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Thesis abstract
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Characterizing carbon-dioxide fluxes from oceans and terrestrial ecosystems

Understanding the processes that change the amount of carbon stored in the ocean and in the land biota, with their implications for future climate and ecology, is a fundamental goal of earth-system science. I have developed, refined, and applied several approaches that combine data analysis and modeling to better understand processes affecting carbon fluxes.

(1) Using a database of tree-ring widths from some 40,000 trees, I looked at the impact of large volcanic eruptions in the past millennium on tree growth globally. I found a decline in growth north of 45° N lasting for several years after eruptions, presumably due to eruption-associated cooling, and no significant impact at lower latitudes. This argues against the hypothesis that the increased diffuse-light fraction due to volcanic aerosols greatly increased plant carbon uptake after the 1991 Pinatubo eruption, suggesting that other explanations are needed for the slow increase in atmospheric CO_2 levels in the early 1990s.

(2) I applied generalized cross-validation (GCV) to the problem of estimating a regional CO_2 source/sink pattern consistent with observed geographic variation in atmosphere CO_2 levels. I showed that GCV works for selecting data and regional-flux uncertainty levels to assume for this inverse problem; these have usually been estimated rather arbitrarily, though they can have a large impact on the solution.

(3) The air-sea gas transfer velocity determines how fast the surface ocean adjusts to a change in atmospheric composition, and hence is important for understanding ocean CO_2 uptake. By modeling the ocean's adjustment to fluctuations in atmospheric carbon isotope composition and analyzing a variety of atmosphere and ocean bomb-^{14}C and ^{13}C measurements, I estimated regional and global mean gas transfer velocities, concluding that there may be less latitudinal variation in the gas transfer velocity than usually thought – implying, for example, relatively low CO_2 uptake in the Southern Ocean.