

Robust estimates of preindustrial and anthropogenic of air-sea carbon dioxide flux

Sara Mikaloff Fletcher, Nicolas Gruber, Andrew Jacobson, Scott Doney, Stephanie Dutkiewicz, Mick Follows, Keith Lindsay, Dimitris Menemenlis, Anne Mouchet, and Jorge Sarmiento

The exchange of anthropogenic and pre-industrial carbon dioxide across the air-sea interface cannot be measured directly; however, the contributions of preindustrial and anthropogenic air-sea exchange to dissolved inorganic carbon (DIC) can be estimated from observations of DIC and other nutrients. Using an ocean inversion analogous to atmospheric inversions, global and regional air-sea fluxes of anthropogenic and pre-industrial carbon dioxide are estimated separately from their reconstructed concentrations and an Ocean General Circulation Model (OGCM). This approach is appealing because, unlike atmospheric inversions, it is not data-limited; however, sensitivity studies have shown that model circulation may cause substantial biases in the ocean inversion. We present estimates of preindustrial and anthropogenic air-sea carbon dioxide exchange using a suite of nine different OGCM's in order to quantify the robustness of our results and explore the role of different representations of ocean circulation in the inversion.

Most of the large scale features of the inverse estimates are robust across all models. Both the preindustrial and anthropogenic carbon dioxide flux estimates are most robust at mid and high northern latitudes, except for the high latitude North Atlantic. These flux estimates are most uncertain in the Southern Ocean, where the inverse estimates are strongly dependent on the rates of deep water ventilation in the OGCM.

The inverse estimates of preindustrial air-sea fluxes generally follow the expected pattern of uptake at high latitudes and out gassing in the tropics. All of the models call for out-gassing in the Southern Ocean between 44S and 58 S. Preliminary analysis suggests that the inverse estimates do not support the hypothesis of preindustrial oceanic carbon transport from high northern latitudes to the southern hemisphere.

The greatest anthropogenic carbon uptake occurs at mid- to high- latitudes, with a large anthropogenic carbon sink in the Southern Ocean, while the bulk of the anthropogenic carbon storage occurs at mid-latitudes. Overall, the models estimate a global anthropogenic carbon uptake of 2.2 ± 0.25 Pg C/yr, scaled to a nominal year of 1995. In addition, there are interesting, robust differences between the preindustrial and anthropogenic inverse estimates and estimates from forward model simulations using the same OGCM's.