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Report

REPORT OF OBSERVATION PROJECT ON "ATMOSPHERIC CIRCULATION AND MATERIAL CYCLE IN THE ANTARCTIC" BY JARE-38

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Abstract: An observation project on "Atmospheric Circulation and Material Cycle in the Antarctic" was started by the 38th Japanese Antarctic Research Expedition (JARE-38). The project aims to understand the atmospheric circulation fields, behavior of minor constituents, and their relations. Extended observations including GPS sondes, radiometers, lidar and aerosol sondes were conducted at Dome Fuji Station and collocated observations at Syowa Station.

1. Introduction

Since 1997, a project on "Atmospheric Circulation and Material Cycle in the Antarctic" has been carried out by the Japanese Antarctic Research Expedition (JARE). The project aims to clarify the transport and transfer of atmospheric minor constituents related to the atmospheric circulation. During the wintering in 1997, extended observations with rawinsondes, cloud imager and radiometers, lidar, aerosol sondes, ozone sondes, and sampler and counter of aerosols at the surface were made at Dome Fuji Station (77°19′S, 39°42′E, 3810 m a.s.l.; Fig. 1) by JARE-38. This inland station was originally operated for deep ice core drilling, which reached 2500 m depth in 1996 by JARE-36 and -37. At Syowa Station (69°00′S, 39°35′E), airborne aerosol observations, aerosol sondes and surface observations were conducted. Also, cryogenic sampling of the stratospheric air by large balloon was done in January 1998 by JARE-39. These observation results were synthesized to draw a meridional cross section of those atmospheric constituents. Three atmospheric scientists were engaged in the project, two at Dome Fuji and one at Syowa Station. Two glaciologists together with all the wintering members at Dome Fuji and five meteorologists at Syowa Station of JARE-38 supported the observations.

Outline of the project is reported in the paper.

2. Objectives and Annual Plan of the Project

Several topics in the atmospheric sciences obtained in the past lead to the objectives of the project. A long record of variation of atmospheric CO_2 concentration at the surface of Syowa Station (AOKI and NAKAZAWA, 1997), for example, suggested need for more work to determine the cause of this variation. In particular, to determine the

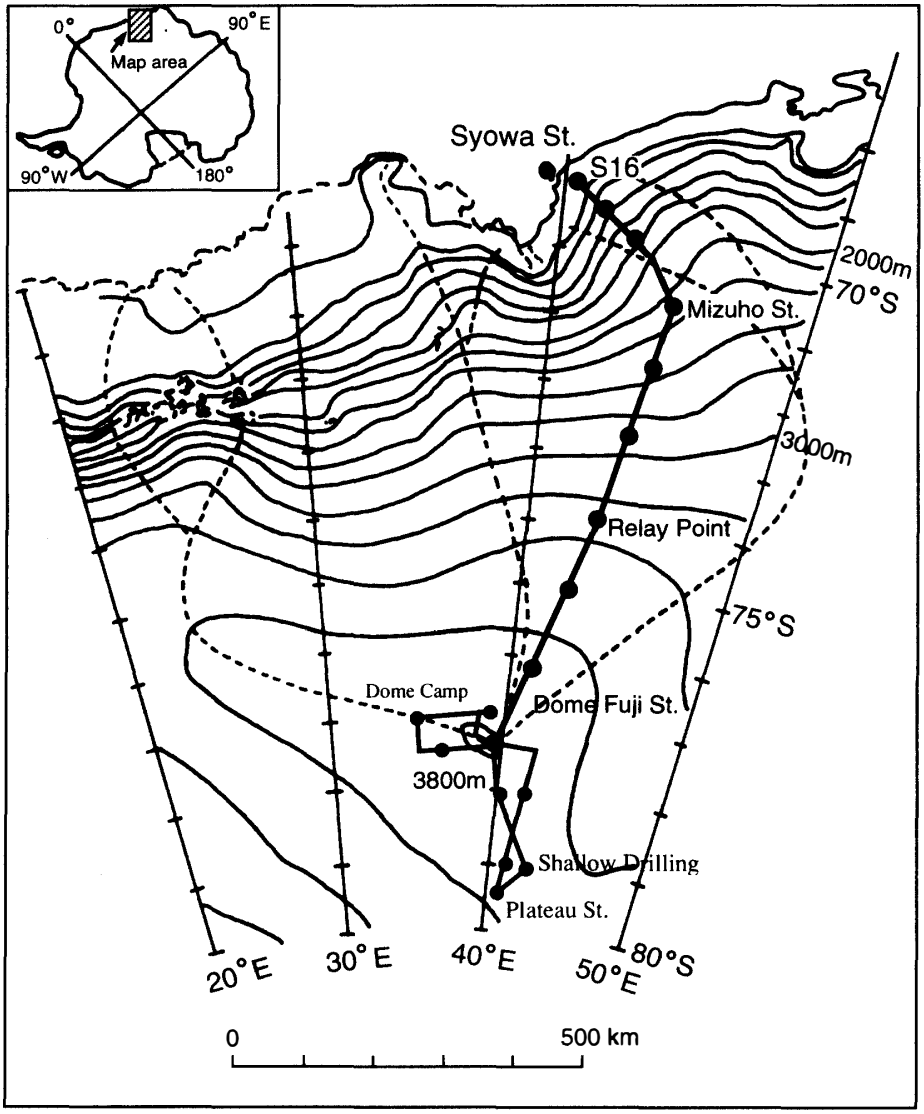

Fig. 1. Map showing stations and area of observation.

transportation mechanism, vertical profile and wide horizontal distribution of these species are essential. In order to clarify the development of ozone hole, it is indispensable to examine the behavior of stratospheric aerosols (PSCs) and the polar vortex. Large difference was found in the distribution of chemical composition in the atmosphere and surface snow, along the route from Syowa to Dome Fuji Station, between the coastal area and the interior (KANAMORI *et al.*, 1997; KAMIYAMA *et al.*, 1996). The possibility of transport from the stratosphere to the troposphere and then to the snow surface has been discussed. The transport and transformation of radiatively active greenhouse gases, ozone, aerosols and water vapor from the low latitude to high latitude, from the coastal region to the interior of the Antarctic continent, within and between the stratosphere and troposphere, between the atmosphere and cryosphere and between the atmosphere and ocean, namely the "material cycle", is to be examined referenced to the atmospheric circulation. It has already been reported that a sudden increase of the

surface temperature occurred at inland area on occasion of formation of a blocking high (ENOMOTO *et al.*, 1998). It is of great interest to know the contribution of a blocking high to transport to the inland area not only of heat but also of minor constituents.

Annual plan of the five year project on "Atmospheric Circulation and Material Cycle in the Antarctic" is as follows:

—JARE-38 (wintering in 1997): Collocated wintering observations of atmospheric circulation and aerosols at Dome Fuji Station and Syowa Station. Preliminary experiment of sampling balloon and observation on the research vessel SHIRASE.

—JARE-39 (1998): Sampling balloon experiment with cryogenic sampler in summer, continued aerosol observations and new observations related to the exchange of minor constituents between atmosphere and ocean and between atmosphere and firn snow.

—JARE-40 (1999): Continuation of observations at Syowa Station.

—JARE-41 (2000): Airborne observation of water vapor and aerosols over a wider area from Syowa to Mizuho Station (70°42′S, 44°20′E, 2230 m a.s.l.) and then to the interior of the continent. Ground based observations at Mizuho Station is also made.

—JARE-42 (2001): Continuation of observations at Syowa Station.

3. Observations at Dome Fuji Station

As part of the program of JARE-38, extended atmospheric science observations were conducted at Dome Fuji Station in 1997, as shown in Table 1. During the first two years of wintering at Dome Fuji by JARE-36 and 37, surface synoptic observations had been carried out together with deep ice core drilling (FUJII *et al.*, 1999). The station is located 1000 km from Syowa Station on the coast, at 3800 m a.s.l., and is characteristic of average surface pressure of 598 hPa and lowest recorded temperature of −79.7°C in 1997.

Aerological observations were carried out throughout the year using a Väisala GPS sonde type 80-15G (HIRASAWA, 1999; HIRASAWA *et al.*, 1999a). Normally, the sonde was launched once each other day or once a week; it was launched every 6 hours during intensive observation periods when the blocking high intruded inland (HIRASAWA *et al.*, 1999b). Additionally, moored observations were made on some occasion in order to obtain precise distributions of wind, temperature and humidity in the strong surface inversion layer.

Radiation measurements were made to obtain the radiative effect of clouds and index of atmospheric circulation. Quantities measured were downward and upward shortwave radiation, and downward and upward longwave radiation. Also measurements of all sky image by infrared scanning radiometer and all sky camera were conducted to obtain cloud distributions. These observation results will also help to assess cloud distributions derived from satellite data. The radiation budget under an ice crystal precipitation (diamond dust) was an issue of discussion.

Observations of aerosols included vertical distribution, continuous measurements, and sampling (HAYASHI, 1999). Vertical distributions of aerosols were measured by compact lidar, from March to December, and also by aerosol sonde about once a month together with the ozone sondes. From these observations, detailed variations of aerosols in the troposphere and stratosphere, especially a whole seasonal cycle of Polar

Table 1. Observations of project on "Atmospheric Circulation and Material Cycle in the Antarctic" by JARE-38.

Item	Syowa	Dome Fuji	Shirase
(Atmospheric circulation)			
synoptic observation	(○)	○	
aerological observation	(○)	○	
radiation budget	(○)	○	
cloud image		○	
satellite data	○		
(Material cycle)			
lidar		○	
aerosol sonde	○	○	
ozone sonde	(○)	○	
sampling balloon	○		
airborne sampling	○		
airborne observation of water vapor and aerosols	○		
aerosols size distribution	○	○	○
dew point temperature		○	
surface ozone	(○)	○	(○)
radon concentration		○	
cosmic rays		○	
sampling of aerosols	○	○	○
stable isotope ratio	○		

○ : conducted under this project
(○): conducted under other project

Stratospheric Clouds (PSCs), from the beginning of development to the end of decay, were obtained referenced to the polar vortex and ozone hole. The middle part of polar vortex normally covers about the location of Dome Fuji Station.

Ground based observations of aerosols were made; size distributions of aerosol concentration were measured using optical particle counters and condensation particle counters. Aerosols were sampled for chemical analysis and electronic microprobe analysis, and also acid and alkaline gases were sampled. Concentrations of surface ozone and radon (UI *et al.*, 1998) were also measured throughout the year.

4. Observations at Syowa Station

Collocated observations were conducted at Syowa Station. Ground based observations of aerosols were made. Size distribution of aerosol concentration was measured using optical particle counters and condensation particle counters (IWASAKA *et al.*, 1997, 1998). Aerosols were sampled using a high volume air sampler and medium volume impactor for chemical analysis and electronic microprobe analysis, and also acid and alkaline gases were sampled (OSADA *et al.*, 1998; HARA *et al.*, 1999).

Carbon dioxide was extracted from air and sampled using liquid N_2 to analyze isotope ratio. Carbon and oxygen isotope ratio give some information on the source and sink of CO_2.

In order to derive vertical distributions of greenhouse gases, such as CO_2, airborne sampling was performed using a small aircraft, a Cessna A185F. Sampling flights were carried out over the sea ice in the vicinity of Syowa Station, at altitudes every 1 km, from 1 km to 5 or 6.5 km, once per month except in June.

Airborne observations of water vapor and aerosols using a dew point meter and optical particle counters were made along the route from Syowa to Mizuho Station. Horizontal flights were made at the height of 3800 m a.s.l., which is the altitude of Dome Fuji Station, and return flights at about 300 to 500 m height from the ground surface. Seven flights were conducted from March to December 1997 (YAMANOUCHI *et al.*, 1999).

Sampling was done by large balloon to derive vertical profiles of greenhouse gases and their isotope ratios in the stratosphere. JARE-39 launched a cryogenic sampler with liquid He using a B30 balloon on January 3, 1998, and sampled the air at eleven altitudes from 10 to 30 km. The sampler was landed with a parachute on open water near sea ice floe. Originally it was planned to be landed on sea ice and recovered by helicopter; however, the sea ice condition was extremely poor in this season so it was landed on open water, and recovered successfully by the research vessel/icebreaker SHIRASE, three days later.

Before this experiment, a preliminary experiment was performed. Three grab samplers were launched using small rubber balloons, recovered by helicopter from sea ice or a snow field on the continent. Stratospheric air was successfully sampled in January 1997. A similar experiment had been done by JARE-37 in January 1996, and a feasibility study was done in January 1995 by JARE-36. These experiments were done to improve the sampling balloon technique, since launching and recovering the balloon was accompanied by many difficulties. At the same time, this small grab sampler has become a simple way of sampling stratospheric air independently (HONDA *et al.*, 1996).

Apart from these project observations, long term monitoring of atmospheric minor constituents, greenhouse gases (AOKI and NAKAZAWA, 1997), aerosols and ozone; data acquisition from NOAA satellites using a newly equipped receiving station; and routine meteorological observations including synoptic, aerological, ozone and radiation measurements were continued at Syowa Station.

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