The Footprint of CO_2 Fluxes from a Joint Ocean Atmosphere Inversion on Atmospheric CO_2 and $^{13}C/^{12}C$ Ratios in CO_2

S.E. Mikaloff-Fletcher[1], A.R. Jacobson[2], J.L. Sarmiento[1], N.P. Gruber[3], and the Ocean Inversion Modelers

[1]Atmospheric and Oceanic Sciences, Princeton University, 300 Forrestal Road, 311 Sayre Hall, Princeton, NJ 08540; 609-258-8340, E-mail: mikaloff@princeton.edu
[2]NOAA Earth System Research Laboratory, 325 Broadway, Boulder, CO 80305
[3]ETH-Zurich, Zurich, Switzerland

Recent inverse modeling studies have used ocean interior observations of dissolved inorganic carbon (DIC) and other tracers and Ocean General Circulation Models (OGCMs) to estimate separately the natural and anthropogenic air-sea fluxes of CO_2 and carefully quantify the error associated with these estimates. Furthermore, the results from the ocean inversion have been combined with an analogous atmospheric inversion using surface observations of atmospheric CO_2 concentrations and atmospheric transport models to estimate air-sea and air-land fluxes. This work suggested that there might be an unexpectedly large source of CO_2 to the atmosphere from tropical land regions.

We add to this body of work by using the air-sea fluxes estimated from ocean interior observations as boundary conditions for the Model for OZone And Related chemical Tracers (MOZART) in order to obtain the atmospheric distribution of CO_2 associated with these air-sea fluxes and compare these gradients with observations from the NOAA ESRL network. In addition, we use atmospheric observations of $^{13}C/^{12}C$ isotopic ratios in CO_2 to independently test the finding of a large terrestrial source in the tropics, since the terrestrial biosphere discriminates against ^{13}C much more strongly than the oceans.

These results have significant implications about the nature of the northern hemisphere carbon sink that has been inferred from comparisons between observed latitudinal gradient of CO_2 from the NOAA ESRL flask network and model simulations of the latitudinal gradient that would be expected from fossil fuel emissions. There has been substantial debate about whether this sink is due to uptake by the terrestrial biosphere or natural oceanic uptake that would have already existed in preindustrial times. This oceanic would lead to a preindustrial latitudinal gradient with low atmospheric CO_2 in the northern hemisphere relative to the southern hemisphere. Our model simulations indicate that the natural air-sea fluxes from the ocean inversion would cause this type of latitudinal gradient, supporting the hypothesis of a northern hemisphere ocean sink (Figure 1). However, we find that this ocean carbon sink is not large enough to explain the observed gradients of atmospheric CO_2 without the existence of a substantial terrestrial carbon sink.

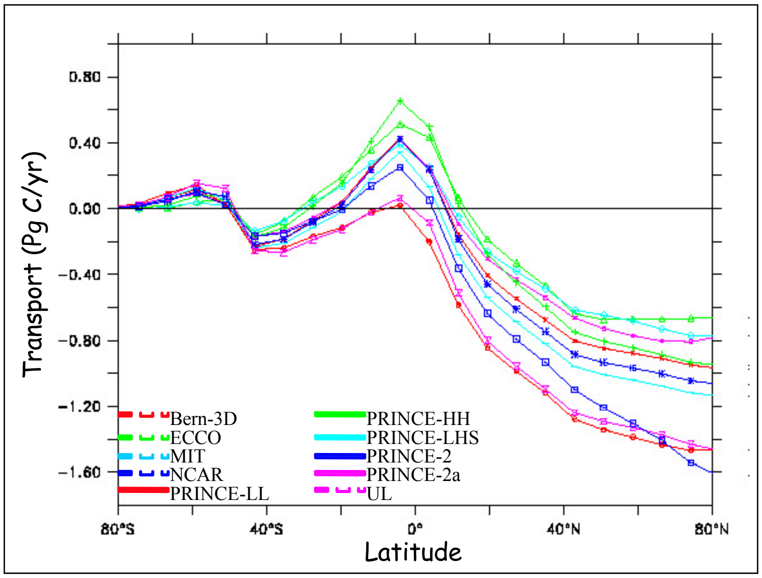

Figure 1. The latitudinal gradient of atmospheric CO_2 associated with preindustrial air-sea fluxes from an ocean inversion. The 10 lines represent the 10 different ocean models that were used in the ocean inversion to test the robustness of the results.