A Study on Dust and Sand Storms (DSS)

－Summary－

1. Introduction

Since 2002, the Ministry of the Environment, Japan has been studying the situation of dust and sand storms (DSS) with the cooperation from local governments and the National Institute for Environmental Studies (NIES). The study consisted of sampling aerosol collectively at multiple survey sites throughout Japan in DSS events, and analyzing particle size distribution and chemical composition. This summary highlights the results of the study on DSS that was conducted from 2002 to 2007.

2. Method

(1) Sampling

Aerosol in the atmosphere was collected using the following sampling instruments over a one-day or two-day period in units of 24 hours, in principle, on the days when DSS was expected to reach Japan.

(i) 8-stage low-volume Andersen sampler

The main purpose is to examine particle size distribution.

(ii) High-volume sampler

The main purpose is to analyze the concentration of total suspended particles (TSP), the metal composition and ion composition in aerosol, and the composition of pesticides that have adsorbed strongly to the aerosol.

(iii) 2-stage low-volume sampler

The main purpose is to analyze the metal composition and ion composition of aerosol that has been classified as either coarse or fine particles.

(iv) High-volume sampler (polyurethane foam and activated carbon fiber felt are attached to the stage behind the filter paper)

The main purposes are to acquire pesticide components more efficiently and to identify the ratio of pesticide components in particle and gas form and pesticide components that have strongly been adsorbed to the aerosol.

(2) Sampling period

DSS event season (from February to June) between 2003 and 2008.

(3) Sampling sites

9 sites were as follows:

- Sapporo City (Sapporo National Atmospheric Monitoring Station)
- Tsukuba City (National Institute for Environmental Studies)
- Niigata City (Niigata Acid Deposition Monitoring Station)
- Toyama City (Tateyama Monitoring Station)
- Kanazawa City (Ishikawa Prefectural Institute of Public Health and Environmental Science)
- Inuyama City (Inuyama Acid Deposition Monitoring Station)
- Matsue City (Matsue Atmospheric Monitoring Station)
- Dazaifu City (Fukuoka Institute of Health and Environmental Sciences)
- Nagasaki City (Shikimi Dam Acid Deposition Monitoring Station)

(4) Physical and chemical analysis

Metal components, ion components, and pesticides components were analyzed, in addition to measuring the weight of TSP.

(5) Comprehensive analysis

Analysis data on chemical components, data on general meteorological conditions and from ambient air monitoring stations, LIDAR (Light Detection and Ranging; equipment for observing DSS using laser beams) observations, Chemical Weather FORecasting System (CFORS), which is used for predicting the transport of air pollutants, and other elements based on numerical calculations, were comprehensively reviewed and the main events of DSS were analyzed.

3. Results

(1) Transport conditions of DSS

- Concentration of TSP was often higher at the Nagasaki, Dazaifu, and Maki survey sites than the average concentration of all the survey sites. Upon making relative comparisons for the same survey date, the concentration of TSP tended to be 20 to 30% higher in western Japan than in eastern Japan, and on the Sea of Japan side than on the Pacific Ocean side. Similarly, the amount of suspended particulate matter (SPM) in western Japan tended to be approximately three-fold of that in eastern Japan on days with DSS.

(2) Chemical properties of DSS

- With regard to the components of TSP, there are days when the concentration of air pollutants such as sulfate may be high or low, depending on the day that DSS reaches Japan. Furthermore, DSS is transported in various ways, depending on

meteorological conditions such as the air mass that transports the DSS, and the passage and stalling of fronts associated with this air mass.

- The average concentration of air pollutants such as anthrogenic nitrate and sulfate tended to be higher during DSS and lower with no DSS, based on LIDAR observations. As a result, during DSS events, concentration of these pollutants is relatively high. In addition, the interaction of air pollutants to DSS is not uniform, and differs depending on the time that DSS reaches the survey sites, the path taken by the DSS from its source to Japan, such as through industrial areas, and mixture during transport via air masses in association with the fronts.
- The concentrations of pesticides components were found to be equal to or lower than the level of environmental concentration. A large portion of the pesticides detected in this survey are used in Japan. However, as pesticides once used in Japan but now prohibited may remain in the soil, it was difficult to judge whether these prohibited but detected pesticides had reached Japan together with the DSS.
- A large proportion of the mercury components was lower than the detection limit, so there is virtually no domestic impact from adherence of mercury to DSS.

(3) Physical properties of DSS

- At many of the survey sites, the DSS particle sizes were mainly 4 μm, and the particle size of DSS carried to western Japan, which is close to its source, also appeared to be larger. There were also no differences in particle size distribution based on the scale of DSS.

(4) Comprehensive analysis of events of airborne DSS

Based on analyses of suspended particulate matter (SPM) concentration and sulfur dioxide concentration, the conditions of DSS on the survey dates can be classified into three patterns: DSS, mixed DSS (mixture of DSS and air pollutants), and non-DSS. For the five large DSS events, comprehensive analysis was conducted using LIDAR observations, and the conditions of DSS and nonsea-salt sulfate were as follows.

・Event 1 (April 8 to 9, 2006): DSS
DSS is thought to have been transported directly from the Gobi Desert, mainly from the eastern part of the Chugoku region to the Kinki, Chubu and Kanto areas. In the marginal areas of the DSS, which extended over a broad range, the ratio of pollutants in the atmosphere was high.

・Event 2 (April 18 to 19, 2006): Mixed type DSS
DSS spread all over Japan, except some parts of Hokkaido and the southwestern islands. Among the five events, this event had a relatively high ratio of pollutants contained in the atmosphere, and a high possibility that many pollutants had interacted with the aerosol in the DSS.

・Event 3 (April 1 to 2, 2007): DSS
DSS spread all over Japan, except Hokkaido and the southwestern islands. Among the 5 events, there were relatively few pollutants in the atmosphere in this event.

・Event 4 (May 8 to 9, 2007):
The dust concentration was high, due to air pollutants rather than DSS.

・Event 5 (May 26 to 27, 2007): Mixed type DSS
DSS expanded broadly over mainland China and reached western and eastern Japan. Among the five events, there were high concentrations of pollutants in the atmosphere, and a high possibility that many pollutants had adsorped to the DSS aerosol.

4. Discussion and challenges

・ DSS occurs in various forms, as it is largely affected by the scale of origination, climate conditions, and others. In this report, the transport of DSS and the state of interaction of pollutants to DSS aerosol were reviewed for five events of DSS transport, and the transportation of DSS was categorized as either consisting only of DSS or a mixed type where DSS was mixed with air pollutants. In the future, to clarify the transportation of DSS in more detail, it is necessary to review analyses that consider changes due to the advection path and process, and the alteration process in the case that DSS advects within Japan. It is also necessary to conduct further analyses of specific examples, review their effectiveness, and identify the conditions of DSS in greater detail.

・Since DSS affects northeast Asia, progress has been made on policy dialogues under the framework of the Tripartite Environment Ministers Meeting (TEMM) among Korea, China and Japan. In 2008, joint research on measures for sources and the construction of a DSS monitoring network was initiated. Japan must collaborate with countries such as China and Korea, and contribute to joint research such as by

clarifying the transportation route of DSS and the relationship between DSS and air pollutants. In addition, to sharing observation data among countries, it is necessary to standardize measurement and analysis methods.

・This survey revealed that the peak in the size distribution of DSS is at approximately 4 μm. In addition, air pollutants such as sulfate and nitrate may interact with DSS during the transportation process. Since the concentration of nitrate was high among aerosol with a particle size of over 2.5 μm, they might interact with DSS. Therefore, further research on the environmental and health impacts of DSS based on this kind of fundamental information is required.

・It is necessary to continue observing annual variations over long period related to how the conditions of DSS will change depending on climate changes and human activities. To achieve this, networks need to be built both within Japan and abroad.