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Volcanic forcing feedback on future global climate and carbon cycle

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Using a fully coupled global climate-carbon cycle model, we assess the potential role of volcanic eruptions on future projection of climate change and its associated carbon cycle feedback. The volcanic-like forcings are applied together with business-as-usual IPCC-A2 carbon emissions scenario. We show that very large volcanic eruptions similar to Tambora lead to short-term substantial global cooling. However, over a long period, smaller but more frequent eruptions, such as Pinatubo, would have a stronger impact on future climate change. In a scenario where the volcanic external forcings are prescribed with a five-year frequency, the induced cooling immediately lower the global temperature by more than one degree before return to the warming trend. Therefore, the climate change is approximately delayed by several decades and by the end of the 21st century, the warming is still below two degrees when compared to the present day period. The cooler climate reduces the terrestrial heterotrophic respiration in the northern high latitude and increases net primary production in the tropics, which contributes to more than 45% increase in accumulated carbon uptake over land. The increased solubility of CO2 gas in seawater associated with cooler SST is offset by reduced CO2 partial pressure gradient between ocean and atmosphere, which results in small changes in net ocean carbon uptake. Similarly, there is nearly no change in the seawater buffer capacity simulated between the different volcanic scenarios. Our study shows that even in the relatively extreme scenario where large volcanic eruptions occur every five-years period, the induced cooling only leads to a reduction of 46 ppmv atmospheric CO2 concentration as compared to the reference projection of 878 ppmv, at the end of the 21st century. In addition to the carbon uptake, changes in the dominant climate variability, such as the ENSO and NAO due to different frequencies and amplitudes of volcanic forcing in the future will also be discussed. With respect to sulphur injection geoengineering method, our study suggest that small scale but frequent mitigation is more efficient than the opposite. Moreover, the longer we delay, the more difficult it would be to counteract climate change.