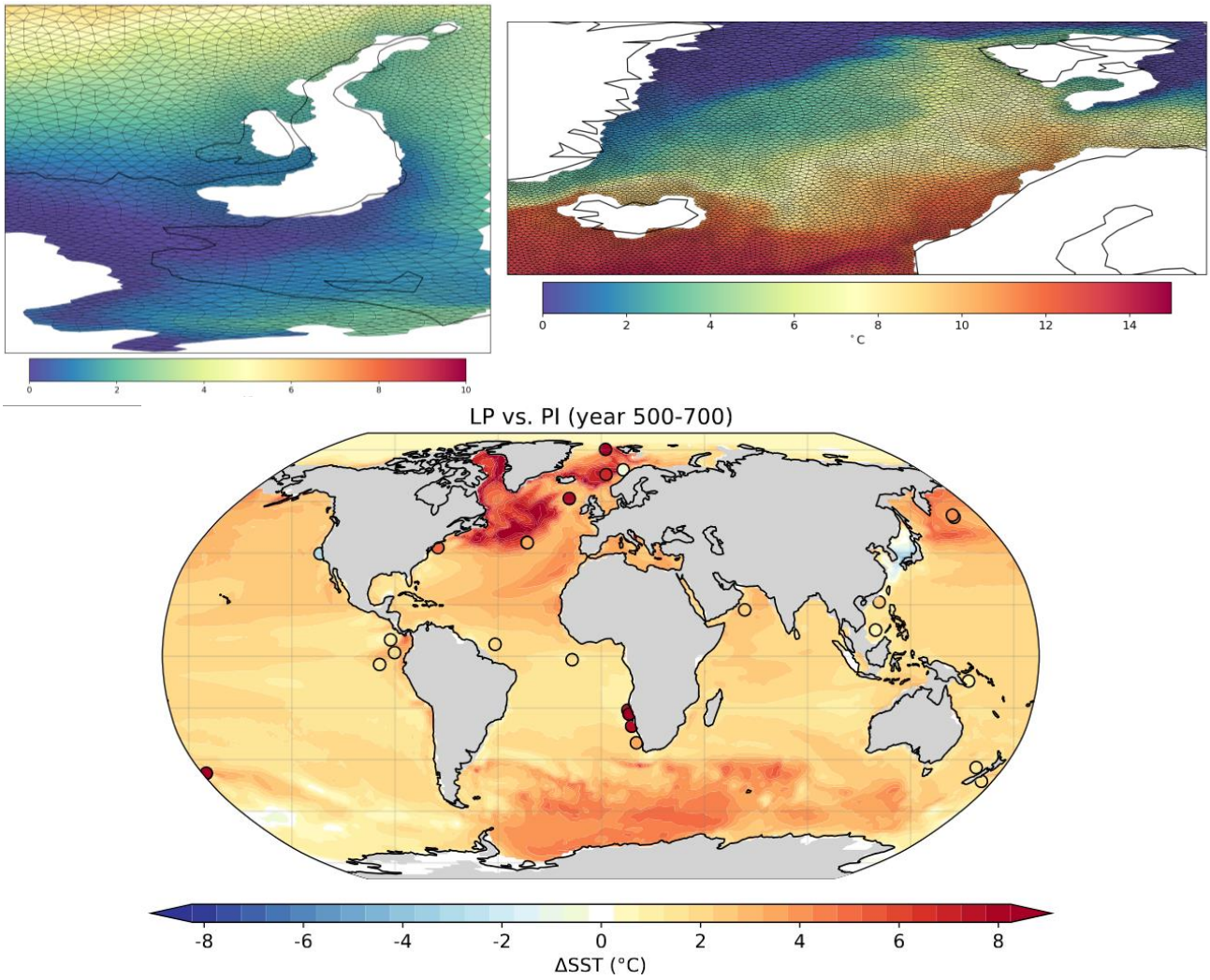

Figure 2: Absolute Late Pliocene annual mean sea surface temperature (SST) simulated with AWI-CM3 for a Late Pliocene West Antarctis (up, left) and North Atlantic (up, right). Anomaly of simulated Pliocene annual mean SST (bottom; shading) in comparison to the PRISM4 reconstruction (bottom; circles).