



## Reversibility of the Earth System under an “overshoot” scenario

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Climate scenarios whereby atmospheric concentrations of greenhouse gases exceed a particular target before decreasing towards the target have been considered by some authors and are referred to as “overshoot” scenarios. They can result from a continued growth in CO<sub>2</sub> emission followed by a rapid decrease in emissions or even negative emissions under some aggressive climate policy. Overshoot scenarios are relevant to a class of geoengineering techniques referred to as CO<sub>2</sub> air capture or carbon dioxide removal (CDR). Given that CDR could only be realistically implemented over several decades with further inertia coming from the carbon cycle, such a scenario would cause CO<sub>2</sub> atmospheric concentrations to increase before they eventually decrease.

The aim of this study is to present how various components of the Earth system behave under an idealised climate change scenario where CO<sub>2</sub> atmospheric concentrations are increased and then decreased. The reversibility of the Earth system component is investigated using the Met Office Hadley Centre HadGEM2-ES model. We ramp up the CO<sub>2</sub> atmospheric concentration by 1% yr<sup>-1</sup> starting from pre-industrial level (286 ppm) up to a quadrupling (1144 ppm). Four ramp-down scenarios have been branched with the CO<sub>2</sub> concentration prescribed to decrease at 1% yr<sup>-1</sup> starting from 4xCO<sub>2</sub>, 3xCO<sub>2</sub>, 2xCO<sub>2</sub> and 1.5xCO<sub>2</sub>. It is shown that while most parameters exhibit a high degree of reversibility, there are some variables that respond with a significant time lag to a decrease in CO<sub>2</sub> concentrations, with some hysteresis effect.