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Modeling the response to changes in tropospheric methane concentration: application to the Permian-Triassic boundary

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We discuss a collection of model experiments valid for the Permian-Triassic boundary in which we explore the impact of changes in tropospheric methane. For scenarios relevant to methane clathrates release, we consider surface methane concentration with values up to 5000 times its pre-industrial concentration. We have developed a comprehensive three-dimensional tropospheric-stratospheric model with chemistry that allows for the feedbacks between chemistry and climate. We show that the ozone starts collapsing for methane surface concentrations of the order of 1000 times their pre-industrial concentration. At 5000 times, more than half of the ozone has disappeared. Consequently, a large rise (up to a factor of 7) in surface UV-B radiation is found. Other chemical consequences include a rise in CO and ozone surface concentrations; although becoming very large (up to 17 ppmv for CO) neither seem to reach lethal values. Finally, we show that for no scenarios is the tropospheric OH collapsing; a corollary of this is the finite methane lifetime (45 years at the most). In the most extreme case analyzed, the tropospheric OH is actually recovering; this exhibits an important feature in the ability of the atmosphere to restore its stratosphere after extreme depletion events.