B-7.2 Partial pressure of carbon dioxide and quantitative evaluations of ocean parameters.

Contact person Shoichi Taguchi
Scientist
Inter-spheric Environmental Section
Environmental Assessment Department
National Institute for Resources and Environment
National Institute of Advanced Industrial Science and Technology
Ministry of Economy and Industrial Technology
Onogawa 16-3, Tsukuba,Ibaraki,305-8569 Japan
Tel:+81-298-61-8384 Fax:+81-298-61-8358
E-mail: s.taguchi@aist.go.jp

Total Budget for FY1996-FY2000 52,033,000Yen (FY2000; 9,043,000Yen)

Abstract Flux of carbon dioxide from the atmosphere to the ocean over north Pacific Ocean, 15°N-60°N was estimated to be 0.35 PgC/yr based on the gradient of partial pressure of carbon dioxide and gas transfer velocity derived from surface winds. The same flux was estimated to be 0.3 PgC/yr based on the concentrations of carbon dioxide in the atmosphere using atmospheric inverse method. These estimates are smaller than the previous estimate of 0.45 PgC/yr. Filling gaps among these estimate requires accurate observations of the gradient of partial pressure at middle of the north Pacific, Sea of Japan and Sea of Okhotsk in winter to spring.

Key Words Carbon dioxide, material transport between atmosphere and ocean, inverse method, IPCC

1. Introduction

Future projections of atmospheric CO_2, critical to current international negotiations on climate change, require an accurate assessment of regional carbon sources and sinks. In 1990's, combustion of fossil fuel emitted 6.3 PgC/yr and the change of land use emitted 2.0 PgC/yr. CO_2 was remained in the atmosphere only 2.9 PgC/yr. Therefore 5 PgC was absorbed somewhere in the ocean or land biosphere. The geographical distribution of absorption is not known well. The luck of knowledge of Carbon-cycle is one of the obstacle to set a regulation of the emission of CO_2.

2.Research Objective

Exchange of CO_2 between atmosphere and ocean has been studied from oceanic side, such as the studies of the biogeochemical fate of CO_2 absorbed by the ocean, the studies of partial pressure of CO_2 in the ocean, the studies of transport of CO_2 inside the ocean. The use of recent reanalysis wind data is of interest because former estimate (Takahashi *et al.*, 1999) [1)] was based on an old archive of surface wind almost 20 years ago (Esbensen and Kshunir,

1981) [2]. Recent improvement in atmospheric transport model and accumulation of monitoring data all over the world also encourage us to make an estimate using an atmospheric inversion technique.

3.Research Method

We took two approaches for estimation of the exchange of CO_2. First is a traditional technique of gas transfer velocity and surface winds, but the winds fields is an updated reanalysis. Second is an inverse method recently developed using observations of the atmospheric concentrations world wide.

(1) Flux of CO_2 estimate based on partial pressure of CO_2 and wind speed at 10 m

Our estimate is based on the equation of Wanninkhof et al. (1992) [3] , and Etcheto et al. (1991) [4] . Wanninkhof et al.(1992) showed a relationship between long-term average wind at 10m height and gas transfer velocity. Etcheto et al. (1991) showed a relationship between gas transfer velocity and exchange coefficient. Flux of CO_2 was estimated by multiplying partial pressure gradient and exchange coefficient.

Wind fields used in this study were 15 years version of European Centre for Medium Range Weather Forecasts Reanalysis (ERA), although we only used 13 years of 1979- 1991. This data set was created using a numerical weather prediction model of T106 resolution and 31 vertical levels. Data assimilation technique was applied for the analysis (http://wms.ecmwf/int/research/era/Era-15.html).

(2) Inverse method of CO_2 flux

Basian synthesis inversion technique was applied to annual mean CO_2 concentrations obtained from NOAA/CMDL Global View. Inversion was conducted as a part of International transport model inter-comparison project (TransCom) of IGBP/GAIM. Fifteen transport model participated the project. (http://transcom.colostate.edu) .

Prescribed sources and sinks for fossil fuel emission, land biosphere emissions and absorptions based on Carnegie-Ames-Stanford Approach (CASA), oceanic emissions and absorptions by Takahashi *et al.* (1999) [1] were used to produce a background concentrations. Adjustment of sources and sinks were made using a principle to minimize squared differences between model estimated concentrations and observations. A prior estimate of source and sinks were set zero but have different prior error. Observations also had different error based on the magnitude of standard deviations for estimating monthly mean values.

4.Results

Figure 1 shows monthly mean air-sea flux of CO_2 estimated from partial pressure gradient of CO_2 presented by Takahashi *et al.* (1999). Annual sum of air to sea flux over the presented area is 0.35 PgC/yr which is smaller than the original estimate of 0.45 PgC/yr. Large sources and sinks were observed at the edge of ocean, such as north east of Japan. No gradient was shown in Takahashi *et al.* (1999) over sea of Japan and sea of Okhotsk. If we simply extrapolate values at the edge in January to March, significant source will appear at these area and affect the sum of flux at these area.

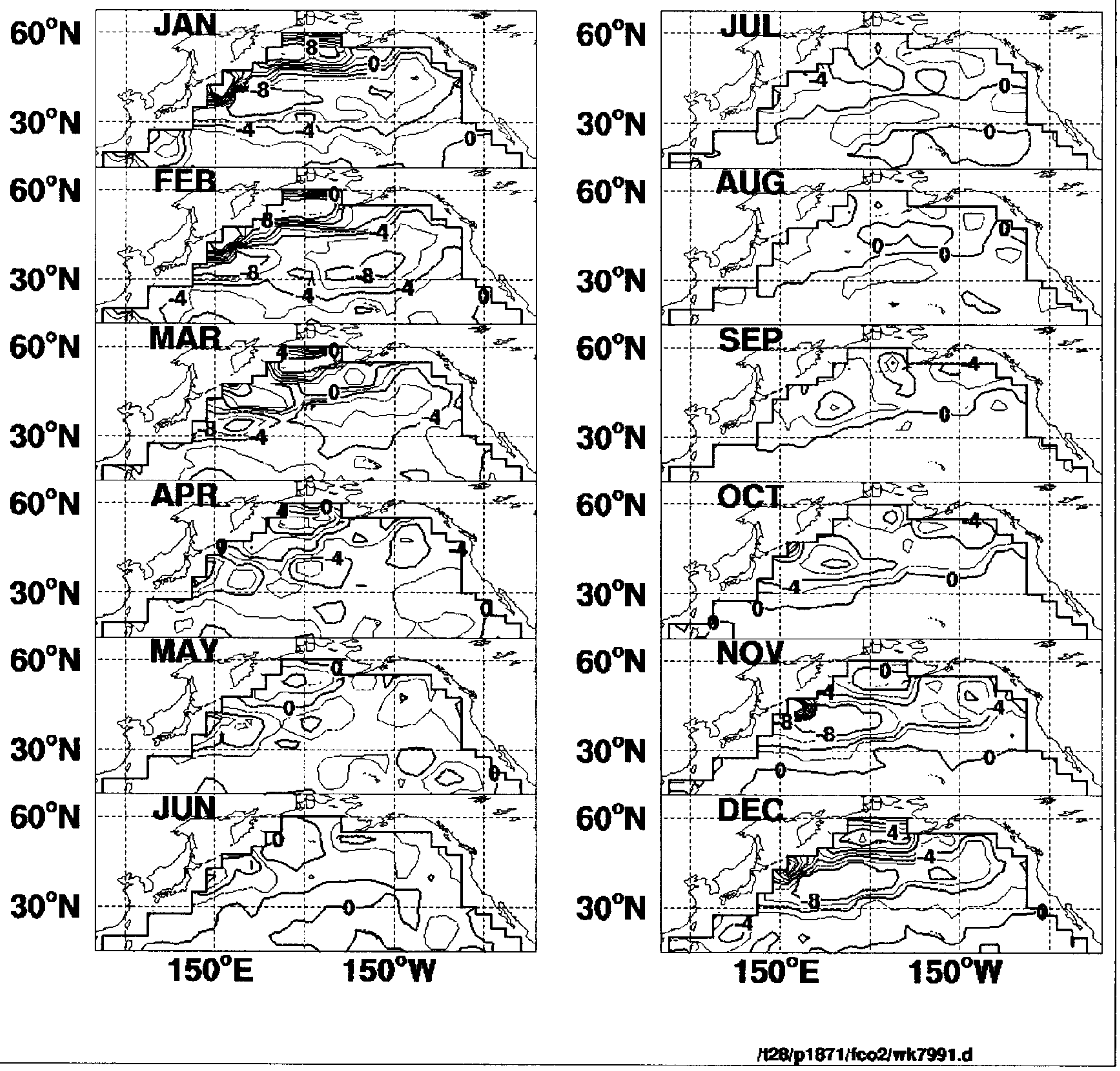

Fig.1 Sea to Air flux of CO_2 estimated monthly. Unit is x10^6 kgCO_2/grid/6h. Grid interval is 2.5 degrees in latitude and longitude directions.

In a standard setting for inversion, we acquired 0.15 PgC/yr increase as a mean of responses from 15 transport models over north Pacific (15°N-60°N), making 0.30 PgC/yr absorptions. This increase was estimated to be 0.2x10^6 kgC/grid/6hr at 15°N and 0.1x10^6 kgC/grid/6hr at 60°N if corrections were applied homogeneously over north Pacific Ocean of 4.4x10^{13} m^2. Both corrections were too small compared to the values shown in Fig.1.

5.Discussion

We obtained two estimates for north Pacific CO_2 absorptions; 0.35 PgC/yr from partial pressure of CO_2 data set plus monthly mean winds, and 0.30 PgC/yr from atmospheric inversion method. Both estimates were smaller than the estimate of Takahashi *et al.* (1999). Because gas transfer velocity depends on the winds speed, and the winds speed is large at middle of the north Pacific in winte, an accurate estimate of the gradient of partial pressure at the middle of the north Pacific may be required to improve the estimate, although current data of partial pressure gradient at these area is smaller than other area. Flux of CO_2 was largest at the edge of western side of the north Pacific, which indicates that sea of Japan and sea of Okhotsk in winter to spring may be required to fill the gaps among these estimates.

Reference

(1) Takahashi, T., R.H. Wanninkof, R.A. Feely, R.F. Weiss, D. W. Chipman, N. Bates, J.Olafsson, C.Sabine, and S. C. Sutherland, Net sea-air CO2 flux over the global oceans: An improved estimate based on the sea-air pCO_2 difference. (In Proceedings of the 2nd international symposium CO_2 in the oceans, Center for global environmental research, National Institute for Environmental studies, 1999)

(2) Esbensen, S. K., and Y. Kushinier, The heat budget of the global ocean: An atlas based on estimated from the surface marine observations,(Climate Research Institute Report #29, Oregon State University, Corvalis, OR, 1981).

(3) Wanninkhof, R., Relationship between wind speed and gas exchange, (J. Geophys. Res., 97, 7373-7382, 1992)

(4) Etcheto J., J. Boutin and L. Merlivat, Seasonal variation of CO_2 exchange coefficient over the global ocean using satellite wind speed measurements, (Tellus, 43B, 247-255, 1991).