Proceedings of First Symposium on Joint Siberian Permafrost Studies between Japan and Russia in 1992

edited by M. Fukuda

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This proceedings is published based on the presentations to the First Symposium on Joint Siberian Permafrost Studies between Japan and Russia. The joint research program initiated in 1992 and continues until 1995. There were 23 presentations at the Symposium, which was held on 27th January 1993 at the Institute of Low Temperature Science,Hokkaido University,Sapporo Japan. Total number of participants to the Symposium recorded as 67. After the Symposium, papers which were presented were sent to the Institute Low Temperature Science.
Dr.Fukuda compiled papers into this proceedings. Mrs.Nakayama assisted him to edit the papers.

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Preface

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More than 20 years ago, Prof.Kinosita of Institute of Low Temperature Science, Sapporo and his group conducted joint permafrost study in Yakutia cooperating with Academy of Science,USSR. That group was exceptionally allowed to enter the mid of Yakutia permafrost region as scientific expedition from out side USSR. Since that time, Siberian permafrost has been nearly closed for scientific study to the foreign scientists. Siberian permafrost, which occupies vast areas in sub-arctic region, plays an important role to global climate as source of CO_2 from vast Taiga and CH_4 from Taiga and Tundra. There are also many existences of characteristic landforms,vegetation and faunas, which are unique from the view point of both physical and biological environments. Many scientists of western countries including Japan paid attention to the results of scientific research done by Soviets. Most of them considered the importance to conduct the joint scientific expedition cooperating with Soviets scientists. However the policy of science managements in Soviet was not enough flexible to permit these joint study cooperating with foreign institutions for long time. In 1990, there were obvious changes of policy of science in Soviet. Prof.Fukuda received a letter from Dr.Kamensky , Director of the Permafrost Institute, Yakutsk. He asked for possible joint study on permafrost between Japan and USSR. Nation wide tendency of Pelestroika was going on in USSR and a rigid policy of science started softening. The closed door to Siberia was almost to open to foreign scientists.

Profs.Fukuda and Yoshida of Institute of Low Temperature Science were invited to Yakutsk in November,1990 for further discussion on joint study. It was cold enough time in November at Yakutsk, but it was warm enough atmosphere among peoples at Yakutsk. All members felt that it was high time to initiate new joint research program on Siberian permafrost.

In May 1991, Dr.Kamensky and others were invited to Sapporo as to continue the discussion on joint research program. Two major topics were proposed in the research field;physical and biological environments in Siberian permafrost regions. Additionally Center for Global Environmental Research , National Institute for Environmental Studies initiated the possible joint study on Methane emission specially related to the recent global warming trend in climate. During stay of Dr.Kamensky and his group, intensive and serious discussions were made among various groups at Sapporo. Concrete objectives and programs were established after sessions of discussion and agreements were developed between individual institutes and department.

According to these agreements, preliminary surveys were conducted in summer and autumn 1991. Each group from Japanese institutes participated joint preliminary surveys or discussions in Yakutsk and Siberian regions. These exchanges of information and adjustments of schedules were very useful for establishments of concrete programs as to conduct joint field surveys in next year. The schedules from individual group were compiled in winter 1991. In summer season of 1992, the joint permafrost studies started based upon well organized and prepared programs and more than 23 scientists from Japan participated with corroborating scientists and personnels from various institutes in Russia.

The success of this field surveys is mainly due to well organized system which was developed spontaneously among the institutes in both countries. The complicated system is shown in Fig.1. Participating institutes and departments from Japan are categorized into two major groups from the view points of financial supports from the Japanese government. Group I is mainly supported by the Ministry of Education,Culture and Science,Japan and Group II is furnished by Environmental Agency Japan. Frankly speaking, there is rare case that institutes and departments which had different sources of budget cooperate to each other in case of field surveys in abroad. This new experiments of joint studies among Japanese institutes with different financial supports proved the importance of interdisciplinary approach in Earth Science.

On 27th Janruary 1993, many scientists who participated joint field works in previous year assemble at Institute of Low Temperature Science. Some Russian members were invited as to participate the meeting. The meeting must be called as an ideal symposium in sense of sharing the common knowledges and information which were derived from joint surveys. Most of presentations at that symposium are compiled in this report. It is an internal report among participants, but it will be an early report of last field survey. If one reads this report, he easily finds the contents are all original ones. Hopefully final reports in scientific journals will follow to this short reports soon. As one of organizing members, present author expresses a great thanks to all participating peoples and all institutes which assisted the joint studies.

---------- **List of key persons** --------------

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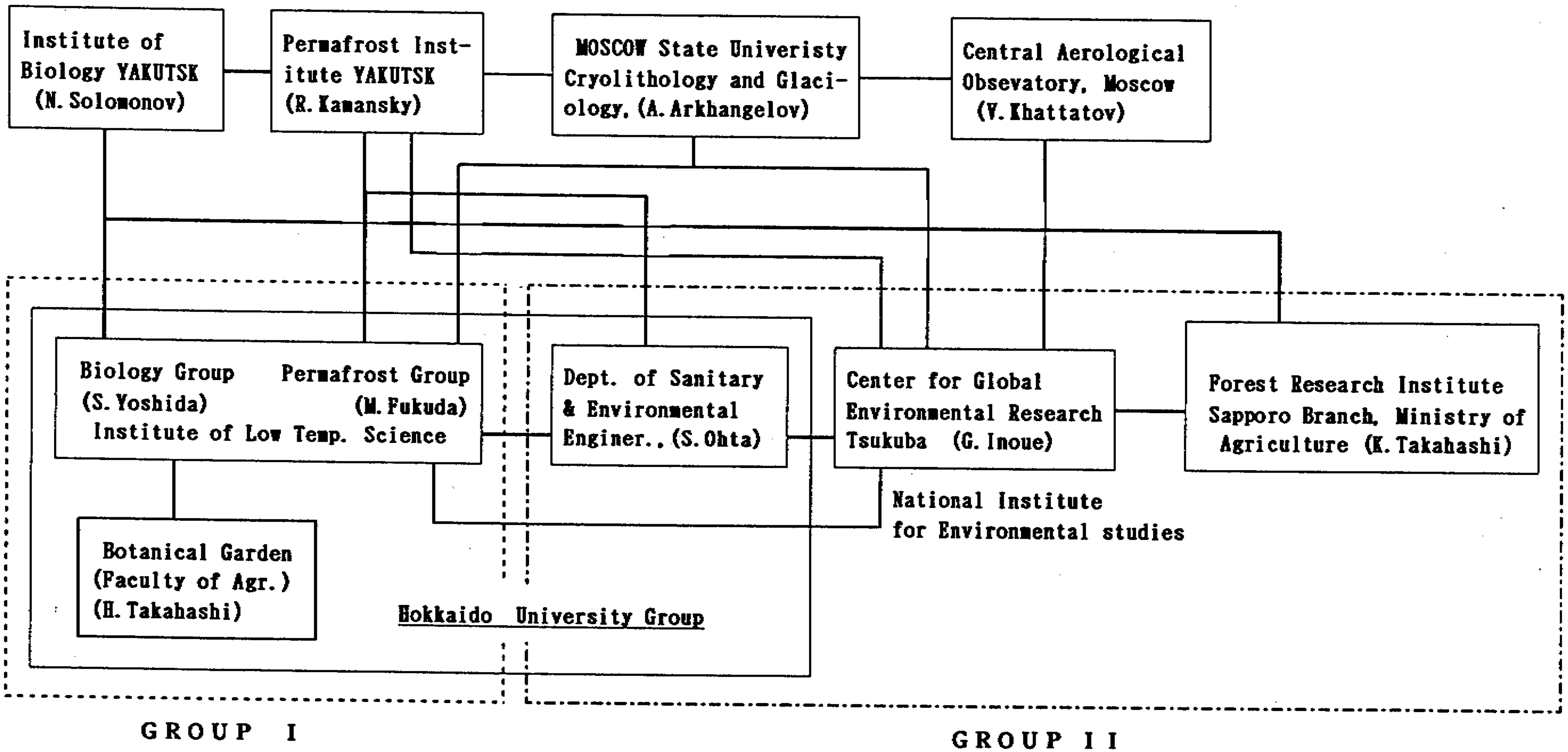
JOINT PERMAFROST STUDIES BETWEEN JAPAN & RUSSIA



1 Geochemical Study of Atmospheric Aerosols in Yakutsk

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Introduction

Atmospheric aerosols affect the global climate through scattering and absorption of solar radiation. In order to estimate the climatic effects, we need global distribution of optical depth (total amount of aerosols in the whole air column) and optical properties (complex refractive index and size distribution) of atmospheric aerosols. We can estimate the optical depth through measurement of direct solar radiation. Many measurements have been made for the size distribution of aerosols. But, there have been only sparse data for the complex refractive index of aerosols.

We have studied determination of the complex refractive index based on chemical characterization of atmospheric aerosols. Thus, if we obtain the chemical data, we can determine the complex refractive index of aerosols. In the central Eurasia, however, we have no chemical data on the aerosols. We, then, planned to measure the concentration and chemical components of aerosols in a rural area of Yakutsk. We also measured the concentrations of atmospheric SO_2 and HNO_3, since they are precursors in conversion to sulfate and nitrate aerosol in the atmosphere.

Sampling of aerosol and gaseous components

Atmospheric aerosol and gaseous components were collected every 24 or 48 hours in July 23-31,1992 at a radio relay station 25 km west of Yakutsk city. We collected atmospheric aerosols on quartz fiber filter (Pallflex 2500 QAST-UP) and Teflone filter (Sumitomo Fluoropore AF07P) with two high volume air samplers (Shibata Scientific Technology Ltd., HVS-500) at a flow rate of 500 liters per minute equipped with impactors whose 50% cut off diameter were 5 μm. We also collected atmospheric particulate carbon on quartz fiber filter (Pallflex 2500 QAST-UP) with an air sampler at a flow rate of 20 liters per minute equipped with a cyclone separator whose 50 % cut off diameter was 2 μm. Atmospheric SO_2 and HNO_3 were collected with reagent soaked filters at a flow rate of 25 liters per minute. We used the filters soaked with Na_2CO_3 and NaCl for sampling of SO_2 and HNO_3, respectively.

Figure 1 shows the sampling system of atmospheric aerosol and gaseous components. We set the sampling system in the room of the radio relay station building. Air in the outdoors was sucked through the funnels (F in Fig.1) about 5 m height above the ground. The high volume air samplers were set on the roof of a barn beside the building.

Analysis of aerosol and gaseous components

We measured the concentrations of sulfate, nitrate and chloride with ion chromatograph (Yokogawa Electric Works Inc., IC-100) in aqueous solution extracted aerosol components from the sampled Teflone filter. Concentrations of sodium, calcium and magnesium were measured with atomic absorption spectrometer (Hitachi Inc., 170-30). Ammonium concentration was determined colorimetrically using indophenol method. Concentrations of total carbon and elemental carbon were measured with carbon analyzer using combustion technique. We measured the concentration of SO_2 with ion chromatograph after extracting the collected SO_2 from the filter into distilled water and oxidizing sulfite into sulfate with addition of H_2O_2. Concentration of HNO_3 was determined colorimetrically using hydrazine reduction GR method after extracting the collected HNO_3 from the filter into distilled water.

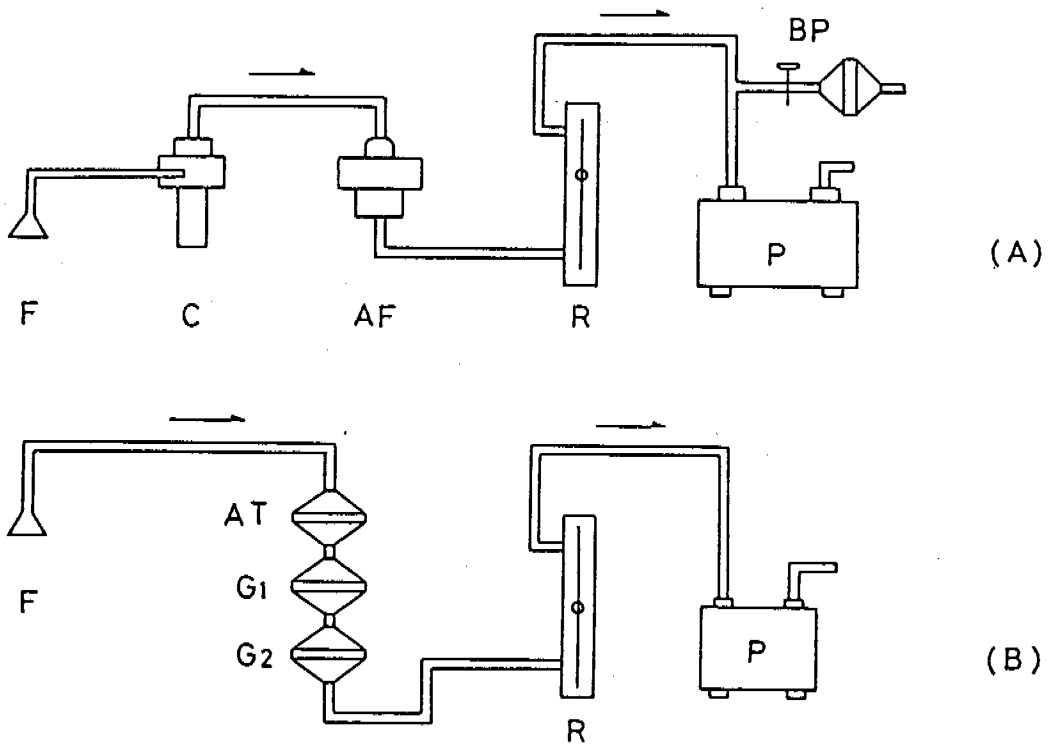

Fig.1 Sampling system of atmospheric aerosol and gaseous components
(A) Aerosol sampling system (1 line)
F: funnel, C: cyclone separator
AF: quartz fiber filter, R: rotameter, BP: bypass
P: air pump
(B) Aerosol-gas sampling system (2 lines)
F: funnel, AT: Teflone filter
G1, G2: gas sampling filter, R: rotameter, P: pump

Results and discussion

Table 1 shows the concentrations of atmospheric aerosols in a rural area of Yakutsk. Concentrations of total and elemental carbon ranged from 3.8 to 9.9 $\mu gC\ m^{-3}$ and from 0.3 to 1.9 $\mu gC\ m^{-3}$, respectively. Atmospheric concentration of elemental carbon in the rural area of Yakutsk was about the same as those at Mt. Niseko (0.40-0.95 $\mu gC\ m^{-3}$) in Hokkaido and Bonnin Islands (0.5-1.5 $\mu gC\ m^{-3}$) in the Pacific Ocean, 1000km south of Japan (Ohta and Okita, 1984), and about ten times more than that at Ester Dome (0.09-0.11 $\mu gC\ m^{-3}$) in a rural area of Fairbanks, central Alaska.

Atmospheric concentrations of sulfate (SO_4^{2-}) and nitrate (NO_3^-) were 0.1-0.8 and 0.01-0.10 $\mu g\ m^{-3}$, respectively, in the rural area of Yakutsk. They were about the same as those at Ester Dome (the concentrations of SO_4^{2-} and NO_3^- were 0.1-0.5 and 0.002-0.10 $\mu g\ m^{-3}$, respectively), and 1/4 ~1/2 of those at Mt. Niseko (1.0-3.5 and 0.0-0.3 $\mu g\ m^{-3}$) and Boninn Islands (2.1-2.9 and 0.3-0.4 $\mu g\ m^{-3}$). Table 2 shows atmospheric concentrations of SO_2 and HNO_3 in the rural area of Yakutsk. The concentrations of SO_2 and HNO_3 were less than 0.11 and 0.02 ppbv, respectively. They were about the same as those at Ester Dome (0.01-0.16 and 0.007-0.04 ppbv) and 1/5~1/2 of those of Bonnin Islands (0.05-0.5and 0.02-0.7 ppbv).

The concentration of elemental carbon in the rural area of Yakutsk was ten times more than that at Ester Dome, while the concentrations of the other components were the same level. In summer, forest fire often occurs in Siberian taiga. The high concentration of elemental carbon may be derived from the fire.

Table 1. Concentrations of atmospheric aerosol components ($\mu g/m^3$) in rural area of Yakutsk (July 23-31, 1992)

Date	T.C.	E.C.	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	Ca^{2+}	Mg^{2+}
July 23-24		0.99	0.53	0.034	0.010	0.19	0.054	0.57	0.021
24-25	4.65	0.93	0.48	0.047	0.017	0.16	0.053	0.57	0.024
25-26	4.91	0.58	0.21	0.032	0.018	0.08	0.033	0.47	0.017
26-27	3.97	0.34	0.11	0.011	0.002	0.04	0.017	0.27	0.009
27-29	4.05	0.76	0.35	0.056	0.011	0.11	0.036	0.80	0.025
29-30	9.88	1.89	0.75	0.103	0.017	0.23	0.057	1.16	0.042
30-31	3.82	0.27	0.24	0.013	0.032	0.09	0/027	0.05	0.006

T.C. : Total carbon, E.C. : Elemental carbon

Table 2. Atmospheric concentrations of SO_2 and HNO_3 (ppbv) in rural area of Yakutsk (July 23-31, 1992)

Date	SO_2	HNO_3
July 23-24	0.034	0.001
24-25	0.080	0.008
25-26	0.030	0.004
26-27	0.005	0.000
27-29	0.051	0.005
29-30	0.109	0.020
30-31	0.000	0.001

2 Measurements of methane flux in Yakutsk

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Introduction

Atmospheric methane affects the global climate through the green house effect in the infrared radiation. Global sources of methane are enteric fermentation, biomass burning, landfills, fossil fuel exploration, natural gas distribution and wetlands. Siberian permafrost layer is supposed to emit much amount of methane in melting season. But, we have no data on the flux of methane from the Siberian wet land. Thus, we planned to measure the flux in Yakutsk area in summer of 1992.

Experimental method

We measured methane flux from the surface of wet land in the suburbs of Yakutsk city in July 24-28, 1992. We chose 10 sampling sites for the measurements as follows.

- Site A and B
  They were in the shore of the Kyurdegeleph lake in Chabyda, which was a lake in taiga and 15km south west of Yakutsk city.
- Site C and D
  They were in the shore of the Prophladnoe lake, which was an alaas lake near Magan air port 15 km northwest of

Yakutsk city. They were used as grazing land.

- Site E and F

  They were in the shore of the Gimein lake, which was a pond in alaas in Maya across the Lena River from Yakutsk city. They were used as grazing land.

- Site G and H

  They were in drying alaas near Ulu-Mali across the Lena River from Yakutsk city. They were used as grazing land.

- Site I and J

  They were marsh in alaas near Ulu-Mali.

On the sites, methane flux was measured with chamber method shown in Figure 1. The chamber is made from aluminum and the size is 30cm×30 cm in section and 65 cm in height. We inserted the chamber in surface soil and sucked 500 mL of the air in the chamber into gas sampling bag (Tedlar bag) every 10 minutes for 30 minutes. We took back the bags to our University and analyzed the methane concentration in the bag. Figures 2 shows the methane concentration in the chamber every 10 minutes on the sites D and G. The methane flux was calculated from the rate of change of the concentration. On the site D we had no methane flux, while on G we obtained the flux of 48 mg m^{-2} hour $^{-1}$.

On the sites, we also made sampling of soil core 50 cm deep with a hand auger. Soil pH was measured in every 10 cm from the surface to 50cm depth in the core sample. We spooned up a lump of soil in the core every 10 cm depth into glass vials, and took back to our university to analyze concentrations of methanogen and methane oxdizing bacteria.

We, further, made following measurements on the sites : measurements of soil temperature, air and surface temperature and ground water level. Figure 3 shows the measurement system of temperature profile in soil. Thermistor sensors are embedded on the surface of polyvinyl chloride tube. Figure 4 shows the measurement system of ground water level. The tube is made of stainless steel with many holes.

Results and discussion

The results of methane flux measurements are shown in Table 1. Methane flux from the wet land in Yakutsk ranged from 0 to 113 mg $m^{-2}hour^{-1}$. The methane flux was much variable even in ten meters apart in the same shore of an alaas. High methane flux in Yakutsk area was correlative with high ground water, high soil temperature and neutral soil pH (pH 6 ～7).

In a rural area of Sapporo, we also measured the methane flux at the shore of the Tsukiga-umi lake in 1992. The methane flux were 0 ～ 1.2 mg $m^{-2}hour^{-1}$ in April to June, 2.6 ～23.9 mg $m^{-2}hour^{-1}$ in August and 1.4～4.6 mg $m^{-2}hour^{-1}$ in September.

Thus, the wet land in Yakutsk emits about the same amount of methane in melting season as in the rural area of Sapporo. But, the flux were so variable in Yakutsk that it is hard to estimate the total amount of methane emission from the wet land in Yakutia.

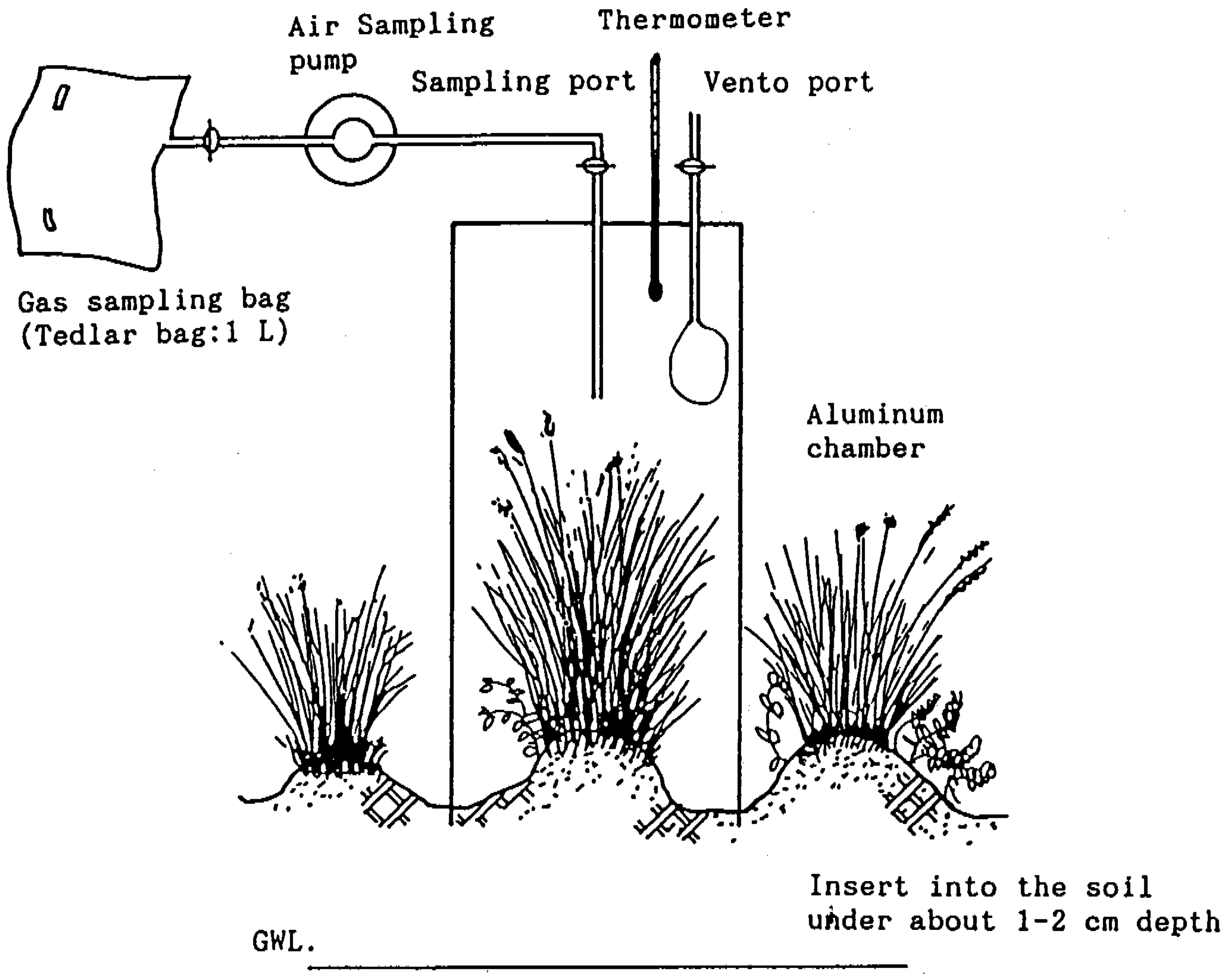
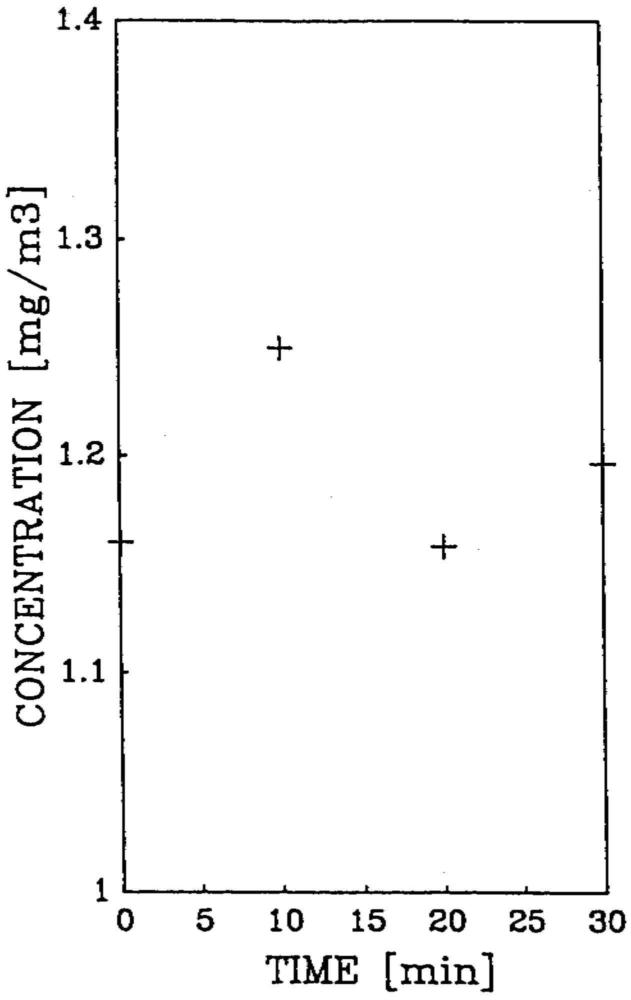


Fig.1 A chamber method for meaurement of methane flux

sampling site D: Prophladnoe



sampling site G: drying alaas near Ulu-Mali

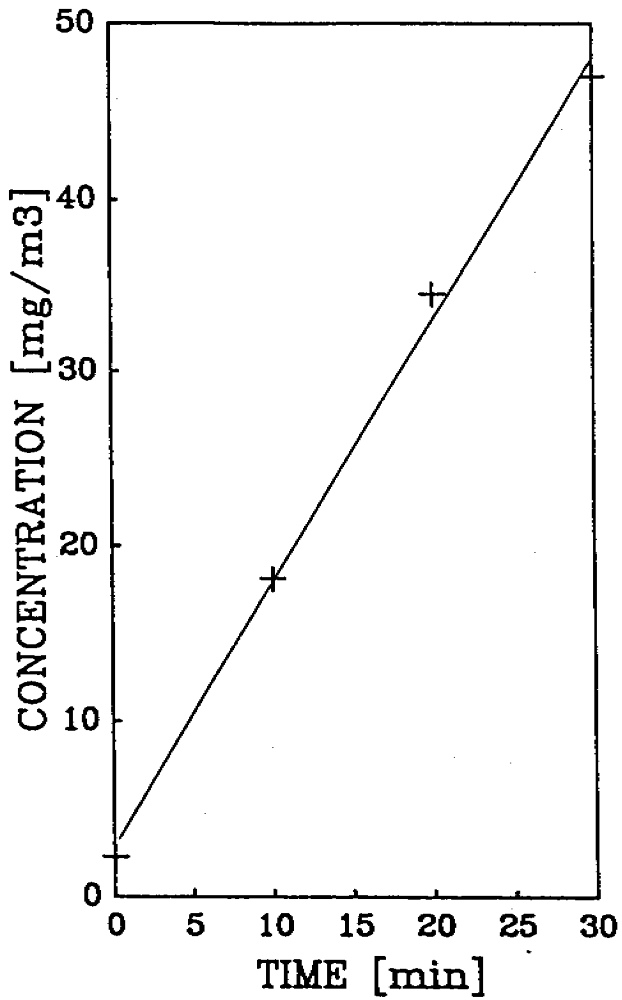


Fig.2 Methane concentration in chamber at sampling site D and G

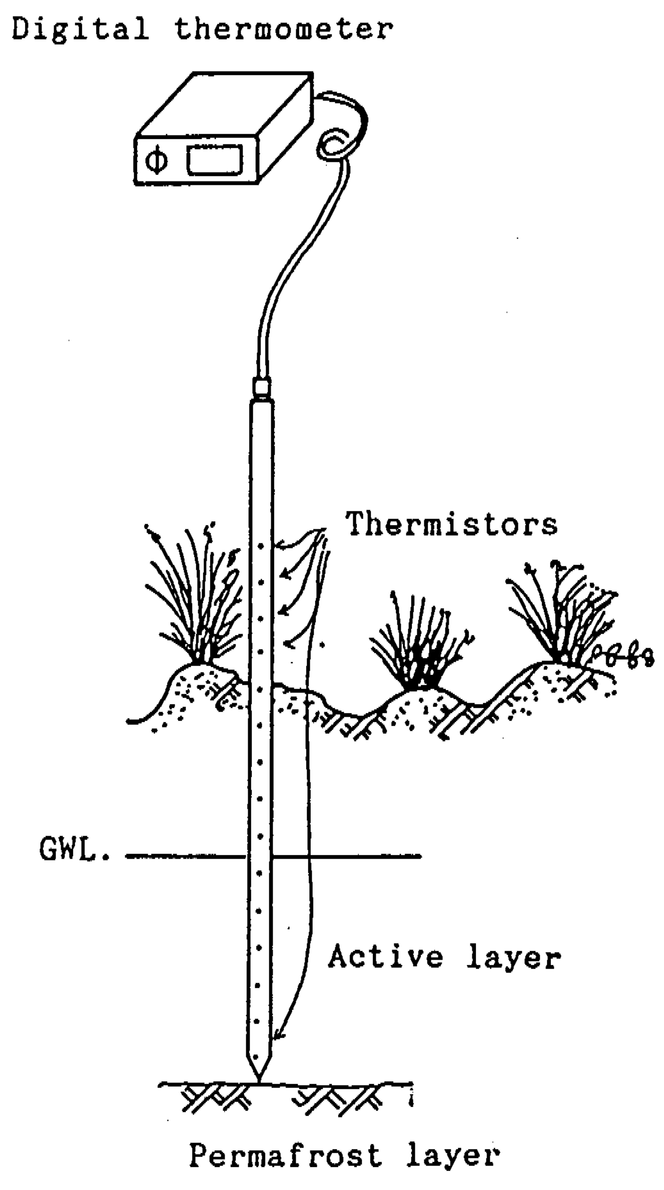


Fig.3 Measurement system of temperature profile in soil

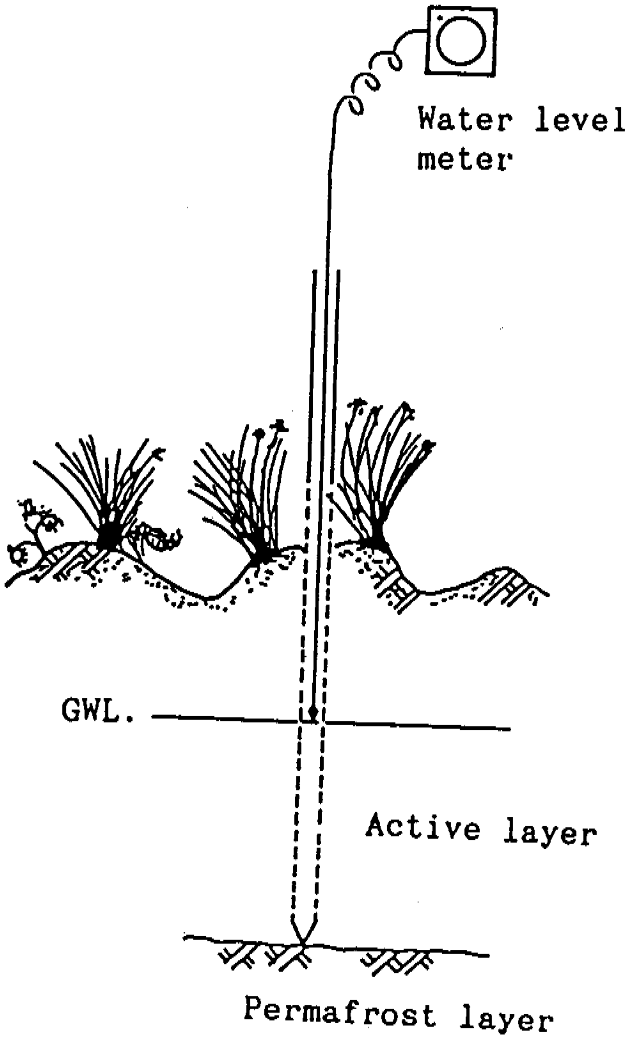


Fig.4 Measurement system of ground water level

Table 1. Methane flux measurements in Yakutsk (July 24-28, 1992)

Site	A	B	C	D	E	F	G	H	I	J
Date	7/24	7/24	7/26	7/26	7/27	7/27	7/28	7/28	7/28	7/28
Time	13:27	13:36	14:02	13:57	18:40	18:35	12:00	11:55	14:38	14:34
Methane Flux (mg/m²hr)	0.02	0	0.03	0	0	113	48	0	0.71	23
Ground water level (cm)	—	—	7	8	—	8	19	—	20	0
Soil pH (15 cm)	2.9	3.0	7.2	7.2	7.4	7.4	6.4	5.5	7.1	6.5
Surface temp (℃)	24.5	37.4	22.0	20.0	21.9	22.0	18.0	18.0	25.4	20.0
Soil temp. (℃, 15cm)	7.2	8.2	14.4	16.8	15.5	21.6	18.8	14.8	15.8	13.9
Air temp. (℃)	27.0	27.0	24.2	24.2	27.0	27.0	27.1	27.1	25.5	25.5

3 Overview of Research Program of NIES in Siberia

Gen Inoue
National Institute for Environmental Studies(NIES)

Purpose

The estimation of the rates of the methane emission and the sink of carbon dioxide in Siberia, which affect the global atmospheric concentrations, is one of the important and urgent research subject.

Very large seasonal variation of carbon dioxide in high latitude in the northern hemisphere is ascribed to the photosynthesis and aspiration of boreal and temperate forest. And it is one of the possible missing sink of carbon dioxide. Taiga in Siberia is the largest in area, but their interaction with atmosphere is not understand well mainly because of the luck of atmospheric data in this area.

It is estimated that global wetlands contribute over 20% of the total methane emission, and most of which(16%) was attributed to northern wetlands. However, more recent estimation suggests it is much smaller, between 4 and 7%. There remains very large uncertainty because of poor observational coverage of major continuous wetland region, the Western Siberian Lowlands and the Hudson Bay Lowlands, which comprise 34% of all northern wetlands. No observation in the Western Siberian Lowlands is reported and no projects but ours are planned at this moment.

Another important point of discussions on the climate change problem is the estimation of feedback of the climate change on the natural ecological, biochemical, and cryological systems in Siberia. The limiting factor of biological activities in Siberia is the temperature, mainly, the supply of water and nutrients in Eastern Siberia. The forecasting of the change of ecosystem in Siberia when the climate system has changed as model calculations predict is quite difficult because of poor understanding of nature in Siberia. One of the scenarios is that it will be covered by wetlands because a large amount of permafrost will melt, another is that it will be very dry because of smaller rainfall, another is deforestation because of sudden change of climate and the ecosystem cannot adapt to it, etc. The estimation of the change of the rates of methane emission and carbon dioxide sink in these scenarios is very important but it will remain the future subject of research.

Subjects

1.Measurement of semi-global 3-dimensional distribution of CO2 and CH4 by an airplane.

The circulation of atmosphere along the latitude is quite fast, order of week, and the concentrations of atmospheric trace gases which have long lifetimes are estimated to be uniform. Nevertheless, if the interaction with biosphere is strong, the real lifetime of CO2 is quite different from the global averaged lifetime. It is very interesting to observe the gradient of CO2 concentration along a latitude. A very precise measurement for a long distance is required. No such measurement has been reported. In this campaign, the measurement of CO2 between Moscow and Yakutsk, 37E - 130E, has been performed.

The latitudinal distributions of CO_2 are reported to be very variable, and it is widely recognized to be the key observation to understand the exchange of CO_2 between atmosphere and ocean and terrestrial ecosystem. In this campaign, the measurement between Yakutsk and Tiksi, 63N - 72N, has been performed.

2.Measurement to estimate the fluxes of CO_2 and CH_4 on an airplane.

The emission and absorption strength of CO_2 and CH_4 is very deeply dependent on the places and times. The observation of CO_2 and CH_4 distribution in a scale of tens km gives us the information on the averaged value. The methodology to reduce the observed value to the flux value is relatively simple if the ground can be recognize to be uniform in the scale of observation. One of the method is to evaluate from the vertical gradient, from the Eddy correlation method, and from the computational simulation based on the real meteorological data set.

3.Continuous measurement of CO_2 and CH_4 on the ground.

The emission or sink observed during the flight campaign in 1992 is simply an episode, and it must be deduced to an annual emission or sink rate to review the role of Siberia on the atmosphere-biosphere interaction system. One of the key observations is ground base monitoring of CO_2 and CH_4. We started the ground base measurement of CO_2 and CH_4 in a suburbs of Yakutsk. The diurnal and seasonal variation of vertical distribution will be obtained sampling the air from 11,44 and 77 m points. Combining with the temperature distribution and wind speed, the flux of CO_2 and CH_4 are estimated. This observation has been interrupted right now, but it will be restarted soon.

4.Organizations

a. Airplane measurement;

Japanese side:

NIES;	Inoue, Izumi, Uchiyama, Makushutov
Tohoku Univ.	Nakazawa, Sugawara
GEF;	Takeuchi, Tanonaka, Watanabe / Nojiri
JWA;	Minakami

Russian side:

CAO;	Khattatov, Vinnichenko, Nikolaev, Postnov, Galaktionov, Shagin, Kopylov, Vetrov, Serykh, Rmekh, Puzaev, Tyabotov, Slexeev, Skuratov, Tolchinsky, Pilipenko, Mezrin, Strunin, Dmitriev

b.Ground station;

Japanese side:

NIES;	Inoue, Uchiyama
Tohoku Univ.	Nakazawa, Sugawara
GEF;	Tanonaka

Russian side:

Permafrost Institute;

Kamensky, Fedoseev

c.Supporting Staffs

Japanese side;

NIES/CGER Nishioka, Uehiro, Araki

4 Aircraft Measurement of Atmospheric CO_2 over Siberia

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Introduction

Rising atmospheric concentrations of greenhouse gases such as CO_2, methane is anticipated to lead to significant global climatic changes. Forests in the frigid and subfrigid zones, known as Taiga, cover 15 % of the world forest areas and most part of them exist in Siberia. They are supposed to play an important role in suppression of a rise of the CO_2 concentration. However, the contribution of Taiga to the uptake of atmospheric CO_2 is quite unknown because no data on the CO_2 concentrations in Siberia are available.

In view of this situation, we made on board-measurement of atmospheric CO_2 in the Flight Expedition during the period between 16th and 26th of July last year. In particular, we made intensive observation flights for three days, 17th, 18th and 20th, in West Siberian Lowlands. One of the main purposes was to estimate the amount of CO_2 uptake by plants by observing upwind and downwind concentrations of CO_2 along prevailing winds of synoptic scale. Unfortunately, no such winds blew during the intensive flights, but we obtained interesting data on the spatial distribution of CO_2 over a Taiga area, which characterize Siberian atmospheres in a summer season.

Method

Ilusin 18 (IL-18) aircraft was used that belongs to Central Aerological Observatory of Russian Federation. The airplane has four turboprop engines and has been used in meteorological studies. Meteorological parameters (for example, temperature, wind velocities, humidity) and navigational data were measured by the Russian side. In this Expedition, a new sampling port was prepared on the left side of the fuselage for the measurement of greenhouse gases. Outside air taken through this port was supplied by diaphram pumps after removing moisture with traps cooled to 0 and -20 degree C. To avoid the interference of water vapor with CO_2 measurement, the air was further dried with anhydrous magnesium perchlorate.

A CO_2 analyzer based on nondispersive infrared (NDIR) absosrption at 4.3 micrometer (Shimadzu model XURA-207) was put on an anti-vibration rack to reduce noise resulting from fuselage vibration. Two standard gases in tanks were used as calibration gas: 330 and 380 ppm. They were a reference gas to determine the zero level and a span gas to determine the full scale, respectively. Nonlinearity of the CO_2 analyzer was corrected for by calibration curves that were estimated from the calibration data obtained in advance under one atmospheric pressure: an additional standard gas of 355 ppm was used to fit the discrepancy from the linearity to a quadratic function of the CO_2 concentration. Since the sensitivity was found to depend on the pressure of the cabin, the calibration curves were estimated on the basis of the pressure dependence of the sensitivity, which was obtained from the calibrations in the actual flights.

The output of the CO_2 analyzer was taken in a computer for every 1 second. The response time defined by the moving average was about 20 seconds and thus the CO_2 concentrations were given as those averaged over every 20 seconds. The precision of the measurement was found to be as low as $\pm$0.3ppm on the whole while in a low level flight (less than 500m) the range of uncertainty increased to $\pm$ 0.5ppm because of larger vibration due to turbulence of air.

In addition, grab sampling of air was made to confirm the accuracy of the continuous measurement and to analyze the isotopic composition of CO_2. The samples amounted to 300 were taken in 1 l glass bottles or 3.3 l stainless steel canisters at a few atmospheric pressures and analyzed in our laboratory after returning to Japan. It was found that the agreement of data between the grab sampling and the in situ measurement of CO_2 is quite well being as low as $\pm$0.5ppm.

Results and Discussion

The flight course is given in Fig.1. After loading instruments in Moscow, we moved to Tumen on 16th of July and made extensive observation flights over West Siberian Lowlands for three days, being based on Tumen. Then, we transferred to Yakutsk on 21st and made observations in East Siberia for two days, in which a flight to Tiksi was involved. After that, we returned to Moscow in 26th via Tumen. The total flight time was 54 hrs, including transit. The continuous measurement by the CO_2 analyzer was made in all the transit and observation flights. In the following discussion, it should be noted that all the absolute time in figures represent Moscow standard time.

a)Transit Flight

In the transit flights, whose altitudes were 6000-7500m, free tropospheric air was sampled. Figs.2(a)-2(d) show the concentration of CO_2 for these flights. Except for 25th (Fig.2(c)), we found a weak longitudinal decline of the CO_2 concentration toward east. On the way of the two flights on 16th and 21st, the altitude was lowered to 500-1000m to get the vertical distributions. The concentration of CO_2 near the surface was found to be significantly lower than that in the free troposphere. The difference was close to 15ppm. On the other hand, the free tropospheric concentration of CO_2 was higher in the west of Ural Mountains (flight time of 3-4 hrs in Fig.2(a)) than in the east: it was close to 360ppm near Moscow while 350-355ppm near Tumen. Fluctuations in the CO_2 concentration increased over Ural Mountains. As described earlier, the fluctuations are not due to instability of the CO_2 analyzer but attributable to mountain waves. These facts are likely due to dilution of air by mixing with different air masses during the transportation from the large emission area of Eastern Europe. The analysis of humidity or temperature, which is under way, will help our discussion. Similar eastward decline was observed for the flight in 21st as in Fig.2(b). Moreover, as Figs.3(a) and 3(b) show, a southward decrease in the CO_2 concentration was discernible in the round trip from Yakutsk to Tiksi in the flight on 23rd. However, the reason for these declines will be discussed in future because the trajectory analysis of air at the flight level and isotopic measurements are on the way.

b)Observation Flight

As an example, the result from the extensive observation on 20th is given in Fig.4. Fig.5 and Fig.6 show the flight course and a surface weather chart in West Siberian Lowlands at Tumen local time of 3 am, respectively. It should be noted that B, H and bold curves in Fig.6 represent high pressure, low pressure and fronts, respectively. A high pressure lay in the north east of the observation area (shown in Fig.6 with shade) while a low pressure in the south east of Tumen (indicated in the same figure by a small circle). It was fine in the flight area as well as in Tumen.

Figs.7(a)-7(c) show the CO_2 concentration in the mixing layer, which was observed in level flights. The data in these figures indicate that

(1)the concentration is fairly constant to be 340ppm in a mixing layer independent of the altitude.
(2)the distribution of the concentration is uniform at least over a horizontal scale of 100km because the speed of the airplane was about 400 km h^{-1}.

Vertical distributions of CO_2 were obtained during the ascent and descent flights. It was found that the vertical profiles of air temperature corresponded to those of the CO_2 concentration: the CO_2 concentration decreased sharply from the free tropospheric value of 350ppm to as low as 340ppm, typical of a mixing layer value in the day, in accord with the inversion of the temperature.

On the contrary, CO_2 that was emitted from the surface, was found to accumulate at night in a low stagnant layer by the formation of a weak surface inversion layer. This is shown in Fig.8 along with Fig.9. These data were obtained in taking off from Tumen. Sunrise was 3:20 of Moscow standard time. The line in Fig.9 stands for the dry adiabatic lapse rate of 9.8 degree C per km, which is expected for a well-mixed dry atmosphere, with a surface temperature of 20 degree C. There were several lateral layers in the CO_2 profile of Fig.9, in accord with the distribution of the temperature. Such a structure disappeared after 4 hrs at the time of landing on Tumen, as demonstrated in Fig.10. The CO_2 concentration decreased in the mixing layer from 370 ppm to 340ppm. Although the decrease suggests the uptake of CO_2 by plants on the ground, observation throughout one day is needed to understand the diurnal variation.

c)Vertical Distributions of CO_2 over Different Locations

Figure 11 shows an example of the vertical profiles of CO_2 concentrations obtained from the grab sampling in several different locations. In Moscow, the CO_2 concentrations are highest both in the mixing layer and in the free troposphere. This is because Moscow is located in a large emission area. On the other hand, the CO_2 concentration of the mixing layer is significantly lower in the Taiga area than that of the free troposphere: in Tumen, Tomsk and Yakutsk, the concentration difference is larger than 10 ppm. Similar values were also obtained from the continuous measurement for all the locations in West Siberia and East Siberia. Such a large concentration gap indicates the existence of a large sink on the ground, which suggests the importance of Taiga forests in the uptake of CO_2.

Finally the following measurements will allow us to improve understanding of the role of Siberian forests in the cycling of carbon:

(1) Measurement of a tracer gas such as chlorofluorocarbon in the next extensive flight expedition, which is independent of the interaction with the surface ecosystems.
(2) Monitoring of CO_2 through one year by the grab sampling to evaluate how long the concentration gap is continued.

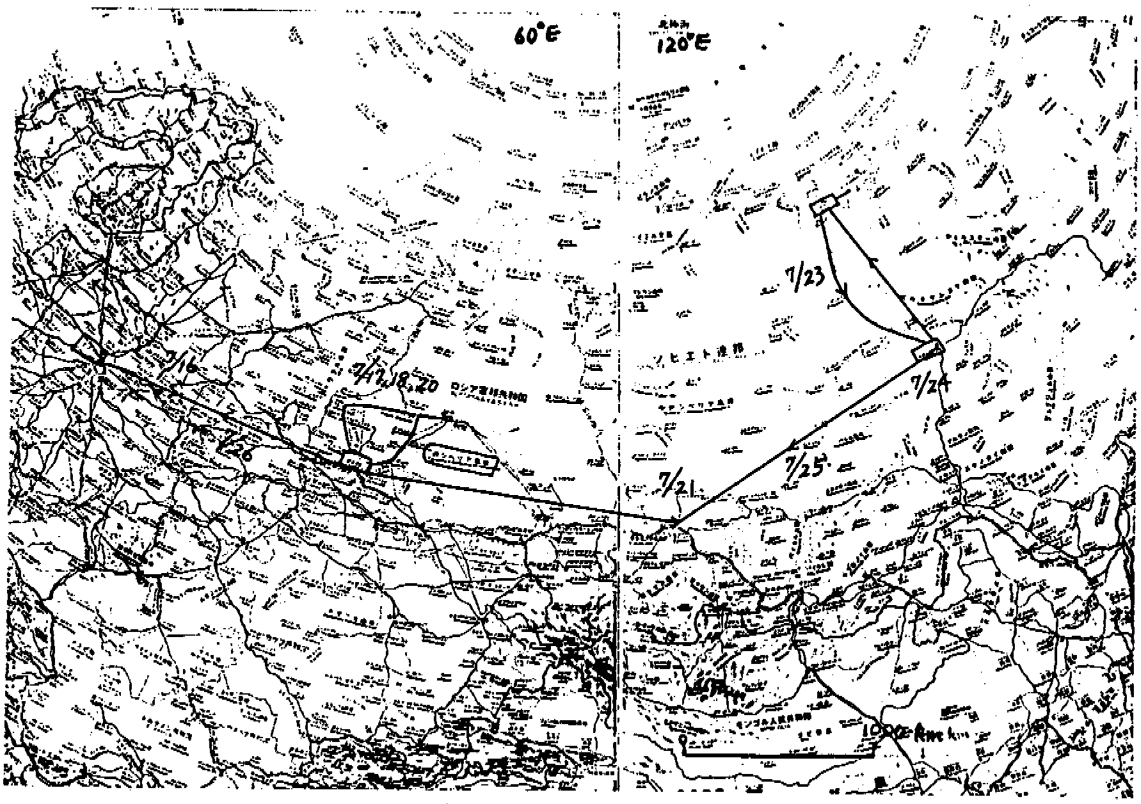

Fig.1 Flight course of the Expedition '92 in Siberia.

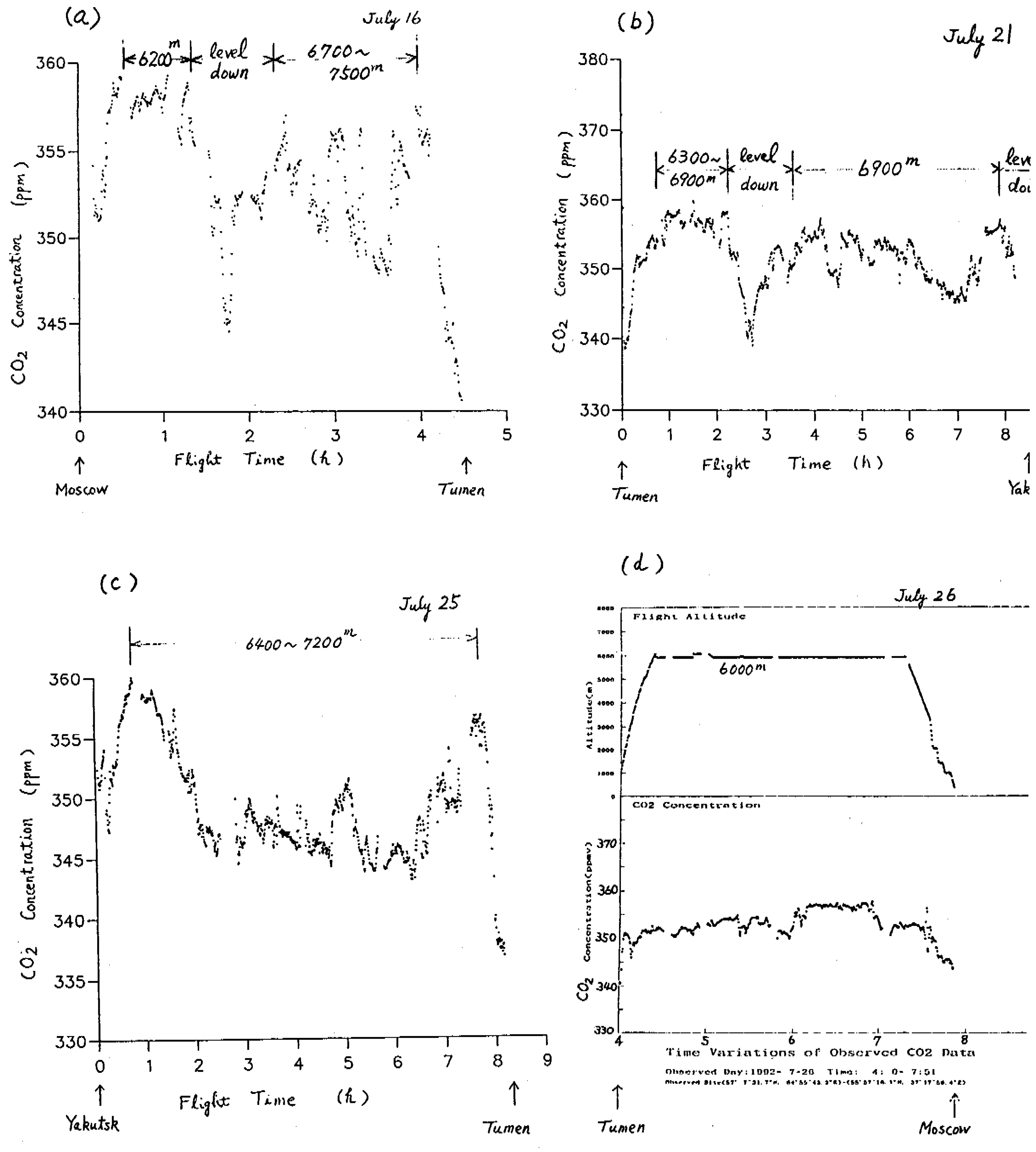

Fig.2 Variations of the CO_2 concentration observed in transit flights. (a); Moscow to Tumen, July 16, (b);Tumen to Yakutsk, July 21, (c); Yakutsk to Tumen, July 25, (d); Tumen to Moscow, July 26.

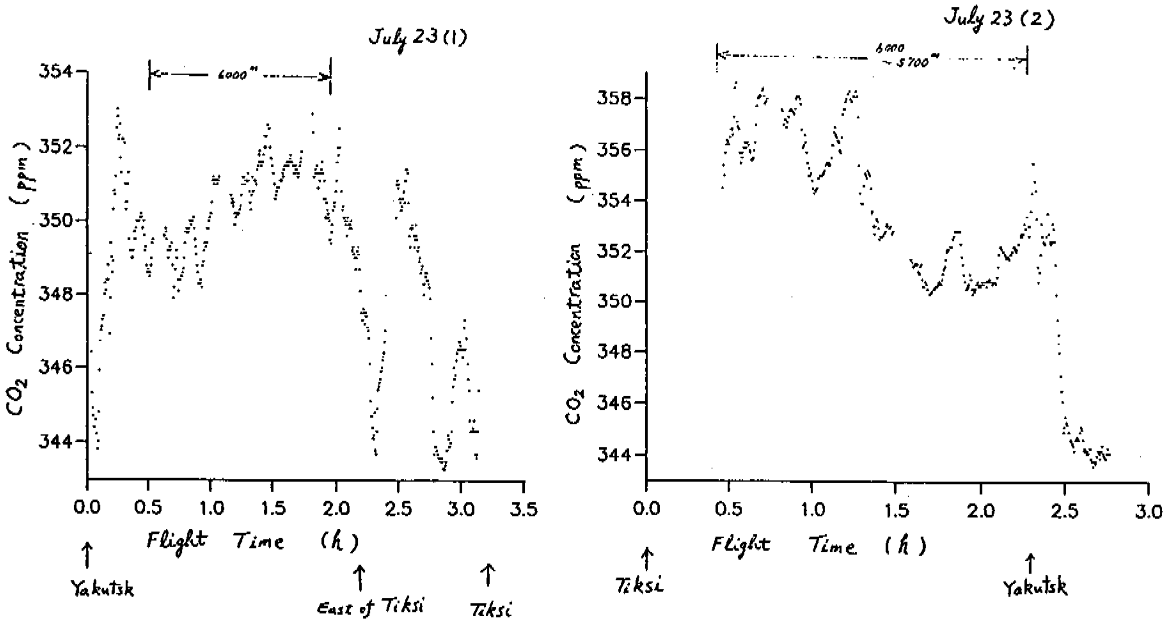

Fig.3 Variations of the CO_2 concentration observed in flights between Yakutsk and Tiksi on July 23. (a); Yakutsk to Tiksi, (b); Tiksi to Yakutsk.

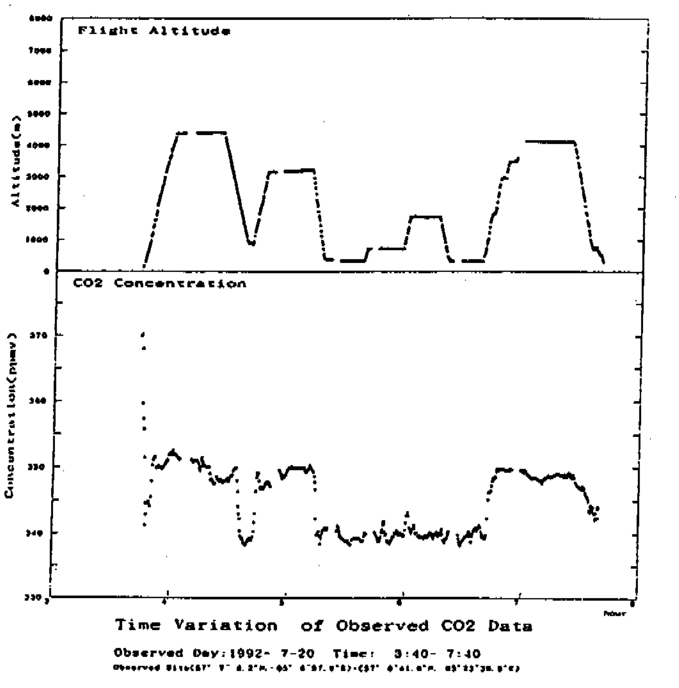

Fig.4 Variations of flight altitudes and the CO_2 concentration in an extensive observation made on July 20.

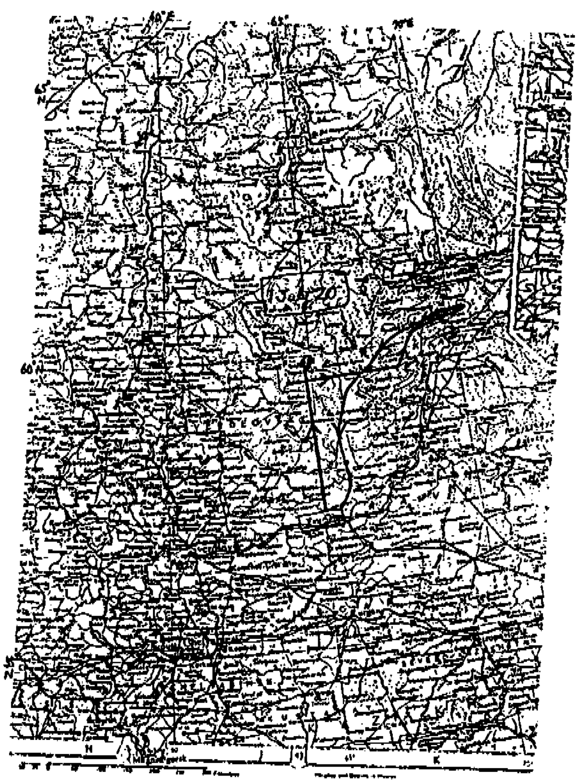

Fig.5 Flight course of the extensive observation on July 20.

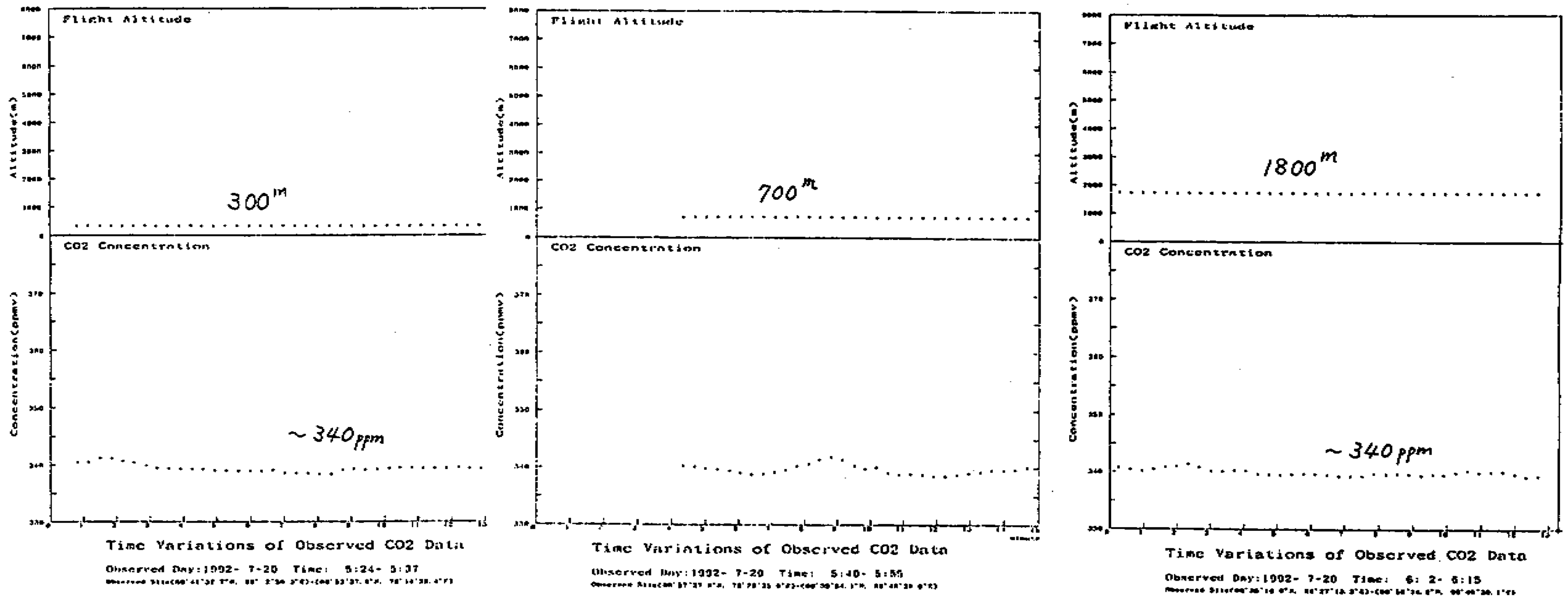

Fig.7 The concentration of CO_2 in the mixing layer at different altitudes. (a); at 300m, (b); 700m, (c); 1800m.

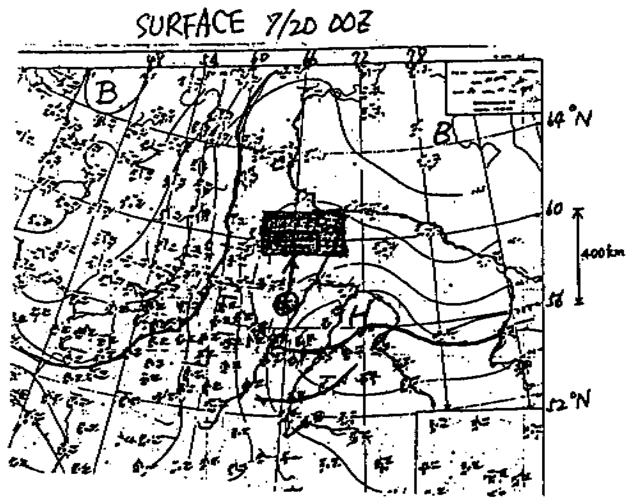

Fig.6 Surface weather chart in West Siberian Lowlands on July 20.

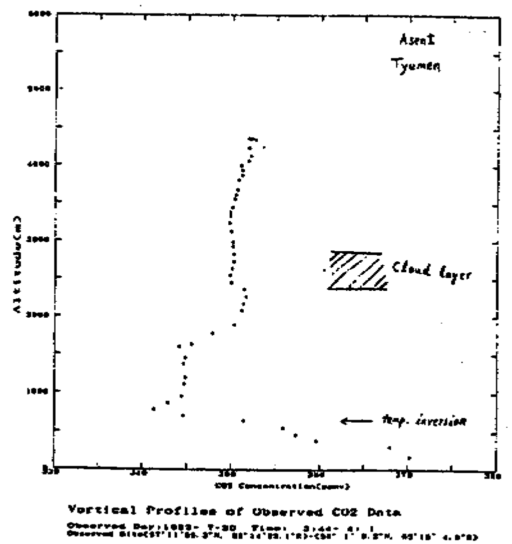

Fig.8 Vertical profile of the CO_2 concentration observed in taking off at Tumen. 3:44-4:01 on July 20, 1992.

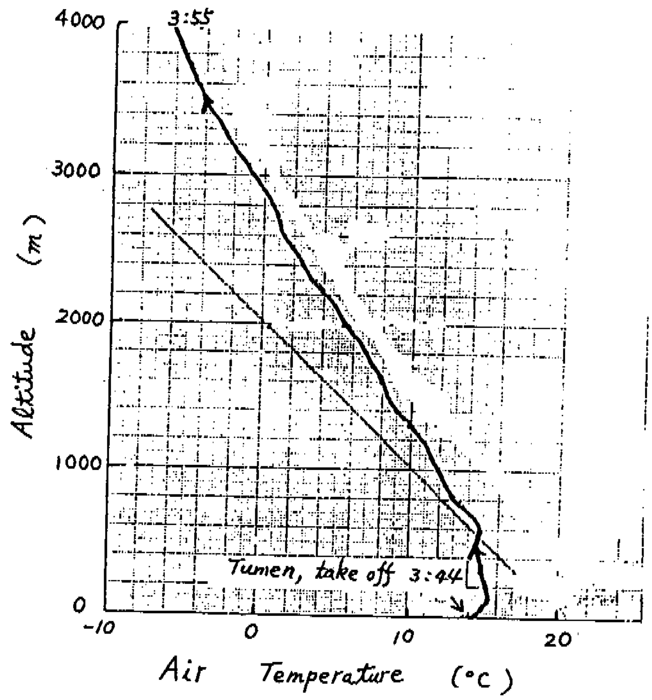

Fig.9 Vertical profile of the temperature observed in taking off at Tumen. July 20. The line stands for the dry adiabatic lapse rate of 9.8 degree C per km, which is expected for a well-mixed dry atmosphere, with a surface temperature of 20 degree C.

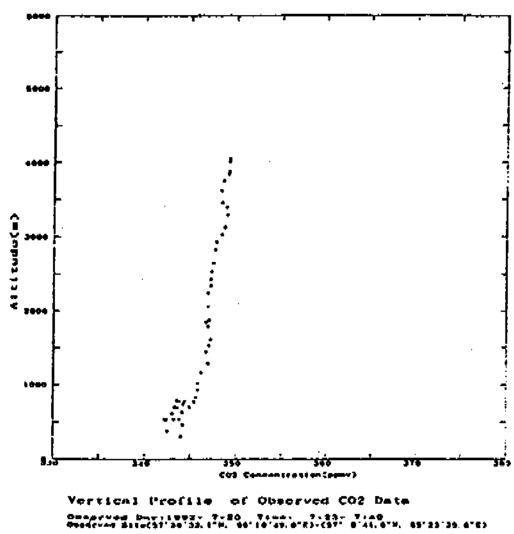

Fig.10 Vertical profile of the CO_2 concentration observed in landing on Tumen. 7:23-7:40 on July 20.

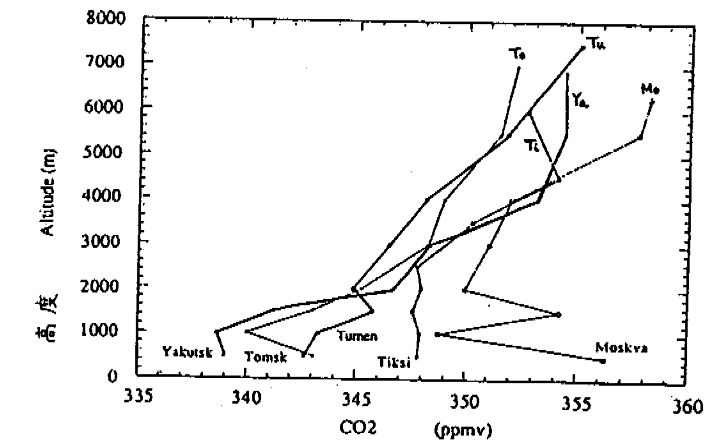

Fig.11 Vertical profiles of the CO_2 concentration in various locations. The symbols, Mo,Tu,To,Ti and Ya represent Moscow, Tumen, Tomsk, Tiksi and Yakutsk, respectively.

5 航空機によるシベリア上空のメタン濃度の測定

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Measurement of methane concentration in the atmosphere over Siberia

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はじめに

夏季のシベリアの湿原は巨大なメタン発生源と言われ、この時期のシベリアの大気中のメタン濃度は高いことが予想されているが実際の観測いまだ行われていない。そこで、我々は1992/7/16 から1992/7/24 にかけてチュメニ--> ヤクーツク--> チクシのルートで航空機による大気中のメタン濃度の測定を行った。この観測によりシベリア上空のメタン濃度について若干の知見を得たのでここに報告する。

分析方法

通常のGC-FID(HP5890,分離カラム: モレキュラーシーブ5A) を航空機に搭載して測定を行った。サンプルは観測機（CAO 所属:IL-18）に設置されている共用の大気サンプリングラインから加圧されて供給されるものをGCに導入し、サンプルループの大気圧開放はキャビンに対して行った。測定の4 回毎に標準ガス（日本酸素製,2.202ppm:重量法）を導入した。一回の分析に要する時間は凡そ 4min であった。キャビン圧の変動が大きいので、GCへのサンプル導入量は導入時のキャビン圧(30sec.毎のキャビン圧の測定を内挿した値）により補正した。最も長時間（8 時間）飛行したチュメニーヤクーツク間での標準ガスのピークから求められる標準偏差の不偏推定値は 0.012ppm であった。Fig.1 は横軸に標準ガスのrun numberを、縦軸に標準ガスのGC出力(peak height) をプロットしたものである。ここで各run numberの間隔は凡そ20min である。Fig.1 は明らかに検出感度に時間的な変動があることを示している。この原因は明らかではないが、暖気運転時間の不足、室内温度の変動あるいは電源の不安定性などが考えられる。いずれにせよ、この様な傾向が見られたのでサンプリング大気の測定値はその測定時刻に最も近い時刻の標準ガスのGCの出力値で校正した。Fig.1 に見られる 3つのグループに対する経時変化を無視した標準偏差の不偏推定値は0.0005-0.009 ppmであった。従って、実際の精度は+/-0.02ppm（3 σ）程度と思われる。サンプルの測定値には更にサンプリングラインの除湿の不完全さによる誤差が加わる。この誤差とキャビンプレッシャー

の測定誤差についてはそれぞれの担当者の報告書を参照されたい。Fig.2 に典型的なクロマトグラフの一例を示す。

結果および考察

本研究の調査地および調査期間は次の通りである: 1.西シベリア低地（チュメニの北),1992/7/18,20; 2.チュメニ -からヤクーツクの間,7/21; 3. ヤクーツクとチクシの間,7/23; 4. ヤクーツク周辺の湿地,7/24 。調査地のメタンの濃度は1.70-1.90 ppm の範囲にあった。Fig.3 に西シベリア低地の観測結果，メタン濃度と高度、露点および地表面温度との関係，を示す。メタン濃度と高度の間には逆比例の関係が、またメタン濃度と水蒸気濃度および表面温度との間には比例関係が見られた。メタン濃度に対する高度と地表面温度および露点との関係が逆なので、更にFig.4 にメタン濃度と高度および地表面温度と露点のプロットを示す。Fig.3 とFig.4 は西シベリア低地がメタンの発生源であり、またメタンが表面温度が高い時に水蒸気と共に供給されていることを示唆しており、湿原がメタンの供給源であることを推測させる。

Fig.5 にチュメニからヤクーツクへの西から東への飛行高度5000-6000mでのメタン濃度を示す。メタン濃度に特徴的な変化は見られず、Fig.5 はシベリア上空の東西方向のメタン濃度はかなり均質であることを示している。

Fig.6 ににヤクーツクーチクシ往復の飛行（凡そ東経130 ° に沿っての南北の飛行）での緯度に対する飛行高度とメタン濃度度および地表面温度を示す。メタン濃度は北緯66度付近で減少を示した。飛行コースのヤクーツク側は湿原であるが、往路に比して復路の時にこの湿原上空で比較的高濃度のメタンが観測された。また、Fig.6 は復路に地表面温度が比較的高いことを示している。この結果は地表面温度が上昇して地表面からのメタンの供給が多くなると同時に対流により地上の気塊が持ち上げられて飛行高度にメタンが供給されたことを示唆する。

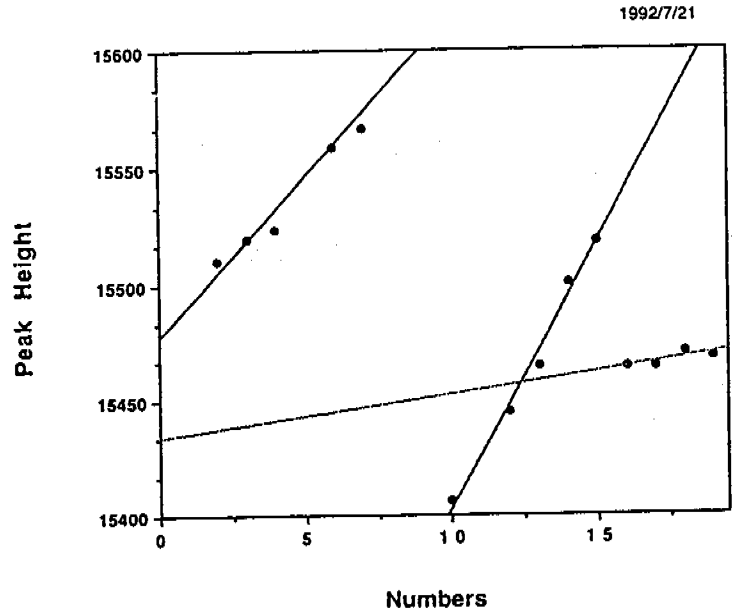
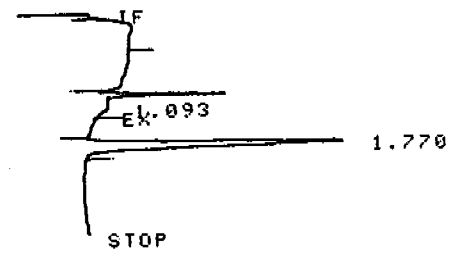


Figure 1

********** sampling time is JUL 16, 1992 10:01:38
RUN #   29   JUL 16, 1992   10:01:39
START



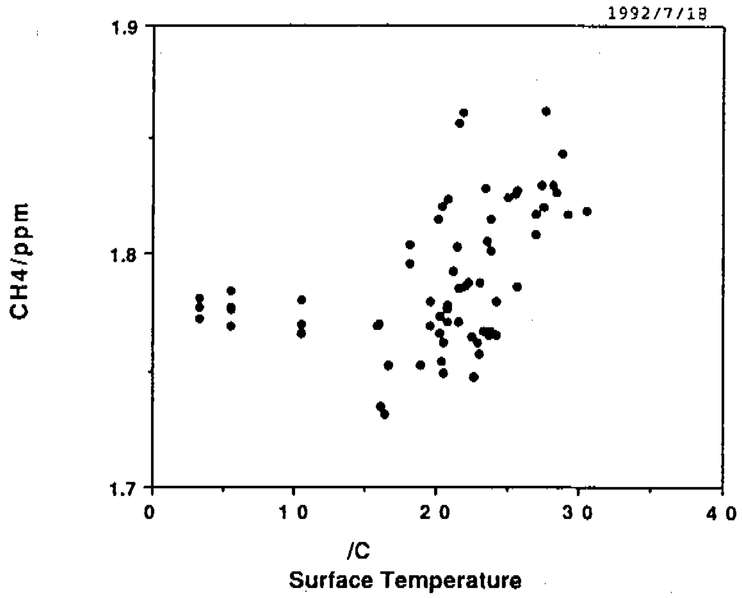
Closing signal file H:Q4DE6684.BNC
Storing processed peaks to H:Q4DE6684.PRO
Storing report to H:Q4DE6684.RPT

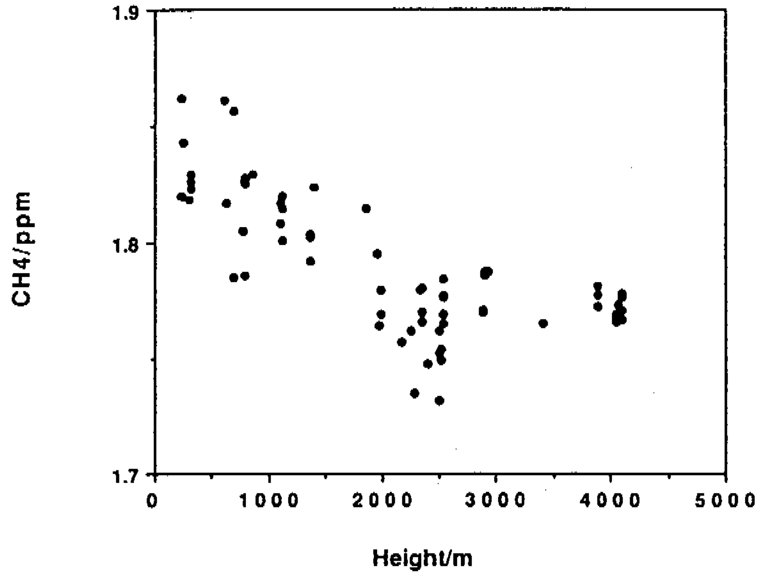
RUN#   29   JUL 16, 1992   10:01:39

SAMPLE# 170

SIGNAL FILE: H:Q4DE6684.BNC
REPORT FILE: H:Q4DE6684.RPT
PEAK FILE : H:Q4DE6684.PRO

Figure 2


1992/7/18
1.9
1.8
1.7
CH4/ppm
0
10
20
30
40
/C
Surface Temperature


1.9
1.8
1.7
CH4/ppm
0
1000
2000
3000
4000
5000
Height/m

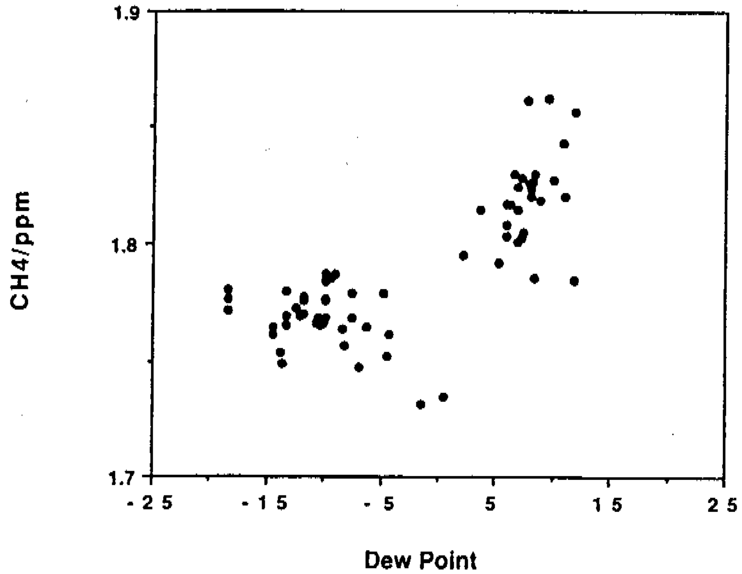

1.9
1.8
1.7
CH4/ppm
-25
-15
-5
5
15
25
Dew Point

Figure 3

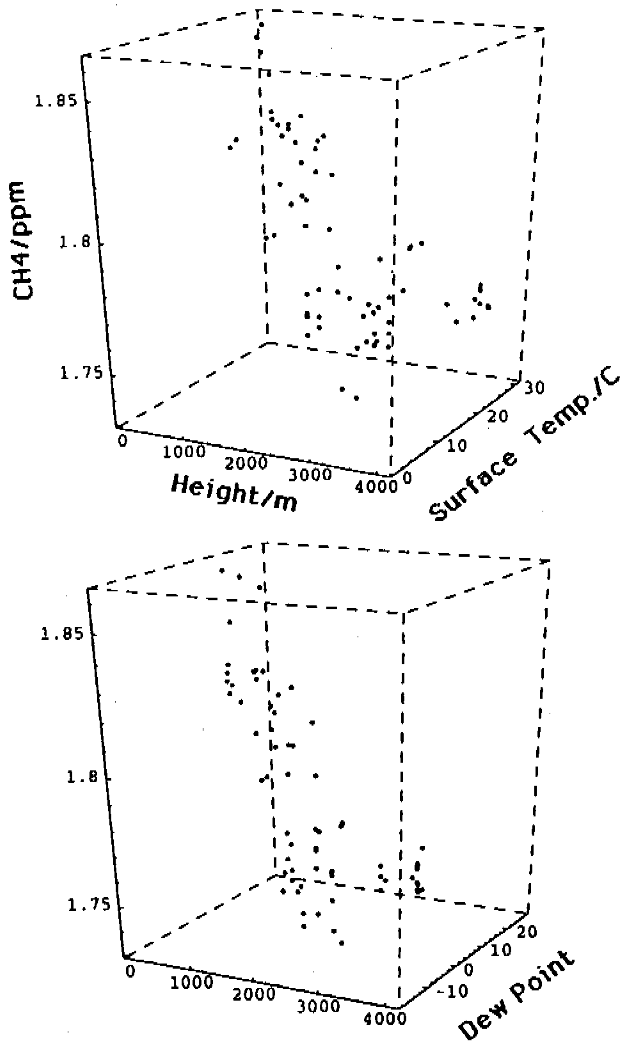


Figure 4

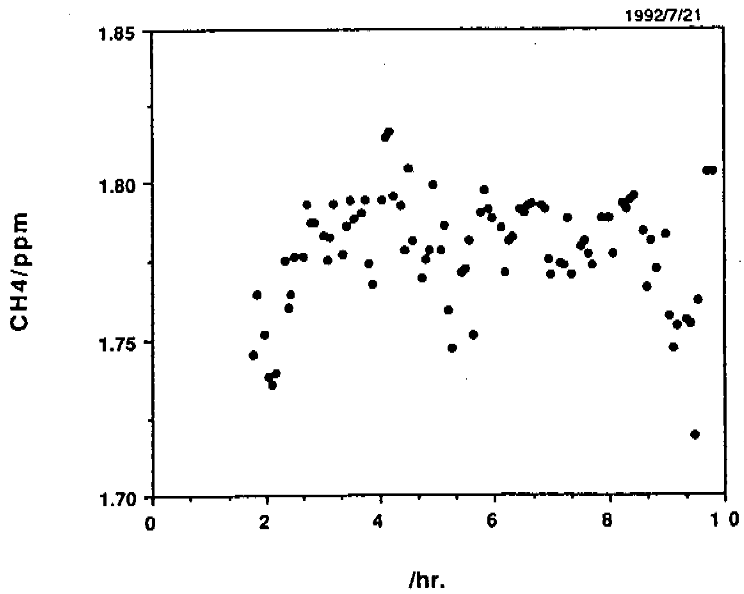


Figure 5

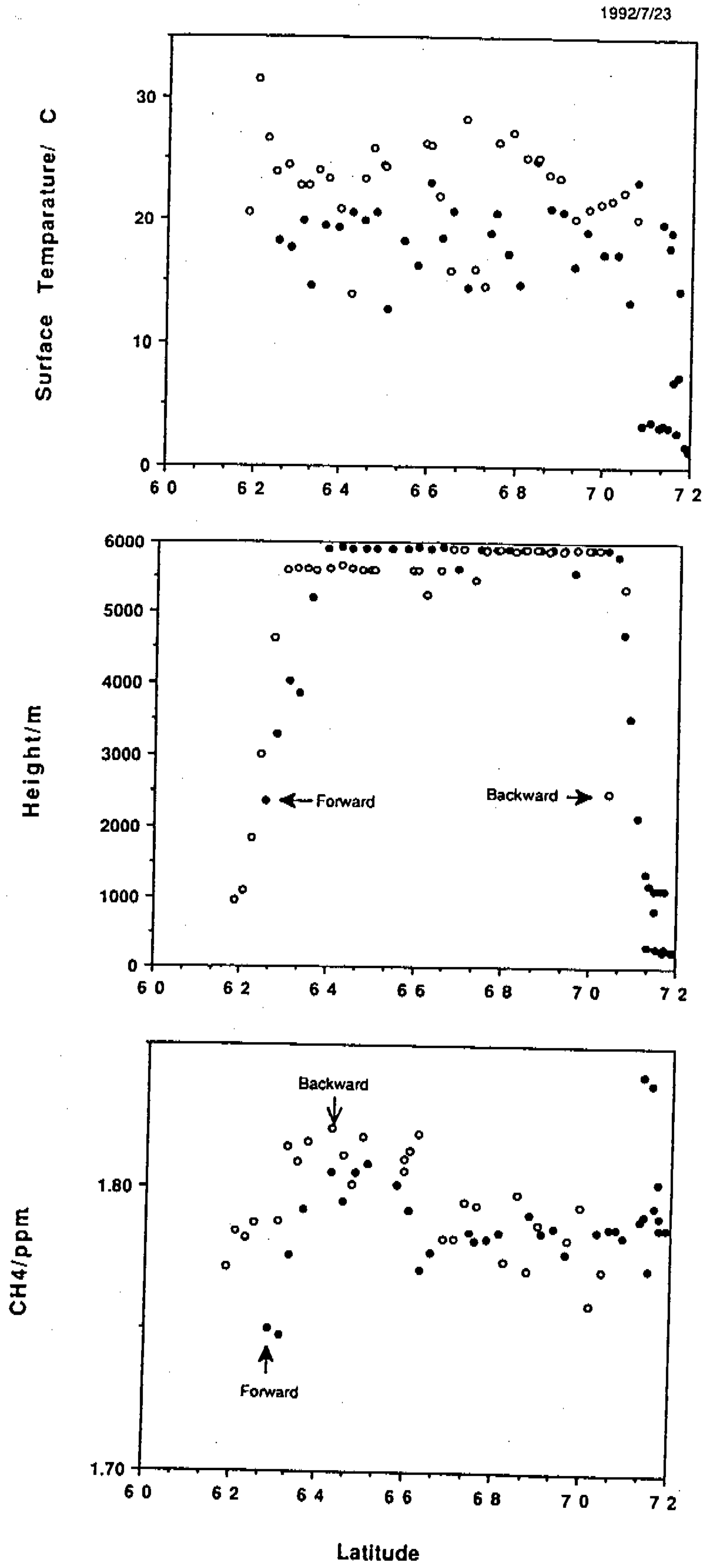

1992/7/23
Surface Temparature/ C
30
20
10
0
60
62
64
66
68
70
72
Height/m
6000
5000
4000
3000
2000
1000
0
Forward
Backward
CH4/ppm
1.80
1.70
Latitude

Figure 6

6 Numerical Simulation of Methane Transport in the Atmospheric Boundary Layer.

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Introduction. The greenhouse gas emission and sink rates appear to be very inhomogeneous and depend on a variety of natural conditions. Detailed information obtained from on site measurements and emission inventories has to be scaled up in order to provide total emission and sink rates corresponding to a large area. A large degree of uncertainty still exists in the scaled up data (Roulet,1992). So alternative verification procedure including atmospheric concentration measurements are required in order to obtain the regional emission rate distribution. The relationship between observed concentrations of atmospheric tracer gases and corresponding emission rates is complicated because the tracer transport and distribution in the atmosphere are affected by several factors that include: surface conditions, vertical temperature profile, wind field, radiative heat flux and further more. This study is devoted to analysis of relation ships between the emission flux on the surface and corresponding concentration distribution in the atmosphere in the area of Joint Japan-Russian Airplane Expedition 1992 (Izumi,1993). Vertical concentration distribution in atmospheric boundary layer is numerically simulated in order to analyze the diurnal cycle in the one-dimensional model. Three-dimensional mesoscale model is applied to the case study of methane distribution over Siberian area. A global tracer transport model is also developed in order to estimate a long range transport and large scale distribution features.

Diurnal cycle of methane concentration in the atmospheric boundary layer. An absolute value of methane concentration is rather difficult to predict by numerical model as long as the life time of methane in the atmosphere is very long as compared to typical transport rates and a local concentration is affected by the transport from outside the area of analysis. Only a local source is taken into account in the case of one-dimensional analysis. One-dimensional model of atmospheric boundary layer is based on parameterizations of radiative transport and turbulence closure model (Gross,1987). The evolution of atmospheric concentration distribution is determined by surface source strength and vertical turbulent eddy diffusion coefficient that is predicted by model. The values of solar radiation, albedo, surface temperature, geostrophic wind are accepted from observations or typical values for the Tyumen area in West Siberia. Under clear sky conditions the most intensive vertical turbulent transport occurs in the afternoon, at that time the methane concentration gradient is lowest. During the night a radiative cooling causes development of a stable layer near the ground and the methane concentration grows up without being transported to the upper layers. The concentration difference between the altitude levels 300 m and 600 m varies between minimum 0.02 ppm in the afternoon and 0.2 ppm in the morning provided the constant surface methane flux is equal to 0.1 $g/m^2/day$.

Three-dimensional mesoscale model simulation. More detailed analysis is available with the three-dimensional mesoscale meteorological model applied to the study of methane concentration distribution. The methane emission rates are taken from (Matthews,1987), despite lower values are supposed to be more realistic (Roulet,1992). Same initial and boundary conditions are accepted as for the one-dimensional model simulations. Upwind concentration on boundaries where set to zero in order to exclude influence of outside sources. An area of the model is 4 degree North and 10 degree East from (58N,62E). Geostrophic wind velocity is 5 m/s East-West. The vertical methane gradients obtained from numerical simulation in three-dimensional model show the diurnal cycle similar to that in one-dimensional model. The horizontal distribution of the vertical concentration gradient mimics the surface emission pattern with some distortion in the areas of large emission rate gradient. The diurnal cycle of the maximum difference between layers resembles that in one dimensional model. Lower and higher limit are of the same order despite maximum emission rate is 0.2 $g/m^2/day$ (higher than in one-dimensional model). The emission pattern resolution is coarse as compared to the grid size of meteorological model so the distortion of the vertical gradient distribution is minor. In order to obtain the absolute concentration distribution a large scale distribution pattern should be added to regional model, otherwise the horizontal concentration gradients can not be predicted quantitatively. Thus the global scale model is necessary for analysis of large scale features of methane distribution.

A development of global tracer transport model. The global meteorological analysis data set from ECMWF is used in the global model for convective transport modeling. Equal area grid algorithm was developed in order to increase time step in computations. The model was use for the analysis of the global transport of methane originating from wetlands using the same data sets in order to obtain typical horizontal gradients. In the large scale model even a slow chemical reaction can produce feasible effect upon the resultant concentration values. The inclusion of a chemical reaction parameterization and nesting mesoscale model to global model are under development.

References:

Izumi M. et all., 1993, Aircraft measurement of atmospheric CO2 concentrations. - This issue.

Gross G., 1987, Some effects of deforestation on nocturnal drainage flow and local climate - a numerical study. - Boundary Layer Meteorology, 1987, v.38, 315-337.

Matthews E., I. Fung,1987, Methane emissions from natural wetlands: Global distribution area and environmental characteristics of sources. - Global Biogeochem. Cycles, v.1, n.1, 61-87

Roulet N.T., L.A.Barrie, 1992, Methane emissions from northern wetlands: source strength and uncertainties in estimates.-Pap. pres. IUPAC Workshop on Atmospheric methane, 19-20 July, 1992, Moscow, Russia.

7 CH_4 Continuous Concentration Measurement of Atmosphere

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Methane is a flammable and explosive gas and it is one of factors which make the temperature rise of the atmosphere. The developing system is a methane monitoring system of the atmosphere applied by the gas leakage detection technique using a diode laser.

There are some CH_4 absorption bands in the infrared region. The ν_3 band at 3.3 μm and the ν_4 band at 7.7 μm are very strong. However at present, it is very difficult to make diode lasers of wavelengths longer than 2 μm which operate at room temperature. And their sensors are needed to cool in order to detect small power.

The strongest band of CH_4 in the region below 2 μm is the $2\nu_3$ band whose center is located at 1.665 μm. The $2\nu_3$ band consists of P, Q, R branches. The isotopic ratio of $^{13}C/^{12}C$ can be measured to select the proper wavelengths, e. g. near to the R(0) line of $^{12}CH_4$ and the R(2) line of $^{13}CH_4$, the R(4) line of $^{12}CH_4$ and the R(6) line of $^{13}CH_4$.

The oscillation wavelength of a diode laser can be easily modulated by changing the injection current which makes intensity modulation simultaneously. The wavelength was modulated sinusoidally, and the synchronously detected second harmonic signal was used for high sensitivity detection.

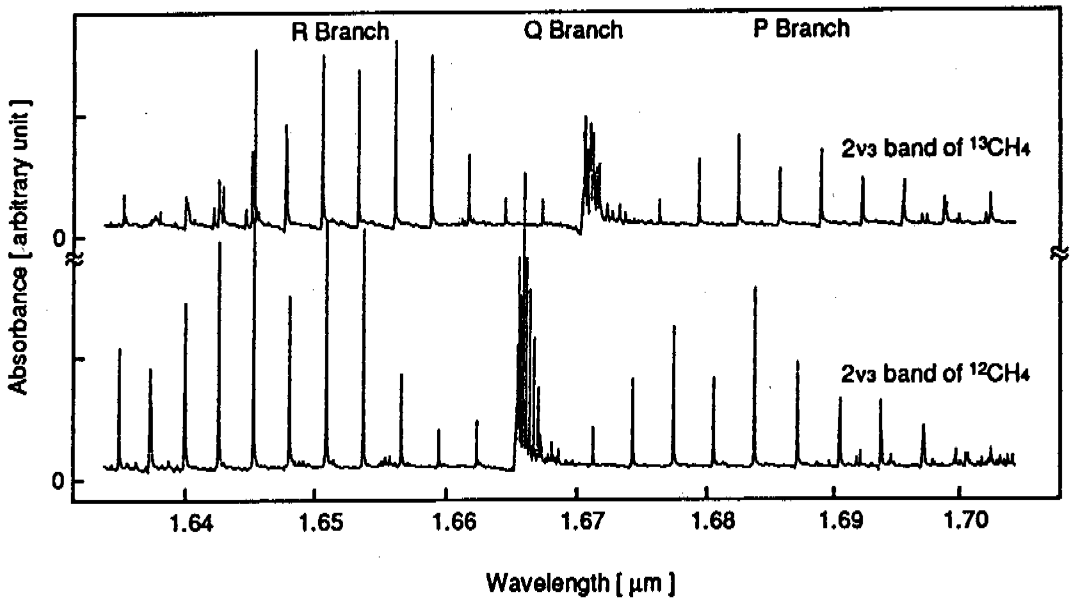

Fig. 1 F.T.I.R. Spectra of $^{12}CH_4$, $^{13}CH_4$

Fig.2 shows the lock-in detected spectra of the R(0) line of $^{12}CH_4$ and the R(2) line of $^{13}CH_4$ at atmospheric pressure, observed by temperature-turning of a 1.66-μm DFB diode laser. Both traces were recorded as a function of the laser junction voltage which is a good monitor of the oscillation wavelength. Upper and lower spectra are lock-in detected fundamental f and second harmonic 2f components of the absorption signal respectively, when the injection current was sinusoidally modulated at 50 kHz while the laser center frequency was scanned by temperature tuning.

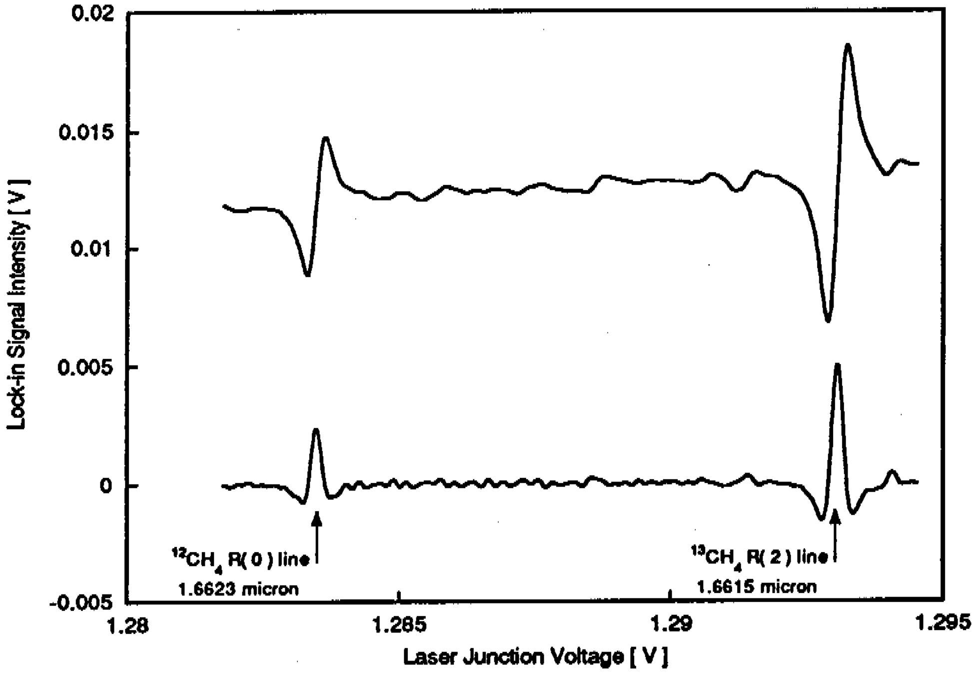

Fig.2 $^{12}CH_4$, $^{13}CH_4$ Lock-in Spectra about 1.66 micron

The background of the f signal suffers a large offset as a result of intensity modulation. On the other hand, the offset is much smaller in the 2f signal, so the 2f signal is more advantageous for absorption detection.

To obtain the maximum of the 2f signal, the center wavelength of the laser must be stabilized to the center of the absorption line. The f signal is used for feedback control of the operating temperature of the diode laser after the compensation of the offset.

In practical system there are some other factors besides the gas absorption which change received laser power: for example, misalignment and dust adhered to optical elements. So the magnitude of the 2f signal does not indicate the quantity of the probed gas. However, the magnitude of the f component is directly proportional to the received laser power. Quantitative detection is possible by normalizing the 2f signal by the f signal.

It was achieved that detection limit at the R(0) line of $^{12}CH_4$ is 33 ppm using a 60-mm long cell on the condition of S/N = 1 and the signal averaging time is 1 second. This year it is planed to monitor $^{12}CH_4$ concentration and to use the multiple optical pass cell which has 200-m long pass. So it is expected of the detection limit as 0.01ppm or smaller.

8 Springtime ozone depletion and volatile organic compounds in the lower Arctic atmosphere

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Dramatic decrease of ground-level ozone (from 30-40ppb to almost 0ppb) has often been observed after the sunrise in the Arctic Region. Some chemical destruction of ozone is likely to be responsible for the decrease of ozone together with the suppression of ozone transport from lower stratosphere due to the inversion over the ice cap. Here we report a new finding of significant correlations of volatile organic compounds (VOCs) and surface ozone, obtained from the serial GC/MS measurements at Alert(82.5^{o}N, 62.3^{o}W), Canada.

Measurements of volatile organics were conducted with an automated preconcentration/capillary GC/MS which was installed in the special lab of AES(Atmospheric Environment Service of Canada) at Alert, from April 1 to April 14 as a part of "Polar Sunrise Experiment 1992 (spring)". Target compounds of this study include dimethyl sulfide(DMS, CH3SCH3), 5 bromomethanes(CHBr3, CH2Br2, CH2BrCl, CHBr2Cl, CHBrCl2), iso-pentane(i-C5H12), n-butane(n-C4H10), acetone(CH3COCH3), chloroform(CHCl3), trichloroethylene(CHCl=CCl2) and tetrachloroethylene (CCl2=CCl2). Among them, DMS and 5 bromomethanes are believed to be marine-derived natural organics. CHCl=CCl2 and CCl2=CCl2 are anthropogenic chloroolefins which have been used as solvents.

258 data sets of VOCs were obtained for the period. The variations of CHCl=CCl2, i-C5H12, CHBr3(bromoform) and acetone are shown in Figs. 1-4 with the hourly averaged data of surface ozone, which depletion was observed when the airmasses having stayed over the ocean for several days came to Alert. The extremely similar variation was found for CHCl=CCl2 and ozone (Fig.1). I-C5H12(Fig.2) as well

as CCl2=CCl2 and n-C4H10 was also positively correlated to ozone. CHBr3(Fig.3) which is likely to build up in the air mass over the ocean, and acetone(Fig.4) were anticorrelated to ozone.

The decrease of CHCl=CCl2 and hydrocarbons at the ozone depletion events accompanying the increase of acetone which is a major oxidative product of hydrocarbons, strongly suggests their decay by OH radicals reaction. The reaction of CHCl=CCl2 with OH radicals is known to produce chlorine atoms(Cl) with a yield of 60%. As is well known, Cl atoms destruct O3 through the catalytic chain of reactions as follows;

Cl+O3 → ClO+O2

ClO+ClO → Cl+OClO   etc.

under the condition of low NOx. This scenario that CHCl=CCl2 may contribute to the surface ozone depletion in the spring Arctic via Cl-induced reaction, is very similar to that for the stratospheric ozone hole where Cl-atoms are produced from the photolysis of chlorofluorocarbons.

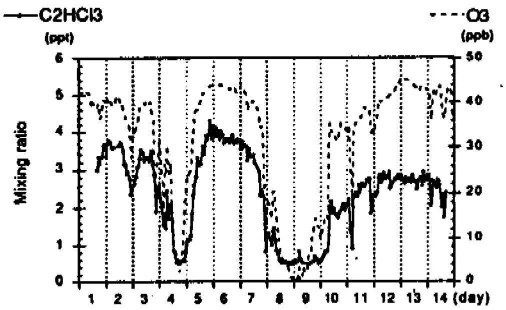

Fig. 1

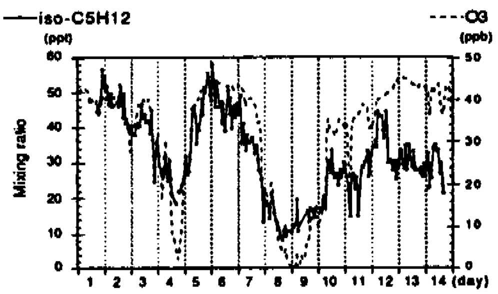

Fig. 2

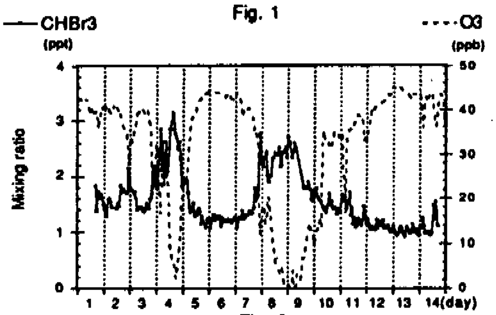

Fig. 3

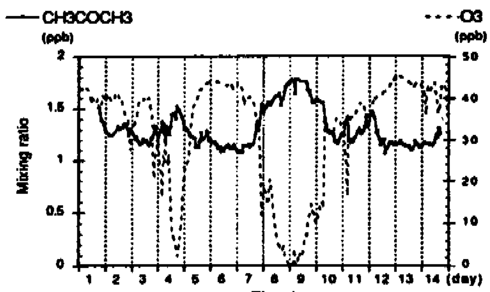

Fig. 4

(Ozone was measured by Dr. K. Anlauf of AES)

This work was funded by Science and Technology Agency of Japan.

9 Methane emission measurement from water surface

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I started the study to estimate methane flux from inland water environment, measurements of methane concentration, production, air-water exchange and oxidation in Japanese fresh water lakes. An automated methane analyzer for natural water samples, utilizing a purge and trap/FID-GC technique, was developed and applied. Dissolved methane, in the concentration range from atmospheric equilibrium to 10 μM, can be measured accurately by the system.

Lake Kasumigaura is a shallow eutrophicated freshwater lake. It has the surface area of 171 km^2, 2nd largest in Japan, and the average depth of 4 m. I measured dissolved concentration of methane and its distribution in Lake Kasumigaura monthly since Apr. 1990. Because of the shallow depth, the lake water is not stratified all over the year. The lake water methane concentration was far higher than the equilibrated concentration (2-4 nM) with the atmospheric methane during the whole measurement period. Vertical distribution of dissolved methane is usually uniform, that is consistent with the results for other chemical components. The variation of whole lake averaged concentration is shown in Fig.1. Averaged surface water concentration during the two and half years was around 200 nM. Concentration maximum, observed at summer and early autumn, corresponds to the maximum production in the lake.

Methane in the lake water is supplied from the bottom sediment. The major extinction routes of the methane from the lake water are escape from water surface with air/water gas exchange (diffusive flux) and oxidation in the water column. Variation of oxidation rate was measured monthly by the incubation experiment of the water sample. The diffusive flux can be estimated from the concentration data and local meteorological data (Fig. 1). The methane supply rate to the water was calculated from the sum of the oxidation flux and the diffusive flux (Fig.2). The results indicates the importance of bacterial oxidation in the water column, which controls the net methane flux from in Lake Kasumigaura in summer and autumn. The gas exchange is dominant extinction route in the winter and spring. From the results, the residence time of methane in the lake water column was estimated (Fig.3).

The developed techniques to measure the methane concentration, flux from the sediment and water surface, and the oxidation rate in the water column can be applicable to the research of Siberian freshwater lakes and wetlands. The microbial methane generation and oxidation processes are to be investigated.

We now established a rapid measurement of carbon . stable isotope measurement op methane using GC/C/MS (Gas Chromatograph Combustion Isotope Ratio Mass Spectrometry). I will analyze the stable isotope of carbon in methane emitted from various sources in Siberia in the project. This will contribute to the understanding of the origin of methane and its contribution to the global flux.

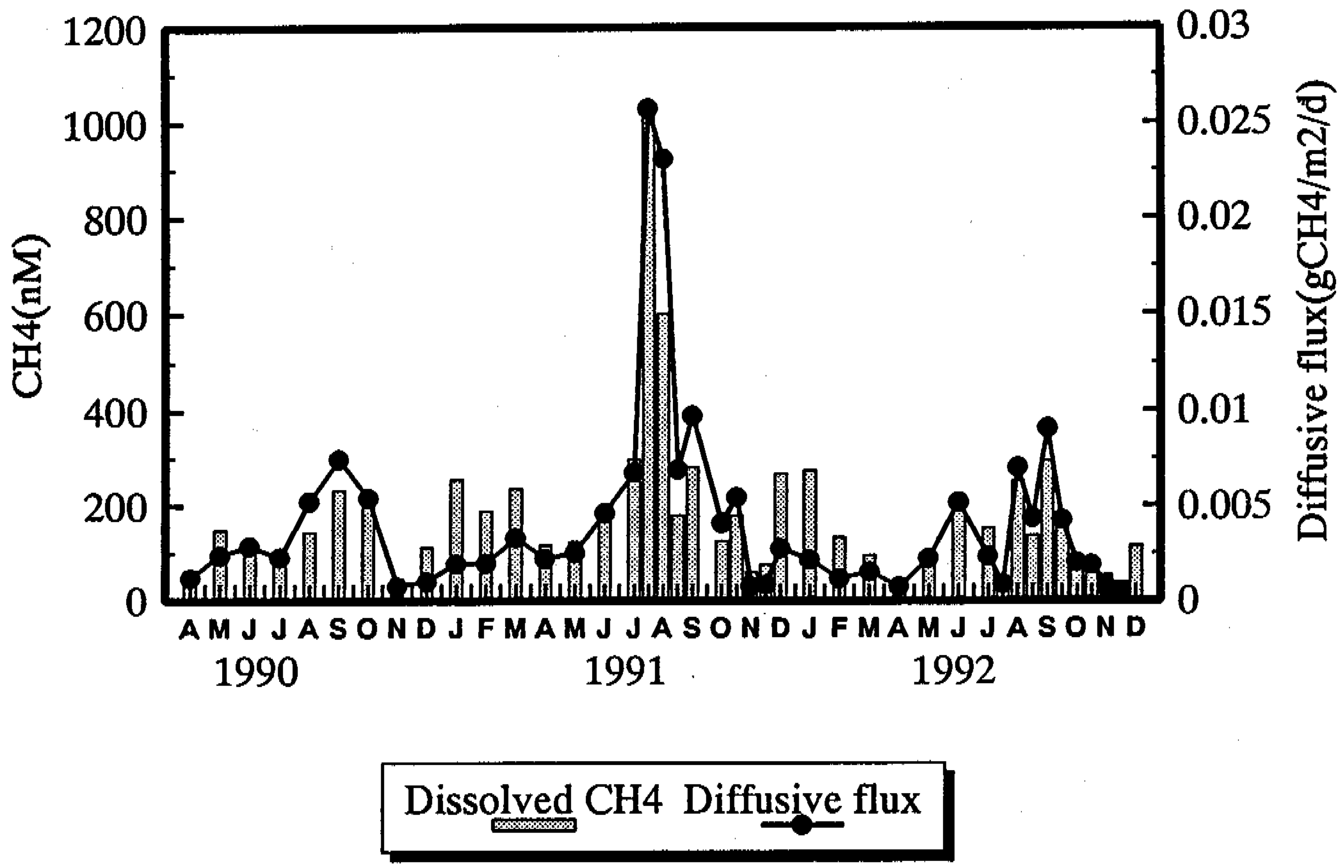

Fig.1 Dissolved methane concentration in Lake Kasumigaura water and diffusive flux from the water surface

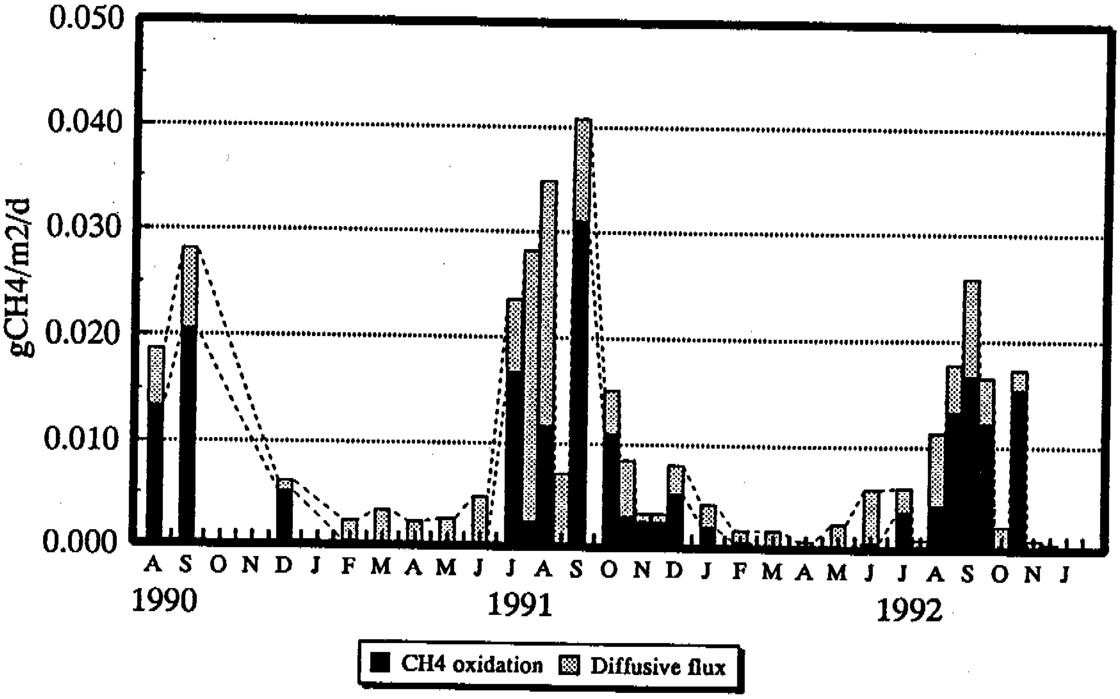

Fig.2 Diffusive flux from the water surface and oxidation in the water column of Lake Kasumigaura

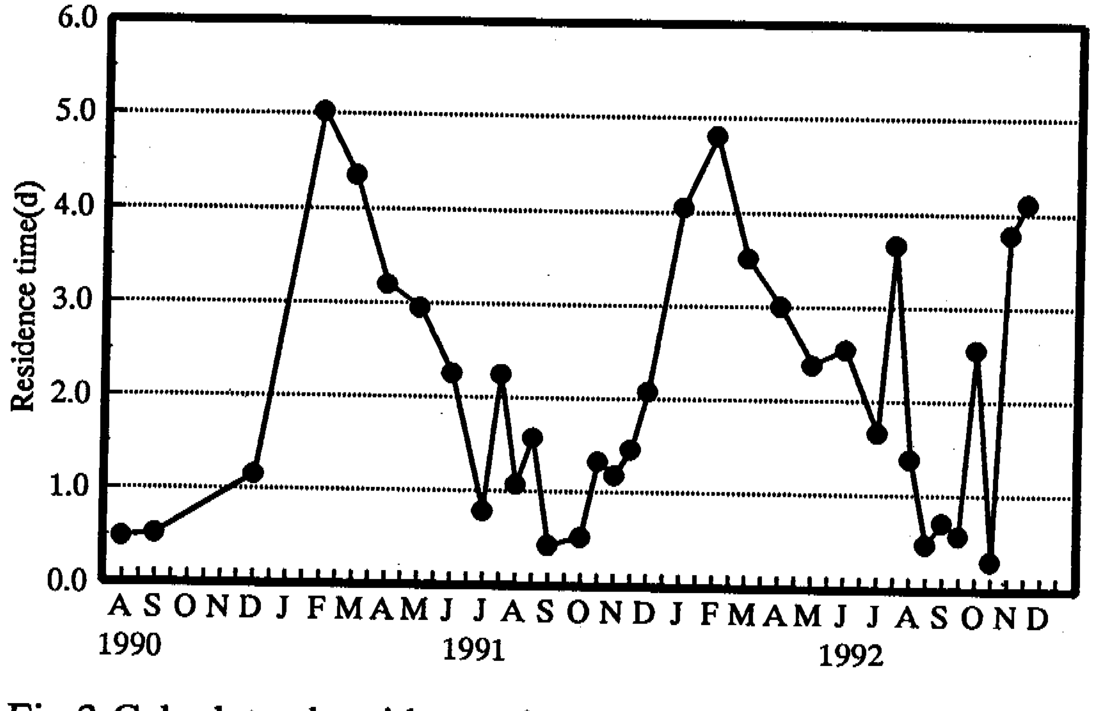

Fig.3 Calculateed residence time of methane in the water column of Lake Kasumigaura

10 INVESTIGATION OF SOILS AND VEGETATION IN SIBERIA BY REMOTE SENSING TECHNIQUES

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1. BACKGROUND

The joint Japanese-Russian flight expedition has recently started to investigate vertical distributions and flux of green-house-effect gases (GHGS) in Siberia. The concentration of these gases would be greatly affected by emission and absorption by soils and vegetation. Hence knowledge of ground cover characteristics is indispensable to understand the relationship between ground surface conditions and distributions of GHGS.

2. OBJECTIVES

In this study we investigate soil characteristics and vegetation distributions by satellite remote sensing, which is one of the most powerful tools to obtain surface distribution data in a vast area like Siberia. This study will contribute to understanding how the concentration of GHGS is affected by soils and vegetation and also estimating overall emission and absorption of GHGS by Siberian ground.

3. METHOD

We use NOAA AVHRR data to obtain overall vegetation images and monitor vegetation seasonal dynamics over the whole Siberia. Distributions and changes of vegetation and wetlands are estimated from these data sets.

We chose several observation fields representing typical vegetation types such as wetland, grassland, permafrost and forest. High-resolution satellite data are taken in the observation fields from LANDSAT, ERS-1, JERS-1, etc. We analyse these data and examine what we can detect about soil characteristics and vegetation features of the fields. Ground-truth studies are also conducted in the observation fields.

11 Analysis of forest regeneration processes in Siberian Taiga: Research Proposal

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In wet forests in lower latitude regions, light is the major environmental resource limiting the growth and survival of seedlings under forest canopies. The suppressed seedlings, together with newly established seedlings, start vigorous height growth only after death of canopy tree(s) and improvement of light conditions.

In boreal forests under cold and dry climate, however, other environmental factors such as limited water availability and short growing season might be controlling seedling growth on the forest floor. Natural fire is also a probable environmental factor affecting forest dynamics in Taiga. Moreover, changes in physical environment due to the removal of trees would be also different in higher latitude regions. Lower angular elevation of the sun might be one of the possible causes of such differences, because changes in radiation environment due to canopy destruction must be critically affected by the solar position.

I would like to observe the process of forest regeneration after disturbance and analyze how it is affected by environmental factors. Major subjects of the study will be as follows.

Species composition and size distribution of regenerating tree seedlings in disturbed area .

I will survey disturbed areas at different stages of regeneration. I expect that the state of forest recovery is affected by the type of the disturbance (such as sporadic death of canopy tree(s) and natural fire), topographic conditions of the site, and type of surrounding vegetation.

Demography of tree seedlings and saplings in disturbed area

I will investigate the establishment, survival and growth of tree seedling by tagging and observing them periodically for 2 - 3 years at several study sites at different stages of regeneration.

Radiation environment in disturbed and undisturbed forest stands

I will analyze the radiation environment mainly with photographic method. I will take photographs of forest canopies from the forest floor with a fish-eye lens and analyze them for the light transmission.

[Introduction]

12 FEEDBACK OF GLOBAL WARMING IN SIBERIAN PERMAFROST REGIONS

(Subtitle)

Carbon storage and carbon dioxide budget in forest ecosystems

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Background

Increase in the concentration of atmospheric carbon dioxide has been over one ppm/year in recent years. Such increase in CO_2 may result in the increase of air temperature at a magnitude of two degrees C in 50 years. Rapid temperature increase would greatly affect the forest ecosystems. The effect is particularly keen in boreal forest ecosystems where approximately 25% of total edaphic carbon of the earth's surface is stored. Little is known about the carbon balance of Taiga(boreal forest) that occupies much of the Siberian permafrost regions. Such knowledge must be gained as soon as possible for supplying basis for consideration of the global warming problems.

The forests of the former USSR cover 814 million hectors, about 26% of the closed forest in the world. The forests' area is divided into four parts statistically in 1988 as shown Table 1. Siberian Taiga occupies a huge area in both Transition RSFSR(Western Siberia) and Asian Pacific Part(Eastern Siberia and Far East). Coniferous forests consist of *Larix, Pinus, Spruce* and *Fir*. *Quercus, Fraxinus* and *Acer* are classified in hardwood deciduous trees, and *Betula, Alnus* and *Salix* are in softwood deciduous trees.

Far East has about 275 million ha in forest area and about 21 billion m^3 in stand volume, and 53% of the forest area(5.8 times as large as Japan) and 45% of stand volume are in Sakha Republic. However, the average value of annual growth is only 0.6 m^3/ha in the forests of Sakha, lower than the annual growth in other forests of RSFSR, because a considerable amount of the forests in Sakha consist of mature and over–mature forests and the conditions of climate and soil are very severe.

To know whether the huge Siberian Taiga is a sink or a source of CO_2 is very important for us to estimate the influence of global warming on the Taiga. Our research project is to be focused on these problems.

Table 1. Growing stock and forest area in USSR

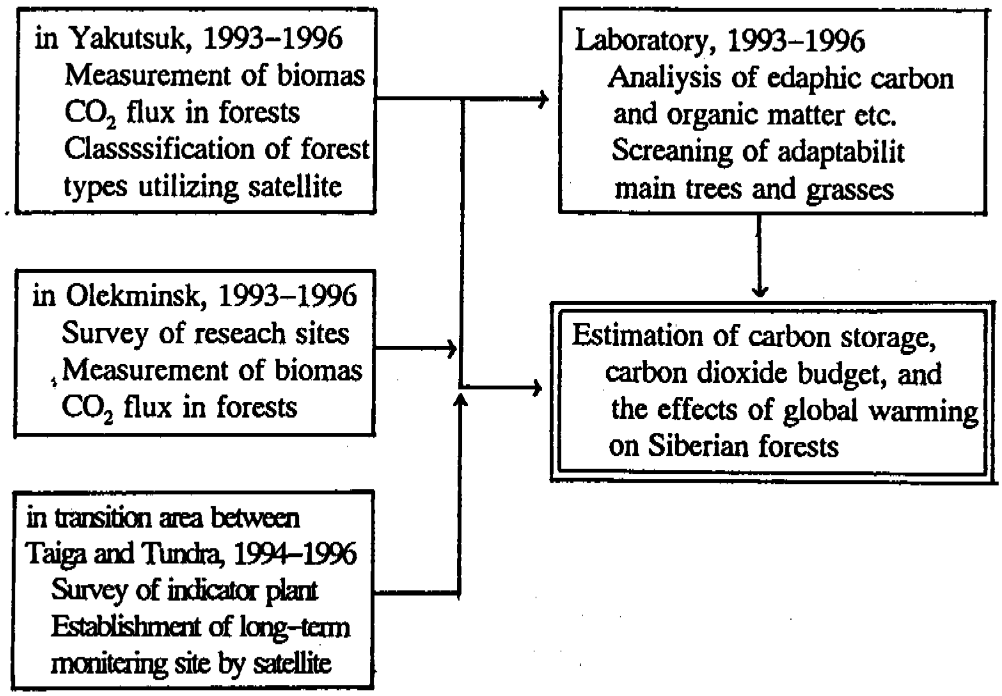
	Conifer-ous	Hardwood Deciduous	Softwood Deciduous	Other Species	Total
European Part	15,120 116.3	1,880 13.8	7,094 61.5	39 0.7	24,133 192.3
Transition RSFSR	7,221 59.4	0 0	3,567 30.0	6 0.7	10,749 90.1
Asian Pacific Part	43,828 389.2	1,149 13.0	4,239 51.6	1,356 61.1	50,572 514.9
Central Asia	251 2.5	28 10.1	124 1.5	17 2.7	420 16.8
Total	66,420 567.4	3,057 36.9	15,022 144.6	1,419 65.2	85,919 814.1

Note: Upper figures;growing stock(millions cubic meters), Lower figures;forest area(millions hectors) from C.A.Backman & T.R.Waggener(1991)

Research Plan

The purpose of the project is to clarify the following four areas for representative forests in the permafrost regions of Siberia in relation to the effect of global warming; 1)Measurements of carbon storage and increase in aboveground and belowground components; 2)Examination of photosynthetic, respiratory, and evaporative characteristics in representative tree species
in relation to adaptation to environmental fluctuation; 3)CO_2 flux above and below ground in forests; and 4)Classification of forest types around reseach sites utilizing satellite data.

The first stage of this project is from 1991 to 1993 and the first investigation in Yakutia was carried out in July of 1992 by surport of Yakutian Institute of Biology. Our investigation is behind in the original research plan because of the shortage of the budget for our oversea travel. The second stage of the project is going to be carried out from 1994 to 1996. The flow of our studies from 1993 is shown as Figure-1.



Figure–1 Flow of our research plan

Institution and Researcher in charge

Japanese side:Forestry and Forest Products Research Institute, Forest Agency, Ministry of Agriculture, Forestry and Fisheries

Kunihide TAKAHASHI(Project Leader, Hokkaido Research Center)

Youichi KANAZAWA(Silviculture Lab., Hokkaido Research Center)

Akira OSAWA(Silviculture Lab., Hokkaido Research Center)

Hiromichi KUSHIMA(Silviculture Lab., Hokkaido Research Center)

Seiich OTA(Forest Soil Lab., Hokkaido Research Center)

Youjirou MATSUURA(Forest Soil Lab., Hokkaido Research Center)

Takayoshi KOIKE(Ecophysiolgy Lab., Hokkaido Research Center)

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Russian side;Yakutian Institute of Biology, Siberian Branch of Russian Science Academy of Russia

Nikita G. SOLOMONOV(Director, Yakutian Instute of Biology)

Boris I. IVANOV(Deputy Director, Yakutian Institute of Biology)

Trofim C. MAKSIMOV(Plant Physiology Lab., Yakutian Instute of Biology)

Results in 1992

The first investigation in Yakutia was carried out in July of 1992 by the sincere surport of Yakutian Institute of Biology. We were studied the following five subjects; 1)Field reconnaisance of Skaspayapait Forest Site; 2)Dendroclimatological analysis of tree growth patterns (Dr. A. Osawa); 3)Soil characteristics and Carbon and Nitrogen storage in soil (Dr. S. Ohta et al.); 4)Nutrient analysis in tree leaves (Dr. T. Sasa); 5)Estimation of soil respiration (Dr. T. Sasa); 6)Measurement of CO_2 concentration in a forest and photosynthesis of woody species (Dr. T. Koike). These results are presented in the following pages and this research project is supported by the Grant of the Environment Agency.

Aknowledgement

We are much obliged to Prof. N. G. Solomonove, Dr. B. I. Ivanov, Dr. T. C. Maksimov, and other menbers of Yakutian Institute of Biology who supported our research project in Russia.

13 FIELD RECONNAISANCE OF SKASPAYAPAIT FOREST SITE

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Abstract: A field map of the study area was produced with a compass-and-pacing survey at Skaspayapait Experimental Forest, 35 km north of Yakutsk, Sakha. Availabe data of the permanent tree plots that were established in early 1950's were also examined through interviews with the scientists at Yakutsk Biology Institute. Amount and quality of the available data appeared substantial. These information will be of great value in future studies in the region.

Objectives

No field maps of reasonable accuaracy and scale for use in the present study were available at Skaspayapait Experimental Forest near Yakutsk, Sakha. Therefore, the objective of the field reconnaissance was to travel throught the potential study sites within the boundary of the Forest, and to produce a rough map for use in the field. The second objective was to identify the extent and quality of the available data of the permanent tree plots in the Forest.

Materials and Methods

A hand-held compus and pacing were used for the survey. The declination was not know initially, so the magnetic north was used as the base axis. The available tree-plot data were examined through interviews with the scientists of Yakutsk Biology Institute which inherited the Experimental Forest in 1991 from the third research establishment in Krasnoyarsk, Russia.

Results

Fig. 1 shows the field map of the research site that was produced with the compass-and-pacing. About two dozen plots of natural tree stands are located within a few square kilometer area near a field camp that was established by a small lake. The tree plots are rectangular shape of various sizes, and consist of three species, dahurica larch *(Larix dahurica)*, scots pine *(Pinus sylvestris)* and paper birch *(Betula platyphylla)*. Many are pure species stands, others are of mixed species. The corners of the plots are originally labeled with the approx. one-meter-tall wooden pillars that are painted blue and numbered. Total number of the permanent plots is still not clear, but the largest plot number observed in the field was 24. There may well be more plots if we search the forest extensively. Detailed tree data are avialable for 12 plots; some of which were measured repeatedly in 1954, 1977 and (by us) 1992. Table 1 shows summary of the available data for the permanent plots.

This project was supported in part by Japan Environment Agency Grant for Integrated Global Environment Research.

Research Plan for 1993

The produced field map will be used in the 1993 study. Corrections and additions shall be made. If time permits, and if the plots are to be used for a long period, it will be preferable to make an additional survey and produce a rough map that also shows the topographical features of the study area.

Fig. 1.

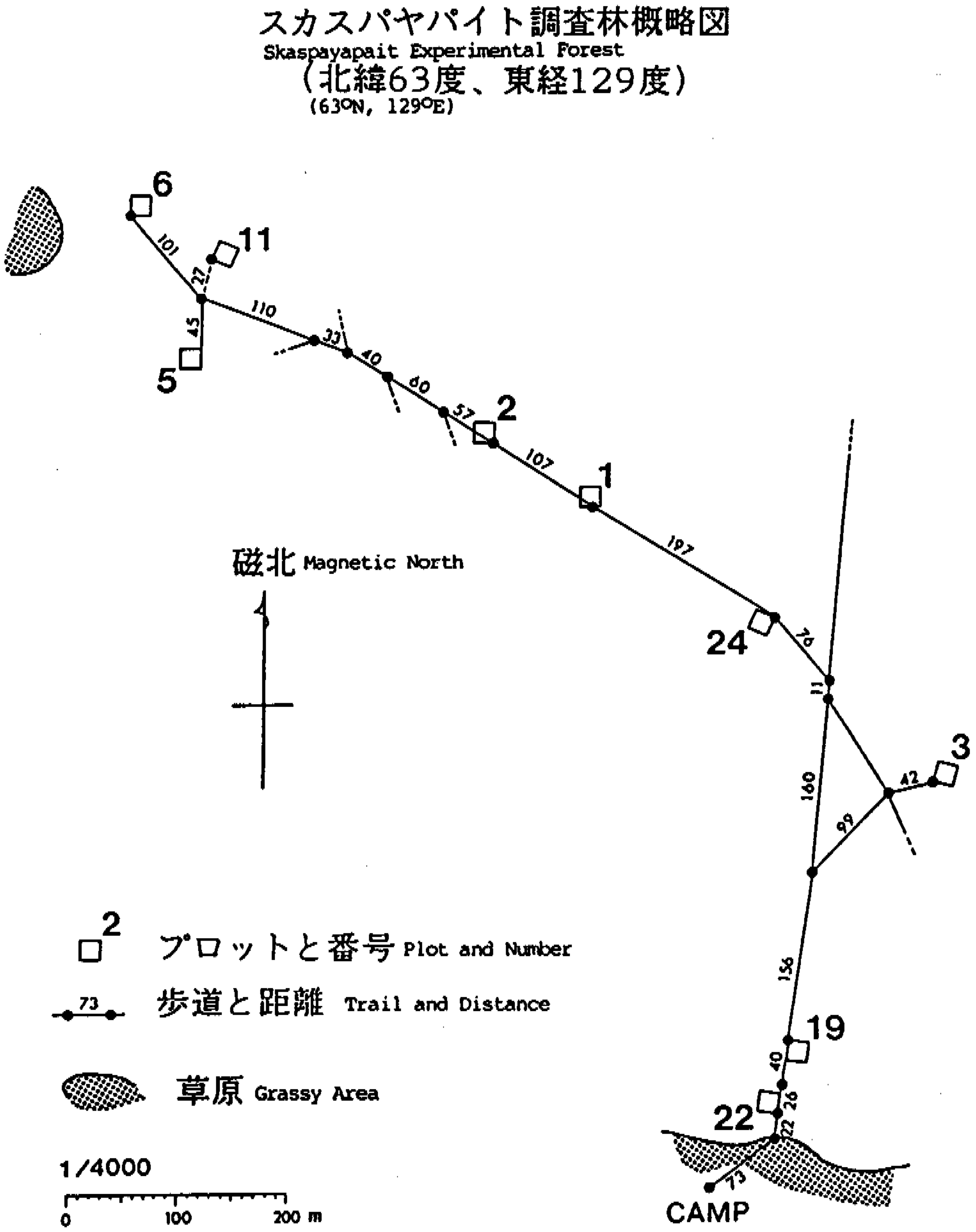

Table 1.

ヤクーツク調査林分のデータ
Stand Data in Yakutsk Area

プロット番号 Plot No.	林令 Age (yr)	樹種[1] Spp.	平均樹高 Tree Ht. (m)	平均直径 Diameter (cm)	密度[2] Dens. (No./ha)	断面積[3] St. Area (m²/ha)	幹材積 Stem Vol. (m³/ha)
V1954	49	L	12.1	7.0	4127	15.77	110
		B	10.6	9.4	311	2.16	12
IV1954	100	L	17.4	11.5	2704	28.30	264
II1954	130	L	18.4	16.3	796	20.28	168
XVIII1957	170	L	17.0	19.4	708	20.85	171
XI1957	?	L	16.1	26.7	304	17.08	136
		B	9.6	10.0	64	0.58	
X1957	?	L	14.0	17.2	485	11.20	84
		B	9.0	11.0	21	0.20	
XIV1957	210	L	12.2	18.4	448	12.02	85
	120	C	9.4	13.3	48	0.72	3
XV1957	220	L	14.0	26.4	208	11.43	79
XVI1957	130	L	7.7	11.0	575	5.45	32
XVII1957	140	L	7.8	16.3	150	3.12	21
III1954	113	C	11.4	14.4	1024	16.78	105
XII1957	155	C	6.8	9.5	3472	24.52	112
		L	-	-	80	0.30	2
VI1954	30	B	10.3	5.8	4770	12.56	?
V1977	72	L(B)	-	8.2	3886	25.92	-
IV1977	123	L	-	11.6	2400	31.43	-
II1977	153	L	-	16.3	936	22.72	-
XVIII1977	190	L	-	19.5	680	22.96	-

Table 1.(Cont.)

XI1977	?	L	-	25.6	?	18.78	-
		B	-	11.9	48	0.54	-
X1977	?	L	-	17.0	453	12.00	-
		B	-	12.2	16	0.19	-
XIV1977	230	L	-	17.8	448	12.02	-
	140	C	-	13.6	48	0.72	-
XVI1977	150	L	-	12.1	525	6.50	-
XVII1977	160	L	-	15.6	150	3.58	-
III1977	136	C	-	15.5	944	19.22	-
XII1977	175	C	-	9.6	3312	26.43	-
		L	-	7.3	48	0.23	-
VI1977	53	B	-	7.8	3933	21.23	-
II1992	168	L	15.5	13.7	969	16.5	208
III1992	151	C	12.6	16.8	753	17.8	159
V1992	87	L(B)	12.9	9.8	3368	28.8	268
VI1922	68	B	13.2	11.1	2445	25.7	162

[1] L=カラマツ (Larix dahurica); B=シラカンバ (Betula platyphylla); C=欧州アカマツ (Pinus sylvestris).

[2] 立木密度 Stem Density

[3] 幹の胸高断面積合計 Stem Cross-sectional Area Sum

14 DENDROCLIMATOLOGICAL ANALYSIS OF TREE GROWTH PATTERNS

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Abstract: Patterns of tree growth were analyzed in dahurica larch (*Larix dahurica* Turcz) of Siberian Taiga in relation to the events of shifts of the stem growth curves, and to the estimated changes of the atmospheric CO_2 concentration. Stem increment cores were taken at breast height of 104 trees growing in two bogs at Skaspayapait Experimental Forest (63°N, 129°E), Yakutia. Growth curves and their shifts over time were determined for individual trees utilizing a *U–W* phase diagramatic analysis. Regional patterns of the growth shift frequencies and the relative increase in the asymptotic maximum values of the stem cross sectional area (*W* index) were reconstructed for approx. a 300–year period between the late 1600's and the present. The analysis indicated a peculiar ca. 30–year cycle of growth shift events in this species during the entire period of the observation. The values of the *W* index indicated a minimal increase during the past 100 years, and the correlation between the *W* index and atmospheric CO_2 concentration is not significant. Despite the possible increase of atmospheric CO_2 concentration and air temperature since the end of the Little Ice Age in about 1850, the trees did not respond by the increase in the potential maximum stem size. The ca. 30–year perio of growth shifts is also unaffected by such changes. It is concluded that the growth patterns of dahuriuca larch in Yakutia has been constrained by the environmental factors other than atmospheric CO_2 concentration and air temperature.

Objectives

The objective of this analysis is to evaluate if the atmospheric increase in CO_2 levels and the associated warming of the air temperature have been affecting the long–term growth patterns of dahurica larch trees in Yakutia, Siberia, one of the places where the global warming has been suggested to alter the forest ecosystems substantially.

Materials and Methods

Stem increment cores were collected from breast height (135 cm aboveground) of 104 dahurica larch trees in two bog areas in Skaspayapait Experimental Forest of Yakutsk Biology Institute at approximately 63°N and 129°N, 35 km north of the city of Yakutsk, Sakha, eastern Siberia. Two cores were taken from each sample tree at opposit sides of the stem. The stem diameter at breast height (dbh) was also measured. The stem core samples were brought to the laboratory in Sapporo, Japan, mounted on a wooden frame, air dried, and sanded. The widths of the growth rings and the bark thickness were measured with a tree–ring analyzer to the 0.05 mm accuracy. The data were then corrected to reflect the stem sizes of the sample trees under the field condition; the dbh, bark thickness and the length of the air–dried core were used for the correction. When the core sample did not contain the stem center, its location and the length of the core sample were estimated from the curvature of the growth rings near the stem center.

The tree ring data were then converted to those of stem cross sectional area for the analysis with the *U–W* phase diagrams (Hozumi 1985, 1987. **Bot. Mag. Tokyo**). The regional mean values of the dates of shifts in the *U–W* curves and the relative (as to that of 1800) values of the maximum asymptotic stem size (*W* index) were then examined in relation to the established history of atmospheric CO_2 concentration (Pearman et al. 1986 **Nature**).

Results

Approx. 30–year cycle of growth shifts was observed in the data (Fig. 1). Large portion (30–50%) of the trees shifted their growth curves to attain greater asymptotic maximum stem sizes nearly at the same time (with a resolution of 10 years) at an interval of 30–40 years. This cycle appears to be unchanged during the entire period of observation since early 1700's. The peak years of growth shifts are 1730's, 1760's, 1780's, 1820's, 1860's, 1890's, 1920's, 1950's, and 1970's. It is noted that the drastic change in the environment since the end of the Little Ice Age (ca. 1850) did not appear to affect this cycle. (About 90% of growth shift percentage observed in the 1780's could be a response to the onset of the present warmer period.) The value of *W* index also did not change very much during the past 100 years since the end of the Little Ice Age (Fig. 2), and this is asoociated with the absence of clear correlation between the *W* index and the atmospheric CO_2 levels (Fig. 3). Although Siberian forests have been suggested to be affected substantially by the global warming, there is no indication of such effects in the present data. It is likely that the growth of dahurica larch trees are constrained by the environmental factors other than the CO_2 concentration or the air temperature. It will be important to identify the factors that are most influencing growth of the larch trees in Siberia, since we do not know if those factors are unrelated to global warming (thus causing no alarm for the health of Siberian forests), or could cause drastic changes in the forest ecosystems in due course. Similar analyses in other parts of Siberia are also necessary for identifying generality of the present finding.

Publication

Osawa, A. and Sugita, S. 1992. Global warming and forest growth: records for the past centuries and implications. *In* Abstracts, Disturbed Climate, Vegetation and Foods, International Symposium for the 50th anniversary of the Society of Agricultural Meteorology of Japan. October 13–16, 1992, Tsukuba, Japan.

Osawa, A. 1992. A 30–year cycle of growth shifts in northern circumpolar conifers. *In* Abstracts, Annual Meeting of the Hokkaido Branch of Ecological Society of Japan. 19 December 1992, Hokkaido University, Sapporo, Japan.

Osawa, A., Takahashi, K., Maksimov, T.C., and Ivanov, B.I. 1993. Forest biomass in eastern Siberia. *In* Transactions of the meeting in Hokkaido Branch of the Japanese Forestry Society, No. 41. (*in press*)

This project was supported in part by Japan Environment Agency Grant for Integrated Global Environment Research.

Research Plan for 1993

Stem core samples will be collected at additional sites in different parts of Yakutia, and generality of the present results will be examined by a similar analysis. The technique will also be applied to the growth and biomass data at the ecosystem level, since it is a more appropriate level of organization for assesing the effects of the global changes in the environment.

Fig 1

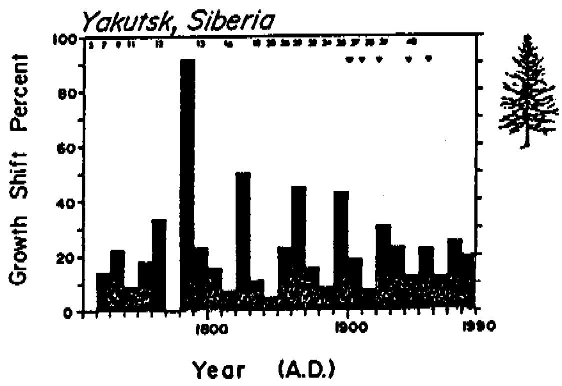


Fig 2

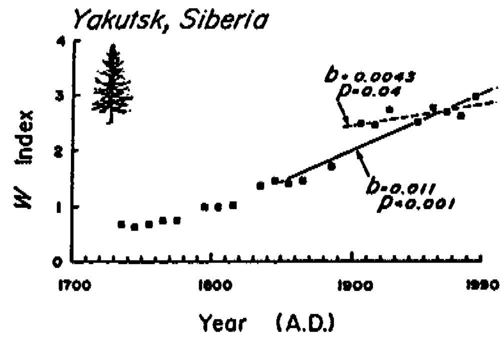
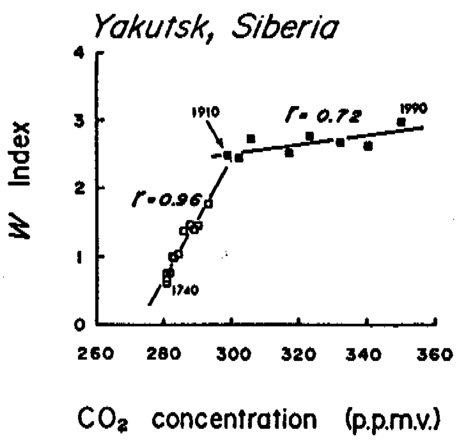
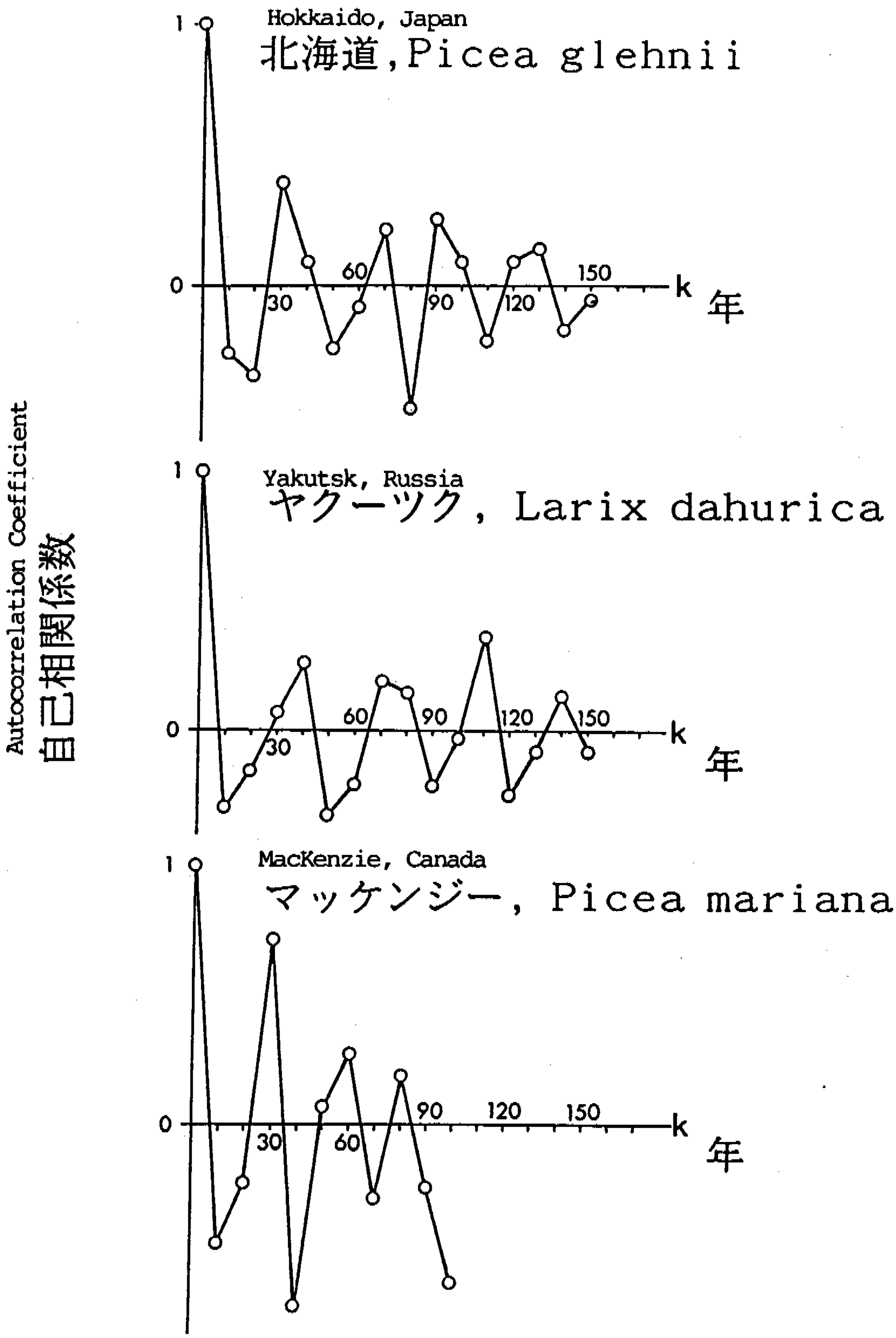


Fig 3



APPENDIX Correlograms of the relative frequencies of shifts in stem growth patterns for Picea glehnii, Larix dahurica and Picea mariana in three region of the northern circum-polar boreal forests



15 Soil characteristics and C and N storage in soil

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Objectives

The soils under different vegetations and topographies were characterized morphologically and physico-chemically for the research area on the terrace of Lena River near Yakutia city. Data on carbon storage in the forest soils were collected as the basis of estimating carbon cycling in the different types of forest ecosystem on Siberian permafrost. Simultaneously, monitoring of temperature and moisture condition of the soils were initiated for future's modeling of CO_2 release from the permafrost soils associated with climatic change.

Materials and Methods

Survey was carried out in Skaspayapait research area near Yakutia city. Soils from 5 locations along a slope transect were described morphologically; two from *Larix dahurica* stands, two from *Betula platyphylla* stands and one from *Pinus sylvestris* stand. Soil samples were taken from each soil horizon using a core cylinder of known volume for estimating carbon storage in soil and for analyzing some other physico-chemical properties.

Instruments were set up in different depths of the two soil pits, one under Larix (YK-1) and another under pinus (YK-2) stand, to initiate measuring temperature and moisture condition of the soils under different condition. The recorded data will be collected in the summer of 1993.

Total carbon and nitrogen contents of the soil samples were determined by dry-combustion method. The C and N storages in the soils were calculated by using values of content of each element, bulk density and horizon thickness. Soil pH and particle size composition were as well determined by the glass-electrode method and the sedimentation method, respectively.

Results

The research area on old river terrace of the Lena was characterized with very gently rolling topography and coarse textured less fertile soils derived from the old sediment of Lena River. There was a clear correlation between distribution pattern of *Larix dahurica* and *Pinus sylvestris*, and topography in the area. The former species were found on mid to lower slopes with moist condition, while the latter only on the upper slopes subjected to severer drying. Formation of *Betula platyphylla* stands appeared to be associated with disturbance such as felling or forest fire (Fig. 1).

In the soils on mid to lower slope under *Larix* or *Betula* stands, organic matter and fine mineral particles (clay and silt fractions) accumulated in subhorizons (spodic horizon). They were classified into Spodosols (Pergelic Cryohumods or Pergelic Cryorthods) based on U.S. Soil Taxonomy. Remarkable involution was observed in every B horizon of the Spodosols. Meanwhile only the soil on the upper slope of the *Pinus* stand did not fall under Spodosols but under a Pergelic Cryochrept (Inceptisol) because of the absence of spodic horizon (Figs 1 and 2). Thickness of the active layer of permafrost soil ranging from 120 to 180 cm was thicker in the *Pinus* stand on the upper slope and thinner under *Larix* stands. The soils of the study area were judged to be minor soil type in extent in the Siberian Taiga area. The soil pH was neutral to alkaline, 6 to 8, and usually increased with depth.

The carbon storage in soil (active layer of permafrost including surface organic layer) ranged from 85 to 199 ton C/ha, and was larger in the order of *Larix* stands>*Betula* stands>*Pinus* stand (Table 1). Larger carbon storages in the soils of *Larix* stands were attributed mainly to the high carbon contents of spodic horizons, and partly to the larger accumulation of carbon in the forms of coarse organic materials such as litter and roots in upper portion of the solum. The absence of organic accumulation in subsoils was responsible for the smaller carbon storage in the *Pinus* soil (Table 1 and Fig. 3). These difference in carbon storage among the soils, which is associated with magnitude of the formation of a spodic horizon or podzolization, is not known to be connected either with tree species or topography.

This project was supported in part by Japan Environment Agency Grant for Integrated Global Environment Research.

Publications

Ohta, S., Koike, T., Osawa, A., Sasa, T. and Takahashi, K. 1993: From the survey of Siberian Taiga in permafrost area. *Forest Science*, No. 7, (*in press*)

Ohta, S., Matsuura, Y., Sanada, M., Ivanov, B.I., and Maximov, T.C. 1993: Storage of some elements in active layer of Permafrost soil developed on terrace of Lena River in Eastern Siberia. Transactions of the meeting of the Japanese Forestry Society, No. 104, (*submitted*)

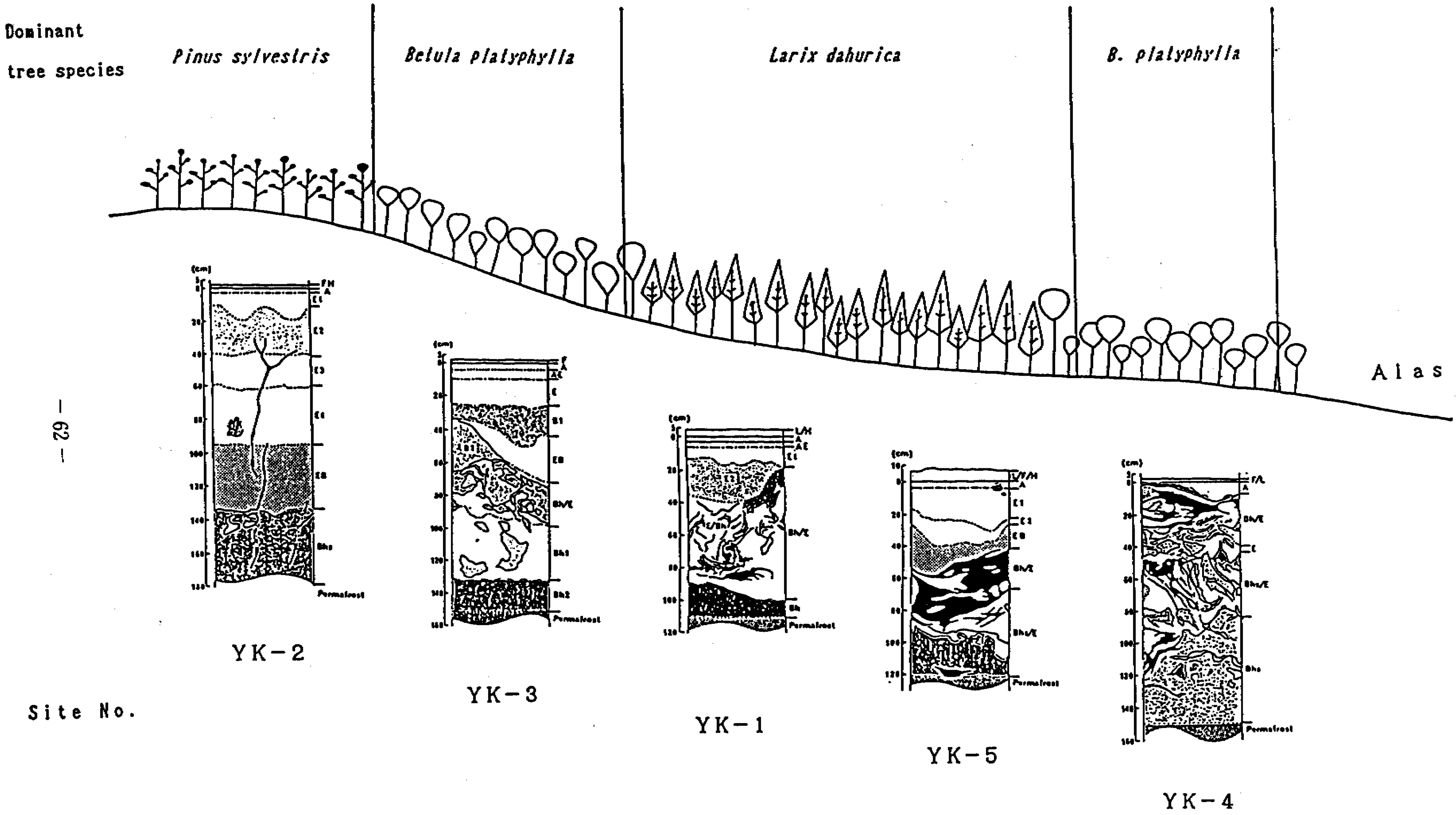

Fig. 1. A schema showing soils found in the study area.

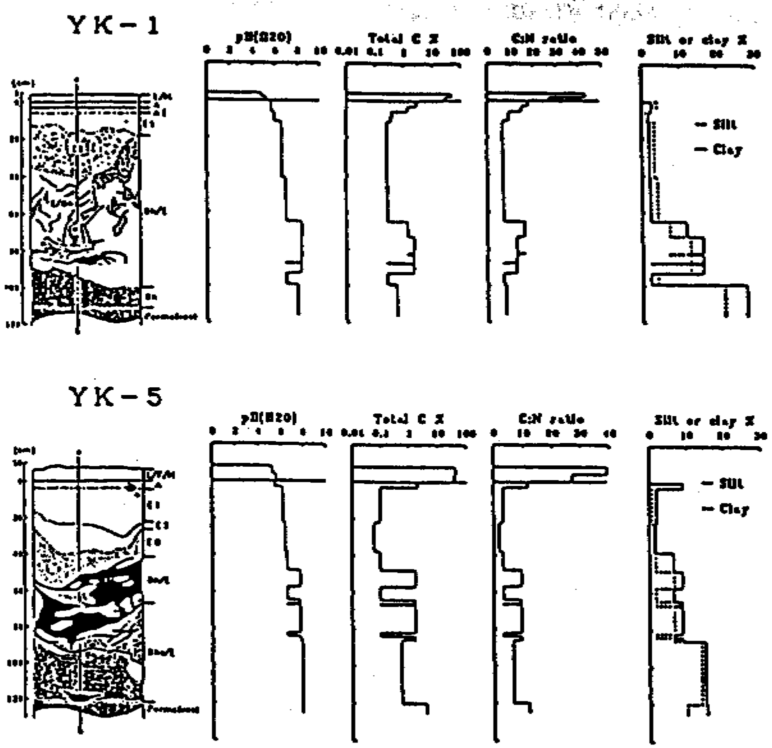

Fig. 2-a. Changes in chemical properties and soil texture of soil profiles in *Larix dahurica* stands (YK-1,5).

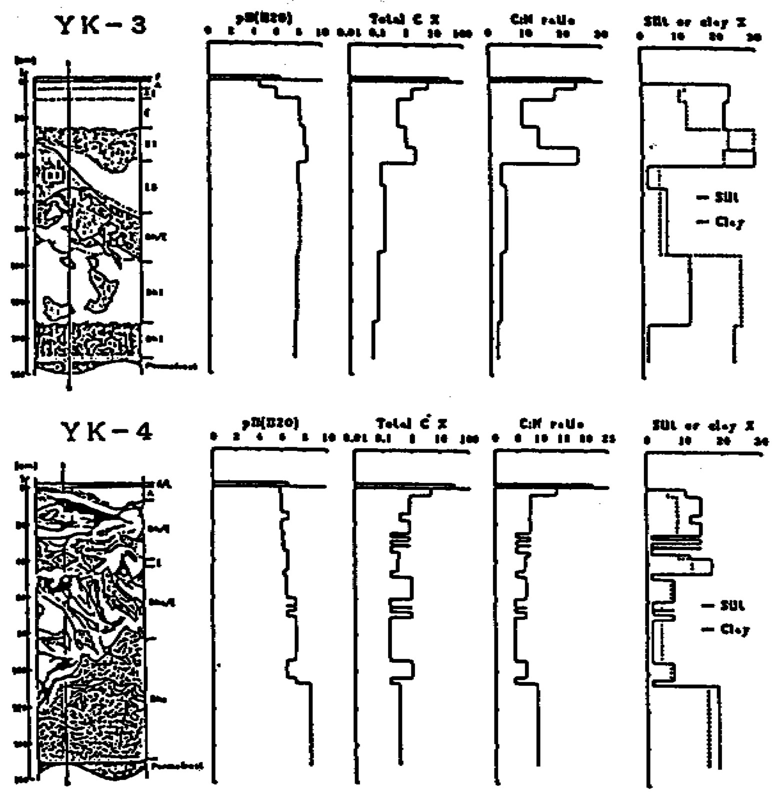

Fig. 2-b. Changes in chemical properties and soil texture of soil profiles in *Betula platyphylla* stands (YK-3,4).

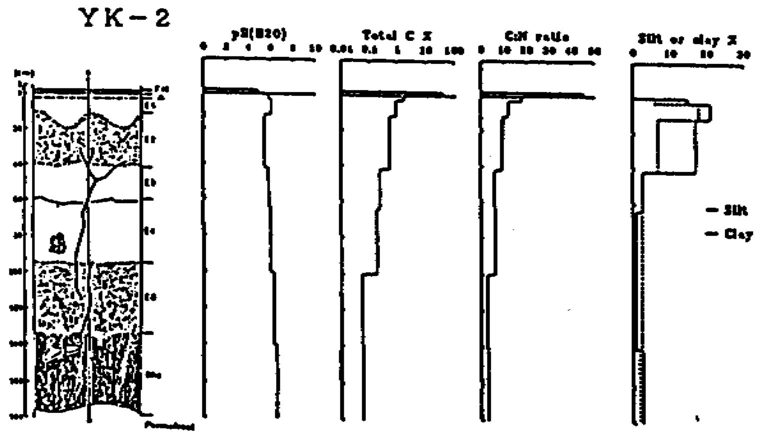

Fig. 2-c. Changes in chemical properties and soil texture of a soil profile in a *Pinus sylvestris* stand (YK-2).

Fig. 2.

Changes in chemical properties and soil texture of soil profiles.

Table 1. Storage of C and N in soils (ton/ha).

Profile	Vegetation	Position	Depth	C(SOM)	C(COM)	Total C	N(SOM)	N(COM)	Total N	C(COM %)	N(COM %)
YK-1	Larix	Middle	Total	157.64	32.58	190.22	12.87	0.99	13.87	17.13	7.15
	cajanderi	solpe	Ao-10 cm (%)	6.37	83.52	19.59	5.63	84.40	11.27		
YK-5	Larix	Lower	Total	153.19	45.46	198.65	18.89	1.41	20.30	22.88	6.93
	cajanderi	slope	Ao-10 cm (%)	2.36	87.39	21.81	2.74	87.57	8.62		
YK-3	Betura	Middle	Total	96.86	31.13	127.98	10.99	1.00	11.99	24.32	8.32
	platyphylla	slope	Ao-10 cm (%)	20.38	82.42	35.47	9.27	83.37	15.44		
YK-4	Betura	Lower	Total	107.10	15.51	122.61	14.20	0.72	14.92	12.65	4.82
	platyphylla	slope	Ao-10 cm (%)	16.26	79.30	24.23	11.29	79.24	14.56		
YK-2	Pinus	Upper	Total	62.09	22.54	84.63	8.79	0.53	9.32	26.63	5.69
	sylvestris	slope	Ao-10 cm (%)	18.49	81.85	35.36	9.90	80.66	13.92		

Remark: SOM, soil organic matter; COM, coarse organic material (undecomposed or partially decomposed litter and roots)

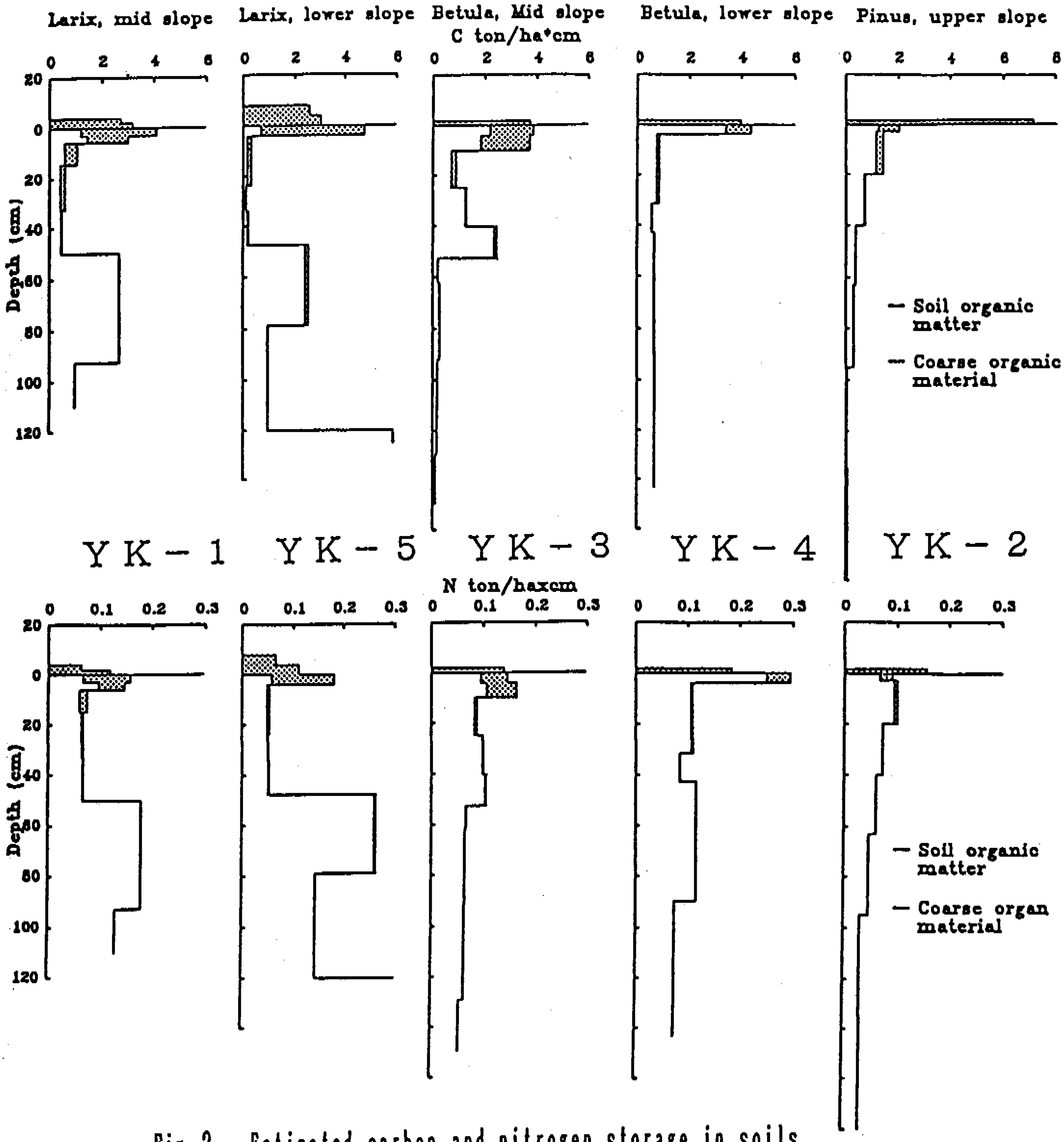

Fig. 3. Estimated carbon and nitrogen storage in soils.

16 Nutrient analysis in tree leaves

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Objectives

The objective of this analysis is to make clear the leaf nutrient level of three tree species (Dahurica larch, European red pine and Birch) in three regions under different climatic condition (Yakutsk, Sapporo and Morioka), to get the basic data for estimate the increase of tree growth by the global warming of air temperature.

Materials and Methods

Leaf samples of three tree species were collected in Skaspayapait Experimental Forest of Yakutian Institute of Biology (63° N, 129° E), Hitsujigaoka Experimental Forest of Hokkaido Research Center, FFPRI (43° N, 141° E) and Morioka Experimental Forest of TohokuResearch Center, FFPRI (40° N, 141° E), and their nutrient concentrations (N, P_2O_5, K_2O, CaO, MgO) were analyzed. Number of used tree was three in each case.

Results (Figure–1)

Concentration of calcium, magnesium and potassium in birch leaves is higher than in larch and red pine under every conditions. That of nitrogen, the most important element for CO_2 income (photosynthesis) and outgo (respiration) is lower in the tree species from Yakutsk than from the others. That of phosphorus, so important element for plant energy metabolism seems to be high in tree species from Yakutsk, as compared with the others.

This research is supported by the Grant of the Environment Agency.

17 Estimation of soil respiration

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Objectives

The objectives of this research is to make clear the actual condition about the annual amount of CO_2 released by soil respiration of each forest type in Yakutia where the global warming has been suggested to accelerate the decomposition of soil organic matters and the melting of permafrost.

Materials and Methods

Seven soil cores were sampled in Skaspayapait Experimental Forest of Yakutian Institute of Biology, that is; A_h+A_E and A_h layer from larch forest, A_h layer from red pine forest. A_E layer from birch forest and illuval holizon from each forest.

These annual respiration amounts are determined by the calibration curves based on released CO_2 amounts measured at regular intervals under artificial conditions with different soil moisture and temperature, and by the annual data of soil T-M condition from the forest stands in Yakutia, with next formula; $N=N_0[1-\exp(-k\ t)]+B$ and $k=A\ \exp(-E_a/R\ T)$, here N_0: amount of easily resolvable organic matters T: time, k: constant of reaction speed, R: gas constant (1.987 cal/deg./mol), T: absolute temperature, E_a: activate energy, A and B: constant.

Results until today and forecasts for the future (Figure-2)

The case of (A_h+A_E) layer in larch forest is shown by the figure as an example. The parts given in solid line are already finished measurement until today, under different soil moisture content and soil temperature coditions. But measurements will have to be continued from now on untill the day of A shown in Figure-2 when the integrated amount of released CO_2 of each sample reach constant. Annual soil respiration amount will be estimated by the formula above mentioned with the annual data about soil temperature and soil moisture in each forest.

This research is supported by the Grant of the Environment Agency.

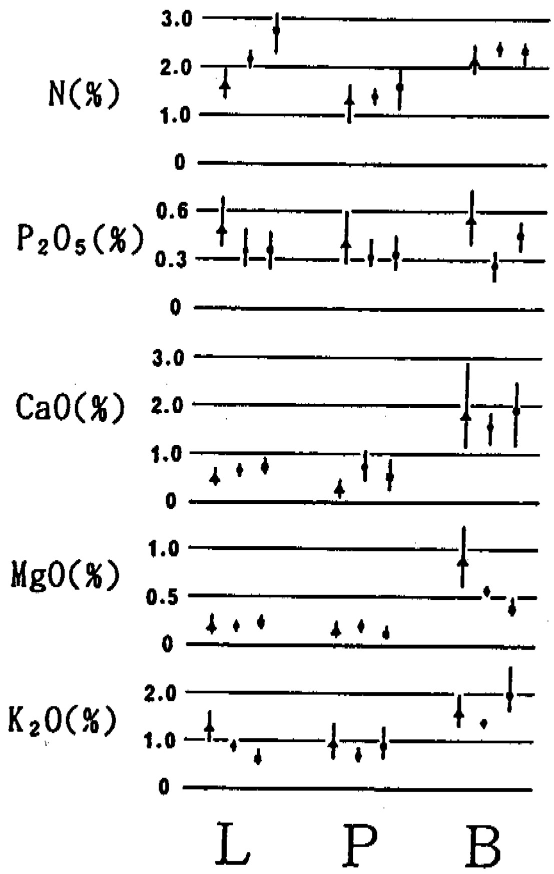

Figure-1

Nutrient concentration in leaves

L : Larix
P : Pinus
B : Betula

▲ : Yakutsk
● : Sapporo
■ : Morioka

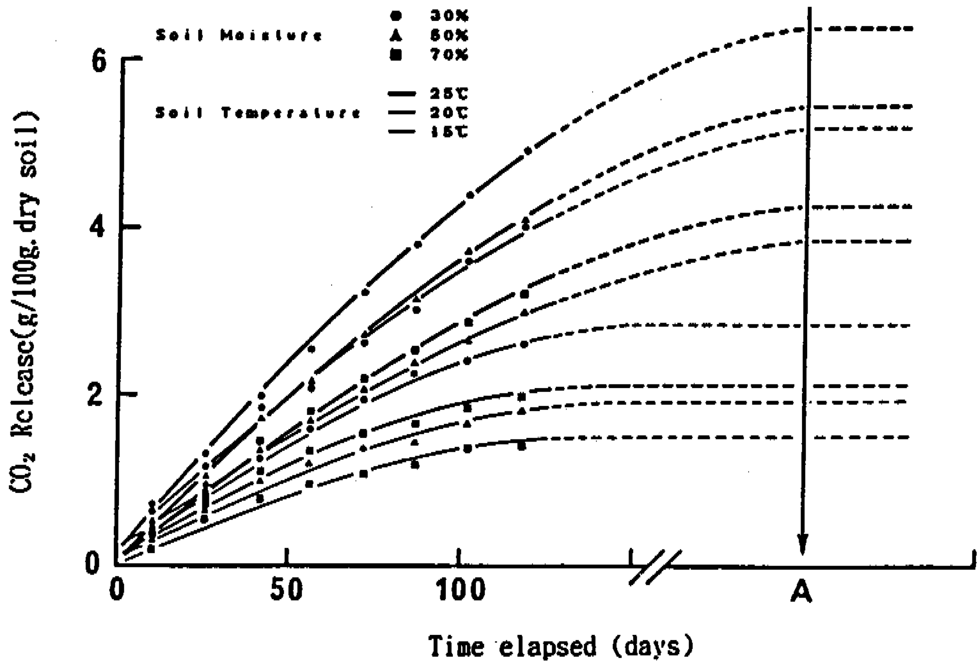

Figure-2

Soil respiration speed under several M-T conditions ((A_h+A_E) layer of the larch forest)

A trial of the measurement of CO_2 concentration in a forest and photosynthesis of woody species native to eastern Siberia

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Abstract

The new device of measuring CO_2 concentration in a forest with use of a battery were developed. The heat absorbing filter was selected for the acrylic chamber. The CO_2 concentration near ground reached ca.600 ppm in midnight and 320 ppm after sunrise. The height growth of pine and larch was correlated well with the sum of precipitation (May + June), which may suggest that the photosynthetic production of Siberian tree species is strongly influenced by the water condition during the growing season.

Development of the device

Objectives

The objectives of this research are to develop the device for measuring CO_2 concentration in a forest where we have no electronic power supply and search the filter for cutting the heat wave to keep an optimum temperature for photosynthesis. We need the new equipment which can automatically measure and store the data of CO_2 concentration under field condition.

Composition and Capacity of the device

The equipment was composed of three parts (Fig.1); the CO_2 sampler (6CH) and the Infra red gas analyzer (Fuji Electric, ZDP 5) which controlled by the timer (KADEC-Timer), and the data logger (KADEC-UV). The capacity is as follows (DAIWA air regulator Co.Ltd.);range = 0 - 2000ppm, 10 min interval, 24 hrs running with a 60 Ah battery. Flow rate is 1 $l \cdot min^{-1}$. Data are stored upto 30720.

We employed the filter (KENKO, HA-50) as a heat absorber. The percent of transmittance was shown in Fig.2. Most of heat wave were cut and the photosynthetically active wave is transmitted more than 90 % We could keep leaf temperature below 33°C under the clear sky (PhAR > 1200 $\mu E \cdot m^{-2} s^{-1}$).

Measurement of CO_2 concentration in a forest and photosynthesis

Objective

The objective of this study is to estimate the dynamics of CO_2 flux in a forest based on the measurement of photosynthesis of representative tree species native to eastern Siberia.

Materials and Methods

The vertical distribution of CO_2 concentration in the birch stand near the main building of Skaspayapait Experimental Forest was measured with the new device. The height and DBH of the stand mixed with larch are ca. 10 m and 23 cm, respectively. Monitoring experiment on the CO_2 exchange rates of birch leaves was detected with the porometer (KIP-9010, Koito Co.Ltd.) under field condition. Light-photosynthesis curve of birch (sun leaf) was also measured with the heat absorbing filter.

Results

The CO_2 concentration near ground reached 600ppm at mid night (Fig.3B). It decreased from 2 o'clock at sunrise and showed below 320 ppm in a canopy at around 3 o'clock when the net photosynthetic rate was positive (Fig.3A). The soil respiration rate decreased after sunrise.

The net photosynthetic rate of birch leaves was saturated at the PhAR of 600 $\mu E \cdot m^{-2}s^{-1}$. The maximum rate of net photosynthesis was ca. 2.8 $\mu mol \cdot m^{-2}s^{-1}$ lower than that of Japanese white birch (Fig.4).

Prediction of factors affecting photosynthesis based on the measurement of the height growth

Objective

The photosynthetic production is affected by the climate conditions. We would like to predict the climate effect on the photosynthetic production of trees based on the measurement of height growth.

Materials and Methods

The height growth of pine, larch and birch was measured at the same stands where soil profiles were studied (see Ohta et al. in this volume). The tree height, DBH, and the length between each trace of knots were measured upto 6 years ago. The monthly record (April to October) of temperature and precipitation at Yakutsk offered by Dr.T.C.Maximov was employed.

Results

The average temperature above 5°C was observed between May to September (Fig.5A). The pattern of precipitation was fluctuated year by year, while temperature showed the similar pattern (Fig.5B). Except for birch, a positive correlation between tree height and the height growth in smaller sized individuals was found (Fig.6). The flush of pine shoot is observed at the beginning of growing season. A positive correlation between the sum of precipitation in May + June and the height growth of pine (below 4 m in height) was observed (Fig.7). Based on this, precipitation may be one of the most important factors to affect the photosynthetic production.

Research plan for 1993

The objectives of research in 1993 are to make clear the effect of CO_2 concentration and water stress on the net photosynthetic rate of pine, larch and birch trees and to monitor the CO_2 flux in different types of forests. The photosynthetic capacity of birch and pine seedlings phytotronically grown under elevated CO_2 and temperature will be measured.

Acknowledgements

This research is supported in part by the Japan Environmental Agency (The joint Siberian Permafrost Study; Feedback of global warming in Siberian Permafrost Regions). This report is a part of subproject "Carbon storage and carbon dioxide budget in forest ecosystems," which is organized by Dr.K.Takahashi. We thank Dr.T.C.Maximov and his family, Dr.B.I.Ivanov and Prof.N.G.Solomonov of the Yakutian Institute of Biology, Russian Academy of Sciences, for their kind cooperation. Thanks are also due to Prof.M.Fukuda of the Low Temperature Scieces of Hokkaido University for the help of field survey.

Publications

Koike,T., R.Tabuchi, S.Ohta, T.C.Maximov, B.I.Ivanov and K.Takahashi. (1993) Height growth of pine, larch and birch grown on the terrace of Rena River, eastern Siberia. 15th IBC, S2.PS.(by T.Hirose) Ecology and Environment Botany (submitted)

Koike,T., S.Ohta, R.Tabuchi, T.C.Maximov, B.I.Ivanov and K.Takahashi.(1993) A trial measurement of CO_2 concentration and tree growth in the Siberian forested stands. Northern Forestry (Hoppo Ringyo) 45:(in preparation)

Ohta,S., T.Koike, A.Osawa, T.Sassa and K.Takahashi. (1993) From the survey of Siberian Taiga in permafrost area. JFS Forest Sciences 7: 68-73.

Takahashi,T., T.Koike and T.Sassa (1993) Comparison of the leaf nutrient status of pine, larch and birch grown under Siberian Taiga and northern Japan. Trans.J.For.Soc., 104 (submitted)

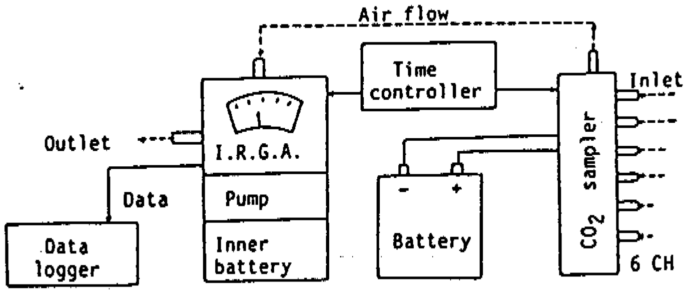

Fig.1. Schematic representation of the CO_2 monitor with auto-sampler(by DAIWA Air Reg.Co.)

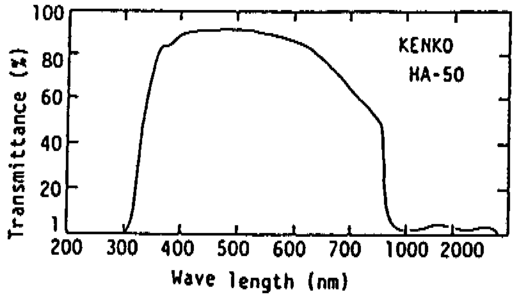

Fig.2. Spectral transmittance curve of the heat absorbing filter. (KENKO HA-50)

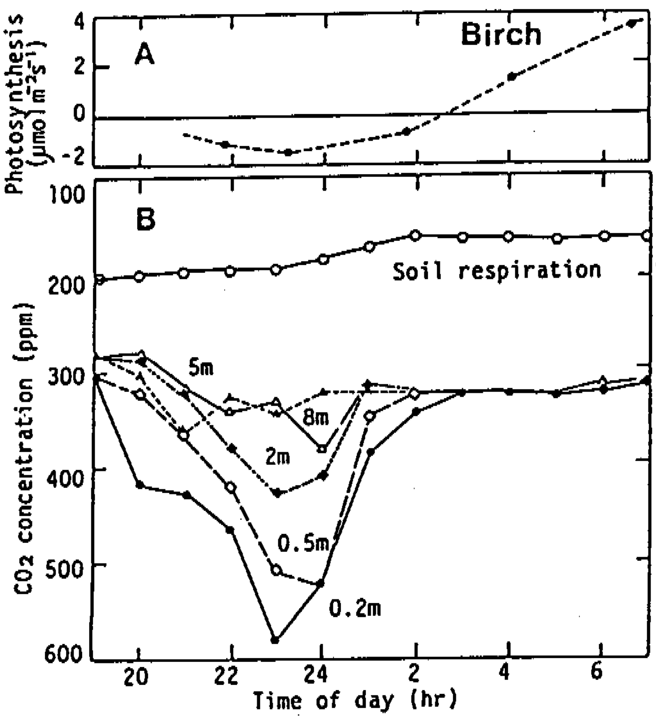

Fig.3. Time course of the net photosynthetic rate of birch (A) and CO_2 concentration of the different strata in a birch forest (B).

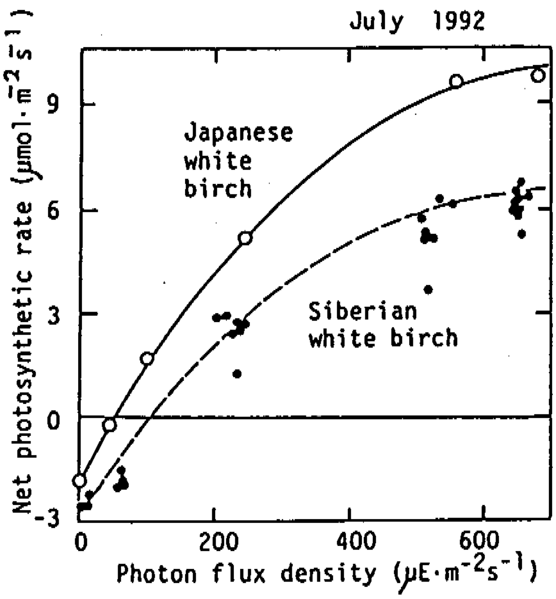

Fig.4. Light-photosynthesis curve of birch leaves at 31°C and Japanese white birch from Koike (1985).

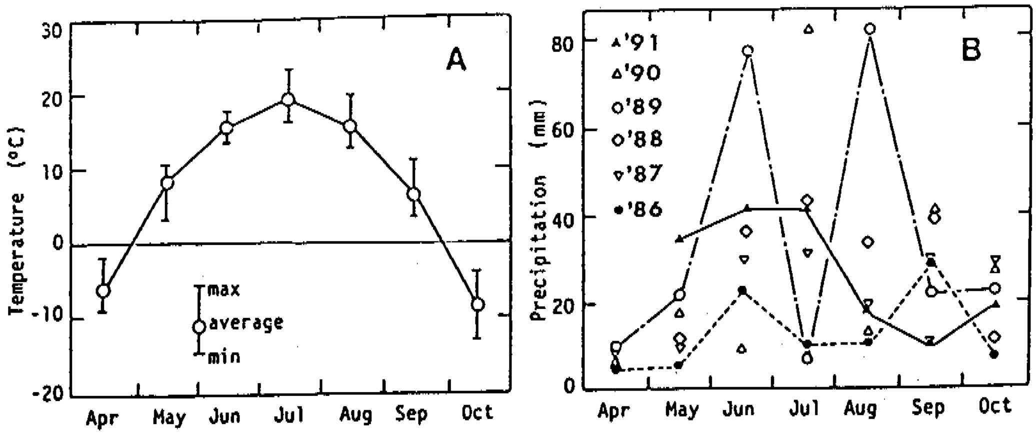

Fig.5. Seasonal change in the temperature (A) and precipitation (B)during the growing season in Yakutsk, eastern Siberia. Temperature; average value between '77 and '91 with the range of max. and min. The typical patterns of precipitation are shown.

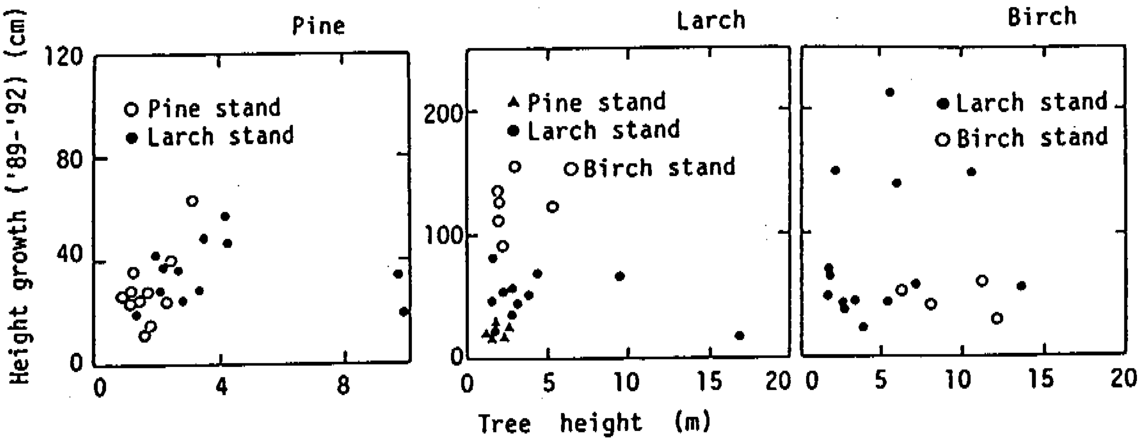

Fig.6. The relationship between tree height and the height growth between '89 and '92, in pine, larch, and birch grown in the Skaspayapait Experimental Forest.

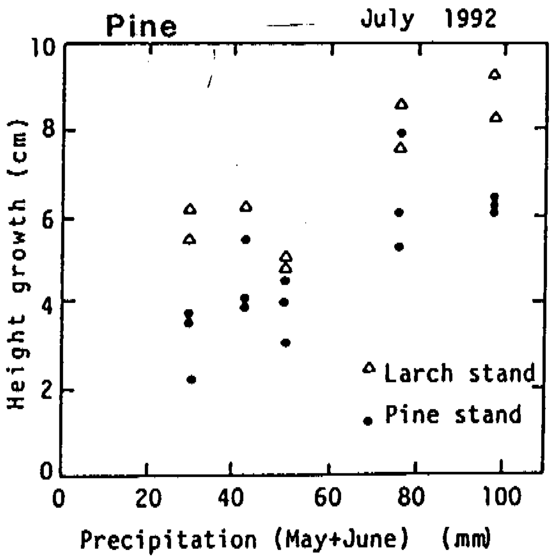

Fig.7. The relatioship between the sum of precipitaion in May and June in each year and the height growth of pine grown in pine stands and larch stands.

シベリア永久凍土地帯森林のCO_2濃度測定と光合成測定 '92

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温暖化の進行にともなう、シベリアの永久凍土地帯に成立する森林からの二酸化炭素（CO_2）の固定・放出速度を直接測定することを本課題の目的とする。'92年度は、測定装置の開発、林内CO_2濃度のモニターと主要樹種の光合成速度の測定、樹高成長から推定した光合成生産に及ぼす環境条件の影響について調べた。

○測定装置の開発
シベリアの無電源地帯で、１日以上森林内部の異なる高さにおけるCO_2濃度変化をモニターする測定機器を開発した。本機器の特色は１台の赤外線ガス分析器を共有して６点の測定が行なえる、CO_2濃度変化のデータを直ちにデータ・ロガーに収録できる点にある（Fig.1）。光合成測定用のポロメーターの同化箱部分はアクリル製であるため、屋外で使用すると同化箱内の温度上昇が問題となる。このため熱線をカットし光合成有効放射を透過するフィルターの選択を行い良好な結果を得た（Fig.2）。

○林内CO_2濃度のモニターと光合成測定例
シラカンバ林内（カラマツ稚樹を交える）の地表付近20cmでは、日没（午後１０時）後から日の出（午前２時半）までの間CO_2濃度が上昇し続け約600ppmに達した。樹冠内部のCO_2濃度もこの時間帯には380ppmまで上昇した。土壌呼吸も類似の傾向を示した。日の出とともに光合成速度が上昇し、日中のCO_2濃度は約330ppmで樹冠内部（8m）では320ppmを下回った（Fig.3）。
シラカンバ個葉の光－光合成速度関係は日本のシラカンバの測定例（Fig.4）と比較すると、光飽和域はほぼ同様の600$\mu E \cdot m^{-2}s^{-1}$付近であるが、光飽和時での最大光合成速度は約2.8$\mu mol \cdot m^{-2}s^{-1}$低かった。これは測定時の葉温が、約31℃で光合成適温を越えていたこと、葉内の窒素濃度が低いことと関連があると考えられる。

○伸長成長の測定から推定した光合成生産の制限要因
過去１５年間の生育期間（4～10月）の気温と降水量をみると（Fig.5）、気温は年変動が小さかったが、降水量には年度間に大きな差が認められた。一方、過去４年間（'89-'92）の伸長成長と樹高との関係をみると、シラカンバ以外では樹高の低い個体の伸長成長と樹高には正の相関があった（Fig.6）。シラカンバでは他の樹種より生育地の微地形の影響を強く受けると思われる。
そこで、最も伸長成長（年毎の節間成長）の変化が明瞭なマツの成長と５・６月の降水量との関係を調べると、カラマツ林での伸長成長量がマツ林を上回る。さらに伸長量と降水量の間には正の相関が認められた（Fig.7）。なお、マツは春にシュートを短期間で伸長させるので、５・６月の降水量合計値を用いた。この関係から、光合成生産には成長時期の降水量が大きく影響することが示唆された。

問題点
今年度は、測器の搬入に予想外の時間を要したことと、供給電源が極めて不安定であったので測定値が限られた。この点を改善しなければならない。

謝辞
本調査は環境庁の地球環境研究総合推進費［シベリア永久凍土地帯］による。資材の運搬をはじめシベリア地区での研究に御配慮いただいている北海道大学低温科学研究所の福田正己教授に深謝する。また、測器の開発には大和空調㈱の上田龍四郎技師の全面的な協力を得た。記して感謝する。なお、本調査はロシア科学アカデミー・シベリア支部ヤクーツク生物学研究所との共同研究である。

19 A quantitative comparison of pteridophytes flora between eastern Siberia and Northernmost Japan -changes in frequency with scaling-

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Key words : Coexistence, Frequency, Physiognomy, Scaling, Similarity index.

Abstract

Distribution pattern and frequency of some cryosphere ferns were quantitatively compared between Eastern Siberia and northernmost Japan, Hokkaido, with reference to scaling by visual scope enlargements. Here I will introduce three attempts of quantitative analysis of cryosphere pteridophytes distribution in east Siberia and Northernmost Japan, Hokkaido.

1) Frequency increase by scope enlargements on 8 ferns

Frequencies of collection sites of 8 species show different trajectory patterns depend upon the different starting regions (Tiksi,Yakutsk and Hokkaido). Quadrats of 3000x2000km2 and 4000x3000km2 from Tiksi show disjunctive higher frequencies.

2) Relative frequency change by scope enlargements

For two species of Gymnocarpium, relative frequencies fluctuate with mirror immage each other with scaling (from local to global enlargements).---Different environmental filters influence for relative frequencies of species.

3) Coexistence and floristic similarity among populations

Coexistence (%;SI, 100x2C/A+B) is about 50-60% even in a small quadrat(0.1x0.1m; 1x1m, --- 1000x1000km) in Tiksi, in contrast to Temperate regions (Japan) which show variation of coexistence (10-80%) with scaling. The higher α-diversity seems dominate in tundra and the higher β-diversity in tropical rain forest.

Discussion

(?) Smaller-size and moderate disturbance of ground (frozen and melted) permit the higher floristic richness.

(?) Short-growing and flowering season; Freezing disturbance; Coexistence by small-size plants and geographical relation might support the higher floristic richness.

(?) Measurements of vegetation in 10m--1000m quadrats and observation of organ and tissue levels are necessary during 1993 and 1994 field survey in Siberia.

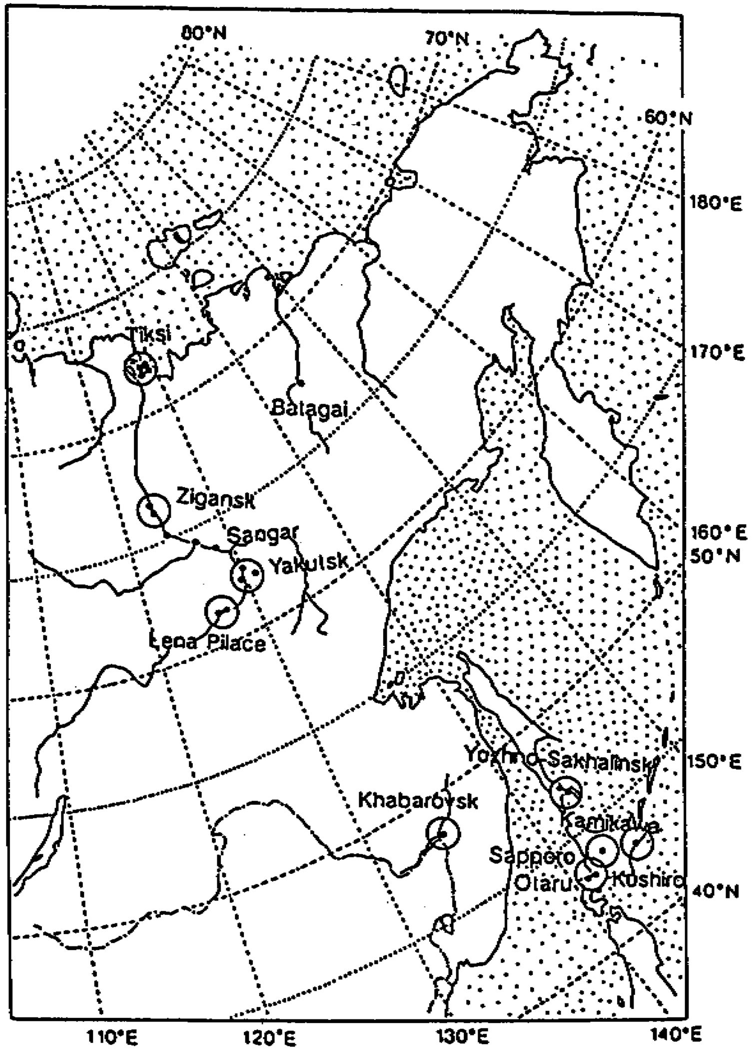


Fig. 1.

Localization of survey sites in Far-east Eurasia.

Table 1. Records of collection number of plants in Far-east Eurasia.

Locality(N,E)	Site number	Research date	Number of species (aff.) Spermatophyta	Pteridophyta
Tiksi (72N,128E)	4	Jul.11-21 1992	150-	3-
T-1 Hillside				
T-2 Meadow				
T-3 Seashore				
T-4 Rocky slope				
Batagai(68N,145E)	1	Jul.11,21,1992	10-	1-
Zigansk(66N,123E)	2	Jul.26-29,1992	80-	3-
Z-1 Mountain site				
Z-2 Sandy riverside				
Linda (65N,124E)	1	Jul.25,1992	50-	3-
Kitcan (64N,126E)	1	Jul.23-24,1992	40-	2-
Sangar (64N,128E)	1	Jul.22,1992	30-	2-
Yakutsk(63N,130E)	4	Jul.30-Aug.3,1992	150-	2-
Y-1 Forest station				
Y-2 River port				
Y-3 Alace station				
Y-4 Alace grassland				
Lena-Pilace(61N,127E)	2	Aug.7-10,1992	100-	5-
LP-1 Rocky mountains				
LP-2 Sandy island				
Khabarovsk(48N,134E)	1	Aug.16-17,1992	40-	5-
Yuzhno-Sakhalinsk(47N,143E)	4	Sept.15-20,1989	--	21-
YS-1 Lakeside				
YS-2 Abies forest				
YS-3 Mountain slope				
YS-4 Pondside				
Kamikawa(44N,142E)	20	1977-1992	--	50-
Otaru-Sapporo(43N,141E)	10	1977-1992	--	55-
Kushiro(43N,144E)	21	1977-1992	--	40-
Hakodate(42N,141E)	22	1977-1992	--	60-

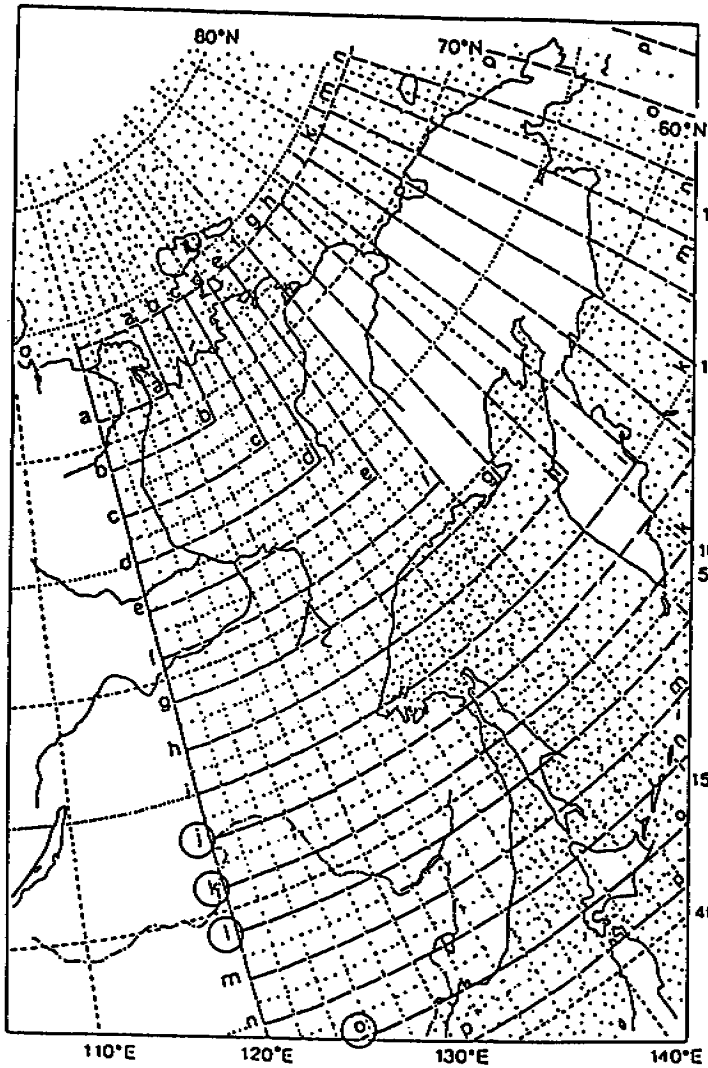


Fig. 2.

Illustration of scope enlargements from Tiksi to eastern Eurasia. Bold lines (j,k,l,o) indicate boundaries of larger increase in number of collection sites.

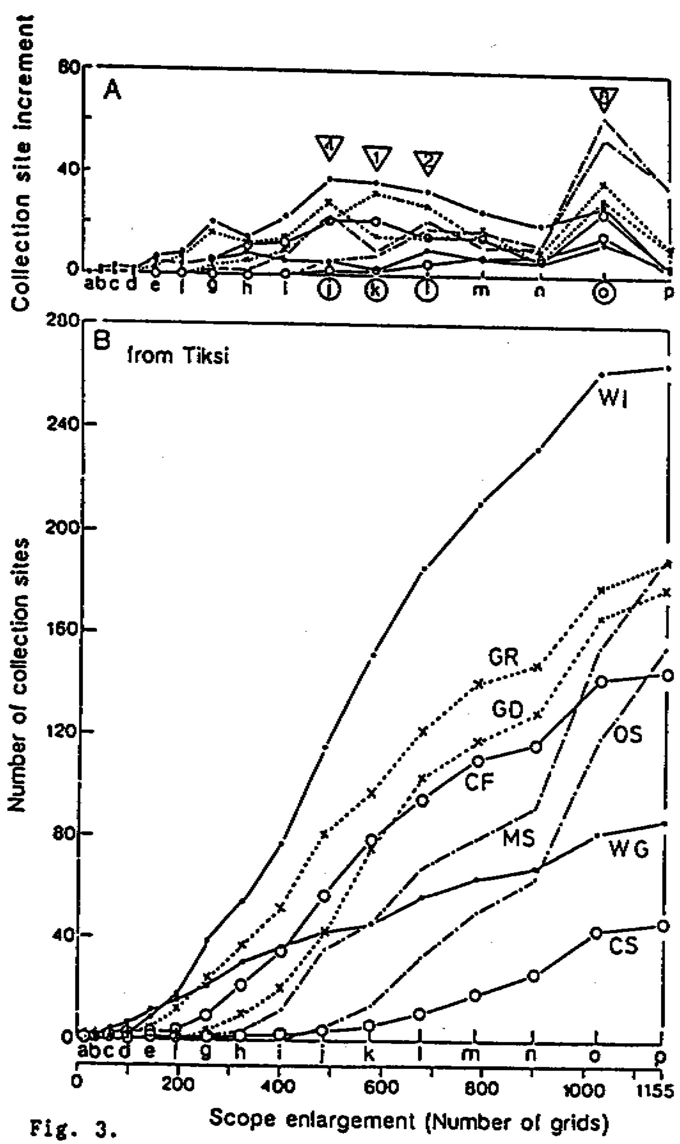


Fig. 3.

Increase in number of collection sites for 8 ferns with scope enlargements from Tiksi to eastern Eurasia.
A: Increments in number of collection sites between boundaries. Number in triangles shows boundaries with first and second peaks of the trajectories.
B: Sum of collection numbers with scope enlargements.

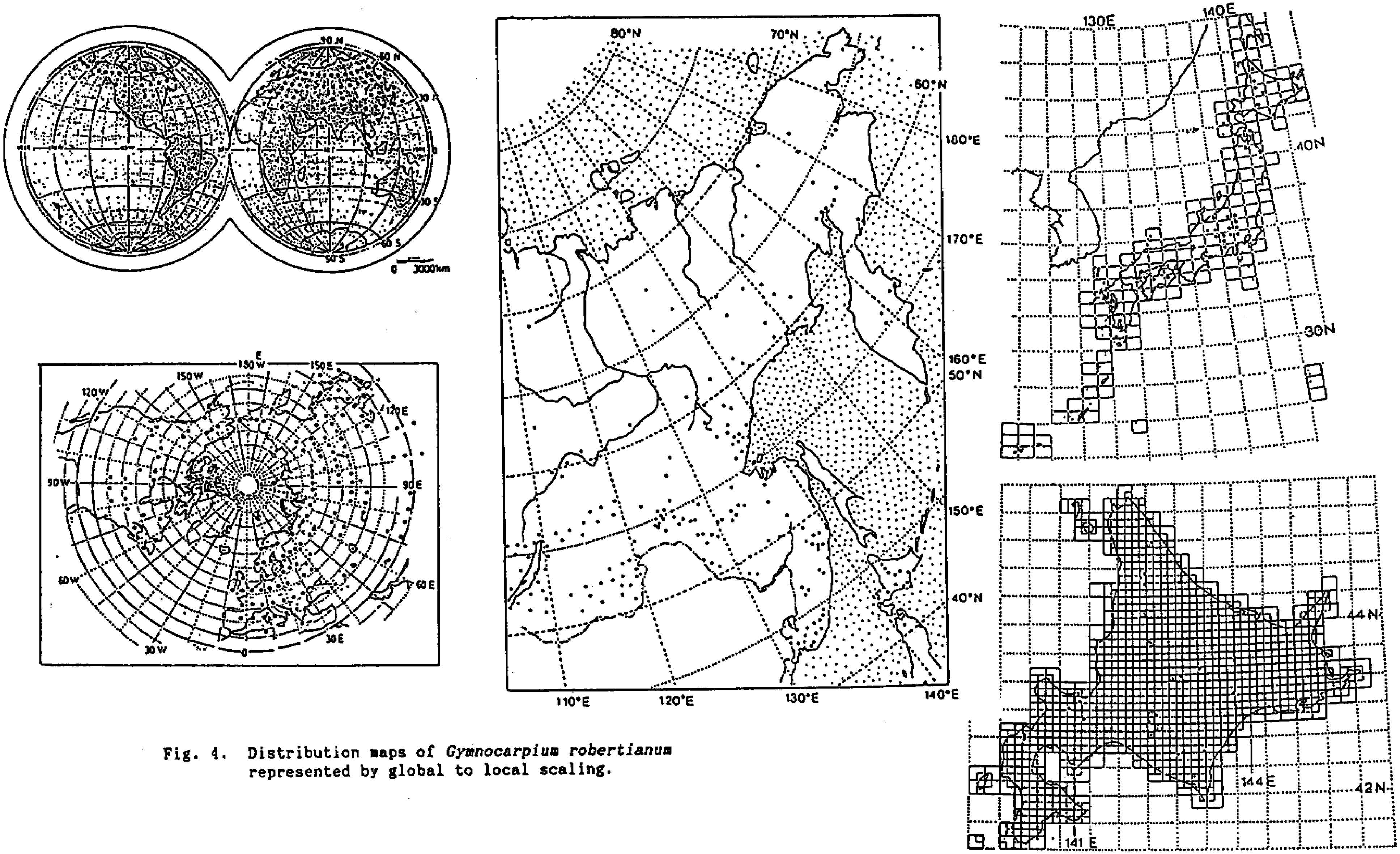


Fig. 4. Distribution maps of *Gymnocarpium robertianum* represented by global to local scaling.

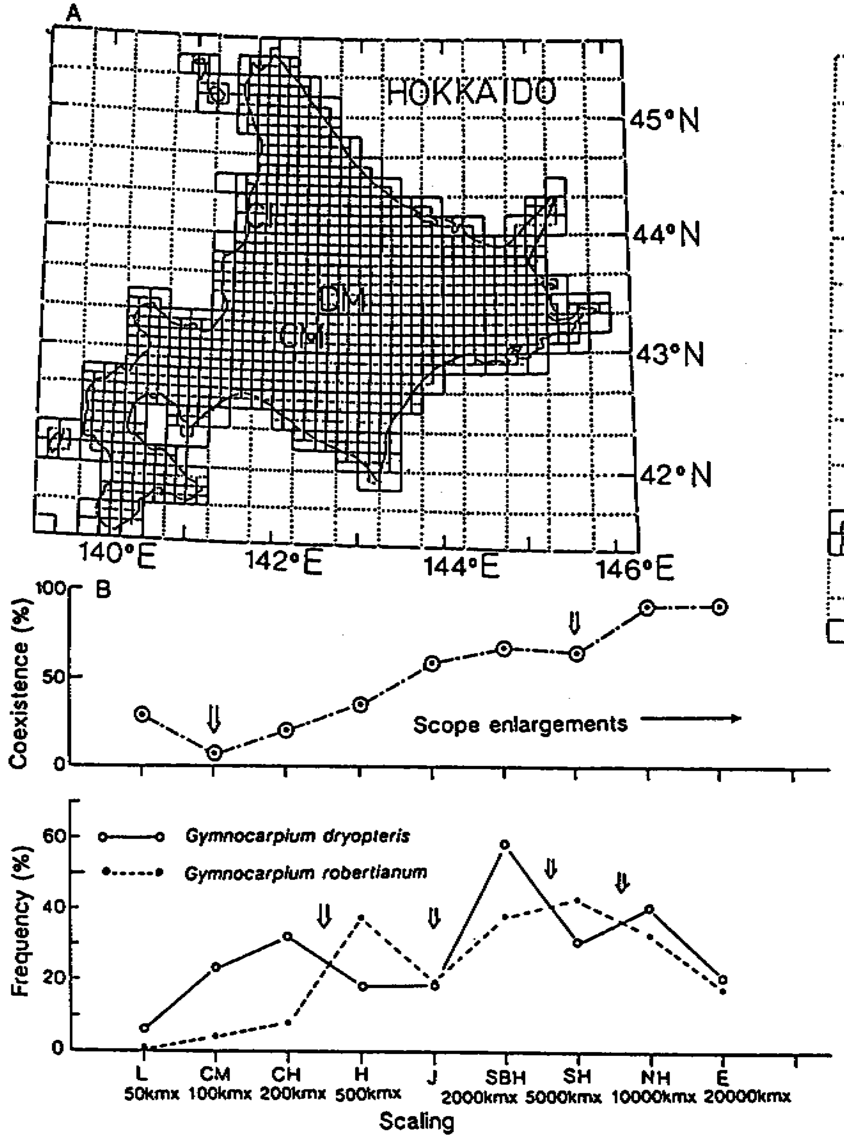


Fig. 5A. Illustration of scope enlargements in Hokkaido.
Fig. 5B. Changes in relative frequencies and coexistence of *Gymnocarpium robertianum* and *Gymnocarpium dryopteris* from local to global scaling.

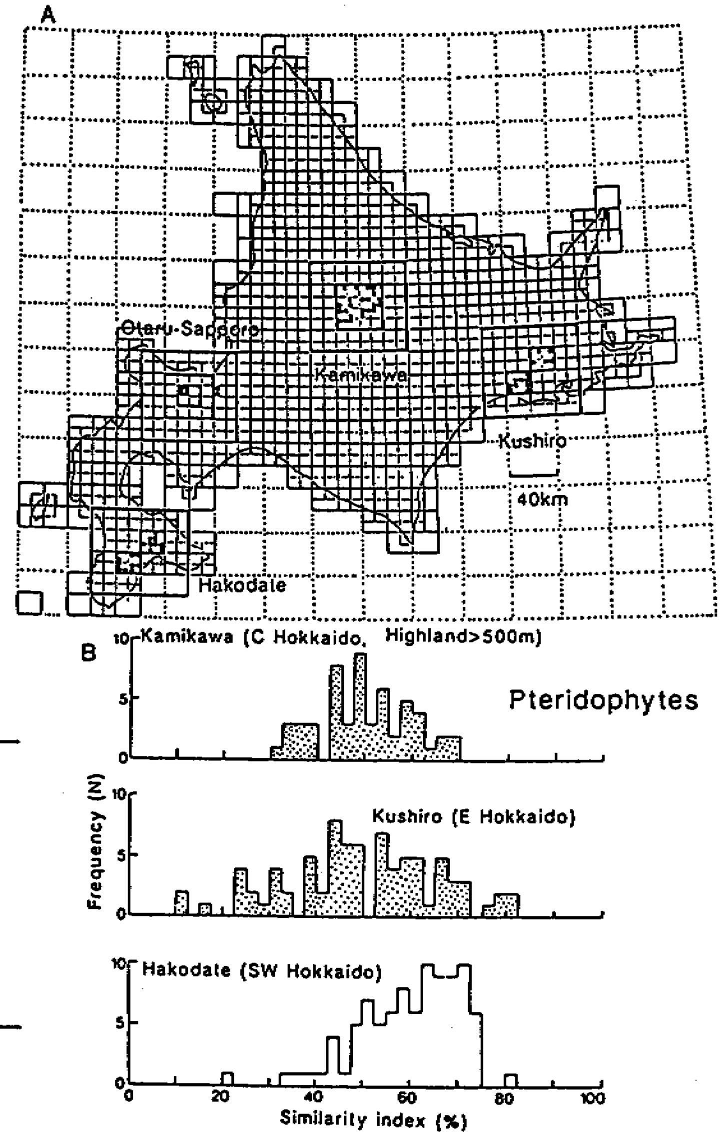


Fig. 6A. Localization of survey sites in Hokkaido.
Fig. 6B. Frequency distribution of similarity indices of pteridophytes flora in Hokkaido.

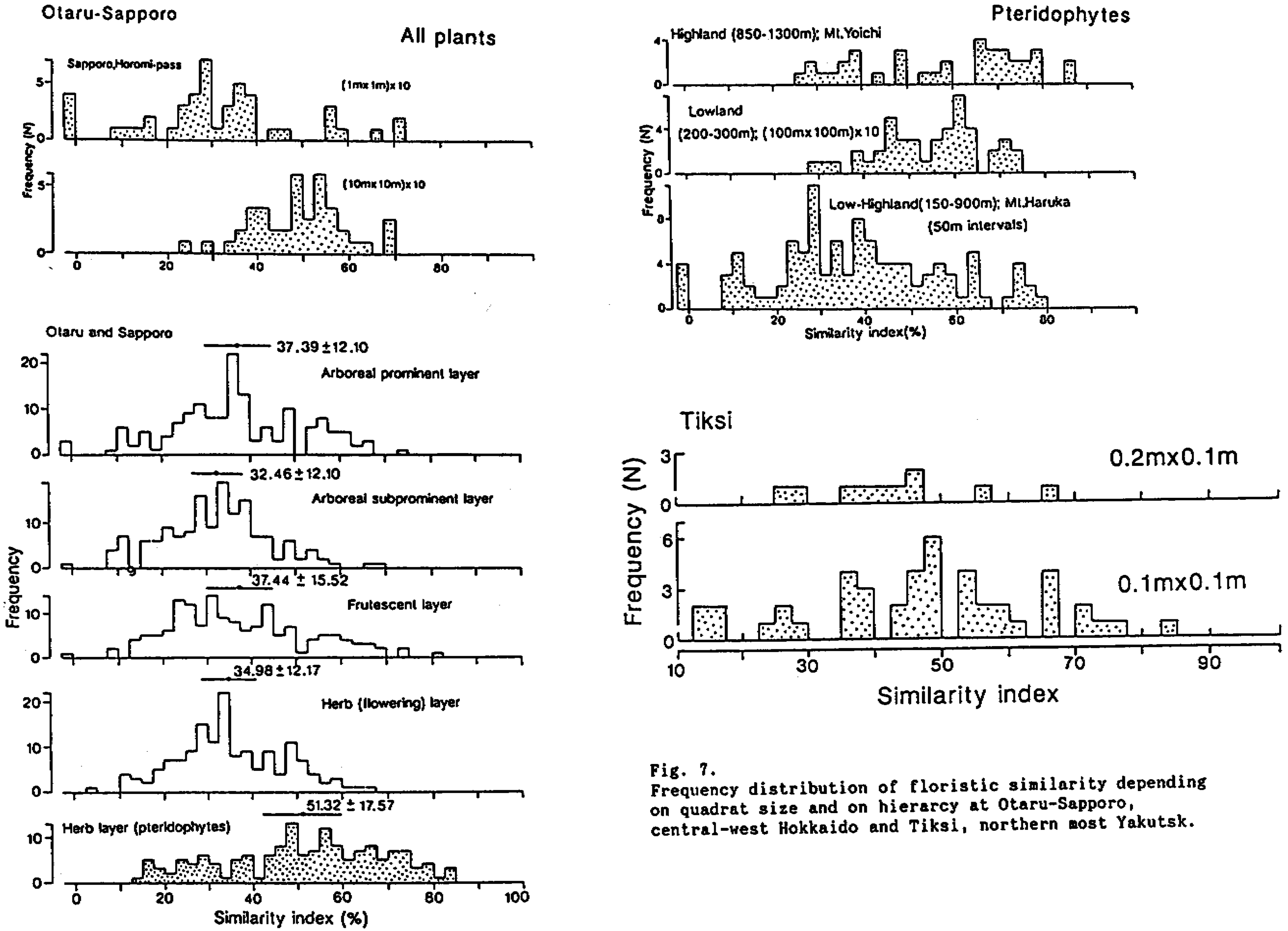
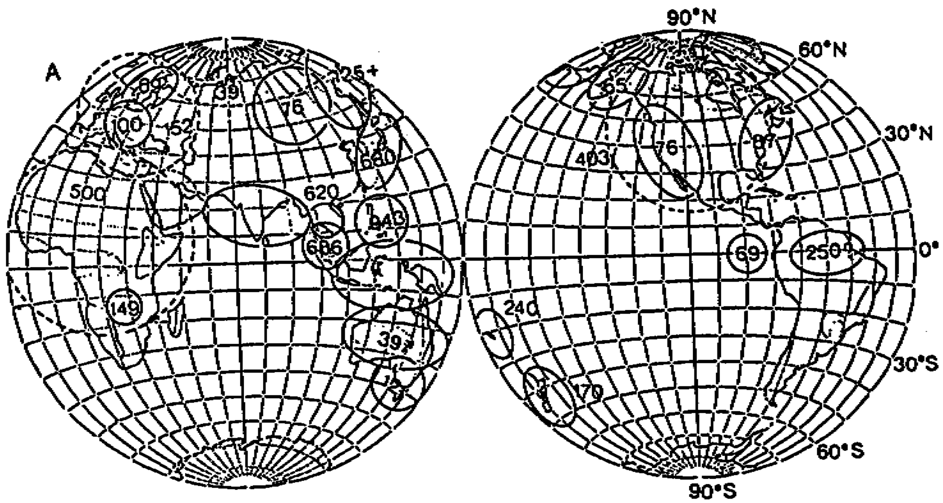


Fig. 7.
Frequency distribution of floristic similarity depending on quadrat size and on hierarcy at Otaru-Sapporo, central-west Hokkaido and Tiksi, northern most Yakutsk.



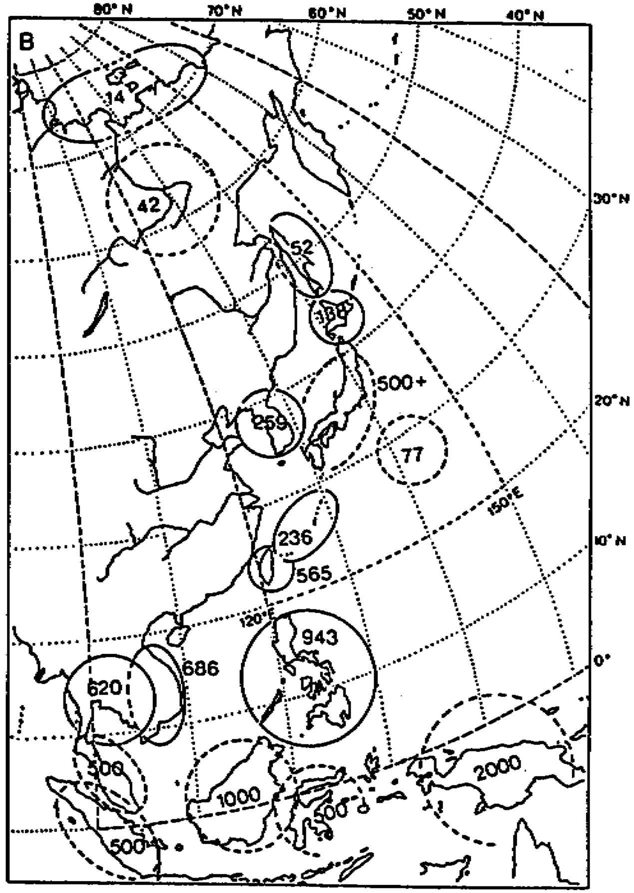


Fig. 8A. Possible number of pteridophytes species over the world.
Fig. 8B. Possible number of pteridophytes species eastern Eurasia.

Table 2. Number of plant species in Siberia and Northernmost Japan with respect to quadrat size.

Scale	0.1x0.1m^2	1x1m^2	2x2m^2	10x10m^2	100x100m^2	Sample(N)
Tiksi (No forest)	4.4+2.4	17.8+8.2	24.7+8.9	-	-	12
Gigansk						
Forest	4.0+1.1	11.6+3.0	14.8+4.2	-	-	5
Yakutsk						
Alace	4.7+1.7	14.3+5.6	18.0+8.8	-	-	5
Forest	3.4+1.0	9.8+4.2	12.8+5.3	-	-	3
Otaru-Sapporo						
Forest	-	7.9+2.2	-	25.6+3.7	52.2+12.4	10
Hierarchy I					8.9+ 2.8	18
II					11.9+ 3.2	18
III					11.3+ 3.9	18
IV					41.2+13.2	18
V					14.7+ 3.2	18

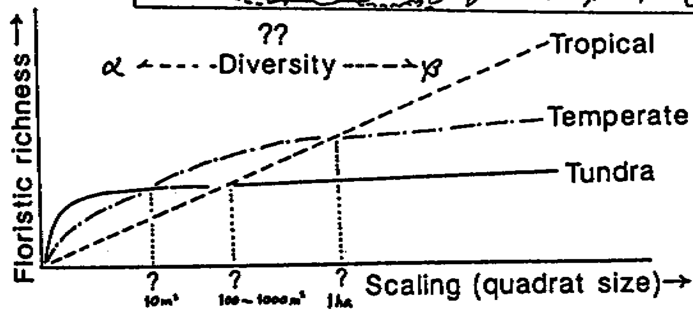


Fig. 9. Schematic illustration of possible floristic diversity in the climatic zone.

20 AN ANALYSIS OF SPERMATOPHYTES FLORA OF SAKHA SSR (YAKUTSKAYA), EASTERN SIBERIA

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Abstract : Based on the taxonomic literature, spermatophytes flora of Yakutskaya was compared with Japan and Scandinavia. Distinct features are: (1) species numbers of vascular plants per unit area of Yakutskaya are much lower than those of Japan (1/110 in pteridophytes and 1/22 in spermatophytes) ; (2) a quantitative comparison of dominant families and genera of vascular plants indicated that flora of Yakutskaya is more similar to that of Scandinavia than that of Japan; (3) about 26% species of Yakutskayan vascular plants are distributed in Japan and about 48% popular species in Yakutskaya are distributed in Japan; (4) about 30% vascular plant species of mountain tundra of Taisetsu Mountains are found in Yakutskaya. Based on this data-base analysis of vascular plants of Yakutskaya, floral relationships between the seven regions within Yakutskaya are demonstrated; (1) species numbers of arctic region is higher than those of Olenek or Kolyma region; (2) high similarity in floral composition is noted between the three southern regions; Lensk, Yakutsk and Aldan; (3) medium floral similarity is shown from arctic region through Yana-Indigirka to Aldan region. Unexpected high species numbers of arctic region of Yakutskaya might result from the supply through Yana-Indigirka region from southern, Aldan region. A geographical distribution pattern of the genus Parrya supports the floristic connection between the arctic regions and central Asiatic highland.

Table 1. Comparison of species numbers between three regions of Northern Old World.

Region	Latitude N. (°)	Area (A) (x10000km^2)	Pteridophyta (B) (spp.)	(B/A)	Spermatophyta (C) (spp.)	(C/A)
Scandinavia	55 - 71	111	69	0.6	2,091	18.8
Yakutskaya	55 - 76	310	42	0.1	1,518	4.9
Japan*	30 - 45	37	413	11.2	4,040	109.2

Based on **Norsk, Svensk, Finsk Flora** (Lid, 1987), **Manual of Higher Plants of Yakutskaya** (Tolmachev (ed.), 1974), **New Flora of Japan** (Ohwi, 1983) and **Flora of Japan, Pteridophyta** (Ohwi & Nakaike, 1978).
* Excl. Okinawa and Ogasawara.

Table 2. Comparison of species numbers of native woody genera between Scandinavia, Yakutskaya and Japan.

	Scand.	Yak.	Jap.
Pinus	1	3	6
Picea	1	2	7
Abies	-	1	5
Larix	2	2	1
Betula	3	8	11
Alnus	2	4	11
Corylus	1	-	2
Carpinus	1	-	5
Fagus	1	-	2
Quercus	2	-	14
Ulmus	3	-	3
Tilia	2	-	6
Acer	3	-	24
Prunus	3	1	25

Table 3. Comparison of dominant families of spermatophytes between Scandinavia, Yakutskaya and Japan.

	Scandinavia (636 g., 2091 spp.) ($111 \times 10,000 km^2$)			Yakutskaya (430 g., 1518 spp.) ($310 \times 10,000 km^2$)			Japan (1041 g., 4040 spp.) ($37 \times 10,000 km^2$)		
	Family	g.	spp.(%)	Family	g.	spp.(%)	Family	g.	spp.(%)
1	Composit	64	195(9.3)	Composit	40	179(11.8)	Composit	71	359(8.9)
2	Graminea	65	192(18.5)	Graminea	48	155(22.0)	Graminea	108	347(17.5)
3	Cyperace	10	144(25.4)	Cyperace	10	139(31.2)	Cyperace	16	322(25.5)
4	Crucifer	52	129(31.6)	Crucifer	35	90(37.1)	Rosaceae	31	177(29.9)
5	Rosaceae	22	129(37.8)	Ranuncul	20	79(42.3)	**Orchidac**	63	168(34.1)
6	Legumino	23	121(43.6)	Rosaceae	22	75(47.2)	**Liliacea**	40	168(38.3)
7	Caryophy	22	95(48.1)	Legumino	14	75(52.1)	Ranuncul	20	146(41.9)
8	Scrophul	18	88(52.3)	Caryophy	17	74(57.0)	Legumino	43	119(44.8)
9	**Umbellif**	46	64(55.4)	**Salicace**	3	46(60.0)	Scrophul	26	93(47.1)
10	Labiatae	24	60(58.3)	Labiatae	17	43(62.8)	**Ericacea**	21	91(49.4)
11	Ranuncul	14	60(61.2)	Scrophul	9	38(65.3)	Labiatae	28	90(51.6)
Others:									
	Orchidac	23	48	Liliacea	13	29			
	Liliacea	19	39	Ericacea	12	24			
	Ericacea	12	18	Orchidac	16	22			

Boldface indicates characteristic families of each region in this list.

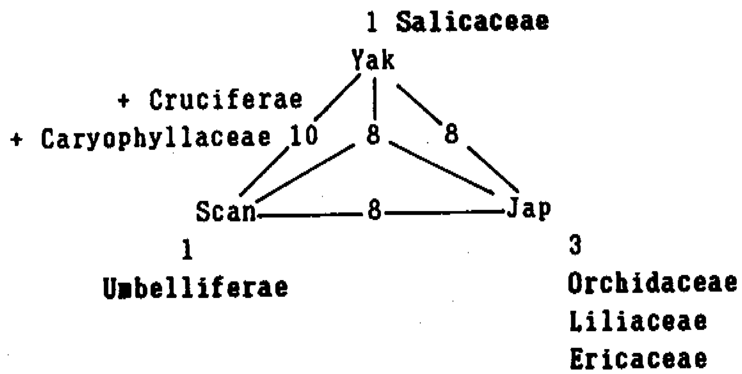


Table 4. Comparison of dominant genera of spermatophytes between Scandinavia, Yakutskaya and Japan.

	Scandinavia		Yakutskaya		Japan	
	(2091 spp.)		(1518 spp.)		(4040 spp.)	
	(111 x 10,000km2)		(310 x 10,000km2)		(37 x 10,000km2)	
	Genus	spp. (%)	Genus	spp. (%)	Genus	spp. (%)
1	Carex	109 (5.2)	Carex	112 (7.4)	Carex	205 (5.1)
2	Salix*	32 (6.7)	Salix*	43 (10.2)	**Cirsium**	55 (6.5)
3	**Ranunculus**	31 (8.2)	**Artemisia**	33 (12.4)	**Viola**	51 (7.8)
4	**Veronica**	28 (9.5)	Potentilla	31 (14.4)	**Polygonum**	50 (9.0)
5	Potentilla	26 (10.7)	**Draba**	27 (16.2)	**Rhododendron***	43 (10.1)
6	**Juncus**	25 (11.9)	Saxifraga	27 (18.0)	Salix*	39 (11.1)
7	**Vicia**	24 (13.0)	Stellaria	22 (19.4)	**Rubus***	38 (12.0)
8	**Alchemilla**	23 (14.1)	**Oxytropis**	21 (20.8)	**Sedum**	37 (12.9)
9	**Saxifraga**	22 (15.2)	**Senecio**	21 (22.2)	**Hosta**	36 (13.8)
10	**Chenopodium**	21 (16.2)	**Pedicularis**	21 (23.6)	**Sasa**	35 (14.7)

Boldface indicates characterisitc genera of each region within the ten largest genera.
* Woody genera.

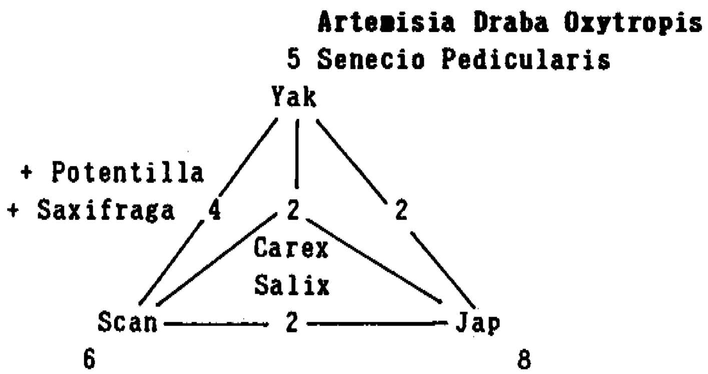
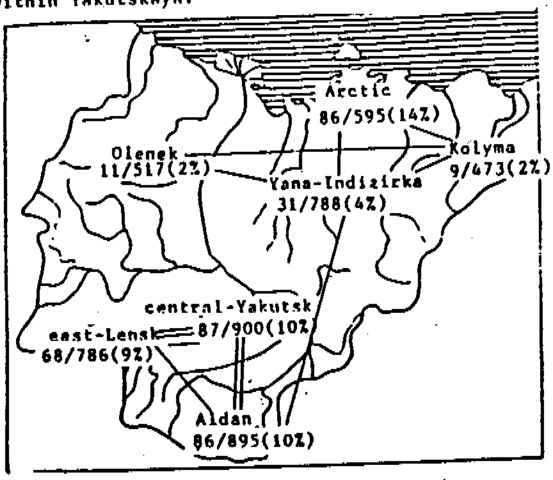


Fig. 1. Floral relationships between the seven regions within Yakutskaya.



Species found only in the region / total species found in the region (percentage).
Index of similarity: ═══ , over 70 %; ——— , over 60 %.

Fig. 2. Species numbers of <u>Saxifraga</u>, a dominant genus in tundra zone.

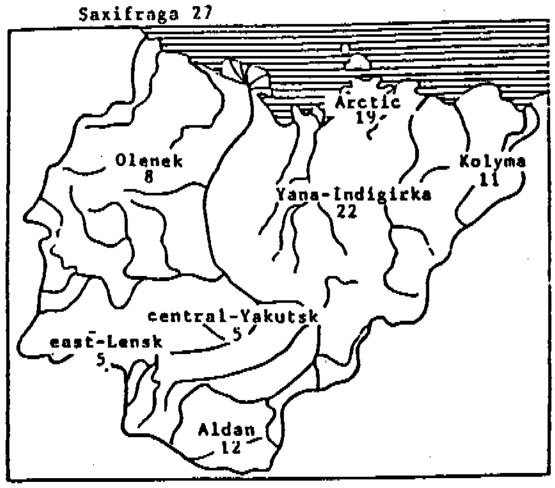
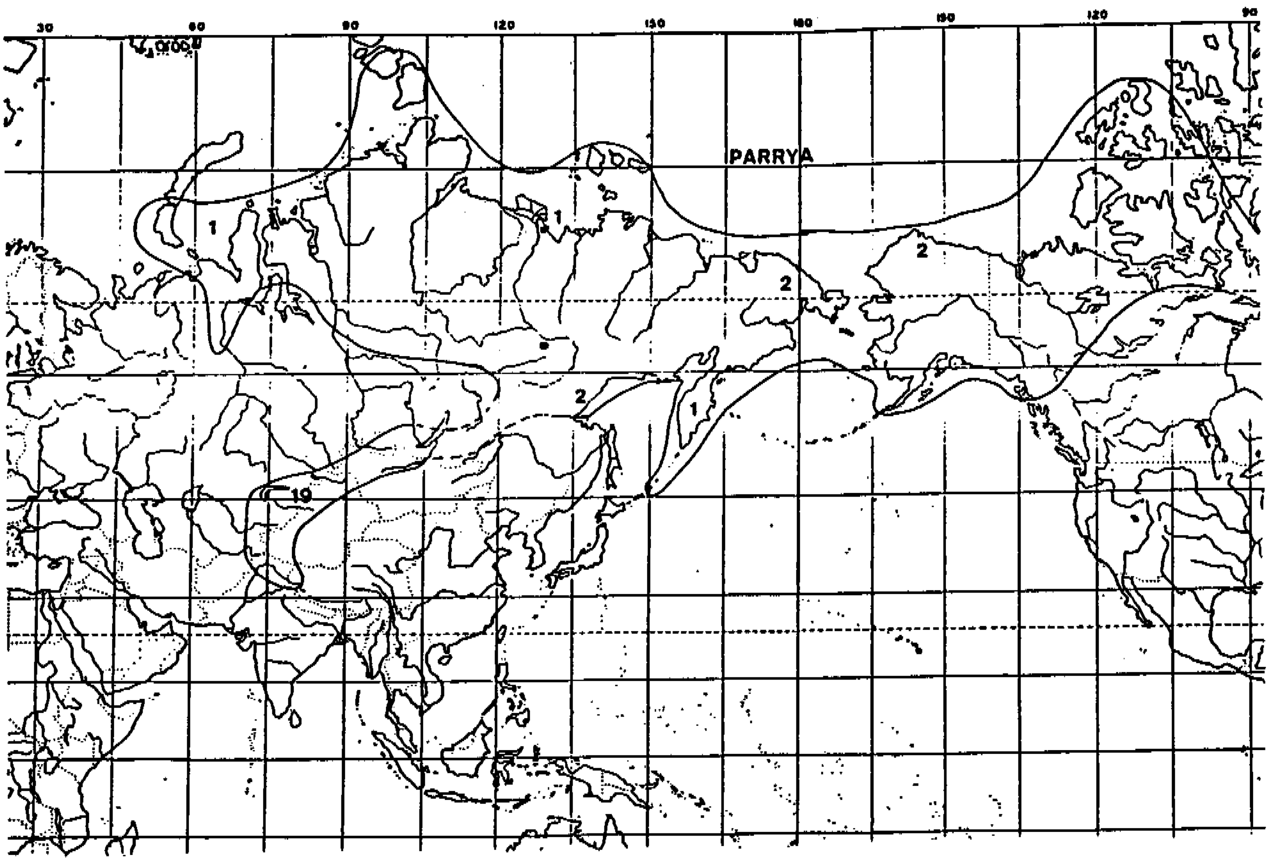


Fig. 3. Distribution and species numbers of the genus <u>Parrya</u>.



21 Leaf characteristics and survivorship in an evergreen shrub, *Ledum palustre* ssp. *decumbens* in accordance with latitudinal change

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Introduction

Ecological significances of leaf life-span have been understood from the view point of carbon economy; leaf life-span is determined by a balance between cost for leaf construction, maintenance or defense, and benefit by photosynthetic carbon gain (Chabot and Hicks 1982; Williams et al. 1989; Kikuzawa 1991). Under nutrient stresses (Monk 1966; Small 1972; Reader 1978; Shaver 1981; Jonasson 1989) or shade stresses (Bentley 1979; Kikuzawa 1984; Nilsen 1986) in which photosynthetic rate is reduced, leaf life-span lengthens within and among species because of slow carbon gain. On the other hand, the length of the favorable periods for photosynthesis within a year also affects leaf life-span.

Recently, Kudo (1992) compared leaf life-span of four alpine species along a snowmelt gradient in snow beds, and found that the leaf life-span of evergreen shrub species extended under a short growth condition. When annual photosynthetic period is limited, the cost of rapid leaf turnover may exceed the benefit gained by photosynthesis in new leaves, thus slow turnover of leaves is favorable and the leaf life-span lengthens.

Because favorable period for growth gradually decreases from tropical to arctic regions, regulation of leaf life-span may occur within a species along a latitudinal gradient. Kikuzawa (1991) presented a theoretical model of leaf life-span based on the hypothesis that longevity of a leaf was determined to maximize the net carbon gain per unit time at the leaf, and simulated that leaf life-span would change with favorable period within a year. Moreover, biogeographic distribution pattern of evergreen trees, which is a bimodal distribution at lower and higher latitudes, was explained with his model. However, quantitative evidence for predictions of the model is scarce.

Karlsson (1992) compared the leaf life-span of some ericaceous and empetraceous species at three latitudes, and found that the leaf life-span was longer at the higher latitude than at the two lower latitudes. He attributed it to poor soil nutrient conditions at the higher latitude. Considering the length of annual growth season among the latitudes, however, this phenomenon should be minutely re-examined from the both aspects, nutrient condition and the length of favorable period. In order to make clear the intraspecific response to latitudinal change, in this study, leaf life-span and other leaf characteristics of evergreen shrubs, *Ledum palustre* ssp. *decumbens*, were compared at three latitudes in consideration of soil nitrogen condition.

Materials and methods

Ledum palustre ssp. *decumbens* (Ait.) Hult. has a wide distribution range from middle to high latitudes in north America and east Asia (Hulten 1968). Three sites were chosen along the range of latitudinal distribution as shown in Figure 1. Tiksi (71° 25'N, 129° 0'E, elevation 50-100 m) is located in arctic tundra near the mouth of Lena River, east Siberia, and in northern edge of the range of *L. palustre*. Yakutsk (62° 10'N, 129° 30'E, elevation 100-150 m) in east Siberia is located in central taiga forest composed of *Larix dahurica* and *Pinus sylvestris*. Hokkaido island, northern Japan is in southern edge of the range, where *L. palustre* inhabits mountain tundra regions above ca. 1500 m elevation with little snow cover during the winter. Study site in Hokkaido is set in the Taisetsu Mountains (43° 30'N, 142° 50'E) of 1700 m elevation. The annual mean temperature in Yakutsk was -10.4° C, ranging from -42° C (January) to 18.8° C (July); that in the Taisetsu Mountains, Hokkaido was -0.9° C, from -16.2° C (January) to 12.1° C (August). Number of non-frost days was 112 in Yakutsk (average of 10 years, 1978-1987), and 140 in Hokkaido (in 1990). Although there is no meteorological data for Tiksi, the non-frost days is easily considered to be shortest of all sites.

In Tiksi and Hokkaido, *L. palustre* grows at exposed tundra habitats where no vegetation cover above the plants. In Yakutsk, forest edges and gaps were chosen for study site, for avoidance of shade effects on leaf characteristics. In each site, 20 to 30 individuals of *L. palustre* were randomly chosen. Two or three stems of each individual that had not flowered and branched for at least the last 5 years were sampled. Number of sampled stems was 50 in Tiksi and Hokkaido, respectively, and 40 in Yakutsk. Leaf loss of *L. palustre* usually occur during the early growing season, simultaneous with expansion of new leaves (Shaver 1983), and leaf age structure is rather stable in other season.

Sampling in Tiksi was taken place in early July, 1992, before expansion of new leaves. Sampling in Yakutsk and Hokkaido took place in mid to late August, after new leaves completely produced.

Because bud-scale scars and leaf scars remain on the stem for several years, the fraction of stem and the number of leaves produced in each year can be identified for the previous several years. Leaf and leaf scar numbers in each annual fraction of stem were obtained, then survivorship of leaves in annual cohorts and leaf life-span in each stem were estimated using standard demographic methods (Krebs 1972). Leaf age in Yakutsk and Hokkaido was counted under the estimation that all leaves in the sampled season would remain until next season just before expansion of new leaves. Annual shoot elongation and produced leaf number were measured for fractions of last 3 years in each stem. Moreover, leaf area and dry weight (after 24 hours at 60°C) of last year's leaves were measured, and specific leaf area (SLA: leaf area to dry mass ratio) was obtained. For the measurement of SLA, two leaves of medium size were chosen in each stem.

For the comparison of soil nutrient condition, surface soil (0-5 cm deep) was sampled at randomly selected 7 points in each site. After dried at 70°C for 48 hours, total nitrogen content of the soil was analyzed using a C-N analyzer (Yanaco MT-3).

Results

Annual shoot growth was shortest in Tiksi (12±5 mm/yr), and there was no significant difference ($p>0.05$, Mann-Whitney U-test) between Yakutsk (21±9) and Hokkaido (19±6; Fig.2 a). Similar tendency was shown in leaf number produced per year (Fig.2 b). The leaf number was significantly ($p<0.01$) smaller in Tiksi (14±2) in comparison with in Yakutsk (18±4) and Hokkaido (20±5). Individual leaf area was largest in Yakutsk (16±4 mm^2), then in Hokkaido (14±4), and smallest in Tiksi (12±3; $p<0.01$; Fig.2 c).

The survivorship of leaf cohorts in Tiksi gradually decreased from year to year, and 6 year-old leaves were maximum (Fig.3). In Yakutsk, the survivorship was maintained in higher level until third year, then abruptly decreased in the forth year. The oldest leaves were 4 year-old in Yakutsk. In Hokkaido, the survivorship was highly decreased in the second and third years, and 3 year-old leaves were maximum. Although leaf loss pattern was different as shown in Figure 3, there was no significant difference in the leaf life-span ($p>0.05$, Mann-

Whitney U-test) between Tiksi (3.9±0.7 yr) and Yakutsk (3.8±0.5; Fig.4). The leaf life-span in Hokkaido (2.8±0.4) was significantly short ($p<0.01$) in comparison with in other two sites.

SLA was significantly increased with the decrease in latitudes ($p<0.01$, ANOVA and Duncan's multiple range test) from Tiksi (23±4 cm^2/g) through Yakutsk (30±4) to Hokkaido (36±7; Fig.4). Increased SLA means the decrease in leaf dry weight per area, indicating cheaper construction cost per unit leaf area. Among three sites, highly significant negative correlation was recognized between leaf life-span and SLA ($r=-0.53$, $n=140$; $p<0.01$). Between leaf life-span and shoot growth, there was negative correlation among three sites ($r=-0.22$, $n=140$; $p<0.05$), and the correlation was highly significant ($r=-0.42$, $n=100$; $p<0.01$) in case of comparison between both the tundra habitats, Tiksi and Hokkaido.

Total nitrogen content in soil was highest in Tiksi, and there was no significant difference between Yakutsk and Hokkaido ($p>0.05$, Mann Whitney U-test; Table 1).

Discussion

In comparison with leaf characteristics in the mountain habitat of southern distribution edge, SLA, shoot growth, leaf number and leaf size of *L. palustre* were decreased, and leaf life-span lengthened in the arctic habitat of northern edge where annual growth season was restricted. In the intermediate taiga habitat, those leaf characteristics were within the range of those two edges with only the exception of leaf size. Thus, with increase in latitudes, plant growth is restricted, and plants produce fewer but costly leaves and utilize them for long period.

Shaver (1981) proved in a soil fertilizing experiment that the leaf life-span in *L. palustre* reduced with increase in soil nitrogen content. This study reveals, however, that extension of leaf life-span at the higher latitude is not because poor nutrient condition since nitrogen content was highest in Tiksi. It is more probable to attribute longer leaf life-span to decrease in the length of favorable season within a year as predicted above.

It is known that leaf life-span is negatively correlated with SLA (positively correlated with SLW; specific leaf weight) or shoot growth within and among species (Kohyama 1980; Coley 1988; Reich et al. 1991; 1992; Kudo 1992). Similar tendency was recognized also in *L. palustre* in this study. But *L. palustre* in

Yakutsk showed similar leaf life-span in Tiksi, and similar shoot growth in Hokkaido, in spite of significant differences in SLA among sites. Because plants in taiga is less affected by mechanical pressure by strong wind or blown sand and ice particles in comparison with that in exposed tundra, leaf loss by mechanical damages is considered to be not serious. Therefore, simultaneous turnover of leaves may occur when maintenance cost exceeds benefit by photosynthetic gain because of aging; it is known that photosynthetic capacity for *L. palustre* is highest in one year-old leaves, then gradually declined with increasing age (Johnson and Tieszen 1976). Rapid leaf loss in the forth year observed in Yakutsk seems to be results of physiological regulation of carbon balance in each leaf. On the other hand, gradual leaf loss pattern in Tiksi may reflect forced loss by mechanical damage before loss by regulation of carbon balance. Large leaf size and shoot growth observed in Yakutsk may be related to the mild environmental condition in the taiga habitat.

In summary, extension of leaf life-span and reduction of SLA with decrease in the length of favorable period occur in phytogeographic level along a latitudinal gradient, as previously shown within a local area along a snowmelt gradient (Kudo 1992). This result supports the prediction of phytogeographic pattern in leaf longevity simulated by Kikuzawa (1991).

References

Bentley BL (1979) Longevity of individual leaves in a tropical rainforest under-story. Ann Bot 43:119-121

Chabot BF, Hicks DJ (1982) The ecology of leaf life spans. Ann Rev Ecol Syst 13:229-59

Coley PD (1988) Effects of plant growth rate and leaf lifetime on the amount and type of antiherbivore defense. Oecologia 74: 531-536

Hulten E (1968) Flora of Alaska and neighboring territories. Stanford University Press, Stanford

Johnson DA, Tieszen LL (1976) Aboveground biomass allocation, leaf growth, and photosynthesis patterns in tundra plant forms in arctic Alaska. Oecologia 24:159-173

Jonasson S (1989) Implications of leaf longevity, leaf nutrient re-absorption and translocation for the resource economy of five evergreen plant species. Oikos 56:121-131

Karlsson PS (1992) Leaf longevity in evergreen shrubs: variation within and among European species. Oecologia 91:346-349

Kikuzawa K (1984) Leaf survival of woody plants in deciduous broad-leaved forests. 2. Small trees and shrubs. Can J Bot 62: 2551-2556

Kikuzawa K (1991) A cost-benefit analysis of leaf habit and leaf longevity of trees and their geographical pattern. Am Natu 138: 1250-1263

Kohyama T (1980) Growth pattern of *Abies mariesii* saplings under condition of open-growth and suppression. Bot Mag Tokyo 93:13-24

Krebs CJ (1972) Ecology. Harper and Row, New York

Kudo G (1992) Effect of snow-free duration on leaf life-span of four alpine plant species. Can J Bot 70:1684-1688

Monk CD (1966) An ecological significance of evergreenness. Ecology 47:504-505

Nilsen ET (1986) Quantitative phenology and leaf survivorship of *Rhododendron maximum* in contrasting irradiance environments of the southern appalachian mountains. Amer J Bot 73:822-831

Reader RJ (1978) Contribution of overwintering leaves to the growth of three broad-leaved, evergreen shrubs belonging to the Ericaceae family. Can J Bot 56:1248-2161

Reich PB, Uhl C, Walters MB, Ellsworth DS (1991) Leaf lifespan as a determinant of leaf structure and function among 23 amazonian tree species. Oecologia 86:16-24

Reich PB, Walters MB, Ellsworth DS (1992) Leaf life-span in relation to leaf, plant, and stand characteristics among diverse ecosystems. Ecol Monogr 62:365-392

Shaver GR (1981) Mineral nutrition and leaf longevity in an evergreen shrub, *Ledum palustre* ssp. *decumbens*. Oecologia 49: 362-365

Shaver GR (1983) Mineral nutrition and leaf longevity in Ledum palustre: the role of individual nutrients and the timing of leaf mortality. Oecologia 56:160-165

Small E (1972) Photosynthetic rates in relation to nitrogen recycling as an adaptation to nutrient deficiency in peat bog plants. Can J Bot 50:2227-2233

Williams K, Field CB, Mooney HA (1989) Relationships among leaf construction cost, leaf longevity, and light environment in rain-forest plants of the genus *Piper*. Am Natu 133:198-211

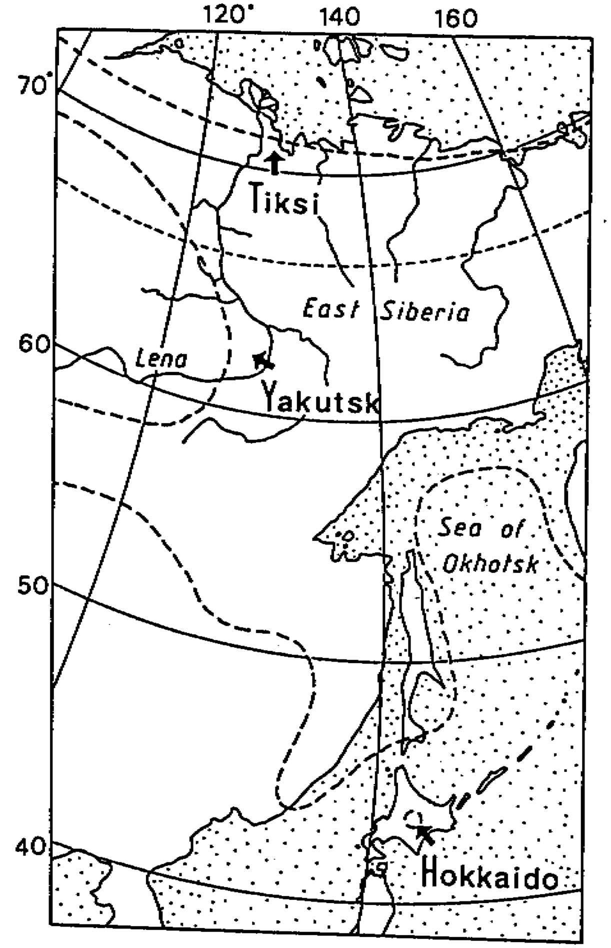

Fig. 1 Geographical distribution range of *Ledum palustre* ssp. *decumbens*, and location of survey sites. Thick broken lines indicate the distribution edges of *L. palustre* (Hulten 1968).

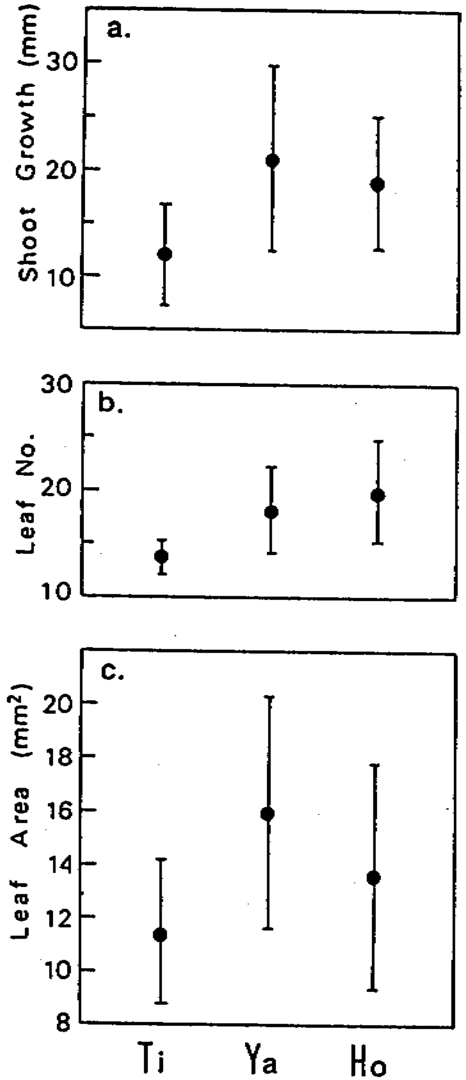

Fig. 2 Annual shoot growth (a), annual produced leaf number (b), and individual leaf area (c) in each site (Ti: Tiksi, Ya: Yakutsk, Ho: Hokkaido; mean $\pm$ SD.). For shoot growth and leaf number, averages of last three years were obtained in each stem.

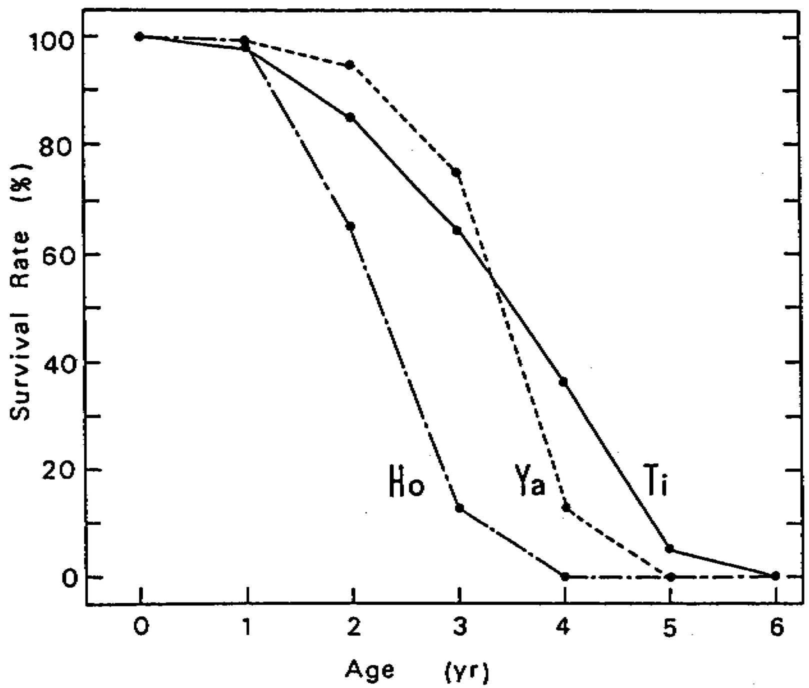

Fig. 3 Survival curve of leaves in each site, which was estimated with survival rate of each leaf cohort. N=50 for Tiksi and Hokkaido, and 40 for Yakutsk.

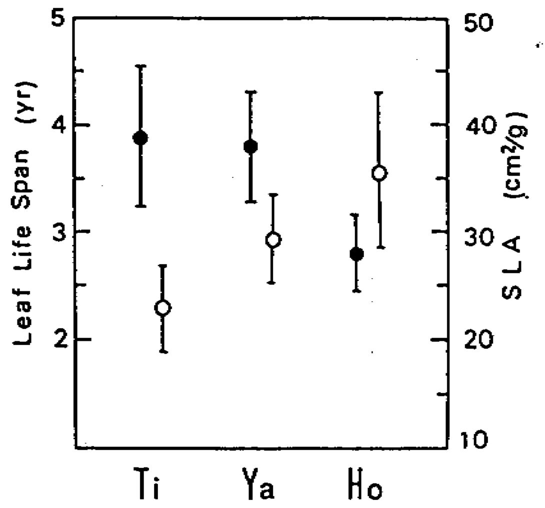

Fig. 4 Leaf life-span (closed symbol) and SLA (open symbol) in each site. N=50 for Tiksi and Hokkaido, and 40 for Yakutsk; mean ± SD.

Table 1. Total nitrogen contents in surface soil (0-5 cm in depth) in each site. Sample size was 7; mean ± SD.

Tiksi	0.68 ± 0.11^{a} %
Yakutsk	0.28 ± 0.19^{b} %
Hokkaido	0.35 ± 0.16^{b} %

a-b: p<0.01, Mann Whitney U-test.

22 Faunal Survey of Carabid Beetles (Coleoptera; Carabidae) and Phoretic Mites (Acari; Gamasina) in Sakha SSR.

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Last summer, joint biological research between Institute of Low Temperature Science (Hokkaido University) and Yakutsk Biological Institute was carried out in Sakha SSR from latitude 60 N. (near Lena Pillars) to latitude 72 N. (Tiksi) (Fig.1). I reseached fauna of Coleoptera, particularly carabid beetles, and mites appeared on those beetles. Those beetles were collected by bait-trapa made by plastic cups. Phoretic mites were detached from body surface of beetles and fixed in 70% alcohol. Those materials were taken to Japan in order to identify. Until now Ihave finished identification of the mites, but as for the beetles I continue to identify the materials, so identification of the beetles have been done at only genus level. In this report I compared distributional pattern of carabid beetles and phoretic mites between in Sakha SSR and in Hokkaido (northern Japan).

I could collect many beetles belonged to the 9 subfamilies 13 genera, and one species of mites. List of the beetles and mites is showed in table 1.

I calculated the common species rate (number of species inhabiting in both Siberia and Hokkaido or both Siberia and Daisetsu mountain range / number of species inhabiting in Hokkaido Island or the Daisetsu mountain range) of family Carabidae between Siberian region and Hokkaido Island, and between Siberian region and the Daisetsu mountain range of Hokkaido. As a result, common species rate between Siberia and Hokkaido was 90/315 (=28.6%) and the rate between Siberia and Daisetsu was 59/122 (=48.4%) (These data were based on Hirashima 1989, Yasuda 1985 and Lafer et al. 1989). Those rate could been seen higher than other region, but minute examination could clarify that relationship between Hokkaido and more east Siberia - for examples, Primorskii, Khabarovsk, Sakhalin and so on - is still more higher than other Siberian region.

Some specialist estimate that recent distibution of carabid beetles in Hokkaido had been led by invasion from from Sakhalin at final glacial period. And the distibution in Yakutsk might be led from Mongolia or central area of China because many common species inhabit anmong above mentioned area (Yakutsk, Mongolia and central China). To understand minutely, detail faunal survey, taxonomic study and analysis should be done in future.

As for phoretic mites, Poecilochirus carabi collected in this research was the common species among Palaearctic region and developmental stage of all mites were deutonymph (stage just before adult) (Fig.2). The mites were appeared on 4 species of genus Carabus, and frequency which the mites appeared on the beetles were 2.8% to 50.0%. Average of number of mites per one beetle was 13. Some measured values of the mites were showed in table 2. Measured values of European population of same species overlap those of Sakha population, but all values of Sakha population are slightly smaller than European. Frequency of apprearance and number of mites per one beetle tend to high values in southern part, Lena Pillars. In this research, however, collected material is not so many, so in next research I would like to collect material enough to analyze biogeographical cline in measured values, frequency of appearance, and number of mites per a beetle.

In Europe and Japan, the mite species almost appears on beetle of the genus Nicrophorus (Silphidae; Silphinae), and only small number of mites are occasionally found on the genus Carabus. In this research, I could not collect beetle of the genus Nicrophorus, so distribution of the mites to the beetles exept carabid beetles is unknown in Siberia. I hope to clarify the distribution and compare frequrency of appearance of mites in this summer.

And in Hokkaido Island, quite different species of mites ride on carabid beetles instead of Poecilochirus carabi. P. carabi collected in Sakha appeared on body surface of the beetles, but Japanese species inhabit under elytra(=hard wing). So, condition of inhabiting is also different. Research in future may make clear how such mites inhabiting in Japan distribute and from where.

At the end, I wish to express my sincere thanks to following persons for their great help in research of last summer: Drs. Solomonov, Ivanov, Vinokurov, Averensky, Vasily, Kaimuk, Daniel, Maksimov, Volotovsky, Timofeyev, Mrs. Revina, and other members of Yakutsk Biological Institute.

Table 1: List of carabid beetles and phoretic mites collected in Sakha SSR.

<Carabid Beetles>

- Family Carabidae
  - Subfamily Carabinae
    - Tribe Carabini
      - Genus *Carabus*
        - *C. canaliculatus* (F.S., A.S, L.P.)
        - *C. kruberi* (B.G.)
        - *C. odoratus* (near Zhigansk)
        - *C. aeruginosus* (?) (A.S.)
        - *C. maeander* (A.S.)
        - *C. granulatus* (?) (A.S.)
        - *C. clathlatus* (A.S.)
        - *C. regalis* (near Zhigansk)
        - *C. truncaticolis* (Tiksi)
        - *C. henningi* (F.S.)
        - *C.* sp. (near Zhigansk)
      - Genus *Calosoma*
        - *Calosoma investigator* (L.P.)
  - Subfamily Pterostichinae
    - Tribe Pterostichini
      - Genus *Pterostichus* (Yakutsk-Tiksi)
      - Genus *Tapinopterus* (?) (Tiksi)
    - Tribe Agonini
      - Genus *Agonum* (Y.-Z.)
    - Tribe Zabrini
      - Genus *Amara* (A.S., AG.S., near Zhigansk)
  - Subfamily Harpalinae
    - Tribe Harpalini
      - Genus *Trichotichnus* (Y.-Z., AG.S)
  - Subfamily Elaphrinae
    - Tribe Elaphrini
      - Genus *Elaphrus* (A.S.)

Table 1 (continued)

Subfamily Nebriinae	
Tribe Nebriini	
Genus <u>Nebria</u>	(Y.-Z.)
Tribe Notiophilini	
Genus <u>Notiophilus</u>	(A.S.)
Subfamily Loricerinae	
Genus <u>Loricera</u>	(A.S.)
Subfamily Bembidiinae	
Tribe Bembidiini	
Genus <u>Bembidion</u>	(Yakutsk-Tiksi, AG.S.)
Subfamily Patrobinae	
Tribe Patrobini	
Genus <u>Patrobus</u>	(near Zhigansk)
Subfamily Lebiinae	(A.S.)

Parenthesized terms mean collection sites. Meaning of abbreviations are as follow: A.S.=Alas Station; AG.S.=Agriculture Station; B.G.= Botanical Garden of Yakutsk; F.S.= Forest Station of Yakutsk; L.P.= Lena Pillars; Y.-Z.=sites from Yakutsk to Zhigansk.

<Phoretic Mite>

Cohort Gamasina
  Superfamily Parasitoidea
    Family Parasitidae
      Genus <u>Poecilochirus</u>
        <u>Poecilochirus</u> <u>carabi</u>

This species was collected from body surface of <u>Carabus</u> <u>canaliculatus</u>, <u>C</u>. <u>odoratus</u>, <u>C</u>. <u>aeruginosus</u> and <u>C</u>. sp.

Table 2: Measured values of <u>Poecilochirus</u> <u>carabi</u> (deutonymph)

		mean + S.D.(μm)	range(μm)
idiosoma	length	1125.4 ± 57.4	1004 - 1240
podonotal	length	569.2 ± 30.3	481 - 604
shield	width	708.0 ± 66.8	612 - 849
opisthonotal	length	424.3 ± 19.8	384 - 457
shield	width	678.3 ± 65.0	563 - 816
sternal	length	343.8 ± 10.0	326 - 355
shield	width	230.7 ± 12.2	208 - 257
anal shield	length	141.1 ± 17.7	114 - 184
	width	102.5 ± 5.3	90 - 110

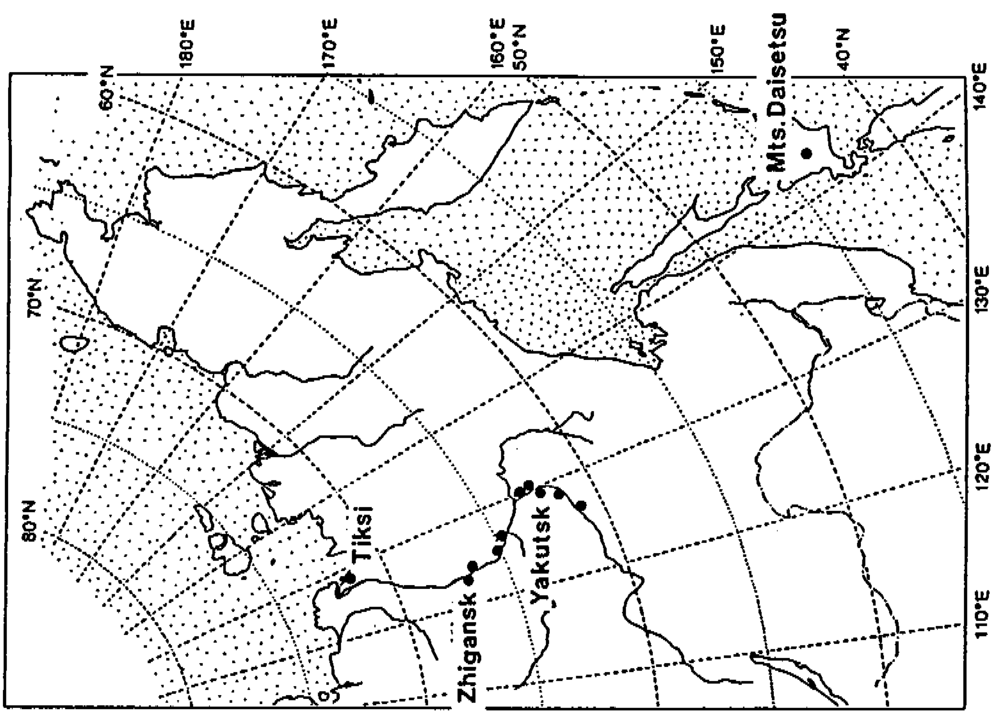

Figure 1: Collection sites in Sakha SSR.

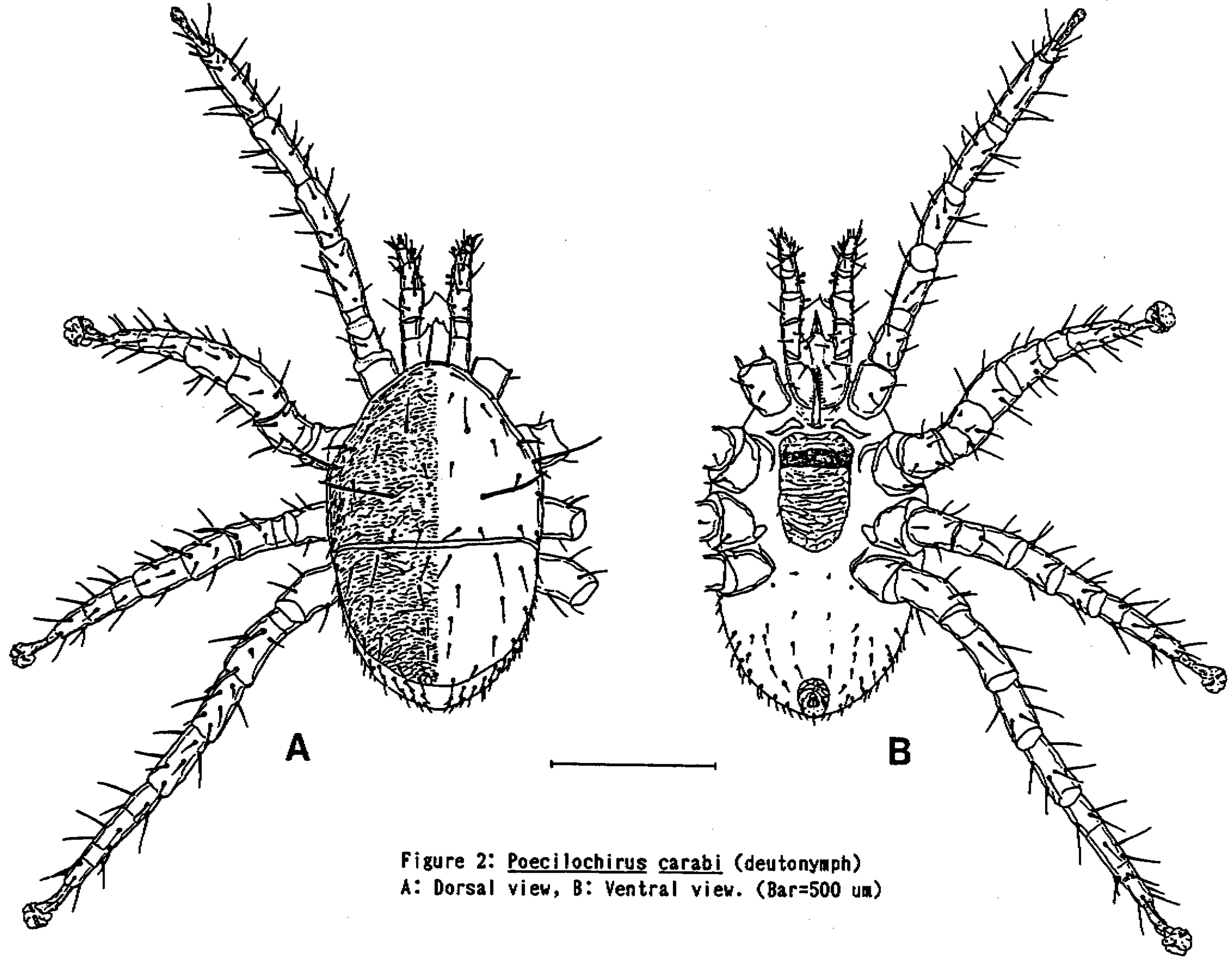

Figure 2: Poecilochirus carabi (deutonymph)
A: Dorsal view, B: Ventral view. (Bar=500 um)

23 Genesis and Occurrence of Ice Complex(Edoma) in lowland area along Arctic coast of east Siberia near Tiksi

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1. INTRODUCTION

Ice Complex, which widely distributes in low land areas along the Arctic coast of eastern Siberia and middle stream area of Lena River, is an unique feature of permafrost. At the most of exposure sites, the thickness of Edoma is about 30 - 40 m, and major part of Edoma consists of large size of ice wedge. Ice may contains profound information on climatic change in the past just like ice sheet of Antarctica and Green land. Aiming to reconstruction of palaeo-environment of Siberia, the site of exposure of Edoma along the coast of Bykovsky Peninsula, near Tiksi was selected. The field survey was conducted in summer season of 1992 under the cooperation between members of Institute of Low Temperature Science and Permafrost Institute. The locations of the site is indicated in Fig.1 and Fig.2.

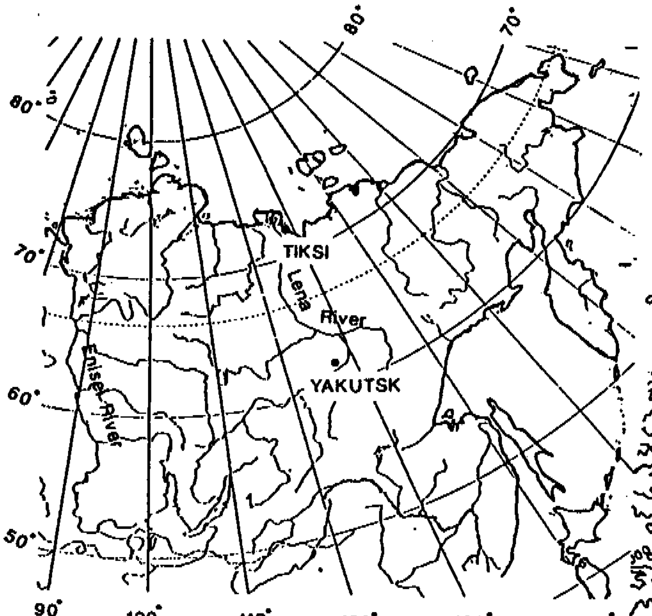

Fig.1 Location of Surveyed Area

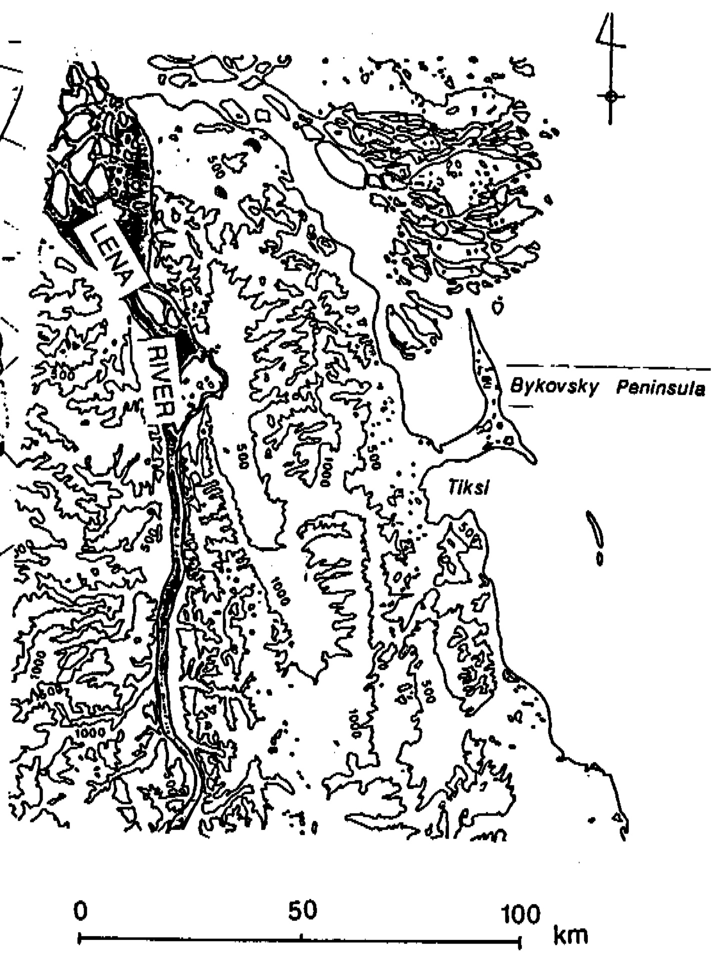

Fig.2 Location of Bykovsky Peninsula near Tiksi

2.FIELD SURVEY and ANALYSIS

Field surveys were conducted as to collect ice samples and sediments from the exposure. Ice was sampled at every 3 meter interval and sediments among ice body also were sampled. The vertical structure of ice indicates that ice is originated by ice-wedge formation. Many air bubbles were found along the vertical structures and were vertically elongated. Typical size of air bubble is 2-3mm in diameter and 1-2 cm in length. Sampled ice was treated on the spot to extract air from ice. NaCl solution was heated and ice sample was emerged into solution. A plastic funnel placed over ice sample. Released air bubbles were trapped into special grass holder. By this procedure of sampling, contamination by ambient air was minimized to occur.

Peat layers in the sediments were traced to the certain horizon of the stratigraphy of the sediment. ^{14}C datings were made by AMS method at Nagoya University using peat samples. Isotropic analysis of water was also made at Nagoya University. Results of analysis were summarized in Fig.3.

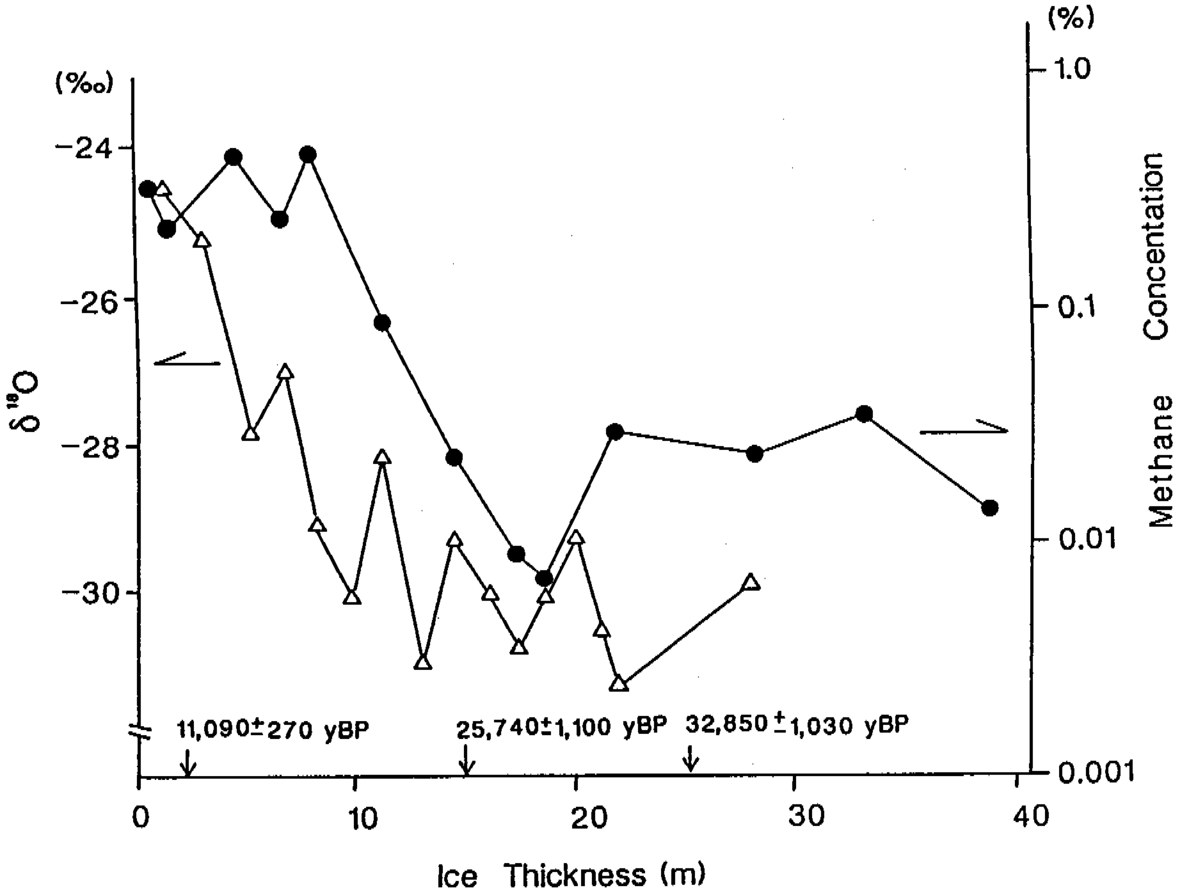

Fig.3 Isotropic and methane concentrations of ice and air bubbles from Edoma

3.DISCUSSION and CONCLUSION

Estimated ages obtained by dating using peaty sediments imply that major part of Edoma developed during last Glacial period, especially not in Mid Glacial period of Sartan (Wisconsin) but in Interstadial of Karginsky dated from 40,000 yBP to 24,000 yBP. There are few information of palaeo-temperature at that period. Recently new records of palaeo-temperatures from Green land Ice sheet has been reported with high resolution of isotropic analysis. That data was modified as to correlate to palaeo environment in Siberia and indicated in Fig.4.

During Karginsky Interstadial from 38,000 yBP until 23,000 yBP, temperatures osculated with larger amplitude than in Sartan Glacial period. Mean temperatures during Sartan Glacial was lower than that of Karginsky. However the lowest peaks of temperature osculation during Karginsky Interstadial period were lower than those in Sartan Glacial period. Highest peaks during Karginsky Interstadial were as warm as those in Holocene. If one considers these oscillated temperatures, he expects that fluvial process and active sedimentations might occur at the time of highest peaks in osculation and active ice wedge formation would take place in lowest peaks during Karginsky Intaerstadial. It may be concluded based on early analysis that Edoma developed during Karginsky Interstadial period with repeated warm and cold environments.

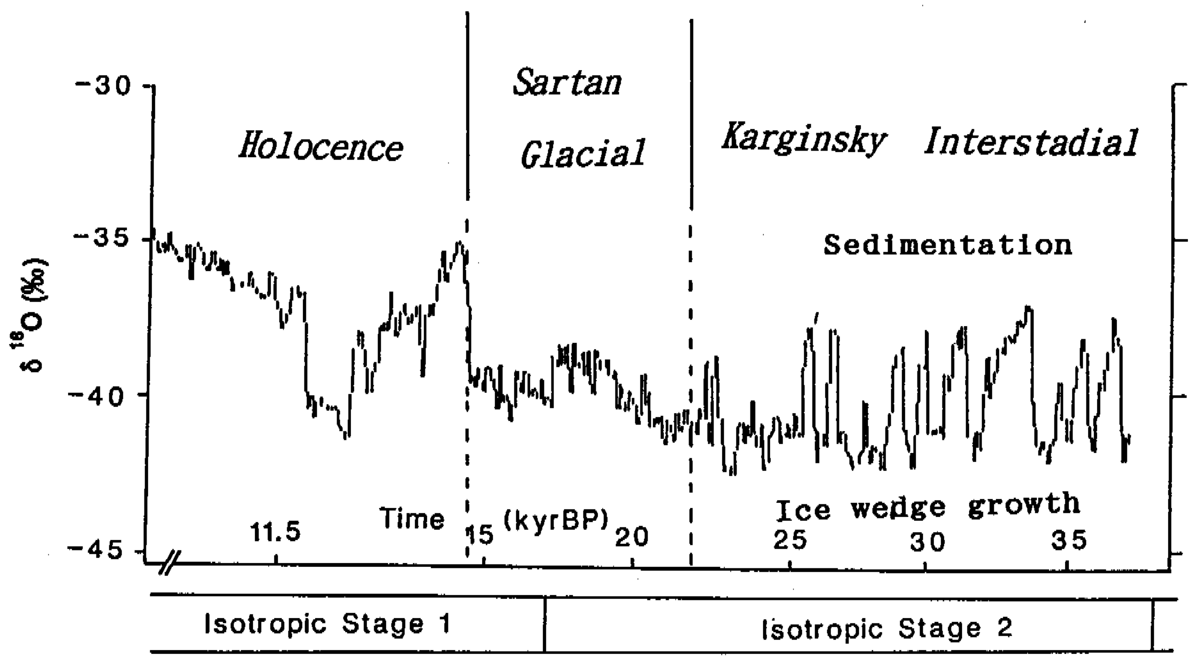

Fig.4 Palaeoenvironments in last glaicial related to formation of large scale ice wedge(Edoma) in eastern Siberia

24 Grain-Size Distribution of the Edoma Deposits on Cape Bykovskiy

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Introduction

As far as genesis of edoma deposits concerned, there are two hypotheses. One is that it was formed by floodplain alluvial deposits, the other is by eolian deposits (loess). The edoma deposits on Cape Bykovskiy which we made an investigation this time, is regarded as loess origin by Tomirdiaro (1980). But, we have some questions about a point of view for loess origin this area.

The purpose of this paper is to consider depositional environment of the edoma deposits by using grain size analysis.

Method and Result

The samples collected from the edoma deposits (Sampling points are shown in Fig.3) were, at first, warmed in H_2O_2 solution to remove organic materials. After that, they were passed through a sieve of 4.5ϕ mesh. Materials that remained on it were dried and passed through sieves of each mesh size from 0ϕ to 4ϕ with every 0.5ϕ. The other materials which passed through 4.5ϕ mesh were measured by a centrifugal particle size analyzer (SA-PC3L, Shimazu Corporation). The grain size distribution was calculated as weight percent of each phi

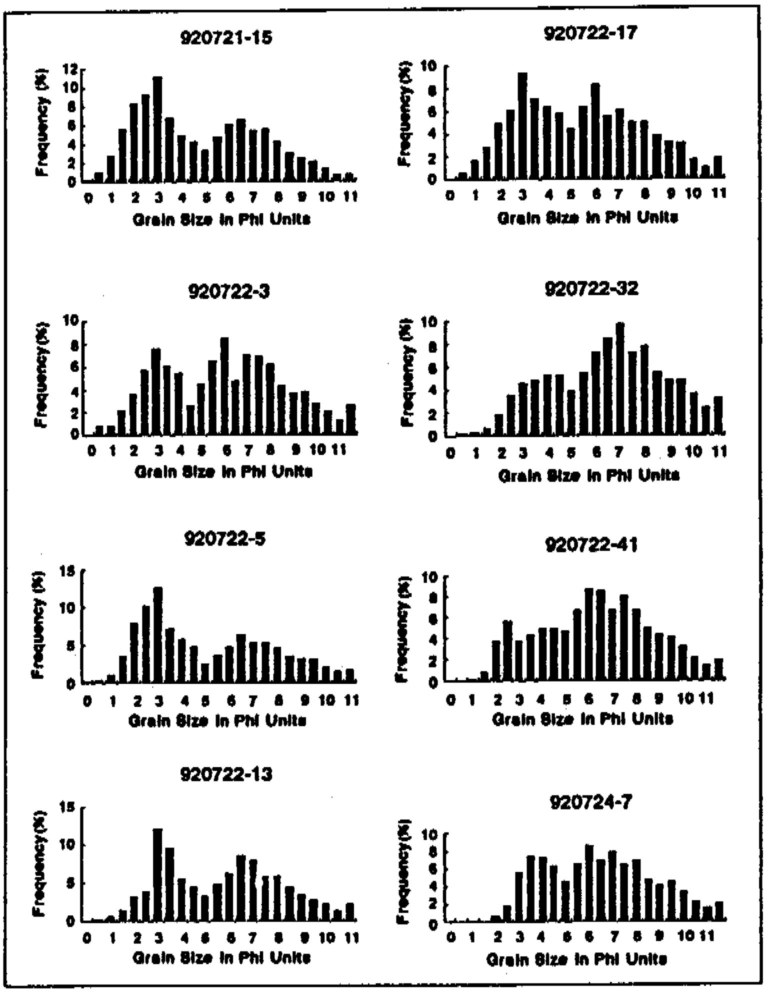

Fig.1 Histograms of grain size distribution analyzed for the sediments sampled at Cape Bykovskiy.
All of them show bimodal distribution.

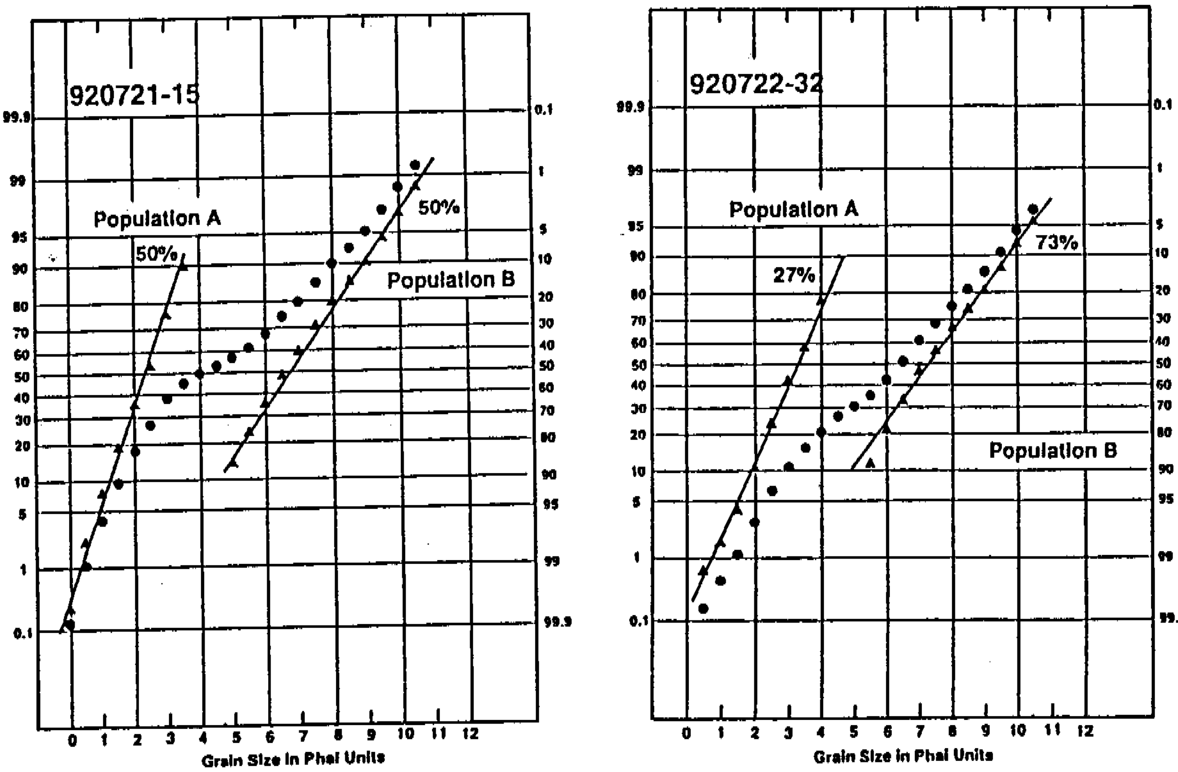

Fig.2 Examples of grain size disribution and its subpopulations separated by the method of Inoguchi and Mezaki (1974)

unit.

Fig.1 shows some histograms of grain size distribution. All of them are characterized by bimodality, which suggests that the edoma deposits are mixed by two materials of different grain size distribution. All of samples are, then, separated into two normal distributed

Table 1 Results of grain size analysis

Sample No.	Original Population				Population A				Population B			
	Mean Size		Stand. Dev.	Skewness	Rate	Mean Size		Stand. Dev.	Rate	Mean Size		Stand. Dev.
	(Phi)	(mm)	(Phi)		(%)	(Phi)	(mm)	(Phi)	(%)	(Phi)	(mm)	(Phi)
920721-15	4.53	0.0432	2.54	0.380	50	2.35	0.1961	0.85	50	6.73	0.0094	1.66
920721-21	4.09	0.0586	2.45	0.827	64	2.58	0.1672	0.98	36	6.78	0.0091	1.88
920721-25	4.54	0.0428	2.69	0.497	57	2.55	0.1708	0.95	43	7.25	0.0066	1.75
920722-3	5.69	0.0193	2.67	0.103	35	2.8	0.1436	1.1	65	7.15	0.0070	2.15
920722-5	4.83	0.0351	2.65	0.441	56	2.83	0.1406	1.03	44	7.35	0.0061	1.85
920722-9	5.89	0.0168	2.76	-0.071	35	2.72	0.1518	1.1	65	7.55	0.0053	1.85
920722-13	5.43	0.0232	2.47	0.200	48	3.45	0.0915	1.2	52	7.2	0.0068	1.9
920722-17	5.11	0.0290	2.50	0.255	40	2.65	0.1593	0.95	60	6.58	0.0105	2.08
920722-22	3.35	0.0978	2.43	1.284	75	2.15	0.2253	0.75	25	6.9	0.0084	2.05
920722-27	5.21	0.0269	2.46	0.248	40	2.73	0.1507	0.83	60	6.8	0.0090	1.9
920722-32	6.26	0.0131	2.37	-0.117	27	3.3	0.1015	1.1	73	7.3	0.0063	1.9
920722-35	6.10	0.0146	2.46	-0.094	32	3.2	0.1088	1	68	7.4	0.0059	1.8
920722-38	5.55	0.0213	2.46	-0.014	24	2.33	0.1989	0.73	76	6.6	0.0103	1.9
920722-40	6.03	0.0154	2.28	0.052	34	3.5	0.0884	0.85	66	7.2	0.0068	1.8
920722-41	6.05	0.0151	2.45	0.011	18	2.45	0.1830	0.6	82	6.8	0.0090	2.1
920724-11	6.21	0.0135	2.35	-0.188	22	2.85	0.1387	0.85	78	7.15	0.0070	1.85
920724-10	6.00	0.0156	2.14	0.114	32	3.65	0.0797	0.95	68	7.03	0.0077	1.78
920724-9	6.42	0.0116	2.26	0.147	32	4.05	0.0604	1.05	68	7.5	0.0055	1.95
920724-3	6.55	0.0107	2.17	0.198	32	4.4	0.0474	1.1	68	7.5	0.0055	2
920724-5	6.05	0.0151	2.19	0.136	33	3.65	0.0797	0.85	67	7.13	0.0071	1.83
920724-7	6.18	0.0138	2.33	0.219	30	3.53	0.0866	0.78	70	7.7	0.0048	2.05

sub-populations by the method of Inoguchi and Mezaki (1974). Fig.2 shows examples of grain size distribution curve and its two sub-populations A and B. Table 1 shows, each sample, mean size, standard deviation and skewness of original population and compositional ratio between population A and B, and mean size and standard deviation of each population. Vertical changes of grain size distribution are indicated in Fig.3 which shows the rate of sand, silt and clay, and that between population A and B.

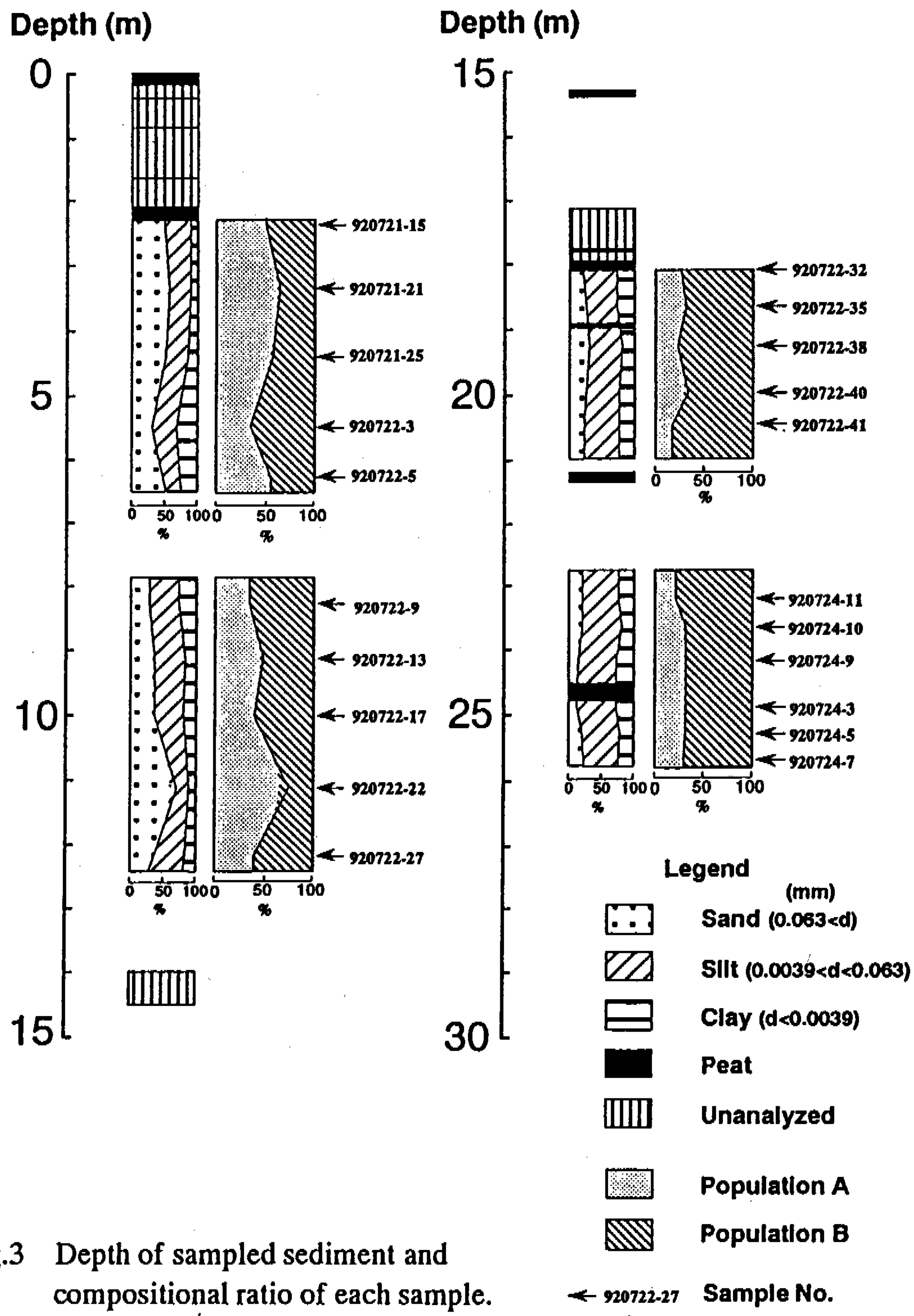

Fig.3 Depth of sampled sediment and compositional ratio of each sample.
Left side of each column : the rate of sand, silt and clay.
Right side : that between population A and population B.

Discussion

Results of grain size analysis suggest as the following two notions :

1) grain size composition of the edoma deposits include a lot of sand size material, particularly in upper part, at rate of the rather than about 50%. Loess deposits, in general, comprise material which is finer than silt size, and genesis of the edoma deposits, therefore, are considered not to be loess. And as the upper part of the deposits are coarser than the lower part, we have an idea about the depositional environment of the deposits. It is delta (its model shows in Fig.4). In depositional environment of delta, fine materials accumulate in offshore and coarse material deposits landward. The shoreline of delta has advanced seaward with time, delta sediments therefore are coarse upward.

The Lena, at the present time, forms the huge delta, so we are able to consider that the depositional environment of delta was formed in the mouth of the Lena when the edoma deposits accumulated there.

2) The edoma deposits can be separated into two sub-populations. Fig.5 shows relationship between standard deviation and mean size in original population (upper) and population A and B (lower). The relationship in original population is trend to scatter, on other hand, that in sub-populations is concentrated comparatively. This result seems to suggest that the edoma deposits have two origins. Now, we regard one of these origins (population

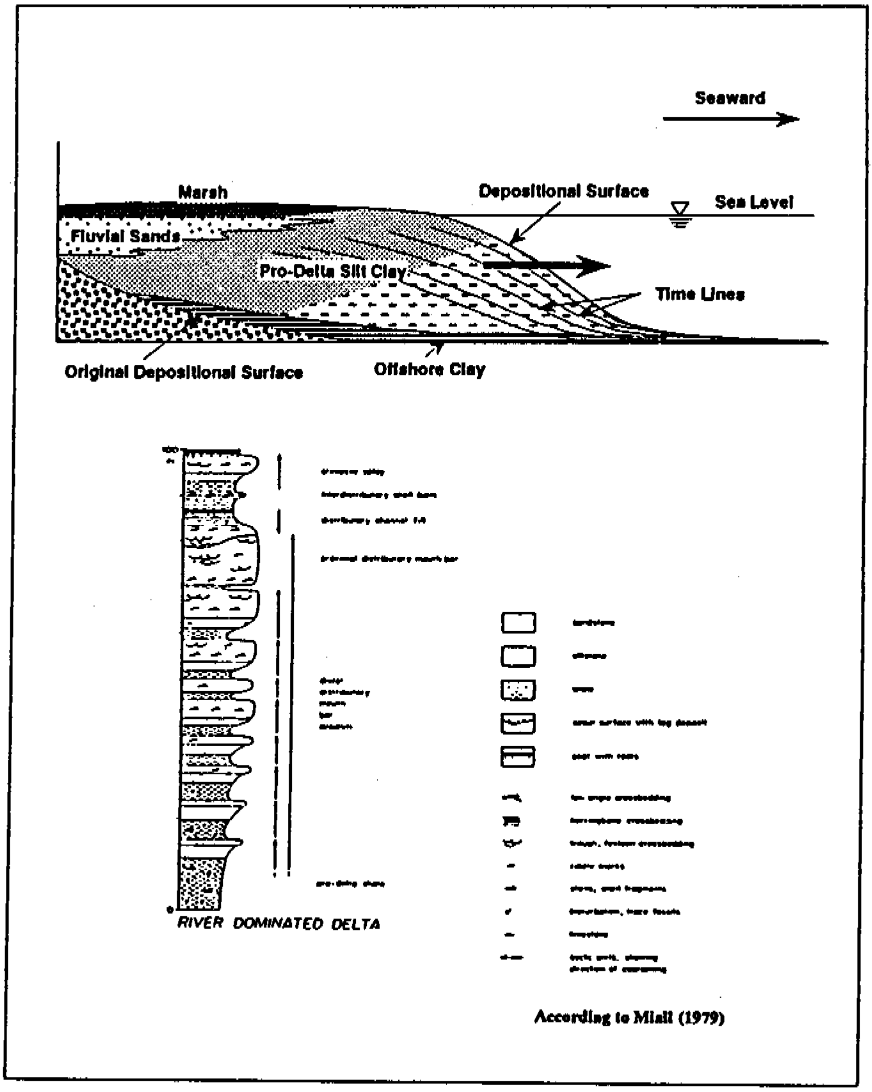

Fig.4 Generalized profile and stratigraphic section of delta

B) as loess, because it seems to be reasonable that, in upstream area of the Lena that loess widespread, fine sediments (like population B) are regarded as it. The other origin (population A) seems to be river bed material originated in weathered bedrocks, etc.

In this consideration, the depositional system of the edoma is shown in Fig.6.

Summary

Based on grain size analysis, we tried to reveal the genesis of the edoma deposits on Cape Bykovskiy. In the result, we suggest that the edoma deposits accumulated in the sedimentary environment of delta and that the sediments are composed of loess and river bed material.

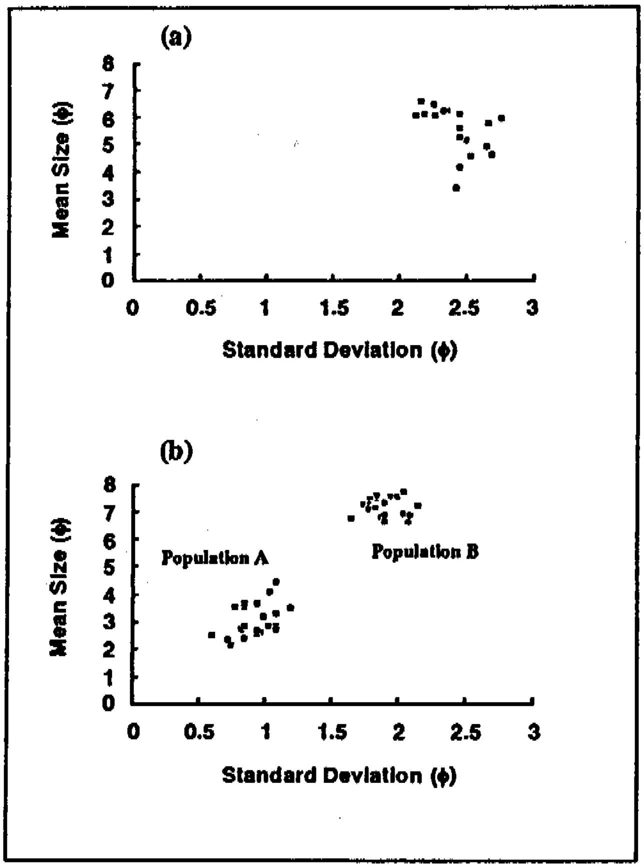

Fig.5 Relationship of standard deviation and mean size
Upper : Original population
Lower : Population A and B

Fig.7 shows schematic geological developments of the edoma on Cape Bykovskiy.

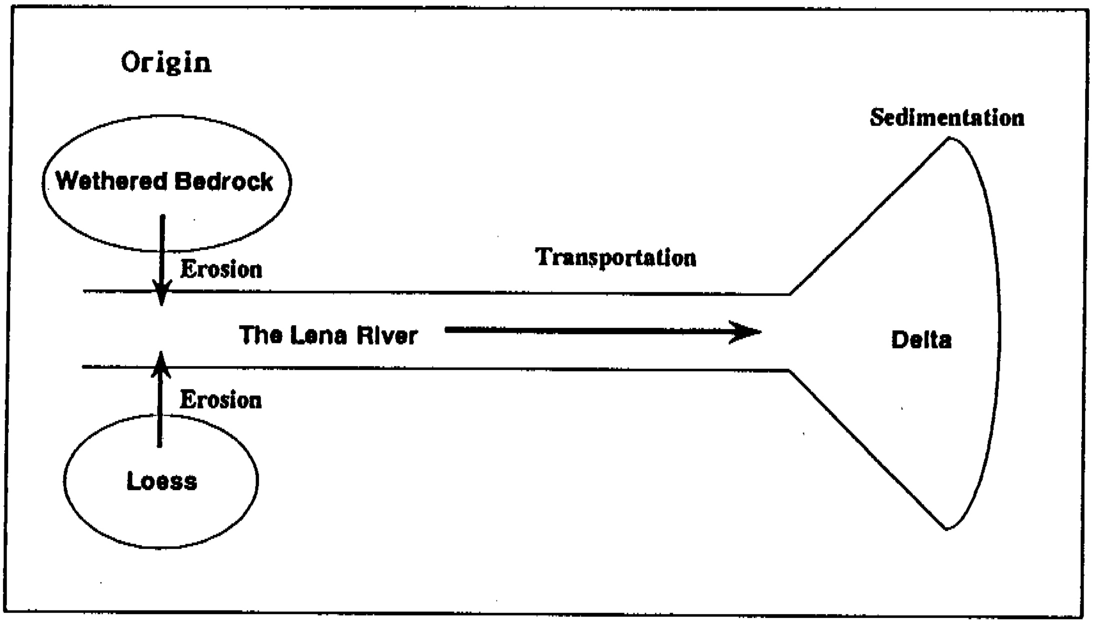

Fig.6 The sedimentary system of the edoma deposits

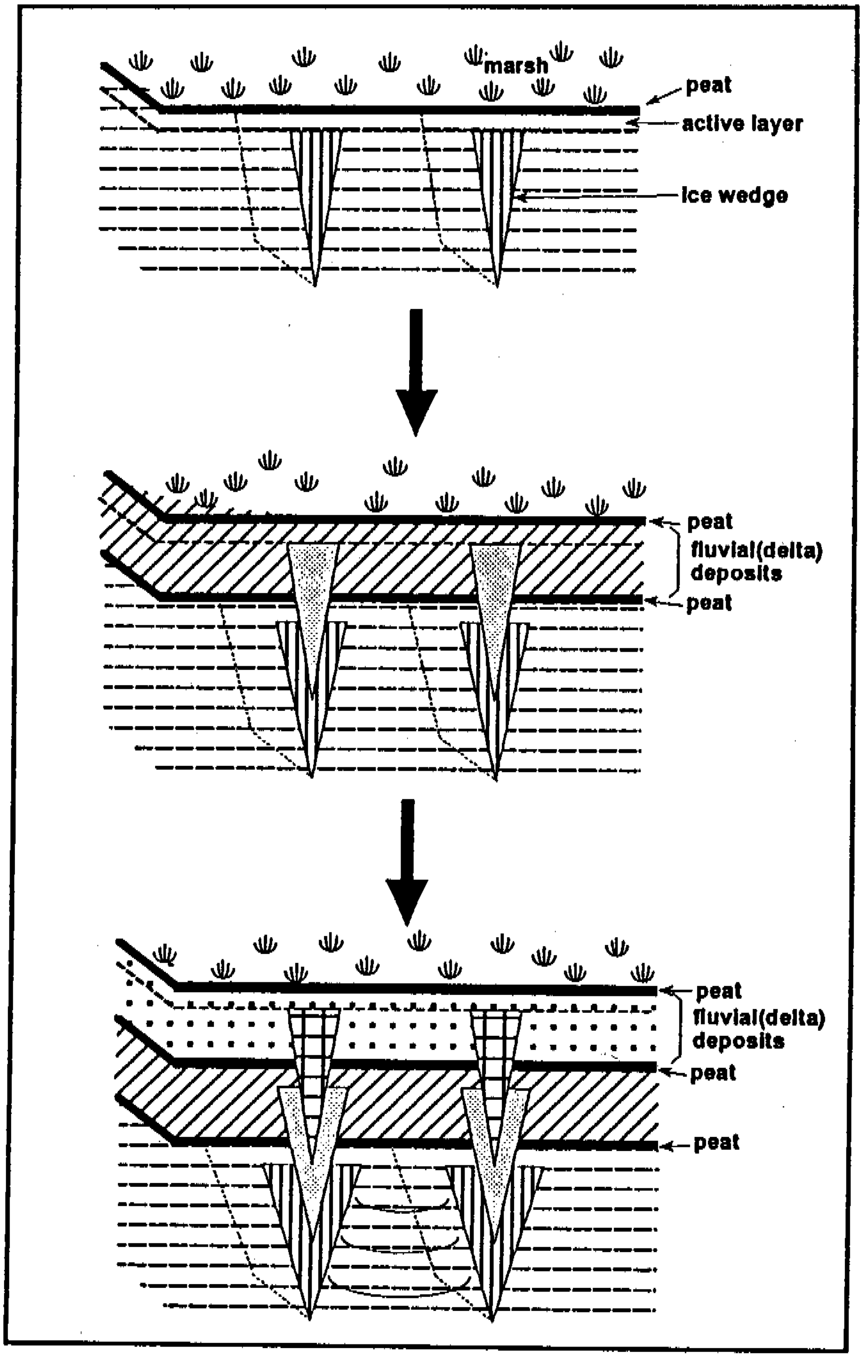

Fig.7 Schematic geological developments of the edomas on Cape Bykovskiy

References

Inoguchi M. and Mezaki S. (1974) : Analysis of the grain size distribution of bedmaterial in alluvial rivers, *Geographical Review of Japan*, 47, 9, 545~556.

Matsumoto H. (1983) : Grain size distribution of aeolian and marine sands particular to each coastal area, *Annals of the Tohoku geographical association*, 35, 1, 1~10.

Miall A. D. (1979) : Facies models 5. Deltas, *Geoscience Canada (1979) "FACIES MODELS"*, 43~56.

Velichko A. A. Ed. (1984) : Late Quaternary Environments of the Soviet Union. *University of Minnesota Press, Minneapolis* 327p.

25 Measurement of Methane Flux in Tiksi, Siberia

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INTRODUCTION

It is important to know the change of methane budget in the atmosphere, because methane gas is a prominent greenhouse gas. Therefore, the gas released from wetland in Tiksi, Siberia was sampled in summer, 1992 and the measurement of the methane flux from ground surface in tundra region was carried out. In high latitude region, when the temperature above the upper permafrost is above zero during summer, seasonal wetlands are formed on permafrost. Peat in active layer begins to decay under anaerobic conditions and the methane gas is produced there and released to the atmosphere. The wetland in tundra region is one of major source of methane gas. However, few studies have ever been tried to measure the methane flux in tundra region and its contribution is still uncertain.

Most climatic models predict that air temperature near ground surface will increase mainly in high latitude of the northern hemisphere. An increase of air temperature results in increases of ground surface temperature and ground thermal regime, disregarding changes of snow, humidity, vegetation, and so on. In tundra region like Siberia and Alaska, rised ground temperature causes an increase of active layer thickness. Therefore, there is the possibility that methane emission from the active layer in tundra region will rapidly increase under future climatic warming.

The objectives of this research are the following ; One is to ascertain whether if the methane gas is released from the wetland in tundra region. Another is to obtain basic data related to the change of methane emission under a climatic warming.

METHOD OF METHANE FLUX MEASUREMENT

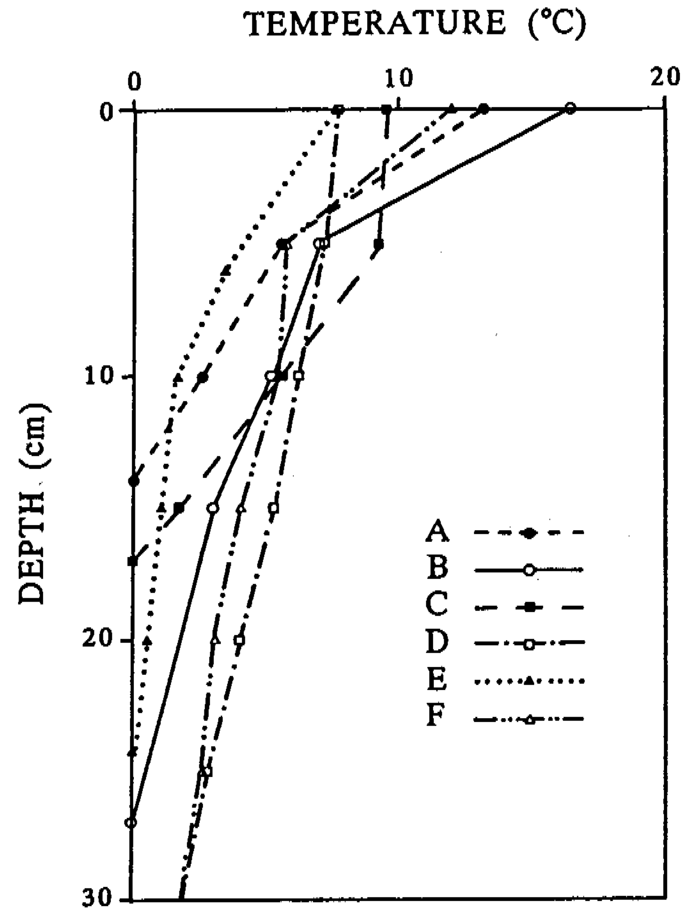
The chamber technique, which is a common method for the flux of atmospheric trace gas to or from soil and water, was adopted to this research. An aluminum chamber that has an open bottom was placed on the measuring site and gas in the chamber was sampled four times every ten minutes using air pump. The methane flux was obtained from change of methane concentrations in gas samples. The samplings of gas were carried out on four sites in Bykovskiey Peninsula and two sites in Kalahari Island in the vicinity of Tiksi (72°N) from July 19 to July 29, 1992. Air temperatures, Ground temperature profiles and underground water level were measured during the sampling time.

RESULTS

Results of the measurements are summarized in Table 1 and Figure 1 shows the ground temperature profiles of six sampling sites. Site A was located on the terrace of ice complex and Site B, C and D were located in alas in Bykovskey Peninsula. Site E and F were in Kalahari Island. Site B, D and F were situated in the center part of ice wedge polygon and these sites were covered with sedge and had high underground water levels. The thicknesses of the active layers in these sites were about 30 to 40 cm. Site C and E were in the border of ice wedge polygon and covered with moss. The active layer thickness was nearly 20 cm. The methane emission was obtained at the site B, C, D and F. The values of those flux are about 1 [mg/m²/h]. Because the number of sampling is a few, it can't suggest from these results the relation between the methane flux and various factors, for example, the active layer thickness, the ground temperature and the underground water level.

Table 1 Results of measurements of methane flux (mg/m²/h)

Site	A	B	C	D	E	F
Date	92.7.19	92.7.20	92.7.20	92.7.23	92.7.29	92.7.29
Time	PM 4:15	PM 0:03	PM 2:23	AM 11:27	AM 11:07	PM 0:10
Methane flux	-	1.28	1.08	1.00	-	0.51
Air temp. (°C)	12.8	19.8	10.6	10.6	7	10.5
Surface temp. (°C)	13.2	16.5	9.6	7.7	7.5	12.1
Water table (cm)	-	5	-	2	-	5



At the same season, the methane flux in Yakutsk (62°N) was measured by Ohta et al. and the values of 113, 47.9, 23.2 [mg/m²/h] were obtained. The values observed in Tiksi are very low in comparison with these values. This discrepancy may depend on the differences of active layer thickness or ground temperature.

CONCLUSION

1. The methane fluxes with the value over 1 [mg/m²/h] were observed at three sites in Tiksi. The methane emission from tundra region in Siberia was therefore ascertained.

2. The values of methane fluxes obtained in Tiksi are much lower than those in Yakutsk at the same season.

3. To clarify the change of methane emission with a climatic change, it is necessary to understand the relation between the methane flux and the active layer thickness or other factors from a long term observation.

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