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Revisiting the problem of simulating Mid-Miocene Climate Optimum with an Earth System Model

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The Mid-Miocene Climate Optimum (MMCO, 17 – 15 Ma) represents the most recent time in Earth's history when the range of estimated CO_2 levels was comparable to predictions of the near future assuming intermediate anthropogenic greenhouse gas emissions. During this period, North American mammals rapidly diversified. Shortly after, many modern ecosystems were established. Similar to other well-studied warm periods during the Cenozoic, the MMCO had a reduced equator-to-pole temperature gradient with amplified polar warming. The MMCO also displayed an El Padre state in the tropical Pacific, strong orbital scale climate variability, and a dynamic Antarctic ice sheet.

The MMCO has been difficult for atmosphere-ocean coupled models to simulate. There are several possible reasons for this proxy-data/climate-model mismatch, including proxy underestimation of CO_2 concentration, model underestimation of Earth System sensitivity to greenhouse forcing, unresolved orbital scale climate variability in the proxy records, and changes in ocean circulation that are not captured by the models.

Major improvements have been made to the Community Atmospheric Model (CAM) during the past few years, including a more realistic representation of moist processes and radiation budget. A prototype of this model shows greater climate sensitivity to CO_2 forcing, and appreciably different simulation of past warm periods, especially in the tropical Pacific and polar regions. In this presentation, we employ the latest version of CAM within the framework of the atmosphere-ocean coupled Community Earth System Model to test whether this new model can resolve some of the persistent proxy-data / climate-model discrepancies of the MMCO.

Our preliminary results are promising. In a simulation with 400 ppm CO_2, the new model simulates an additional 3°C reduction in equator-to-pole surface temperature gradient and an addition 1°C reduction in east-west equatorial Pacific SST gradient compared to its predecessor. With new CO_2 estimates suggesting higher concentrations during the MMCO, and the latest climate model developments, we will demonstrate a significant reduction in the previously reported proxy-data / climate-model mismatches of the MMCO.