研究課題名 : 大気輸送モデルとインバースモデルによる温室効果ガス収支量の推定とその高精度化に関する研究（Application of the transport models for inverse modeling studies of the greenhouse gas fluxes）

課題代表者：国立環境研究所地球環境研究センター　Shamil Maksyutov
共同研究者：国立環境研究所地球環境研究センター　Dmitry Belikov・Nikolay Kadygrov・
Vinu Valsala・Heon-Sook Kim・白井知子・古山祐治・中塚由美子・齊藤 誠・
佐伯田鶴・斉藤 龍・小田知宏
東京大学気候システム研究センター　今須良一・丹羽洋介
実施年度：平成 14 年度～平成 20 年度

1. Objective

The purpose of this research is to estimate the global and regional distributions of CO_2 fluxes with the available ground-based and aircraft observations as well as forthcoming satellite observation data.

2. Research plan

Inverse model of the atmospheric CO_2 transport is used for the analysis of the global and regional carbon budget. Our current research focuses on the use of the CO_2 data of the whole troposphere as observed by monitoring programs and GOSAT satellite. To provide more accurate estimation of the surface fluxes with inverse modeling, both atmospheric transport model and inversion algorithms have to be improved.

3. Progress

We completed development and testing of a flux form version of the global tracer transport model with is suitable for carbon flux inverse modeling using 4-D variational assimilation approach, based on adjoint code of a transport model. The model uses a 2-nd order mass conservative algorithm (van Leer scheme), and a mass conservation enforcement based on wind correction scheme employing a 2-D Poisson equation solver. The Poisson solver is implemented with library procedures for 2-D FFT transformations. In addition to improved mass conservation properties, a new model shows better balance between vertical mixing and surface CO_2 flux seasonality (Fig.1), and reasonable inverse model results for north hemispheric extratropical carbon sink.

We also completed an evaluation of global distribution of the transport model biases and errors for use in the GOSAT column CO_2/CH_4 concentration retrievals. A global map of the tracer concentration variability and model errors at synoptic, seasonal and interannual scales were constructed (Fig. 2).

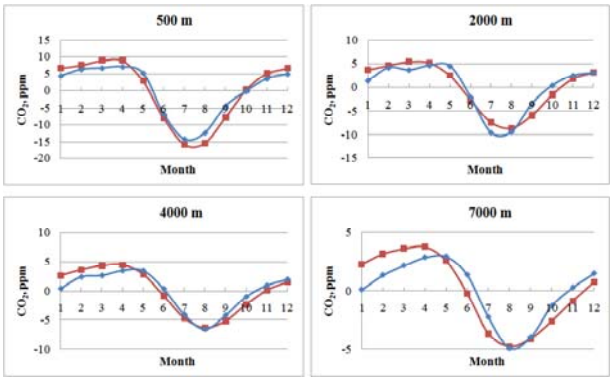

Fig. 1 Seasonal cycle amplitude of the atmospheric CO_2 over Siberia is simulated reasonably well both in PBL and free troposphere (red – observations, blue - model).

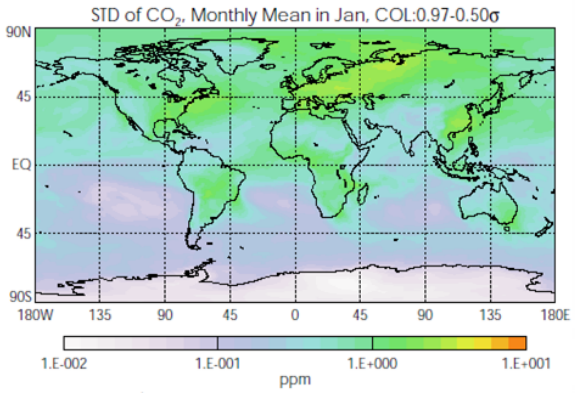

Fig. 2 Global distribution of the short-term CO_2 variability.

4. Future plan

The recently developed transport modeling tools will be applied to analysis of the global carbon cycle for last 15-20 years using ground based airborne and satellite data. A global distribution of the seasonally varying regional CH_4 surface fluxes will be studied with inverse model.

5. CPU use in the current year (from April to October 2008)

14 users, CPU hours ＜1 node：2,819 hours,
1 node：82 hours, 2 node：1 hour, total：2,902 hours

6. Summary of Research during the last year

6.1. Title

Application of the transport model for inverse modeling studies of the regional and global budgets of CO_2

6.2. Objective

The purpose of this research is to estimate the global and regional distributions of CO_2 fluxes with the available ground-based and aircraft observations as well as forthcoming satellite observation data.

6.3. Summary of Results

A global inverse model was used to estimate the optimal set of parameters for CASA terrestrial biosphere model, by first calculating sensitivities of the CO_2 seasonal cycle to model parameters, and then finding the set of parameters that provides best fit to the observed CO_2 vertical profile seasonality (Fig 3). For this purpose, the data from several continuous ground-based observations were used in addition to the vertical profiles from airborne measurements and GLOBALVIEW dataset.

Also, based on GOSAT orbit data coupled with the results of transport model, the satellite observations and data uncertainties were simulated. Our results show that, when relatively low biases are present in the observation, the forthcoming GOSAT data can reduce the uncertainties of monthly regional surface-CO_2 fluxes by up to 60% in comparison with the case when the same prior flux uncertainties are assumed but without satellite observations. Map of flux uncertainty reductions shown on Fig 4.

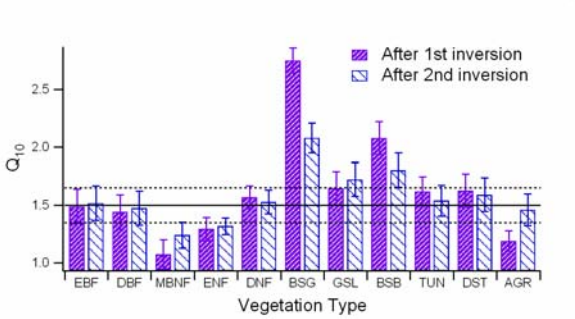

Fig. 3 Optimal ecosystem model parameters (Q10 for each vegetation type and after 1st and 2nd iterations) that provide best fit to observed seasonal cycle of CO_2 concentration.

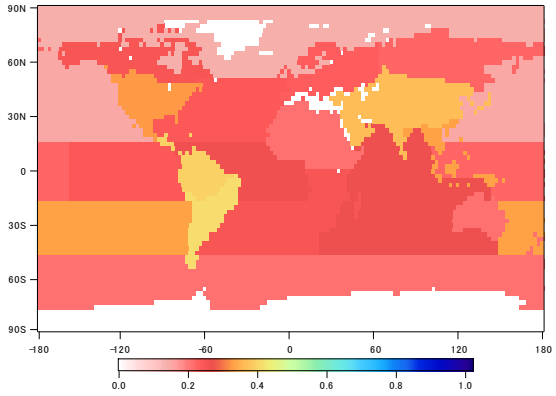

Fig. 4 CO_2 flux uncertainty map (GtC/year/region) after adding satellite observations.

6.4 CPU use in the previous year

13 users, CPU hours ＜1 node：1,138 hours,
1node：0 hour, 2 node：303 hours, total：1,440 hours