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Alternative warming scenarios for the Eocene and implications for climate sensitivity

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Recent work in modelling the warm climates of the Early Eocene shows that it is possible to obtain a reasonable global match between model surface temperature and proxy reconstructions, but only by using extremely high atmospheric CO_2 concentrations or more modest CO_2 levels complemented by a reduction in global cloud albedo. Understanding the mix of radiative forcing that gave rise to Eocene warmth has important implications for constraining Earth's climate sensitivity, but progress in this direction is hampered by the lack of direct proxy constraints on cloud properties. Here, we explore the potential for distinguishing among different radiative forcing scenarios via their impact on regional climate changes. We do this by comparing climate model simulations of two end-member scenarios: one in which the climate is warmed entirely by CO_2, and another in which it is warmed entirely by reduced cloud albedo (which we refer to as the low CO_2-thin clouds or LCTC scenario) . The two simulations have almost identical global-mean surface temperature and equator-to-pole temperature difference, but the LCTC scenario has $\sim$11 cooler midlatitude continents and warmer oceans than the high-CO_2 scenario, a tropical climate which is significantly more El Niño-like, and a substantial equatorward shift of the mid-latitude eddy-driven jets. We show that increased precipitation in the LCTC case is due to its lower CO_2 concentration. Furthermore, the increased precipitation in the LCTC case is concentrated in the equatorial Pacific, and drives an extratropical response which explains the equatorward jet shift. Overall, the differences in regional climates between the two simulations are strong enough to be potentially detectable in the geological record.