AIR-SEA FLUXES OF CO_2 DETERMINED BY INVERSE MODELING OF DIC OBSERVATIONS

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Direct estimates of the net exchange rates of CO_2 across the air-sea interface are associated with large uncertainties caused by the high spatial and temporal variability of the air-sea partial pressure difference and uncertainties in the parameterization of air-sea gas exchange. We have developed an inverse modeling technique that avoids these problems by estimating the net pre-industrial air-sea flux based on the observed oceanic *DIC* distribution corrected for biological cycling and the anthropogenic transient. We do this using an ocean general circulation model to establish the relationship between interior concentrations and surface fluxes. The primary assumption made is that the ocean transport is known sufficiently well from an ocean general circulation model. We invert ocean temperature data to check the inversion scheme and to identify regions where model deficiencies limit our ability to estimate the fluxes reliably.

The large number of dissolved inorganic carbon (DIC) observations obtained by JGOFS on the WOCE hydrographic survey provide us with an outstanding snapshot of the ocean carbon distribution. A technique has been developed in order to separate the anthropogenic carbon component from the pre-industrial component of the DIC (Gruber et al. [1996]) and this has been applied to data from the Atlantic, Indian, and Pacific Oceans (Gruber [1998]; Sabine [1999]; Sabine et al., personal communication). We make use of these results to estimate the pre-industrial and anthropogenic air-sea fluxes of carbon dioxide. The pre-industrial component shows the expected pattern of loss in the tropics balanced by uptake in high latitudes. The anthropogenic component is into the ocean everywhere with a total uptake of 1.8 Pg C yr^{-1}. We compare the resulting air-sea fluxes with those of Takahashi et al. [1999]. There is generally good agreement, particularly in regions where both techniques have good data coverage. However, our results show a shift of uptake from the high to the mid-latitudes, with far less uptake in the Southern Ocean. The inversion results do not show as large a cross-equatorial southward carbon transport in the Atlantic as has been proposed by Keeling et al. [1989] and Broecker and Peng [1992]. Neither does it show a large efflux of carbon dioxide from the Southern Ocean, such as would be required by Keeling et al. [1989]. The interhemispheric transport obtained by the inversion is 0.37 Pg C/yr, which is closer to that proposed by Keeling and Peng [1995].

The technique is also applied to oxygen data corrected for biological cycling to estimate the annual net air-sea fluxes of oxygen. We find that the equatorial regions emit about 330 Tmol O_2 yr^{-1}, which is compensated by uptake in the high latitudes of both hemispheres. The inversion result indicates a small interhemispheric transport of oxygen in the Atlantic of about 50 Tmol O_2 yr^{-1} directed toward the south. This transport is, however, compensated by northward transport in the Pacific and Indian Oceans, resulting in a near zero global interhemispheric oxygen transport.

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