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Understanding the extreme spread in climate sensitivity across the RCEMIP simulations

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We compare climate sensitivities across simulations from the radiative-convective equilibrium model intercomparison project based on the temperature dependence of the top-of atmosphere radiation budget, and find that climate sensitivities are extremely variable. The spread in climate sensitivity is particularly high in large domain simulations because convection is free to aggregate. We find that the dependence of climate sensitivity on convective self-aggregation itself is relatively weak, but that climate sensitivity is strongly sensitive to the temperature dependence of convective self-aggregation: if self-aggregation increases with temperature, then climate sensitivity is small, and if self-aggregation decreases with temperature, then climate sensitivity is high or even infinite. The main reason is that outgoing longwave radiation increases when convection aggregates, both because of an expansion and a drying of the subsiding regions, the latter resulting from an increase of subsidence velocity and from a larger distance to the closest convective regions. In addition, clouds contribute to the extreme spread in climate sensitivity, in particular the temperature dependence of shallow cloud fraction.
Overall, convective self-aggregation and shallow cloud fraction increase with temperature in GCMs, while there is no overall tendency in CRMs, which explains the smaller climate sensitivities in the GCMs compared to the CRMs.

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