Atmospheric CO_2 stabilization by means of ocean alkalinization within the 21st century

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Artificial ocean alkalinization (AOA) is one of the ocean-based carbon dioxide removal (CDR) methods that aims at enhancing the natural and slow process of weathering by which CO_2 is taken out of the atmosphere. Alkalinity is the charge balance of ions in seawater and it determines the CO_2 oceanic uptake and storage as well as seawater pH. This technology would not only tackle climate change, but also ocean acidification. We use the Max Planck Institute Earth System Model based on the Coupled Model Intercomparison Project Phase 5 version with low-resolution to investigate the mitigation potential and side-effects of AOA. Model scenarios of alkalinity enhancement are designed to keep the atmospheric CO_2 levels similar to values of the stabilization scenario Representative Concentration Pathway (RCP) 4.5, whilst fossil fuel emissions follow the pathway of the high CO_2 scenario RCP8.5. In total, approx. 105 Petamol would be needed until the year 2100 for such a scenario. Compared to the unmitigated scenario (RCP8.5) this AOA scenario leads to a reduction in the annual global mean of air surface temperature of around 1.5.K, following more closely the RCP4.5. The slightly higher temperature (0.5.K) of AOA compared to RCP4.5 is mainly due to the radiative forcing effect of other GHGs (e.g. N2O, CH4 and Halogenated GHGs). AOA strongly mitigates ocean acidification leading to higher pH and saturation state of carbonate minerals values than those associated with the RCP4.5. This climate engineering scenario leads to changes in different properties of the climate system that are noticeable within centennial timescale. Between others, changes in temperature, precipitation, ocean circulation, sea ice extent as well as in the carbon cycle are here addressed. After our analysis, it is clear that this technology leads to a state of the climate that approaches the one of the RCP4.5 scenario. However, mitigating atmospheric CO_2 alone does not lead to an identical climate state.