Geophysical Research Abstracts, Vol. 8, 08066, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08066

Perturbations to the global carbon cycle following large volcanic eruptions

A. D. Friend (1) , N. Bellouin (2), O. Boucher (2) , F.-M. Breon (1), A. Cescatti (3) , F. Chevallier (1), Ph. Ciais (4), Ph. Peylin (1), and N. Viovy (1)

(1) Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif-sur-Yvette, France, (2) Met Office, Exeter, UK, (3) Centro di Ecologia Alpina, Trento, Italy, (4) INRA-Grignon, Thiverval Grignon, France (Andrew.Friend@cea.fr/ Phone: +33-(0)1.69.08.91.18)

Each large volcanic eruption during the period of precision atmospheric CO_2 measurements was followed by a significant decrease in the CO_2 growth rate. Despite the relevance of this observation for our understanding of the global carbon cycle, there remains no consensus as to the dominant process(es). Volcanic stratospheric aerosols scatter solar radiation, thereby cooling the troposphere, perturbing the hydrological cycle, and increasing the diffuse portion of downward shortwave radiation. A number of modelling studies suggest that cooling alone can explain the observed atmospheric CO_2 response to this forcing as a consequence of a greater reduction in terrestrial ecosystem respiration than photosynthesis. This explanation is challenged by theoretical considerations suggesting that the increase in the downward diffuse radiation flux could enhance photosynthetic CO_2 uptake sufficiently by itself to account for the observed atmospheric anomalies. This enhancement is thought to occur because diffuse light can penetrate deeper into plant canopies and illuminate shaded leaves more efficiently than direct beam radiation. In addition to theoretical considerations, an enhancement due to the diffusive flux has also been observed at several sites in the FLUXNET network, while a consistent global estimation of this effect is still lacking.

Existing models account for diffuse light in an empirical manner, and yield conflicting results. We constructed a new global modelling framework to overcome these limitations and mechanistically simulate the effects of both the climate and radiation perturbations due to volcanic eruptions on terrestrial CO_2 fluxes. A ray tracing approach to simulating canopy radiation is coupled to a physiologically-based model of canopy photosynthesis. Plant and soil respiration are treated using process-based representations of responses to C-substrate supply, temperature, and moisture. The effects of stratospheric aerosols on the quantity and the diffuse fraction of clear-sky visible radiation are modelled explicitly using a radiative transfer approach. The global distribution of the simulated terrestrial CO_2 flux anomaly following the Mt Pinatubo eruption in June 1991 is compared to estimates from an inversion study and enhanced uptake attributed to mechanisms using factorial model experiments.