3

Recent Moves to Address the KOSA (Yellow Sand) Phenomenon
— Towards Solutions for a Problem that is an age-old Natural Phenomenon and has concurrently been Influenced by Anthropogenic —

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1 Introduction

To the Japanese, the KOSA (Yellow Sand) is seen as a tranquil sign of spring, as well as the first spring storm. KOSA (Yellow Sand) is often observed from early spring through early summer when low atmospheric pressure passes over East Asia. When the KOSA (Yellow Sand) phenomenon occurs, the sky fills with a yellow haze, so it is well known to the people of Japan. KOSA (Yellow Sand) was observed around Japan in the spring of 2006, and on April 18 was detected in the center of Tokyo for the first time since April 14, 2000, an elapse of six years. It was also observed on April 19, the first time in 18 years the phenomenon had been detected on two consecutive days. The last time that this had occurred was April 14 and 15, 1988. (See color photographs on the front cover; taken with the MODIS sensor on board NASA's Aqua/Terra Earth observation satellite and received and processed by the Japan Aerospace Exploration Agency [JAXA].) Desert sandstorms on the largest scale have struck China during the past several years, causing extensive damage and even deaths.

For three consecutives years from 2000 through 2002, the number of observations of the KOSA (Yellow Sand) phenomenon exceeded the records set during the previous 30 years. Furthermore, the KOSA (Yellow Sand) phenomenon was observed in northern Japan and in early autumn, in places and times it has rarely occurred in the past. This has caused a steady increase in society's interest in the phenomenon.

Recent research has found that KOSA (Yellow Sand) suspended in the atmosphere has profound direct and indirect effects on global climate. Along with being a natural disaster in the areas where the KOSA (Yellow Sand) phenomenon originates, the phenomenon affects air quality in areas to which KOSA (Yellow Sand) is carried and it affects global climate[1]. KOSA (Yellow Sand) had been considered a natural phenomenon, but some researchers point out that the rapid expansion of damage in China and elsewhere indicates a major anthropogenic influence. More detailed elucidation of the phenomenon is necessary. At this point, however, researchers do not fully understand even the physical and chemical properties of KOSA (Yellow Sand) itself.

2 KOSA (Yellow Sand) phenomenon

KOSA (Yellow Sand) is a phenomenon in which soil and mineral particles are picked up by the wind in arid and semi-arid regions such as Takla Makan Desert and Loess Plateau in inland China, and Gobi Desert spreading between China to Mongolian, and are carried to a height of several thousand meters. Prevailing westerlies then carry the particles to eastern Asia and the western Pacific region, including Japan, where they remain suspended in the atmosphere or fall to the ground.

The KOSA (Yellow Sand) picked up by the wind in the continent's arid and semi-arid regions does not merely cause major damage to agricultural production and living environments near the areas where it originates. It also impacts global climate by forming clouds of KOSA (Yellow Sand) suspended particulate acting as nuclei to form precipitation. Furthermore, some scientists theorize that the particulate falls to the ocean and significantly affects the oceanic ecosystem by altering the mineral supply to surface plankton[2]. However, the details of this phenomenon remain unclear.

The KOSA (Yellow Sand) phenomenon had been understood as a "natural phenomenon" in which the wind carried dust from the Yellow River basin, deserts, and so on. Recently however, the enormous increase in the frequency of its occurrence and the damage it causes, indicates that the relentless rapid spread of overgrazing and the expansion of cultivated areas through agricultural conversion are factors that influence the severity of the phenomenon. Scientists are rediscovering KOSA (Yellow Sand) as an environmental problem influenced by anthropogenic forest reduction, soil degradation, and desertification rather than being simply a natural phenomenon[2].

Table 1 : Definitions of KOSA (Yellow Sand) in various countries

[China]

Visibility	Name for weather when "KOSA (Yellow Sand)" appears	Terminology	Note: (http://www.weathercn.com/room/shuyu.jsp) (China Meteorological Administration, "Guide to Surface Weather Observation [2003]")
Less than 10 km	Dust weather Dust storm weather	Drifting dust	Weather phenomenon where sand or dirt particles are suspended in the air and horizontal visibility is less than 10 km
1-10 km		Blowing dust	Weather phenomenon where dust is lifted from the ground by wind, the sky is turbid, and horizontal visibility is 1-10 km (also called "high wind dust")
Less than 1 km		Dust storm	Weather phenomenon where dust is lifted from the ground by wind, the sky is rather turbid, and horizontal visibility is less than 1 km
Less than 500 m		Strong dust storm	Weather phenomenon where big (strong) winds lift dust from the ground, the sky is very turbid, and horizontal visibility is less than 500 m (Note: "big winds" are generally at least an 8 on the Beaufort scale [momentary wind speed of 17.2 m/s] and above)
Less than 50 m		Extreme dust storm	Weather phenomenon where raging (very strong) winds lift large amounts of dust from the ground, the sky is very turbid, and horizontal visibility is less than 50 m (Note: "raging winds" are generally at least a 10 on the Beaufort scale [momentary wind speed of 24.5 m/s] and above)

[South Korea]

Particle size, Density	Name for weather when "KOSA (Yellow Sand)" appears	Terminology	Note: (Republic of Korea Meteorological Administration 2002, Chu 2004)
1~1000μm	Hwangsa (Yellow Sand)	Sand	Evenly distribution in the air with little or no wind
1~10μm		Dust, KOSA (Yellow Sand)	Particle size 10 μm: suspended for a few hours to a few days Particle size 1 μm: suspended for a few years
		KOSA (Yellow Sand)	A phenomenon, usually occurring in spring, in which dust from arid and semi-arid areas such as the Badain Jaran, Tengger, Mu Us Shamo, Hunshandak, Kerchin, Gobi, and the Loess Plateau regions of Asian Continent floats and falls, impacting visibility and air quality. Three stages, levels 0, 1, and 2, depending on observation of visibility in visual. KOSA (Yellow Sand) density is used for forecasts. When the forecast is issued for an average hourly density of more than 300 μg/m^3 for over 2 hours, a KOSA (Yellow Sand) advisory is issued. A KOSA (Yellow Sand) watch is issued for greater than 500 μg/m^3, and a KOSA (Yellow Sand) warning for greater than 1,000 μg/m^3.

[Japan]

Particle size • Visibility	Name for weather when "KOSA (Yellow Sand)" appears	Terminology	Note: (Japan Meteorological Agency 2002)
	KOSA (Yellow Sand)	KOSA (Yellow Sand)	Generally, a phenomenon in which large amounts of dust blown from Asia's loess belt soar high in the air and fill the sky and gradually drift to the ground. In extreme cases, the sky turns yellow, the sun looks remarkably dark, snow appears colored, and objects on the ground are covered with dust. Visibility is 10 km or less as determined by visual meteorological observatories.

Prepared by the STFC based on the References[3, 4]

2-1 Definition of KOSA (Yellow Sand)

The term "KOSA" is used in Japan and Korea, but in China it is not used by the government or the public, with the exception of some researchers[4].

As described in Table 1, in Japan "KOSA (Yellow Sand)" recognize to the atmospheric phenomenon of large amounts of dust blown from the continent's loess region soar high in the air and filling the sky and the decreased visibility accompanying that phenomenon. In South Korea, three stages of KOSA (Yellow Sand) warnings are issued depending on the density of the matter suspended in the air. In the most severe stage, people are warned not to go outside. In China, there are five stages of "dust storm weather" based on standards for wind strength and density as determined by visibility. Damage from dust storms is recognized.

2-2 The mechanism of KOSA (Yellow Sand) formation

The mechanism by which KOSA (Yellow Sand) is formed is associated with temperate-zone low pressure activity. The KOSA (Yellow Sand) phenomenon begins when dust is swept up in areas where strong winds blow from high pressure to low pressure centers and frontal zones[3] (see Figure 1).

Weather conditions such as wind strength are not the only factors that determine the formation of the KOSA (Yellow Sand) phenomenon and how much KOSA (Yellow Sand) it carries. Surface conditions on the ground subjected to the strong winds are an important factor. These surface conditions include topography, the existence of vegetation on the ground, surface roughness and the existence of snow cover, amount of soil moisture, and soil particle size. These conditions have a major effect on the amount of sand carried. The Japan Meteorological Agency has determined that the three major influences on the formation of KOSA (Yellow Sand) and the amount carried are (i) soil conditions in generating areas such as dryness, vegetation, and snow cover, (ii) the existence of strong winds raising dust in generating areas, and (iii) prevailing westerlies. The exact mechanism and the priority of its aspects, however, are still unknown.

Once KOSA (Yellow Sand) particles originating

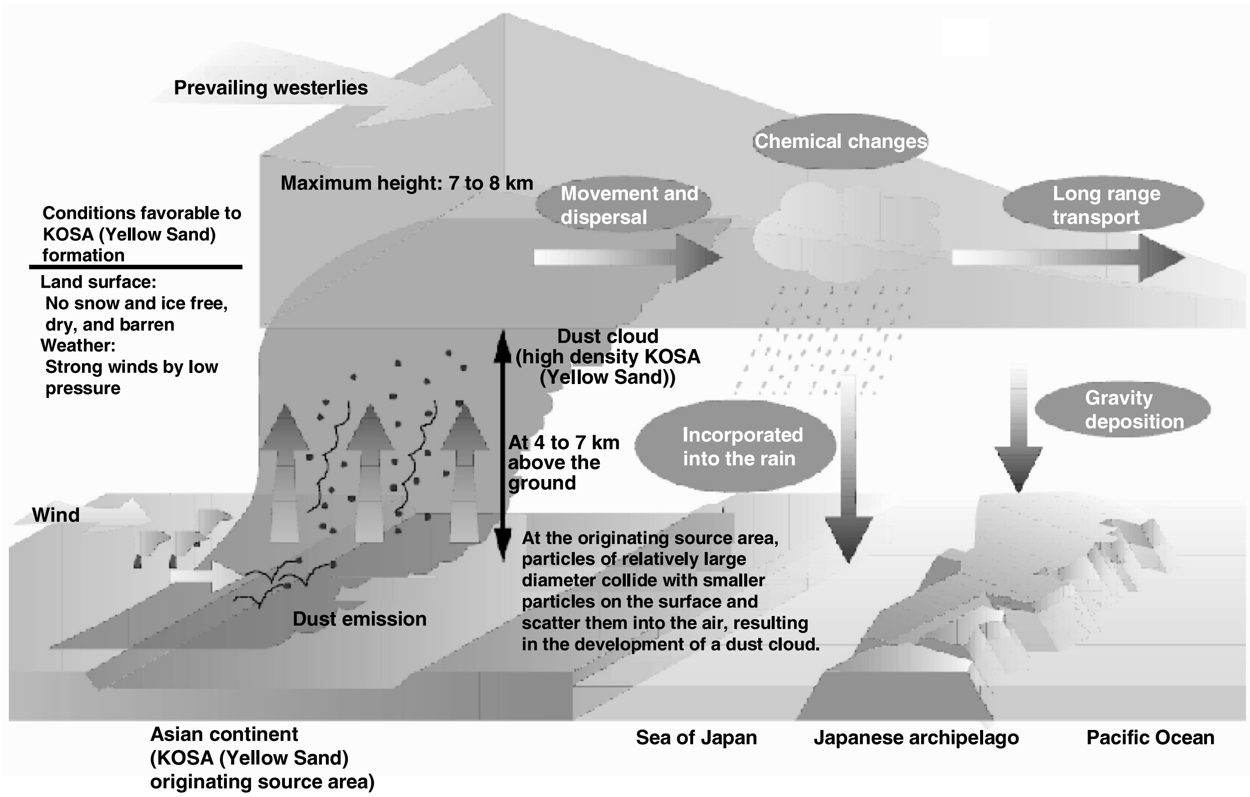

Figure 1 : Formation Mechanisms of KOSA (Yellow Sand)*

* KOSA (Yellow Sand) is referred to as "Dust and Sandstorms" in Ministry of the Environment Source: Reference[2]

in Northeast Asia are carried into the atmosphere, prevailing westerlies transport them. Gravity causes the relatively large particles (with diameters of 10 μms or greater) to fall quickly, but winds in the upper atmosphere carry smaller particles (with diameters of a few μms or less) over great distances. Earth observation satellites have observed KOSA (Yellow Sand) formed in East Asia crossing the North Pacific to North American continent. In some cases, it has even crossed the North Atlantic and traveled as far as the European Alps[1].

Similar phenomena can occur anywhere in the world when the conditions for soil particles to rise into the air are met[1]. Phenomena similar to KOSA (Yellow Sand) are found in many parts of the world, especially near large deserts. The world's four major dust belts are in Central Asia, North America, Central Africa, and Australia[5]. The dry sirocco winds that blow from Africa's Sahara Desert to southern Italy affect a particularly extensive area. They carry fine particulate matter from the Sahara to the Mediterranean, where it causes red rain to fall. This dust is the base material of the red soil (terra rosa) all around the Mediterranean[3].

2-3 Characteristics of KOSA (Yellow Sand) particles

Most KOSA (Yellow Sand) particles in the atmosphere are not composed of simple mineral particles. Instead, they are composed of particles of clay minerals that clump together, or clay mineral particles with rough-grained substances such as quartz and feldspar on their surfaces[3]. As for the mineral composition of the KOSA (Yellow Sand) particles that reach the atmosphere surrounding Japan, the primary minerals are rock-forming minerals such as quartz and feldspar, with many clay minerals such as mica (illite), chlorite, and kaolinite. The peak of the size distribution of the KOSA (Yellow Sand) that reaches Japan is a diameter of about 4μm[2]. Analysis of the chemical composition of KOSA (Yellow Sand) particles has found ammonium ions (NH_4^+), sulfate ions (SO_4^{2-}), and nitrate ions (NO^{3-}), which are not believed to exist in the soil where the particles originate. This indicates the possibility that KOSA (Yellow Sand) particles adsorb anthropogenic air pollutants during transport[2]. The process that forms the particles' surfaces is believed to be extremely complex, but it remains largely unknown.

3 The impact of the KOSA (Yellow Sand) phenomenon

3-1 Frequency of KOSA (Yellow Sand) phenomenon formation

KOSA (Yellow Sand) is carried to the Japanese archipelago year-round, but it is most common from March through May.

Looking at the number of visual observations of KOSA (Yellow Sand) conducted annually in Japan

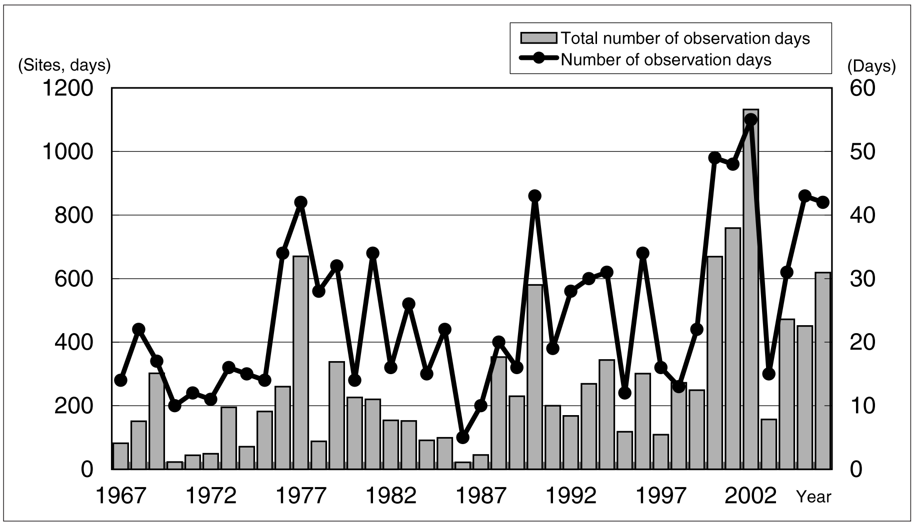

Figure 2 : Annual KOSA (Yellow Sand) total number of observation days and number of observation days*1

As of May 31, 2006, at 103 domestic observation points

Prepared by the STFC based on Japan Meteorological Agency observation data from 1967 through May 31, 2006 (see Figure 2), there were few observations after 1991 until there was a sudden increase over the period from 2000 to 2002. KOSA (Yellow Sand) total number of observation days*1 at Japan's 103 monitoring stations rarely exceeded 300 days annually until the late 1980s, but frequently surpassed that number after 1988. The totals were particularly high in the three years from 2000 to 2002, reaching 669, 759, and 1,132, respectively. As of May 31, 2006, there have been over 600 total number of observation days, with over 40 number of observation days*1.

As for the mechanism that causes changes in the frequency of KOSA (Yellow Sand) occurrence, research is focusing on changes in surface conditions such as snow cover, soil moisture, and vegetation and large-scale fluctuations in air circulation environments, but the causes remain unclear at this time[1].

3-2 Major causes of the KOSA (Yellow Sand) phenomenon

China's State Forestry Administration has suggested the following factors as possible causes of the frequent occurrence of the KOSA (Yellow Sand) phenomenon in northern China during the spring of 2006[6]. (i) In many parts of the northern Chinese desert zone of the central Inner Mongolia Autonomous Region and the Xinjiang Uygur Autonomous Region, early spring temperatures were 1-2°C above average. Frozen ground therefore thawed more quickly than normal, and moisture rapidly evaporated from the soil. (ii) Precipitation in much of northern China's desert region from winter through spring was 30-80 percent below average, making it the second-driest year in the last 50. This caused the topsoil to dry out, reducing moisture in the soil. (iii) Stronger than normal Siberian cold air frequently passed over the desert region, and low pressure occurring near Mongolia caused large amounts of sand to be swept up in frequent sandstorms. In short, the main causes in China were changes in weather.

Historically, the facts that there is little rainfall in winter and no plant growth from winter to early spring in the Gobi (a sand and gravel desert in China and Mongolia) and the semi-arid lands of the Loess Plateau and the Hexi Corridor, the areas where the phenomenon originate[3], have been seen as providing conditions that make it easy for soil particles to be swept up into the sky. Although many aspects of the causes of KOSA (Yellow Sand) remain unclear, it is possible that there is also a relationship with soil degradation due to over-cultivation, overgrazing, and excessive water pumping in northwestern China.

3-3 The amount of damage caused by KOSA (Yellow Sand)

The KOSA (Yellow Sand) problem is a shared issue for the countries of northeastern Asia. The closer to the originating source area, the greater the damage it causes (see Figure 3).

(i) An instance of damage caused by dust storm weather in China

In China, which includes areas where KOSA (Yellow Sand) originates, it is seen more as a weather-related hazard in the form of dust storms accompanied by high winds than as a dust-fall phenomenon (see Table 1).

A dust storm in northwestern China in May

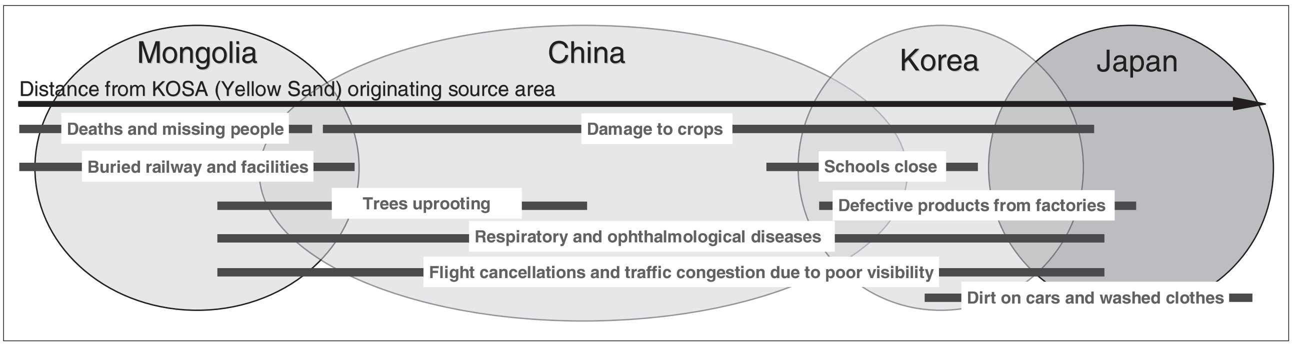

Figure 3 : Types of damage caused by KOSA (Yellow Sand) in each country

Prepared by the STFC based on Reference[2]

1993 caused the greatest harm to people and livestock of any such event in recent years. Most of the damage was in the form of collapsed buildings, buried railways, fallen electric poles and trees, and buried fields and orchards that caused agricultural losses.

The dust storm caused extensive damage in 74 municipalities in Gansu province and three autonomous regions of Xinjiang Uygur, Inner Mongolia, and Ningxia Huizu. In Gansu province, wind gusts reached a maximum momentary wind speed of 34 m/s, with a 300 meter high wall of dust reducing visibility to almost zero. The dust storm paralyzed transportation and communications networks, caused water and power outages, damaged or destroyed homes and buildings, and covered farmland with sand. A survey by China's Ministry of Forestry at the time found that the dust storm had killed 85 and injured 264. It damaged 373,000 hectares of crops and killed or caused to go missing 120,000 head of livestock. Estimated direct damage totaled 560 million Yuan (about ¥7.3 billion at 1 Yuan = ¥13). In addition to direct damage, sand dunes advanced by one to eight meters, invading farms and pastures. The dust is also believed to have affected the health of people living in the area[3].

(ii) An instance of damage caused by KOSA (Yellow Sand) in Korea

In Korea, which is near the area of origination, the KOSA (Yellow Sand) phenomenon often causes the density of particulate matter in the air to exceed environmental standards. Korea considers the KOSA (Yellow Sand) phenomenon to be a serious environmental problem[1]. In 2002 in particular, a major occurrence caused extensive socioeconomic damage. In Seoul in March 2002, the density of PM10*2 (particulate matter) reached 2,266 μg/m^3. KOSA (Yellow Sand) caused the first issuance of a school closure order, shutting a total of 4,949 kindergartens, elementary, middle, and high schools. Poor visibility caused the cancellation of 102 flights, and precision equipment factories had to be shut down. Hospitals saw a sudden increase in patients with respiratory, dermatology, and ophthalmological diseases. This 2002 KOSA (Yellow Sand) incident caused a sudden increase in interest in the phenomenon in Korea, which passed laws to respond to the problem[3].

(iii) An instance of damage caused by KOSA (Yellow Sand) in Japan

The primary forms of damage caused by KOSA (Yellow Sand) in Japan are air pollution from particulate matter, poor visibility that interferes with air transportation, and KOSA (Yellow Sand) particles sticking to cars and washed clothes[3]. To date, there have been no reports of damage to crops or livestock, but recently there has been continued concern that it may damage crops. Although KOSA (Yellow Sand) may neutralize acid rain, it also absorbs air pollutants, serving as a medium for their transportation.

3-4 Recent interest in the KOSA (Yellow Sand) phenomenon

The environmental impacts of KOSA (Yellow Sand) have diversified as it has expanded in scale and society has advanced (see Table 2). As science has developed, it has recently begun to focus attention on some aspects of the phenomenon. For example, in the past there was little interest in the effects of KOSA (Yellow Sand) on human health. As the scale of the KOSA (Yellow Sand) phenomenon has expanded, it has arrived in heavily populated urban areas, revealing hitherto unknown problems[3]. In China and Korea, it has begun to affect people's health, leading to increased interest and the beginning of research. In Japan, however, general interest remains low.

(1) The effects of KOSA (Yellow Sand) on health

Chinese medical experts report that dust does its greatest harm to the human respiratory system. In addition to mineral components, dust particles can include bacteria, fungi, chemical pollutants, and other substances. Microscopic particles in dust can penetrate lung tissue, with people with low immunity being the most easily affected[3].

Moreover, in Korea a study of the three-month periods of March to May in 1995 through 1998 compared death rates in Seoul during periods when KOSA (Yellow Sand) was observed and

Table 2 : KOSA (Yellow Sand) impacts

Field	Examples
Industry	Factory air conditioning (especially precision machinery)
Transport	Decreased transportation volume of transportation and traffic (especially air transport) or temporary cancellations due to poor visibility. Buried roads. Damage to water line, drainage and water supply system.
Schools	Some school closed (due to unsafe commuting and health concerns)
Health	Health damage and deaths due to difficulty in breathing
Construction	Buried, collapsed, and damaged buildings. Damaged power lines, etc.
Agriculture	Deaths of sheep and other livestock (unable to flee due to being penned, or trapped under by collapsing buildings). Damage to orchards and fields. Damage to plastic greenhouses.
Social life	Need for air conditioning (to clean dirty outside air). Need for lighting (due to darkened daylight conditions).
Scenery	Discovery of unique scenery. Sense of the season.
Oceans	Provision of nutrients and minerals to plankton
Acid rain	Neutralization effect
Global warming	May accelerate warming or influence a cooling effect depend on the situation (research is underway)

Prepared by the STFC based on Reference[4]

not observed. The epidemiological study found that the death rate for those 65 and older increased when KOSA (Yellow Sand) was present, especially for those with cardiovascular or bronchial illnesses[3].

In Japan, there have been few epidemiological survey reports or research results regarding the effects of KOSA (Yellow Sand) on human health. However, according to recent research that inserted KOSA (Yellow Sand) into the tracheas of mice to examine the pathological effects, KOSA (Yellow Sand) tends to worsen inflammation of the pulmonary airway[3]. Furthermore, experiments with mice have shown that KOSA (Yellow Sand) aggravates hay fever, bronchial asthma, and other allergy symptoms. The impact of KOSA (Yellow Sand) on health is thus beginning to attract attention. Because the KOSA (Yellow Sand) particles that reach Japan are smaller than those in Korea, they may enter the lungs more easily. Inhaling even a small amount may worsen symptoms.

(2) The relationship between KOSA (Yellow Sand) and acid rain

The possibility that KOSA (Yellow Sand) in the atmosphere absorbs sulfur oxides (SOx) and nitrogen oxides (NOx) had previously been considered[4]. Recent observations have confirmed that KOSA (Yellow Sand) particles that cross from China to Japan do absorb many pollutants that cause acid rain, such as nitrogen oxides and sulfur oxides. KOSA (Yellow Sand) collected in advance in China's interior did not include substances that cause acid rain. This indicates a high likelihood that while they drift from China to Japan, KOSA (Yellow Sand) particles somehow react with factory smoke, automobile emissions, and other sulfur compounds in the atmosphere to absorb and neutralize pollutants that cause acid rain. In other words, this absorption effect appears to play a positive role by enabling the alkaline components of KOSA (Yellow Sand) to neutralize substances that cause acid rain and thereby mitigate their environmental impact.

(3) The relationship between KOSA (Yellow Sand) and marine microbial ecosystems

KOSA (Yellow Sand) reportedly has the effect of supplying the Pacific Ocean with minerals and nutrients[3]. Because KOSA (Yellow Sand) particles contain iron and other essential trace elements, KOSA (Yellow Sand) that falls onto the ocean surface provides nutrients for marine surface-layer phytoplankton and serves as a limiting factor in plankton growth. Marine surface-layer phytoplankton play a major role in carbon cycling between the atmosphere and the oceans. Furthermore, plankton generates dimethyl sulfide (DMS), which is related to the formation of clouds over the ocean. In this way, KOSA (Yellow Sand) may play an important indirect role in fluctuations in radiative forcing. An international research program to elucidate this relationship, the Surface Ocean-Lower Atmosphere Study (SOLAS), has begun. Evaluation is now underway on the impact of KOSA (Yellow Sand) on climate through the nutrients it provides to the ocean[1].

(4) Relationships with global environmental problems

In recent years, KOSA (Yellow Sand) has been drawing attention as a global environmental problem. The reason for this is because KOSA (Yellow Sand) particles scatter and absorb sunlight and may thus be a major influence on global temperature. It is unknown whether the effect of KOSA (Yellow Sand) on solar radiation is sufficient to affect the global environment and global climate[4]. However, the KOSA (Yellow Sand) phenomenon appears to be connected to global environmental problems through various processes (see Figure 4).

For example, through the process of scattering and absorbing solar and infrared radiation, KOSA (Yellow Sand) particles in the atmosphere have effect to heat or cool the Earth's atmosphere (direct radiative forcing effects). Furthermore, attention is beginning to focus on the fact that KOSA (Yellow Sand) particles in the upper atmosphere become ice nuclei, which are related to the formation of cirrus clouds, and the fact that the mixing of KOSA (Yellow Sand) particles that travel long distances with human-originated particles plays a role in forming cloud nuclei (indirect radiative forcing effects). Whether the effect is heating or cooling may depend on the vertical distribution of KOSA (Yellow Sand) particle size in the atmosphere, the particles' optical properties (scattering and absorption properties), ground surface albedo (reflectivity), and so on[1]. At this time, however, it is unclear whether KOSA (Yellow Sand) has an overall effect of accelerating global warming or of cooling the

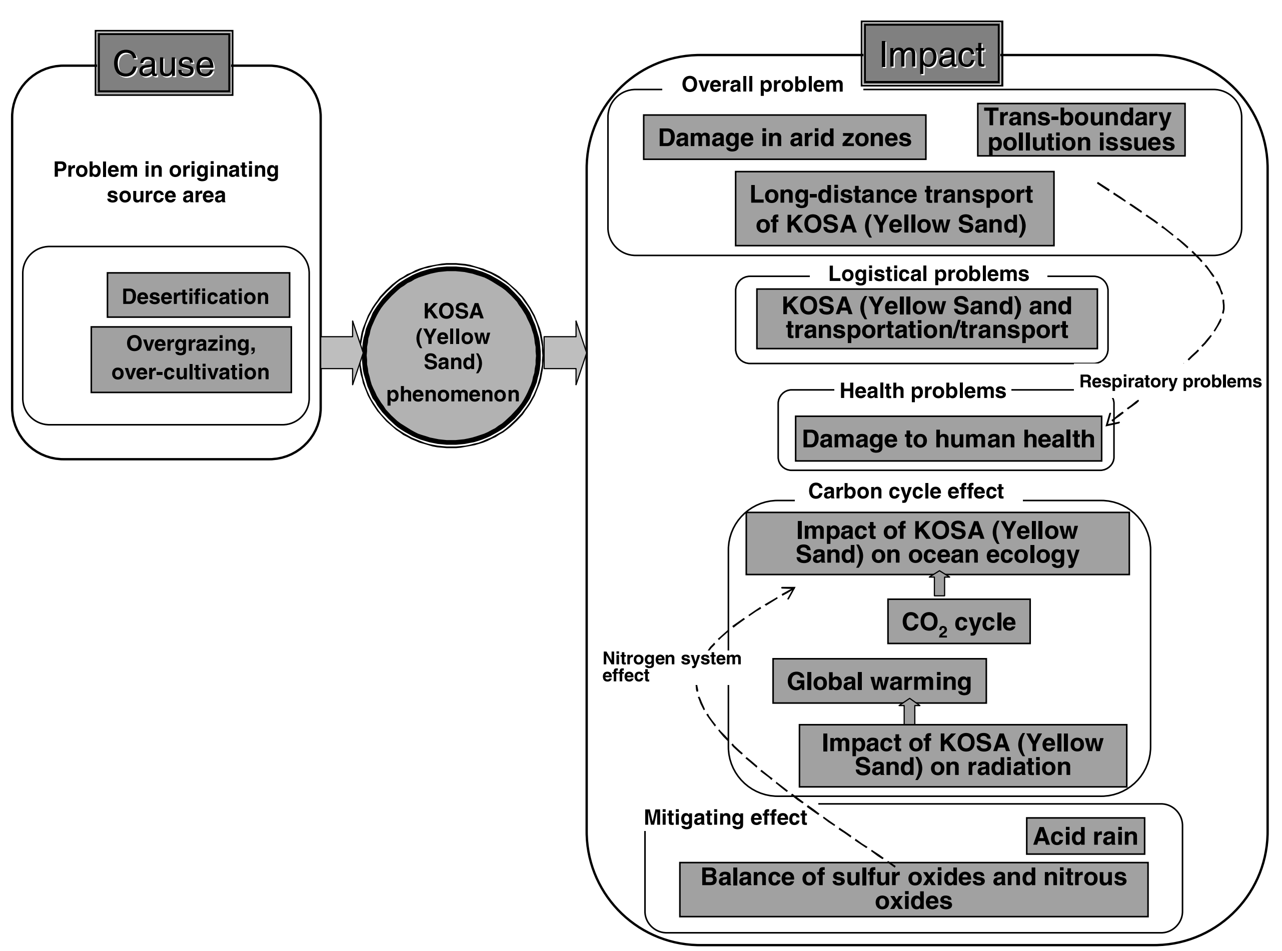

Figure 4 : KOSA (Yellow Sand) in global environmental problems

Prepared by the STFC based on Reference[4]

Earth.

Many aspects of the causes of KOSA (Yellow Sand) are still unexplained, but some researchers point to an association with soil degradation in northwestern China. In recent years, low rainfall and high temperatures have promoted rapid desertification in northwestern China, which in turn may be creating conditions that make it easy for the KOSA (Yellow Sand) phenomenon to occur. There is therefore a growing awareness in Japan that KOSA (Yellow Sand) is not simply a seasonal weather phenomenon, but instead is an environmental problem related to forest reduction, soil degradation, and desertification[3].

In particular, high temperatures and low rainfall in inland China is considered a likely cause of the large amount that reached Japan in 2006. According to the Japan Meteorological Agency, average March temperatures in eastern China and Central Asia were abnormally high, with high pressure creating clear skies and scant precipitation. In addition to dryness in inland China, meandering prevailing westerlies in 2006 appear to have created the ideal conditions for KOSA (Yellow Sand) to fall in Japan.

4 Measures against the KOSA (Yellow Sand) phenomenon

4-1 Social problem arising from KOSA (Yellow Sand)

Although KOSA (Yellow Sand) is a shared problem for the countries it affects, the degree of awareness is different in each country. In China, the damage is so severe that people have died, and it is widely recognized that the phenomenon is connected with soil degradation and desertification. In Japan, the public is aware of poor visibility and dust sticking to cars and washed clothes, but researchers clearly recognize the phenomenon as a form of air pollution. Like Japan, Korea has no domestic source of KOSA (Yellow Sand). In contrast to Japan, however, Korea focuses on KOSA (Yellow Sand) as a weather hazard, especially since experiencing huge economic damage during the major incident in 2002. In Mongolia, moving sand directly threatens local people's livelihoods. In each country, therefore, different social problems arise.

4-2 KOSA (Yellow Sand) countermeasures

KOSA (Yellow Sand) countermeasures can be divided into those taken in originating source areas and those taken in affected areas[3].

Originating source areas are where KOSA (Yellow Sand) is formed and the areas surrounding them. These areas, located in inland China and Mongolia, are directly impacted by KOSA (Yellow Sand). In addition, originating source areas can be divided into those areas where preventative measures are possible (areas where anthropogenic impact has degraded the environment) and areas where countermeasures are unlikely to be technically or economically feasible (arid and extremely arid desert zones)[3].

Affected areas are distant from the source of the KOSA (Yellow Sand) but influenced by it, with that influence apparent through medium- and long-term climactic and environmental changes. The main areas are Japan, Korea, and China's coastal region[3].

KOSA (Yellow Sand) countermeasures can be divided into short-term measures such as forecasts and warnings, and long-term measures such as protecting ecosystems in originating source areas. Effective countermeasures vary greatly depending on targets (wind speed, soil moisture, vegetation rate, etc.) and goals to control and defend[3]. It is therefore important to consider priorities, determine what countermeasures should be taken in the short, medium, and long term, and proceed systematically.

(1) Countermeasures in originating source areas

In originating source areas, first it is important to reduce flying dust through long-term countermeasures that control the formation of KOSA (Yellow Sand) through conservation of vegetation and changes in land use. In areas in China that are considered primary sources of KOSA (Yellow Sand), these include technological countermeasures, protection of natural ecosystems, and promotion of the natural regeneration of trees and other vegetation to protect plants that cover sandy soil. Furthermore, excessive tree cutting for firewood, pasturing, and clearing land for cultivation are strictly forbidden by strengthened laws[7].

Table 3 summarizes concrete countermeasures in originating source areas.

On the other hand, the KOSA (Yellow Sand) phenomenon is a long-standing weather phenomenon that has existed since ancient times before the advance of desertification. There is no way to eliminate the KOSA (Yellow Sand) formed in the Earth's desert macroclimates. The originating source areas where KOSA (Yellow Sand) countermeasures are implemented are therefore arid climates near desert areas, where new soil degradation and loss of vegetation generate flying sand and where desertification is advancing. Desertification is not necessarily the only cause of the KOSA (Yellow Sand) phenomenon, so it may not be possible to apply all the countermeasures. Because some aspects of the cause and effect relationship between desertification and KOSA (Yellow Sand) remain unexplained, however, the methods already used as desertification countermeasures are likely to form the basis of any future examination of KOSA (Yellow Sand) source countermeasures.

(2) Countermeasures in affected areas

In affected areas, the goal is to reduce damage from KOSA (Yellow Sand). First, forecasts and warnings regarding KOSA (Yellow Sand) are important, and the information they provide differs by country. Currently, Japan offers "KOSA (Yellow Sand) information," Korea provides "KOSA (Yellow Sand) forecasts," and China gives "dust storm weather forecasts."

(i) China's dust storm weather forecasts[3]

Currently, dust storm weather forecasts are carried out by using satellite images to monitor the movement of dust. Next-day forecasts are therefore the only kind available. There are now five types of Chinese dust weather forecasts and these are related to accuracy and timing: current conditions and warnings, very short-term forecasts and warnings, short-term forecasts and warnings, medium-term forecasts, and seasonal outlooks.

(ii) Korea's KOSA (Yellow Sand) forecasts[3]

Korea has been making KOSA (Yellow Sand) forecasts since April 2002. In order to perform KOSA (Yellow Sand) forecasts, the Korea Meteorological Administration analyzes airborne dust and weather-satellite images from KOSA (Yellow Sand) originating source areas and

Table 3 : Primary countermeasures in originating source areas

Measure	Category	Description
Rehabilitating and improving the land surface	Reforestation/planting	Reducing barren land through reforesting and planting degraded land
	Crop changes	Preventing land surface loosening caused by spring ploughing (the cultivation of perennial crops, etc.)
Controlling the movement and encroachment of sand by wind	Creating tree windbreaks	Planting trees with strong windbreak effects at appropriate intervals
	Straw checkerboard	Reducing ground level wind velocity by inserting straw bundles into the sand in a checkerboard pattern
	Stabilization of sand dunes	Controlling the movement of sand using creeping plants
Mitigating human impacts	Fencing of land	Rehabilitating vegetation by erecting a fence around degraded land and restricting the entry of people and domestic animals (grazing ban)
	Felling of trees and land reclamation, limits on number of livestock	Laws enforcing the prohibition of land reclamation and felling of trees
	Efficient energy use, use of new forms of energy	Maximizing the heat efficiency of cooking stoves and the insulation efficiency of houses in order to reduce the cutting of trees for fuel
	Resettlement of people	Supporting the resettlement of people from degraded land
Improving the environmental capacity of the soil	Fertilization	Improving land productivity by the application of farm animal manure
	Water management and water-saving technology	Introducing water-saving and water management techniques for the efficient use of water
	Artificial rain	Increasing rainfall

Prepared by the STFC based on References[2, 3] monitors horizontal distribution. In addition, the Administration predicts the passage of KOSA (Yellow Sand) over Korea and the deposition of sand based on predicted airflow and atmospheric pressure patterns. The Ministry of Environment and the Meteorological Administration monitor the density of particulate matter of 10 μm or less. For forecasting, the Meteorological Administration uses a data transfer system that shares information in real time (at five-minute intervals) from these continuous measurements and applies the data to the KOSA (Yellow Sand) forecast/warning system in its weather data system (see Table 1) .

(iii) Japan's KOSA (Yellow Sand) information

The Japan Meteorological Agency began releasing information on KOSA (Yellow Sand) in January 2004. When the KOSA (Yellow Sand) phenomenon is predicted to affect transportation or people's everyday lives over a wide area, the agency announces weather information such as "meteorological information related to KOSA (Yellow Sand)"[1]. In addition, the Japan Meteorological Agency's website[8] provides a distribution map of points near Japan where the KOSA (Yellow Sand) phenomenon has been observed (KOSA (Yellow Sand) observation status map) and a map predicting the distribution of KOSA (Yellow Sand) based on a forecasting model (KOSA (Yellow Sand) forecast map).

4-3 The KOSA (Yellow Sand) monitoring network

In order to note the occurrence of KOSA (Yellow Sand) as early as possible and to ascertain the status of its development and movement, the creation of an international KOSA (Yellow Sand) monitoring network stretching from northwestern China's continent to the Japanese archipelago has begun. The network is appropriately installing three types of monitoring equipment to measure the density of particulate matter of 10μm or less, visibility (the distance that can be seen) and LIDAR. The network emphasizes the transmission of monitoring data to relevant organizations for reliable, accurate monitoring of KOSA(Yellow Sand)[2].

The formation and transport of KOSA (Yellow Sand) depend on a combination of regional weather, geography and soil properties, land usage, and other factors. Research on the formation mechanism and transport process is underway[3]. At this point, however, it is difficult even to accurately pinpoint individual originating source areas for the KOSA (Yellow Sand) phenomenon. The first necessity is therefore to collect and sort monitoring data on the atmosphere, land surface, vegetation, and human activities[3] in KOSA (Yellow Sand) originating source areas and along the routes of KOSA (Yellow Sand) movement. It is also necessary to analyze the physical properties (e.g. particle size distribution, particle shapes, surface structure, etc.) and chemical properties (e.g. chemical composition, mineral composition, absorbed/adhered substances, etc.)[3] of the particles carried by the KOSA (Yellow Sand) phenomenon and to collect more data.

Research methods can be roughly divided into the following two types.

(i) KOSA (Yellow Sand) monitoring

There are currently a variety of monitoring methods used to understand the KOSA (Yellow Sand) phenomenon and forecast its occurrence. In more concrete terms, these include continuous measurement such as remote sensing and batch measurement that measures and analyzes actual KOSA (Yellow Sand) particles obtained by sampling. Continuous measurement primarily obtains data on optical and physical properties, while batch measurement primarily obtains data on chemical properties[3] (see Table 4).

LIDAR and satellite observation are used in KOSA (Yellow Sand) monitoring.

LIDAR (Light Detection And Ranging) is a form of radar that uses laser light rather than radio waves. It is a type of remote sensing device that makes it possible to measure KOSA (Yellow Sand) passing above from the ground. By observing the way in which laser light emitted from the ground is scattered by tiny particles in the air, researchers can obtain data on the vertical density distribution of KOSA (Yellow Sand) and its changes over time. This gives them information on the three-dimensional structure of KOSA (Yellow Sand) and on its movement.

In addition, use of a polarized laser enables researchers to distinguish between the shapes of KOSA (Yellow Sand) particles and ordinary air pollutants. Except in the presence of clouds or heavy dust, LIDAR has the ability to carry out continuous, unmanned, real-time monitoring of all KOSA (Yellow Sand) that passes through the troposphere above observation points[2].

In addition to KOSA (Yellow Sand) monitoring from ground stations, airplanes and helicopters, balloons, ships, and mountains all serve as platforms for KOSA (Yellow Sand) monitoring. Source weather monitoring and surface and groundwater monitoring are carried out to obtain KOSA (Yellow Sand) originating source area weather information and surface data, as are on-site investigations and social surveys.

(ii) KOSA (Yellow Sand) transport models

Simulations using KOSA (Yellow Sand) transport models are necessary in order to predict the formation and transport of KOSA (Yellow Sand) and to forecast its arrival. In recent years, it has become apparent that although the KOSA (Yellow Sand) phenomenon is a natural phenomenon, human influence has increased the frequency with which it occurs. KOSA (Yellow Sand) transport models also provide data useful

Table 4 : Summary of primary KOSA (Yellow Sand) monitoring methods

		Method	Target of measurement
Continuous measurement	Observation of optical properties	LIDAR	• Altitudinal distribution of KOSA (Yellow Sand): Provides dynamic atmospheric information on the three-dimensional structure and transportation conditions of the KOSA (Yellow Sand) phenomenon. • Also measures aerosols from other sources.
		Satellite observation	• Optical thickness of aerosol, albedo, normalized difference vegetation index (NDVI), etc.
		Actinometers, radiometers	• Amount of solar radiation. Amount of infrared radiation from ground surface and atmosphere.
		Nephelometers, aerosol absorption meters	• Scattering condition by bearing of dust. • Absorption coefficient of dust.
	Measurement of physical properties	Mass concentration meters, particle counters	• Mass concentration and particle size distribution of aerosol.
	Measurement of chemical properties	Aerosol TOF/MS analyzers	• Ionizing chemical components in aerosol.
	Observation of visibility	Visibility meters	• Visibility (degree of turbidity in the atmosphere near the ground).
Batch measurement	Sampling observation	Andersen samplers	• Dust amount and size distribution. • Collected samples are used for element analysis and mineral type measurement. • Direct observation with an electron microscope to observe particle shape.
		High-volume samplers	• Dust amount. Used to sample trace substances above the threshold of analysis. • Collected samples are used for element analysis and mineral type measurement. • Direct observation with an electron microscope to observe particle shape.
		Low-volume samplers	• Dust amount. Used to find the average value of floating dust volume over long periods of time. • Collected samples are used for element analysis and mineral type measurement. • Direct observation with an electron microscope to observe particle shape.
		Various impactors for observation of individual particles	• Dust particle shape, surface conditions, and size. • Chemical composition. • Mineral composition.
Visual observation		Routine observation by meteorologists	• Occurrence of KOSA (Yellow Sand) phenomenon. Size and strength of KOSA (Yellow Sand) phenomenon.

Prepared by the STFC based on Reference[3]

for distinguishing among such multiple causes. Transport models that deal with the arrival of KOSA (Yellow Sand) basically comprise weather models, source models, and advective diffusion models (deposition models in some cases)[3]. In addition to use as weather information, the results are used to estimate sources and predict influence on future climate change.

The primary KOSA (Yellow Sand) transport models are those of the Meteorological Research Institute (MASINGAR: Model of Aerosol Species in the Global Atmosphere) and Kyushu University.

MASINGAR adds KOSA (Yellow Sand) release, transport, and disappearance processes to the global model (MRI/JMA98) developed by the Meteorological Research Institute and the Japan Meteorological Agency. The model's horizontal resolution is about 110 km, while its vertical resolution covers 30 layers (from the ground to about 23 km). It divides KOSA (Yellow Sand) into 10 stages based on particle sizes of 0.1-10 μm. The Japan Meteorological Agency has been utilizing its results to provide information on the KOSA (Yellow Sand) phenomenon since January 2004[1].

The model for predicting KOSA (Yellow Sand) arrival developed at Kyushu University utilizes a weather model and the Regional Atmospheric Modeling System (RAMS) developed at Colorado State University in the USA. The model's vertical grid spacing is therefore very close. Because it can handle the atmospheric boundary layer in detail, it is widely used to predict air pollution[3].

4-4 Domestic and international system building and infrastructure development for KOSA (Yellow Sand) countermeasures

(1) Systems and infrastructure in Japan

Relevant agencies such as the Ministry of the Environment, the Japan Meteorological Agency, the Ministry of Agriculture, Forestry and Fisheries, and the Forestry Agency are currently carrying out a number of initiatives. In addition, various research institutes and universities are engaged in research on KOSA (Yellow Sand) monitoring, modeling, and source countermeasures.

Relevant government agencies are working in close cooperation on various policies concerning the KOSA (Yellow Sand) problem. In order to promote such cooperation, in February 2005 they formed a liaison council on KOSA (Yellow Sand) countermeasures[3]. The liaison council comprises the Ministry of Foreign Affairs, the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Agriculture, Forestry and Fisheries, the Forestry Agency, the Japan Meteorological Agency, and the Ministry of the Environment. Currently, the Ministry of the Environment is carrying out research to explain the precise nature of the KOSA (Yellow Sand) phenomenon, while the Japan Meteorological Agency releases meteorological data related to KOSA (Yellow Sand). The Ministry of Agriculture, Forestry and Fisheries carries out basic studies on KOSA (Yellow Sand) source countermeasures through sustainable farming and rural development, and the Forestry Agency studies the degradation and restoration of vegetation in originating source areas[3]. While carrying out varied research such as meteorological and climatological research on KOSA (Yellow Sand), soil degradation surveys in originating source areas, research on the chemical and mineral composition of KOSA (Yellow Sand) particles, and research on reactions that occur on the surface of the particles, Japanese universities and research institutes need to establish greater organic cooperation and collaboration.

(2) International cooperation systems

KOSA (Yellow Sand) is an environmental problem that transcends national borders, so cooperation and collaboration with China, Korea, and Mongolia and with international agencies is necessary in order to implement effective research and countermeasures. In particular, since Japan has no KOSA (Yellow Sand) originating source areas, joint activity through international cooperation on collection of source data and implementation of countermeasures is essential.

(i) The ADB/GEF Project on Prevention and Control of Dust and Sandstorms

The ADB/GEF Project on Prevention and Control of Dust and Sandstorms was carried out from 2003 through March 2005. One of the preliminary investigations of the Global

Environment Facility (GEF), it was to launch a joint project of four international organizations, the United Nations Environment Programme (UNEP), the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), the United Nations Convention to Combat Desertification (UNCCD), and the Asian Development Bank (ADB), and four countries, Japan, China, Korea, and Mongolia[2]. Utilizing GEF and ADB funds, the project collected and evaluated data related to KOSA (Yellow Sand) and created a master plan for KOSA (Yellow Sand) countermeasures. The project received $1 million in funding, $500,000 from the GEF's Medium-Sized Project fund, and $500,000 from the ADB's technical cooperation funds[3].

(ii) Japan-China-Korea Tripartite Environment Ministers Meeting[3]

At the Third Tripartite Environment Ministers Meeting among Japan-China-Korea (TEMM) in Tokyo in April 2001, the Ministers agreed to promote systematic research cooperation in order to find solutions to the KOSA (Yellow Sand) problem. At the Fourth Meeting (April 2002 in Seoul), the three countries agreed to work to strengthen KOSA (Yellow Sand) monitoring and collaboration with international organizations. Furthermore, at the Fifth Meeting (December 2003 in Beijing), they once again acknowledged the importance of local cooperation on KOSA (Yellow Sand) countermeasures. They agreed that appropriate steps should be taken based on the results of the ADB/GEF Project on Prevention and Control of Dust and Sandstorms. They particularly noted the immediate necessity of each country considering a system for KOSA (Yellow Sand) monitoring and early warning. At the Sixth Meeting in December 2004, the Environment Ministers of Japan, China, and Korea were joined by the Mongolian Minister of Nature and Environment and the four international organizations that participated in the ADB/GEF Project on Prevention and Control of Dust and Sandstorms. Held in Tokyo, it was the first ministerial-level meeting by the four relevant countries on the KOSA (Yellow Sand) problem. The Ministers agreed on the need to build a network of experts to examine technical issues related to KOSA (Yellow Sand).

(iii) Bilateral cooperation[3]

Since 1996, the Sino-Japan Friendship Centre for Environmental Protection and the Japanese Independent Administrative Institution National Institute for Environmental Studies have been involved in a cooperative project. They have carried out on-site studies of desert and arid zones, created standards for KOSA (Yellow Sand) specimens, studied KOSA (Yellow Sand) particle size distribution, formulated the basic concept for a monitoring network, and researched KOSA (Yellow Sand) measurement methods. Currently, they are engaged in research on KOSA (Yellow Sand) transport routes, transport modes and amounts formed, the percentage contribution of KOSA (Yellow Sand) in the particulate matter in the air of specified areas, and creation of proposals for KOSA (Yellow Sand) prevention.

In addition, the Japan-China joint project Aeolian Dust Experiment on Climate impact (ADEC) implemented in 2000 to study the effects of aeolian dust*3 on climate. Cooperative research was carried out by the Japan Meteorological Research Institute on the Japanese side and a research organ of the Chinese Academy of Sciences on the Chinese side. Utilizing a global-scale dust model, the project predicted the amount of aeolian dust supplied to the atmosphere, its three-dimensional distribution in the atmosphere, and the amount of dust deposited on the ground, and evaluated the direct effects of radiative forcing.

As for cooperation between Mongolia and Japan, the Japanese Independent Administrative Institution National Institute for Environmental Studies is working with the National Agency for Meteorology, Hydrology and Environment Monitoring of the Mongolian Ministry of Nature and Environment on KOSA (Yellow Sand) observation with LIDAR.

Korea and China carry out joint KOSA (Yellow Sand) observation by establishing KOSA (Yellow Sand) observation stations and monitoring points in China, and providing observation data to Korea. Furthermore, Korean support is advancing afforestation and grassland recovery projects in western China.

5 Future initiatives on KOSA (Yellow Sand) countermeasures

The short-term, direct effects of KOSA (Yellow Sand) on the environment and industry are relatively clear. However, many aspects, such as long-term effects related to climate change and environmental science effects (neutralization of acid rain, transport of nutrients, etc.) related to KOSA (Yellow Sand) matter cycling, are still unclear. In particular, the combined effects and influence of other phenomena (e.g. absorption and transport of air pollutants by KOSA (Yellow Sand) particles) are almost entirely unexplained[3]. In Japan's future initiatives on the KOSA (Yellow Sand) problem, therefore, elucidation of the phenomenon, monitoring, and countermeasures are important as basic strategies.

(1) Construction of domestic and international systems for collaboration and cooperation on infrastructure development for KOSA (Yellow Sand) countermeasures

In order to effectively promote KOSA (Yellow Sand) countermeasures, it is first necessary to promote interagency cooperation within the Japanese government. In particular, the functioning of the above-described interagency liaison council on KOSA (Yellow Sand) countermeasures that was formed in February 2005 must be improved. Universities and other research institutions have been studying the KOSA (Yellow Sand) phenomenon, but their findings have not been sufficiently incorporated into policy. As one of the approaches Government-affiliated research institutions studying KOSA (Yellow Sand) require clear indications of the government's needs. Furthermore, construction of a system of cooperation by which researchers can input promptly technical advice and findings useful in international cooperation to government agencies is essential[3]. Government and research institutions must frequently exchange information and work in close cooperation.

Because KOSA (Yellow Sand) is a trans-boundary environmental problem, cooperation among the relevant countries is also essential. In particular, international cooperation is necessary in order to carry out effective monitoring for source countermeasures and KOSA (Yellow Sand) forecasts. Working to share the KOSA (Yellow Sand) data held by various organizations, establishing a KOSA (Yellow Sand) monitoring network, and contributing to each country's effective KOSA (Yellow Sand) countermeasures is likely to promote international cooperation. Moreover, development of networks requires the strategic promotion of the selection and deployment of monitoring devices and development of technology for real-time sharing of the data obtained[3].

At the same time, cooperation that complements but does not overlap existing efforts and frameworks that are related to KOSA (Yellow Sand) countermeasures, such as those of the Acid Deposition Monitoring Network in East Asia (EANET)[9] and Earth observation networks[10], is needed so that each project can proceed effectively.

Human exchanges and human resources development related to KOSA (Yellow Sand) currently vary significantly from one country to another. First, each country must build capacity. In particular, working to acquirement and dissemination basic knowledge of the KOSA (Yellow Sand) problem to citizens and technicians from local governments in originating source areas is the most important step in effectively promoting KOSA (Yellow Sand) countermeasures. However, in order to carry out source countermeasures, multifaceted approaches adapted to individual originating source areas are necessary. These include the identification of the originating source areas, the evaluation of the economic impact of the measures, and dealing with existing social and industrial structures in order to prevent soil degradation. The cooperation of stakeholders from experts to indigenous peoples is therefore essential, and international human exchange is vital.

(2) Promotion of effective study and research

Because it is not easy to quantify the direct and indirect effects of KOSA (Yellow Sand) countermeasures, many aspects remain scientifically unclear. In particular, obtaining real-time data on the KOSA (Yellow Sand) phenomenon is important. The necessary data span weather data, surface data, chemical composition, and so on, and are collected and held by a variety of agencies. It is therefore important for research institutions in each country to share the KOSA (Yellow Sand) data they hold individually and to carry out joint research in order to find effective measures to remedy the problem. In addition, depending on their goals, KOSA (Yellow Sand) countermeasures may be short-term and temporary or long-term and ongoing. When selecting the methods to be used as countermeasures, they need to be appropriate to the land conditions in each area. In particular, control measures in KOSA (Yellow Sand) originating source areas are an urgent issue requiring an immediate response.

(3) Examination from a socioeconomic perspective

In the short- and medium-term, there is a strong tendency to put efforts into measures against damaged farmland and other primarily impacts in source and affected areas. Attention should be paid, however, to what kind of secondary effects and side effects they bring about. As industrial activity in Northeast Asia intensifies, the KOSA (Yellow Sand) phenomenon will become even more closely linked to society and the economy. It is therefore necessary to turn attention towards evaluating the effects of the KOSA (Yellow Sand) phenomenon on economic and production activities. In recent years, production facilities that require highly clean environments, such as those in the semiconductor industry, have seen increases in defective product, clogged filters, and so on during periods when KOSA (Yellow Sand) is present[3]. In Korea, precision manufacturing plants have had to suspend operations. At the same time, the KOSA (Yellow Sand) phenomenon may be related to climate change as it carries minute particles over long distances. Future efforts must be clearly divided into categories such as climate, environment, health, and industry, and combined impacts and countermeasure effects must be evaluated and studied.

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Glossary

*1 Total number of days KOSA (Yellow Sand) was observed

Accumulated number of days on which KOSA (Yellow Sand) was observed at any Japanese monitoring station. (E.g., if five different monitoring stations observed KOSA (Yellow Sand) on the same day, that would equal a total of five observation days.)

Number of days KOSA (Yellow Sand) was observed

A day on which KOSA (Yellow Sand) was observed at any Japanese monitoring station. (Observations at multiple stations on the same day count as one observation day.)

*2 PM10

This term refers to total amount of particulate matter that is suspended in the atmosphere and is smaller than 10 μm in diameter. It is widely used in fields related to air pollution and the atmospheric environment.

*3 Aeolian dust

Particulate matter suspended in and transported by the air.

References

[1] Japan Meteorological Agency (2005): "Report on Climate Change 2005" (Japanese): http://www.data.kishou.go.jp/climate/cpdinfo/climate_change/2005/index2.html

[2] Ministry of the Environment "Dust and

Sandstorms":
http://www.env.go.jp/en/earth/dss/pamph/pdf/full.pdf

[3] Special Committee on Dust and Sandstorm Issues (2005): "Report of the Special Committee on Dust and Sandstorm Issues" (Japanese):
http://www.env.go.jp/earth/dss/report/02/index.html

[4] Yasunobu Iwasaka (2006): "KOSA: Global Impact of Little Dust" Kinokuniya Co., Ltd. (Japanese)

[5] China Internet Information Center (2006): "Why is this year's KOSA (Yellow Sand) severe? [2] Reducing topsoil exposure," April 19, 2006 (Japanese):
http://www.china.org.cn/japanese/233231.htm

[6] China Internet Information Center (2006): "Why is this year's KOSA (Yellow Sand) severe? [1] Winter drought and desertification," April 19, 2006 (Japanese):
http://www.china.org.cn/japanese/233224.htm

[7] China Internet Information Center (2006): "Why is this year's KOSA (Yellow Sand) severe? [3] Ecosystem protection and poverty measures," April 20, 2006 (Japanese):
http://www.china.org.cn/japanese/233982.htm

[8] Japan Meteorological Agency Aeolian Dust information page (Japanese):
http://www.jma.go.jp/jp/kosa/index.html

[9] Hirokazu Fukushima (2006): "Air Pollution Monitoring in East Asia— Japan's Role as an Environmentally Advanced Asian Country —," Science and Technology Trends Quarterly Review No. 18

[10] Teruhisa Tsujino (2006): "Construction of an Integrated Earth Observation System Driven by Utilization Needs," Science and Technology Trends Quarterly Review No. 18

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