B-1.2 A preliminary study on derivation of aerosol distribution using a climate model on the basis of anthropogenic emission data of aerosol sources

Contact person Hiroshi KANZAWA
Head, Atmospheric Physics Section
Atmospheric Environment Division
National Institute for Environmental Studies
Environment Agency of Japan
16-2, Onogawa, Tsukuba, Ibaraki 305-0053, Japan
Tel: +81-298-50-2431 Fax: +81-298-51-4732
E-Mail: kanzawa@nies.go.jp

Total Budget for FY1997-FY1999 2,626,000 Yen (**FY1999**; 2,626,000 Yen)

Abstract The input interface of aerosol-related emission scenario data into a climate model is investigated, and the input data are made on the basis of the investigation. Grid digitization of the aerosol emission data and derivation of spatial distribution of aerosols in the atmosphere are carried out: This derivation is required for a future projection of global warming by a climate model as a contribution to the IPCC TAR (Third Assessment Report). In the derivation, not only sulfate aerosols but also carbonaceous aerosols are treated, and IPCC SRES (Special Report on Emissions Scenarios) scenario data are used. It is found that the following issues should be overcome to make the input data in a more comprehensive way: (i) To develop comprehensive methods of treating the case that the CO2 emission sources required by climate models are different from those of the emission scenarios given by integrated assessment models; (ii) To develop methods of treating economic growth rates for each country, population change, etc.

Key Words Emission Scenario Data, Grid Digitization, Aerosol Distribution

1. Introduction

The ultimate purposes of this research project are to estimate time and spatial distribution of global warming (climate scenarios) by numerical integration of the CCSR/NIES climate model developed through joint research of NIES (National Institute for Environmental Studies) with CCSR (Center for Climate System Research, University of Tokyo) on the basis of emission scenarios made by integrated assessment models such as AIM (Asian-Pacific Integrated Model) developed mainly by NIES and Kyoto University with international cooperation. In this project, the interfaces between climate models and integrated assessment models such as the method of incorporating the emission scenario data given by integrated assessment models into the global climate models are investigated.

2. Research Objective

The final goal of the research project is to derive aerosol distribution as a given parameter to a climate model on the basis of anthropogenic emission data of aerosol sources.

3. Research Method

This research is the start of a concrete realization of coupling of the CCSR/NIES climate model and AIM. This is a trial to integrate two research groups of modeling natural and socio-economic which exist in NIES: two groups are located not in other institutions in Japan and located rarely in the world.

4. Results and Discussion

4.1 Harmonization of emission data in the IPCC SRES scenarios

SRES (Special Report on Emissions Scenarios) made by IPCC WG III has 4 narrative scenario families of A1, A2, B1, and B2 (e.g., Morita, 1999). Emissions are calculated for each 4 scenario family using each integrated assessment model (IPCC, 2000). In the final stage of SRES report, A1 scenario family is divided into 3 scenario groups, i.e., A1B, A1T, and A1FI. We treat A1B which has been the representative of A1: The marker scenario of A1, which was originally posted on the SRES web site, was A1B made by the AIM model. The

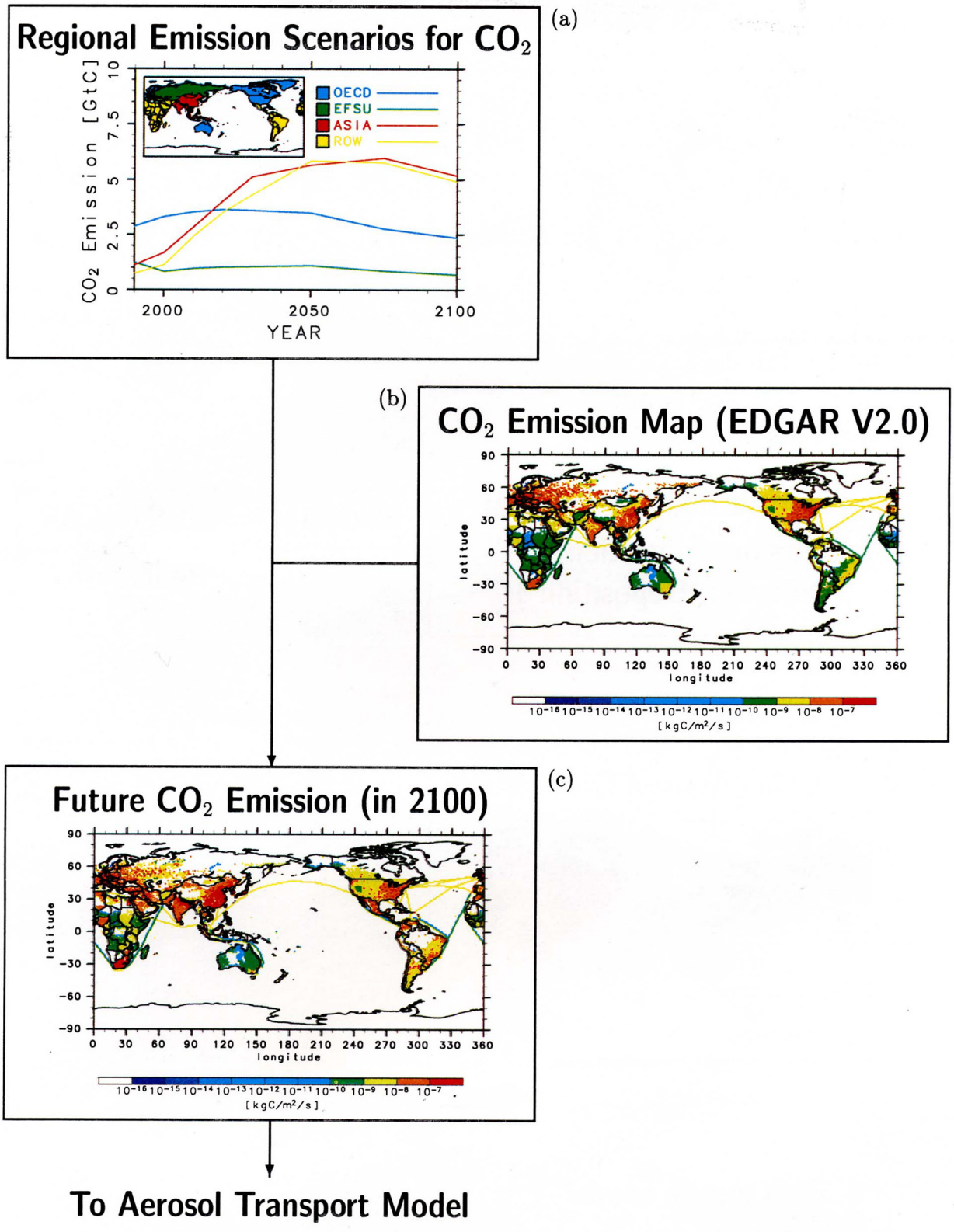

Figure 1: Flow chart showing how to estimate geographical distribution of future CO_2 emission. By way of illustration, CO_2 emissions by fossil fuel are shown for SRES A1 scenario which are made by AIM model. (a) Harmonized regional emission scenarios. (b) Existing fossil fuel CO_2 emission from EDGAR V2.0 (Oliver et al., 1996). (c) Geographical distribution of the estimated fossil fuel CO_2 emission in 2100.

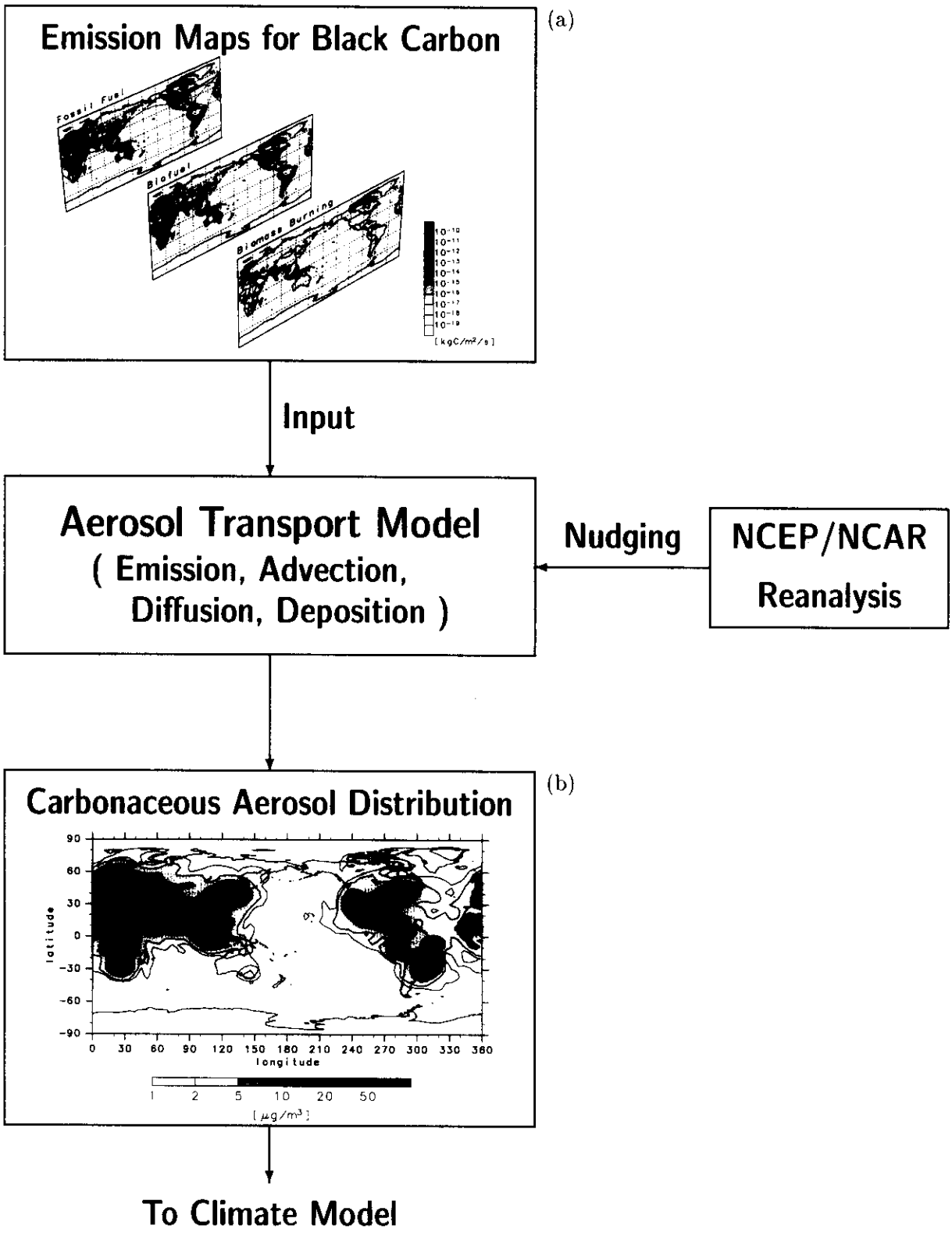

Figure 2: Flow chart showing how to derive future spatial distributions of carbonaceous aerosol. By way of illustration, the carbonaceous aerosol in 2100 is shown for SRES A1 scenario which are made by AIM model. (a) Geographical distribution of the black carbon (BC) emission in 2100. Estimated by the method shown in Fig. 1. (b) Geographical distribution of the surface carbonaceous aerosol concentrations in 2100.

values of emission in 1990 and 2000 are different among 4 marker scenarios for the 4 families although they should be same in each year. Therefore we harmonize the emission data as follows:

(i) The average value of emissions of the 4 marker scenarios (A1B, A2, B1, and B4) is adopted for each scenario in 1990 and 2000.

(ii) After 2010, the difference between the average value and the original value in 2000 is added to the original value in future. With regard to emission values which are anticipated to decrease in future such as carbon dioxide relating to land-use-change and sulfate dioxide, however, the added values are set to decrease 10 %/decade to make the values in 2100 equal to the original values in 2100.

4. 2 Grid digitization of carbonaceous aerosol emission data

Emission data are given in ten or less areas in the world considering economic growth rates and regional characteristics. Grid digitization is required for input to climate models. The grid digitization is made according to the following method (see Fig. 1):

(i) The world is divided into 4 regions: OECD, East Europe and past USSR; Asia; Others (Fig. 1a).

(ii) The grid point data of EDGAR V2.0 (Oliver et al., 1996), GEIA (Cooke and Wilson, 1996), etc. (Fig. 1b) are adopted for horizontal distributions in a relative sense. The horizontal distribution of emission within the region is scaled by the integrated values of the region (Fig. 1c).

4.3 Aerosol distribution in the atmosphere using a transport model

Because the parameters required for the CCSR/NIES climate model is atmospheric concentration of aerosol, aerosol concentration in the atmosphere should be calculated from the gridded emission data as shown in Fig. 2. An aerosol transport model of off-line developed in the framework of CCSR/NIES model (Takemura et al., 2000) is used. The distinction between organic carbon (OC) scattering the solar radiation and black carbon (BC) such as soot absorbing the solar radiation is considered for carbonaceous aerosols.

Global warming future projection experiments using CCSR/NIES climate model on the basis of the aerosol distribution were done as shown in Nozawa et al. (1999, 2000) and in this project's report of sub-theme (1). The experiment data have been submitted to the IPCC data center, and will contribute to IPCC TAR.

References

Coke, W.F. and J.J.N. Wilson (1996): A global black carbon aerosol model. J. Geophys. Res., 101, 19395-19409.

IPCC (2000): Special Report on Emission Scenarios. Cambridge Univ. Press, to be published.

Morita, T. (1999): Global warming and economics. In "Change in Atmospheric Environment" (Iwanami Lecture on Earth Environment Science), Chap. 6, Iwanami-shoten, 249-279. 9 (in Japanese).

Olivier, J.G.J., A.F. Bouwman, C.W.M. van der Maas, J.J.M. Berdowski, C. Veldt, J.P.J. Bloos, A.J.H. Visschedijk, P.Y.J. Zandveld and J.L. Haverlag (1996): Description of EDGAR Version 2.0. A set of global emission inventories of greenhouse gases and ozone-depleting substances for anthropogenic and most natural sources on a per country basis and 1° x 1° grid. RIVM report nr. 771060 002 (TNO-MEP report nr. R96/119), 171pp.

Takemura, T., H. Okamoto, Y. Maruyama, A. Numaguti, A. Higurashi and T. Nakajima (2000): Global three-dimensional simulation of aerosol optical thickness distribution of various origins. J. Geophys. Res., 105, D14, 17853-17874.

Nozawa, T., H. Kanzawa, Y.N. Takayabu, S. Sugata, S. Emori, A. Higurashi, K. Takata, A. Numaguti, A. Abe-Ouchi and M. Kimoto (1999): Direct and indirect radiative forcings due to various aerosols. CGER's Supercomputer Activity Report, Vol. 7, 16-21.

Nozawa, T., S. Emori, A. Numaguti, T. Takemura, T. Nakajima, A. Abe-Ouchi and M. Kimoto (2000): Coupled ocean-atmosphere model experiments of future climate change based on IPCC SRES scenarios. 11th Symposium on Global Change Studies, Am. Meteorol. Soc., Long Beach, CA, U.S.A., January 2000.