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Transient response to well-mixed greenhouse gas changes

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A change in CO_2 concentration induces a direct radiative forcing that modifies the planetary thermodynamic state, and hence the surface temperature. The infrared cooling, by assuming a constant temperature lapse-rate during the process, will be related to the surface temperature through the Stefan-Boltzmann law in a ratio proportional to the new infrared opacity. Other indirect effects, such as the water vapor and ice-albedo feedbacks, may amplify the system response. In the present paper we address the question of how a global climate model (GCM) with a mixed layer ocean responds to different rates of change of a well [U+2010] mixed greenhouse gas such as CO_2. We provide evidence that different rates of CO_2 variation may lead to similar transient climates characterized by the same global mean surface temperature but different values of CO_2 concentration. Moreover, it is shown that, far from the bifurcation points, the model's climate depends on the history of the radiative forcing displaying a hysteresis cycle that is neither static nor dynamical, but is related to the memory response of the model. Results are supported by the solutions of a zero [U+2010] dimensional energy balance model.