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What caused mid-Piacenzian warming? Energy balance results from PlioMIP Experiment 2

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The Pliocene model intercomparison project (PlioMIP) was initiated to assess the ability of climate models to reproduce a warmer, higher CO_2 climate of the recent geological past. The model boundary conditions were specified, so each of the eight models in the coupled ocean-atmosphere Experiment 2 were running equivalent experiments. Here we present a new analysis of the energy balance of each of the PlioMIP Experiment 2 simulations, elucidating the causes and important features of the warm mid-Piacenzian climate.

Energy balance results from each of the different models show broadly similar patterns. Greenhouse gas warming and changes in cloud albedo drive mid-Piacenzian warming of 1 - 2 °C at tropical and Southern Hemisphere temperate latitudes. At the poles the warming is dominated by a reduction in the cloud free albedo, which originates from ice sheet and Arctic sea ice retreat and snow albedo feedbacks. The other components in the analysis all show smaller but significant impact on the warming of the polar regions, but the negative impact from cloud albedo and meridional heat transport approximately balance the enhancement from greenhouse gas warming and cloud emissivity. The response of the Northern Hemisphere temperate latitudes to the prescribed forcing in each of the models seems to be different. Although greenhouse gas increases produce a similar warming, the models disagree on both the magnitude and sign of change for each of the other components. As well as increasing the spread of PlioMIP surface air temperatures, this model disparity is particularly prevalent in sea surface temperatures in the North Atlantic and Nordic Seas, where previous data-model comparison have identified significant differences between the data and models.

Moves towards timeslices within the mid-Piacenzian warm period may reduce uncertainty in the data and provide a target sea surface temperature reconstruction for a coherent single time period. Despite the North Atlantic being the most well studied region of the Pliocene ocean, it seems that it is here and in the Nordic Seas where further data could provide better understanding of the mid-Piacenzian climate and greater possibilities for evaluating climate models. Combining new data with model sensitivity simulations may also increase our understanding of the importance of Arctic and North Atlantic palaeogeographic differences on temperature changes in these regions.