EGU2020-2427
https://doi.org/10.5194/egusphere-egu2020-2427
EGU General Assembly 2020

Lessons from a high CO2 world: an ocean view from ~3 million years ago

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A range of future climate scenarios are projected for high atmospheric CO_2 concentrations, given uncertainties over future human actions as well as potential environmental and climatic feedbacks. The geological record offers an opportunity to understand climate system response to a range of forcings and feedbacks which operate over multiple temporal and spatial scales. Here, we examine a single interglacial during the late Pliocene (KM5c, ca. 3.205 +/- 0.01 Ma) when atmospheric CO_2 concentrations were higher than pre-industrial, but similar to today and to the lowest emission scenarios for this century. As orbital forcing and continental configurations were almost identical to today, we are able to focus on equilibrium climate system response to modern and near-future CO_2. Using proxy data from 32 sites, we demonstrate that global mean sea-surface temperatures were warmer than pre-industrial, by ~2.3 ºC for the combined proxy data (foraminifera Mg/Ca and alkenones), or by ~3.2ºC (alkenones only). Compared to the pre-industrial, reduced meridional gradients and enhanced warming in the North Atlantic are consistently reconstructed. There is broad agreement between data and models at the global scale, with regional differences reflecting ocean circulation and/or proxy signals. An uneven distribution of proxy data in time and space does, however, add uncertainty to our anomaly calculations. The reconstructed global mean sea-surface temperature anomaly for KM5c is warmer than all but three of the PlioMIP2 model outputs, and the reconstructed North Atlantic data tend to align with the warmest KM5c model values. Our results demonstrate that even under low CO_2 emission scenarios, surface ocean warming may be expected to exceed model projections, and will be accentuated in the higher latitudes.