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Benchmark calculations of present-day instantaneous radiative forcing in clear, aerosol-free skies

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At the root of the effective radiative forcing driving climate change is the change in radiative flux at the top of the atmosphere due to changes in atmospheric composition – the so-called “instantaneous radiative forcing” (IRF). Estimates of global mean present-day instantaneous radiative forcing under cloud- and aerosol-free conditions show surprising diversity given the level of understanding of spectroscopy and radiative transfer. Much of this diversity, especially in estimates from climate models, is artificial, reflecting only differing errors and approximations in radiative transfer parameterizations. Calculations with more accurate line-by-line models have been considered far too expensive to be practical on a global scale.

We report here on benchmark calculations of present-day instantaneous radiative forcing by greenhouse gases in the absence of clouds and aerosols made with very high spectral-resolution models. The problem is made computationally practical by defining a set of roughly 100 atmospheric profiles and associated weights obtained from present-day atmospheric conditions as represented by reanalysis via simulated annealing to reproduce global- and regional-mean fluxes with sampling errors of less than 1% (verified by cross-validation with independent radiative transfer models). Cloud- and aerosol-free IRF is then computed from these profiles using present-day and pre-industrial greenhouse gas concentrations. We report on results from two line-by-line and one high-resolution k-distribution model.