

B-1 Evaluation of Temporal and Spatial Variability of Greenhouse Gases

Project Leader: Hiroshi Bandow

Institution: The National Institute for Environmental Studies

Period: FY1990 - 1992 Budget: 52,153,000 yen

Research (1) Study on the Environmental Behavior of Greenhouse Gases of

Organization: Industrial Origin

Koji Kitabayashi, Masayasu Hayashi, Minoru Gamo,
Shoichi Taguchi, Ryouichi Imasu, Susumu Yamamoto,
Hiroshi Yoshikado, Hiroaki Kondo, Toshiyuki Tanaka,
and Takeki Mizuno

National Institute for Resources and Environment
Agency of Industrial Science and Technology
Ministry of International Trade and Industry

(2) Studies on Temporal and Spatial Variability of Reactive
Greenhouse Gases and Their Related Compounds in The
Atmosphere

Hiroshi Bandow, Yoko Yokouchi, Fumio Sakamaki,
Hitoshi Mukai, and Atsushi Tanaka

The National Institute for Environmental Studies
Japan Environment Agency

Key Words: Carbon Dioxide, Methane, Reactive Greenhouse Gases,
Aircraft Measurement, Spatial Distribution

Summary:

1. Background

The problem of global warming has been arising by the increase of carbon dioxide, a greenhouse gas (GHG), in the atmosphere emitted from fossil fuel burning. Also other atmospheric trace gases, such as methane, nitrous oxide, chlorofluorocarbons (CFCs), and tropospheric ozone, are now known to have much higher radiative forcing than carbon dioxide on a molar basis, and the concentrations of these gases are increasing significantly in the environment. However, scientific understanding of the dynamics of GHGs, i.e. sources, sinks, transforming processes, and causes of their increase is quite limited. In order to clarify the dynamics of the GHGs and related atmospheric trace gases, it is required to know their concentrations in the environment, their

trends, and their temporal and spatial variabilities precisely.

2.Objectives

This project consists of two sub-projects and main objectives of each sub-project are as follows:

(1) Study on the environmental behavior of greenhouse gases of industrial origin: Investigation of the sources and sinks of CO₂ and CFCs, and field observations over and around Japan in order to study behavior of CO₂ in the environment.

(2) Studies on temporal and spatial variability of reactive greenhouse gases and their related compounds in the atmosphere: Field observations of methane (CH₄), non-methane hydrocarbons (NMHCs), CO, NO_x, and atmospheric sulfur compounds in order to evaluate photochemical reactivity of the atmosphere and assess the indirect effect on radiative forcing.

3.Results

In this fiscal year, the following studies have been performed.

(1): Spatial and temporal variation of CO₂ concentration and meteorological conditions were measured using an aircraft and a tower around Iriomote Island (24.4N, 123.8E) in November 1991. From the data, net-uptake rate by vegetation is derived to be 2 to 4 g/m²hr under daytime condition at Iriomote in March (previous data) and November, and the value is roughly proportional to strength of the insolation. The up-take rate becomes ca. 1g/m²hr under the cloudy condition or in the evening. In addition, similar field measurement of CO₂ was carried out using a tower in a temperate pine woods at Tsukuba, and the up-take rate of CO₂ obtained in the daytime at the site is found to ca. 70% of the value in a sub-tropical forest at Iriomote.

(2): Spatial and temporal variability of CH₄ and C₂-C₅ NMHCs has been measured for more than 2 years at three remote areas in Japan using a grab-sampling method (monthly basis) and GC analysis. Latitudinal distribution and annual change of CH₄ concentration obtained show agreement with those of global average reported so far. The result also indicates a longitudinal gradient of CH₄ which could be attributable to significant sources of CH₄ in the Asian continent. Change in the ratio of the concentration between paraffinic and olefinic NMHCs suggests that the olefinic NMHCs originate in part from sea water. Also, dimethyl sulfide (DMS) in the atmosphere was measured using automated pre-concentration/capillary-GC/MS system. The result indicates other emission sources except ocean contribute the atmospheric DMS. Analysis of DMS in some soils was done and revealed that the amount of DMS in the soil is ca. several ng/g soil, implying that the soil is a potential source for atmospheric DMS.

No.B-1 No.(Subtitle) (1)

Title Evaluation of Temporal and Spatial Variability of Greenhouse Gases

Subtitle Study on the Environmental Behavior of Greenhouse Gases of Industrial Origin

Project Leader Koji Kitabayashi

Institution National Institute for Resources and Environment

Period FY1989 - 1992 Budget 30,461,000 yen (32,740,000 yen)

Research organization Koji Kitabayashi, Masayasu Hayashi, Minoru Gamo, Shoichi Taguchi
Ryouichi Imasu, Susumu Yamamoto, Hiroshi Yoshikado, Hiroaki Kondo
Toshiyuki Tanaka and Tateki Mizuno

 National Institute for Resources and Environment,
 Agency of Industrial Science and Technology,
 Ministry of International Trade and Industry

Key Words CO₂ Exchange process Airplane measurement Iriomotejima Vegetation

Summary

1. Background

Assessments of the CO₂ concentration in future and its impact on environment have large ambiguity due to uncertain behavior of CO₂ in the environment and uncertainty of the fossil-fuel consumption. In this study, the sources and sinks of CO₂ and CFCs (Chlorofluorocarbons) are investigated and field observations to study the behavior of CO₂ in the environment are carried out over and around Japan.

2. Objectives

Main objectives of this study are as follows;

- (1) Investigation of the sources and sinks of CO₂ and CFCs .
- (2) Development of field sensors of these gases and field measurement method.
- (3) Field observations using the airplane, boat and tower to study the exchange rates of CO₂ among the atmosphere, vegetation and sea.

3.Result

In last fiscal year, spatial and time variations of the CO₂ concentration and meteorological condition such as air-temperature, wind and insolation were measured using an airplane and tower from 21st to 24th of March, 1991. Same survey around Iriomote Island were carried out from 6th to 8th of November, 1991. In this survey, the behavior of CO₂ in the fall conditions of vegetation were investigated. Total number of flights was 7 runs and the flight path covered three or four heights between 200m and 1500m and the duration of each run was approximately one and half hours. In the same period, air above and around the Iriomote was sampled using airplane and three poles. The concentration of CO₂ was analyzed by a non-dispersive infrared gas analyzer. Time variations of CO₂ and meteorological conditions such as air-temperature, wind and insolation were measured continuously by a tower.

We carried out other field experiment to study the intake rate of CO₂ of temperate evergreen forest such as pine trees at Tsukuba-city in July, September 1991 and January 1992. Time variation of CO₂ intake rate and the relations between intake rate and meteorological conditions were investigated.

According to observational results, net-intake rate of CO₂ due to the activity of vegetation takes a value of 2 to 4 g/(m²hr) under daytime condition of the Iriomote in March and November, and the value is roughly proportional to the amount of insolation. These values become about 1 g/(m²hr) under the cloudy condition or in the evening. From the experiment in the pine trees at Tsukuba-city, we get the net-intake rate of CO₂ of 1.5 to 2.5 g/(m²hr) in daytime. These values are 70 % of the intake rate of the vegetation in the Iriomote.

In next fiscal year, we will carry out the field experiment in summer of the Iriomote and in fall of northern part of Hokkaido. From these results, we will construct the CO₂ cycle model under the temperate vegetation and weather conditions.

International Cooperation

Attendance at the meeting of the committee of Global Emission Inventories Assessment (USA) and at the Workshop for Trace Gas Measurement (Australia).

Publication

- (1) Yamamoto, S. et al., 1992: Study on the Natural Sinks and Sources of CO₂ in Iriomote Island (2) Airplane Measurement of CO₂, Kogai, Vol.27 No.1 (in Japanese).
- (2) Hayashi, M. et al., 1992: Prospects for Innovative Environmental Technologies, Kogai Vol.27 No.1 (in Japanese).
- (3) Yamamoto, S., 1992: Regional Aircraft Measurement of CO₂, Proceeding of Workshop for Trace Gases Measurement (Australia).

No. B-1 No.(Subtitle): (2)

Title: Studies on Temporal and Spatial Variability of Reactive Greenhouse Gases and Their Related Compounds in The Atmosphere

Project Leader: Hiroshi Bandow

Institution: The National Institute for Environmental Studies

Period: FY1990-1992 Budget: 21,319,000 yen (19,413,000 yen)

Research Organization: Hiroshi Bandow, Yoko Yokouchi, Fumio Sakamaki, Hitoshi Mukai*, and Atsushi Tanaka*
Global Environment Division
*Environmental Chemistry Division
The National Institute for Environmental Studies

Key Words: Reactive Greenhouse Gases, Indirect Greenhouse Effect, Methane, Non-methane Hydrocarbons, Reduced Sulfur Compounds

Summary:

1. Background

Gases can exert a radiative forcing both directly and indirectly, the latter being resulted from yielding greenhouse gases(GHGs) or affecting the atmospheric lifetime of GHGs through chemical transformations of the original gases. Recent findings of the increase of tropospheric ozone and sulfate aerosols have made the concept of indirect greenhouse effect of the atmospheric constituent important. However, there are large uncertainties in assessing the indirect effect because of our incomplete understanding of distributions and chemical transformation processes of reactive GHGs and their related compounds in the atmosphere. It is required to identify sources and sinks and to quantify the dynamics(i.e. temporal and spatial variability) of these compounds to assess Global Warming Potentials including the indirect effect.

2. Objectives

Methane, as well as CO, non-methane hydrocarbons(NMHCs), and NO_x, has an indirect effect on the radiative forcing of the atmosphere through changes in tropospheric ozone and the atmospheric OH radicals, while methane is known as one of the important greenhouse gases. Atmospheric sulfur compounds have also the indirect effect by producing sulfate aerosols which are the precursor of cloud droplets over the ocean. In this research project, temporal and spatial variabilities of these gases in the atmosphere are investigated by field measurements in order to evaluate photochemical reactivity of the atmosphere

and assess the indirect effect.

3. Results

Results obtained in the 1991 fiscal year are as follows.

(1)Variability of the concentration of methane and NMHCs in a background air around Japan: Grab-sampling of the air has been carried out monthly at three unpolluted sites, Ishigaki(24.5N, 124.3E) and Ogasawara(26.7N, 142.1E) Islands, and Nossapu Peninsula(43.4N,145.8E). Concentration of methane and C2-C5 NMHC were analyzed. Latitudinal distribution and annual change of methane concentration show agreement with those of global average reported. The result also indicates that methane concentration at Ishigaki is higher than at Ogasawara, suggesting a longitudinal gradient which may be caused by significant sources of methane in the Asian Continent. Changes in the concentrations of methane and NMHC with wind directions measured at Iriomote Island near Ishigaki also indicate the effect of the continent on the air of the west rim of the Pacific Ocean, i.e. at the site the concentrations of these gases are found higher in northwesterly(air mass from the continent) than in southerly wind (that from the Pacific). Also the change in the ratio of the concentration between paraffinic and olefinic hydrocarbons(HCs) suggests that the olefinic HCs originate in part from sea water.

(2)Spatial Distribution of HCs and NO_x in maritime air masses around Japan and over the western Pacific: In IGAC/APARE Activity, two aircraft measurement campaigns, GTE/PEM-West(by NASA) and PEACAMPOT(by NIES), were carried out in fall, 1991. We joined in both campaigns and measured concentrations of HCs(in both) by the same method as mentioned above and NO_x(in PEACAMPOT campaign). Detailed analyses of the observed data are under way.

(3)Reduced sulfur compounds in the atmosphere: Dimethyl sulfide(DMS) in the atmosphere was measured using automated pre-concentration/capillary-GC/MS system. Hourly measurements were done at Monitoring Station of our institute in Tsukuba. Concentration of DMS was found to be usually much higher in the nighttime than in the daytime and anti-correlated with ozone. The result could be attributable to rapid decay of DMS by reactions with OH radicals and ozone in the daytime. There are no clear correlation between DMS concentration and wind directions(from sea or from inland). This result suggests that there might be other significant sources of DMS than the ocean. Soil and plants are possible candidates for the source. New technique has been, therefore, developed for measuring volatile organic compounds in the soil based on thermal vaporization from sampled soil. Analysis of some soils in our institute revealed that the amount of DMS in the soil is in the range of several ng/g soil. This value is comparable to that in the sea water, implying that the soil is also an important source for atmospheric DMS.