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The Reversibility of Sea-Level Rise

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For the last century, global climate has been warming and projections indicate that such a warming is likely to continue over coming decades. Much of the extra heat trapped in the climate system penetrates into the ocean where it results in thermal expansion of sea water and global sea level rise.

Previous studies have shown that, if atmospheric greenhouse gas concentrations are stabilised, the rate of increase in near-surface air temperature rapidly slows. Furthermore, if greenhouse gas concentrations subsequently decline then the temperature tends to fall as well, potentially with some small delay due to committed warming. In climate model experiments with only changes in CO_2 concentration, the maximum temperature attained depends on the cumulative emissions of carbon, or equivalently the peak CO_2 concentration, but not on the CO_2 emissions pathway. Here we use idealised-scenario climate model experiments to show that sea level behaves differently. After CO_2 stabilisation in the atmosphere, heat continues to penetrate into the ocean and the sea-level rise continues for centuries. If CO_2 concentration is subsequently reduced, the highest sea level attained is found to depend on the time-integral of the CO_2 concentration, and thus on the CO_2 emission pathway. It is possible to replicate some of the behaviour of the complex climate model (AOGCM) simulations using a two layer ocean model, which brings useful insights of how the system might behave for a wider range of forcing scenarios.

Finally, our experiments show that a long term multi century commitment to rising thermal expansion is not inevitable. Reducing the radiative forcing back towards pre-industrial levels would reduce the time of further committed thermal expansion. A large negative forcing could be used to return this component of sea level to its pre-industrial levels more quickly but technologically this is not yet feasible and the side effects unknown.