The Third Session of the Scientific Advisory Committee
on the Acid Deposition Monitoring Network in East Asia
24-26 November 2003, Pattaya, Thailand

Review of Ongoing Research Activities

I. Joint research project with Russia

INC/NC started implementing of the joint research project Phase 1 on "Standardization and Advancement of Assessment Methods of Acid Deposition in Frigid Zone" with the Limnological Institute, Russian Academy of Science, Siberian Branch (RAS/SB) in 1998. The objectives of this joint research were to obtain basic information for improving monitoring methodologies applicable to frigid zone by implementing test monitoring in accordance with the technical manuals on Acid Deposition Monitoring Network in East Asia (EANET) and to evaluate the following items mainly: (1) applicability of QA/QC programs; (2) workability and applicability of wet-only sampler; (3) applicability of filter pack methods in dry deposition monitoring.

This project had continued until 2001 and following results were obtained mainly:

(1) Hydrogencarbonate analysis for wet deposition obviously improves the ion balance of the sample and it is strongly recommended that this ion should be determined for the samples with a pH of more than 5, and when the sum of the calcium and magnesium in the total cations concentration is more than 40 percent[1].

(2) In a case study at a meteorological observatory, for snow samples an average wind loss is about 80%. At present, there is no perfect method to collect the wet-only snowfall samples. Collection of fresh snowfalls seems to be convenient and the simplest method for every deposition event in winter.

(3) There are no any difficulties to monitor the concentration of gaseous and particulate matters by the filter park method in both cold and warm seasons.

NC has been implementing the joint research project Phase 2 on "Evaluation of Atmospheric Environment in East Siberia and Primorsky Region" with the Limnological Institute since 2002. The objective of the Phase 2 project is to obtain basic information on atmospheric environment in East Siberia and Primorsky Region and on trans-boundary air pollution over North East Asian/Pacific part in Northern Hemisphere. In this project, data analysis of wet deposition in East Siberia and Promorsky Region has been carried out. Monitoring data used for analysis are obtained by the method developed within the previous project. And concentrations of heavy metals (mercury and lead) and lead isotopic composition in snow samples have been determined to obtain information on trans-boundary air pollution.

This project will be continued until 2004. The summary of the first year 2002 research is as follows.

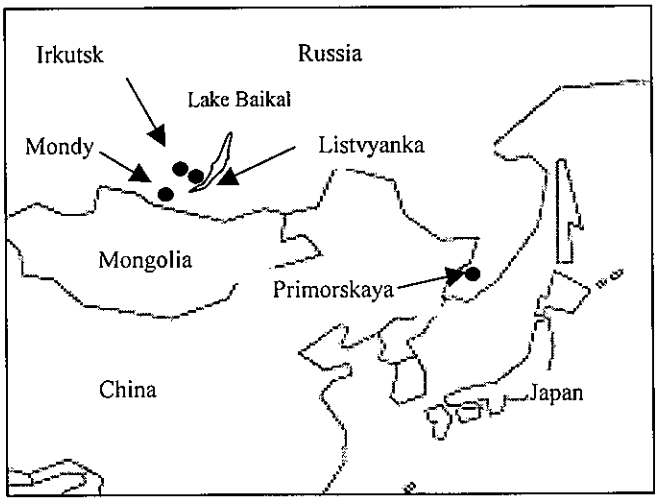

Fig.1 Location of monitoring sites

1. Introduction

Russian East Siberia and Primorsky region are located in northeastern part of Eurasian continent. Their atmospheric environment may be influenced by European sources of pollution and affect air quality in Japan. Therefore, it is important to clarify atmospheric environment there in order to evaluate long-range transportation of air pollutants. For these reasons, data analyses of wet deposition and monitoring of gas/aerosol concentrations were carried out annually at a remote site (Mondy, MO), a rural site (Listvyanka, LI), an urban site (Irkutsk, IR) in East Siberia, and a rural site (Primorskaya PR) in Primorsky region (Figure 1). And mercury and lead concentration and lead isotopic composition were also determined in snow cover in East Siberia.

2. Data analysis of wet deposition in East Siberia and Primorsky region

Annual precipitation amounts were ranged from 204mm (MO) to 728mm (PR) in 2002 with seasonal variation, higher in warm season. Annual mean pH were ranged from 4.85 to 6.19 and concentration of major components were in order of IR>PR, LI>MO. Concentrations and deposition amounts of major components varied with season, the first ones were higher in cold season meanwhile the depositions were larger in warm season, respectively. Although annual mean concentration of nss-SO_4^{2-} and NO_3^- in the precipitation in East Siberia were higher than in Japan, annual deposition amounts of these ions were extremely smaller than that in Japan[2)] due to small precipitation amount (Figure 2).

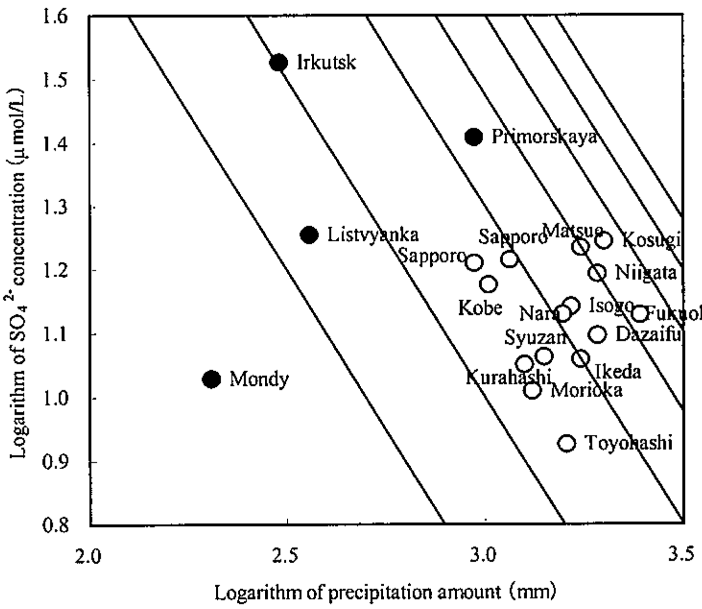

Fig. 2 Relationship between precipitation amount and nss-SO_4^{2-} concentration (●Russia: 2002, ○Japan: 1999JFY)
Solid lines show the scale of deposition corresponded to 5, 10, 20, 30, 40, 50, 60 mmol/m²

3. Data analysis of gas and aerosol concentration in East Siberia and Primorsky region

SO_2 and HNO_3 gas concentration monitored using filter-pack method were higher in LI and lower in MO harmonizing to concentration of corresponding components in the precipitation. NH_3 gas concentration in MO was equal to that in LI, and NH_3 concentration in IR was two times higher than that in LI and MO. Concentration of gases and major components in aerosols were measured as lower than that in Japan, and ratios among components did not show significant differences. Concentrations of all components in MO were the lowest among 4 sites. Gaseous SO_2 and HNO_3 and aerosol NH_4^+ concentrations varied with season being higher in winter and spring while lower in summer. These variations may be strongly influenced by the variation of precipitation amounts. On the other hands, because NH_3 gas concentration did not decrease in summer, NH_3 emission amount was considered to increase in summer.

4. Lead and mercury concentration and lead isotopic composition of snow covers

Lead concentrations in snow cover samples collected in the area from IR to LI were ranged from 0.4 to 1.7 μg/L decreasing along the distance far from urban area (Figure 3). These

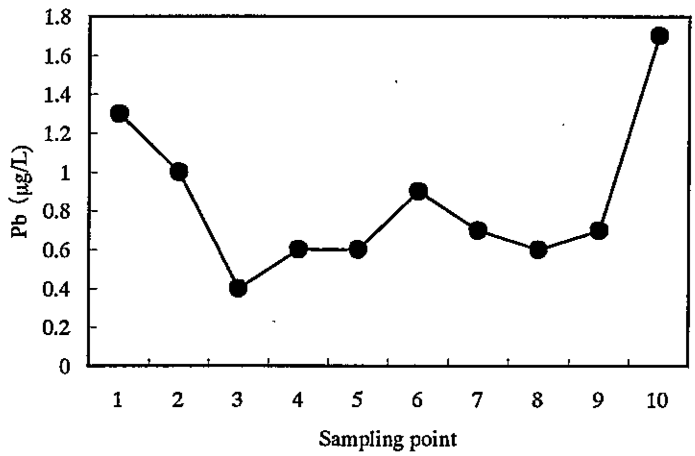

Fig. 3 Pb concentration in snow cover
(Irkutsk~Listvyanka, Russia, 2003)

concentrations were lower than that of snowfall collected in Japan[3]. Lead isotopic compositions of these samples were shown in figure 4 with the result of study in Japanese coast of the Sea of Japan[3]. In this figure, open circles show the areas in which samples with same air mass trajectory are plotted on monitoring in Japan. Lead isotopic compositions of Russian samples were in good agreement with that of snowfall, which was brought by air mass inflow from East Siberia to

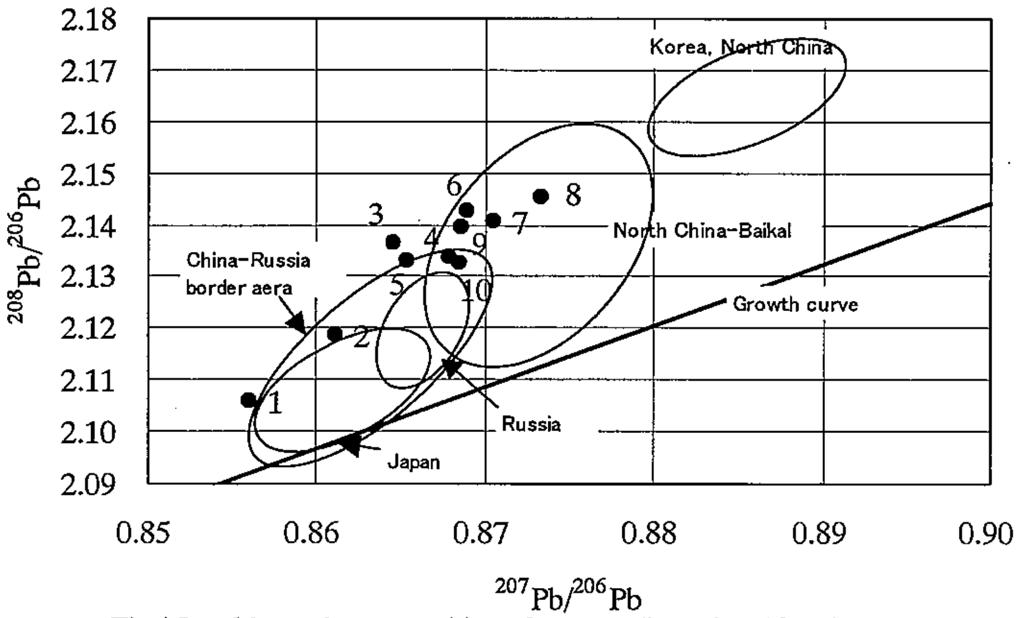

Fig.4 Lead isotopic composition of snow collected at 10 points along the line from Irkutsk to Listvyanka (Russia, 2003)

Japanese coast of the Sea of Japan. These results confirmed the close relationship between two regions.

Although these results are based on monitoring of one year performed for the first step to clarify the atmospheric environment in East Siberia and Primorsky region in Russia that occupy large area in East Asia, these results are very useful for data analysis of EANET. However, long term measurements are necessary to evaluate the quality of atmospheric environment in these areas due to very important of their as a transition area where long-range transportation of air pollutants from Europe and industrial regions of Russia to East Asia can be monitored.

5. Reference

1) Norio Fukuzaki, Tamara V. Khodzher and Hiroshi Hara, Quality Control of Chemical Analysis in Acid Deposition Monitoring -Improvement in Ion Balance by Hydrogenecarbonate Determination-, Journal of Japan Society of Atmospheric Environment, 37, 393-401 (2002).
2) Research Committee on Acid Deposition, Japan Environmental Laboratories Association, Report on Nationwide Acid Deposition Survey Phase 3 (1999JFY), Journal of Japan Environmental Laboratories Association, 26, 66-116 (2001).
3) Hitoshi Mukai, Atsushi Tanaka and Toshihiro Fujii, Lead Isotope Ratios in Snow Collected in Japan and Their Relations to Long-range Transport of Air Pollutants, Journal of Japan Society of Atmospheric Environment, 34, 86-102 (1999).

II. Joint research project with Thailand

1 Introduction

In order to research on dry deposition flux and velocity for a tropical forest, Network Center has been promoting a joint research program on dry deposition flux with Pollution Control Department, Thailand since January 2000 (JFY1999). The program is one of the activities following the Strategy Paper for Future Direction of Dry Deposition Monitoring of EANET that was endorsed by ISAG through the diplomatic channel in September 1999. A teak forest in Mae Moh, Lampang Province, Thailand was selected to study SO_2 and O_3 fluxes and deposition velocities in the joint research and observational station was established in the teak forest in 2001. Observations were regularly started in December 2001. In this time, the data on O_3 flux from December 2001 to September 2002 were analyzed.

2 Methods

2.1 Feature of the teak forest

The study field is located in Mae Moh area (18.28oN, 99.72oE). Observational station was constructed in a Teak (deciduous) forest in this area. The forest is flat and uniform as far as a distance of 1 km along main upwind directions. Density of the forest is about 625 trees/ha with height of crowns about 12 meters. An observational tower (24 meters) is constructed in the forest.

2.2 Measurement system

The measurement system consists of an ultrasonic anemometer, radiometers, ventilated wet and dry thermo meters (for temperature difference measurement), soil heat flux meters, a SO_2 monitor (UV fluorescence method), an O_3 monitor (UV photometric method) and a sampling changer. Differences of concentrations for SO_2 and O_3 were measured by using the sampling changer. Interval of sampling change was set at 5 minutes. In the system, some methods such as Bowen ratio and gradient methods are available to output the fluxes.

2.3 Computation of fluxes

At the first a modified aerodynamic gradient method (Feliciano et al., 2001) was applied to simulate the fluxes. The method assumes that heat and mass are transported in a similar way within a well-developed surface layer to be calculated by using of the equation:

$$F = u_* c_*,$$
$$c_* = k\,\Delta c \,/\, [\ln(z_2/z_1) - \Psi_h(z_2/L) + \Psi_h(z_1/L)],$$

where u* is the friction velocity and c* is the eddy concentration. Δc is the differences between SO_2 concentrations at levels z_2 and z_1, k is the Von Karman constant, L is the Monin-Obukhov length and Ψ_h is the integrated stability correction function for heat defined as by Erisman and Draaijers (1995).

Another gradient method was also applied by using diffusivity of latent heat flux (Q_h) based on sonic thermometry (Kaimal and Gaynor, 1990). The basic equation is the following:

$$F = K_h\,\Delta c,$$
$$K_h = Q_h \,/\, \rho C_p\,\Delta T,$$

where K_h is the diffusivity of the latent heat flux, ρCp is the specific heat capacity of the air at constant pressure.

3 Results

Figure 1 shows seasonal variation of O_3 at Mae Moh from December 2001 to September 2002. Seasonal change was clearly observed with dry season maximum and wet season minimum. The pattern of the seasonal change was also observed in Thailand according to a previous study (Pochanart et al., 2001). Fluxes, especially Δc was observed more precisely in dry season than that in wet season because high concentration condition is preferable for the precise flux measurement (Matsuda et al., 2002).

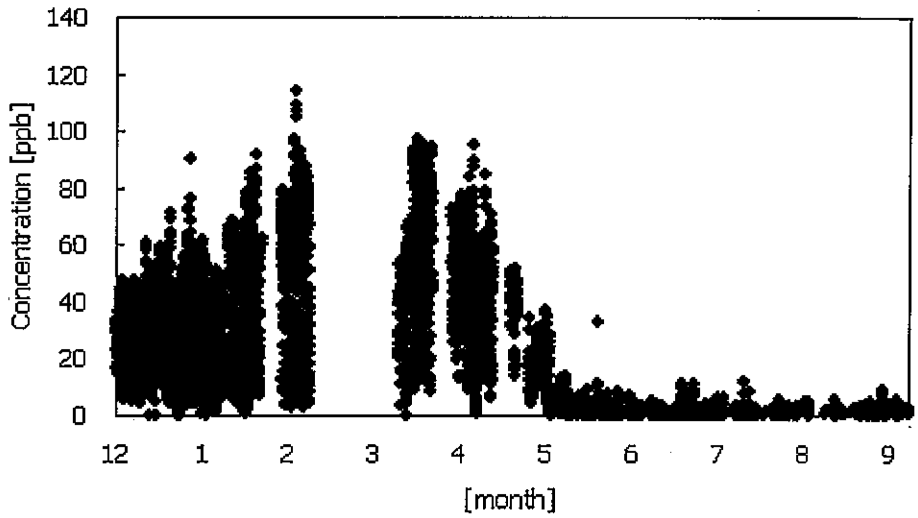

Fig. 1 Seasonal variation of O_3 at Mae Moh from December 2001 to September 2002

Figure 2 shows averaged diurnal variation of O_3 deposition velocities by two gradient methods from December 2001 to May 2002. Both deposition velocities increased in daytime, especially morning. Averaged diurnal variation of O_3 concentration from December 2001 to May 2002 is shown in Fig. 3. O_3 concentration rapidly increased in morning. There is a possibility that high and scattered deposition velocities in morning were caused by the measurement error of Δc under the condition of rapid change of O_3 concentration. Therefore the deposition velocities in afternoon, which varied around from 0.4 to 0.8 cm/s were considered to be relativelyreliable.

Level of the deposition velocity obtained in this study was not quite large different from previous studies on O_3 deposition velocities for deciduous forest according to a review in Lamaud et al. (2002).

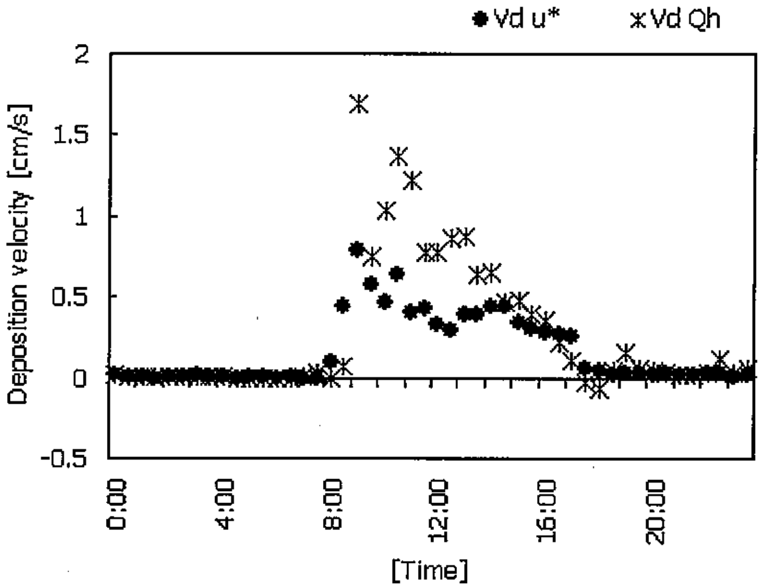

Fig. 2 Averaged diurnal variations of O_3 deposition velocities by two gradient methods from December 2001 to May 2002. Vd u* and Vd Qh mean the deposition velocities computed from friction velocity and diffusivity of latent heat flux respectively. Averaged values are given as median.

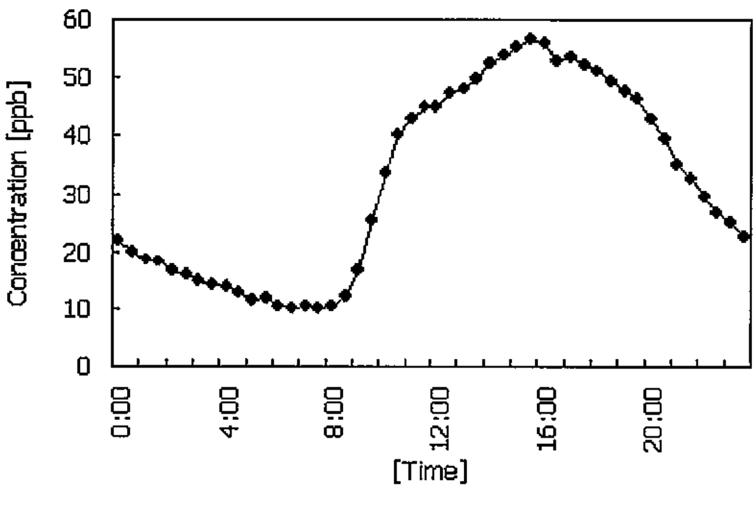

Fig. 3 Averaged diurnal variation of O_3 concentration from December 2001 to May 2002. Averaged values are given as median.

4 Next step

Problems to be solved and next subjects are suggested as follows:

- In order to obtain precise fluxes under the conditions of low concentration and rapid change of concentration, criteria of data screening should be considered taking into account the methodologies of flux calculation (e.g. Feliciano et al., 2001).
- Flux computation methods should be evaluated including Bowen ratio method.

- Study on SO_2 deposition fluxes should be done.
- In order to validate some parameterizations for inferring deposition velocity, observed variables such as wetness and leaf index should be expanded following the Strategy Paper.

5 References

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III. Joint research project with Mongolia

1. Objectives

East Asian Region is latitudinally wide area, and ecosystems are quite diverse depending on climatic zones. For evaluating direct effects of acid deposition on plant, it is necessary to accumulate information on plant sensitivity to acid deposition in respective climatic zones. However, in (sub-) arid zone, sensitivity and/or physiological response of plants to acid deposition have not been enough studied.

A decline of larch trees (*Larix* sp.) has been reported in Bogdkhan Mountain around Ulaanbaatar, Mongolia, and it might be due to air pollution from the thermal power plants. A number of useful plant (grass) species also grows in the mountainous area, and effect of the air pollution on plant species should be studied.

Based on the above background, Joint Research Project on plant sensitivity to acid deposition in Mongolia started in 2001. From 2001 to 2002, basic information on air concentration and physiological response of these plants to acid deposition has been obtained.

In 2003, Network Center for EANET obtained research budget from non-profit organization, "Sumitomo Foundation", and the Joint Research Project is being carried out in order to obtain information on implication between emission from a thermal power plant and chemical/ (eco-) physiological properties on plant and soil, and basic information on Mongolian plant sensitivities

2. Research team

The Central Laboratory of Environmental Monitoring, National Agency of Meteorology, Hydrology and Environmental Monitoring of Mongolia (hereinafter referred to as the "CLEM") and the Acid Deposition and Oxidant Research Center (hereinafter referred to as the "ADORC") are jointly carrying out the Joint Research Project. For implementation ofthe project, both parties are supported by relevant organizations such as National University of Mongolia (NUM) and National Institute for Environmental Studies of Japan (NIES).

3. Present studies

3.1. Measurement of air pollutant concentration using passive samplers

Air concentration of gaseous pollutants is being measured in the following monitoring site using passive samplers.

1) Monitoring sites
   - City area (2 point): Site A1 and A2 (the Ulaanbaatar Monitoring Site and the CIEM compound)
   - Grassland and forest areas facing the thermal Power Plant No.3 (2 points): Sites B and C (same as in the joint research project in JFY2001)
   - Reference forest area (2 points): Sites RF1 and RF2 (new sites: RF1, 17 km east from the power plant; RF2, 10 km east from the power plant)
2) Sampling interval
   Every two-week from the beginning of August 2003 through the end of November 2003
   Totally 4 months (8 sampling terms)
3) Measurement parameters
   - SO_2
   - O_3

3.2. Field observation of forest decline in the Bogdkhan Mountain

Distribution of declining trees in the mountainous area and these growth and visible conditions are surveyed in the Bogdkhan Mountain. The results of surveys will be described on the map with photographs of tree crown condition.

The decline scale of EANET Technical Manual will be usedfor observation of trees with referring useful information on ICP Forests. Detailed survey method will be discussed with the experts of NUM. Possibility of establishing the guideline wih photograph for observation of trees (Photo-guide) will be discussed during the mission.

3.3. Analysis of soil elements

In the forest area and grassland, soil sample (0-10 cm depths) will be collected at 6 points, namely Sites A1, A2, B, C, RF1 and RF2. Concentration of heavy metals in soil will be analyzed using Graphite Furnace Atomic Absorption Spectrometer (GF-AAS).

Elements to be analyzed: Cd, Co, Cr, Cu, Ni, Pb, Zn, etc.

3.4. Analysis of Larch needles

Larch needles will be collected before change of needle color in early autumn in 6 points, namely Site A1, A2, B, C, RF1, and RF2. Preferably the needles will be collected from 3 trees individually in each site. The needles will be powdered after washing and drying.

The powdered needles will be digested with nitric acid, and then analyzed by ICP-AES.

Elements to be analyzed: Cd, Co, Cr, Cu, Ni, Pb, Zn, S, etc.

3.5. Exposure test for Mongolian plant species in Japan

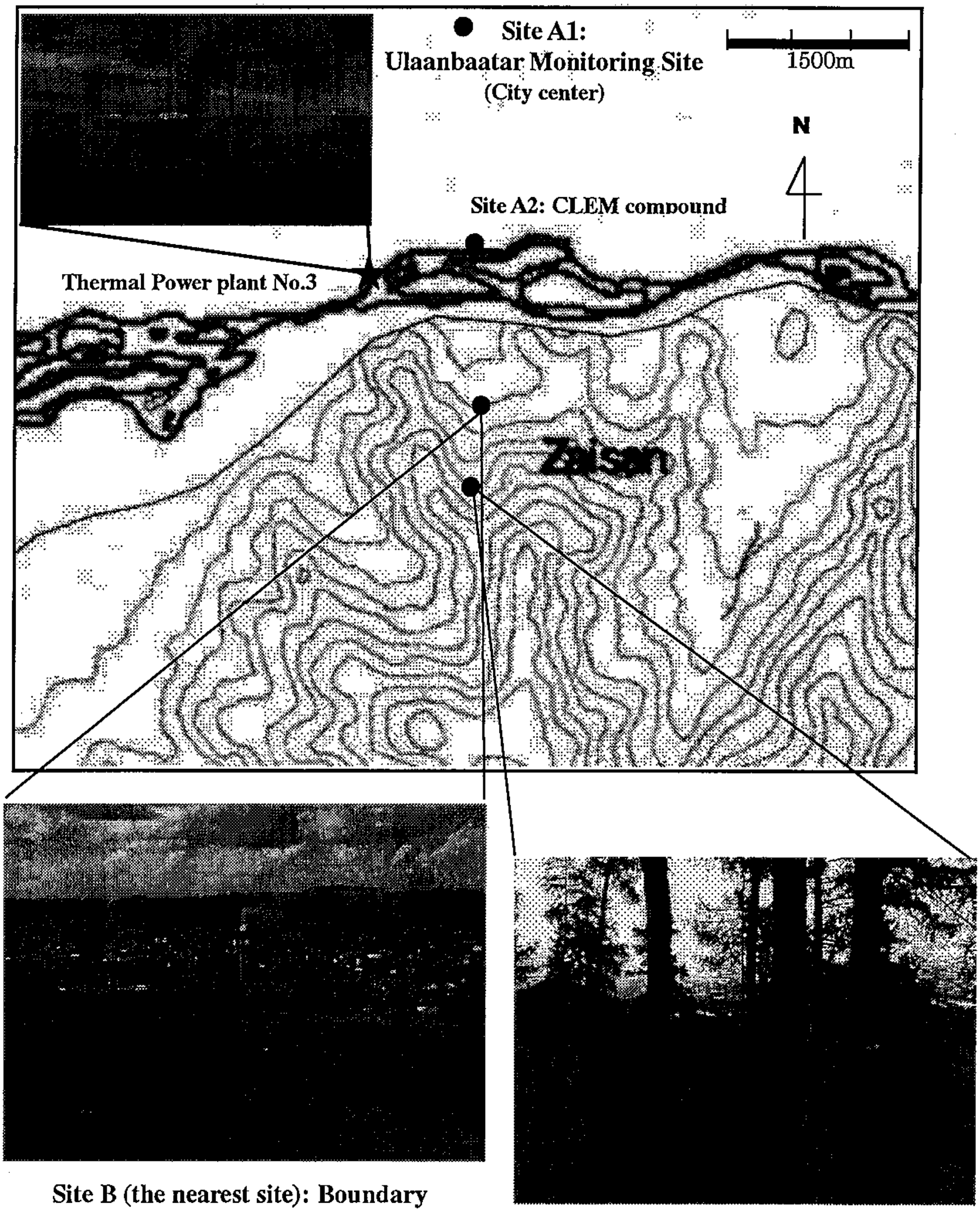
Grass and Larch seeds will be collected in the Bogdkhan Mountain. The followig species are candidates, which were collected in 2001.

- *Astragalus sp.*
- *Carex sp.*
- *Polygonum alopecuroides*
- *Sanguisorba officinalis*
- *Chamaenerion angustifolium*
- *Larix sibirica*

Grass and Larch seeds will be exposed to acid deposition such as SO_2 and O_3 in NIES.

4. Expected outcomes

- Air concentration in the mountainous area, especially in the slope facing the Power Plant No.3 and the reference area (at certain distance from the power plant)
- Distribution of declining trees in the mountainous area and these growth and visible conditions
- Concentration of sulfur and heavy metals in Larch (*Larix* sp.) needles and soils
- Information on sensitivities to acid/acidic substances for Mongolian plant species in the Bogdkhan Mountain



Site B (the nearest site): Boundary area between grassland and larch

Site C: Larch forest

Figure. Research field around the Bogdkhan Mountain
Reference forest areas, RF1 and RF2, were established at certain distance (more than 10 km east) from the Thermal Power Plant No.3 (outside of the map).

IV. Collaboration with existing initiatives on developing emission inventory and numerical modeling

1. Introduction

The Second Session of the Intergovernmental Meeting (IG2) for the Acid Deposition Monitoring Network in East Asia (EANET), held in October 2000, concluded that the preparatory-phase activities of EANET had been successful and decided to start the monitoring on a regular basis from January 2001. IG2 issued the "Joint Announcement on the Implementation of EANET" (EANET/IG 2/5/2rev.) in order to start the EANET activities on a regular basis. Operational paragraph 6 of the Joint Announcement indicates that "the participating countries will discuss future EANET activities in order to contribute to development of international cooperative efforts for preventing or reducing adverse environmental impacts of acid deposition." In this connection, it is described in the "Tentative Design of the Acid Deposition Monitoring Network in East Asia (EANET)" (EANET/IG 2/5/3) that the "participating countries will promote studies of other scientific issues in order to improve understanding of the risks of acid deposition." And according to the "Work Program and Budget in 2001 for the Acid Deposition Monitoring Network in East Asia (EANET)"(EANET/IG 2/7/2), the EANET activities include "starting consideration of further scientific issues such as emission inventory studies and numerical modeling."

At the Third Session of the Intergovernmental Meeting (IG3) held in November 2001, the Interim Secretariat presented the document on "Future Development of EANET" (EANET/IG 3/9). With regard to "efforts for preventing and reducing adverse environmental impacts", one of the topics about future development indicated in the document, some countries pointed out the importance of such activities as emphasized the usefulness to learn experiences from existing initiatives on emission inventories and modeling as the first step of such activities. The research activities of the Network Center (NC), which are described in the "Work Program and Budget in 2002 for the Acid Deposition Monitoring Network in East Asia (EANET)"(EANET/IG 3/10/1rev.) adopted at IG3, include "Review of existing initiatives on developing emission inventories and numerical modeling."

Following the Work Program and Budget in 2002, NC carried out the review of existing initiatives on developing emission inventory and numerical modeling such as (1) Longrange Transboundary Air Pollutants in Northeast Asia (LTP project), (2) RAINS-Asia, (3) Model Intercomparison Study in Asia (MICS-Asia), (4) the Study on the Acid Deposition Control Strategy in the Kingdom of Thailand (TAciDES) and (5) Cooperative research program between the Malaysian Meteorological Service and the Swedish Meteorological and Hydrological Institute.

"Work Program and Budget in 2003 for the Acid Deposition Monitoring Network in East Asia (EANET)"(EANET/IG 4/8/1) adopted at the Fourth Session of the Intergovernmental Meeting (IG3) in November 2002 includes "Collaboration with existing initiatives on developing emission inventories and numerical modeling." as one of the research activities of NC. Following the Work

Program and Budget in 2003, NC has collaborated with some of initiatives on developing emission inventories and numerical modeling.

This document summarizes present situation regarding collaboration of NC with existing initiatives on developing emission inventories and numerical modeling.

2. Collaboration with existing initiatives on developing emission inventory and numerical modeling

2.1. Model intercomparison study in Asia (MICS-Asia)

[Project]

In order to have a common understanding of model performance and uncertainties in Asia, a model intercomparison study on long-range transport and deposition of sulfur, called MICS-Asia Phase I, was carried out during the period from 1998 to 2000.

Eight models participated in the Phase-I study. The outcome of the model intercomparison exercise was discussed at the Third Workshop on the Transport of Air Pollutants in Asia, held at IIASA, Austria in September 2000.

As it was concluded at the Fourth Workshop on the Transport of Air Pollutants in Asia held at IIASA, Austria in October 2001, further model intercomparison study (MICS-Asia Phase II) would be useful to improve the understanding of the long-range transport of air pollutants in Asia. While the Phase I focused exclusively on sulfur compounds, it was recognized that a wider perspective could yield important insights including nitrogen compounds, ozone and aerosols to be critical for effective control of various environmental problems.

Taking into account the conclusions of the Forth Workshop, plans of MICS-Asia Phase II were discussed at the Fifth Workshop on Transport of Air Pollutants in Asia held at IIASA, Austria in January 2003.

Following the discussions at the workshop, a model intercomparison study focusing on transport and deposition of sulfur, nitrogen compounds, ozone and aerosols in East Asia has been started since March 2003. Four study periods are selected as follows:

Period 1: March 1 to 31 in 2001,
Period 2: July 1 to 31 in 2001,
Period 3: December 1 to 31 in 2001,
Period 4: March 1 to 31 in 2002.

[Relationship with EANET]

NC has cooperated with the project by announcing the latest information of the activities in its website. (http://www.adorc.gr.jp/adorc/mics.html).

In response to participants' expectations, NC plans to provide EANET monitoring data mainly from "Data Report on the Acid Deposition in the East Asian Region 2001" for the model validations following the agreement of the "Procedures on Data and Information Disclosure for EANET", which was adopted at the Third Session of the Intergovernmental Meeting of EANET in 2001.

Models developed in EANET participating countries are planned to join the project. They include ATMOS II model [*1] in Thailand and MATCH model [*2] in Malaysia.

*1 See 2.2.

*2 Following an initiative of the Sweden International Development Cooperation Agency (Sida) and a request from the Environmental Studies Division of Malaysian Meteorological Service, a collaborative research project has recently started between MMS and SMHI. The study focuses on the use of a regional transport model (Multiple-scale Atmospheric Transport and Chemical modeling system; MATCH) in Southeast Asia.

The 6th Expert Meeting for the Long-range Transboundary Air Pollutants in Northeast Asia (LTP project), held on 4-6 November 2003 in Jeju, Korea, adopted next simulation periods including the period from March 1 to 31 in 2001 to harmonize with the period 1 of MICS-Asia Phase II.

2.2. The study on the acid deposition control strategy in the Kingdom of Thailand (TAciDES)

[Project]

The Japan International Cooperation Agency (JICA) undertook the study on the acid deposition control strategy in the Kingdom of Thailand (TAciDES). Pollution Control Department acted as the counterpart agency to the JICA study team. The study began in January 2002 and completed in March 2003. In the study, the emission inventories of SO_2 for whole Thailand and NO_x for Bangkok metropolitan region were developed and the simulation analysis using the developed inventories were carried out.

[Relationship with EANET]

EANET monitoring data in 2000 were utilized for validating the simulation results by ATMOS II model. Table 1 shows results of the validation. The ATMOS II model is one of the models to participate the MICS-Asia Phase II.

Table 1 Comparison of simulation results on sulfur wet deposition with EANET monitoring data in 2000

	Bangkok (OEPP)	Samutprekarn (TMD)	Patumthani (ERTC)	Khao Lam
Calculated [mgS m^{-2} $year^{-1}$]	833.0	744.2	498.8	25.7
Measured [mgS m^{-2} $year^{-1}$]	776.9	777.8	573.6	87.0

An international seminar on this project was held on 29 and 30 January 2003 in Bangkok attended by EANET participating countries.