Abstracts

## HYDROGRAPHIC AND MOORING OBSERVATIONS OFF ADELIE LAND, ANTARCTICA

Yasushi FUKAMACHI[1], Masaaki WAKATSUCHI[1], Keisuke TAIRA[2],
Shoji KITAGAWA[2], Akiyoshi TAKAHASHI[3], Kohshiro OIKAWA[4],
Hiroyuki YORITAKA[4], Shuki USHIO[5], Temo FURUKAWA[5],
Mitsuo FUKUCHI[5] and Takashi YAMANOUCHI[5]
[1]*Institute of Low Temperature Science, Hokkaido Univ.*
[2]*Ocean Research Inst., Univ.of Tokyo,* [3]*Geo Tecs Co.*
[4]*Hydrographic Dept., Maritime Safety Agency*
[5]*National Institute of Polar Research*

The region off Adelie Land is thought to one of the sources of Antarctic Bottom Water. Hydrographic observations were carried out during December 1994 and January 1995 in this region. A vertical section near 140°E shows the existence of colder and fresher bottom water with higher dissolved oxygen and lower silicate concentrations. Current-meter moorings were also carried out at three locations on the continental slope in this region. At one of these moorings (139°59'E, 65°10'S, 2665 m deep), data were successfully obtained from January 1995 to March 1996. Three current meters were deployed at 1075, 1778, and 2632 m depths in this mooring. The data show that current speeds and variability of speeds and temperatures were largest at the lower current meter near the bottom. In addition, seasonal variability of speeds and temperatures was evident only at this current meter. From August to December, speeds and their variability were larger, temperatures were lower and their variability was larger. This suggests that the formation of bottom water occurs seasonally in this region.

## OBSERVATION OF OCEAN CURRENTS WITH SUBSURFACE FLOATS IN THE SOUTHERN OCEAN

Shuki USHIO[1], Koshirou OIKAWA[2], Yasushi FUKAMACHI[3],
Kay I. OHSHIMA[3] and Masaaki WAKATSUCHI[3]
[1]*National Institute of Polar Research*
[2]*Hydrographic Department, Maritime Safety Agency*
[3]*Institute of Low Temperature Science, Hokkaido Univ.*

To clarify characteristics of current fields in the Southern Ocean, three subsurface floats "ALACE" (Automonous LAgrangian Circulation Explorer, made by the Webb Res. Co., USA) have been deployed by JARE-38 in December 1996 and in March 1997. The target of this study is the eastern area of the Kerguelen Plateau. It is suggested that this area contributes importantly to heat and salt exchange in the Indian Ocean sector. However, current fields have not been fully understood yet. Positions of the ALACE floats are being measured by the ARGOS system every three or four weeks. Trajectories of the floats have been successfully obtained. One of the floats was deployed at a location of 63.5°S, 120°E and has been drifting clockwise. The average speed shows about 1.6 km/day (2 cm/s). It has been found that cyclonic eddies form in this region. Also, temperature profile data, which are obtained when the float rises to the surface, will be useful to reveal thermal structures around the area of drifting floats. These data will be considered together with historical hydrographic data and sea ice variations.

## A RELATIONSHIP BETWEEN OCEAN CURRENT AND SEAFLOOR TOPOGRAPHY IN THE ARCTIC OCEAN

Koji SHIMADA[1], Kiyoshi HATAKEYAMA[1], Takatoshi TAKIZAWA[1],
Noboru KOYAMA[2] and Greg HOLLOWAY[3]
[1]*Japan Marine Science and Technology Center*
[2]*IMOC,* [3]*IOS, Canada*

Features of the ocean circulation in the southern Canada Basin in the Arctic Ocean were investigated using ADCP data of a Beaufort Gyre Ice-Ocean Environmental Buoy (BG-IOEB) during 1992-1994. The major results were as follows. The first was the spatial distribution of eddy kinetic energy. On the flat and deep Canada Basin off Alaska, the circulation was governed by mesoscale eddies with their maximum activity in the cold halocline layer. In contrast, on the Northwind Ridge and Chukchi Plateau the activity of the mesoscale eddies considerably weakened and the circulation was governed by the seafloor topography from the upper cold halocline layer to the Atlantic layer. This implied that the eddy kinetic energy was converted into energy of topographically trapped currents. The second was a correlation between the seafloor topography and the horizontal velocity in the Atlantic layer below the main pycnocline. Based on the first result, the eddies-topography interaction (Holloway, 1992) was considered to be an important driving force for the Atlantic Water intrusion along the shelf breaks or the rim of sea mounts in the Arctic Ocean. The third was an intensification of both the barotropic and baroclinic current on the eastern slope of the Northwind Ridge. This could be established through interactions between the Rossby wave and sea floor topography. In addition, evidence of current scattering around the small scale submarine canyons and ridges on the Northwind Ridge and Chukchi Plateau was shown using the distribution TOPOSTROPHY which was an indicator how the current was parallel to the bathymetry.

## MELTING PROCESS OF SEA ICE IN THE ANTARCTIC OCEAN: RELATIONSHIP BETWEEN ICE CONCENTRATION AND MELTING RATE

Sohey NIHASHI and Kay I. OHSHIMA
*Institute of Low Temperature Science, Hokkaido Univ.*

In the Antarctic ocean, the melting process of sea ice is considered to be as follows: first, solar radiation is supplied to the upper ocean and its heat is used for bottom and lateral melting. Then the melting rate of sea ice should increase with decrease of ice concentration. On the basis of this concept, the relationship between the mean ice concentration and melting rate of sea ice is investigated, using DMSP SSM/I data. The mean ice concentration is certainly negatively correlated with melting rate of sea ice, which supports the above concept.

## SATELLITE MICROWAVE STUDIES OF COASTAL POLYNYAS IN THE SEA OF OKHOTSK

Noriaki KIMURA and Masaaki WAKATSUCHI
*Institute of Low Temperature Science, Hokkaido Univ.*

A coastal polynya is one of the key regions to understand the processes of the advancing of sea ice, because sea ice is efficiently produced there. However, its temporal and spatial variations are not yet understood completely. In this study, variations in the coastal polynya area are investigated using SSM/I data. Sea ice concentrations and sea ice types are calculated from SSM/I data with the algorithm established in Cavalieri (1994). Coastal polynyas are detected by the existence of new ice and high concentration. The variation of the polynya area is compared with that of atmospheric fields. For almost all cases, coastal polynyas occur under steady offshore wind conditions. On the other hand, a correlation between polynya area and air temperature is not evident. Frequency of the occurrence of coastal polynya has high interannual variability, while there is no significant correlation between frequency of coastal polynya occurrence and the total sea ice extent in each year. This study suggests that ice production in coastal polynyas is not necessarily an important factor for the determination of sea-ice extent.

## OZONESONDE EXPERIMENTS AT SYOWA STATION, ANTARCTICA FOR ILAS VALIDATION

Hiroshi KANZAWA[1], Yasuhiro SASANO[1], Susumu KANETO[2],
Toshinori TAKAO[2] and Takashi YAMANOUCHI[3]
[1]*National Institute for Environmental Studies*
[2]*Japan Meteorological Agency*
[3]*National Institute of Polar Research*

ILAS is a satellite-borne solar occultation sensor for observing the ozone layer in high latitudes. ILAS aboard the ADEOS satellite (named "Midori") operated from November 1996 to June 1997 when the ADEOS operation was stopped. Conventional ozonesonde measurements are considered to be one of the most reliable and cost effective measurements for validating vertical profiles of ILAS measurements of ozone ($O_3$) and temperature. ILAS project ozonesonde measurements were carried out at Syowa Station (69°S, 40°E) as a core validation experiment. Ozonesonde measurements oriented to ILAS validation were conducted, under the framework of cooperative research with the National Institute of Polar Research (NIPR), by the Japanese Antarctic Research Expedition (JARE) at Syowa Station (69°S, 40°E), Antarctica from 1996 to 1997. They were conducted when ILAS occultation events occurred over Syowa Station, in principle, within the range of 350 km. The measurements were conducted in two periods: 23 soundings in November 1996-- February 1997; 23 soundings in May – August 1997. 11 soundings among the 23 soundings in the latter period made in May – June 1997 are used for ILAS validation. The ozonesondes were nominally planned to be launched at the same time as the ILAS occultation over Syowa Station in the former period,and about 60-90 minutes prior to the ILAS occultation over Syowa Station in the latter period, to measure ozone concentration around 20 km altitude at the same time as the ILAS measurements. The ozonesonde experiments have given basic and valuable data for validating ILAS data through validating $O_3$ which is the most basic measurement item of ILAS. ILAS $O_3$ compares well with ozonesonde $O_3$: It shows good quality of ILAS $O_3$ data. Results of validation analyses will be presented.

## WARM SPELL IN THE INLAND REGION OF ANTARCTICA AND SEMI-ANNUAL OSCILLATIONS IN THE ATMOSPHERIC CIRCULATION

Hiroyuki ENOMOTO[1], Takao KAMEDA[1], Shuhei TAKAHASHI[1], Shuji FUJITA[2],
Hideaki MOTOYAMA[3], Yoshiyuki FUJII[3] and Okitsugu WATANABE[3]
[1]*Kitami Institute of Technology,* [2]*Hokkaido Univ.*
[3]*National Institute of Polar Research*

Seasonal changes in the air temperature show abrupt rise in winter in the inland region of Antarctica. Automatic weather station data have recorded such warming since the year of 1993. Associatied atmospheric conditions were investigated using upper air data over Syowa Station. Although warm advection in the troposphere was the cause of abrupt warming, the polar vortex moved from East Antarctica to West Antarctica and formed a circulation pattern which brought north wind to Syowa Station in 1994. Interannual variations of these relationships between the warm spell and atmospheric circulation were examined using temperature data estimated from microwave data since 1987.

## TEMPORAL CHANGES IN ATMOSPHERIC AEROSOL SIZE-NUMBER CONCENTRATION MEASURED AT SYOWA STATION, ANTARCTICA

Yasunobu IWASAKA[1], Kazuo OSADA[1], Masahiko HAYASHI[1] and Hirotaka UI[2]
[1]*Solar Terrestrial Environment Laboratory, Nagoya Univ.*
[2]*Department of Education, Toyama Univ.*

Atmospheric aerosol number-size distribution in the boundary atmosphere was monitored with an optical particle counter from February 1996 to January 1997 at Syowa Station, Antarctica. Measurements show the seasonal variation in aerosol concentration and aerosol size distribution. Short term variations which are possibly due to exchange of air-mass are frequently found. Effects of atmospheric low-pressure system are strongly suggested.

## VOLATILE SULFUR COMPOUNDS IN THE ATMOSPHERE AND SEA WATER DURING AN ANTARCTIC CRUISE OF SHIRASE

Yayoi INOMATA, Kakuji MATSUNAGA, Masahiko HAYASHI,
Kazuo OSADA and Yasunobu IWASAKA
*Solar Terrestrial Environment Laboratory, Nagoya Univ.*

The concentration of volatile sulfur compounds (COS, $H_2S$, $CS_2$, DMS) in the atmosphere and sea water were measured during a cruise between Japan and Antarctica from 17 November to 19 December 1996, as part of the Japanese Antarctic Research Expedition. The concentrations of COS in the atmosphere were estimated to average $344 \pm 34$pptv, during the cruise. The concentrations of $H_2S$ and $CS_2$ in the atmosphere were estimated at 70 pptv and 70 pptv respectively, in the middle northern hemisphere, and decreased rapidly southward. These distributions were caused by the long range transport of air influenced by continental input. The concentrations of DMS in the atmosphere were estimated from 7 to 698 pptv. In addition, the concentrations of DMS in sea water were 0.02-16.3 nM. The highest concentration of DMS in the atmosphere and sea water was obtained near the marginal sea ice zone; these concentrations drastically decreased with increasing sea ice cover in the Antarctic Ocean (60° S, 40-110° E). These distributions of atmospheric volatile sulfur compounds suggest that the concentrations of anthropogenic compounds, $H_2S$ and $CS_2$, decrease southward, and then COS and DMS are the dominant sulfur compounds in the remote marine boundary layer.

## COARSE AEROSOL PARTICLES CONTAINING NITRATES IN THE WINTER ARCTIC TROPOSPHERE

Keiichiro HARA, Kazuo OSADA, Masaharu WATANABE, Masahiko HAYASHI,
Kakuzi MATSUNAGA and Yasunobu IWASAKA
*Solar Terrestrial Environment Laboratory, Nagoya Univ.*

Aerosol particles and acidic gaseous components were collected at Ny-Ålesund (78°55'N, 11°56'E), Norwegian high Arctic, in 1996/97 winter for bulk analysis and individual particle analysis. More than 90% of atmospheric inorganic nitrates were distributed in the particle phase. A similar tendency was also observed in the 1995/96 winter. The positive reaction rate of coarse aerosol particles (>2.3 m) on nitron-thin-fim increased in aged oceanic air masses. According to observation in 1995/96, more than 90% of coarse nitrates were identified as internal mixtures of nitrates and sea salts. Thus, nitrates in coarse particles might be caused by uptake of gaseous $HNO_3$ in sea salt particles, and the formation of inorganic nitrates through some heterogeneous processes during transportation.

## ATMOSPHERIC CONCENTRATIONS OF CFC SUBSTITUTES ( HCFC-22, HCFC-142b, HCFC-141b and HFC-134a ) IN THE NORTHERN AND SOUTHERN HEMISPHERES

Tomoko SHIRAI and Yoshihiro MAKIDE
*Radioisotope Center, Univ.of Tokyo*

HCFC-22 ($CHClF_2$), HCFC-142b ($CH_3CClF_2$), HCFC-141b ($CH_3CCl_2F$) and HFC-134a ($CH_2FCF_3$) are currently widely used as substitutes for ozone-depleting CFCs. Air samples collected at remote locations in Japan and in Antarctica were analyzed with preconcentration and cryofocusing followed by capillary GC/MS to obtain tropospheric concentrations in the Northern and Southern Hemispheres. The concentrations showed monotonic growth in both hemispheres and relatively new compounds, HCFC-141b and HFC-134a showed more rapid growth and larger interhemispheric gradients than HCFC-22 and HCFC-142b.

## THE STUDY OF THE MELTING PROCESS OF ICE CRYSTALS JUST BELOW THE MELTING POINT

Takehiko GONDA[1] and Satoshi ARAI[2]
[1]*Aichi Gakuin Univ.,* [2]*Seiken Co. Ltd.*

We observed the melting process of the prismatic and basal faces of polyhedral ice crystals with increasing temperature of 0.27°*C*/min between 0 and −0.1°*C*. It was found that the prismatic face did not have facets at 0°*C*, but the basal face had facets. A possible explanation of the experimental results is discussed.

## INFLUENCE OF THE ARCTIC ON THE CLIMATE OF MID-LATITUDES IN SUMMERTIME

Mari TACHIKAWA and Kunio RIKIISHI
*Hirosaki Univ.*

The Arctic is the only source of cold air masses in summertime. This implies that cold weather in mid-latitudes is likely to be caused from time to time by intrusion of cold air from the Arctic. In order to see if this is true or not, objectively analyzed data of sea level pressure and height fields (700, 500, and 200 hPa) for the period 1963-1988 have been analyzed together with daily mean temperatures at mid-latitude stations. It has been found that cold weather at Kiev and Chicago is caused by direct intrusion of the Arctic air when the jet stream is displaced toward the mid-latitudes. On the other hand, cold weather occurs at Hachinohe when the Arctic air mass over the Bering Sea is brought to northern Japan by the Yamase circulation, which is driven by blocking by westerlies over the Sea of Okhotsk.

## THE STRUCTURAL ANALYSIS OF SEA ICE SAMPLED IN THE SOUTHERN PART OF OKHOTSK SEA

Takenobu TOYOTA[1], Toshiyuki KAWAMURA[1],
Jinro UKITA[2] and Masaaki WAKATSUCHI[1]
[1]*Institute of Low Temperature Science, Hokkaido Univ.*
[2]*National Space Development Agency of Japan*

It still remains unknown where and how the sea ice in the Sea of Okhotsk is formed and grows because of the lack of in-situ ice samples. In recent years ice breakers (patrol vessels) have obtained sea ice samples and investigated their structural characteristics by analyzing thin section, salinity, and density as a first step. Here we present the results of analysis of samples taken in the southern part of the Sea of Okhotsk in February, 1997. The structure of first-year ice was different in each sample, indicating complicated growing processes. Most young ice samples showed columnar structure. The layer where C-axes of crystals are almost vertical could be seen at the top of the sea ice in all the samples of pancake ice and nilas. In some of the samples, all the layers were occupied by this structure. Salinity of pancake ice and nilas was 6 to 10‰, greater than that of first year ice (2 to 4‰) and young ice (3 to 6‰).

## DETECTION OF FLOW-VECTOR FIELD OF PACK ICE IN THE SEA OF OKHOTSK BY MEANS OF IMAGE SEQUENCE PROCESSING

Masayuki OHI[1], Yasushi TAUCHI[2], Etsuro YOKOYAMA[2] and Atsushi NOMURA[3]
*[1]Institute of Low Temperature Science, Hokkaido Univ.*
*[2]Yamaguchi Univ., [3]Yamaguchi Prefectural Univ.*

We present a method to detect the velocity vector field of the motion of pack ice in the Sea of Okhotsk by means of image sequence processing. The method is based on the continuity equation of brightness density corresponding to echo intensity of radar images, assuming that the brightness distribution is smooth in space and there is no internal brightness generation. Since our data are sampled at evenly spaced intervals in time, we can calculate numerically the flow vector field using a finite difference method. As a test of our techniques, we treat the image sequence data produced by computer simulation, and show that the flow vector is determined accurately.

## SEA ICE CLASSIFICATION USING A JERS-1 SAR IMAGE IN THE SEA OF OKHOTSK

Haruhito SHIMODA, Shotaro UTO and Hiroshi YAMANOUCHI
*Ship Research Institute, Ministry of Transport*

Classification of sea ice in the Sea of Okhotsk off the coast of Hokkaido was studied by a JERS-1 SAR image. The sea-truth data were obtained by on-board measurements of sea ice in February 1996. The distribution of ice thickness along the ship's track was monitored by the VTR on-board the icebreakers "SOYA" and "TESHIO". The measured location, i.e. the ship's track, was recorded by GPS. Part of the ship's track was preserved in fragments in the SAR image. It can be clearly detected because of the high back scatter coefficient ($\sigma_0$). By pattern matching of these fragments with the original track, 10 segments can be specified as the data set of the sea-truth study. Along each segment, $\sigma_0$ was collected and averaged as well as the corresponding ice thickness data. The range of mean ice thickness along each segment is from 20 to 40 cm. Through the comparison of satellite and sea-truth data, it is found that the $\sigma_0$ of sea ice is below -14dB and tends to decrease with increase of ice thickness in general. However, there exists ice about 30 cm thick, which has very low $\sigma_0$ (-18 dB). Such ice is found to have a very smooth surface from on-board observation. Therefore, the surface roughness is regarded as one of the dominant factors for the $\sigma_0$. This suggests a possibility of detection of thicker ice by JERS-1/SAR, because thicker ice in this area consists of rafted, hummocked or ridged ice and its top surface has significant roughness.

## OBSERVATION OF SEA ICE USING 85GHZ CHANNEL OF DMSP SSM/I

Kazutaka TATEYAMA[1], Hiroyuki ENOMOTO[1], Shuhei TAKAHASHI[1],
Kinji HYAKUTAKE[1] and Fumihiko NISHIO[2]
[1]*Kitami Institute of Technology*
[2]*Hokkaido Univ.of Education*

19 GHz and 37 GHz channels of DMSP SSM/I have been used for sea ice observation. Although SSM/I also has a 85 GHz channel, this channel has not been used for sea ice observation, because this channel is affected by vapor. But, 85 GHz has higher resolution than the other channels, and the effect of vapor is small in the polar region in winter. This study uses AMR (Airborne Microwave Radiometer) data obtained on the 85 GHz channel to develop a new algorithm for sea ice classification, and attempted to apply the algorithm to SSM/I.

## ICE DISPLACEMENTS OBSERVED BY SYNTHETIC APERTURE RADAR NEAR THE NEW SIBERIAN ISLANDS

Shinya KAKUTA[1] and Shouji TAKEUCHI[2]
[1]*Japan Marine Science and Technology Center*
[2]*Remote Sensing Technology Center of Japan*

Ice displacement can be calculated from a pair of images of Synthetic Aperture Radar (SAR) with pattern-matching. On 4 and 6 November 1996, we obtained 75 km×75 km JERSI SAR images near the New Siberian Islands around 72.5-73°N 135-137°E (the Laptev Sea), where ice concentration (compactness) was more than 70%. Every week from December 1996, we obtained a 500 km×500 km RADARSAT SCANSAR image in the Western half of the East Siberian Sea including the New Siberian Islands. We improved the algorithm of ice-displacement calculation to avoid mismatching sea-ice patterns. We succeeded in measuring ice deformation while the absolute velocity of ice floes is still uncertain.

## ANALYSIS OF PRECIPITABLE WATER AND INTEGRATED LIQUID WATER CONTENT OVER THE SEA AREA AROUND SVALBARD USING SSM/I DATA

Makoto WADA
*National Institute of Polar Research*

SSM/I data from 1987 in polar regions are distributed by the National Snow and Ice Data Center, Cooperative Institute for Research in Environment Science, Boulder, Colorado. These data have been used for analysis of sea ice type and content in polar regions by many researchers. Variations of precipitable water and integrated liquid water content over the sea area around Svalbard have being presented in this symposium using the 22 GHz and 37 GHz brightness temperature data. Two points are selected for studying annual variations (1988-1996) of precipitable water and integrated liquid water content. The B point is at 75°N latitude and 0° longitude, and the F point is at 75°N latitude and 10°E longitude. Both points are located between Greenland and Svalbard. We compared the average summer data (June-September) only at point B and point F, because point B is sometimes covered with sea ice in winter. The following results were obtained. The brightness temperature of 22 GHz at point F is higher than that at point B in every year. However, the brightness temperature of 37 GHz at point F is not always higher than that at point B. Sea surface temperature and atmospheric disturbance, which transport much water vapor and liquid water, are considered to be factors affecting brightness temperature. We discuss the relationships between the brightness temperature data and the sea surface temperature, and the disturbance data.

## DEVELOPMENT OF A TOOL FOR ANALYZING BRIGHTNESS IMAGE DATA

T.SHIGA[1], Masahiko HATANAKA[1], Kenichi ITAKURA[1],
Yutaka YOSHIDA[1], Makoto WADA[2] and Naohiko HIRASAWA[2]
[1]*Muroran Institute of Technology*
[2]*National Institute of Polar Research*

A series of the brightness temperature image data CD-ROMs is distributed by NSIDC. To analyze the long term variations, we develop a software tool for these CD-ROMs. This prototype tool contains media conversion, data rearrangement and data processing functions for brightness temperature data and temperature data.

## SEASONAL PRECIPITATION VARIATIONS ON SPITSBERGEN ISLAND, NORWAY

Nao OGITANI[1], Yoshio ASUMA[1], Katsuhiro KIKUCHI[1] and Makoto WADA[2]
[1]*Graduate School of Science, Hokkaido Univ.*
[2]*National Institute of Polar Research*

It is very important to understand the water vapor transportation mechanism through the Norwegian Sea into the Arctic region from the viewpoint of global water circulation. Seasonal variations of the precipitation observed on Spitsbergen Island were analyzed using the vertical pointing X-band radar set up by the National Institute of Polar Research of Japan. Seasonal features of the frequency of radar echoes with height were found from their monthly statistics through a year from April 1994 to March 1995. These features reflected seasonal variations of four types of precipitation pattern (Type A-D) closely related to storm characteristics in this region. Strong radar reflectivity with higher echo top (Type A) appeared most frequently through the year. This pattern was associated with the passage of a low pressure system. Weak echoes which were restricted to the upper layer (Type B) appeared mostly in winter. This pattern was also associated with passage of disturbances over the frozen sea surface. Low level radar echoes which were suppressed their top at several kilometers A.S.L. (Type C) frequently appeared in spring and fall. This pattern corresponded to precipitation in the mixing layer over the open water before it froze. Strong echoes between higher altitude and the ground surface with short period (Type D) appeared in summer. This precipitation corresponded to summer convective storms. These storm characteristics account for the monthly statistics of the frequency of radar echo with height.

## THREE DIMENSIONAL FINE STRUCTURES OF BULLET TYPE SNOW CRYSTALS OBSERVED AT SYOWA STATION, ANTARCTICA

Kunimoto IWAI
*Shinshu Univ.*

Bullet type snow crystals are the most common snow crystals observed at Syowa Station, Antarctica. Their three-dimensional fine structures are shown by stereo-photomicrographs. Apparent pyramidal planes are not the crystallographic pyramidal planes but are mere skeleton structures. Inside prismatic planes named by Yamashita (1971) are well developed, particularly on bullet type crystals with plates at the ends. It is suggested that single bullet crystals are formed by integration of combination of bullet type. Other many types of bullet snow crystals are shown.

## HIGH TEMPERATURE OBSERVED AT SYOWA STATION FROM JULY TO OCTOBER, 1996

Hitomi MIYAMOTO , Masamichi NAKAMURA ,
Osamu NARITA and Ayumi YOKOTA
*Members of the 37th Japanese Antarctic Research Expedition, Japan Meteorological Agency*

From July to October 1996, surface temperature at Syowa Station was higher than the average of 30 years from 1961 to 1990. Especially monthly mean temperature of September 1996 was 6.1°C higher than the average. High temperature at Syowa during winter is usually caused by snowstorms. But ten-day-mean sea-level pressure from August to September 1996 was higher than the average. Other stations in Antarctica also observed high surface temperature from July to September 1996. On the other hand, high surface temperature in October was observed only at Syowa.

## GEOGRAPHICAL DISTRIBUTION OF WATER SOLUBLE CONSTITUENTS IN AEROSOL PARTICLES OBTAINED FROM THE MARINE ATMOSPHERE DURING THE ANTARCTIC CRUISE (JARE-38) OF SHIRASE

Kazuo OSADA, Masahiko HAYASHI, Mizuka KIDO, Keiichiro HARA,
Yayoi INOMATA, Kakuji MATSUNAGA and Yasunobu IWASAKA
*Solar Terrestrial Environment Laboratory, Nagoya Univ.*

Methanesulfonate and sulfate are oxidation products of marine biogenic DMS. Size distributions of $CH_3SO_3^-$ , $nssSO_4^{2-}$ and other ionic constituents were obtained by using a cascade impactor during the Antarctic cruise (JARE-38) of Shirase to study their geochemical cycle through the marine boundary layer. Geographical distributions of water soluble constituents in size separated aerosol particles are discussed in terms of their orign and removal processes.

## CONTINUOUS $^{222}$RN MONITORING IN ANTARCTICA BY USING A HIGH SENSITIVITY RADON DETECTOR

Shigeki TASAKA[1] , Hirotaka UI [2] and Masahiko HAYASHI [3]
*[1]Gifu Univ., [2]Toyama Univ., [3]Nagoya Univ.*

The radon concentration was continuously observed at Syowa Station during JARE 37 between 1 August 1996 and 7 February 1997 by a high sensitivity radon detector. The air radon concentration was suddenly increased to about 0.4 (Bq/m$^3$), 15 times higher than ordinary levels, on 19 October 1996. The radon observation was started on 6 February 1997 at Dome Fuji Station during JARE 38, and the system operated without any trouble until 1 October 1997. This radon detector was developed for continuous monitoring in the Super-Kamiokande experiment. The radon concentration in pure water should finally decrease to 5 (mBq/m$^3$). We developed an electrostatic collection radon detector with PIN photodiode to measure changes of radon concentration. We constructed a calibration system to study the high voltage dependence and absolute humidity dependence of the detector. As a result, absolute humidity dependence appeared clearly in the region less than 1.6 (g/m$^3$) and was constant in the region greater than 1.6(g/m$^3$). The calibration factor for $^{214}$Po was 1.8 [(count/d) / (mBq/m$^3$)] at 0.05 (g/m$^3$). The detection limit was estimated to be 13 (mBq/m$^3$). This radon detector is the most suitable detector for continuous radon observation at the time of surface ozone depletion in Syowa Station.

# RECENT TRENDS OF ATMOSPHERIC CONCENTRATIONS OF CFC-11, CFC-12, CFC-113 AND 1,1,1-TRICHLOROETHANE IN THE NORTHERN AND SOUTHERN HEMISPHERES AND THEIR RELEASE

Mikihiro HIRABAYASHI , Sakae TOYODA and Yoshihiro MAKIDE
*Univ. of Tokyo*

Atmospheric concentrations of CFC-11($CCl_3F$),CFC-12($CCl_2F_2$), CFC-113 ($CCl_2FCClF_2$) and $CH_3CCl_3$ in the mid/high-latitude Northern Hemisphere (NH) and the high-latitude Southern Hemisphere (SH) have been obtained by analyzing samples collected in Hokkaido, Japan (42-45°N), and at Syowa Station, Antarctica (69°S), respectively. The increasing trends of the atmospheric concentrations of these major halocarbons (CFCs and $CH_3CCl_3$) changed drastically in the NH, corresponding to the start of regulation and phasing out of their production according to the revised Montreal Protocol. While the observed concentrations in the SH have followed the changes in the NH with a few years delay, the concentration differences between the hemispheres are diminishing, reflecting the recent ban of production/use in developed countries in the NH. The observed change of concentration of each compound is compared with the industrial production statistics and the estimated release.

# A STUDY OF AIR-SEA $CO_2$ EXCHANGE IN THE GREENLAND SEA AND THE BARENTS SEA

Satoru YOSHIMURA[1], Shuji AOKI[1], Takakiyo NAKAZAWA[1], Shinji MORIMOTO[2], Gen HASHIDA[2], Kunio SHIRASAWA[3] and Torgny VINGE[4]
[1]*Center for Atomospheric and Oceanic Studies, Tohoku Univ.*
[2]*National Institute of Polar Research*
[3]*Institute of Low Temperature Science, Hokkaido Univ.*
[4]*Norwegian Polar Institute, Oslo, Norway*

To elucidate air-sea $CO_2$ exchange quantitatively, measurements of surface oceanic $CO_2$ partial pressure ($pCO_2$) were made in the Greenland Sea in August 1992, August 1993, and April to May 1994, and in the Barents Sea in June 1995 and July to August 1996. Vertical distribution of the total concentration of dissolved inorganic carbon ($n\Sigma CO_2$) and its carbon isotopic ratio ($\delta^{13}C$) were also measured. Atmospheric $CO_2$ concentration has been obtained by grab sampling once a week since August 1991 at Ny-Ålesund, Svalbard. $n\Sigma CO_2$ and $\delta^{13}C$ were almost constant everywhere below 200 m depth in the Greenland Sea and the Barents Sea in August, with respective mean values of 2.1 mmol kg-1 and 1.2 per mill. The vertically and horizontally uniform distributions of $n\Sigma CO_2$ and $\delta^{13}C$ can be ascribed to strong downwelling of the surface water in this area. On the other hand, $n\Sigma CO_2$ and $\delta^{13}C$ above 200 m depth were lower and higher, respectively, compared with those below that depth, and the measured values of these two components show a good linear relationship with a coefficient of -12 per mill (mmol $kg^{-1})^{-1}$, suggesting that the decrease in $n\Sigma CO_2$ is caused by strong oceanic biological activity. $pCO_2$ in the surface layer of the Greenland Sea was rather high in April and then decreased drastically to extremely low values in mid-May; these low values continued until August. Measured values of $pCO_2$ were always lower in the surface ocean than in the atmosphere from April to August. The difference of $pCO_2$ between the atmosphere and the sea ($\Delta pCO_2$) amounted to about 60 μatm in April and reached a maximum of about 190 μatm in mid-May. $CO_2$ uptake by the Greenland Sea and the Barents Sea calculated from $\Delta pCO_2$ and wind velocity was 0.8 to 3.3 GtC $yr^{-1}$. This value corresponds to a few percent of the total $CO_2$ uptake by the world oceans.

## CONVERSION FROM SULFUR DIOXIDE TO SULFURIC ACID IN THE WINTER ARCTIC

Keiichiro HARA, Kazuo OSADA, Masaharu WATANABE,
Masahiko HAYASHI, Kakuji MATSUNAGA and Yasunobu IWASAKA
*Solar Terrestrial Environment Laboratory, Nagoya Univ.*

Atmospheric aerosol particles and acidic gases were sampled at Ny-Ålesund, (78°55'N, 11°56'E), Norwegian high Arctic, in 1996/97 winter using a 2-stage low volume impactor with a back-up filter and alkaline impregnated filters with prefilter for removing particulate matter. Concentrations of non-sea-salt (nss-) $SO_4^{2-}$ and $SO_2$ increased in Arctic air masses cold and dry conditions. The rate of nss-$SO_4^{2-}$ to total atmospheric sulfur spices (particle fraction) was a minimum in mid-January, while the particle fraction gradually increased with recovery of solar radiation. Also the variation of oxidation rate of $SO_2$ had similar variation to that of particle fraction. This tendency could be caused by increase of the oxidation ability of the atmosphere, and the contribution of $SO_2$ photooxidation. However, poor solar radiation should provide relatively large contribution of non-photochemical $SO_2$ oxidation in winter Arctic. According to previous observation in 1995/96 winter, more than 70% of nss-$SO_4^{2-}$ was identified as an internal mixture of nss-$SO_4^{2-}$ and soot. Thus, nss-$SO_4^{2-}$ might have been also internally mixed with soot in the 1996/97 winter through conversion from $SO_2$ to nss-$SO_4^{2-}$ on soot particles, and cloud processes.

## HAZE IN THE CANADIAN HIGH ARCTIC BASED ON THE LAST 4 WINTERS OF OBSERVATION

S. ISHII[1], Takashi SHIBATA[1], Toshikazu ITABE[2], Kohei MIZUTANI[2],
Michio HIROTA[3], Tomohiro NAGAI[3] and Toshifumi FUJIMOTO[3]
[1]*Solar Terrestrial Environment Laboratory, Nagoya Univ.*
[2]*Communications Research Laboratory*
[3]*Meteorological Research Institute*

Information about vertical profiles of arctic haze and cloud in the troposphere is poor and is not sufficient to discuss atmospheric phenomena during the arctic polar night in detail. We installed a lidar to observe arctic haze at Eureka (80°N, 86°W) in the Canadian high Arctic in 1993. We observed continuously during winter in each year. We discuss the differences between arctic haze and cloud during the polar night in the troposphere based on the last 4 winters observations.

## OBSERVATION OF ARCTIC STRATOSPHERE BY MILLIMETER WAVE SPECTROMETER

Satoshi OCHIAI, Yoshihisa IRIMAJIRI and Harunobu MASUKO
*Communications Research Laboratory*

Stratospheric ozone concentration was measured by millimeter wave spectrometer from September 1996 to the end of February 1997 at Ny-Ålesund, Svalbard. Height profiles of ozone concentration are retrieved from the observation in February in the height range between 15 and 60 km with a height resolution of 8 km. We could not obtain enough observations of ClO because of bad weather in February and instrumental malfunction in March. The instrument will be moved to Fairbanks in the next year, after it is modified in CRL.

## LIDAR OBSERVATION OF SPHERICAL AND NON-SPHERICAL PARTICLES OF POLAR STRATOSPHERIC CLOUDS AT NY-ÅLESUND

Hiroshi ADACHI[1], Takashi SHIBATA[1], Masahiko HAYASHI[1], Tetsu SAKAI[1], Koichi TAMURA[1], Masahiro NAGATANI[1], Koichi SHIRAISHI[2], Syu AYUKAWA[2], M. FUJIWARA[2] and Yasunobu IWASAKA[1]
[1]*Solar Terrestrial Environment Laboratory, Nagoya Univ.*
[2]*Fukuoka Univ.*

Polar Stratospheric Clouds (PSCs) were observed by lidar at Ny-Ålesund, Svalbard. The backscattering ratio of spherical or non-spherical particles can be obtained by polarization lidar data under the assumption that PSCs consist of spherical and non-spherical particles which have a specific depolarization ratio. The continuous profiles of backscattering ratio of each particles show that amounts of each particle change in PSCs.

## LIDAR OBSERVATIONS OF POLAR STRATOSPHERIC CLOUDS OVER SVALBARD

Syu AYUKAWA[1], Koichi SHIRAISHI[1], M. FUJIWARA[1], Hiroshi ADACHI[2], Tetsu SAKAI[2], Takashi SHIBATA[2] and Yasunobu IWASAKA[2]
[1]*Fukuoka Univ.*
[2]*Solar Terrestrial Environment Laboratory, Nagoya Univ.*

Polar stratospheric clouds (PSCs) and background aerosols over Ny-Ålesund, Svalbard (79°N) have been observed by Nd:YAG lidar since January 1994. The appearance of PSCs depends on the background temperature but not the amount of background aerosols. Types of PSCs observed are twofold: the layer of liquid droplets, the top and bottom sides of which are frozen, and the layer of frozen particulate. The latter appeared in the initial stage of stratospheric cooling and the former in the fully developed stage. Other important observational results are also reported.

## DEVELOPMENT OF A CRYOGENIC AIR SAMPLING SYSTEM USING A JT CRYOSTAT

Shinji MORIMOTO[1], Gen HASHIDA[1], Makoto WADA[1], Takashi YAMANOUCHI[1], Hideyuki HONDA[2], Shuji AOKI[3], Akihiro OHBA[4] and Masaki HIROKAWA[4]
[1]*National Institute of Polar Research,* [2]*Institute of Space and Astronautical Science*
[3]*Tohoku Univ.,* [4]*Nippon Sanso Corp.*

In order to clarify distributions and variations of atmospheric trace gases in the stratosphere using an unmanned aircraft, it is necessary to develop a small and light weight air sampler. For this purpose, some fundamental experiments were performed to develop a new cryogenic air sampler using a Joule-Thomson (JT) cryostat. A high pressure cylinder filled with neon was connected to a pre-cooling unit, in which the neon gas was cooled to 77 K with liquid nitrogen. Then, the neon gas was introduced into the JT cryostat and expanded. Measurements of temperatures at the inlet and release ports of the JT cryostat indicated that the refrigeration efficiency was between 13.9 and 17.9 J/s at the inlet pressure of 110 kgf/cm$^2$. It was also confirmed that the neon gas was liquefied after 145 s of continuous gas introduction.

## OUTLINE OF THE GLACIOLOGICAL RESEARCH AT DOME FUJI IN 1996

Shuji FUJITA[1], Yoshiyuki FUJII[2] and Okitsugu WATANABE[2]
[1]*Hokkaido Univ.*
[2]*National Institute of Polar Research*

In 1996, the 37th Japanese Antarctic Research Expedition carried out glaciological surveys that had been planned by the Dome F Project Group. The field operations included the following work: 1) deep ice core drilling down to 2503 m, 2) ice core processing, 3) glaciological observation at and around Dome Fuji Station, 4) automatic weather stations at the station and along the route, and 5) radar sounding of the ice sheet. Outlines of these field works are presented.

## ICE CORE PROCESSING OF THE DOME-FUJI STATION CORE, ANTARCTICA

Shuji FUJITA[1], Yoshiyuki FUJII[2], Nobuhiko AZUMA[3], Hideaki MOTOYAMA[2], Hideki NARITA[1] and Okitsugu WATANABE[2]
[1]*Hokkaido Univ.*
[2]*National Institute of Polar Research*
[3]*Nagaoka Univ. of Technology*

In 1996, the 37th Japanese Antarctic Research Expedition carried out glaciological surveys that had been planned by the Dome F Project Group. The field operations included the following work: 1) deep ice core drilling down to 2503 m, 2) ice core processing, 3) glaciological observation at Dome Fuji Station, 4) automatic weather stations at the station and along the route, and 5) radar sounding of the ice sheet. An outline of the ice core processing is presented. Procedures of the field work at the station and the preliminary results are presented.

## CONTRIBUTION OF SUBLIMATION PROCESS TO THE SURFACE MASS BALANCE OBSERVED AT DOME FUJI STATION AND MIZUHO STATION, ANTARCTICA

Takao KAMEDA and Shuhei TAKAHASHI
*Kitami Institute of Technology*

The contribution of the sublimation process to the surface mass balance was investigated using measurements at Dome Fuji Station and Mizuho Station, Antarctica. Sublimation fluxes for snow and ice surfaces were measured by the evaporation-pan method at Dome Fuji Station from February 1995 to January 1996. Sublimation for the ice surface was measured from March 1982 to January 1983 at Mizuho Station where a glazed surface was commonly observed. Measurements at Dome Fuji Station and at Mizuho Station show that total sublimation fluxes during the winter months from April to October are 0.49 and 0.11 g $cm^{-2}$ respectively. These correspond to 30 and 45% of the surface mass balance which was estimated from stake-farm and surface snow density measurements. Total sublimation fluxes during summer months from November to February at the two sites are -0.39 and -5.0 g $cm^{-2}$ respectively. These control the surface mass balance in summer. For the annual balance, sublimation flux from atmosphere to snow surface (0.16 g $cm^{-2}$ $yr^{-1}$) prevailed at Dome Fuji Station. Sublimation flux from ice surface to atmosphere (-5.2 g $cm^{-2}$ $yr^{-1}$) prevailed at Mizuho Station.

## CHANGES IN STABLE ISOTOPE CONTENT IN THE SURFACE SNOW LAYER OVER DOME FUJI, ANTARCTICA

Masayoshi NAKAWO[1], Kazuki NAKAMURA[2] and Shigemasa HASHIMOTO[1]
[1]*Institute for Hydrospheric Atmospheric Sciences, Nagoya Univ.*
[2]*Japan Weather Association*

A long ice core covering more than two hundred thousand years in the past has been retrieved at Dome Fuji, Antarctica, and subjected to various analyses to reconstruct the past climate and environment. Stable isotope content is one of the most important parameters to indicate not only the past temperature but also the past water circulation system. It is well known, however, that the content changes with time from the original value at snow deposition, in association with snow metamorphism in the surface snow layer. It is important, therefore, to examine the evolution of the isotope content, in order to interpret the core data for reconstructing past conditions, in particular near the Dome Fuji area where intensive dry snow metamorphism is expected because of a large temperature gradient near the surface. The heavier isotope content for both hydrogen and oxygen has been measured for snow pit samples from DS40, which is close to the drilling site at Dome Fuji. A linear relation is found between the deuterium content and the content of oxygen 18, when plotted with the delta value, the deviation from the isotope content for Standard Mean Ocean Water. The slope of the linear regression line, however, is smaller than 8, which is obtained for world wide precipitation. This could indicate a kinetic effect of isotope fractionation during the snow metamorphism, presumably when water vapor condenses at snow particles with relatively small curvatures.

## PROTON ARRANGEMENT IN DOME-FUJI ICE

Shinji MAE
*Dept. Applied Physics, Hokkaido Univ.*

The spectroscopy of Raman and Neutron scattering of Dome-Fuji ice core showed that ice at temperatures below -34℃ had a proton-ordered structure. The temperatures are not temperatures of the measurements, but are temperatures of ice in the ice sheet. On the other hand, the measured dielectric permittivity of Dome-Fuji in the micro-wave range showed that the temperature dependence of dielectric permittivity changed clearly and discretely at -34℃. In this case, the temperatures are those of the measurements. The change of the temperature dependence is observed in the proton-disordered ice. These new observations may be explained by the order-disorder transition of proton arrangement in ice; the transition takes a very long period, for example 1000 years.

## INTRODUCTION FOR ACTIVITIES ON ISOTOPIC AND CHEMICAL ANALYTICAL WORK FOR DOME FUJI DEEP ICE CORE, ANTARCTICA

Okitsugu WATANABE[1], Yoshiyuki FUJII[1], Kokichi KAMIYAMA[1], Hideaki MOTOYAMA[1], Teruo FURUKAWA[1], Wataru SHIMADA[1], Makoto IGARASHI[1], Shuhei TAKAHASHI[2], Tomomi YAMADA[3], Kazuo FUJINO[3], Shuji AOKI[4], Takakiyo NAKAZAWA[4], Shunichi KOBAYASHI[5], Kohtaro YOKOYAMA[6], Kazuhide SATOW[7], Keisuke SUZUKI[8], Masayoshi NAKAWO[9], Yutaka AGETA[9], Hiroshi TANAKA[9], Ippei NAGAO[9], Satoru KANAMORI[9] and Yohichi TANAKA[10]
[1]*National Institute of Polar Research,* [2]*Kitami Inst. Tech.,*
[3]*Inst. Low Temperature Science, Hokkaido Univ.,* [4]*Tohoku Univ.,* [5]*Niigata Univ.,*
[6]*HRIA,* [7]*NTI,* [8]*Shinsyu Univ.,* [9]*Nagoya Univ.,* [10]*Geosystems*

A deep ice core was successfully obtained at Dome Fuji Station, Antarctica. The station is located at the highest point of the Shirase Glacier basin, where the glacier flow lines begin. A complete chronology of past precipitation is expected to be recovered. The core will record the climate signals from present up to several hundred thousand years ago. At Dome Fuji Station, a shallow ice core of 112.59 m depth was obtained by JARE-34 in 1993 and a deep ice core of over 2500 m depth by JARE-36 and -37 in 1995 and 1996. Now the core up to 2250 m depth is in Japan and ready for analyses. The analyses of oxygen isotopic ratio, concentrations of chemical constituents and numbers of micro particles and so on, will give us information on the paleo-environment. Data were obtained from whole core samples analyzed in Japan with a certain interval. The stable isotopic profile tells us that the core can cover at least two glacial-interglacial stages. These core samples are useful for .paleo-environmental studies on glacial-interglacial stages during the past several hundred thousand years.

## ANALYSIS OF DOME FUJI ICE CORES, ANTARCTICA

Okitsugu WATANABE[1], Wataru SHIMADA[1], Morimasa TAKADA[1], Takeo HONDOH [2],
Hideki NARITA[2], Akira HORI[2], Atsushi MIYAMOTO[2], Kazushige TAYUKI[2],
Michiko FUJII [2], Hitoshi SHOJI [3], Takao KAMEDA [3],
Shinji MAE [4], Shuji FUJITA [4], Nobuhiko AZUMA [5] and Y. WONG [5]
[1]*National Institute of Polar Research,*
[2]*Inst. Low Temperature Science, Hokkaido Univ.,* [3]*Kitami Inst. Tech.,.*
[4]*Graduate School of Engineering, Hokkaido Univ.,* [5]*Nagaoka University of Technology*

Recent progress in physical analysis of Dome Fuji ice cores is briefly described. We have obtained preliminary depth profiles of the number density of air bubbles, average bubble diameter, average diameter of ice grains, texture degrees of ice crystal c-axes and total gas content. These data are compared with the depth profile of $\delta^{18}O$ as well as both DC-and AC-ECM profiles in order to see any degree of correlations.

## TEPHRA LAYERS FOUND IN DOME FUJI DEEP ICE CORE

Yoshiyuki FUJII[1], Shuji FUJITA [2], Nobuhiko AZUMA [3],
Takaaki FUKUOKA [4],Tadashi KIKUCHI[5] and Toshitaka SUZUKI [6]
[1]*National Institute of Polar Research,* [2]*Graduate School of Engineering, Hokkaido Univ.,*
[3]*Nagaoka University of Technology,* [4]*Gakushuin Univ.,*
[5]*Sci. Univ. of Tokyo in Yamaguchi,* [6]*Yamagata Univ.*

25 visible tephra layers were found in the Dome Fuji deep ice core. The thickness was in the range between 1 and 22 mm. The tephra layers are concentrated in the depth ranges of 500-550 m, 1100 m, 1300-1450 m, 1750-1900 m and 200-2200 m. Some of them appear in cold glacial periods suggesting a relation between volcanic activity and land ice volume.

## THE GRAVITATIONAL SEPARATION OF AIR COMPONENTS IN FIRN AT H15, ANTARCTICA

Kenji KAWAMURA[1], Takakiyo NAKAZAWA[1], Shuji AOKI [1],
Toshinobu MACHIDA[2], Yoshiyuki FUJII[3] and Okitsugu WATANABE[3]
[1]*Center for Atmospheric and Oceanic Studies, Tohoku Univ.*
[2]*National Institute for Environmental Studies*
[3]*National Institute of Polar Research*

Ice core analysis is the most reliable method to obtain past changes of concentration and the isotopic ratio of green house gases. However, it has been pointed out by previous studies that air in ice does not represent exactly the past atmospheric composition because of gravitational separation of gases in firn layer due to molecular diffusion. In this study, stable the isotopic ratio of nitrogen in air extracted from ice core samples from H15, Antarctica was measured with the precision of ±0.02‰ so as to estimate the magnitude of gravitational separation. Prior to measuring the ice core air, air samples were globally collected and analyzed for $\delta^{15}N$ in $N_2$ to confirm that the atmosphere can be used as a standard gas for measuring $\delta^{15}N$. The averaged $\delta^{15}N$ value of air extracted from the ice core samples at 15 different depths, covering the whole length of H15 core, was +0.155‰ against the air over Syowa Station, which was lower by 0.08‰ than the value calculated on the assumption that the air in whole firn was under a state of barometric equilibrium. The profile of $\delta^{15}N$ in firn was estimated by using the one dimensional air diffusion model, in which the progressive decrease of diffusivity with increasing depth and the process of air occlusion in the ice were considered. The results suggest that the air was mixed well with the atmosphere in the firn layer from the snow surface down to the depth of 17 m. Using the measured $\delta^{15}N$, values of $\delta^{13}C$ of $CO_2$ obtained from the H15 core were gravitationally corrected by subtracting 0.155‰ from the measured values.

## ICE CORE STUDIES OF ANTHROPOGENIC SULFATE AND NITRATE TRENDS IN THE ARCTIC

Kumiko GOTO-AZUMA[1], Roy M. KOERNER[2] and Chester C. LANGWAY, Jr.[3]
[1]*Nagaoka Inst. of Snow & Ice Studies*
[2]*Geological Survey of Canada*
[3]*State Univ. of New York at Buffalo, U.S.A*

Ice core studies have shown that sulfate and nitrate concentrations in Arctic snow have increased significantly since the last century due to the influx of anthropogenic pollutants transported to mid-latitudes. Increasing trends of sulfate and nitrate concentration levels are evident in all the ice core data from Greenland, the Canadian Arctic and Spitsbergen. Temporal patterns, however, show spatial variation. The difference in the increasing trends of sulfate and nitrate between the sites on Greenland and Baffin Island on the one hand and Spitsbergen and Northern Ellesemere on the other, can be explained by the different sources and pathways of air pollutants.

## 3-D NUMERICAL MODELING OF ANTARCTIC ICE SHEET (1) EQUILIBRIUM RESPONSE

Fuyuki SAITO and Ayako ABE-OUCHI
*Center for Climate System Research, Univ. of Tokyo*

A three dimensional time-dependent numerical model incorporating the shallow ice approximation is applied to the Antarctic ice sheet and some preliminary experiments are made. Equilibrium states are calculated under empirical functions of boundary conditions. In the experiments, for simplicity ice shelves, basal sliding and isostatic response are neglected. In the future the response of the model to physical factors, the effects of higher-order stress components and unstable responses will be considered.

## CHEMICAL ANALYSES OF THE BASAL ICE OF HAMNA ICEFALL, ANTARCTICA

Yoshinori IIZUKA[1], Hiroshi SATAKE[2], Makoto IGARASHI[3], Takayuki SHIRAIWA[1], Renji NARUSE[1] and Kohtaro YOKOYAMA[4]
[1]*Institute of Low Temperature Science, Hokkaido Univ.*, [2]*Toyama Univ.*,
[3]*National Institute of Polar Research*, [4]*HNAES*

To examine melting-refreezing process which may occur at the ice-bedrock interface in Soya drainage, Antarctica, we carried out analyses of stratigraphy, debris concentration, dissolved ions, pH and stable isotopes ($\delta^{18}O$,$\delta D$) of the basal ice of Hamna Icefall, sampled by JARE-35. The results of analyses suggest that liquid water exists at the ice-bedrock interface in the inland area of Soya drainage, and it refreezes on the bed of the ice sheet during the flow of the ice sheet toward the coast. According to the result of dissolved ion balance, the basal ice of Hamna Icefall can be divided into two parts. One is the upper part of the basal ice, which was formed at the interface of ice and bedrock in the inland region. The other is the lower part of the basal ice, which was formed at the interface of ice and bedrock near the coast. The upper part of the basal ice was initially formed and, subsequently, the lower part was added. The result suggests that there is a difference in the formation process of basal ice between the inland and the coastal areas of the ice sheet.

## A GLOBAL NETWORK OF SPECIMEN BANKS WITH PRESERVATION IN ANTARCTICA -BIOLOGICAL ENVIRONMENTAL SPECIMEN TIME CAPSULE 2001 PROJECT-

Toshikazu SHIBATA[1], Okitsugu WATANABE[2],
Yasuyuki SHIBATA[3] and Takeharu ETOH[1]
*[1]Kinki Univ., [2]National Institute of Polar Research, [3]NIST*

The BESTCapsule 2001 Project will retain biological and environmental specimens and data for an ultra-long period. They will serve as fundamental references for researchers in the distant future. A master capsule will be desposited on top of a dome on a polar ice cover. Dome Fuji in Antarctica is the best candidate for the site. The dawn of the new millennium is symbolically appropriate to initiate the project. The natural cryogenic preservation in Antarctica serves both as a symbol of and a backup for a global network of artificial cryogenic preservations of biological and environmental specimens.

## ANALYSIS OF DOME FUJI ICE CORE THIN SECTIONS WITH AN AUTOMATIC ICE FABRIC ANALYZER

Y. WANG[1], Nobuhiko AZUMA[1], Mitsuo KAWAGUTI[1],
Hideki NARIDA[2], Hitoshi SYOUJI[3] and Okitsugu WATANABE[4]
*[1]Nagaoka Univ. of Technology, [2]Hokkaido Univ.,*
*[3]Kitami Inst. of Technology, [4]National Institute of Polar Research*

An automatic ice fabric analyzer has been developed. It is controlled by a program that runs under Windows 95 / Windows NT. By using this analyzer, Dome Fuji ice cores were analyzed as to c-axis orientation, grain size, grain shape, etc. With this analyzer, one sample can be measured in about 20 min. It was found that the average grain size increases generally in the first several hundreds meters, and abruptly decreases from the depth of about 500 to 600, then increases again after that. From the orientation data it was found that c-axis orientations are random at shallow depth, and tend to align vertically with depth.

## USE OF HIGH RESOLUTION MICRO FLOW ANALYSES FOR CHEMICAL ANALYSES OF SNOW/ICE SAMPLES

Masahiro MARUO[1], Kohkichi KAMIYAMA[2],
Takeshi KIMOTO[3] and Eiichiro NAKAYAMA[1]
*[1] Univ. of Shiga Prefecture, [2] National Institute of Polar Research,*
*[3]Research Institute of Oceanic Chemistry*

For analyzing chemical constituents in snow/ice samples, flow analytical methods are considered to be one

of the best methods. Flow analyses, which make the measuring system simpler and access data more rapidly, have sometimes been used for in-situ measurements for snow/ice and atmospheric trace gas samples. The samples are introduced to detectors through flow lines to avoid contamination. For in-situ measurements, a smaller system is desirable. Micro flow analyses are developed to decrease the volumes of samples and reagents needed for the measurements and to keep the systems under more stable conditions in the field measurements. The detection limit targets are appropriate for ice/snow samples in polar regions, especially Antarctica. Concentrations of Ca, $NH_4$, $NO_3$ and $H_2O_2$ as low as *n* Mol levels could be detected with sample volumes as low as 0.1 ml for each measurement. An injection system can decrease contamination without being exposed to free air, which is useful especially for the measurement of $NH_4$. The methods were successfully developed for snow samples obtained from pit walls in Antarctica, and will be utilized for continuous measurements of ice core samples. This analyzing system combined with a melting device is possibly available for continuous measurements of ice core samples with 1.5×1.5 (2.5 ×2.5) $cm^2$ cross-sectional area for every 0.4 (0.1) cm interval.

## CHARACTERIZATION OF DOME F-CORE BY TOTAL-REFLECTION X-RAY FLUORESCENCE SPECTROSCOPY (TXRF)

Tadashi KIKUCHI[1], Kohkichi KAMIYAMA[2], Yoshiyuki FUJII[2] ,
Okitsugu WATANABE[2], Shinjiro KOJIMA[3] and Yoshiyuki KUDO[4]
*[1]Sci. Univ. of Tokyo in Yamaguchi, [2]National Institute of Polar Research,*
*[3]Rigaku Industrial Co., [4]Sci. Univ. of Tokyo*

Few particulates are contained in the F-core of the South Pole dome, according to the results obtained from the "Mizuho" ice sheet core which is closely related to the F-core. The following points were therefore investigated in the shallow-layer of the core for evaluation of the particulates contained in the core. First is the way of sampling (e.g. filtration) without contamination, second is finding conditions in which to analyze the form, elemental composition, and chemical states of the individual particulates. Exact values are required, especially for particulates in the deep-layer core sample without contamination during the sampling and analyzing procedure within the limited quantity of the sample. On the basis of the results, the number of the particulates is 9300/g and the average diameter is 1.5 μm. More than 80% of the particulates contain Si or Si and Al as a main component. Other particulates contain metallic elements other than Si and Al as main components. Comparison of the analytical results between total reflection X-ray fluorescence spectroscopy and PIXE, and state analysis of these particulates, are also carried out.

## SURFACE OBSERVATIONS AT DOME FUJI STATION IN 1996

Hiroyuki IKEGAYA
*Japan Metorological Agency*

The 37th Japanese Antarctic Research Expedition (JARE-37) conducted surface observations at Dome Fuji Station (77.18°S 39.41°E, 3810 m a.s.l.) in 1996. The air temperature was coreless from April to October. In 1996, the annual mean temperature was -54.4°C, the maximum temperature was -18.6°C (Jan. 31) and the minimum temperature was -79.7°C (May 14). Air pressure increases from January to February and from August to September were very acute. The wind speed increased gradually from summer to fall. There is little difference between the maximum wind speed and peak gust speed. It was unusual to observe cumulus at Dome Fuji Station.

## UPPER AIR OBSERVATIONS AT DOME FUJI STATION IN 1996

Hiroyuki IKEGAYA and Masamichi NAKAMURA
*Japan Meteorological Agency*

In 1996, 26 Omega sondes were launched at Dome Fuji Station (77.18°S 39.41°E 3810 m a.s.l.). Wind data could not be obtained, because VLF radio waves from omega stations could not be received at Dome Fuji Station. Some omega sondes failed due to problems with batteries. The average maximum height the sonde reached was about 10 km. Intensive observations were taken in January (in summer) and September (in winter). The following results were obtained.

1) The ground inversion layer was found in all of the winter observations.
2) The maximum temperature difference between the top and bottom of the layer was 29.9 degrees on 19 August 1996.
3) The inversion layer extended from 150 m to 1500 m.
4) The tropopause was not clear in winter.

## METEOROLOGICAL OBSERVATIONS ALONG A TRAVERSE ROUTE FROM THE COAST TO DOME FUJI STATION, ANTARCTICA, RECORDED BY AUTOMATIC WEATHER STATIONS IN 1996.

Takao KAMEDA[1], Shuhei TAKAHASHI[1], Hiroyuki ENOMOTO[1],
Shuji FUJITA[2], Hideaki MOTOYAMA [3], Yoshiyuki FUJII [3], Okitsugu WATANABE [3],
G. A. WEIDNER[4] and C. R. STEARNS [4]
*[1]Kitami Institute of Technology, [2]Hokkaido Univ.*
*[3]National Institute of Polar Research, [4]Univ. of Wisconsin, Madison*

Meteorological data recorded by CMOS type automatic weather stations (CMOS-AWS) at six sites along a route from the coast toward Dome Fuji Station, Antarctica were retrieved by members of the 37th and 38th Japanese Antarctic Research Expeditions. ARGOS-AWS units installed at Dome Fuji Station and the Relay Point continue transmitting meteorological data to NOAA satellites. Remarkable warm spells were observed in the winter and summer of 1996 at all sites. Although the warm spells in winter have been observed since 1993, the warm spell in summer was observed for the first time. The occurrence of the warm spells corresponds with the entrance of cyclones into Queen Maud Land according to the satellite composite images. This suggests that the warm air during the spells is brought by the cyclones. The mean wind speed was the highest at MD180 site located 430 km inland from the coast. As a result of low temperature and frost in winter, there are periods of missing data at five sites.

## METEOROLOGICAL FEATURES OBSERVED BY AUTOMATIC WEATHER STATIONS ALONG SYOWA STATION TO DOME FUJI STATION, ANTARCTICA

Shuhei TAKAHASHI [1], Hiroyuki ENOMOTO [1], Takao KAMEDA [1],
Takayuki SHIRAIWA [2], Yuji KODAMA [2], Shuji FUJITA [2], Hideaki MOTOYAMA [3],
Okitsugu WATANABE [3], G.A. WEIDNER [4] and C.R. STEARNS [4]
*[1]Kitami Institute of Technology, [2]Hokkaido Univ.*
*[3]National Institute of Polar Research, [4]Univ.of Wisconsin*

JARE has set up Automatic Weather Stations (AWS) at six sites on a 1000 km-long traverse route between Syowa Station (21 m a.s.l.) and Dome Fuji Station (3810 m a.s.l.) since 1993. Sudden temperature rise at all sites was observed several times in winter. There were two patterns of time delay of temperature rise. One occurred when the temperature rise at Mizuho Station preceded that at other stations, and the other when the rise at Dome Fuji Station preceded the others. The former one happened when a disturbance came from the coast between east Enderby Land and Amery Ice Shelf, and the latter when it came from the coast of west Wilkes Land.

## CHANGE IN SNOW DEPTH AT SYOWA STATION MEASURED WITH GRADUATED SNOW STAKES

Hitomi MIYAMOTO[1], Masamichi NAKAMURA[1],
Osamu NARITA[1], Ayumi YOKOTA[1] and Toshinori TAKAO[2],
[1]*Japan Meteorological Agency, Members of the 37th Japanese Antarctic Research Expedition*
[2]*Office of Antarctic Observation*

It is difficult to measure the snow depth at Syowa Station using a rain gauge because of the strong wind and drifts. Since 1974, JMA members have been measuring the snow depth once a week by use of 9 bamboo poles on the sea ice on the windward side of the Station. In 1996, snow depth increased in a short time during severe storms in May and September. Snow depth at Syowa Station was less than normal from 1983 to 1989, but since 1990 it has been increasing yearly.

## SNOW ACCUMULATION PATTERNS AND THEIR RELATIONSHIP TO SURFACE AND BEDROCK TOPOGRAPHIES IN EAST DRONNING MAUD LAND, ANTARCTICA

Teruo FURUKAWA[1], Kohkichi KAMIYAMA[1] and Hideo MAENO[2]
[1]*National Institute of Polar Research*
[2]*Communications Research Laboratory*

Distributions of net snow accumulation and snow surface features such as sastrugi, dunes and glazed surface are compared with surface and bedrock topographies of the ice sheet along the traverse route from the coast to Dome Fuji, in east Dronning Maud Land, Antarctica. On the basis of regional characteristics of the net snow accumulation and snow surface features, the traverse route can be divided into three sections: the coastal region (600-2000 m a.s.l.), the katabatic wind region (2000-3600 m a.s.l.) and the inland plateau region (3600-3810 m a.s.l.). In the katabatic wind region, the glazed surface develops on downwind slope of surface undulations. These sections where the glazed surface was observed are situated above relatively large convex bedrock undulations. The net snow accumulation is small in the sections where glazed surface was observed. The snow accumulation patterns are influenced by the bedrock topography. This indicates that the bedrock topography is one of the factors controlling the present snow accumulation patterns on the Antarctic ice sheet.

## AN ATTEMPT TO ESTIMATE ANTARCTIC SNOW ACCUMULATION BY USING METEOROLOGICAL DATA OF NCEP REANALYSIS

Kooiti MASUDA
*Department of Geography, Tokyo Metropolitan Univ.*

By using a data set of atmospheric variables produced by the 'reanalysis' project of the U.S. National Center for Environmental Prediction (NCEP), the mass exchange of water at the surface, which may be equated to the accumulation of snow, is evaluated for the 23-year period 1973 – 1995. The estimated 'accumulation' averaged over the area south of 70° S including the oceanic area has a clear annual cycle with maximum in winter (May to July), and its annual mean is 205 mm / year, a little larger, but not much different from, the previous results of Masuda (1990) and Yamazaki (1992). When the area is limited to the ice plateau (ground height being above 1500 m ), the annual cycle of estimated 'accumulation' still has a maximum in

winter. However, the result based on NCEP 'reanalysis' is considered invalid for this area, because negative values of moisture content persist in winter.

## RADAR SOUNDING OF THE ICE-SHEET AROUND DOME FUJI STATION, ANTARCTICA

Shuji FUJITA [1], Hideo MAENO [2], S. URATUKA [2], Teruo FURUKAWA [3], Yoshiyuki FUJII [3] and Okitsugu WATANABE [3]
*[1] Hokkaido Univ., [2] Communication Research Laboratory,*
*[3] National Institute of Polar Research*

In 1996, the 37th Japanese Antarctic Research Expedition carried out radar sounding of the ice sheet around Dome Fuji Station. Radio waves at two frequencies, 60 MHz and 179 MHz, were used to investigate ice sheet internal structures. This radar survey includes the following measurements: 1) Long-term data aquisition at Dome Fuji drilling site; 2) Bed-rock survey in the area whthin 30 km radius around the station; 3) Survey along the routes from the dome summit to the coast line. On outline of the survey and some preliminary results are presented.

## RELATION BETWEEN ATTENUATION COEFFICIENT AND BEDROCK TOPOGRAPHY OBTAINED BY RADIO-ECHO SOUNDER

Hideo MAENO [1], Shuji FUJITA [2] and S. URATSUKA [1]
*[1] Communication Research Laboratory*
*[2] Hokkaido Univ.*

The regional dependence of radio attenuation coefficient in the Antarctic ice sheet was investigated using JARE-33 data. In the region between 100 km and 196 km north from Dome-F, the average attenuation coefficients on the 30 km Dome-F sides (south of MD580) are smaller than 0.01 dB/m with a minimum value of approximately 0.005 dB/m.The values on the 30 km coast side (north of MD580) are approximately 0.01 dB/m. The locations of the peak attenuation coefficients correspond with the highest points of the bedrock topography.

## OUTLINE OF THE PLAN TO OBSERVE INTERNAL STRUCTURES OF THE ICE SHEET WITH A MULTI-FREQUENCY ICE PENETRATING RADAR SYSTEM IN ANTARCTICA

Kenichi MATSUOKA[1], Teruo FURUKAWA[2], Hideo MAENO[3], Shuji FUJITA[4], Renji NARUSE[1], Fumihiko NISHIO[5] and Okitsugu WATANABE[2]
*[1] Institute of Low Temperature Science, Hokkaido Univ., [2] National Institute of Polar Research,*
*[3] Communication Research Laboratory, [4] Faculty of Engineering, Hokkaido Univ.,*
*[5] Hokkaido Univ. of Education*

During the next stage (1999-2002) of the Japanese Antarctic Research Expedition (JARE), research utilizing a multi-frequency ice penetrating radar system is planned focusing on internal reflections in the Antarctic ice sheet. The system is composed of a newly developed 30 MHz radar (the lowest frequency practical for snow car loading) and the current 60 and 179 MHz radars. The following are the main topics of the observations:
1) Frequency dependence of backscattering coefficients of reflection layers ($\sigma$) and the mechanisms of

reflections. The hypothesis on the dependence deduced from experiments on dielectric properties of ice is to be verified.
2) Effects of ice temperature and flow conditions on σ. Observations along a flow line of Shirase glacier is carried out.
3) 3-D isochronal layers in the ice sheet. The 30 MHz radar is expected to detect them. The layers are useful to discuss the paleo-climate and ice flow in the large area of the Shirase basin.
4) Flow mechanisms, particularly over the undulating bed.

As a new technique, a simultaneous 3 frequencies observation device will be loaded on a snow car to make observations efficiently and easily.

## DEEP ICE CORE DRILLING AT DOME FUJI STATION, ANTARCTICA IN 1996

Yoshiyuki FUJII and the members of the 37th wintering team at Dome Fuji Station
and working group of deep ice core drilling
*National Institute of Polar Research*

Deep ice core drilling was carried out to a depth of 2503 m at Dome Fuji Station in December 1996 by the 37th JARE wintering team. The drilling was done with an electro-mechanical drill in a bore hole filled with liquid n-butyl acetate. The system worked satisfactorily in spite of some trouble with chip transportation. The cutting blade pitch was as small as 2 mm due to the ice hardness at -50°C. The total numbers of drilling runs and days were 1370 and 291 respectively. Quality of ice cores obtained was excellent even in the depth range of the brittle zone and leading to good results from the core analyses.

## FIELD ACTIVITIES OF THE JAPANESE CONTINGENT DURING THE 1997 SEASON OF THE NORTH GREENLAND ICE CORING PROJECT

Okitsugu WATANABE[1], Makoto IGARASHI[1], Morimasa TAKATA[1],
Hideki NARITA[2], Nobuhiko AZUMA[3], Yoichi TANAKA[4] and Hitoshi SHOJI[5]

[1]*National Institute of Polar Research,* [2]*Institute of Low Temperature Science, Hokkaido Univ.,*
[3]*Department of Mechanical Engineering, Nagaoka Univ.of Technology,*
[4]*Geosystems, Inc.,* [5]*Kitami Institute of Technology*

Two deep ice cores obtained in the Summit area of Central Greenland in 1992 and 1993 revealed valuable information on past changes of global environment and climate. However, a significant ice flow disturbance was observed near the bottom of the ice sheet including the Eemian interglacial ice, which could have direct implications for our present-day climate. The North Greenland Ice Coring Project (NGRIP) was established as an international collaboration effort to obtain more information, especially from the Eemian ice (PI: Dr. Claus Hammer, Copenhagen University, Denmark). Japanese researchers have been collaborating in physical, mechanical and chemical core-studies and participating in the field operations (PI: Dr. Okitsugu Watanabe, NIPR, Tokyo). The deep coring, from the surface to a depth of 351.47 m in 1996, was continued down to a depth of 1371.80 m at the NGRIP site (75.1°N, 42.3°W) during the 1997 season. A brittle zone was encountered in the depth range from 680 to 1280 m; the ice core from it has been kept in a core buffer in the field for volume relaxation until the next season. The deep drill (JARE-EPICA type) was successfully modified with a new mechanical pump and achieved a core productivity of 170 m/week with a 16-hour daily working routine. Unfortunately, the drill was stuck at the bottom of the hole at a depth of 1373 m, efforts to recover it have continued since then. The Japanese contingent performed field tasks in core logging, core processing (ECM, chemistry/isotope sampling, bulk density, packing) and deep drilling with collaborators. Selected samples from the deep ice core, shallow ice core and surface pits have been air-transported to the NIPR cold laboratory for core studies to be conducted in Japan.

## MEASUREMENTS OF MICROWAVE DIELECTRIC CONSTANTS OF DOME-FUJI ICE CORE

Takeshi MATSUOKA[1], Shuji FUJITA[2], Shinji MAE[2] and Okitsugu WATANABE[3]
[1] *Communication Research Laboratory,* [2] *Faculty of Eng. Hokkaido Univ.*
[3] *National Institute of Polar Research*

Investigation of the dielectric properties of ice is important for analysis of microwave remote sensing data of the cryosphere. The measurements of dielectric constants ($\varepsilon^* = \varepsilon' - i\varepsilon''$) of Antarctic Dome-Fuji ice were carried out at 33 GHz in the temperature range 213 - 263 K. The open resonator method was used for precise measurement of the real part ($\varepsilon'$) and imaginary part ($\varepsilon''$) of dielectric constants. The ice sample was polycrystalline ice and was recovered from 350 m depth. The following results were obtained: small dielectric anisotropy, $\Delta\varepsilon' = \varepsilon'//c - \varepsilon'\perp c$, was observed and was independent of temperature. The increase rate of $\varepsilon'$ with temperature changed at around 238 K. The increase rate above that temperature was three times larger than below that temperature.

## EFFECT OF ICE TEMPERATURE ON PROTONS IN DOME-FUJI ICE CORE

Hiroshi FUKAZAWA[1], Shinji MAE[1], Susumu IKEDA[2] and Okitsugu WATANABE[3]
[1] *Hokkaido Univ.,* [2] *KEK.* [3] *National Institute of Polar Research*

It has been believed that Antarctic ice is in the proton-disorderd phase, $I_h$-disorder. From the Raman spectra of Antarctic ice, we found the following result: above the ice temperature $Ti$ =237 K, the intensity ratio, $I_{300} / I_{220}$ , is the same as that of the $I_h$-disorder, but below 237 K $I_{300} / I_{220} \propto \exp(-0.79 / k\,Ti)$ which indicates a phase transition from the $I_h$-disorder to a new phase, where $k$ is the gas constant. In order to determine the structure of the new phase we observed the incoherent inelastic neutron scattering of Antarctic Dome-Fuji ice ($Ti$= 213 K, 201 m depth). The spectra indicate that 46% of protons in Dome-Fuji ice are ordered. We conclude that the new phase is the proton-ordered structure, which had never been realized on a laboratory time scale.

## IN SITU OBSERVATION OF THE TRANSFORMATION TO AIR-HYDRATE CRYSTALS USING A MIZUHO ICE CORE

Wataru SHIMADA[1] and Takeo HONDOH[2]
[1] *National Institute of Polar Research*
[2] *Institute of Low Temperature Science, Hokkaido Univ.*

Using a MIZUHO ice core, *in situ* observations of the transformation from air-bubbles to air-hydrate crystals are carried out at 258 – 268 K under hydrostatic pressure. The number and size of air-hydrate crystals were measured under microscopy during an experiment at 258 K. At 230 kgf/cm$^2$, all air bubbles of diameter larger than 100 μm and about 30% of air bubbles of diameter smaller than 100 μm start the transformation to air-hydrate crystals within 10 days. On the other hand, at 150 kgf/cm$^2$, no air-hydrate crystals appeared during a period of 41 days. At 200 kgf/cm$^2$, about 60% of air bubbles (d>100 μm) and about 15% of air bubbles (d<100 μm) started the transformation within 10 days. Therefore, nucleation of air-hydretate crystals depends on excess pressure. Next, the temperature decreased from 268 K to 258 K at 200 kgf/cm$^2$ 25 days after pressurization. At 268 K, about 60% of air bubbles (d>100 μm) started transformation to air-hydrate crystals within 10 days. After decrease of temperature to 258K, an additional 20% of air bubbles started the transformation. In this case, cooling means increase of excess pressure from the phase diagram. Therefore, nucleation of air-hydrate crystals depends on excess pressure except for the effect of pressure change.

## METAL CONCENTRATION IN SNOWFALL

N. ICHITANI[1] and Kokichi KAMIYAMA[2]
[1]*Grad. Univ. Advanced Studies,* [2]*National Institute of Polar Research*

The study of snowfall is needed for analysis of ice cores. The purpose here is to explore a little further into snowfall using metal analysis. The snowfall samples were collected at Rikubetsu in eastern Hokkaido. Rikubetsu is greatly influenced by the Arctic atmosphere in winter. The measurements were carried out with graphite furnace atomic absorption spectrometry. Precipitation, wind direction, wind velocity and metal concentration can be schematized.

## CHEMICAL ANALYSES OF THE ICE CORES AND SURFACE SNOW FROM NORTH GREENLAND

Makoto IGARASHI[1], Kokichi KAMIYAMA[1], Okitsugu WATANABE[1],
Morimasa TAKATA[1], Hitoshi SHOJI[2], J.P.STEFFENSEN[3] and H.B.CLAUSEN[3]
[1]*National Institute of Polar Research,* [2]*Kitami Inst. Tech,*
[3]*University of Copenhagen*

Two deep drilling programs (GRIP and GISP) were carried out on the Summit of Greenland in 1992; both of them obtained ice cores extending nearly to bedrock. The stable isotope ($\delta^{18}O$) profiles of each ice core depicted dramatic temperature changes in Greenland through the last two glacial cycles, including abrupt climatic shifts during the Em/Sangamon Interglaciation, which is elsewhere recorded as a warm and stable period. However it is possible that these apparenyly drastic climatic changes during the Eemian period, especially the early and the middle part, were due to confusion of the ice layers. The ice layers corresponding to the Eemian period were likely to be influenced by severe flow effects because the layers were very close to bedrock. In order to examine this problem, deep ice cores extending nearly to bedrock have been obtained from the northern part of the Greenland ice sheet by the North GReenland Ice-core Project (NGRIP). Here we report about chemical analyses of the ice core and surface snow.

## CHEMICAL FLUXES ON VESTFONNA ICE CAP IN SVALBARD

Sumito MATOBA[1], Kokichi KAMIYAMA[2], Hideaki MOTOYAMA[2],
Hideki NARITA[3] and Okitsugu WATANABE[2]
[1]*Grad. Univ. Advanced Studies,* [2]*National Institute of Polar Research,*
[3]*Institute of Low Temperature Science, Hokkaido Univ.*

In 1995, a continuous ice core of 210 m was taken from the summit of Vestfonna (21°00'N, 79°50'N), Svalbard. *In situ*, we measured the bulk density, stratigrapy and continuous ECM (Electric Conductivity Method). After melting, we measured pH, electric conductivity, $\delta^{18}O$ and major ions. The vertical profiles of electric conductivity, ECM and sulfate concentration are shown. The peaks corresponding to Laki (1783) and Tambora (1815) volcanoes are shown in these graphs.

## TEMPORAL AND SPATIAL VARIATION OF SNOW COVER THICKNESS IN THE FORMER SOVIET UNION

Junko SAKAKIBARA and Kunio RIKIISHI
*Hirosaki Univ.*

Historical data of the snow cover thickness at 284 stations in the former Soviet Union for the period 1960-84 have been analyzed in order to see the basic features of temporal and spatial variation of the snow cover. Mean seasonal variations of the snow cover and snowfall (or snowmelt) have been delineated together with spatial distributions of the maximum snow depth and length of the snow cover period. Correlation analysis and EOF analysis of the snow cover thickness have been done to examine possible interaction between the snow cover and the atmospheric circulation.

## CHEMICAL INFORMATION ON SNOW DEPOSITION AT AND AROUND DOME FUJI STATION, ANTARCTICA, IN 1995

Nobuhiko AZUMA[1], Takao KAMEDA[2], Shuhei TAKAHASHI[2], Hiroyuki ENOMOTO[2], Takayuki SHIRAIWA[3], Okitsugu WATANABE[4], Yoshiyuki FUJII[4], Kokichi KAMIYAMA[4], Hideaki MOTOYAMA[4], Makoto IGARASHI[4], Yutaka AGETA[5], Satoshi KANAMORI[5] and Takashi SAITO[6]
*[1]Nagaoka Univ.of Technology, [2]Kitami Institute of Technology,*
*[3]Institute of Low Temperature Science, Hokkaido Univ.,*
*[4]National Institute of Polar Research, [5]Nagoya Univ., [6]Kyoto Univ.*

There exists a close relationship between climate and atmospheric chemistry. An ice core stores information about atmospheric trace constituents and offers the possibility for tracing back the atmospheric environments at the time of deposition. The archives do not provide direct information about atmospheric composition and need to be translated into glaciological and atmospheric environments. Three dimensinal distribution for snow chemistry over an inland ice plateau, Antarctica, which can be offered through the chemical analyses on surface and pit snows at and around Dome Fuji Station, might possibly enable us to understand the glaciological and atmospheric environments over the plateau. Through this process, the archive is related quantitatively to the atmospheric environment. The concentrations of $H_2O_2$, $NO_3$ and HTO in snow at Dome Fuji Station show sudden increase in late spring, while the ratios of $H_2O_2$/HTO and $NO_3$/HTO increase in late summer. Their concentrations in surface snow also increase with distance from the sea and/or with altitude, while their ratios decrease. The ratio of $NH_4$/Ca in snow at Dome Fuji Station was rather constant independent of seasonal distribution, while that in surface snow increased with distance from the sea and/or with altitude. HTO was brought through the stratosphere and/or high altitude in the atmosphere. The reservoirs for $H_2O_2$ and $NO_3$ in the atmosphere are different from that for HTO. The reservoirs for Ca and $NH_4$ have similar behavior over the inland plateau. Snow chemistry possibly tells us the atmospheric environments and their behavoir.

## CHEMISTRY OF SNOW, ATMOSPHERIC AEROSOL AND ACID GAS AT DOME FUJI STATION, ANTARCTICA (2)

Satoru KANAMORI[1], Nobuko KANAMORI[1], Okitsugu WATANABE[2], Yoshiyuki FUJII[2] and Takao KAMEDA[3]
*[1]Nagoya Univ., [2]National Institute of Polar Research, [3]Kitami Institute of Technology*

Year-round observation (1995-1996) of surface snow, atmospheric aerosol and acidic gases, at Dome Fuji Station, was continued by JARE-37 for one more year (1996-1997). The concentration levels of main ionic species in these three phases showed the same levels and trends as those observed in the last year. The rough

linear relationship of ionic species concentrations ($Cl^-$, $SO_4^{2-}$, $NO_3^-$, MSA, $Na^+$) in aerosol and snow, which have been observed also in the Mizuho Plateau area, was indistinct in Dome Fuji and the concentration ratio in aerosol to that in snow was lower in Dome Fuji. These observations point to a different mode of accumulation of atmospheric aerosol into snow between Mizuho Plateau and Dome Fuji. Seasonal variations of their concentrations in aerosol as well as in snow, high in the summer and low in the winter, were observed and suggest that the concentration of chemical species in surface snow always follows the changes in aerosol concentration, and also that the chemical species has been transported mainly from maritime or coastal air in the southern hemisphere, not far from Dome Fuji.

## DISTRIBUTIONS OF ORGANIC COMPOUNDS IN ANTARCTIC SNOWS: A PRELIMINARY RESULT

Kimitaka KAWAMURA[1], Yoshie IMAI[1], Naohiko OHKOUCHI[1],
Mutsumi NISHIKIORI[2], Yoshiyuki FUJII[3] and Okitsugu WATANABE[3]
*[1]Inst. Low Temp. Sci., Hokkaido Univ., [2]Tokyo Metropolitan Univ.*
*[3]National Institute of Polar Research*

Fresh snow samples were collected from Antarctica between Syowa Station and Dome Fuji, and six samples were analyzed for organic compounds using capillary gas chromatography and GC/MS. Here, we report molecular distributions of lipid class compounds including hydrocarbons, alcohols and fatty acids, as well as low molecular weight dicarboxylic acids in Antarctic snows. A homologous series of normal alkanes (C20-C34) were detected in the samples with concentration range of 1.4-83 ng/kg-snow. Except for the Dome Fuji snow, which showed local contamination, n-alkanes generally showed an odd carbon number predominance with a maximum at C29 or C31, suggesting that terrestrial higher plant waxes were transported long distances from low and/or mid-latitudes over Antarctica through the atmosphere. Interestingly, higher concentrations of C29 and C31 n-alkanes were found in the inland snow samples. Saturated fatty acids (C8-C32), whose concentration range was 720-4500 ng/kg-ice, showed an even carbon number predominance with two maxima at C16 and C24. Their distributions suggest that they are derived from both marine and terrestrial plants. Inland snow samples showed higher concentrations of fatty acids, consistent with the conclusion suggested from the n-alkane distribution. The relative abundance of nonanoic acid (C9 monoacid) and azelaic acid (C9 diacid) in the snow suggests that biogenic unsaturated fatty acids are photochemically oxidized during the atmospheric transport and/or after deposition on the ice sheet. Analytical results of low molecular weight (C2-C10) dicarboxylic acids (2600 - 13500 ng/kg-ice) and related compounds showed the dominant presence of oxalic (C2), malonic (C3), succinic (C4), and phthalic (C8) acids. This study indicates that molecular compositions of organic matter in the Antarctic snows provide information on long range atmospheric transport of marine and terrestrial materials and photochemical transformation processes.

## MICRO TEPHRA PARTICLES IN SNOW AND ICE CORE FROM ANTARCTICA

Nobuyuki HAYASHI[1], Takaaki FUKUOKA[2],
Mika KOHNO[3] and Yoshiyuki FUJII[4]
*[1] Nihon Univ., [2] Gakushuin Univ., [3] Okayama Univ.*
*[4] National Institute of Polar Research*

H 15 core was cut into 41 blocks (7-8 cm in length) from a section with high ECM values expected to contain the signal from the Tambora 1815 eruption. They were melted and filtered with 0.2 μm filter paper. The micro particles on all of the filters were counted under a microscope, and classified into four size-groups. The number of particles less than 10 μm in stereo diameter correlates with the ECM values of the ice blocks and $SO_4^{2-}$ contents in water from the ice blocks. This suggests that the micro particles are volcanogenic, that is, micro tephra particles. Micro particles on the 0.2 μm filter papers for the Dome Fuji shallow core ice with the ECM value and Dome Fuji surface snow, which is expected to contain the signal from the Pinatubo 1991

eruption, were also examined.

## AN AUTOMATED SYSTEM FOR HYDROGEN ISOTOPE RATIO OF SNOW SAMPLES IN THE POLAR REGION USING WATER-HYDROGEN EQUILIBRATION

Hiroshi SATAKE[1] and Yoshinori IIZUKA[2]
*[1]Department of Environmental Chemistry, Toyama University*
*[2]Institute of Low Temperature Science, Hokkaido University*

For the D/H measurement of snow and ice samples in the polar region, we applied an $H_2O$-$H_2$ isotope exchange reaction promoted by a Pt catalyst combing with an automatic $H_2O$-$CO_2$ equilibrium system. As a result, the D/H ratio of 60 samples can be measured at one time with the precision of $\pm 2‰$ ($1\sigma$) using water samples smaller than 1ml.

## DETERMINATIONS OF TRACE METALS IN ARCTIC ICE AND SNOW SAMPLE BY ICP-MS

Sumito MATOBA[1], Masataka NISHIKAWA[2], Masatoshi MORITA[2], Ahmet E. EROGLU[3] and Okitsugu WATANABE[4]
*[1]Grad. Univ. Advanced Studies, [2]National Institute for Environmental Studies, [3]Univ. of Sheffield, [4]National Institute of Polar Research*

Metal elements are emitted from anthropogenic activities and the continental environment. Because anthropogenic activities cause significant changes in the global environment and the continental environment is considered to influence the glacial-interglacial cycle, metal elements in polar ice cores are studied. It is quite difficult to measure trace metals in polar ice cores because of the low concentrations of metal elements and the high contamination during the drilling process, and the sampling and analytical procedures. Therefore, it is necessary to apply very sensitive analytical techniques to determine such low concentrations, and to employ an effective decontamination method. In this study, we developed a new nebulisation system with a quadrupole ICP-MS. The system is a microconcentric nebuliser with membrane desolvation (MCN-6000, CETAC), which is a recent development and is of particular interest in this work. The MCN-6000 combined with the quadrupole ICP-MS permits quantitative determinations at the sub ng/L level, and we can determine heavy metal (Al, Cu, Pb, etc.) concentrations in ice cores from Vestfonna Ice Cap, Svalbard with a decontamination method applied to this sample.

**Program of the 20th Symposium on Polar Meteorology and Glaciology, held at National Institute of Polar Research, Tokyo November 26–27, 1997**

I. Ocean–Sea ice (Chair: Tatsuo MOTOI)

1. Hydrographic and mooring observations off Adelie Land, Antarctica. Y. FUKAMACHI, M. WAKATSUCHI, K. TAIRA, S. KITAGAWA, A. TAKAHASHI, K. OIKAWA, H. YORITAKA, S. USHIO, T. FURUKAWA, M. FUKUCHI and T. YAMANOUCHI.
2. Observation of ocean currents with subsurface floats in the southern ocean. S. USHIO, K. OIKAWA, Y. FUKAMACHI, K. I. OHSHIMA and M. WAKATSUCHI.
3. A relationship between ocean current and seafloor topography in the Arctic ocean. K. SHIMADA, K. HATAKEYAMA, T. TAKIZAWA, N. KOYAMA and G. HOLLOWAY.
4. Melting process of sea ice in the Antarctic ocean: relationship between ice concentration and melting rate. S. NIHASHI and K. I. OHSHIMA.
5. Satellite microwave studies of coastal polynyas in the Sea of Okhotsk. N. KIMURA and M. WAKATSUCHI

II. Stratospheric events (Chair: Makoto WADA)

6. Ozonesonde experiments at Syowa Station, Antarctica for ILAS validation. H. KANZAWA, Y. SASANO and S. KANETO, T. TAKAO and T. YAMANOUCHI.
7. On the ozone over Eureka station in the Canadian Arctic. M. HIROTA, T. NAGAI, T. FUJIMOTO, Y. MAKINO, K. MIYAGAWA, O. UCHINO and H. FAST.
8. Lidar observation above Svalbard in the winter of 1996/7—Characteristics of back scattering-ratio and depolarization ratio of PSCs particles. K. SHIRAISHI, S. AYUKAWA, M. FUJIWARA, H. ADACHI, T. SAKAI, K. TAMURA, T. SHIBATA and Y. IWASAKA.
9. Warm spell in the inlaid of Antarctica and semi-annual oscillations in the atmospheric circulation. H. ENOMOTO, T. KAMEDA, S. TAKAHASHI, S. FUJITA, H. MOTOYAMA, Y. FUJII and O. WATANABE.

Poster presentation–I

10. Increase in the floe size through freezing. H. ITO.
11. The structural analysis of sea ice sampled in the southern part of the Sea of Okhotsk. T. TOYOTA, T. KAWAMURA, J. UKITA and M. WAKATSUCHI.
12. Detection of flow-vector field of pack ice in the Sea of Okhotsk by means of image sequence processing. M. OHI, Y. TAUCHI, E. YOKOYAMA and A. NOMURA.
13. Sea ice classification using a JERS-1 SAR image in the Sea of Okhotsk. H. SHIMODA, S. UTO and H. YAMANOUCHI.
14. Observation of sea ice during the freezing season using satellite (MOS-1, ADEOS). K. SHIRASAKI and H. ENOMOTO.
15. Observation of sea ice using 85GHz channel of DMSP SSM/I. K. TATEYAMA, H. ENOMOTO, S. TAKAHASHI, K. HYAKUTAKE and F. NISHIO.
16. Ice displacements observed by synthetic aperture radar near the New Siberian Islands. S. KAKUTA and S. TAKEUCHI.
17. Analysis of precipitable water and integrated liquid water content over the sea area around Svalbard using SSM/I data. M. WADA.
18. The observations of liquid water, waver vapor, and downward infrared flux in the Arctic region with a microwave radiometer and a pyrgeometer. H. ISHIDA, T. HAYASAKA, M. KAJIKAWA, K. KIKUCHI, H. UYEDA, Y. ASUMA and Y. INOUE.
19. Clouds extraction from polar satellite data. M. KUBO, H. SAITO, T. TOKUNAGA, K. MURAMOTO

and T. YAMANOUCHI.

20. Development of a tool for analyzing the brightness temperature image data. T. SHIGA, M. HATANAKA, K. ITAKURA, Y. YOSHIDA, M. WADA and N. HIRASAWA.
21. Seasonal precipitation variations on Spitsbergen Island, Norway. N. OGITANI, Y. ASUMA, K. KIKUCHI and M. WADA
22. Three dimensional fine structures of bullet type snow crystals observed at Syowa Station, Antarctica. K. IWAI.
23. High temperature observed at Syowa Station from July to October, 1996. H. MIYAMOTO, M. NAKAMURA, O. NARITA and A. YOKOTA.
24. Report of the comparison of the aerological data measured by RS2-91 and RS2-80 Rawinsondes at Syowa Station. H. MIYAMOTO, M. NAKAMURA, O. NARITA and A. NAKAMURA.
25. Geographical distributions of water soluble constituents in aerosol particles obtained from the marine atmosphere during Antarctic cruise (JARE-38) of SHIRASE. K. OSADA, M. HAYASHI, M. KIDO, Y. INOMATA, K. MATSUNAGA and Y. IWASAKA.
26. Continuous $^{222}Rn$ monitoring in Antarctica by using a high sensitive radon detector. S. TASAKA, H. UI and M. HAYASHI.
27. Recent trends of atmospheric concentration of CFC-11, CFC-12, CFC-113 and 1,1,1-trichloroethane in the northern and southern hemispheres and their release. M. HIRABAYASHI, S. TOYODA and Y. MAKIDE.
28. A study of air-sea $CO_2$ exchange in the Greenland Sea and Barents Sea. S. YOSHIMURA, S. AOKI, T. NAKAZAWA, S. MORIMOTO, G. HASHIDA, K. SHIRASAWA and T. Vinge.
29. Conversion from sulfur dioxide to sulfuric acid in the winter Arctic. K. HARA, K. OSADA, M. WATANABE, M. HAYASHI, K. MATUNAGA and Y. IWASAKA.
30. Haze in the Canadian high Arctic based on the last 4 winters of observation. S. ISHII, T. SHIBATA, T. ITABE, K. MIZUTANI, M. HIROTA, T. NAGAI and T. FUJIMOTO.
31. Observation of Arctic stratosphere by millimeter wave spectrometer. S. OCHIAI, Y. IRIMAJIRI and H. MASUKO
32. Lidar observation of spherical and non-spherical particles of polar stratospheric clouds at Ny-Ålesund. H. ADACHI, T. SHIBATA, M. HAYASHI, T. SAKAI, K. TAMURA, M. HASE, K. SHIRAISHI, S. AYUKAWA, M. FUJIWARA and Y. IWASAKA.
33. Lidar observation of polar stratospheric clouds over Svalbard. S. AYUKAWA, K. SHIRAISHI, M. FUJIWARA, H. ADACHI, T. SAKAI, T. SHIBATA and Y. IWASAKA.
34. Development of a cryogenic air sampling system using a JT cryostat. S. MORIMOTO, G. HASHIDA, M. WADA, T. YAMANOUCHI, H. HONDA, S. AOKI, A. OHBA and M. HIROKAWA.
35. Analysis of seasonally variation of background ozone levels on the earth, ozone reactivity and environmental signals. Y. FUTATSUGI, O. WATANABE and K. KAMIYAMA.

III. Atmospheric gases and aerosols (Chair: Katsuji MATSUNAGA)

36. Radon and aerosol observation at the time of SOD on Syowa Station. H. UI, S. TASAKA, K. OSADA, G. HASHIDA and S. AOKI.
37. Water soluble ionic constituents in aerosol particles obtained from Syowa Station during JARE-37. K. OSADA, M. HAYASHI, T. UI and Y. IWASAKA.
38. Temporal changes in atmospheric aerosol size-number concentration measured at Syowa Station, Antarctica. Y. IWASAKA, K. OSADA, M. HAYASHI and H. UI.
39. Volatile sulfur compounds in the atmosphere and sea water during Antarctic cruise of SHIRASE. Y. INOMATA, K. MATSUNAGA, M. HAYASHI, K. OSADA and Y. IWASAKA.
40. Coarse aerosol particles containing nitrates in the winter Arctic troposphere. K. HARA, K. OSADA, M. WATANABE, M. HAYASHI, K. MATUNAGA and Y. IWASAKA.
41. Aerosol observation at Barrow, Alaska in spring. Y. ZAIZEN, K. OKADA, M. IKEGAMI, T. AOKI, Y. SAWA, F. NISHIO and Y. TACHIBANA.
42. Atmospheric concentrations of CFC substitutes (HCFC-22, HCFC-142b, HCFC-141b, and HFC-134a) in the northern and southern hemispheres. T. SHIRAI and Y. MAKIDE.

IV. Atmospheric physics–Climate (Chair: Koji YAMAZAKI)

43. Experimental study on light scattering from the artificial ice crystal cloud. Y. SASAKI, N. NISHIYAMA and Y. FURUKAWA.
44. The study of the melting process of ice crystals just below the melting point. T. GONDA and S. ARAI.
45. Spectral albedo observation on the snow field at Barrow, Alaska. Te. AOKI, Ta. AOKI, M. FUKABORI, Y. ZAIZEN, F. NISHIO and Y. TACHIBANA.
46. Influence of the Arctic on the climate of mid-latitudes in summertime. M. TACHIKAWA and K. RIKIISHI.
47. Sea-ice in the North Pacific and the Kuroshio SST relation to forcing of the winter monsoon. Z. FANG and J. M. WALLACE.
48. Preliminary study on decadal scale oscillation and its oscillation source of air-sea-ice system at the northern hemisphere. D. GAO and B. WU.
49. Impact of Antarctic sea ice-El Nino event on atmospheric circulation and natural disasters. C. BAO and Y. XIANG.

V. Dome Fuji Project (Chair: Renji NARUSE)

50. Outline of the glaciological research at Dome Fuji in 1996. S. FUJITA, Y. FUJII and O. WATANABE.
51. Ice core processing of the Dome-Fuji Station core, Antarctica. S. FUJITA, Y. FUJII, N. AZUMA, H. MOTOYAMA, H. NARITA and O. WATANABE.
52. Contribution of sublimation process to the surface mass balance observed at Dome Fuji Station and Mizuho Station, Antarctica. T. KAMEDA and S. TAKAHASHI.
53. Changes in stable isotope content in the surface snow layer over Dome Fuji, Antarctica. M. NAKAWO, K. NAKAMURA and S. HASHIMOTO.
54. Proton arrangement in Dome-Fuji ice. S. MAE.

IV. Ice cores (Chair: Yutaka AGETA)

55. Introduction for activities on isotopic and chemical analytical work for Dome Fuji deep ice core, Antarctica. O. WATANABE, Y. FUJII, K. KAMIYAMA, H. MOTOYAMA, T. FURUKAWA, W. SHIMADA, M. IGARASHI, S. TAKAHASHI, T. YAMADA, K. FUJINO, S. AOKI, T. NAKAZAWA, S. KOBAYASHI, K. YOKOYAMA, K. SATOW, K. SUZUKI, M. NAKAWO, Y. AGETA, H. TANAKA, I. NAGAO, S. KANAMORI and Y. TANAKA.
56. Activities on physical analysis of Dome Fuji deep ice core, Antarctica. O. WATANABE, W. SHIMADA, M. TAKATA, T. HONDOH, H. NARITA, A. HORI, A. MIYAMOTO, K. TAYUKI, M. FUJII, H. SHOJI, T. KAMEDA, S. MAE, S. FUJITA, N. AZUMA and Y. WANG.
57. Tephra layers found in Dome Fuji deep ice core. Y. FUJII, S. FUJITA, N. AZUMA, T. FUKUOKA, T. KIKUCHI and T. SUZUKI.
58. The gravitational separation of air components in firn at H15, Antarctica. K. KAWAMURA, T. NAKAZAWA, S. AOKI, T. MACHIDA, Y. FUJII and O. WATANABE.
59. Ice core studies of anthropogenic sulfate and nitrate trends in the Arctic. K. GOTO-AZUMA, R. M. KOERNER and C. C. LANGWAY, Jr.

Poster presentation–II

60. Surface observation at Dome Fuji Station in 1996. H. IKEGAYA.
61. Upper air observation at Dome Fuji Station in 1996. H. IKEGAYA and M. NAKAMURA.
62. Meteorological observations along a traverse route from the coast to Dome Fuji Station, Antarctica, recorded by automatic weather stations in 1996. T. KAMEDA, S. TAKAHASHI, H. ENOMOTO, S. FUJITA, H. MOTOYAMA, Y. FUJII, O. WATANABE, G. A. WEIDNER and C. R. STEAMS.
63. Meteorological features observed by automatic weather stations along Syowa Station to Dome Fuji Station, Antarctica. S. TAKAHASHI, H. ENOMOTO, T. KAMEDA, T. SHIRAIWA, Y. KODAMA, S. FUJITA, H. MOTOYAMA, O. WATANABE, G. A. WEIDNER and C. R. STEAMS.
64. Change in snow depth at Syowa Station measured with graduated snow stakes. H. MIYAMOTO, M. NAKAMURA, O. NARITA, A. NAKAMURA and T. TAKAO.
65. Snow accumulation patterns and their relationship to surface and bedrock topographies in East

Dronning Maud Land, Antarctica. T. FURUKAWA, K. KAMIYAMA and H. MAENO.

66. Estimation of Antarctic ice accumulation by using 'reanalyzed' meteorological data. K. MASUDA.
67. Radar sounding of the ice-sheet around Dome Fuji Station, Antarctica. S. FUJITA, H. MAENO, S. URATSUKA, T. FURUKAWA, Y. FUJII and O. WATANABE.
68. Relation between attenuation coefficient and bedrock topography by radio-echo sounder. H. MAENO, S. FUJITA and S. URATSUKA.
69. Outline of the observation plan on internal structures of the ice sheet with a multi-frequency ice penetrating radar system in Antarctica. K. MATSUOKA, T. FURUKAWA, H. MAENO, S. FUJITA, R. NARUSE, F. NISHIO and O. WATANABE.
70. Deep ice core drilling at Dome Fuji, Antarctica in 1996. Y. FUJII, K. KAWADA, S. FUJITA, K. SHINBORI, H. NARITA, N. AZUMA, K. KATAGIRI, A. TAKAHASHI, S. YONEYAMA, Y. NAGATA, K. TANIGUCHI, H. IKEGAYA, M. MIYAKE, Y. TANAKA, Y. NAKAYAMA, H. MOTOYAMA and O. WATANABE.
71. Report on drilling and processing of ice core of NGRIP 1997. H. SHOJI, H. NARITA, N. AZUMA, Y. TANAKA, M. TAKATA, M. IGARASHI and O. WATANABE.
72. Measurements of microwave dielectric constants of ice core from Dome Fuji, Antarctica. T. MATSUOKA, S. FUJITA, S. MAE and O. WATANABE.
73. Effect of ice temperature on protons in Dome-Fuji Antarctic ice. H. FUKAZAWA, S. MAE, S. IKEDA and O. WATANABE.
74. *In situ* observation of the transformation to air-hydrate crystals using a Mizuho ice core. W. SHIMADA and T. HONDOH.
75. Metal concentration of snowfall. N. ICHITANI and K. KAMIYAMA.
76. Chemical analyses of the ice cores and surface snow from north Greenland. M. IGARASHI, K. KAMIYAMA, O. WATANABE, M. TAKATA, H. SHOJI, J. P. STEFFENSEN and H. B. CLAUSEN.
77. Chemical fluxes on Vestfonna Ice Cap in Svalbard. S. MATOBA, K. KAMIYAMA, H. MOTOYAMA, H. NARITA and O. WATANABE.
78. Temporal and spatial variation of the thickness of snow cover in former Soviet Union. J. SAKAKIBARA and K. RIKIISHI.
79. Chemical information on snow deposition at and around Dome Fuji Station, Antarctica, in 1995. N. AZUMA, T. KAMEDA, S. TAKAHASHI, H. ENOMOTO, T. SHIRAIWA, O. WATANABE, Y. FUJII, K. KAMIYAMA, H. MOTOYAMA, M. IGARASHI, Y. AGETA, S. KANAMORI and T. SAITO.
80. Chemistry of snow, atmospheric aerosol and acid gas at Dome Fuji, Antarctica (2). S. KANAMORI, N. KANAMORI, O. WATANABE, Y. FUJII and T. KAMEDA.
81. Distributions of organic compounds in Antarctic snows. K. KAWAMURA, Y. IMAI, M. NISHIKIORI, Y. FUJII and O. WATANABE.
82. Micro tephra particles in snow and ice core from Antarctica. N. HAYASHI, T. FUKUOKA, M. KOHNO and Y. FUJII.
83. An automated system for hydrogen isotope ratio of snow samples in the polar region using water-hydrogen equilibration. Y. IIZUKA and H. SATAKE.
84. Determinations of trace metals in Arctic ice and snow sample by ICP-MS. S. MATOBA, M. NISHIKAWA, M. MORITA, A. E. EROGLU and O. WATANABE.

VII. Glaciological process (Chair: Fumihiko NISHIO)

85. 3-D Numerical modeling of Antarctic Ice Sheet (1) equilibrium response. F. SAITO and A. ABE.
86. The Shirase flow-line model: an additional tool for interpreting the Dome-Fuji signal. F. PATTYN and H. DECLEIR.
87. Chemical analyses of the basal ice of Hamna Icefall, Antarctica. Y. IIZUKA, H. SATAKE, M. IGARASHI, T. SHIRAIWA, R. NARUSE and K. YOKOYAMA.
88. A global network of specimen banks with preservation in Antarctica—Biological and Environmental Specimen Time Capsule 2001 Project—. T. SHIBATA, O. WATANABE, Y. SHIBATA and T. ETOH.

VIII. Analytical methods for glaciology (Chair: Toshitaka SUZUKI)

89. Analysis of Dome Fuji ice core thin sections with an automatic ice fabric analyzer. Y. WANG,

N. AZUMA, H. NARITA, H. SHOJI and O. WATANABE.

90. Use of high resolution micro flow analyses for chemical analyses of snow/ice samples. M. MARUO, K. KAMIYAMA, T. KIMOTO and E. NAKAYAMA.
91. Characterization of Dome F-core by total-reflection X-ray fluorescence spectroscopy (TXRF). T. KIKUCHI, K. KAMIYAMA, Y. FUJII, O. WATANABE and S. KOJIMA.