A Japanese Field Experiment Plan for Aerosol-Cloud-Radiation Research in the Arctic

M. Shiobara, M. Wada, T. Yamanouchi, S. Morimoto, G. Hashida and N. Hirasawa
National Institute of Polar Research
Tokyo, Japan

Introduction

The National Institute of Polar Research (NIPR) promotes atmospheric research in both Arctic and Antarctic regions. In the Arctic, NIPR has maintained a research station since 1991 at Ny-Aalesund (79N,12E), Norway, in collaboration with the Norwegian Polar Institute. The station has been used mainly for sampling and continuous measurements of greenhouse gas. NIPR is planning a next-generation observation system at Ny-Aalesund in order to extend its research to aerosol-cloud-radiation studies. Airborne observation from aircraft and balloons will be operated for an intensive field campaign. The scientific objectives of this program and the currently planned strategies are presented for consideration of a possible international collaboration in the future.

Research Objectives

Atmospheric aerosols play an important role in the global climate system, not only directly by their radiative effects on the earth's radiation budget, but also indirectly by their chemical and physical processes of gas-aerosol-cloud interactions.

Previous results from ground-based measurements at Ny-Aalesund have suggested that seasonal variations in greenhouse gases reflect transportation and chemical processes in the atmosphere. Arctic aerosols, as well as minor constituents, may be deeply interactive with the ozone destruction process in the Arctic stratosphere and troposphere. Airborne in-situ measurements with aircraft and balloons can be helpful for further investigation regarding such processes and the spatial variations of gas and aerosols.

In the 1980s and early 1990s, international projects such as the Arctic Gas and Aerosol Sampling Program (AGASP) series (e.g., Schnell 1984, AGASP-II 1989) were carried out and attained great success in studying the Arctic aerosol. In those airborne experiments, gas, aerosol, and radiation measurements were performed, and it has been suggested that the Arctic haze is strongly responsible for the radiation budget in the Arctic (Ackerman et al. 1986). Thus, the scientific objectives of this experimental research are summarized as follows:

- To investigate the Arctic aerosols, which may modify the optical properties of Arctic clouds
- To understand the physical and chemical processes concerned with gas-aerosol-cloud interactions in the polar stratosphere and troposphere
- To clarify the transportation and exchange processes of greenhouse gases and aerosols
- To quantitatively assess the radiative effects of the Arctic haze on the radiation budget in the atmosphere-surface system.

Observation Strategies

To achieve the research objectives mentioned above, the following strategies are currently planned:

1. Ground-based observation at Ny-Aalesund will acquire long-term measurements of gases, aerosols, clouds, and radiation. Such measurements may clarify the temporal variability of optical properties and the vertical distribution of Arctic aerosols. Those measurements can be compared with the airborne observation and also provide data for validation of the satellite remote-sensing retrievals.

2. Airborne observations with aircraft and balloons are essential for spatial structure measurements. Two flight patterns are currently planned for the instrumented aircraft flight: a ladder-step flight over Ny-Aalesund and a long-range horizontal flight between Ny-Aalesund and Kiruna, Sweden (68N, 20E). In the future, unmanned

aerospace vehicles may be used in place of manned aircraft since they are powerful for high-altitude measurements of gas, aerosol, and radiation (Valero et al. 1996) and offer the additional advantage of safety of operation, especially in the polar region.

Instrumentation Plan

The instrumentation planned for ground-based observations includes an aureolemeter, a star photometer, a micropulse lidar (MPL), and conventional flux radiometers. The aureolemeter is used to acquire the spectral optical thickness and size distribution of aerosols from the solar aureole measurements (Shiobara et al. 1991, Nakajima et al. 1996). Spinhirne (1993) developed the MPL to acquire long-term datasets of backscatter profiles of aerosol and clouds. The star photometer can measure the spectral attenuation of star light to obtain the optical thickness and size distribution of aerosols. The instrument is powerful for measurements during the polar night in particular (Herber et al. 1996). Flux radiometers are also used to obtain surface albedo and radiation budget from downward/upward facing pyranometer/pyrgeometer measurements. A mobility analyzer, an optical particle counter, a 3-wavelength nephelometer, and hi-/low-volume samplers are used for ground aerosols. A dual-channel microwave radiometer is planned for measuring water vapor and liquid water path. An automatic gas sampling system is now under development.

For airborne observation, the plan is to equip an aircraft with an FSSP-300 aerosol scattering probe, aerosol impactors, a gas sampling system, and ozone and carbon dioxide analyzers as well as downward/upward facing flux radiometers. A cryogenic gas sampling system is now under development for balloon-borne measurements. A compact optical particle counter can also fly along with the gas sampler.

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