International Symposium on Environmental Research in the Arctic

19 - 21 July 1995, Tokyo, Japan

PROGRAM AND ABSTRACTS

Symposium Organizing Committee
National Institute of Polar Research
Tokyo, JAPAN

Changes in the Program

・Session II : Arctic terrestrial and marine ecosystems and environments

(Chair: **S. Kojima** and M. Fukuchi)

・P I -7. *Rotifer composition in freshwater habitats on Spitsbergen (Arctic) and King George Island (Antarctica)*

K. Janiec and K. Salwicka (Department of Antarctic Biology, Polish Academy of Sciences)

・III-3. *NILU's atmospheric research in the Arctic - Results and future plans -*

G. O. Braathen (Norwegian Institute for Air research (NILU))

Canceled

・Session IV : Oceanographic observations in the Arctic

(Chair: **K. I. Ohshima**)

・IV-5. *Recent changes in Arctic Ocean termohaline structure : results fom the U.S./Canada 1994 ArcticOcean section*

E. C. Carmack (Institute of Ocean Sciences, Canada), K. Aagaard (Polar Sci. Center, Univ. Washington), R. W. Macdonald, F. A. McLaughlin, R. G. Perkin (Inst. Ocean Sci.), **E. P. Jones** (Bedford Inst. Oceanography) and J. H. Swift (Scripps Inst. Oceanography, Univ. California)

ENVIRONMENTAL RESEARCH IN ARCTIC CANADA

Fred Roots

As the twentieth century draws to a close, the arctic regions are taking on a new importance in the world spectrum of scientific activities, and the nature and purpose of arctic research is changing in many ways. Increased scientific knowledge about the arctic regions and resources is of value not only to the Arctic but is increasingly vital to understanding of the global environment and its changes; and the social, economic and political problems of the arctic regions are increasingly affected by environmental changes in other parts of the world. People resident in the Arctic are increasingly insistent that they have a say in all research about, or studies which can affect, the region where they live; and there is increasing recognition that the distinctive environmental value systems developed by arctic societies hold lessons of economic and social benefit to all humankind. These developments lead to changes in the subject matter and priorities of arctic research activities, leading to new programmes involving combinations of scientific disciplines and the bringing together of biophysical, human sciences and economic or applied research. There are new and different political and intellectual motives for serious research in the Arctic, and the funding for such research is coming from a variety of sources.

Research in Arctic Canada is a dramatic example of these changes. Fundamental research in a wide range of classical disciplines is vitally needed in the Canadian arctic, in subjects ranging from the chemistry of the polar stratosphere to variations in the DNA of different races of circum-arctic fishes. But increasingly the reasons for and support of such studies is based, not on the value of new knowledge for its own sake but on a conviction that such knowledge is important to the social or economic development of the region, to protection and management of the world environment and resources, or to the exercise of equity and political rights among various societies. Social issues, and particularly the need for research to understand the northern environment and resources as they may affect the needs and rights of northern peoples, play an increasingly dominant role in research policy and the support of research in arctic Canada. Thus, Canada takes part in several of the Global Change Core Programmes of the International Geosphere-Biosphere Programme (IGBP), but in each has added a study of the human dimension. Other international arctic research programmes, such as the International Tundra Experiment (ITEX) of the UNESCO Man and the Biosphere Programme or the multi-disciplinary Boreal Ecosystem and Atmosphere (BOREAS) study are directly related, in Canada, to the effect that the research results may have on understanding the possible future conditions and life styles of persons and human communities in the North.

In its domestic research programmes in the Arctic, Canada has made progress in bringing together physical, biological, social, anthropological, and applied research to address common problems related to environmental and human-imposed changes in northern regions. An example is the Mackenzie Basin Impact Study, which is investigating the potential impacts of postulated climate warming on the landscape, hydrology, vegetation, wildlife, agriculture, forestry, transportation, community development, and traditional or newly-acquired societal values systems and social practices in a diverse but integrated sub-arctic region. The integration and inter-relationships of these many aspects of research on a common problem is a research challenge in itself.

The facilities and support structures for arctic research in Canada are themselves undergoing important change. Canada has 26 universities, eight federal government departments or agencies, two territorial and five provincial governments involved in scientific studies in Arctic Canada. Support for these activities comes from a variety of sources;- there is no dominant Canadian funding source for arctic research. Important co-ordination in a practical sense comes two arctic-wide science logistic support systems - the Polar Continental Shelf Project, which provides field support but not funding to studies in any discipline in arctic areas including the Arctic Ocean, that are distant from human settlements; and the High Arctic Weather Stations, which can provide modest but vital support to field studies from fixed bases. With the increasingly difficult financial restrictions faced by all government scientific bodies, these sources of support and the few research laboratories in the Canadian Arctic are facing serious difficulties.

Environmental research in arctic Canada is facing a dilemma not unusual to science in the 1990's but one that may have serious effects not only for arctic Canada but for the world. At a time when arctic environmental research is proving to be of great importance not only for the future well-being of the arctic regions but for the world, the ability to continue with the high-quality inter-disciplinary research so badly needed is seriously threatened. Is such a situation, international co-operation is more vital than ever.

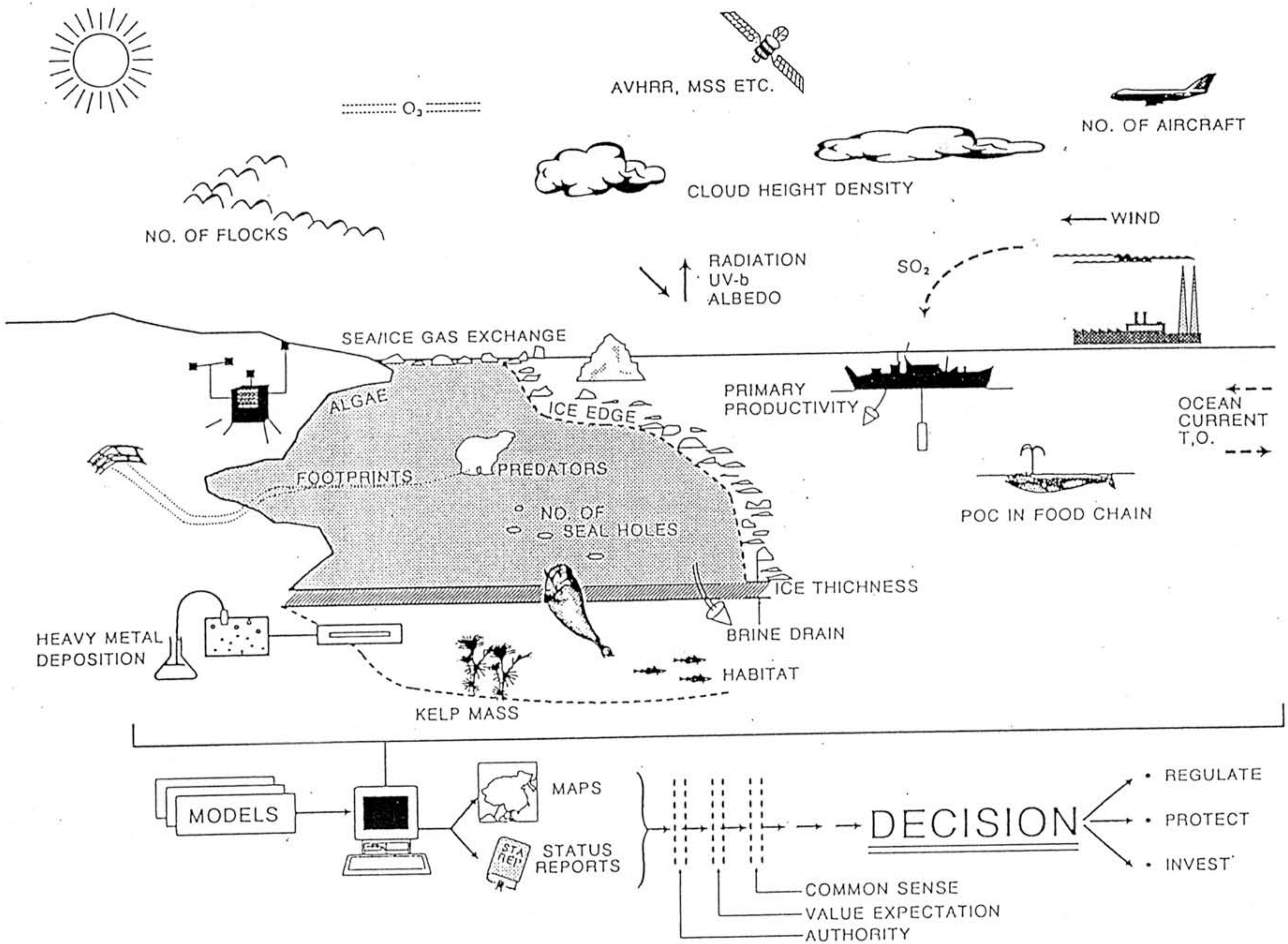

Figure 24 Decisions based on Arctic Science and Data.

ROOTS (I-3)

(From: UNEP. "Global observing Systems"; (in press, 1986).

Climate change and carbon flux in the Barents Sea: 3-D simulations of ice-distribution, primary production and sedimentation

Paul Wassmann & Dag Slagstad

Norwegian College of Fishery Science, University of Tromsø, N-9037 Tromsø, Norway

A 3-dimensional model is described that simulates current fields, ice-distribution, hydrography, primary production and sedimentation in the Barents Sea. The model uses input data from meteorological stations and data from Det Norske Meterologiske Institutt (MI) hindcast database. From initial fields of temperature and salinity, change in the hydrography as a result of transport, fresh-water supply from land, cooling/heating and melting/freezing of ice is simulated. A warm year (1984) and a cold year (1981) were selected on order to investigate how the climate may effect primary production and sedimentation. The annual production of phytoplankton is in particular dependent on the ice distribution during spring. When the ice melts, strong vertical stability is created which reduces the vertical transport of nutrients compared to conditions where thermal heating alone creates stability. A maximal extent of ice-distribution gives thus rise to a maximum area of strong stratification after the ice-melt. Comparing the cold and warm year simulated here, primary production was between 25 to 250 % higher in the ice-free area during warm year. The total annual primary production for the whole Barents Sea increased about 30% during the warm year. Even greater variations were discovered for the vertical flux of carbon. These variations have significant implications for the carrying capacity of the Barents Sea which supports one of the largest fisheries of the world. They also point to the fact that the uptake of atmospheric carbon dioxide on the shelf areas in the Arctic varies and increase during global warming. Future simulations where extreme climatic scenarios are selected will be used in order to investigate and analyse the implied ecological consequences of climate change and the impact of global warming.

The Canadian Arctic and Global Change: a case for neotropication or neoglaciation ?

Josef Svoboda

Department of Botany, University of Toronto
Erindale College, Mississauga, Ontario, L5L-1C6, Canada

It is understood that the present global warming is being conditioned by two factors overimposed upon each other: the natural minor climate shift from the previous cold period called Little Ice Age which ended in the midst of the last century, and the new anthropogenic agents represented mainly by "Greenhouse" gases released during this century . It is also postulated that the recent anthropogenic factor plays a greater role among the two, in the escalation of global temperature during the latest decades. Since the amount of solar radiation reaching the Earth has not change to any significant degree, the present greenhouse warming can be considered a tropospheric event and, consequently, the entire global change a "domestic affair"

From the long-term perspective global change is recent, sudden and most probably also a short-term (centuries) phenomenon. The earth's atmosphere was the fastest to react, while the hydrosphere (oceans and large fresh-water bodies) and the upper crust of the lithosphere have had little time to respond and to reach new energetic balance. The global circulation models all suggest that the effect of climate warming will differ regionaly. Some area should become warmer and drier, some cooler and wetter. During the ongoing period of transition the old climatic momentum "stored" in the earth shell will globally and regionally interact with the climatic trends until new equibilium is reached.

This paper is concerned with the effects of global warming as they could be manifested in regions with a deep and cold permafrost of the east-central Canadian Arctic in a close neighborhood of Greenland - the little Antarctica of the northern hemisphere. Could these arctic regions which have become manifestly cooler during the last several decades be subject (or trigger) of a neoglaciation, if winter precipitation also increases as predicted?

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Part I. Lecture
Overview of the Arctic Environmental Research
19 July, Kudan Kaikan

Part II. Scientific Discussion
20 - 21 July, National Institute of Polar Research

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Outline Program

19 July (Wed.)	20 July (Thu.)	21 July (Fri.)
(10:00~12:00) Registration (National Institute of Polar Research)	**Session II:** (09:30~12:30) Arctic terrestrial and marine ecosystems and environments	**Session III**: (09:30~11:30) Global atmospheric environment in the Arctic - Coffee break - **Session IV**: (11:45~12:45) Oceanographic observations in the Arctic
	- Lunch -	- Lunch -
(14:00~17:30) Openning **Session I**: Overview of the Arctic Environmental Research (Kudan Kaikan)	**Poster session I**: (14:00~15:30) (Biology, Oceanography, Atmosphere) - Coffee break - **Poster session II** : (16:00~17:30) (Atmosphere, Glaciology)	**Session IV**: (14:00~15:00) (Cont'd) - Coffee break - **Session V**: (15:15~17:15) Environment change from circumpolar ice core of the ice sheet and glaciers Closing
Reception (18:00~20:00)		

International Symposium on Environmental Research in the Arctic

19 - 21 July 1995, Tokyo, Japan

PROGRAM

Part I at Kudan Kaikan

19 July (Wednesday)

(14:00 - 17:30)
Opening

Session I : Overview of the Arctic Environmental Research

(Chair: N. Ono and O. Watanabe)

I -1. *A review of the development of international science cooperation in the Arctic with a focus on IASC activities and its science priority projects*
O. Rogne (Executive Secretary of IASC)

I -2. *The role of the Arctic in global climate change*
G. Weller (Geophysical Institute, University of Alaska, U. S. A.)

I -3. *Global environmental research in the Arctic Canada (tentative)*
E. F. Roots (Department of Environment, Canada)

I -4. *A natural complex of the seas of the Siberian shelf (the Laptev Sea)*
S. Pryamikov and L. Timokhov (Arctic and Antarctic Research Institute, Russia)

I -5. *Drilling in ice sheets*
C. C. Langway, Jr. (Department of Geology, State University of New York at Buffalo, U.S.A.)

I -6. *Delightful participation of a Japanese scientist in the Arctic science community*
T. Hoshiai (Professor Emeritus, National Institute of Polar Research, Japan)
星合孝男（国立極地研究所名誉教授）

I -7. *Global Environment Research in the Arctic*
N. Ono (National Institute of Polar Research, Japan)
小野延雄（国立極地研究所）

(18:00 - 20:00)
Reception

Part II Scientific Discussion at National Institute of Polar Research

20 July (Thursday)

(09:30 - 12:30)

Session II : Arctic terrestrial and marine ecosystems and environments

(Chair: T. Masuzawa and M. Fukuchi)

II-1. *Canadian Arctic and Global change : a case for neotropication or neoglaciation?*
J. Svoboda (University of Toronto)

II-2. *Current effort of Japan to develop ecological research in northern regions*
S. Kojima (Toyama University)
小島　覚（富山大学）

II-3. *Vegetation at deglaciated terrain in Spitsbergen Island*
H. Kanda (National Institute of Polar Research), Y. Minami (Hiraoka Envir. Sci. Lab.) and T. Kibe (Grad. Univ. Advanced Studies)
神田啓史（国立極地研究所）ほか

II-4. *Distribution pattern, flowering phenology, pollinator visitation and fruit-set of alpine plants along a snowmelt gradient in the Taisetsu Mountains*
G. Kudo (Graduate School of Environmental Earth Science, Hokkaido University)
工藤　岳（北海道大学）

II-5. *Study on the water and energy cycle and land surface processes in Siberia (GAME/Siberia)*
T. Ohata (School of Environmental Science, The University of Siga Prefecture) and Y. Fukushima (Inst. Hydrospheric-Atmospheric Sci., Nagoya Univ.)
大畑哲夫（滋賀県立大学）ほか

II-6. *Our Marine Ecological Researches in the high Arctic fjord, Kongsfjord*
S. Kudoh (National Institute of Polar Research)
工藤　栄（国立極地研究所）

II-7. *3D model study of ice distribution, primary production and sedimentation as a function of climatic events*
P. Wassmann (University of Tromsø)

II-8. *Food web structure and biogenic carbon export on the continental shelves of the Arctic Ocean*
L. Legendre (Laval University), R. B. Rivkin (Ocean Sciences Centre, Memorial Univ. Newfoundland) and C. Michel (Laval Univ.)

(14:00 - 15:30)

Poster session I : (Biology, Oceanography, Atmosphere)

PI-1. *Some vegetation indication of climate warming as detected on forest-tundra border in the continental Canadian Arctic*
T. Sweda (Department of Biological Resources of Environment, Nagoya University)
末田達彦 (名古屋大学)

PI-2. *Snow and ice algae of Spitsbergen glaciers : possible climate signal in ice core analysis*
S. Kohshima (Faculty of Science, Tokyo Institute of Technology), K. Goto-Azuma (Nagaoka Inst. Snow and Ice Studies, NIED), S. Takahashi, T. Kameda (Kitami Inst. Technology) and O.Watanabe (NIPR)
幸島司郎（東京工業大学）ほか

P I -3. *Distribution pattern of mosses on deglaciated terrain in Ny-Ålesund*

Y. Minami (Hiraoka Environmental Science Laboratory), H. Kanda (NIPR) and T. Masuzawa (Shizuoka Univ.)

南　佳典（平岡環境科学研究所）ほか

P I -4. *Growth and reproduction of two Carex species in Spitsbergen Island*

T. Kibe (The Graduate University for Advanced Studies), T. Masuzawa (Shizuoka Univ.) and H. Kanda (NIPR)

木部　剛（総合研究大学院大学）ほか

P I -5. *Temporal changes of microalgal and bacterial assemblages in and under the sea-ice of Saroma Ko lagoon*

M. Yasuda (The Graduate University for Advanced Studies), S. Kudoh and M. Fukuchi (NIPR)

安田道恵（総合研究大学院大学）ほか

P I -6. *Ecological studies of marine bacterioplankton in the high arctic Kongs Fjord, Ny-Ålesund (Norway) - Quantitative relationships between algae and protozoa during sea ice melting in early summer 1994 -*

M. Yasuda (The Graduate University for Advanced Studies), S. Kudoh and M. Fukuchi (NIPR)

安田道恵（総合研究大学院大学）ほか

P I -7. *Rotifer composition in freshwater habitats on Spitsbergen (Arctic) and King George Island (Antarctica)*

J. Katarzyna and S. Katarzyna (Department of Antarctic Biology, Polish Academy of Sciences)

P I -8. *Soil respiration in three soil-type agro-ecosystems in Finland*

H. Koizumi (National Institute of Agro-Environmental Sciences), M. Kontturi and T. Mela (Agricultural Res.Centre of Finland)

小泉　博（農林水産省農業環境技術研究所）ほか

P I -9. *Biological aspects of Cryoconite and Cryoconite hole of a Spitsbergen glacier, Brøggerbreem. Svalbard*

N. Takeuchi, S. Kohshima (Faculty of Science, Tokyo Institute of Technology) and S. Takahashi (Kitami Inst.Technology)

竹内　望（東京工業大学）ほか

P I -10. *Diversity, seasonally and spatial distribution of freshwater algae in a glacial stream at Ellesmere Island, Canada*

J. Elster and J. Svoboda (University of Toronto)

P I -11. *Photosynthetic and respiratory characteristics of an Arctic ice algal community living in low light and low temperature conditions*

Y. Suzuki (Research Institute of Innovative Technology for the Earth), S.Kudoh (NIPR) and M. Takahashi (Univ. Tokyo)

鈴木祥弘（地球環境産業技術研究機構）ほか

P I -12. *Primary production of phytoplankton in high arctic Kongs fjold, Svalbard, Norway*

Y. Yamaguchi (Tokyo University of Fisheries), O. Matsuda (Hiroshima Univ.) and S. Kudoh (NIPR)

山口征矢（東京水産大学）ほか

P I -13. *Diel variability in vertical flux of chlorophyll a and biogenic silica in Saromako lagoon, Hokkaido, Japan*

S. Taguchi (Soka University), H.Saito (Hokkaido Natl Fisheries Res. Inst.), H. Hattori (Hokkaido Tokai Univ.) and K.Shirasawa (Hokkaido Univ.)
田口　哲（創価大学）ほか

P I -14. *Ecophysiological and genetic studies of Dryas octopetala in polar region and Japan*

T. Masuzawa, Y. Yoda, A. Inamura, K. Yoshinaga (Faculty of Science, Shizuoka University) and H. Kanda (NIPR)
増沢武弘（静岡大学）ほか

P I -15. *Water structure of the Kongsfjorden, Spitsbergen in 1991-1993*

S. Ushio, H. Ito and N. Ono (National Institute of Polar Research)
牛尾収輝（国立極地研究所）ほか

P I -16. *Improvement of SSM/1 sea ice concentration algorithm for the sea of Okhotsk*

K. Cho, N.Sasaki, H. Shimoda, T. Sakata (Tokai University, Research and Information Center)
長　幸平（東海大学情報技術センター）ほか

P I -17. *Sea ice extent in the Okhotsk sea related to global warming*

F. Nishio (Hokkaido University of Education)
西尾文彦（北海道教育大学）

P I -18. *Relation between the variation in the Arctic sea-ice distribution and the atmospheric circulation*

K. Rikiishi and Y. Takamori (Department of Earth Sciences，Hirosaki University)
力石國男（弘前大学理学部）ほか

P I -19. *Numerical simulation of labrador polar low formed off the east coast of Canada*

K. Tsuboki (Ocean Research Institute, University of Tokyo)
坪木和久（東京大学海洋研究所）

P I -20. *Characteristics of fluctuations of wind speed and air temperature in Canadian Arctic in winter season*

H. Toritani (National Institute of Agro-Environmental Sciences), K.Tsuboki (Ocean Res. Inst., Univ. Tokyo), Y. Asuma, Y.Matsukawa(Hokkaido Univ.), T. Endoh (Inst. Low Temperature Sci., Hokkaido Univ.), R. Kimura (Ocean Res. Inst., Univ. Tokyo) and A. Yamashita (Osaka Kyoiku Univ.)
鳥谷　均（農業環境技術研究所）ほか

P I -21. *Cold air formation mechanism in Arctic Canada*

T. Endoh (Institute of Low Temperature Science, Hokkaido University), Y.Asuma (Grad. School of Sci., Hokkaido Univ.), Y. Kodama (Inst. Low Temperature Sci., Hokkaido Univ.), K. Tsuboki and R. Kimura (Ocean Res. Inst., Univ. Tokyo)
遠藤辰雄（北海道大学低温科学研究所）ほか

P I -22. *A study of polar vortex and recent abnormal weather in the Arctic*

R. Kanohgi, H.L. Tanaka and T. Yasunari (University of Tsukuba)
叶木律子（筑波大学地球科学系）ほか

P I -23. *BASE (Beaufort and Arctic Storms Experiment) project in the Canadian Arctic*

Y. Asuma, K. Kikuchi, H.Uyeda, S. Iwata, T. Shimamura (Graduate school of Science, Hokkaido University), R. Kimura, K. Tsuboki (Ocean Res. Inst., Univ. Tokyo), E. Stewart, D. R. Hudak, E. T. Hudson (A.E.S., Canada) and G.W.K. Moore (Univ. Toronto, Canada)

遊馬芳雄（北海道大学理学研究科）ほか

P I -24. *The relationship of chemical components among atmospheric aerosols, gases and snowfall in Spitsbergen*

M. Igarashi (The Graduate University for Advanced Sudies), M. Wada (NIPR), K. Osada (STEL, Nagoya Univ.), K. Kamiyama and O. Watanabe (NIPR)

五十嵐　誠（総合研究大学院大学）ほか

(16:00 - 17:30)

Poster session II : (Atmosphere, Glaciology)

PII-1. *Formations of the cold air mass in the Canadian Arctic area*

Y. Asuma, K. Kikuchi, Y. Matsukawa (Graduate School of Science, Hokkaido University), T. Endoh (Inst. Low Temperature Sci., Hokkaido Univ.), R. Kimura and K. Tsuboki (Ocean Res. Inst., Univ. Tokyo)

遊馬芳雄（北海道大学理学研究科）ほか

PII-2. *Ice crystals and snow crystals observed in Arctic Canada*

A. Yamashita and T. Arakawa (Osaka Kyoiku University)

山下　晃（大阪教育大学）ほか

PII-3. *Observations of winter clouds and precipitation in Ny-Ålesund, Svalbard*

M. Wada (National Institute of Polar Research), S. Aoki (Tohoku Univ.), M. Igarashi (Grad. Univ. Advanced Studeis) and T. Yamanouchi (NIPR)

和田　誠（国立極地研究所）ほか

PII-4. *Large variability of radiation budget in the Greenland Sea sector, Arctic*

T. Yamanouchi (National Institute of Polar Research) and J. B. Ørbæk (NP)

山内　恭（国立極地研究所）ほか

PII-5. *Polar stratospheric clouds observed by a Lidar at Ny-Ålesund in the winters 1994 and 1995*

T. Shibata , Y. Iwasaka (Solar-Terrestrial Environment Laboratory, Nagoya University), M. Fujiwara, K. Shiroishi (Fukuoka Univ.) H.Adachi, T. Sakai (STEL, Nagoya Univ.), K. Susumu and Y. Nakura (Fukuoka Univ.)

柴田　隆（名古屋大学太陽地球環境研究所）ほか

PII-6. *Variation of Arctic stratosphere aerosol observed by balloon-borne particle counter at Ny-Ålesund in 1994/1995*

M. Hayashi, M. Watanabe, Y. Iwasaka, T. Shibata (Solar-Terrestrial Environment Laboratory, Nagoya University) and M. Fujiwara (Fukuoka Univ.)

林　政彦（名古屋大学太陽地球環境研究所）ほか

PII-7. *Arctic aerosol chemistry at Ny-Ålesund, Spitsbergen in 1994/95 winter*

K. Matsunaga, K. Osada, M. Hayashi, Y. Iwasaka(Solar-Terrestrial Environment Laboratory, Nagoya University), M. Igarashi (Grad. Univ. Advanced Studies) and K. Kamiyama (NIPR)

松永捷司（名古屋大学太陽地球環境研究所）ほか

PII-8. *Observation of ozone profiles in the upper stratosphere at Ny Ålesund using a UV sensor on board a light weight high altitude balloon*

S. Okano (National Institute of Polar Research), M. Okabayashi (Fac. Sci., Tohoku Univ.) and H. Gernandt (AWI)
岡野章一（国立極地研究所）ほか

PII-9. *Atmospheric concentration of ^{210}Pb and ^{210}Po in Ny-Ålesund, Svalbard*

T. Suzuki, N. Nakayama (Faculty of Science, Yamagata University), M. Igarashi (Grad. Univ. Advanced Studies), K. Kamiyama and O. Watanabe (NIPR)
鈴木利孝（山形大学理学部）ほか

PII-10. *Aerosol and snow chemistry near Fairbanks, Alaska in 1995 spring*

K. Osada, K. Matsunaga, M.Hayashi, H.Adachi, T. Shibata, Y. Iwasaka(Solar-Terrestrial Environment Laboratory, Nagoya University) and G.E.Shaw (Geophysical Inst., Univ. Alaska)
長田和雄（名古屋大学太陽地球環境研究所）ほか

PII-11. *Environmental fluctuation traced from in situ measurement of snow and ice samples in Northern part of Svalbard*

K. Kamiyama, H. Motoyama (National Institute of Polar Research), H. Narita (Inst. Low Temperature Sci., Hokkaido Univ.), S. Matoba (Grad. Univ. Advanced Studies) and O. Watanabe (NIPR)
神山孝吉（国立極地研究所）ほか

PII-12. *Characteristics of snowmelt heat balance at Ny-Ålesund, Spitsbergen Island*

H. Nakabayashi (Japan Weather Association), Y. Kodama, Y. Takeuchi, T. Ozeki and N. Ishikawa (Institute of Low Temperature Science, Hokkaido University)
中林宏典（日本気象協会）ほか

PII-13. *Runoff characteristics of Bayelva basin in Spitsbergen*

Y. Kodama, H. Nakabayashi, Y. Takeuchi (Institute of Low Temperature Science, Hokkaido University), H. Ito and O. Watanabe (NIPR)
兒玉裕二（北海道大学低温科学研究所）ほか

PII-14. *Glaciological and meteorological observations in Spitsbergen - Observations of Brøggerbreen in summer, 1991 -*

H. Enomoto, S. Takahashi (Kitami Institute of Technology), S. Kobayashi (Res. Inst. Hazards in Snowy Areas, Niigata Univ.), K. Goto-Azuma (Nagaoka Inst. Snow and Ice Studies, NIED) and O. Watanabe (NIPR)
榎本浩之（北見工業大学）ほか

PII-15. *Heat balance in a Cryoconite hole on Brøggerbreen, Svalbard*

S. Takahashi (Kitami Institute of Technology) and S. Kohshima (Tokyo Inst. Technology)
高橋修平（北見工業大学）ほか

PII-16. *Climate changes and acidification environments*

H. Fushimi (University of Shiga Prefecture)
伏見碩二（滋賀県立大学）

PII-17. *Chemical components in the ice core from Åsgårdfonna, Spitsbergen*

M. Igarashi (The Graduate University for Advanced Studies), K. Kamiyama, H. Motoyama, Y. Fujii(NIPR), K. Izumi(Niigata Univ.) and O. Watanabe (NIPR)
五十嵐　誠（総合研究大学院大学）ほか

PII-18. *Vertical distribution of dicarboxylic acids in the Greenland ice core*

K. Kawamura, K. Yokoyama (Department of Chemistry, Faculty of Science, Tokyo Metropolitan University), Y. Fujii and O. Watanebe (NIPR)
河村公隆（東京都立大学理学部化学）ほか

PII-19. *High resolution internal ice layer observation using L-band ice-radar at Agassiz ice cap*

S. Uratsuka, H.Maeno, T. Suitz (Communications Research Laboratory), D. A. Fisher (Geological Survey of Canada), K. Goto-Azuma (Nagaoka Inst. Snow and Ice Studies, NIED) and S. Mae (Hokkaido Univ.)
浦塚清峰（通信総合研究所）ほか

PII-20. *Characteristics of chemical component of superimposed ice in Svalbard*

H. Motoyama, K. Kamiyama (National Institute of Polar Research), M. Igarashi (Grad. Univ. Advanced Studies), F. Nishio (Hokkaido Univ. Education), S. Takahashi (Kitami Inst. Technology) and O. Watanabe (NIPR)
本山秀明（国立極地研究所）ほか

PII-21. *Temporal and spatial variations of ion concentrations and $\delta^{18}O$ in the Aggassiz ice cap, Canadian high Arctic*

K. Goto-Azuma (Nagaoka Institute of Snow and Ice Studies, National research Institute for Earth Science and Disaster Prevention), R.M.Koerner, J.Sekerka (Terrain Sce. Devision, Geol. Survey of Canada), M.Nakawo, K.Nakamura (Inst. Hydrospheric- Atmospheric Sci., Nagoya Univ.), K. Osada (STEL, Nagoya Univ.) and A. Kudo(Natl Res. Council, Canada)
東　久美子（防災科学技術研究所長岡雪氷防災実験研究所）ほか

PII-22. *Ice core analyses and borehole temperature measurements at the drilling site on Åsgårdfonna, Spitsbergen, in 1993*

T. Uchida (Hokkaido National Industrial Research Institute), K. Kamiyama, Y. Fujii (NIPR), A. Takahashi (Geo. Tec.Co. Ltd.), T. Suzuki (Fac. Sci. Yamagata Univ.), Y. Yoshimura (Fac. Sci. Tokyo Inst. Technology) and O. Watanabe (NIPR)
内田　努（北海道工業技術研究所）ほか

PII-23. Seesaw in *$\delta^{18}O$ annomalies between ice cores from Svalbard and Greenland after 1750 AD*

Y. Fujii, K. Kamiyama (National Institute of Polar Research), T. Kameda (Kitami Inst. Technology) and O. Watanabe (NIPR)
藤井理行（国立極地研究所）ほか

PII-24. *Response of Greenland ice sheet to the global warming*

A. Abe-Ouchi (Center for Climate System Research, University of Tokyo)
阿部彩子（東京大学気候システム研究センター）

21 July (Friday)

(9:30 - 11:30)

Session III : Global atmospheric environment in the Arctic

(Chair: H. Gernandt and Y. Iwasaka)

III-1. *Atmospheric science observations at Ny-Ålesund, Svalbard*

T. Yamanouchi (National Institute of Polar Research), S. Aoki (Tohoku Univ.) and M. Wada (NIPR)

山内　恭（国立極地研究所）ほか

III-2. *The impact of Arctic circulation on trace gas measurements*

K. Higuchi (Atmospheric Environment Service, Canada)

III-3. *NILU's atmospheric research in the Arctic - Results and future plans -*

G. O. Braathen (Norwegian Institute for Air research (NILU))

III-4. *Lidar measurements at Alaska and Ny-Ålesund : Effect of polar vortex meandering on stratospheric aerosol processes*

Y. Iwasaka, T. Shibata, H. Adachi, T. Sakai, M. Hayashi, T. Ojio (Solar Terrestrial Environment Laboratory, Nagoya University), M. Fujiwara, K. Shiraishi (Fukuoka Univ.), K. Miyagawa-Kondoh (Aerological Observatory, JMA) and H. Nakane (NIES)

岩坂泰信（名古屋大学太陽地球環境研究所）ほか

III-5. *Variability and long-term changes of ozone and aerosols in the polar atmosphere*

H. Gernandt (Alfred Wegener Institute for Polar and Marine Research)

III-6. *EISCAT observations*

A. Brekke (University of Tromsø, (STEL, Nagoya Univ.))

(11:45 - 12:45, 14:00 - 15:00)

Session IV : Oceanographic observations in the Arctic

(Chair: M. Wakatsuchi)

IV-1. *The European subpolar ocean prgramme(ESOP) : Investigations of the role of sea ice in Greenland Sea convection*

P. Wadhams (Scott Polar Research Institute, University of Cambridge)

IV-2. *Evolution of T-S structure obtained by the ice-ocean environmental buoy in the Nansen basin off Greenland*

T. Takizawa, K. Hatakeyama, T. Nakamura (Japan Marine Science and Technology Center), S. Honjo, R. Krishfield and J. Kemp (Woods Hole Oceanographic Institution)

滝沢隆俊（海洋科学技術センター）ほか

IV-3. *The Arctic ocean in the global climate system*

G. V. Alekseev, V. F. Zakharov and A. V. Yanes (Arctic and Antarctic Research Institute, Russia)

IV-4. *Carbon dioxide variations in the Greenland Sea*

S. Aoki (Center for Atmospheric and Oceanic Studies, Faculty of Science, Tohoku University), S. Morimoto, S. Ushio, H. Ito (NIPR), T. Nakazawa (Fac. Sci., Tohoku Univ.), T. Yamanouchi, N. Ono (NIPR) and T. Vinje (NP)

青木周司（東北大学理学部）ほか

Ⅳ-5. *Recent changes in Arctic Ocean termohaline structure : results fom the U.S./Canada 1994 ArcticOcean section*

E. C. Carmack (Institute of Ocean Sciences, Canada), K. Aagaard (Polar Sci. Center, Univ. Washington), R. W. Macdonald, F. A. McLaughlin, R. G. Perkin (Inst. Ocean Sci.), E. P. Jones (Bedford Inst. Oceanography) and J. H. Swift (Scripps Inst. Oceanography, Univ. California)

Ⅳ-6. *Heat budget of the Arctic Sea*

H. Ito (National Institute of Polar Research)
伊藤　一（国立極地研究所）

(15:15 - 17:15)

Session V : Environment change from circum polar ice core of the ice sheet and glaciers

(Chair: S. Takahashi and H. Clausen)

Ⅴ-1. *Japanese Arctic glaciological studies during 1987-1995*

O. Watanabe (National Institute of Polar Research)
渡辺興亜（国立極地研究所）

Ⅴ-2. *Volcanic records in polar ice cores*

H. B. Clausen (University of Copenhagen)

Ⅴ-3. *Participation in the GRIP programme - Core study on mechanical and physical properties -*

H. Shoji (Kitami Institute of Technology) and O. Watanabe (NIPR)
庄子　仁（北見工業大学）ほか

Ⅴ-4. *Recent trends in mass balance of glaciers in Norway and Svalbard*

J. O. Hagen (University of Oslo)

Ⅴ-5. *Glaciological activities in Svalbard by Japanese Arctic Glaciological Expeditions (JAGE)*

S. Takahashi (Kitami Institute of Technology) and O. Watanabe (NIPR)
高橋修平（北見工業大学）ほか

Ⅴ-6. *Glaciological studies in the Canadian Arctic*

K. Goto-Azuma (Nagaoka Institute of Snow and Ice Studies, National Research Institute for Earth Science and Disaster Prevention), R. M. Koerner and D. A. Fisher (Geol. Survey of Canada)
東　久美子（防災科学技術研究所長岡雪氷防災実験研究所）ほか

Closing

ABSTRACTS

I -1

A Review of the Development of International Science Cooperation in the Arctic with a focus on IASC Activities and its Science Priority Projects.

By Odd Rogne, Executive Secretary of IASC,
The International Arctic Science Committee

In his brief review of the development of international science cooperation in the Arctic, Mr. Rogne will give a survey of the main historical events in the development of circumarctic science cooperation. He will point out that this development is closely linked to the geopolitical situation, as was the founding of the International Arctic Science Committee (IASC).

After a brief survey of IASC, he will focus on the ten IASC science priority projects, their aims and the current status in their planning.

A milestone in the IASC planning process will be the IASC International Conference for Arctic Research Planning (ICARP), to be held 5-9 December, 1995 in Hanover, New Hampshire, USA. The aim of this conference is to finalize science and implementation plans for the science priority projects. Mr. Rogne will also briefly summarize the programme for this conference.

THE ROLE OF THE ARCTIC IN GLOBAL CLIMATE CHANGE

Gunter Weller
Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320, USA.

ABSTRACT

This paper describes the role of the Arctic in global climate change. The matrix below shows the cause-effect relationships between the Arctic and the global climate system.

	EFFECT	
CAUSE	1. A → G	2. A → A
	3. G → A	4. G → G

where A=Arctic, G=Global. Arctic feedback processes on the global climate system are represented by 1. A → G, global effects on the Arctic by 3. G → A. Nos. 2 and 4: Arctic causes with arctic effects, and global causes with global effects are not relevant for discussion in this paper.

The Arctic is a sensitive indicator of global climate change (G → A) but it also affects the global climate through interactions between its atmosphere, ice cover, and oceans and through feedback processes (A → G) . High-latitude snow albedo and trace gas feedbacks may have major influences on the global climate. Changes in the mass balance of polar ice sheets and glaciers influence the global sea level.

External forces and the Earth's internal driving forces on the Arctic climate (G → A) will be examined, including solar influences, greenhouse gases, volcanic eruptions, and changes in ocean circulation. The short-term, large magnitude climate changes revealed by the Greenland ice cores have led to new speculations about the causes of climate change.

Climate models indicate an amplification of the greenhouse warming in the Arctic but there are still a large number of uncertainties about the magnitude and timing of the expected change. This paper will focus on these uncertainties by examining the observed changes in temperature, sea ice extent, snow cover, and the permafrost regime. Considerable warming has occured over northern landmasses in recent decades, although the central Arctic Ocean has not experienced much change. Snow and ice extent and the permafrost regime are also showing the corresponding effects of a warmer climate.

While all the signals of change in the Arctic are consistent with the global greenhouse scenario, it can not be unambiguously stated that the greenhouse effect has already been observed in the Arctic.

I -3

Global Environmental Research in the Arctic Canada

Fred Roots

Science Advisor Emeritus, Environment Canada
Department of the Environment, Ottawa, K1A 0H3, CANADA

I -4

A natural complex of the seas of the Siberian shelf (the Laptev Sea)

S. Pryamikov, L.Timokhov
Arctic and Antarctic Research Institute
St. Petersburg, Russia

The seas of the Siberian Shelf including the deltas andestuaries of the rivers can be considered as a transient zone where fresh waters accumulated from watersheds and transportedfarther by the rivers interact with the waters of the Deep Arctic Basin.

The seas of the Siberian shelf have the following commonfeatures: the presence of a shallow shelf for much of the area of the seas, the ice cover existence and its significant seasonal change, a large input of the river run-off, the interaction of the seas with a deep Arctic Basin. However, each sea has its own specific combination of the depth, bottom relief and coastline, volume and distribution of the coastal outflow, as well, as the degree of being "open" to the Arctic Basin and the adjacent seas. These factors create different conditions for the processes and form the natures of the hydrological regime, different for each sea. The region, which includes the Laptev and East-Siberian Seas, the Taimyr-Severozemel'sky area and the New-Siberian islands is considered to be one of the most interesting and unique regions of the Arctic.

The following natural phenomena are especially well-pronounced in this region:

- in winter the largest amount of sea ice is exported from the sea area of the region to the Arctic Basin, and due to this it is called the Arctic ice actory;
- of all the seas of the Siberian shelf it is to the Laptev Sea that the Atlantic water releases the largest heat amount;
- surface Arctic water stores the "memory" of the freshwater outflow of the Laptev and EastSiberian Seas for along time and the anomalies of water characteristics are traced in the Arctic Basin as a wide branch up to the North Pole;
- the East-Siberian Sea is the most shallow sea, the continental shoal off the New-Siberian islands extends 600-700 km northward from the mainland coast, being adjacent to the Lomonosov Ridge and here the fast ice width reaches 400-500 km in winter;
- in winter extensive water areas form behind fast ice, which are called the Great Siberian Polynya;
- the Laptev Sea is equidistant and it is influenced by the Pacific and the Atlantic oceans, which is the cause for the coexistence of the biological species of the Pacific and the Atlantic provinces in one basin;
- islands disappear over vast shallow areas of the Laptev Sea: the Semenovsky island transformed into a bank for 40 years, earlier such islands as Vasilyevsky, Merkurius, St. Diomid, etc. disappeared;
- at the Zhokhov island (New-Siberian islands) the most old mesolithic stand of the ancient man in the Arctic was found. These circumstances indicate that when the sea is identified as a natural compartment for temporal scales of the climatic period the traditionally delineated marine medium should include the near water (near ice) atmospheric layer, coastal zone of a possible sea advance, surface sediment layer at the bottom, including benthos, etc.

The Program "the Laptev Sea System"(1993-1997) is an example of such a system approach to the study of the natural compartment. A specific implementation plan has been structured in such a way as to achieve the following goals:

- to find out the relationships between the processes, occurring on land (geomorphological processes, river run-off, living nature processes) and in the Laptev Sea (sedimentation features, coastal and hydrophysical processes, ice phenomena, biological processes);
- to find out the relationships between meteorological, ice-hydrological, geomorphological, geophysical, biological and ecological processes in present-day conditions and determine the typical features in the variability of the natural environment of the region;
- to investigate the present state and history of the development of marine and terrestrial ecosystems of the Laptev Sea region, to obtain a background picture of the state of the ecosystems;
- to specify the picture of the geological structure of the region, reconstruct the history of its development;

I −5

Drilling in Ice Sheets

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Polar ice sheets are unique sources of paleoenviromental history that are currently being investigated by a number of international research teams. A review is made of the evolution, development and progress of ice core drilling into ice sheets for scientific purposes. The scope, approach and important results of ice core investigations associated with various core drilling projects are examined.

*Professor Emeritus

Delightful participation of a Japanese scientist in the Arctic science community

Takao HOSHIAI
National Institute of Polar Research

The International Geophysical Year (IGY:1957-58) was one of the epoch-making events in the Japanese history of natural, field sciences, including those in the polar regions. A national project, Japanese Antarctic Research Expedition, actually started in 1956 in the framework of the IGY. Concurrently, in the Arctic region, researches were begun with the bilateral cooperation basis between Japanese and foreign scientists. Successive three decades of 1960's to 1980's, research activities by Japanese scientists had gradually expanded in receiving the funding support by the Ministry of Education, Science and Culture, other governmental agencies and private companies and associations. The rational of the expansion was interests of scientists in (1) the specific characters of natural phenomena within the Arctic, (2) The Arctic in comparison with the Antarctic and (3) the role of Arctic in the global change of environment. In August 1990 the International Arctic Science Committee (IASC) was founded and its first council meeting, participation of 6 non-Arctic countries including Japan was accepted. Fortunately, I was able to attend at the two meetings as the representative of the society of Japanese scientists who had interests in the Arctic science. In response to this international trend, the Arctic Environmental Research Center was set up in the National Institute of Polar Research in 1990. The center has been making services for national and international cooperative research and carrying out its own research as well. It seems that the present national and international systems are useful to further the Arctic research.

Personally, I have a desire to make a field trip to examine if microalgae increase in the sea ice bottom in autumn, because the autumnal increase of algae is usual in the waters along the east Antarctic continent but few information from the Arctic. What relationship there is between ice microalgae and their consumers, copepods in the Arctic sea ice is another question for me. The questions are quite fundamental but important for the deeper understanding of polar sea ecosystems and the more accurate estimation of CO_2 cycle in the ice-covered seas. It is delightfully expected that scientific researches include such basic topics as above with up-dated and cutting-edge researches in the global change related projects under the umbrella of IASC.

I -7

Global Environment Research in the Arctic

Nobuo ONO
National Institute of Polar Research, Japan

The Arctic is considered as one of the most sensitive and early responsive regions of global climatic and environmental changes in the world. Results of GCM simulation predict the most important enhancement of global warming will occur in the Arctic. Surface air temperatures observed at weather stations in the Arctic indicate a large year-to-year fluctuation like noise hiding the signal of a trend of global warming. It is expected that the interannual change of Arctic cryosphere (snow and ice) gives a more noiseless signal that shown up the annual integration of daily mean air temperatures.

An examination of year-to-year variability in the Arctic cryosphere was carried out and a remarkable coinsidence is observed with a global-scale response of ENSO (El Niño-Southern Oscillation). The ENSO is originally a phenomenon occurring in the tropic Pacific. About once in several years, the prevailing trade winds weaken so that warm surface waters, which are normally driven westward by the winds, move eastward to overlie the cold waters of the Peru current during the Christmas season. The spatial mean sea surface temperature (SST) in the quadrangle of 4°N and 4°S, 150°W and 90°W is taken as an index of El Niño, called Niño-3. The Southern Oscillation is also a fluctuation of inter-tropical atmospheric circulation and is strongly linked to El Niño. An indicator of Southern Oscillation is the difference in sea level atmospheric pressure between Tahiti and Darwin, Australia, which is called the Southern Oscillation Index (SOI).

Mysak and Manak (1988) pointed out the ENSO-like variability is recognized in the interannual fluctuation of sea-ice extents in the Baffin Bay and in the Labrador Sea. Such periodicity can be found in the interannual fluctuation of sea-ice extent in each individual subarctic sea. Sea-ice extent in the Bering Sea is synchronous with the Baffin Bay sea-ice, and sea-ice extents in the Barents, Greenland and Okhotsk Seas have the opposite phase with the Baffin Bay sea-ice. The boundary between these two groups of subarctic seas is indicated as a line drawn from the Greenland to Kamchatka peninsula. A large scale seesaw phenomenon exists in the northern hemisphere sea-ice extent with correspond to the ENSO periodicity.

Another ENSO-like periodicity is found in the interannual fluctuation of net mass balance of glaciers in the Arctic region. A glacier named Breggerbreen, behind Ny Ålesund in Spitsbergen, has been studied more than 20 years by glaciologists of the Norwegian Polar Institute. Their net mass balance data mostly show negative values with a large year-to-year fluctuation of ENSO-like periodicity. In El Niño years summer melting decreases and the net mass balance shows small value around zero. The net mass balance data of other glaciers in Svalbard and in the Russian Arctic show also the same periodicity of net mass balance with Breggerbreen.

It must be pointed out that unlike the sea-ice extent in the subarctic seas, there is no lag between the periodicity of net mass balance and the ENSO cycle. This result suggests that the ENSO-cycle phenomenon occurs not only in the tropics, but also in the Arctic through a global-scale atmospheric oscillation.

II -1

Canadian Arctic and Global Change: a case for neotropication or neoglaciation?

Josef Svoboda

Department of Botany, University of Toronto
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II −2

Current effort of Japan to develop ecological research in northern regions

Satoru KOJIMA

Department of Biosphere Science, Faculty of Science, Toyama University, Japan

In this presentation, northern regions are defined as those areas including the Arctic, Subarctic, and northern part of the Boreal biomes. My talk primarily describes research activities of terrestrial vegetation ecology and related studies by Japanese scientists in the regions in terms of chronological development.

Ecological research activities in the northern regions started not long time ago. Before the World War II, only sporadic studies were made mainly on regional floras and general vegetation distributions mostly in the northeastern Eurasia including Sakhalin, Kurile Islands, and Aleutian Islands. Traditionally, however, Japan has been much more actively and extensively involved in low latitude regions. A tremendous research effort had been placed in the tropical regions, but not much in the northern regions so far. This is basically due to geopolitical circumstances of Japan. Inaccessibility and remoteness as well as territorial sovereignty of the northern regions were also restricting conditions for an active research commitment there. Indeed, it was since 1970s when a considerable research effort became placed and various research projects got actually started in northern regions, namely, Spitzbergen, Fenno-Scandinavia, northeastern Siberia, Alaska, and northern Canada.

In recent years, however, in conjunction with the global environmental issues, a necessity to develop multi-disciplinary research in the northern environment was strongly realized. It was generally understood and agreed that Japan should also undertake research in the northern regions and the government agencies should encourage such research activities. Fund became available gradually and number of on-goin projects substantially increased.

In the National Institute of Polar Research of Japan (NIPR), a research project was initiated in 1994 funded by the Monbusho (Ministry of Education, Culture and Science). It was a three-year project and is conducted in Ny-Alsund, Spitzbergen. Main objectives of the project are to describe and analyze ecosystem development in recently deglaciated areas in the Arctic and to carry out some experiments as to ecosystem functions in the sites. ITEX is also important concerns. The project is thought to be associated with the ITEX activities and recommendations presented in the ITEX manual are followed as much as possible. In the meanwhile, domestically in Japan, there are some initiations taking place to establish some ITEX sites mainly in high elevations in such as Mt. Taisetu, Hokkaido, and Mt. Kiso-Komagatake, Nagano, and Mt. Tateyama, Toyama, by young and enthusiastic scientists.

II -3

Vegetation at deglaciated terrain in Spitsbergen Island

Hiroshi KANDA[1] , Yoshinori MINAMI [2] and Takeshi KIBE [3]

[1]National Institute of Polar Research
[2]The Hiraoka Environmental Science Laboratory
[3] The Graduate University of Advanced Studies

The study on the ecosystems of the glacier edge area was carried out during two months from July to August 1994 by the Japanese biological group in collaboration with Norwey. This study will be continued until August 1996.

One of the aims of the study is to get the fundamental data on the vegetation in response to the local or glabal environmental changes. The vegetation of the glacier foreland was investigated by phytosociological method in the East Brogger Glacier near Ny-Alesund, Spitsbergen Island according to the vegetation map compiled by Bratbakk (1976). The areas studied are 1) bare soil terrain, 2) *Saxifraga* dominated area, 3) *Dryas* dominated area and 4) wetland. The percentage of the vegetation cover increased with increasing distance from the margin of the glacier. To know the vegetation pattern of the glacier foreland is effective for assessing influences by a climate change. Therefore the simple chamber for green house effects are set in the morain area and some environmental factors are measured in and out the chamber. The study sites will be managed over three years. In addition to them, *Carex*, *Saxifraga* and *Dryas* vegetation in the lateral morain are marked and clarified on the pattern of the primary succession, the growth and reproduction of these communities. These vegetational units are now going to analize by using the method of Z-M shchool of phytosociology.

On the bare soil terrain there occurred moss vegetation first at the distance of ca. 50 m away from the margin of the glacier. The vegetation is composed of three mosses of *Bryum* sp., *Pottia heimii* and *Funaria arctica*. Subsequently mosses such as *Ceratodon purpureus*, *Leptobryum pyriforme* and *Desmatodon* sp. appeared at the distance of 150-200 m away from the margin. These mosses are considered to be pioneer plants at the glacier foreland.

On the other hand, the moss vegetation was described and classified based on the species and its frequency by the line transect method. Acrocarpous mosses like *Bryum*, *Pohlia*, *Dicranoweisia*, *Racomitrium*, *Gymnomitrion* were predominant at the hilly site. Toward lower and wetter sites, pleurocarpous mosses like *Drepanocladus*, *Scorpidium*, *Tomenthypnum*, *Orthothecium* are occurred. These vegetational division seems to be caused by water ondition and topographic features. Similarly trampling on the vegetation by reindeers was also observed to asess the local environmental changes.

II -4

Distribution pattern, flowering phenology, pollinator visitation and fruit-set of alpine plants along a snowmelt gradient in the Taisetsu Mountains

Gaku KUDO

Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060, Japan

Alpine snow-beds produce an unique environment having a clear snowmelt gradient within a narrow area. Comparisons of various ecological traits of alpine plants along the gradient bring us good information about adaptation mechanism of plants against decreasing growing season. Flowering and fruiting phenology of each species is potentially determined by cumulative temperature of daily mean, and the actual flowering and fruiting times are affected by the timing of snow disappearance. Snowmelt pattern within an area is rather stable, but actual time of snowmelt at the same place is highly variable from year to year. Delay of flowering often reduces the seed production due to restriction of fruit developing season. On the other hand, early flowering induced by early snowmelt may reduce the mating success because activity of pollinating insects in low in early season due to cool conditions. Most available pollinating insects in Japanese alpine regions are flies, syrphid-flies and bumble-bees. Because their most active season is from late July to mid August, flowering within the season is best for entomophilous plants to enhance the mating success. When the length of remaining available time after flowering is shorter than the seed maturation period, reproductive success becomes zero even if pollination process is successful. Also, existence of steep snowmelt gradient enables the occurrence of flowering of many species at a same time. This may bring about interspecific competition for pollination acquisition among plants which affects reproductive success of each species. Thus, distribution pattern of plants along the gradient has to be considered not only by abiotic environments (snow depth, snow-free period, soil conditions and micro-topography) and physiological traits of each species (tolerance for short growing season and temperature dependent phenological traits), but also by biotic interactions (plant-plant interaction and plant-insect interaction).

In this session, I will introduce my work in the Taisetsu Mountains, northern Japan as follows; 1) steepness and the range of yearly variation of the snowmelt gradient; 2) distribution pattern of major species along the snowmelt gradient; 3) flowering pattern among species and intraspecific variations of reproductive phenology along the snowmelt gradient; 4) seasonality of pollinating insects; 5) relationship between flowering timing and fruit set of *Rhododendron aureum* with respect to the activity of flower visitors; and 6) relationship between distribution of two *Phyllodoce* species and foraging pattern of bumble-bees along the snowmelt gradient.

Study on the water and energy cycle and land surface processes in Siberia (GAME/Siberia)

Tetsuo OHATA

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and

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Regional process study of multiscale water/energy cycle in Siberia will be made as part of GAME(GEWEX Asian Monsoon Experiment) within the framework of WCRP/GEWEX(Global Energy and Water Experiment).

The importance of land surface processes in the regional and global water cycle has been recognized in recent years. Many large projects investigating such relation have been done and are also planned in various regions, but limited in the permafrost area which dominates large area in the northern parts of the continents. Among such area, Siberia, located in the northern half part of the Eurasian continent, holds the widest permafrost area. The land surface in Siberia is characterized by tundra with scarce vegetation and Taiga which mainly consists of coniferous tree belts. The surface layer of the permafrost, snow cover and vegetation contributes much to the water/energy fluxes and strongly regulates the various components of the water cycle such as the evapotranspiration and runoff. The seasonal cycle and variation of water cycle in this region is characterized by the interaction between the cryosphere, biosphere and atmosphere. The existence of wide tree belts depend upon the permafrost.

The large rivers which flow northward from this region contribute to fresh water supply to the Arctic Sea which in turn modifies the hydrological and thermal conditions of the Arctic Sea. The variation of these runoffs will have influence on the climatic conditions in the Arctic and surrounding area. On the other hand, the present global warming since the beginning of 1980s has been occurring most intensely in the northern part of the Eurasian continent, radically over Siberia. Spatial and temporal distribution of snow and ice will change as a result interacting with the permafrost conditions. They will affect the water cycle through change in ground surface conditions, soil moisture, runoff and evaporation. We need to understand the possible changes which may occur with the help of GCMs.

Based upon these backgrounds, the present study focuses on the investigation of the characteristics of water and energy cycle in the Siberian region under various spatial and temporal scale to clarify the physical processes related to water/energy fluxes and storage of water/heat on land surface, the role of land surface processes including snow cover, permafrost and vegetation in regional water cycle, and their variability. This study will primary based on field observations, analysis of conventional data sets and modeling. This study is proposed as one of the core projects of GAME, and the first phase is now planned from 1996 to 2000.

II-6

Our Marine Ecological Researches in the High Arctic Fjord, Kongsfjord

Sakae KUDOH

Natinal Institute of Polar Research, Tokyo 173, JAPAN

To figure out some essential points for ecological study in the arctic oceans, temporal changes in biomass, primary production and some physiologogical characteristics of micro algae have been preliminaly studied with references to oceanographic conditions at the high arctic fjord, Kongsfjord (ca. 79 oN, 12 oE) in Spitsbergen Island since 1991. The water mass in the fjord during spring to autumn, which was observed by measureing the salinity and temperature , was vertically stratified due to influx of freshwater from surrounding land and glaciers. A high microalgal biomass was detected in the surface water in 2 spring studies in 1993 and 1994 (so called 'spring bloom' of phytoplankton) just after the sea ice coverage in the fjord was gone away. The high biomass was mainly consisted by relatively large sized algae (diatoms), and that decreased drastically within one week showing correspondance with the decrease of nutriest salts in the surface water. Small sized phytoplankton (<2mm) dominated after that, but their biomass never exceeded that of the former blooming condition (s).

In this presentation, such observational results and some experimental results about photosynthetic responces of the microalgae both in the early succession stage and in later low biomass stage, and some responces to the surface environmental light resorce such as PAR (Photosynthetically active radiation) and UV, as well as primary production were discussed.

Ⅱ－7

3D model study of ice distribution, primary production and sedimentation as a function of climatic events

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II-8

Food web structure and biogenic carbon export on the continental shelves of the Arctic Ocean

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The Arctic Ocean (including Hudson Bay) contains ca. 25% of all continental shelves and receives 10% of freshwater inputs, yet it accounts for <5% of the area of the World Ocean. We propose that the extensive shelf system contributes, in four main ways, to the unique structure and dynamics of Arctic marine food webs: (1) The large freshwater runoff creates a low salinity surface layer and permits the extensive development of sea ice. The fluvial inputs deliver large quantities of particulate material and dissolved inorganic and organic nutrients. The latter sustain autotrophic and heterotrophic production on the shelves. (2) The seasonal ice cover provides a habitat for a benthic-type community of procaryotic and small eucaryotic organisms, it constrains biological production in the water column, and it alters the dynamics of ocean-atmosphere gas exchange. (3) The highly seasonal cycles of incident irradiance constrain all biological cycles, resulting in alternating periods of high microalgal production and rapid sedimentation of POC during spring-summer, and oxidation of organic matter in the benthos and water column during autumn-winter. (4) The persistently low temperature imposes an upper limit on the maximum rates of production and respiration. At these temperatures, the dynamic viscosity of seawater is high and Reynolds numbers (Re) are very small. The dominance of viscous forces may account, in part, for the frequent occurrence of large macrophages which ingest small particles.

The above characteristics result in a large and variable proportion of the ice algal production sinking to the bottom. In the water column, large metazoan grazers are omnivorous. They ingest ice or planktonic algae when available (during the spring and open water periods) and non-chlorphyllous microbial prey during the remainder of the year. Consequently, there would a close coupling between microbial and metazoan food webs. The biogenic material sedimenting to the benthos supports large, diverse and productive infaunal and epibenthic populations. The benthic production is (a) consumed by fish and marine mammals, (b) remineralized in situ, and (c) buried and sequestered in the sediments. The shallow and extensive ecosystems on Arctic shelves are characterized by closely coupled processes of production and remineralization in the water column and benthos. Moreover, because of the sequential cycles of open water, ice development, biological production and sedimentation, the shelves may be sites of active biological CO_2 pumping and efficient biogenic carbon sequestration.

P I -1

Some vegetation indication of climate warming as detected on forest-tundra border in the continental Canadian Arctic

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PI-2

Snow and Ice Algae of Spitsubergen Glaciers :possible climate signal in ice core analysis

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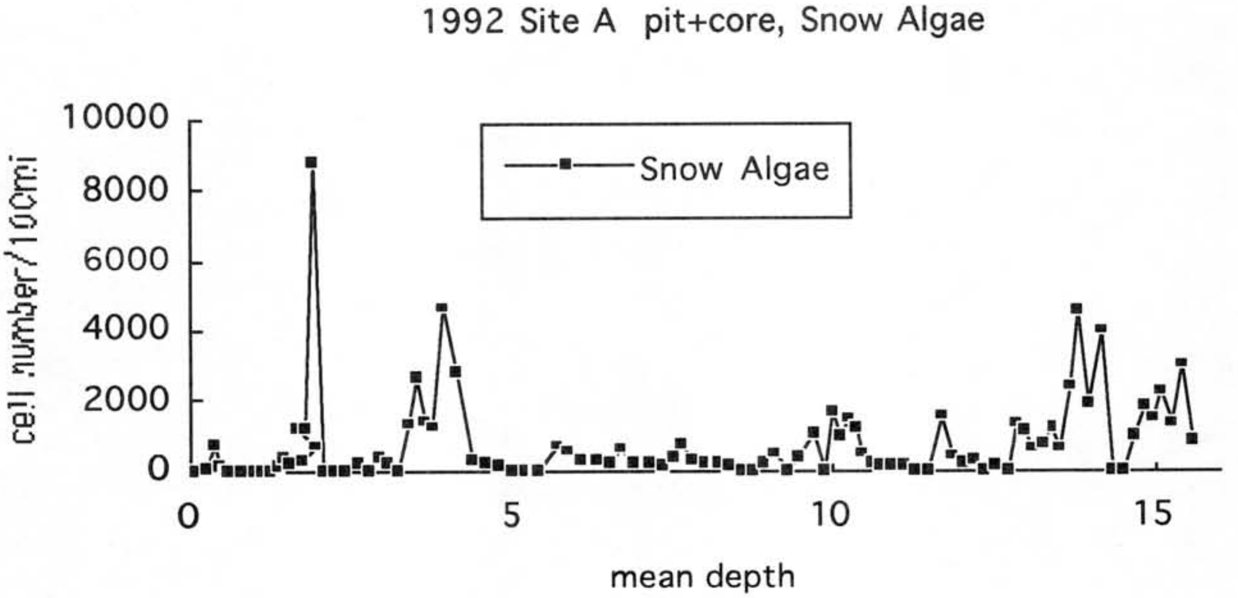
Snow and ice algae are micro algae growing in the snow and ice of alpine,glacial and polar regions. In the spring and summer snowfields of arctic glaciers, colored snow caused by their dens growth are rather common phenomenon: patches or large areas of snowfields are tinted yellow, orange or red. As these snow and ice plant communities should differ by the growth conditions, the algal communities stored in glacial strata can be a new information source for studies on past-climate change. In this study, we analyzed the micro algae contained in ice core samples (83.92 m in depth, 1160 m a.s.l.) obtained at Snøfjellafonna glacier in the western part of Spitsubergen by Japanese Arctic Glaciological Expedition 1992. To clarify the relationship between the algal community and climatic conditions, altitudinal distribution pattern of the algae was also studied at Brøggerbreen Glacier. In the analyzed ice core and surface snow at boring site, many layers containing small number of algal cells (10-100 cells /ml) were observed (Fig1). As these algal cells were belong to snow algal species (*Chloromonas sp.* ,unicellar green algae) growing in melting surface snow, these layers were estimated to be summer strata. Though these algal cells were decomposed and difficult to identify at deeper part, snow algae and their remnants in the ice core could be a good marker of annual layer boundary. Algal biomass and algal flora of the studied glacier largely changed by altitude: as the altitude decrease, algal biomass increased,and the dominant algae changed from unicellular green algae to filamentous blue-green algae. Algal biomass and algal flora in ice core also could be a new information sources in recovering past-environment.



P I -3

Distribution pattern of mosses on deglaciated terrain in Ny–Ålesund

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On the land north of forest limit in the Northern hemisphere, the extensive arctic meadows, rivers and lakes have a very important ecological function at a global level through influencing the cycling of nutrients between marine and terrestrial situations. The ecosystems under severe environmental conditions in the arctic region is easily modified by climatic change caused by global atmospheric warming originated in increasing human activities. Glacial retreat is particularly remarkable, and the influence may produce a serious change in the vegetation along the glacier. However, little knowledge is available about the direct or indirect influence of the changes in environment on Arctic life. To clarify these concerns, it is necessary to establish the influence of environmental change on ecological dynamics, as early as possible.

The relationship between distribution of bryophytes and soil conditions on deglaciated arctic terrain in front of East Brøgger glacier in Ny–Ålesund, Spitsbergen, Svalbard archipelago was studied. Vegetation was divided into four community types, *i.e.* 1. moraine community, 2. *Saxifraga* community (dominated by *Saxifraga oppositifolia*), 3. *Dryas* community (dominated by *Dryas octopetala*), and 4. wetland community. We established study sites randomly in each community (18, 27, 26 and 23 sites respectively), carried out vegetation analysis and sampled soil. Six patterns was observed in the frequency of major species in the four communities. In soil chemistry, total nitrogen concentration was low, and soil pH and EC were high, with soil pH approximated neutral, in the moraine community. Mg and Zn content were also high in the moraine community. Conversely, Al content was highest in the *Dryas* community and lowest in the moraine community. It was considered that the soil conditions in the moraine are distinctive, and greatly influence the bryophytes growing there. We also studied vegetation on moraine using quadrat method along line transect established from glacier edge to downstream of moraine, and recorded species composition and cover (%). Number of species tended to increase with increasing distance from glacier edge, but no visible change at the central part of moraine. Gradients of equitability (*Ec*) and dominance concentration (Simpson Index: *C*) were shown along the line transect, so it was considered that diversity of moraine community was increasing in the direction to that mentioned above. However, it was also understood that importance value concentrated to dominant species at central part of moraine.

P I -4

Growth and reproduction of two *Carex* species in Spitsbergen Island

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In the Arctic tundra, the growing period for plants is restricted by climatic factors such as snow depth or low temperatures. Most plants can only afford to grow for two or three months in summer. The purpose of this study is to clarify how plant growth and reproduction are affected by the environmental factors, such as photon flux density and temperature.
The measurements of plant growth and biomass allocation were carried out on a periglacial moraine area at Ny-Ålesund (78.6 °N) in Spitsbergen Island in July and August in 1994. Vegetation there mainly consists of lichen, moss, grass, perennial herb and dwarf woody plants. Two perennial sedges, *Carex misandra* (caespitose) and *C. rupestris* (prostrate), were studied. Both of them are commonly growing on moraine area at Ny-Ålesund. They showed low allocation to sexual reproductive organ. Peak biomass and highest T/R ratio were observed in the end of July. The number of inflorescences in *C. misandra*. per individual in 1994 were smaller than that in 1993 The fluctuation of the number of inflorescences corresponds to the yearly fluctuation of mean air temperature in summer. Similar fluctuation was not observed in *C. rupestris*.

P I -5

Temporal changes of microalgal and bacterial assemblages in and under the sea-ice of Saroma Ko lagoon

M. Yasuda (Grad. Univ. Advanced Studies), S. Kudoh (NIPR), M. Fukuchi (NIPR)

In order to know material flow from ice algal production through microbial community, data of Chl.*a* concentration and bacterial abundance and frequency of dividing-divided cells (FDDC) were obtained with chemical and physical environmental data in Saroma Ko lagoon during ice covered period. Water input from surrounding rivers induced clear low salinity boundary (10 - 28) at the upper water column, and it seemed to transport large amount of nutrients into the sea ice bottom and upper water column. Vertical distribution of patterns of microalgae (5 - 72 μ g Chl.*a* / l) and bacteria (3 - 10 $\times 10^5$ cells / ml) were well correlated to those of nutrients, however, the observed similarity was consisted by many complex physical, chemical and biological processes. Simultaneous increase of bacterial FDDC (10 - 22 %) and C/N ratio (5.98 - 15) suggested high bacterial activity sometimes occurred during this period.

P I -6

Ecological studies of marine bacterioplankton in the
high arctic Kongs Fjord, Ny-Ålesund (NORWAY)
- Quantitative relationships between algae and protozoa during sea ice melting
in early summer 1994 -

M. Yasuda (Grad. Univ. Advanced Studies), S. Kudoh (NIPR), M. Fukuchi (NIPR)

Quantitative changes of planktonic algae, bacteria and protists associated with sea ice melting were investigated in high arctic Kongs Fjord, Ny-Ålesund (NORWAY) during early summer of 1994. Chl.*a* showed high values only during sea ice melting (1 - 2.5 μ g Chl.*a* / l) then decreased to < 0.5 μ g Chl.*a* / l. Frequency of dividing-divided cells (FDDC) of bacteria changed with Chl.*a* during ice melting, but FDDC correlated with heterotrophic nanoplankton carbon biomass in open sea. This suggested that nutrition source for bacterial growth changed during these periods. Bacterial abundance (10^5 cells / ml order), however, did not show any correlation with FDDC. This might be caused by heavy predation pressure by nano-heterotrophs, which was observed rather densely (> 3 mg C / m^3) in the water column.

Rotifer composition in freshwater habitats on Spitsbergen (Arctic) and King George Island (Antarctica)

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ABSTRACT

The comparison of rotifer species composition, between two polar regions (Spitsbergen, Arctic and King George Island, Antarctica) was made. Four different freshwater habitats (moss banks, moraine ponds, nearshore ponds and thaws) were surveyed. Water samples (0.25 l) were collected at the sediment-water interface, up to 10 cm above the sediment, in the deepest part of the water bodies.

Despite similar climatic and environmental conditions, different monogonont species domianated in the same type of habitat in two regions. In each habitat more species were found on Spitsbergen than on King George Is.

It seems that species composition was different because of:

a. longer colonization on Spitsbergen than on King George Is.

b. shorter distance of Spitsbergen from the nearest continent than King George Is.

c. stronger anthropogenic influence on Spitsbergen than on King George Is.

d. more diverse, abundant and migrating avifauna on Spitsbergen than on King George Is.

P I -8

Soil respiration in three soil-type agro-ecosystems in Finland

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Seasonal changes in soil respiration (SR), soil temperature (ST) and soil water content (SWC) were measured at three different soil types (peat, sandy and clay) in Finnish agro-ecosystems. Rates of CO_2 evolution were measured by a closed chamber method using IRGA at intervals of 2-3 weeks from May to October. The seasonal changes in the SR were different between the soil types: Peat soil, a maximum rate (650 mg CO_2 m^{-2} hr^{-1}) in summer, a positive significant relation between SR and ST and a negative relation between SR and SWC; Sandy soil, a stable SR (300 mg CO_2 m^{-2} hr^{-1}) without seasonal changes and positive relation between SR and SWC; Clay soil, a stable SR (400 mg CO_2 m^{-2} hr^{-1}) without seasonal changes, no significant relation between SR and ST, and between SR and SWC. A statistical model was developed on the basis of the relationships between SR and certain abiotic environmental factors viz. soil temperature (ST, ℃) and soil water content (SWC, %). The statistical model shows that a linear combination of above two abiotic variables explains 78.0% (for peat soil), 56.7% (for sandy soil) and 29.9% (for clay soil) of the variability in soil respiration, respectively. Using the model, amount of carbon evolved from soil during 5 months from May to September could be estimated at 395 gC m^{-2} for peat soil, 340 gC m^{-2} for clay soil and 286 gC m^{-2} for sandy soil, respectively.

PI-9

Biological aspects of Cryoconite and Cryoconite Hole of a Spitsubergen Glacier, Brøggerbreen, Svalbard

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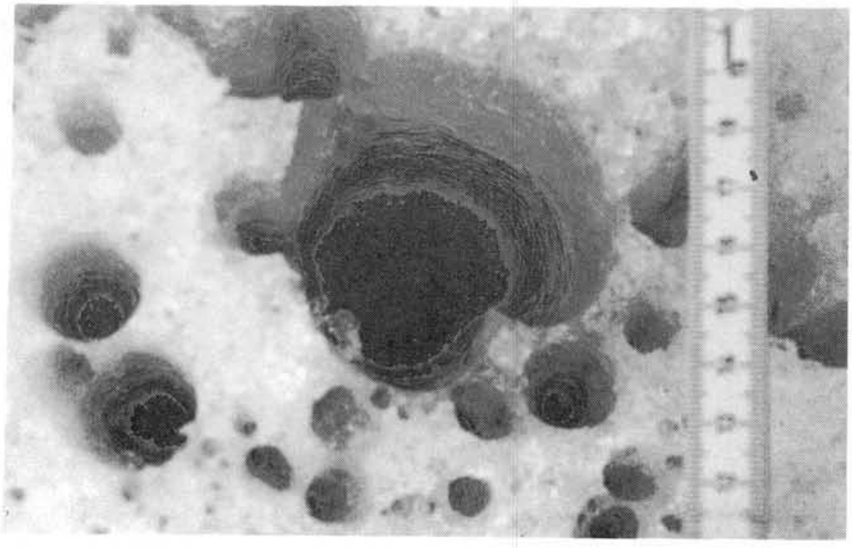
Cryoconite holes, cylindrical water-filled melt-holes are common features of the ablation area of many arctic glaciers. These melt-holes typically have circular section and contain organic and inorganic dark-colored deposit (cryoconite) at their flat bottoms, suggesting that their formation is result of the solar energy absorbed by dark-colored cryoconite. Gerdel and Drouet (1960) reported that cryoconite of Greenland Icesheet contained much algae and suggested that algal activity have some relation with melt-hole formation. However, precise structure of cryoconite and its relation with melt-hole formation is still not clear. In this research, we analyzed structure of cryoconite of Brøggerbreen glacier in Spitsubergen. Most part of cryoconites of this glacier consist of many small dark colored granules. Size of these cryoconite granule was about 1mm in diameter (0.1 mm - 1.3 mm, mean value=0.5 mm). These granules contain much organic matter (10% in dry weight, 30% in volume) and many mineral grains. By microscopic observation, the cryoconite granules were revealed to be a aggregation of much filamentous blue-green algae, black organic matter and mineral particles. Most of these blue-green algae was filamentous species of genus*Phormidium.* Observation by fluorescent microscope revealed that living blue-green algae with active chlorophyll distributed only on the surface of the granules. Inner part of the granule was consist of dead algae and mineral grains entangled by algal filaments. This structure suggests that cryoconite granules were formed by growth of filamentous blue-green algae which trap mineral particles at the surface, just like the formation process of stromatorite. The mucilaginous sheath of *Phormidium.* blue-green algae seemed to help trapping particles. As algae was blue-green and mineral grains were light brown, blackish coloration of cryoconite granule should be due to the decomposed remnant of organic matter such as dead algae. These aquatic blue-green algae seems to create their ideal growth condition by forming dark-colored cryoconite which is very effective for cryoconite hole formation. Distribution pattern and formation process of cryoconite hole were also studied.



P I -10

Diversity, Seasonality and Spatial Distribution of Freshwater Algae in a Glacial Stream at Ellesmere Island

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Abundance, diversity and distribution of freshwater algae were studied in and along 400m long glacial stream fed by meltwater from Teardrop Glacier in Sverdrup Pass 79 N, Central Ellesmere Island, Canada. These organisms produce surprisingly high amount of organic matter in the stream during short growing season. Inclusive of Cyanoprokaryote and algae (Xanthophyceae, Bacillariophyceae, Chlorophyceae, Conjugatophyceae and Euglenophyceae) 69 species were identified in the stream. These organisms colonized the bottom and flooded banks of the stream by various types of periphyton communities (epipelic, epipsamic. epilithic, epiphytic) and metaphyton communities. The species which produce visible or significantly high biomass were divided into 9 groups displaying distinct species composition and ecological role in this seasonal glacial stream. All the species were also sorted into three life-strategy groups:

1. filamentous cyanoprokaryotes (9 species) which produce mucilaginous coatings and films on stones, sandy banks and on the clay bottom;

2. filamentous algae (7 species) which produce mats in the stream current;

3. metaphyton group (53 species) suspended among other algae, mosses and submersed vascular plants. The cyanoprokaryotes (cyanobacteria) and freshwater algae have been proposed by us as initiators of primary succession following the deglaciation of arctic landscapes.

P I -11

Photosynthetic and respiratory characteristics of an Arctic ice algal community living in low light and low temperature conditions

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The massive development of the ice algal community commonly observed under first-year sea ice was studied with particular attention to photosynthetic and respiratory characteristics of ice algae at low temperature and low light conditions. Field experiments were carried out in April and May 1992 at Resolute Passage in the Canadian Arctic. Under ca. 200cm of sea ice with a snow cover of less than 7cm, ice algal biomass increased from 3.7 to 88.7 mgChl*a* m^{-2} with rates increasing from 0.17 to 0.23 doublings day^{-1}, although the development was disturbed between 1 and 6 May. The photosynthetically active radiation (PAR) measured at the bottom of the sea ice around noon was between 8.6 and 1.5 μmol photons m^{-2} s^{-1} (1.0 and 0.1 % of the surface irradiance); the water temperature was near -1.8°C. Corresponding to these low irradiance levels, ice algae exhibited a high a (the initial slope of the photosynthesis vs. irradiance relationship) of 0.26 μgC μgChla^{-1} h^{-1} [μmol photons m^{-2} s^{-1}]$^{-1}$. The dark respiration contributed up to 35% of the gross photosynthetic rate and was estimated to be 0.22 μgC μgChla^{-1} h^{-1} on average. Considering the value of a and the dark respiration rate, light compensation was estimated to be 0.8 μmol photons m^{-2} s^{-1} for the ice algal community, which was enough for ice algae to maintain the positive photosynthesis at the bottom of the sea ice at the maximum daily irradiance. Using a numerical model with these estimated parameters, we evaluated the net positive diel photosynthesis under natural environmental conditions. The numerical model also suggested that the long day length in the late spring and summer in Arctic region allowed the algae to maintain positive net photosynthesis even after the massive development of the ice algal community.

P I -12

Primary production of phytoplankton in high arctic Kongs Fjord, Svalvard, Norway

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Standing stock and primary productivity of phytoplankton were investigated in relation to the environmental conditions in high arctic fjold, Kongs Fjold, Svalbard (Norway) during the early summer of 1993, just after the sea ice melting.

The concentration of chlorophyll *a* in the surface water showed high values only during sea ice melting (1 - 5.7 μg Chl.*a* / ℓ) then decreased to less than 0.5 μg Chl.*a* / ℓ during the successive period. During the period of present experiments (on June 7,1993), water temperature, salinity and Chl. *a* content in the surface water ranged from - 1.16 to 1.72℃, from 33.12 to 34.20 % and from 0.056 to 0.327 μg / ℓ, respectively. At the station located in the central part of the fjold (St. 1; 78°56' N, 12°02'E), clear subsurface maxima, 4.6 times higher than that in the surface water, of Chl. *a* was observed at 50 m depth. Daily variations of photosynthetic available radiation (PAR) ranged from 200 to 1,200 μ Moles m^{-2} sec^{-1} during the experimental period.

Photosynthetic activity of phytoplankton measured by ^{13}C stable isotope method with surface water samples under natural light conditions showed the slight photo-inhibition and the maximum rate of photosynthesis was obtained under 25 percent of natural full light intensity.

Daily (24hours) rates of primary production were calculated by integration of the depth-profiles of photosynthesis, based on the data of standing stock and photosynthetic activity of phytoplankton in combination with the light conditions in the water column and with the daily variation of PAR. Integrated rates of daytime (08:00 - 20:00) production in the water column in the fine and cloud days were estimated to be 75.53 and 54.29 mg C m^{-2} $daytime^{-1}$, respectively. And those in the nighttime (20:00 - 08:00) were calculated to be 43.63 and 32.69 mg C m^{-2} $nighttime^{-1}$, respectively. Thus, about thirty seven percent of the daily production were suggested to be done during white night period.

P I -13

Diel Variability in Vertical Flux of Chlorophyll a and Biogenic Silica in Saromako Lagoon, Hokkaido, Japan

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Diel variability in ice algal vertical flux was determined at four experiments in Saromako Lagoon, Hokkaido in February 1993 and 1994. Multiple sediment traps were deployed at 10 cm below the bottom of sea ice to collect ice algal cells at 2 h intervals for 24 h period. Vertical flux of chlorophyll a (CHL a) during day was always higher than that during night. Contribution of CHL a to total pigments was usually higher than 76% except the fourth experiment. Little difference in the contribution of CHL a to the total pigments was found between day and night except the fourth experiment. The fourth experiment showed the lowest contribution of CHL a to total pigments, i.e., 50% and the higher contribution during night than that during day. The average vertical flux of biogenic silica ranged from 7,200 to 1,500 during day and from 3,600 to 1,600 μg Si m^{-2} h^{-1} during night, respectively. The vertical flux of biogenic silica during day was usually higher than that during night. The average ratio of biogenic silica to chlorophyll a (Si:CHL), by weight, ranged from 52 to 8 during day and from 45 to 11 during night, respectively. Those ratios were higher than ice algal ratio of 10. Those comparison may suggest a possible occurrence of the horizontal transport of biogenic silica associated with non-ice algal cells.

P I -14

Ecophysiological and genetic studies of Dryas octopetala in polar region and Japan

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Dryas is one of the most characteristic of all arctic and alpine plants genera in relation to the ice age. It was a dwarf shrub with xenomorphic leaves adapted to survive periods of insufficient moisture. *Dryas octopetala* is distributed from tundra in polar region to alpine slope in Japanese South Alps. Comparative ecophysiological study of *D. octopetala* was carried out in Alaska and Japanese South Alps. Morphological data, specific leaf weight and photosynthetic rate were measured for comparing with two types of *D. octopetala*. There were some differences between the two types, especially in physiological characteristics.

To compare nucleotide sequences of chloroplast DNA from *D. octopetala* grown at alpine zone and at polar region total DNAs were prepared for cloning and several clones containing *rbcL* gene were identified.

P I -15

Water Structures of the Kongsfjorden, Spitsbergen in 1991-1993

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Oceanographic observations in the Kongsfjorden (79N, 12E), Spitsbergen have been cunducted since 1991. The fjord is linked with the Greenland Sea, and a few glaciers flow in the fjord. This study aims to reveal processes of water exchange between fjords and open ocean. Glacier-ocean interaction is also of interest. Temperature and salinity profiles in the fjord were measured using a conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT). CTD observations were carried out four times and XBT twice. Water column was stratified by density. The hydrographic characteristics of the surface layer can be strongly affected by the atmospheric condition and by fresh-water inflow from the surrounding glaciers. In spring, the surface temperature increased by insolation, but melting of growlers decreased temperature and salinity. Thus, temperature profiles were much complicated. However, both temperature and salinity of the bottom layer increased with time during May-June 1993 as shown in Fig.1. This variation is considered to be due to intrusion of the warm-saline dense water from the open ocean, where the West Spitsbergen Current flows north. The future work is to estimate intrusion nature of the dense water.

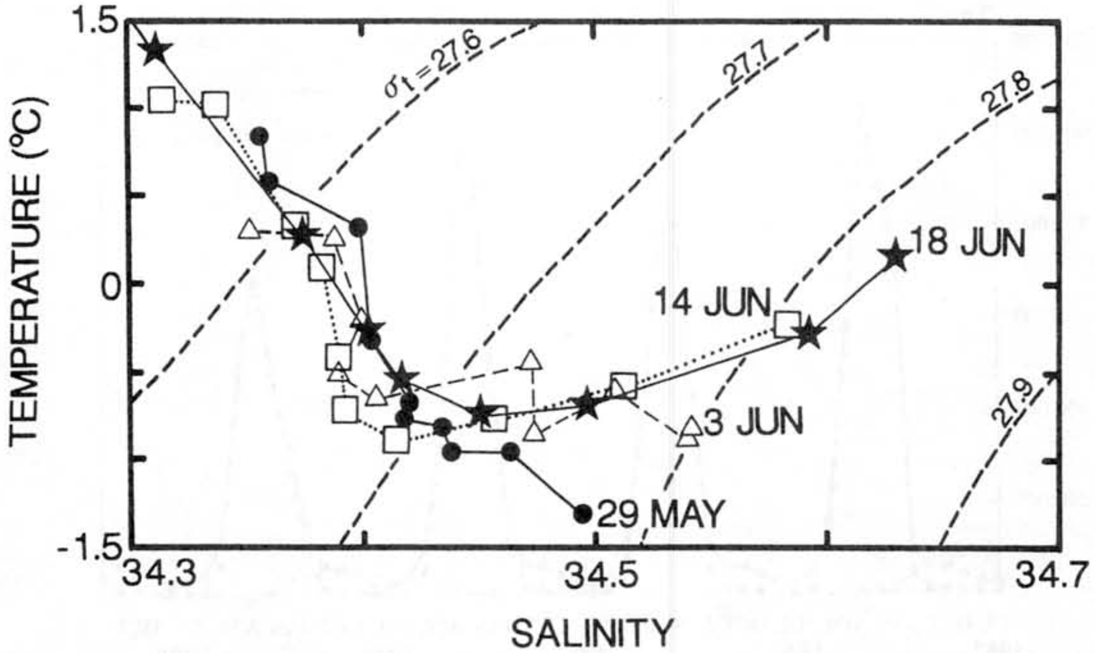

Fig. 1. Time variation of temperature-salinity curve of water masses during May-June 1993. Each curve connects data points at 10, 20, 30, 50, 75, 100, 125, 150, 200, 250m depth in sequence.

P I -16

IMPROVEMENT OF SSM/I SEA ICE CONCENTRATION ALGORITHMS FOR THE SEA OF OKHOTSK

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The NSIDC(National Snow and Ice Data Center) in the U.S. has been distributing DMSP-SSM/I passive microwave datasets of polar regions to the science community. In these datasets, NASA Team algorithm and Comiso algorithm are used for extracting sea ice concentration. Recently, new weather filters were added to the both algorithms to reduce the weather effect which was affecting the ice concentration calculation from SSM/I data. The authors have validated the both algorithms for the Okhotsk Sea. The initial study showed that the new weather filters were effectively reducing the weather effect. However, some increase of sea ice concentration in the "no sea ice season" was still observed. The authors have introduced a 3x3 window filter call LER(Land Effect Reduction) Filter. In this filter, if the land flag of one of the 3x3 pixels were ON, then the center pixel data will be replaced with the lowest ice concentration among the 3x3 pixels. Figure 1 shows the use of LAR filter for reducing the land effect from the sea ice concentration calculation of SSM/I data.

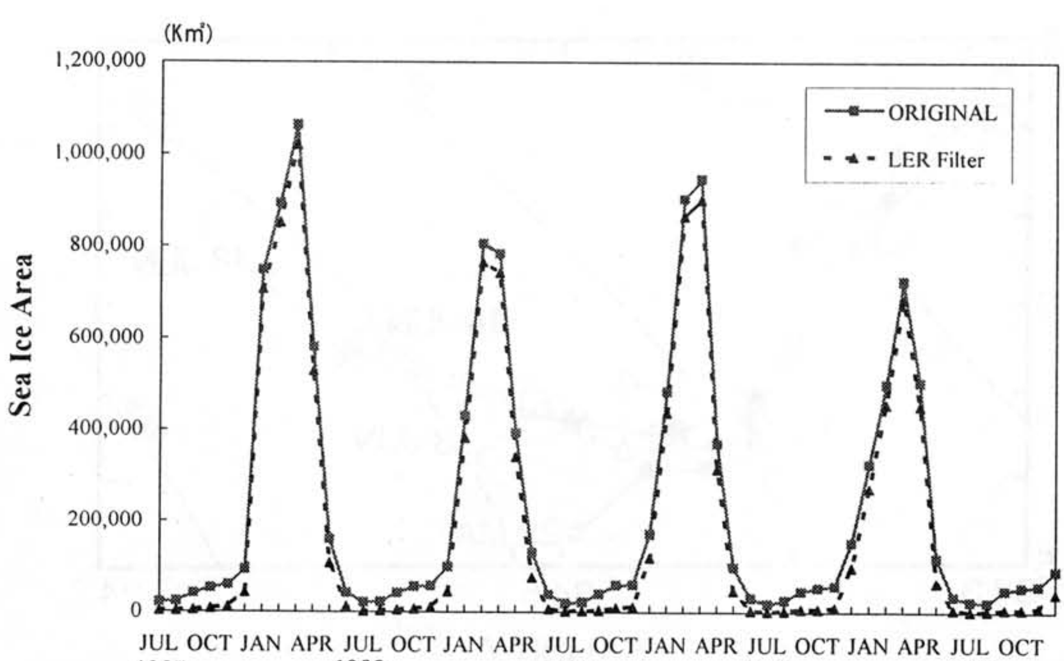

Figure 1. Inter-annual variation of the sea ice area in the Sea of Okhotsk derived from SSM/I data using Comiso Algorithm.

P I -17

Sea ice extent in the Okhotsk Sea related to global warming

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P I -18

Relation between the variation in the Arctic sea-ice distribution and the atmospheric circulation

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(Hirosaki University, Japan)

Possible relation between the Arctic sea-ice distribution and the atmospheric circulation has been investigated by analyzing gridded data of sea- ice concentration (by NASA) and upper air observations (by NMC) for the summer season (May - August) of the years 1979 - 88. It has been found that variation in the sea-ice concentration in the Barents Sea (which shows the maximum interannual variation) is closely related with the atmospheric circulation of the northern Hemisphere : When the sea ice cover is more extensive in the Barents Sea, the westerlies (jet stream) at the 500 hPa level splits into two streams over the Far East region (to the west of Sea of Okhotsk), being associated with southward intrusion of the cold Arctic air through the Bering Strait. Also, both the 500 hPa surface height (Z500) and air temperature at the 850 hPa surface (T850) are higher than usual over the Gulf of Mexico and its surroundings. On inspecting the lagged correlations, it has been suggested that the lower temperature (T850) and lower pressure (Z500) over the Barents and Kara Seas is preceded , after some 20 days , by the increase in the sea-ice concentration in the Barents Sea, and then, after 20-30 more days, by the rise in T850 and Z500 over the Gulf of Mexico.

P I −19

Numerical simulation of Labrador polar low formed off the east coast of Canada

Kazuhisa Tsuboki (Ocean Research Institute, University of Tokyo)

1. Introduction

Polar low is a mesoscale cyclone generated and developed in a cold air streams of the polar airmass. Its horizontal scale is 100 $\sim$ 1000 km and it forms over the sea. The prediction of polar low genesis, therefore, is difficult, while a polar low brings a severe weather to a coastal region. Labrador sea is a region where a polar low frequently develops in winter. In order to study storms including polar low along the east coast of Canada, CASPII (Canadian Atlantic Storms Program II) were conducted from January to March 1992. During this program, several cases of Labrador polar low were observed. We will present in this paper results of numerical simulation of one of Labrador polar lows observed in CASPII.

2. Case study of a polar low

Figure 1 is a NOAA satellite image showing a Labrador polar low observed during the period from 14 to 15 February 1992. A cloud vortex with its horizontal scale of 600$\sim$700 km is significant off the west coast of Greenland. The polar low developed in a cold air stream of polar airmass behind the synoptic-scale cyclone. An upper cold trough was extending to the Labrador sea and the polar low developed below this cold trough.

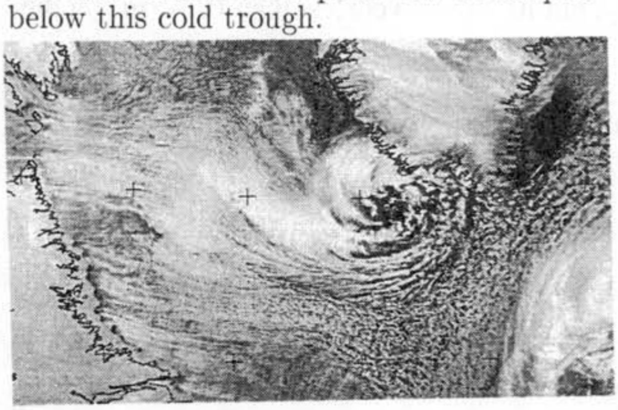


Fig.1 Satellite image of Labrador polar low at 16:50 UTC, Feb. 15, 1992

3. Result of simulation

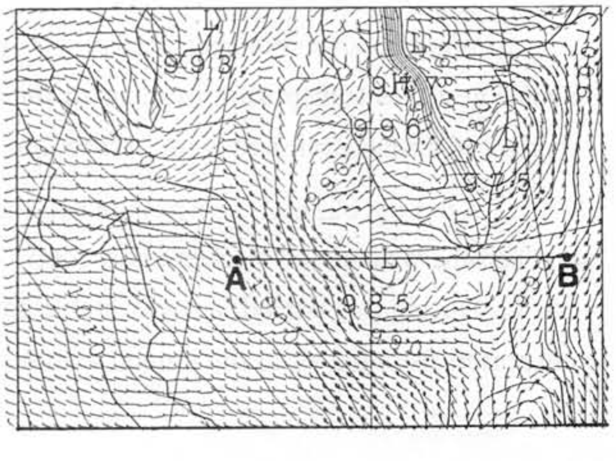
A prediction experiment of the polar low was performed. The simulation showed the development process of the polar low. Figure 2 shows a simulated polar low at 15 hours from the initial value of 00 UTC, February 15, 1992. A polar low with its central pressure of 985 hPa was predicted off the west coast of Greenland. The simulated polar low was developed along a convergence zone formed off the west coast of Greenland. The maximum vertical motion was present at a level of 850 hPa and the polar low extended to 600 hPa.

Some sensitivity simulations showed that Greenland strongly affected movement of the synoptic-scale cyclone and that surface fluxes of latent/sensible heat and diabatic heating due to condensation are important for the development of the polar low.

4. Summary

This study was performed as a part of the Canada-Japan collaboration. There are many common features between the Labrador polar low and a polar low over the sea of Japan: vortex cloud, horizontal scale, synoptic condition and upper cold low as well as their geographical conditions. Some common mechanisms between these polar lows were also suggested.

Fig.2 Simulated surface pressure and wind at 15 UTC, Feb. 15, 1992



P I -20

Characteristics of fluctuations of wind speed and air temperature in Canadian Arctic in winter season

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We observed wind and air temperature near the ground at the aerological station in Cambridge-Bay, North-west Territories, Canada (69.3 N, 105.0 W) from 23rd of January to 6th of February, 1994, to make clear the characteristics of the fluctuations and momentum and sensible heat fluxes between the atmosphere and the surface of the earth when a cold air mass formed in a Canadian Arctic's winter season. We measured horizontal and vertical wind velocities, and air temperature by an ultra sonic anemometer (WAT-395, Kaijyo), and recorded them by a digital recorder (DR-F1, TEAC) with 1 to 10 Hz sampling time, and then we calculated fluxes of momentum and sensible heat with 10 minutes averaging time.

We had a fine and calm weather, that is, high air pressure (more than 1020 hPa), low temperature (below -35 ℃), and weak wind (below 5 $m \cdot s^{-1}$) from 23rd to 28th of January at the weather station of air port which is situated 4 km west-north-west from the aerological station. During this period, air was stable condition and became sometimes unstable near the ground, but it was reported that there was strong surface inversion (0.02 - 0.10 $℃ \cdot m^{-1}$) under 1,000 hPa surface (100 - 250 m high) from sonde observations. Sensible heat was transported from air to the ground and sometimes conversely, but its values were less than 10 $W \cdot m^{-2}$ at the aerological station.

Wind became stronger (5 - 10 $m \cdot s^{-1}$) and air temperature reached -22 ℃ after 28th, and sensible heat was transported from air to the surface with 10 - 20 $W \cdot m^{-2}$. After that, we experienced a severe blizzard from 31st to 2nd, and could not observed fluxes.

After the blizzard, air pressure became higher rapidly (from 1,000 to 1,030 hPa), but wind became weaker and reached under 5 $m \cdot s^{-1}$ and air temperature droped gradually down to - 38 ℃. During this period, air was stable condition near the surface, and sensible heat was transported from the air to the ground with less than 20 $W\ m^{-2}$.

P I -21

COLD AIR FORMATION MECHANISM IN ARCTIC CANADA

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The most important formation factor of cold air is considered to be radiative cooling of the surface. Automated weather observations were carried out in Cambridge Bay and Resolute at 10 min time intervals for a seven month period from October 1992 to April 1993 in order to measure air temperature and its vertical gradient at the surface.

The results showed depressions of air temperature accompanied by a negative gradients of vertical air temperature distribution, which indicated that air temperature increased with height. In some cases, the negative gradients of air temperature are thought to be caused by radiative cooling, while in other cases, a warm air advection or subsidence of upper air may have caused the negative gradients.

To ascertain the factors causing a negative gradient of air temperature, further observations were carried out to measure the vertical profile of air temperature and wind velocity at heights of 20m, 40m and 66m of a radio-beacon tower in Cambridge Bay in addition of same kind of the observations as described above.

In the case of a relatively abrupt temperature depression, with a V-shape pattern, in early winter, negative vertical gradients of surface air temperature were observed at the later stages of the depression. In the later stages of the depression, the vertical profiles of air temperature obtained by the tower began to change to ground inversion type from 66m, 40m to 20m in turn,while in the early stages of depression it was kept in ordinal profile of almost dry adiabatic lapse rate with advection of cold air. On the other hand, in the case of a relatively long-lasting temperature depression, with a U-shape pattern, near mid-winter, negative vertical gradients of surface air temperature were observed over the whole or most of the duration of the depression. The ground inversion was observed from the measurements by the tower and considered to be formed by radiative cooling mechanism.

The former and latter cases are thought to be caused by cold air advection and radiative cooling mechanisms, respectively. Cold air advection and radiative cooling mechanisms are also thought to be involved in the sink effect and origin effect of cold air, respectively. Climatological properties are discussed, comparing the measurements from Resolute and Cambridge Bay by utilizing of the determinants of sink and origin.

P I -22

A Study of Polar Vortex and Recent Abnormal Weather in the Arctic

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Because the Arctic is the thermal sink of the Northern Hemisphere, a polar amplification of the greenhouse warming would change the various meteorological elements, for example, surface pressure and temperature in the Arctic.

Walsh (1994) shows that the 24-month running mean of the vorticity (Laplacian of sea level pressure) over the polar cap, 80° − 90°N has increased during the late 1980's. The annual mean field of Arctic sea level pressure is dominated by an anticyclonic gyre in the vicinity of the Beaufort Sea. So, there is negative vorticity (high pressure) over the polar cap except during summer. While Walsh's result shows that the regional mean vorticity over the polar cap tends to be positive in recent years. It suggests a change to more frequent occurrence of cyclonic circulation patterns near the pole.

In this study, we use JMA Global analysis during 1990 to 1994, and calculate the regional mean volticity over the polar cap at 4 vertical levels (1000, 850, 500, 200hPa). The regional mean vorticity over the polar cap for 1000hPa shows positive value through the 1990 to 1991. Especially during the spring, the Beaufort High tends to disappear in recent years. We will analyze the relation between the variation in the Polar vortex and recent abnormal weather in the Arctic.

P I -23

BASE (Beaufort and Arctic Storms Experiment) Project in the Canadian Arctic

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BASE (Beaufort and Arctic Storms Experiment) project had been carried out over the southern Beaufort Sea and Mackenzie Delta in Northwest Territories (N.W.T.), Canada, during the fall of 1994. A number of storms advected to this region in the observation period. The purposes for the BASE are to better understand the weather system in this region and the climate impaction of these weather systems. As a part of "Monbusho International Scientific Research Program (Influence of the Arctic on mid-latitude weather and climate, Principal Investigator; Prof. R.Kimura)", an radar observation using a polarmetric Doppler radar of Hokkaido University, Japan, was carried out at Tuktoyaktuk (69°27'N,133°02'W).

During the BASE period, 13 IOPs (Intensive Observation Periods) were carried out. The IOPs were decided by the disturbances over the BASE area. These disturbances were classified as 4 types by the synoptic situations. In this paper, however, two types of disturbances of "Pacific Origin" and "Storm Track" types will be described. "Pacific Origin" means the storms are originated over Pacific Ocean and "Storm Track" means that they are originated in the Arctic Area to move over the observation site. We would like to introduce the typical cases for the each type of disturbance.

The "Pacific Origin" storm (September 15-16, 1994): Two major lows existed stationary over the Alaska Gulf and the northern Beaufort near the BASE area. Arctic front also existed stationary between them. A pressure depression was spawned by the Pacific low over the eastern Alaska. This depression moved eastward and rapidly deepened by taking into the Arctic front. This depression approached southward of the radar site from west to east. Radar echoes of this depression with weak reflectivity but strong vertical wind shear were observed at Tuktoyaktuk. Using a VAD (Velocity Azimuth Display) analysis method, two layered air mass with the front of 2-3km a.s.l. in height was clarified. Southerly wind and weak stationary precipitation were dominated in the upper layer. Synchronized with the movement of the depression, an easterly and dry air invaded into the lower layer from the inland at first. And then the wind direction in the lower layer gradually turned to northerly and the wet air was invaded from the Beaufort Sea. When the dry air intruded, precipitation was evaporated in the lower layer and it did not reach on the ground. On the contrary, when the wet air intruded from the Beaufort Sea, weak precipitation from the upper layer rapidly enhanced in the lower layer.

"Storm track" (September 26-27, 1994): Zonally extended open sea was observed along the northern coastline of the Alaska. Cold air outbreaks were appeared from the inland Alaska and the sea ice field in the Arctic Sea. The convergence zone originated both outbreaks recognized over the open sea by he satellite. By our radar observations, band shaped echoes appeared one after another at about three hours interval. These band shaped echoes showed a meandering structure. When the echoes passed over the radar site, drastic changes of wind speed and direction and temperature were recorded at the surface. It was surmised from these features that these band shaped echoes were formed by the front associated with a transformation by the cold air outbreaks from the inland Alaska over the open sea. Subsequently, they formed a meandering structure by the strong horizontal wind shear.

P I -24

The relationship of chemical components among atmospheric aerosols, gases and snowfall in Spitsbergen

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We have analysed vertical profiles of chemical components contained in ice core in Spitsbergen. Little is known, however, with respect to atmospheric transport and origin of the snow and ice chemistry. Therefore we observed aerosols, gases and snowfalls at the same time around Ny-Ålesund, northwest part of Spitsbergen (78 ° 56'N, 11 ° 52'E, 35m a.s.l) and measured each of their Cl^-, NO_3^- and SO_4^{2-} concentration. This time we report the preliminary results.

The observation of aerosols, gases and snowfalls was conducted from 18th February to 10th March, 1995. Aerosol samples were collected at the different two hights. One was done at Rabben in Ny-Ålesund in order to collect ground level aerosols with two stage impactor for about three days. Another was done at the top of Zeppelinfjellet (2.6km south of our station, 554m a.s.l) with gases sampling. Each of sample was continued to vacume the air for two days into the cascade air filter system which was constructed one paper filter and three alkaline papar filters. Snowfalls were collected at near our station and the northern foot of Zeppelinfjellet (42m a.s.l) every 4 hours in a period of precipitation. But it was too hard wind to collect the snowfall at the top of the mountain.

The variations of concentration of aerosols collected near our station were similar to them at the top of Zeppelinfjellet except SO_4^{2-}. Concentration of SO_4^{2-} aerosol at the top of the mountain was about one hundred times larger than that of ground level. We considered the high concentration was caused that the mountain peak was included in surface inversion layer in the most of our observation period. There was only one period of precipitation in the observation and then Maximum concentration of Cl^- aerosol at the summit and Minimum concentration of all three kind of gases were appeared. This phenomenan indicated to washed out gases more effectively than aerosols in the period of precipitation. Whereas the significant concentration of NO_3^- and SO_4^{2-} aerosols at the surface represent just earlier than those of snowfall and low concentration of their surface aerosol was shown in the snowy days. The different construction of washing out exist each period of precipitation.

PⅡ-1

Formations of the Cold Air Mass in the Canadian Arctic Area

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R.Kimura and K.Tsuboki (Ocean Research Institute, University of Tokyo)

To well understand the processes of the cold air mass formation in the Arctic area is useful for the understanding of the global weather system and the global climate change problem and the influence of the Arctic to the mid-latitude areas. As a part of "Monbusho International Scientific Research Program (Influence of the Arctic on mid-latitude weather and climate, Principal Investigator; Prof. R.Kimura)", energy budget observations and analyses were carried out in the Canadian Arctic Area.

The climatological chart indicates that a very cold area compared with the same latitudes exists in the central of Northwest Territories (N.W.T.) in Canada during the mid-winter. It also indicates that the north-westerly wind blows over this area because of the effect of many mountains along the west coast of North American continent and the Greenland.

Using aerological data from September 1992 to March 1993 in Canada, energy budget analyses (the total energy budget, horizontal divergence over the surface to 850hPa layer and 850hPa to 500hPa layer) were carried out with making three triangles over near 75°N (Region A), 70°N (Region B) and 60°N (Region C) along the 100°W line in N.W.T. In the north (Region A), the cold air was formed by the radiative cooling in the lower layer and it was invaded to the upper layer and carried to the south (Region C). In the Region B, both effects of the cold air advection from the north and surface radiative cooling lowered the temperature near the surface.

Energy budget observations were carried out at Cambridge Bay in the central north of N.W.T. through January to February, 1994. It was clarified that a subsiding warm and very dry air existed over 1km a.s.l. in height when a ridge passed over the observation site and wind was relatively weak. Below 1km a.s.l., a strong inversion was formed by the surface radiative cooling. The relative humidity indicated the saturation in the strong inversion layer. The very cold air was accumulated inside the inversion layer. On the contrary, strong winds, clouds and blizzard were observed during the passage of trough. The strong inversion was destroyed during the passage of trough. After that the whole layer was cold and moved to the south.

PⅡ-2

Ice Crystals and Snow Crystals Observed in Arctic Canada

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From 14 January to 6 February in 1994 and from 4 March to 19 March in 1995 ice crystals and snow crystals were observed at Cambridge Bay and Inuvik, respectively, in Northwest Territories, Canada.

Dense ice fog was observed frequently at Cambridge Bay and observed ice crystals were of various types including fragaments of ice crystals, hexagonal or non-hexagonal plates, poly-crystal plates, long prisms and polyhedral crystals. Among them fragaments of ice crystals, which had comparatively rounded shapes and amounted to more than 50% in most cases, were inferred to be those of blowing snow. Observed ice fog was classified to two types: one in which long prisms were distinguished and the other in which polyhedral crystals were distinguished.

At Inuvik ice crystals grown at an early stage of ice fog formation were observed. On 9 March in 1995 thin ice fog came out at about 21:30 and disappeared at about 23:00. It was calm and air temperature dropped to about -29℃. About 52% of ice crystals were thin plates of non-hexagonal trigonal symmetry, only 1% were thin plates of hexagonal symmetry, 5% were long prisms and about 10% were poly-crystals.

Snow crystals observed during these periods were those of low temperature types and those grown at temperatures between -10 and -20℃; they were all of the types which had been observed by several workers. However, it was found that their shapes including gas enclosureses and surface markings suggested remarkable low temperature habit of snow crystals.

This study was carried out by the support of Monbusho International Scientific Research Program (Project "Influence of the Arctic on mid-latitude weather and climate", No.04041029).

P Ⅱ -3

Observations of winter clouds and precipitation in Ny-Ålesund, Svalbard

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Many observations for meteorology in the atmosphere and chemical measurements of snow cover had been planed in Ny-Ålesund from winter to spring of 1994 and 1995 by the groups of Norway, Germany, Japan, and so on. In the environment our Japanese group carried out observations of aerosols, clouds and precipitation in the atmosphere and collecting falling and accumulating snow. An objective of our groups is a study having a knowledge of the relation between some aerosols in the atmosphere and in the snow and characteristics of meteorological phenomena, especially, clouds and precipitation. Our presentation, in which we would like to show the characteristics of clouds and precipitation in Ny-Ålesund, is a part of the studies.

An intensive observation for clouds and precipitation were carried out from 10th February to 15 March 1995. Main instruments for the observation are a 3 cm vertical pointing radar, a 37 GHz Microwave radiometer, an infrared radiation thermometer, a special snowfall gauge using electric balance, a video camera recording snow crystals continuously, and an electric field meter.

There were three periods of precipitation in the observation periods. The first one was from 11th to 15th February. In this case the prevailing wind was from north in the troposhere except near surface and air temperature was relatively cold. The second one was from 5th to 8th March. The wind was not so strong in the troposphere except high altitude(over 150 hPa) and air temperature near the surface was a slightly warm. A high pressure was seen near the Svalbard according to the surface weather map. The last one was from 11th to 15th March. A strong cyclone came over Svalbard and passed away to the north east. The prevailing wind was from south and strong wind was blowing in the 11th and 12th March in the troposphere. The air temperature suddenly went up in the layer from the surface to 500 hPa altitude. The characteristics of the clouds and precipitation in each periods will be reported. Especially, the following items below in each period will be presented and discussed:

*the characteristics of echoes , *e.g.* echo top and echo structure, from radar observations,

*the super cooled liquid water contents in the cloud from microwave radiometer,

*the snow crystal sizes and types, which would relate to the capturing rate of some aerosols,

*the electric field, by which clouds could be classify as convective and stratiform type clouds.

P II -4

Large Variability of Radiation Budget in the Greenland Sea Sector, Arctic

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Radiation budgets in the maritime Arctic are discussed using the surface radiation measurements at Ny-Alesund, Svalbard, and Earth Radiation Budget Experiment (ERBE) satellite data at the top of the atmosphere. The surface radiation fluxes have been measured for a long time since 1974 by Norwegian Polar Institute at Ny-Ålesund over tundra surface. Since the site is on the island, downward fluxes are regarded as typical for the Greenland Sea. Scanner data from ERBE measurements covering polar region from NOAA 10 are used for the present analysis. Both data in 1987/88 are used in the discussions.

The downward longwave radiation at the surface shows a large daily variation in winter. The range is as great as 150 W/m^2, from about 150 W/m^2 under clear sky to more than 300 W/m^2 under overcast sky in some cases. This great variation in winter is due not only to the variation of cloudiness but also to the variation of airmass surrounding Ny-Ålesund. Larger downward longwave radiation with high cloudiness and warmer temperature accompany maritime airmasses; smaller radiation with low cloudiness and colder temerature accompany the Arctic airmass. In summer, the downward longwave radiation has a small range and the difference between clear and overcast is small, while cloud mount isvery high.

At the top of the atmosphere in winter, latitudinal dependence of the outgoing longwave radiation (OLR) is constant from 90° N to 65° N in the Siberian coast, shows some decrease to the minimum over Greenland about 130 W/m^2, and shows rapid increase from 156 W/m^2 at 90° S to 190 W/m^2 at 70° S for the Greenland Sea sector. This large OLR at the higher latitude is due to small sea ice extent, and also due to intrusion of warm air from lower latitude. Standard deviation gradually increases with the decrease of latitude, except for the Greenland Sea sector, where abrupt increase are seen at 75 - 80° S, up to 20 W/m^2. These high standard deviations are comparable to those at 50° S over Southern Ocean near Antarctica.

PⅡ-5

Polar Stratospheric Clouds Observed by a Lidar at Ny-Ålesund in the winters 1994 and 1995

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Polar stratospheric clouds (PSCs) are observed by a lidar at Ny-Ålesund, Spitsbergen in January and February 1994, and December 1994 and January 1995. The lidar observes backscattering at 1064 nm and 532 nm, and depolarization at 532 nm. In the first winter of January and February 1994, the increase only in depolarization was found in a few days of the late January. The layer width was about 1 km. Then PSCs once disappeared, and was observed again in the end of the February. In this time both backscattering and depolarization showed significant enhancement.

In the December 1994 and January 1995, the temperature in the stratosphere was lower than of the former winter, and the PSCs were very often observed. There were two periods of PSCs enhancement. The first was about a week in December, and the second was about two weeks in January. The profiles of PSCs were very variable in these periods, and the lidar observed characteristics of PSCs were also very variable. In some cases the characteristics of the lidar observed PSCs in this winter are rather different from the lidar observed PSCs characteristics that are classified into three types.

P II -6

Variation of Arctic Stratospheric Aerosol Observed by Balloon–Borne Particle Counter, Ny–Aalesund in 1994/1995

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Abstract

Concentrations and size distribution of stratospheric aerosol were observed by balloon-borne optical particle counter (OPC sonde) during winter in 1994/95 at Ny–Aalesund (79°S, 12°E). OPC sondes measure number concentration of aerosol with 5 channels, larger than 0.3, 0.5, 0.8, 1.2, and 3.6 um in diameter. The operations were made in cooperation with Alfred Wegener Institute, Germany. Lidar measurements was also made at Ny–Aalesund from December 1994 to March 1995.

Figure 1 shows vertical profiles of aerosol concentrations. Temperature condition suggest that each of these 3 profiles shows different stage of variation of Junge layer and PSCs. We can identify two differnt layer through three observations. One is main part of Junge layer and the other is top boundary of Junge layer.

At the top of Junge layer, above 17 km, very high concentration for 0.3 um class was observed compare with regular concentrations, but no enhancement were found in other size classes on Dec. 14. Typical PSCs was observed on Dec. 18, and was not found on Jan. 17 in spite of simillar temperature conditions.

In the main layer, enhancement for the 0.3 um and 0.8 um classes were found on Dec. 14, however, temperature is higher than saturation point of Nitric Acid Trihydrate (NAT). On Dec. 18, temperature is lower than saturation point of NAT, but typical PSCs was not found. However, total volume of aerosols were larger than back-ground conditions, and several of giant particles, larger than 3.6 um, were found. Similar results were obtaind on Jan. 17, however total volume is half of that observed on Dec.18.

Difference between top and main Junge layer will be caused by different amounts of pre-existence particles and other condition difference. We will discuss the role of pre-existence particle for the PSCs formations and material transport in the Arctic winter stratosphere, on the basis of relation among nitric acid gas and many kinds of stratospheric particles.

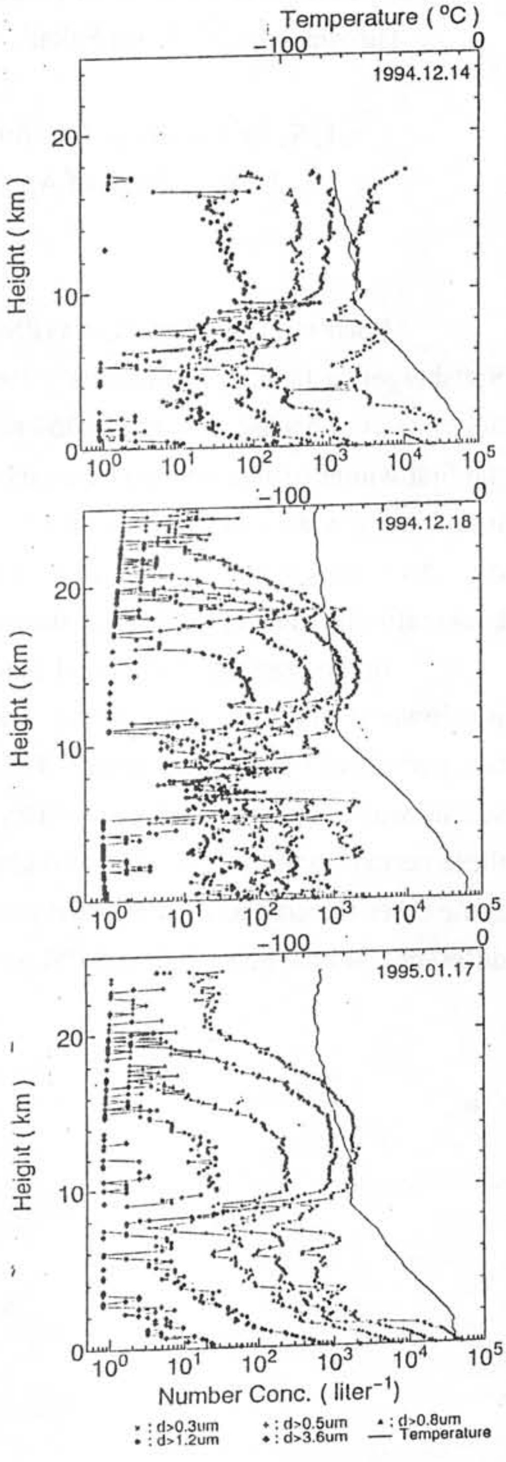

Figure 1 Aerosol profiles observed at Ny–Aalesund by balloon–borne particle counter.

P II -7

Arctic Aerosol Chemistry at Ny Ålesund, Spitsbergen in 1994/95 Winter

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Abstract

Aerosol samples were obtained from Ny Ålesund, Spitsbergen, Norway during winter of 1994/95. The aerosol sampling was planed to compare with vertical distributions of aerosol concentrations from Lidar and balloon-born Optical Particle Counter measurements made by Nagoya University and Fukuoka University, and snow chemistry measurements made by NIPR.

A two stage impactor sampler (cut-off diameter, > 2.3 μm & > 0.2 μm) with a back-up filter (PTFE Omnipore, 0.2 μm pore size) was used for aerosol sampling at 2-m above ground level. Aerosols were collected on clean aluminum sheets. About 2 m^3 air was sampled at a flow rate of 1L/min. The samples were leached by 5-min ultrasonic treatment with 14 ml of Milli-Q water. Water soluble ions were measured by an ion chromatography (Dionex, DX-300) equipped with AS11 and CS12 separation and guard columns and 500 μl injection loops.

Figure 1 shows variations in chemical concentration levels of aerosols in Arctic air from January to March, 1995. Variations in atmospheric concentrations of Cl^-, Na^+, K^+ and Mg^{2+} correlate well and shows sporadically high levels, indicating occasional transport of sea-salt aerosols from southern latitudes. Variations of SO_4^{2-} and NH_4^+ concentrations correlate well with occasional low concentration levels, suggesting frequent Arctic haze contributions from February. Trends in concentration levels of NO_3^- and Ca^{2+} do not correlate well with sea-salts and Arctic haze components. This implies that NO_3^- and Ca^{2+} are non-sea-salt and non-pollutant in origin.

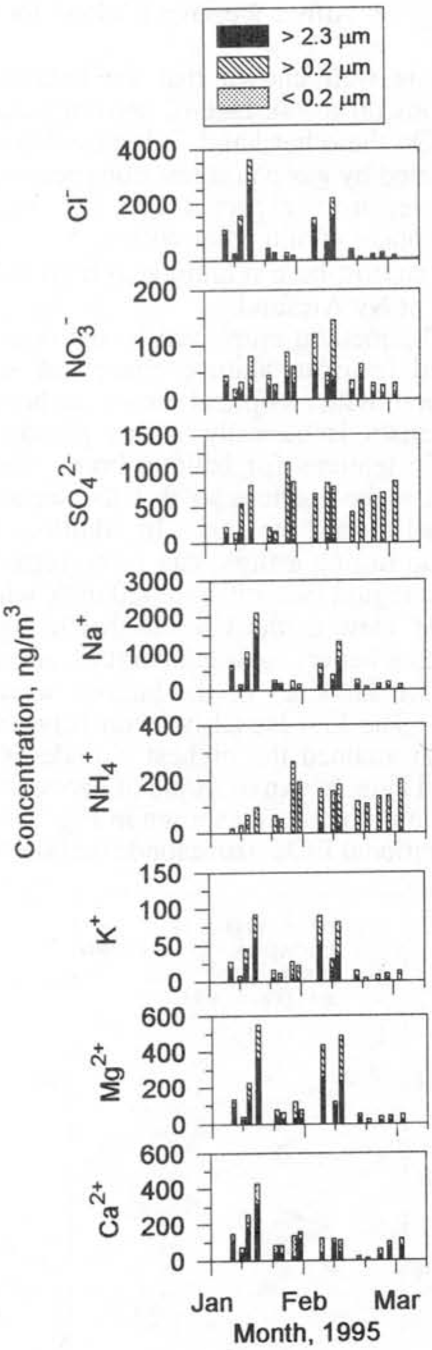

Figure 1 Variations in atmospheric concentration levels of major ionic components in Arctic aerosols.

P II -8

Observation of Ozone Profiles in the Upper Stratosphere at Ny Alesund Using a UV Sensor on board a Light Weight High Altitude Balloon

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It is well known that the antarctic ozone hole is caused by heterogeneous chemical reactions on the surface of aerosol particles and the ozone depletion region is below about 25 km. On the other hand, it is possible that the ozone depletion in the northern hemisphere is originated by gas phase reactions between ozone and ozone destroying molecules; and if this is the case, it is expected that the ozone depletion will appear most clearly in the upper stratosphere within polar vortex. Since there have been no observations of ozone profile in the upper stratosphere at latitude as high as 80 degrees, we have intended to start measurements of ozone at Ny Alesund.

The method employed in the present observation is as follows: A profile of ozone is derived from an altitude change of solar UV radiation at ozone Hartley absorption band measured with an optical sensor on board a BT5 (5000 m^3) light weight high altitude balloon. The sensor is basically a filter photometer at UV region (wavelength 302 nm) with some specific features for balloon borne measurement. First, a diffuser plate made of Teflon is placed at the aperture so that the sensor can measure solar UV radiation even if it does not directed toward the sun. In addition, variations of UV signal due to attitude change of the payload during a flight can be corrected by simultaneous monitoring of the light intensity in visible region (wavelength 420 nm), which is not affected by ozone absorption, with the same field of view to the UV channel using a beamsplitter. The weight of the sensor is 1.1 kg including battery. Air temperature of the sensor are measured along with the optical signals.

Two launches of the balloon were successfully made at Ny Alesund in the summer of 1994. The first launch was on July 23 and the second launch was on July 27, 1994. The balloon attained the highest altitude of 43 km and 43.7 km, respectively, for the first and second launch. An example of ozone profile derived from the July 23 observation is shown in Fig. 1 and the profile shown in Fig. 2 is a result from simultaneous measurement made with a conventional ECC ozonesonde on board the same flight for comparison.

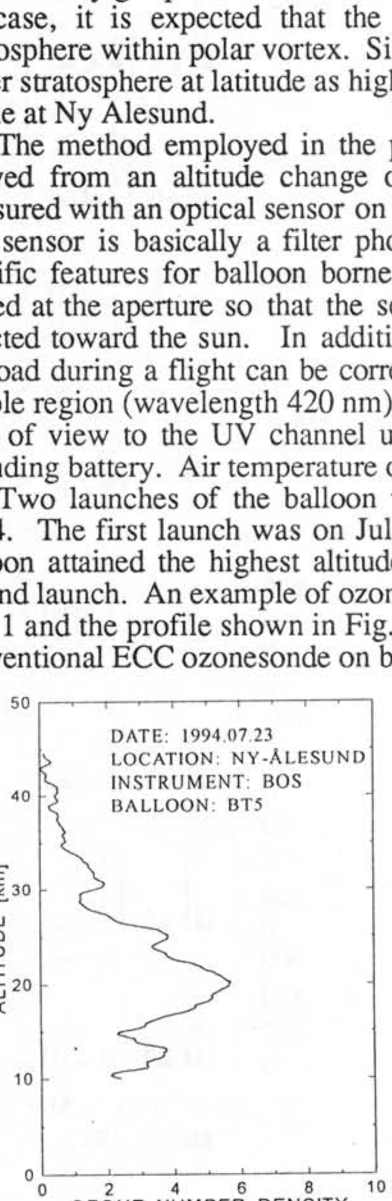

Fig.1 Ozone profile on July 23, 1994 obtained with an optical method

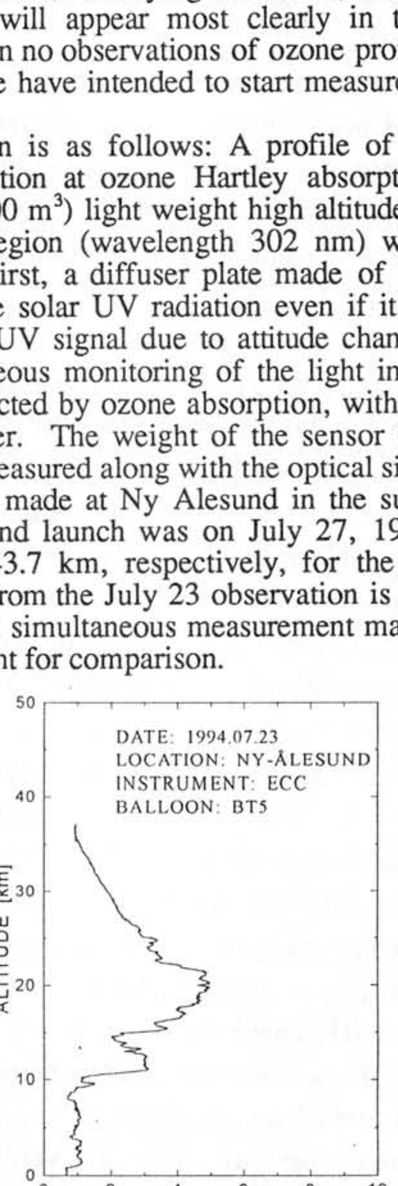

Fig.2 Ozone profile obtained with an ECC for the same flight as in Fig.1.

P II -9

Atmospheric concentration of ^{210}Pb and ^{210}Po in Ny-Ålesund, Svalbard

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Introduction

Atmospheric ^{210}Pb (half-life 22.3yrs) and ^{210}Po (half-life 138days) are useful tracer of terrigenous aerosols because they are almost radioactive decay products of atmospheric ^{222}Rn which are emanated from land surface (Turekian *et al.*, 1989). Furthermore, the activity ratio of these nuclides provide the atmospheric residence time of aerosols, because theses nuclides grow in aerosol surface and the $^{210}Po/^{210}Pb$ ratio in aerosol increases with elapsed time (Warneck, 1988). Here, we report the results of ^{210}Pb and ^{210}Po measurements on aerosol samples which have been obtained from Ny-Ålesund, Svalbard and discuss the temporal variation of specific activities and activity ratios of these nuclides.

Method

Daily aerosol samples were collected from 24 February to 14 March, 1995 by using a hi-volume air sampler which was set on the roof of the Arctic Environmental Research Center, NIPR at Ny-Ålesund, Svalbard (78°56'N, 11°52'E, 35m asl). Activities of ^{210}Po and ^{210}Pb in the aerosol samples were measured by α-spectrometry after suitable chemical separation.

Results and discussion

Daily variation of atmospheric concentration of ^{210}Po and ^{210}Pb are shown in Fig. 1. Maximum concentration of ^{210}Pb, 1200 mBq/1000m^3, was observed in 3 March. On the other hand, the concentration of ^{210}Po showed maximum value, 56.9mBq/1000m^3, in 2 March. The $^{210}Po/^{210}Pb$ activity ratio in 3 March was 0.09 while the ratios of other days were 0.19-0.25. This indicates that the aerosols in 3 March are clearly younger than those in other periods. We also found that the positive correlation between the concentration of ^{210}Pb and pressure gradient was statistically significant at 1% of significance level (r^2=0.72, ϕ=16, P=0.01). Sporadic change of concentrations and ratios of these nuclides may be due to rapid intrusion of continental high into the surface atmosphere over the site.

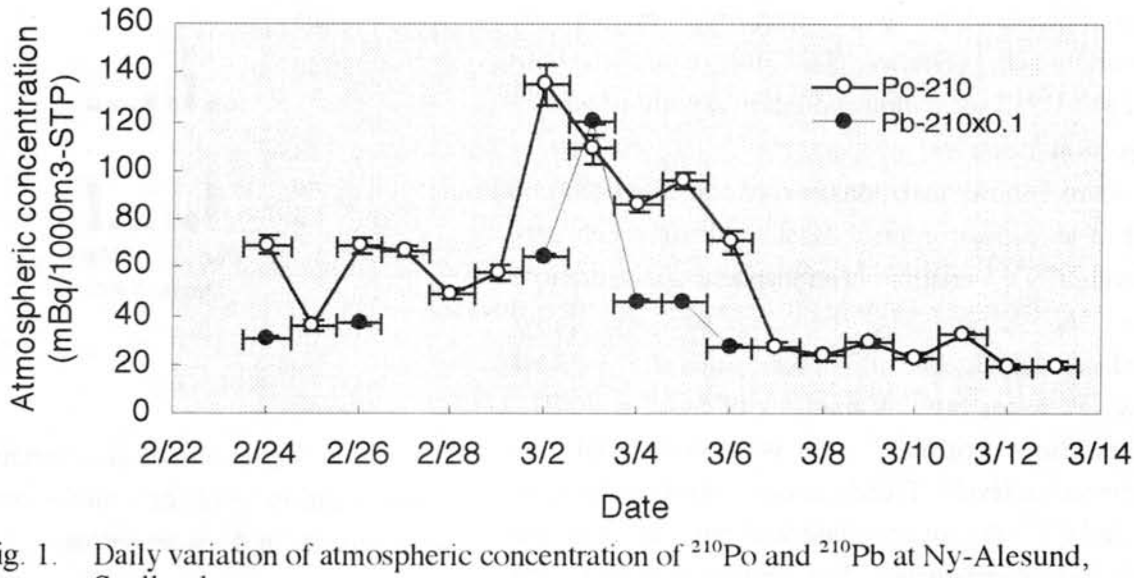

Fig. 1. Daily variation of atmospheric concentration of ^{210}Po and ^{210}Pb at Ny-Alesund, Svalbard.

P II-10

Aerosol and Snow Chemistry near Fairbanks, Alaska in 1995 Spring

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Abstract

Aerosol and deposited snow samples were obtained at Poker Flat Research Range near Fairbanks, Alaska from February to April 1995. Two depth profiles of deposited snow chemistry were also obtained from Ester Dome near Fairbanks in February and March. The air and snow sampling were planed to study air-snow chemical fractionation and to compare with vertical distributions of aerosol concentrations from Lidar measurements made by collaboration of STEL/Nagoya Univ. and GI/UAF.

A two stage impactor sampler (cut-off diameter, > 2.3 μm & > 0.2 μm) with a back-up filter (PTFE Omnipore, 0.2 μm pore size) was established for aerosol sampling at 3-m above the ground level of Climate Monitoring Laboratory at the Poker Flat research Range (394 m a.s.l.). Aerosols were collected on clean aluminum sheets. About 3 m^3 air was sampled at a flow rate of 1L/min. The samples were leached by 5-min ultrasonic treatment with 14 ml of Milli-Q water. Water soluble ions were measured by an ion chromatography (Dionex, DX-300) equipped with AS11 and CS12 separation and guard columns and 500 μl injection loops.

Figure 1 shows variations in chemical concentration levels of aerosols in central Alaskan air from February to March, 1995. Variations in atmospheric concentrations of Cl^-, Na^+, K^+ and Mg^{2+} correlate well and shows sporadically high levels, but Cl^-/Na^+ ratios show values below sea water ratio. Variations of SO_4^{2-} and NH_4^+ concentrations correlate well with occasional low concentration levels. Trends in concentration levels of NO_3^- and Ca^{2+} do not correlate well with sea-salts and Arctic haze components. This implies that NO_3^- and Ca^{2+} are non-sea-salt and non-pollutant in origin. These chemical signatures of central Alaskan aerosols are essentially similar to those collected at Spitsbergen.

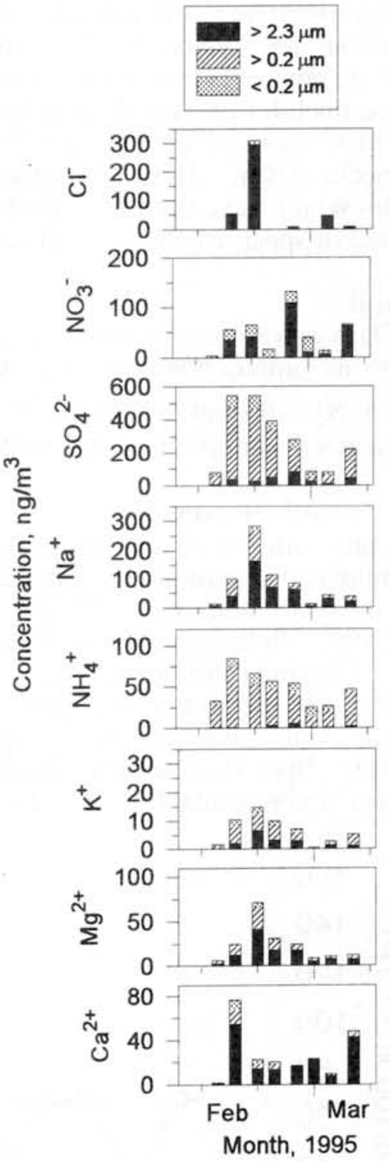

Figure 1 Variations of atmospheric concentration levels of soluble ionic constituents in Alaskan aerosols.

P II -11

Environmental fluctuation traced from in situ measurement of snow and ice samples in Northern part of Svalbard

Kokichi Kamiyama[1], Hideaki Motoyama[1], Hideki Narita[2], Sumito Matoba[1] and Okitsugu Watanabe[1]

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The glaciers in the Svalbard Islands are located in the northern Arctic and are influenced by the environments surrounding the Arctic. In these years, Japanese Arctic Research Expedition (JAGE) have tried to carry out the glaciological research in taking snow and ice samples.

In 1995, we will try to make the coring of the glacier at the summit of Vestfonna (21° 00' E, 79° 50' N, 500 m a.s.l.), Nordaustlandet as below.

Main purpose: Tracing the environmental change in the Arctic with the glacier core and snow.
Target: Coring the glacier at the summit of Vestfonna, Nordaustlandet, Snow sampling at the coring site
Coring depth; no less than 200 meters from the glacier surface
Duration of the operation on the glacier; 4 weeks
The beginning of expedition; Early May, 1995

On the glacier, we will make snow and ice sampling below.
Snow sampling: snow precipitation and accumulated snow walls
Ice sampling: ice core

Some analytical works will be carried out in situ as soon as posssible.
ECM mesurements for ice core
Electrical conductivity and pH measurements for snow and ice core
UV transparency measurements for snow and ice core

Now we are preparing the expedition and will be much pleasure to make some presentation just after our expedition.

P II -12

Characteristics of Snowmelt Heat Balance at Ny-Alesund, Spitsbergen Island

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Heat balance observations were carried out at Ny-Alesund, Spitsbergen Island during the snowmelt seasons (from late of May to middle of June) in 1993 and 1994 in order to understand the characteristics of snowmelt heat balance at high latitude by comparing the heat balance components at the snow surface before and after snowmelt initiation.

In the snowmelt period, air temperature was higher than that of pre-snowmelt period. Daily mean temperatures during the snowmelt period were about +3〜4° C, and daily minimum temperatures never fell down below 0° C. Water vapor pressure was also higher than that of pre-snowmelt period. Albedo of the snow surface was relatively high, and remained higher than 0.6 even in the snowmelt period.

The main factor to the snowmelt heat source was net radiation in both years. The net radiation in the snowmelt period was about 20Wm^{-2} larger than that of pre-snowmelt period, however, the shortwave radiation budget was almost constant. The heat loss by longwave radiation budget in the snowmelt period was less than that in the pre-snowmelt period and consequently the net radiation increased. The main reason for decrease of heat loss by longwave radiation budget was the increase of atmospheric radiation. The remarkable increase of cloudiness during the snowmelt period could not be found, so the increase of the atmospheric radiation was mainly affected by warm and moist air due to the advection from lower latitudes.

PⅡ-13

Runoff Characteristics of Bayelva Basin in Spitsbergen

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In order to better understand hydrological processes of high latitude basin, which is covered by glacier and continuous permafrost, hydrological measurements were carried out in the Bayelva basin (79°N) in Spitsbergen. High latitude area is predicted to have an influence of global warming by increase of greenhouse-effect gases and its effect on hydrologic cycle are most desired and yet unknown research area.

The area of the Bayelva Basin is about 30 km^2 of which about 50 % is covered by glaciers. Non-glacier area is covered by continuous permafrost of which thickness is about 150 m. Nearly all runoff from the basin occurs during the summer months June-September and is dominated by snowmelt and glacier melt. According to the measurements of discharge at the Bayelva Basin weir run by Norwegian Water Resources and Energy Administration (NVE) from 1990 to 1993, the total discharge is from 30 to 40 mega ton (10^6ton) per year, which can be convert to the yield of 1266 mm. In 1993, we Measured the seasonal snow cover just before melting period, which amounts to 340 mm. The glacier summer ablation is, on he average of 1967-88, 1140 mm, which could be averaged to 570 mm for whole basin. The summer precipitation accumulates to 120 mm. The ratio of each terms to total discharge are 27 % for seasonal snowmelt, 45 % for glacier melt and 10 % for summer precipitation. The rest 18 % is unknown. It could be due to the data variation for the year of 1993 from the climatic mean.

At the weir, discharge, water temperature and specific electric conductivity (SEC) were measured from the middle of June to the middle of August in 1993. The daily mean of water temperature variation did not show a clear relationship with the discharge rate, whereas that of SEC showed a good correlation with the discharge, showing increasing SEC with decreasing discharge rate, except sometimes when there was a local maximum of discharge due to rainfall runoff. The mean diurnal hodographs of water temperature and SEC to the discharge showed a clockwise hysteretic loop, which could be explained by the combination of the heat and soluble materials added to the stream and the proportion of glacier ice melt water and the base flow.

The hydrologic cycle of high latitude basin is complex. Englacial, subglacial and subpermafrost water movements are almost entirely unknown. Change in chemical constituents of glacier and discharged water would help to solve these unknown processes.

P II -14

Glaciological and Meteorological Observations in Spitsbergen
- Observations of Brøggerbreen in summer, 1991 -

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1. Introduction

Local circulations characterize atmospheric conditions over a glacier, and affects on ablation of glacier. Meteorological observations were performed on the Brøggerbreen near Ny-Alesund in Spitsbergen. Observations were carried out at six points distributed logitudinally over the slope of the Brøggerbreen. The uppermost observation point (570 m a.s.l) was on a ridge near the top of glacier and the lowest observation point (60 m a.s.l) was near the glacier snout. Meteorological and glaciological observations were done in August, the warmest period, in 1991.

2. Results

Air temperature increases with the adiabatic lapse rate between the ridge (570 m a.s.l.) and the upper part of glacier (440 m.a.s.l). There seems to be little influence from cooling by a cold surface. In the middle part, air layer near the surface was cooled. The air temperature in the middle part was lower than that estimated from the lapse rate. The air temperature increased greatly when the air approached to the snout of Brøggerbreen. Large increase of air temperature in the lower parts was considered to occur due to a mixing of ambient warm air from the sorrounding area of glacier, as adiabatic heating of subsidence can not produce this increase.

The ablation was observed over the glacier. Large ablation was observed near the snout of glacier. The ablation rate was small in the middle part. Since there is an small ice rise near this area, interactions between this atmospheric conditions and glacier topography should be investigated in future.

Temporal fluctuations of wind speed in the middle part were observed to be associated with changes in lapse rate of ambient atmosphere. The wind was strong when a lapse rate was large. It reflects an unstable atmosphere. Near the snout of glacier, this relationship was not clear.

There could be a regional differences in wind field between the middle part and lower part of Brøggerbreen and it may affect on the temperature distribution.

PⅡ-15

Heat balance in a cryoconite hole on Brøggerbreen, Svalbard

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Cryoconite holes are small melt-holes filled with water on a glacier surface, which are common features on glaciers in many latitude in the ablation season. At the bottom of the holes there is a deposit of nonorganic and organic materials (cryoconite). The melt-hole formation should be the results of heat energy absorbed by the cryoconite due to its lower albedo than the surrounding ice layers, though the quantitative observation is very few.

To clarify the formation mechanism, the measurements for heat budget were carried out on Brøggerbreen, Svalbard, in August, 1994. Cryoconite holes with 5 - 30 cm in depth and 1 to 50 cm in diameter were developed on the lower part of Brøggerbreen. For the meteorological conditions, solar radiation, net radiation, temperature, humidity and wind speed was measured. To observe the heat flow in the water, water temperature in a melt-hole was measured in every 3 cm depth. For the ablation rate observation, the surface height changes were observed by snow stake method and the surface sink was measured on various surfaces covered with colored clothes and colored sand to examine the effect of albedo difference on ablation rate (Fig.1). These experiments were carried out at altitudes of 100, 150, 200, 250, 300 m. To examine the contribution of biological heat source to the melt-hole formation, other field experiments were carried out.

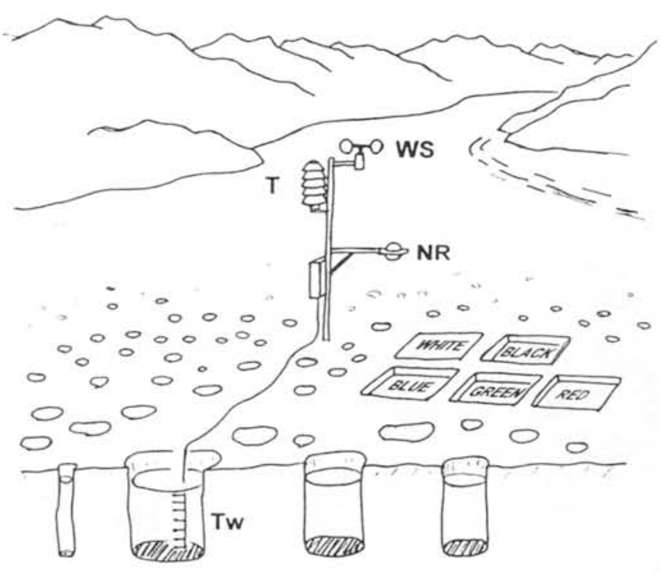

Fig.1. Field experiments for cryoconite holes

PⅡ-16

Climate changes and acidification environments

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PⅡ-17

Chemical components in the ice core from Åsgårdfonna, Spitsbergen

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[2] National Institute of Polar Research

[3] Niigata University

In 1993, the Japanese Arctic Glaciological Expedition(JAGE-93) carried out ice core drilling to 184.62m and 49.21m depths at Åsgårdfonna, northern Spitsbergen (79° 26'38"N, 16° 42'39"E; 1140m a.s.l). The major purpuse of this expedition is to reveal the climatic and environmental change in Spitsbergen for last several hundred years. We chose the 49.21m depth ice core in this study. This ice core was melted after divided at about 8cm-depth interval and these melted samples were brought back to Japan for various analysis.

In situ, we mesured a density of the core. The value of density rapidly increaces from surface to 4.47m depth and slightly increases with depth below it, that is, the ice below 4.47m depth is superimposed ice. The ice date was determined by ^{3}H and ^{137}Cs contents. The significant peak of both elements appeared between 12.50 and 12.82m depth is due to the atmospheric thermonuclear tests in 1962-1963 and gives the core date of 1962-1963 leading mean annual accuulation rate of 0.31 to 0.32m in water.

We also mesured electrical conductivity, pH, $\delta^{18}O$ and chemical components(Cl^-, NO_3^-, SO_4^{2-}, Na^+, K^+, NH_4^+, Mg^{2+} and Ca^{2+}). High values of electrical conductivity and pH were appeared in the layer upper about 6m depth. The pH profile of Høghetta ice core drilled near present drilling site (Fujii et al., 1990) signified the same tendency. The Ca^{2+} concentration of Åsgårdfonna core began to increase from 6m depth to the surface and Uchida et al.(1995) reported high dust concentration in the layer between 5m and 10m depth. These changes suggest that more and more the matter of terrestrial origin has been supplid on the glaciar from the early 1980s.

Reference

Fujii,Y. et al.(1990) Ann. Glaciol., 14, 85-89.

Uchida,T. et al. (1995) Int. Sympo. Environ. Res. Arctic., in press

P II -18

VERTICAL DISTRIBUTIONS OF DICARBOXYLIC ACIDS IN THE GREENLAND ICE CORE

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An ice core (206 m long, ca. 450 yrs old) taken from Site-J, Greenland has been studied for low molecular weight dicarboxylic acids and related compounds using a capillary gas chromatography and mass spectrometry. An homologous series of α,ω-dicarboxylic acids (C2-C10), ω-oxocarboxylic acids (C2-C9), pyruvic acid, and α-dicarbonyls (C2-C3) were detected in the ice core. The molecular distributions of these compounds showed a predominance of succinic acid (C4) followed by oxalic acid (C2), malonic acid (C3), glutaric acid (C5), and azelaic acid (C9) and a predominance of 4-oxobutanoic acid (C4). Their distribution patterns suggest that the dicarboxylic acids and related compounds are photochemical oxidation products of biogenic organic matter such as unsaturated fatty acids, which are produced in the ocean by microorganisms, enriched in the microlayers of surface seawater and emitted to the atmosphere through bubble bursting process. Concentration ranges of total diacids, ω-oxoacids, and α-dicarbonyls were 3.1-32.5 (av. 11.1) ng/g-ice, 0.13-2.8 (av. 0.69) ng/g-ice and 0.09-1.7 (av. 0.47) ng/g-ice, respectively. Total diacid carbon concentrations in total organic carbon (TOC; 0.7-5.7 μg/g-ice, av. 1.7 μg/g-ice) ranged from 0.04 % to 1.3 %. They fluctuated with a smooth trend maximizing at around 1580, 1780, 1840, 1940, and 1980 yrs and minimizing at 1680, 1820 1860 1970 yrs. This trend is apparently in good agreement with the changes in the northern hemisphere temperature as well as sea surface temperatures for the periods after 1800 AD. The vertical profile of the diacids is probably associated with the past changes in the sea-to-air emissions of marine organic matter and subsequent photochemical oxidation in the atmosphere during their long range transport to the Greenland ice sheet. The sea-to-air flux in the north Atlantic may be enhanced during warm periods when sea ice cover areas in the Baffin Bay and Davis Strait were shrunk and low pressure systems were more frequently developed.

P II -19

High resolution internal ice layer observation using L-band ice-radar at Agassiz ice cap

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David A. Fisher *(Geological Survey of Canada)*,
Kumiko Goto-Azuma *(Nagaoka Institute of Snow and Ice Studies)*,
and
Shinji Mae *(Hokkaido University)*

Radar observations were carried out on the Agassiz ice cap in Canadian arctic territory using newly developed high resolution ice-radar. The main purpose of this study is to reveal (1) the three dimensional structure of ice event layers which is detected by the ice core analysis. This point is important to consider the accumulation of snow in old time and present ice flow. And also, from the detail comparison between radar echo and ice core analysis on the dielectric properties, the discussion on (2) the mechanism of scattering from the internal layers is expected.

In order to achieve above purpose, we developed very high resolution ice-radar with microwave (L-band). Radar parameters are shown in Table 1. Using pulse compression technique, the radar has about 63 cm of vertical resolution in ice.

Observation on the ice cap was carried out during April and May, 1994. The routes of radar observation were from summit to 1 km north, 2 km south, 1 km east, and 1km west. At the summit and 2 km south, ice core drilled been carried out. Antenna of the radar was mounted on the sledge and other instruments were mounted on another sledge. These sledges were moved every 25m by skidoo.

Preliminary results of the radar analysis show bedrock topography and internal echoes with high resolution. Signals from bedrock up to 500 meters depth was detected. Internal ice layers were observed from about 40 m to 200 m depth.

Before detail comparison between ice core analysis and radar data, depth scaling correction of radar data was carried out using density profile given by ice core at the summit. Multiple peaks between 40 m and 200 m in the radar data are corresponded to the peaks on the conductivity data by ECM. These echoes are mainly caused by the dielectric change due to acidity. Most of higher conductive layer is corresponded to the volcanic ashes in old days.

Table 1. Major specifications of L-band high resolution ice radar

Transmitter	Frequency	1.2575 GHz	
	Peak power	10 W	667W (effective)
	Pulse	FM Chirp	
		500 ns(extn.)	7.5 ns(compr.)
	PRF	1 kHz	
Receiver	Smin	-88 dBm	
	Band width	270 MHz	
	NF	2.5 dB	
Antenna	1.2 m Parabora		
	Beam	17 degree	
	Gain	19 dBi	

P II -20

Characteristics of chemical component of superimposed ice in Svalbard.

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1. Intruduction

A shallow ice core drilling to find out the climatic and environmental change during hundred years in arctic region has been conducted by Japanese Arctic Research Expedition (JAGE) from 1987. Glaciers in Svalbard are mainly constituted by superimposed ice even in high latitude, 80N, because of Gulf Stream.

10-m ice core was obtained in Austra Br ϕ ggerbreen, Spitsbergen, Svalbard (78 53'N, 11 56'E, 450 m a.s.l.) in September 1994. The core diameter was 7.8 cm. The measurement items of ice core were; stratigraph, bulk density, ECM (acidity), pH, electrical conductivity, majer ions (Cl^-, NO_3^-, SO_4^{2-}, Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}).

2. Results

The characteristicsof stratigraph were grouped by numbers (Fig. 1). 1. compact snow, 2. glanular snow, 5. bubble free ice, 8. with small bubble (<0.5 mm), 9. with middle bubble , 10. with large bubble (>2 mm), 0. boundary layer. Ice layer with many bubbles was continuous appeared except surface snow of 50cm. Bulk density was 850 -900 kg/m^3 below 1 m.

The good corelation between Cl^- and Na^+ was obtained.

$$[Cl^-]=1.14[Na^+] \text{ (micro-eq/L)} \qquad r2 = 0.97$$

The coefficient 1.14 was nearly same value from ocern. The variations of $[Cl^-]/[Na^+]$ and stratigraph were shown in Fig. 1. The high $[Cl^-]/[Na^+]$ and bubble free ice were fitted well.

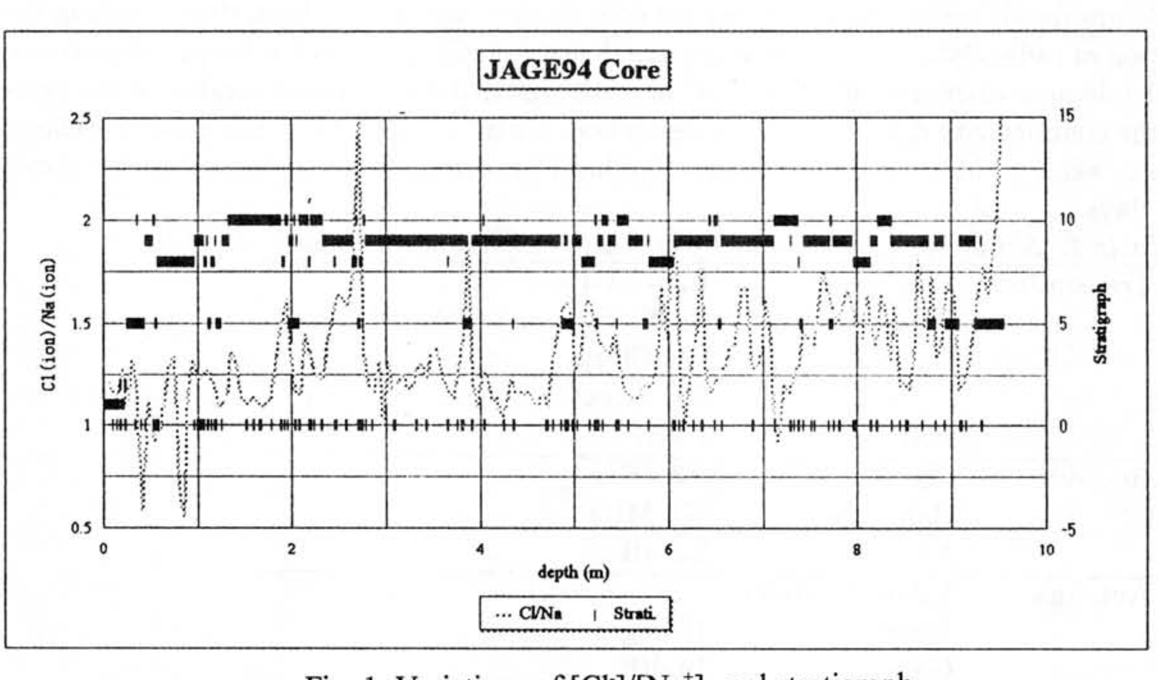

Fig. 1. Variations of $[Cl^-]/[Na^+]$ and stratigraph.

P II -21

Temporal and spatial variations of ion concentrations and $\delta^{18}O$ in the Agassiz Ice Cap, Canadian high Arctic

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Masayoshi Nakawo, Kazuki Nakamura[1]
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Akira Kudo
(Institute for Environmental Research and Technology, National Research Council of Canada)

Several ice cores have been recovered from Agassiz Ice Cap on Ellesmere Island, Canadian high Arctic (80.7°N, 73.1°W) since 1977 and have revealed valuable information about past climatic and environmental change over the last 100,000 years. However, detailed ion chemistry of neither the core nor the recently deposited snow and firn have been undertaken. It is therefore purpose of this paper to present and discuss the results of the first investigation into the ion chemistry of snow deposited over the last few years at this site.

Three sets of samples were taken from each of the pits in the scoured and unscoured zones. The three sets were taken vertically one meter apart down one wall of each pit. In addition, samples were taken in more than one year to examine post-depositional changes. All the samples were analyzed for major anions. One set of samples from each pit were also analyzed for $\delta^{18}O$ to help interpret the anion chemistry. In this paper we discuss the within-site variation due to very local depositional variations, the between-site variation to determine the effects of scouring on snow chemistry, and the between-year variation due to post-depositional processes. The most striking is the fact that the Cl^- and SO_4^{2-} peak concentration, which coincide very closely with the most negative $\delta^{18}O$-snow at the unscoured site, are still evident at almost the same high concentrations at scoured sites. On the other hand, $\delta^{18}O$ at scoured sites showed much reduced amplitude of seasonal variation than that at the unscoured site, due to the removal of the winter snow at the site.

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[1] Present Affiliation: Field Science

P II -22

Ice core analyses and borehole temperature measurements at the drilling site on Åsgårdfonna, Spitsbergen, in 1993

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Two ice cores (184.62 m and 49.21 m depth) were drilled at the middle reaches of Åsgårdfonna, northeastern part of Spitsbergen (N79°26'38", E16°42'39"; 1,140 m a.s.l.), by the Japanese Arctic Glaciological Expedition, 1993 (JAGE '93) with cooperative work by the Norwegian Polar Research Institute (Norsk Polarinstitutt). Analyses of ice cores drilled at Høghetta, the top of Åsgårdfonna, indicated that glaciers in Spitsbergen shrank considerably during the hypsithermal.[1)] One of objectives of JAGE '93 is to reveal the climatic and environmental changes around Åsgårdfonna from ice core analyses.

A shallow type electro-mechanical drill was used for ice-core drillings, which was newly designed to operate by only a few persons. None of drill holes reached to the bedrock. After an ice core was obtained, the distribution of air bubbles and positions of ice layers were recorded. Then the weight and diameters of the ice core were measured to calculate the bulk ice density. Measurements of ice temperature in each borehole were started from one night after the ice coring operation was finished. The direct contact thermistor sensor system[2)] was used for the present study.

In-situ ice core analyses revealed that snow and firn layers were observed in ice cores from the surface to about 6 m depth; these layers gradually densified and turned into ice below about 6 m. Stratigraphic observations of ice cores showed that air bubble distributions were almost uniform except for some thin high bubble concentration layers and for the thin transparent layer at about 65 m depth. Temperature measurements of these boreholes showed an unique profile, that is, it had negative temperature gradient at depths from about 30 m to 130 m.

The stratigrapy of ice cores and the ice temperature of Høghetta obtained by JAGE '89 are different from those of this study, even though each location is not far away. This may indicate that the precipitation mechanisms of each site has changed. We applied a numerical model for the ice temperature deviation from the steady state condition to estimate the environmental changes.

1) Fujii *et al.*, 1990: Ann. Glaciol., **14**, 85-89.
2) Kameda *et al.*, 1993: Bull. Glacier Res., **7**, 221-226.

P II-23

SEESAW IN $\delta^{18}O$ ANNOMALIES BETWEEN ICE CORES FROM SVALBARD AND GREENLAND AFTER 1750 AD

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Ice cores of 86m at Hoghetta, northern Svalbard and 205m at Site-J, southwestern Greenland are well dated using Tritium and volcanic signals for both cores and annual layer counting for Site-J core. As the Hoghetta core has time gap in ice layer formation around 1750 AD, $\delta^{18}O$ profiles are compared during after 1750 AD. Figure shows the 20-year cuttoff annomalies from the average during last ca 200years. We can recognize seesaw variations between them from the figure: namely temperature changed oppositely in northern Svalbard and southwestern Greenland. This is, probably, explained by the changes of strength of Icelandic Low which rules climatic condition in North Atlantic Arctic region. When Icelandic Low develops, anticlockwise atmospheric circulation becomes dominat, cold air mass comes down from north to western Greenland and temperate air mass comes up from south to Svalbard. Contrary when Icelandic Low less develops, opposite temperature changes occur in both regions. It, therefore, can be said from the figure that Icelandic Low may have developed in 1820s, 1850-1910 and 1940s AD.

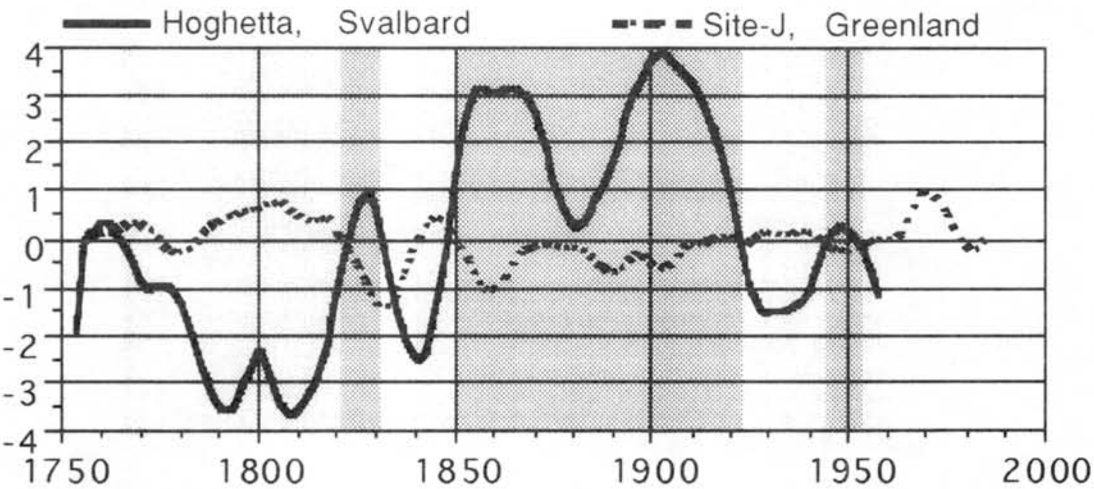

Figure Seesaw in $\delta^{18}O$ annomalies between ice cores from Svalbard and Greenland.

P Ⅱ -24

Response of Greenland ice sheet to the global warming

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III-1

Atmospheric Science Observations at Ny-Ålesund, Svalbard

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Observations on atmospheric sciences at Ny-Ålesund, Svalbard have been started in 1991 at the Rabben observation station, in order to clarify the global atmospheric change in the Arctic. These observations have been performed under the International Cooperative Project on "the Global Environment Research in the Arctic (1990-1994)"; and "Arctic Environment Observations (1995-1999)" according to the IASC (International Arctic Science Committee) initiatives . Those items of atmospheric components are variation of greenhouse gases including surface ozone, clouds, precipitation and radiation, compared and referenced to the observations in the Antarctic.

Observations of greenhouse gases such as CO_2 and CH_4 are conducted with the air sampling at the site once a week, under the cooperation with the Norwegian Polar Institute. Analysis is made at the home institution, and it is found that the site is suitable for the background monitoring. Large seasonal variation with a peak to peak amplitude of about 18 ppmv and north-south difference of annual mean between Ny-Ålesund and Syowa Station, Antarctica of about 4 ppmv were confirmed for the CO_2 concentration. CH_4 also shows large seasonal variation and larger north-south difference. The surface ozone concentration is measured continuously at the station, and clear seasonal variation and some drastic destruction at the polar sunrise have been revealed. In order to clarify sinks and sources of CO_2, partial pressures of CO_2 in the surface sea water have been measured at Greenland Sea in summer and spring on board Norwegian research vessels.

Observations of clouds and precipitation are made with microwave radiometer of 37 GHz for the column liquid water content, and vertical pointing radar of 10 GHz for the ice water content and precipitation. Monthly variations of clouds and precipitation are obtained and some seasonal difference of cloud properties is described. Discussions with Arctic aerosols are to be made with the comparison to the air and snow chemistry. Analysis of surface radiation data observed for a long time by Norwegian Polar Institute has revealed the characteristics of radiation budget at Ny-Ålesund. Radiation budget at the top of the atmosphere has also been analysed from the ERBE satellite data and large variability in winter is shown around Svalbard.

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III-2

The impact of Arctic circulation on trace gas measurements

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Ⅲ-3

NILU's atmospheric research in the Arctic
- Results and future plans -

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III-4

LIDAR MEASUREMENTS AT ALASKA AND NYALESUND: EFFECT OF POLAR VORTEX MEANDERING ON STRATOSPHERIC AEROSOL PROCESSES

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Lidar measurements at Alaska and NyAlesund were made in December 1991 to monitor distribution of stratospheric aerosols and its temporal changes in winter. The measurements show that polar vortex wall seems to make large gap between high and mid latitudes in stratospheric aerosol density distribution. Therefore the meandering motion of polar vortex can disturbe aerosol processes and ozone chemistry in the high latitudes stratosphere.

Above about 20km little aerosol content was observed when the lidar station was inside of polar vortex without PSCs event suggesting the active descending motion of polar stratospheric aerosols inside of the vortex. Additionally, however, there is large difference in feature of distribution of aerosol density inside of the vortex, suggesting difference in descending motion inside of the vortex and active diffusion of particulatematter near the edge of polar vortex. This effects directly global budget of stratospheric aerosols and indirectly stratospheric ozone chemistry.

VARIABILITY AND LONG-TERM CHANGES OF OZONE AND AEROSOLS IN THE POLAR ATMOSPHERE

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Abstract

Compared to the greenhouse gases the contribution of ozone to radiative forcing is of minor importance. There is a small positive effect for increasing tropospheric ozone and a negative one for decreasing stratospheric ozone. Aerosols in the troposphere and stratosphere cause a negative radiative forcing. Despite of the small contribution of ozone to possible changes of surface temperature it mainly controls the UV-B radiative transfer to the Earth's surface and it is one of the most sensitive atmospheric constituents indicating changes in stratospheric and tropospheric chemistry and dynamics.

Ozone and spectral optical depth measurements performed in the Antarctic and Arctic over several years will be presented. Year round observations of vertical ozone distributions in the polar regions at latitudes > 65° obtained from balloon-borne ozone soundings are used to specify changes of ozone concentration in the troposphere and stratosphere in the Antarctic since 1979 and in the Arctic since 1988. Ground-based measurements of the spectral optical depth will be included to discuss stratospheric aerosol loading after volcanic eruptions and the different seasonal variation of aerosols in the polar troposphere.

The ozone content of the polar atmosphere is mainly controlled by hemispheric transport. So its seasonal and interannual variation depends from atmospheric circulation pattern as well as from chemical processes. Mainly in the polar stratosphere the presence of aerosols leads under certain meteorological conditions to the formation of PSCs. Heterogeneous chemical reactions at these aerosol and PSC surfaces are the reason for an increasing effectiveness of chlorine- and bromine-catalysed ozone destruction firstly seen in the southern polar stratosphere during spring. Meanwhile transient increases of the stratospheric aerosol loading by volcanic eruptions and the continuous increase of CFC substitutes have changed the distribution of atmospheric ozone in both polar regions.

Related to the mean pattern before 1979, the stratospheric ozone distribution has almost changed in the Antarctic for all of the seasons of the year. Since then the main feature has been the growing spring ozone depletion in the stratosphere. Also ozone losses have been detected during Arctic winter and spring. Their links to halogen chemistry have been established and clearly separated from the dynamically controlled ozone variations.

In 1992 and 1993 a correlation between both polar regions was found in spring. Additional ozone losses below the base of the polar stratospheric vortex were recorded for the Arctic and Antarctic when the volcanic aerosol loading caused by the Mt. Pinatubo eruption had reached its maximum.

Significant differences between the mean annual pattern of ozone in the Arctic (Ny-Ålesund station at 79°N; 12°E) and the Antarctic (Neumayer station at 70°S; 08°W) are recently evident. While at altitudes above 22 km the mean annual variation is more similar, the seasonal differences increase with decreasing altitude between both stations. They are mainly pronounced in the lower stratosphere and troposphere.

Although studies of the changing atmospheric ozone show dominating features of chemical control the impact of the global atmospheric dynamics is also evident. Consistent data sets only exist for very short time periods compared to the range of periodicity covered by the internal variability of the atmosphere. Currently the long-term variability of the atmosphere due to the internal dynamics and the interactions with external forcing are not well understood as it can be briefly shown by long-term integrations of simple low-order models. Thus observations and model studies related to the polar regions have to be continued as a major contribution for detection of further changes in the atmosphere.

Ⅲ-6

EISCAT Observations

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The ionospheric plasma can be used as a tracer to deduce the neutral wind in the ionospheric E-region of the atmosphere. Examples of the neutral wind at different heights during quiet and disturbed conditions will be presented. A persistent mean eastward wind is observed during quiet as well as disturbed conditions. This component appears to be more varible between seasons than between quiet and disturbed conditions. EISCAT-observations of height dependent E - region currents will be presented and in particular results from special studies of conductivities and energy spectra of precipitating particles during disturbed conditions.

THE EUROPEAN SUBPOLAR OCEAN PROGRAMME (ESOP) - INVESTIGATIONS OF THE ROLE OF SEA ICE IN GREENLAND SEA CONVECTION

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ABSTRACT

The European Subpolar Ocean Programme (ESOP) is a project funded by the Commission of the European Communities under the MAST-II (Marine Science and Technology) programme. It began in 1993 and a continuation until 1999 is being funded under the follow-on MAST-III programme. Its overall objective is to understand the role played by sea ice in the energetics of the Greenland Sea system as a whole, and especially the role of atmosphere-ice-ocean interaction in the process of deep convection in the winter Greenland Sea. The chemical and biological consequences of this convection, including the sequestration of carbon dioxide, also form part of this programme.

There are 22 participating institutions in ESOP, from 7 countries (Denmark, France, Germany, Great Britain, Iceland, Norway and Sweden), with P. Wadhams as Co-ordinator.

The origin of ESOP lay in the Greenland Sea Programme of the 1980s, a multinational project organised by the Arctic Ocean Sciences Board (AOSB). It was discovered that during winter convection occurs in the central part of the Greenland Sea gyre, in the vicinity of an ice tongue called Odden which grows eastward from the main East Greenland ice edge. In most years convection is believed to have reached the bottom, ventilating the deep waters. However, tracer evidence showed that since about 1982 this has not been the case; in consequence the Greenland Sea deep waters have become warmer and more saline. The reason for the reduction in convection was unknown, but it was thought that a reduction in the growth of local ice in Odden, with its attendant salt rejection, could account for the change. Since convection also involves CO_2 sequestration, a reduction in the volume of convection could also have a positive feedback effect on CO_2 levels in the atmosphere.

ESOP has concerned itself with a study of the ice-ocean processes occurring in the central Greenland Sea in a bid to understand these changes. The work has included a number of winter and spring cruises during 1993-5 in which the physical, chemical and biological nature of the central gyre waters were studied, the nature and physical properites of the sea ice in Odden studied, and (by acoustic means) the structure and size of the convective plumes. Only during 1993 did a fully developed Odden occur, composed of locally-formed pancake ice and with convection reaching to 1000 m. In 1994 and 1995 the ice failed to form, and thermal convection reached to only about 600 m.

Other studies in ESOP include the production of a fully coupled atmosphere-ice-ocean model of the Greenland Sea with a 20 km grid scale; the study of the shape of the Odden ice tongue by the use of SAR, SSM/I and other satellite imagery; the measurement of ice and water fluxes into the Greenland Sea through Fram Strait, and at lower latitudes in the Greenland Sea, using moored upward sonar systems; and the measurement and modelling of the carbon cycle. The second phase of ESOP, from 1996 onwards, will concern itself more with the fate of the convected water as it spreads into the Greenland Sea at mid-depth (studied by means of an SF_6 tracer release experiment) and the role of convection in the overall thermohaline circulation of the Greenland Sea system.

IV-2

Evolution of T-S structure obtained by the Ice-Ocean Environmental Buoy in the Nansen Basin off Greenland

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Abstract

The Ice-Ocean Environmental Buoy (IOEB) was developed to acquire and telemeter in near real-time time-series data on atmospheric, oceanographic and ice physics in ice-covered oceans during all seasons. Mechanically, the IOEB consists of an extremely durable surface flotation package and an underwater mooring line of instruments and sensors. The ocean sensors include three conductivity/temperature units, an acoustic doppler current profiler (ADCP), a dissolved oxygen sensor, a transmissometer and a fluorometer. Furthermore, a suspended particle collecting pump (water transfer system) and sediment trap collect biogeochemical samples at the depth of 107m. The meteorological sensors consist of a barometric pressure sensor, an air temperature sensor with a radiation shield and a wind monitor. Two ice-thermistor chains comprising a total of 33 thermistors are installed near the apex. The IOEB obtains an ice thickness measurement from an echo-sounder module pointed upward from a mount situated below the ice floe, and ice stress sensors measure internal ice stress in two directions at three depths.

In April 1994, an IOEB with the latest design was deployed in the northwestern Nansen Basin along the Transpolar Drift in the Arctic Ocean. It traveled southward in a linear fashion at about 6 km/day on the average, and was recovered in November, 1994 in the Greenland Sea. The preliminary results of the data transmission from the 1994 Transpolar Drift IOEB are described.

IV-3

The Arctic Ocean in the Global Climate System

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The Arctic is an important and in some aspects a governing part of the Earth climate system. According to calculations by means of global models the anthropogenic changes of climate should be especially strong in this region. At the same time natural climate variations are also the largest in the Arctic due to a decisive role of interactions with other parts of the global system. The oceanic portion of these interactions has a most strong influence on the global climate changes. This is connected, first, with that the Arctic Ocean can change its capacity for redistribution of the sun heat in consecuence of because the changes of thermochaline structure of the upper layer and the sea ice area on its surface. Second, the vertical oceanic circulation in high latitudes is very sensitive to changes of the fresh water balance on the ocean surface that can cause a profound effect on the production of the new deep water and on the global vertical ocean circulation. The increase of fresh water discharge into the Arctic Ocean can be one of the manifestations of the global warming. The estimations for 1938-93 showed increase of discharge of main arctic rivers, rise of precipitation on the arctic river basins, decrease of snow depth on the Arctic ocean sea ice. Data of regular oceanographic observations indicate the depression of the upper layer salinity in the Siberian Arctic Seas during 1950-1990. These climatic signals correlate with data on interannual variations of the arctic sea ice area which were obtained during historical sea ice observations since 1930th. The most strong variations of the sea ice area occured in the Atlantic Arctic. Minimal sea ice area in the Siberian Arctic Seas was pointed out in 1940-60 th. The amounts of multiyear sea ice were maximal in the middle of 1980th. Freshening of the Arctic Ocean upper layer appeares also in the Greenland Sea, where the depression of salinity and reduction of the frequency of deep winter convection events was found. Analysis of oceanographic data for 1950-1990 th shows that the salinity of the upper layer required for deep convection is attained due to permanent inflow of the transformed atlantic water into the Greenland Sea Gyre. This water arrives to the Arctic Ocean too, where it consututes the main salt source the its water masses. The Atlantic water inflow in the North European Basin and the Arctic Ocean is prone to appreciable interannual variations that are assessed from the oceanographic observations in the Faroe-Shetland Channel for 1902-1990. Distribution and characteristics of the transformed Atlantic water in the Arctic Ocean vary from year to year. According to Russian oceanographic data there was water temperature and salinity reduction from 1950th to 1970th in the Arctic Ocean that was more detectable in the Eurasian Subbasin. These data allowed to refine propagation of the transformed Atlantic water and to detect the traces of cold intermediate and deep water formation in the St. Anna trough, near eastern North Land Island shelf and in eastern part of the Bareanz Sea.

IV-4

Carbon Dioxide Variations in the Greenland Sea

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The Greenland Sea is a most important area for deep water formation in the world oceans. This area is also thought to be an important place for global CO_2 budget, because atmospheric CO_2 is directly transported to the deep ocean. Therefore, we have made measurements of CO_2 partial pressure (pCO_2) of the surface ocean and vertical profile of total inorganic carbon (TIC) from the surface to the deep ocean in August 1992, July - August 1993 and April - May 1994.

pCO_2 in the Greenland Sea showed spatial and temporal variations. Lower values appeared in the western and northern part of the surface ocean and east-west gradient of pCO_2 was larger than north-south gradient. A positive relationship between pCO_2 and sea surface temperature (SST) could be obtained in open water region. The rate of change was 0.06 ℃$^{-1}$. The spatial variations of pCO_2 are not simply explained by the temperature dependence of CO_2 solubility in sea water because the rate is higher than that of pure temperature effect on pCO_2. No relationship between pCO_2 and SST could be seen in packed-ice region. pCO_2 was higher in April. Drastic depression of pCO_2 occurred in mid-May and the lower value was maintained until the end of August. pCO_2 in the surface ocean was always lower than that in the atmosphere from April to August. Differences of pCO_2 between the atmosphere and the surface ocean was about 40 μ atm in April and reached a maximum value of about 190 μ atm in mid-May. Therefore, the Greenland Sea seems to act as strong sink for atmospheric CO_2 especially in summer.

Values of TIC were uniform except for the surface ocean over 100 m depth. These profiles were different from any other oceans. The vertical uniformity in the Greenland Sea suggests strong vertical motion of sea water. The average value of TIC below 100 m was 2.13 mmol kg^{-1} for the Greenland Sea and the value was lower than any other oceans.

Recent Changes in Arctic Ocean Thermohaline Structure: Results from the U.S./Canada 1994 Arctic Ocean Section

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Abstract

Comparison of historical oceanographic data from the Arctic Ocean with that obtained aboard the *CCGS Louis S. St-Laurent* during the U.S./Canada 1994 Arctic Ocean Section (Arctic-94) unequivocally show that the mid-depth layers of the Arctic are experiencing a major warming and ventilation event. The intrusion of new water is characterized by (a) higher values in the Atlantic layer T_{max}, (b) a shallower core depth for T_{max}, (c) displacement of waters of Pacific origin in the upper 100-200 m, and (d) pronounced thermohaline inversions 40 -60 m thick in Atlantic and Upper Deep waters. The largest temperature change, as much as 1°C, is seen in the core of the Atlantic layer, suggesting that the event is related to an increase in the transport and/or temperature of water entering from the North Atlantic. The thermohaline inversions are continuous features across the entire width of the ocean and are persistent in T/S-space over time scales of several years.

Examination of available time series data show a chain of events over the past five years leading up to the Arctic-94 observations. Long-term temperature records off Spitsbergen show a dramatic increase starting 1989-90; and temperatures in the Barents Sea have remained above the long-term mean since 1990. This is coincident with a decrease in surface heat loss in the northern Greenland Sea during this same period (Moore, 1995). Data obtained in 1990 aboard the *Rossiya* show the penetration of anomalous warm water into the Eurasian Basin north of the Barents (Quadfassel et al., 1991), and in 1993 aboard the *CCGS Henry Larsen* and *USCGS Polar Star* into the Canadian Basin along the siberian continental margin. Arctic-94 data show that the disturbance has now spread over the Nansen, Amundsen, and Makarov basins, and is poised to enter the Canada Basin. These and other observations from the 1987 *Polar Stern* and 1991 *Oden*, expeditions suggest that the leading edge of the anomaly appears to be moving is moving cyclonically around the Arctic along the continental margin and ridge system (cf. Aagaard, 1989) with a rate of advance (5-10 cm s^{-1}). These data are interpreted to signal a major, long-term change in the thermohaline structure of the Arctic Ocean, perhaps related via teleconnection patterns to global scale changes.

IV-6

(Abstract)

Heat Budget of the Arctic Sea

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The sea surface of the Arctic Sea is the boundary, through which two large circulation systems of the earth, atmosphere and water cycles, exchange the heat each other, hence the heat exchanged is one of the most important factors which dictate the global environment.

The great extent of the Sea makes the simultaneous large scale observation in situ difficult. Very same reason supplies numerical models with poor input data.

The author proposes studies employing a large scale physical model. Kongsfjorden was used as a model of the Arctic Sea, and the heat budget was calculated. The author emphasizes on the method, and far less on the figures obtained, so that the latter is even not mentioned in the abstract.

V-1

Japanese Arctic Glaciological Studies during 1987-1995

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The Arctic cryosphere is composed of various types of ice masses, showing a clear contrast to a relatively simple huge ice mass in Antarctica. The ice masses in the Arctic have regional varieties in the present air-ocean-ice interactions and in the past glacier fluctuations since Pleistocene.

The objectives of the Japanese Arctic Glaciological Expedition (JAGE) were to study the regional characteristics of glacier processes and the climatic and environmental changes for the last few hundred years in Arctic cyosphere. Glaciological observation and shallow ice core drilling were, therefore, carried out at various places such as Greenland ice sheet, Svalbard archipelago and the main land of Norway during 1987-1995.

(i) Research area and activities of JAGEs

1987	Ice coring (46.9m) in Jøstedalsbreen, southern Norway (61.43N, 7.08E)
	Ice coring (85.5m) in Høghetta ice cap, northern Spitsbergen (79.16N, 16.52E)
1989	Ice coring (206.1m) in Site J, western Greenland (66.52N, 46.16E)
1991-1992	Participation in the GRIP Programme and the test of shallow drilling using deep ice drilling divice in Summit, central Greenland (72.34N, 37.37E)
1991-1994	Glaciological obsevation in Brøggerbreen, northern Spitsbergen
1992	Ice coreing (83.9m) and glaciological observation in Snofjellafonna, northern Spitsbergen (79.08N, 13.19E)
1993	Ice coring (180m) in Asgardfonna, northern Spitsbergen (79.16N, 16.52E)
1995	Ice coring (210m) in Nordaustland, Svalbard (79.58N, 21.01E)

(ii) Major scientific results

1987	Discovery of paleo-bacteria colonies (5670 + 100BP) and petel (4150 + 290BP) in the ice core at Høghetta. Residue of the colonies suggests that rise of vegetation limit in the Hypsithemal period in Høghetta region.
1989	Annual oscillations of $\delta^{18}O$ have been detected in the Site J ice core. Melt feature percentage in the core suggest that cool summer persisted during 1680 - 1700 and 1820 - 1840.
1991	High ionic concentration at layer boundaries were detected in surface layer due to redistribution of ions with meltwater infiltration-refreezing. Microscopic observation in melted water from ice core suggested that number of bacteria correlate with electrical conductivity of the water. This suggests that biological factor probably influence the chemical constitutions of the melt water from ice core.

V-2

Abstract for International Symposium on Environmental Research in the Arctic
National Institute of Polar Research
19-21 July, 1995.

Volcanic Records in Polar Ice Cores

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Records of past major volcanism are obtained from polar ice cores by continuous ECM (Electrical Conductivity Method) measurements along the ice cores. The ECM record reveals the acidity (H^+ concentration) of past precipitation. Major volcanic eruptions, which have ejected vast amounts of acidic gases (e.g. SO_2 and HCl) into the atmosphere, show up in the ECM records as large acid peaks due to the presence of strong acids like sulphuric and/or hydrochloric acid in the ice cores.
The size of the peaks in the record depends upon:
the magnitude and type of the eruption,
the geographical location of the eruption site relative to the ice core drilling site, and
the composition of the acid gases.
A 3029 m deep ice core from the summit of the Greenland ice cap (72.57 °N, 37.62 °W, elevation 3230 m a.m.s.l.) was recovered during the years 1990-1992 in the joint European Greenland Ice Core Project (GRIP) under the auspices of the European Science Foundation (ESF). The time span covered by this ice core is some 250 kyrs., and the last 11,500 years (the Holocene period) are represented by the top 1620 m of the core. During the Holocene period the ECM record reveals in average one huge acid peak per century. The size of these peaks is comparable to the acid signal from the Icelandic Laki eruption (1783 AD) found in all Greenland ice cores, which reached a depth corresponding to some 200 years. A suite of volcanic eruptions from different ice cores, mainly from Greenland, will be presented. This includes:
a characterization of their chemical composition,
an estimate of their magnitude by comparing the deposited amount of strong acids to the deposited amount of radioactive debris from thermonuclear bomb tests in the atmosphere, and
a possible climatic impact by studying the effect of the increased acidity on the stable oxygen isotope ratio, $\delta^{18}O$, of the ice. In polar ice, the $\delta^{18}O$ is mainly determined by the temperature of formation of the precipitation.

V-3

To be submitted for a presentation at International Symposium on Environmental Research in the Arctic, Nat. Inst. Polar Res. Tokyo, Japan, 19-21 July, 1995

6/15/95

PARTICIPATION IN THE GRIP PROGRAMME
- Core Study on Mechanical and Physical Properties -

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Paleoenvironmental change information is preserved in the form of physical and chemical stratigraphic features in large polar ice sheets and the ice core signals extracted allows to characterize and reconstruct the past global variations of climate and atmospheric circulation. A deep ice core drilling effort was started at Summit, central Greenland by the joint European Greenland Ice-core Project (GRIP) in 1990 and concluded by reaching to silty ice close to bedrock at a depth of 3029 m in 1992.

The GRIP Steering Committee chaired by Prof. B. Stauffer, Bern University invited a Japanese scientist to join the GRIP deep drilling program for conducting physical and mechanical property studies in 1991. Accepting this invitation, we attended at the GRIP Workshop on Mechanical Properties of Ice, Bremerhaven, Germany, February 25 - 27, 1991 to formulate a science plan which satisfies flow modellers and physical property scientists as a integral part of the overall GRIP science plan.

According to the science plan - mech. prop., core sample preparations and field measurements were conducted in the field during the 1991 - 92 GRIP operation periods. Selected samples were transported in frozen containers to laboratories for further investigations. The science plan - mech. prop. covers study areas of crystal size and fabrics, firn-to-ice transition, flow law parameters, ice density , relaxation and aging effect, and other field and laboratory research activities. Our role in this science plan was focused on mechanical property testing and air inclusion observations as were made on the other deep core samples earlier.

Microscopic observations of air hydrate crystals were made on fresh ice core samples to locate the depth of a bubble-hydrate transition zone of which the information was utilized for core logging and processing procedures. Stratigraphic observations and photographic recording were made on slab sections prepared from core samples.Uniaxial compression and simple shear tests were made on core specimens in a special snow cave at temperatures ranging from -11 to -22 degree C. Follow-up laboratory experiments have being conducted on field-selected samples in a cold room facility in Japan, taking volume relaxation effect into consideration.

V-4

Recent Trends in Mass Balance of Glaciers in Norway and Svalbard

by

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Abstract

The longest continuous mass balance time series in Norway is from 1948. Since 1963 six glaciers have been monitored continuously in a profile from west to east in South Norway. In northern Norway one glacier has been studied since 1969. Both winter and summer balance have been measured every year. The results show a different trend on the western, maritime glaciers and on the more continental glaciers 200 km inland. In the west the glaciers have been increasing in volume, while in the east the glaciers had a decreasing trend up to 1987.

In the period from 1989 up till now the conditions have changed towards more postive net balance for all glaciers. Even the continental glaciers have had mass surplus in this period. Most of the glaciers in southern Norway had their most positive net blance ever measured in 1989. Apart from 1967 three or four of the most positive years was measured in the period 1989-94. On Nigardsbreen (48 km^2), one of the main outlet glaciers from Jostedalsbreen, the mass balance has shown a positive trend since 1962 with a cumulative mass increase of 6.5 m water eq. in the 26 year period 1962 - 1988. During the last five years, 1989-1993, the cumulative growth has been an additional 8.5 m water eq., due mainly to higher winter precipitation, but also partly to cool summers.

In Northern Norway, the maritime glacier Engabreen has shown a considerable positive mass balance amounting to 18 m of water eq. since 1969 which is more than on any of the glaciers in southern Norway. However, Engabreen has not shown an increasing trend after 1988. Short measurement series from different other glaciers inn Northern Norway indicate that the more continental ones are close to equilibrium or have been slightly decreasing.

One of the longest continuous mass balance observation series in the Arctic is from Svalbard where mass balance measurements were started in 1967 on two small glaciers about 6 km^2 in size in the north-western part of the island Spitsbergen and have been carried out annually since then. The mean net balance on the glacier Brøggerbreen is - 0.43 m of water equivalents for the 28 years period and - 0.32 m on Lovénbreen. Only two years, 1987 and 1991 show positive net balance. Mass balance investigations on Kongsvegen (105 km^2) were started in 1987 and the results indicate that glaciers with high altitude accumulation area are close to equilibrium or growing.

In general no dramatic changes has occured in Svalbard during the last 26 years.
- The winter accumulation is stable or slightly increasing with small annual variations.
- The mean summer ablation is stable with no significant trend, but with large annual variations. There is no sign of increased melting during the observation period.
- The net balance depends on area/altitude distribution:
    - Low altitude glaciers are steadily shrinking but with slightly less negative net balance than 26 years ago.
    - Glaciers with high altitude accumulation area are close to equilibrium or growing.

V-5

Glaciological activities in Svalbard by Japanese Arctic Glaciological Expeditions (JAGE)

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Glaciological works have been carried out on the glaciers of Svalbard since 1987 by Japanese Arctic Glaciological Expeditions (JAGE) to study on the cryosphere-atmosphere interactions and the climatic changes in the last few hundred years. In 1987, an ice core to the bedrock at a depth of 85.61 m was obtained at the top of Høghetta on Asgardfonna in the Northeastern part of Spitsbergen. Chronology of the ice core showed time gap at about 50 m, while the bottom ice was determined as about 5000 year B.P. by ^{14}C method. This chronology and borehole temperature suggest that the glaciers in Spitsbergen shrank during the hypsithermal. Between 1991 and 1994, snow sampling and meteorological observations were carried out on Brøggerbreen for the purpose of chemical analysis of melt-refreeze layers, heat budget on a glacier surface and hydrogeochemical researches. In 1991, two shallow ice-core drillings, 83.9m and 24.4m in depth, were carried out on Snøfjellafonna in the southern part of Eidsvollfjellet. In spite of the high altitude of the drilling site, features of melt-water refreezing were found in ice-cores and one borehole was filled with water. In 1993, two ice cores, at depths of 189 m to the bottom and 49 m, were obtained in the central part of Asgardfonna to confirm the features of 1989 Høghetta core. In 1995, ice coring will be done at Nordaustlandet.

V-6

Glaciological studies in the Canadian Arctic

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For a better understanding of the effects of climatic change on the Arctic, long-term records of past variability need to be completely developed from throughout the Arctic region. It has been recognized that ice cores from Greenland provide valuable information on long-term climatic change. On the other hand, much less attention has been paid to the ice cores from the Arctic region outside of Greenland. Ongoing mass balance measurements of 4 Canadian Arctic ice caps span the last 35 years and provide strong background information for any glacier studies. These studies have been supplemented over the last few years by automatic weather stations on two of the ice caps. The Canadian investigators have drilled and analyzed ice cores from Meighen, Devon and Agassiz Ice Caps in the Canadian Arctic beginning in 1965. They have pointed out that while the central Greenland dry snow sites give excellent undisturbed records back to the Eemian, they do not seem to tell the whole story especially in the Holocene. To provide a complete picture of past climate change, especially on time scales through the Holocene, more ice-core records from smaller ice caps throughout the Arctic, including those from the Canadian Arctic, are needed. An international research network is also necessary to coordinate the collection of these ice cores. Under this background, Canada-Japan cooperative studies on the Arctic ice cores were started in 1992 on Agassiz Ice Cap in Ellesmere Island. Furthermore, the International Circum-Arctic Paleoclimate Program (ICAPP) was initiated in 1994 and cores were extracted from Penny Ice Cap in Baffin Island in 1995 as a part of this program.

Several ice cores have been recovered from Agassiz Ice Cap. The bedrock was reached at a depth of 127 m at the summit and at a depth of 338 m at about 2 km down the flow line. Although the ice cap is relatively shallow, the cores drilled to the bedrock provide proxy climate records over the last 100,000 years. Solid electrical conductivity (ECM) and $\delta^{18}O$ records clearly show the Holocene/Wisconsin transition and pollen records highlight the warm interglacial ice that dates the inception of this ice cap, at the bottom. Melt-layer records, indicating a very warm early Holocene that is not evident in the $\delta^{18}O$ records from Summit, Greenland, have proved to be a very powerful technique for obtaining a picture of summer climate changes. In addition several shallow cores have been analyzed to reconstruct the post-industrial revolution snow chemistry. They indicate that trends in acid increase in Ellesmere Island are different than those in Greenland.

Effects of wind scouring on $\delta^{18}O$ and chemistry records have been intensively investigated on Agassiz Ice Cap through analyses of ice cores and pit samples. Spatial variations have been interpreted in terms of factors such as wind-scouring and surface melting. To extend one-dimensional information provided by the cores and pits to three-dimension, ice radar observations were carried out on Agassiz Ice Cap in 1994. A high resolution ice radar was newly developed to observe internal layers in the ice cap. To help interpret the ice-radar data, laboratory experiments on electrical properties of ice cores have also been carried out. Results of ice-radar observations, laboratory experiments and the other ice-core analyses will be compared.

A 334 m core to near the bedrock, 85 m-deep core and two other shallower cores were recovered from Penny Ice Cap in April-May, 1995. Continuous ECM analysis of the deepest core reveals that pre-Holocene ice exists near the bottom of Penny Ice Cap. The rest of the analyses are now on the way.