Earth’s climate sensitivity to CO2 forcing is determined by its net radiative feedback, which quantifies how much more energy is radiated to space for a given increase in surface temperature. Estimates from present day observations of temperature and earth’s energetic imbalance yield a strongly negative radiative feedback, or, equivalently, a very low climate sensitivity. This value lies outside the range of net radiative feedbacks in coupled climate models. This discrepancy in radiative feedbacks can be linked to discrepancies between models and observations in the pattern of historical sea-surface temperature (SST) anomalies that drive tropical atmospheric circulation and radiative damping. Indeed, we find that an atmospheric model forced with observed SSTs (CAM5 AMIP) yields a net feedback that is consistent with observational estimates, but up to three times more negative than that from the same period (2000-2017) in historical simulations where the same atmospheric model is coupled to a dynamical ocean model (CESM1 Large Ensemble).

To understand the role natural variability plays in this discrepancy, we compare the radiative feedbacks generated by the observed pattern of SSTs to those within the CESM1 large ensemble over the same period. The large ensemble produces a wide range of feedbacks due to internal variability alone. Yet, global radiative feedbacks (cloud feedbacks in particular) generated by observed warming patterns are far outside the range of natural variability in the ensemble. Using both a Green’s function approach, as well as a simple metric based on the East-West tropical pacific gradient, we show that none of the control simulations of CMIP5 climate models can generate sufficiently large natural variability to explain the discrepancy between models and observations. We conclude that the discrepancy in SST patterns, and the resulting discrepancy in radiative feedbacks, is caused by the inability of models to simulate either natural variability or the forced response over the recent historical period.

Live webcast: https://www.ucar.edu/live

For more information, contact Tracy Baker, tbaker@ucar.edu, 303.497.1366