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Undoing climate warming by atmospheric carbon-dioxide removal: can a holocene-like climate be restored?

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Understandably, most climate modelling studies of future climate have focused on the affects of carbon emissions in the present century or the long-term fate of anthropogenically emitted carbon. These studies make an assumption: that once net anthropogenic carbon emissions cease, that humanity will make no further effort to intervene in atmospheric composition. There is a case to be made, however, that there will be a desire to return to a "safe" atmospheric concentration of CO_2. Realistically this implies synthetically removing CO_2 from the atmosphere and storing it is some geologically stable form. For this study experiments were conducted using the University of Victoria Earth System Climate Model (UVic ESCM) forced with novel future atmospheric trace-gas concentration pathways to explore a gradual return to pre-industrial radiative forcing. The concentration pathways follow each RCP (2.6, 4.5, 6.0, and 8.5) exactly until the peak CO_2 concentration of that RCP is reached, at which point atmospheric CO_2 is reduced at the same rate it increased until the 1850 concentration of CO_2 is reached. Non-CO_2 greenhouse gas forcing follows the prescribed RCP path until the year of peak CO_2, then is subsequently linearly reduced to pre-industrial forcing. Pasture and crop areas are also gradually reduced to their pre-industrial extent. Under the middle two concentration pathways (4.5 and 6.0) a climate resembling the 20th century climate can be restored by the 25th century, although surface temperature remains above the pre-industrial temperature until at least the 30th century. Due to carbon-cycle feedbacks the quantity of carbon that must be removed from the atmosphere is larger than the quantity that was originally emitted. For concentration pathways 2.6, 4.5, and 6.0 the sequestered CO_2 is 115–190% of the original cumulative carbon emissions. These results suggest that even with monumental effort to remove CO_2 from the atmosphere, humanity will be living with the consequences of fossil fuel emissions for a very long time.