On the robustness of air-sea flux estimates from ocean inversions

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Inverse methods analogous to those used for atmospheric inversions have been adapted to estimate regional air-sea fluxes of carbon dioxide using ocean interior observations of dissolved inorganic carbon and related tracers and an Ocean General Circulation Model (OGCM). We estimate seperately the preindustrial component and the component due to the anthropogenic perturbation of atmospehric carbon dioxide. Previous sensitivity studies have shown that model circulation is one of the most important sources of error 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. The preindustrial inverse estimates generally follow the expected pattern of uptake at high latitudes and out gassing in the tropics; however, all of the models call for out gassing in the Southern Ocean between 44S and 58 S. 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 2.0 to 2.3 Pg C/yr for a nominal year of 1995. Preliminary results also suggest interesting, robust differences between these inverse estimates and estimates from forward model simulations using the same OGCM's

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 preindustrial inverse estimates are also sensitive to the choice of OGCM in the Indian Ocean, and the anthropogenic estimates have significant uncertainties in the tropical Pacific. Over large spatial scales, inverse estimates based on different OGCM's are in better agreement than estimates based on forward simulations of the same models, but this is not necessarily true for smaller model regions.