Geophysical Research Abstracts
Vol. 12, EGU2010-13726, 2010
EGU General Assembly 2010

Modeling volcanic eruptions to assess the impact of stratospheric sulfur injections on the global carbon cycle

Thomas L. Frölicher (1,2), Fortunat Joos (1,2), Christoph C. Raible (1,2)

(1) Climate and Environmental Physics, Physics Institute, University of Bern, Switzerland, (2) Oeschger Centre for Climate Change Research, University of Bern, Switzerland

Injecting sulfate aerosols precursors into the stratosphere has been proposed to mitigate anthropogenic climate change. Volcanic eruptions could serve as a testbed to estimate the potential of geoengineering efforts related to direct manipulation of solar energy input via aerosols. Understanding how volcanoes affect the global carbon cycle and climate could lead to valuable insights into the response of the coupled carbon cycle-climate system to chronic sulfur loading. Major volcanic eruptions can dramatically increase the sulfate aerosols in the stratosphere having several impacts on surface climate. For example, the eruption of Mt Pinatubo was followed by a decrease in global surface solar radiation, temperature and precipitation including drought in South-East Asia, and an increase in diffuse solar radiation, North Hemispheric winter temperature and terrestrial carbon uptake. Yet, the regional impacts of volcanic eruptions on the global carbon cycle and the connection to initial conditions remain unresolved.

We assess the short- and long-term impacts of volcanic eruptions with the NCAR CSM1.4-carbon model on both the global and regional scale by performing a suite of sensitivity simulations. The coupled carbon cycle-climate model allows us to investigate the full radiative and dynamical response to volcanic eruptions. First, we use an ensemble of six transient simulations from 1820 to 2100 to show that the composite mean decrease in ocean temperature leads to significant carbon uptake on the regional scale, mainly in the tropical Pacific Ocean, although globally negligible. Additionally, we run one transient simulation over the period 1820 to 2100 without volcanoes. Although volcanic eruptions produce mainly short-term transient atmospheric climate perturbations which last for 2-3 years, the ocean integrates volcanic radiative cooling, and dissolved inorganic carbon and oxygen changes could last well into the 21th century. Second, we run several sensitivity experiments (i) starting from different coupled modes (El Niño vs. La Niña), (ii) starting in different seasons (winter vs. summer), and (iii) using different eruption locations (high vs. low-latitude). We show that the response of volcanic eruptions highly depends on the initial conditions with higher atmospheric CO_2 response starting the simulations in El Niño winter season. Finally, we scaled the Mt Pinatubo eruption to investigate the impact of supervolcanoes. Results show that atmospheric surface temperature and CO_2 do not linearly decrease with the amount of stratospheric aerosols.

We conclude that geoengineering by means of stratospheric sulfate aerosols could have adverse effects on regional scale and depends largely on the location of injection and the state of the climate system. Furthermore, geoengineering techniques will not significantly reduce atmospheric CO_2 levels and therefore fail to address the wider effects of rising CO_2 including ocean acidification.