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A modern radiative-convective equilibrium model

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Equilibrium climate sensitivity (ECS) is arguably one of the most investigated properties of the earth system. Since the pioneering work by Manabe and Wetherald in 1967 numerous studies were performed to estimate the ECS. Despite the number of preceding studies, estimates of the ECS show a surprisingly large spread from 0.5 K up to 4 K. The aim of this study is to revisit the simplest possible climate model, clear-sky one-dimensional radiative-convective equilibrium (RCE), and determine its climate sensitivity and associated uncertainty range. This range quantifies a null hypothesis for more complex climate models: The underlying uncertainties are fundamental to all kind of climate models. It is unlikely that full general circulation models are able to reduce this uncertainty.

We develop a single-column RCE model based on a state-of-the-art radiation scheme and latest knowledge on atmospheric processes in the tropics. This RCE framework is used to determine the ECS for a doubling of CO_2, which is roughly 2 K.

We perform several sensitivity studies to determine the range of uncertainty for our estimate. For example, we investigate the impact of stratospheric humidity concentration and uncertainties the used radiation scheme.