C-4.0 Studies on the Current Emission Distribution of Acid Precipitation Precursor and Related Components and Development of its Projection Model(Final Report)

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Abstract In order to fully understand the acidification of precipitation, it is essential to determine ammonia emissions. Detailed gridded NH_3 emission fluxes have been compiled for Europe. In East Asia they have been determined on a national basis. We have calculated NH_3 emission fluxes from livestock and fertilizer applications in Japan and Korea on a 1° latitude×1° longitude basis. The maximum calculated NH_3 emission fluxes for each of the 4 animal categories were 4740, 4740, 4600, and 5180 tonnes NH_3/grid/y from pigs in the central part of Korea, dairy cows in the eastern part of Hokkaido, beef cattle in the central part of Korea, and poultry in the southern part of Kyushu, respectively. The total NH_3 emissions from livestock in Japan and Korea were 4.41, 4.61, 6.02, and 7.77×10^4 tonnes NH_3/y and 2.41, 1.15, 3.71, and 1.92×10^4 tonnes NH_3/y from pigs, dairy cows, beef cattle, and poultry, respectively. The overall total NH_3 emissions from livestock and fertilizer applications in Japan and Korea were 27.8×10^4 and 14.4×10^4 tonnes NH_3/y, respectively.

Key Words East Asia, Emission Inventory, Ammonia, Livestock, Fertilizer

1. Introduction

In order to fully understand the acidification of precipitation, it is essential to determine ammonia (NH_3) emissions, because NH_3 is one of the most important neutralizing components of the atmosphere. When deposited to the ground, it may be oxidized to nitrate ion with the concurrent release of 2 hydrogen ions to the soil. Hence NH_3 is considered to be an air pollutant which is harmful to soil. Detailed gridded NH_3 emission fluxes from livestock and fertilizer applications have been compiled for Europe[1,2].

Sulfuric acid produced by photochemical reactions exists as particulate matter in the atmosphere. After neutralization by NH_3, it remains in particulate form and its dry deposition velocity dose not change. Nitric acid generated by photochemical reactions exists in a gaseous form and its dry deposition velocity is large (about 1.4 cm/sec). Nitric acid is converted into particulate matter by neutralization in the atmosphere by NH_3. The dry deposition velocity of particulate NH_4NO_3 is smaller (about 0.17 cm/sec) than that of gaseous HNO_3, so it is transported great distance before removal from the atmosphere. Thus the NH_3 emission flux is very important to evaluate the long range transport of particulate nitrate.

The amounts of SO_4^{2-} and NO_3^- deposition to the environment in North America and Japan are similar, but the NH_4^+ deposition to Japan is larger than that in other regions [3,4].

2. Research Objectives

In order to understand the characteristics of acid deposition in Japan and Korea, NH_3 emission fluxes must be determined. In the near future, the transboundary air pollution among East Asian countries will be evaluated with an emission, transport, transformation, and deposition model. Detailed gridded emission flux maps of SO_2 and NO_x have been compiled for Asia[5] as the basic data for the model. It is essential to establish an NH_3 emission flux map to run a simulation model of air pollutants among East Asian countries. East Asian NH_3 emission fluxes have been determined by Zhao[6], however, these estimates are on a national basis.

3. Research Method

Detailed NH_3 emission fluxes for Europe have been compiled in order to run simulation models of air pollution among European countries. The NH_3 emission flux estimates used in these European models consider only livestock and fertilizer applications as NH_3 sources. We used the animal emission factors developed by W.A.H. Asman[2] for Europe, 5.36, 23.04, and 0.248 kg NH_3/animal/y for pigs, cattle (dairy cows and beef) and poultry, respectively. In Japan, we generally have much more rainfall and the average ambient temperature is higher than those in European countries. Relative to Europe, the higher rainfall may decrease Japanese emission factors, while the higher temperatures may increase Japanese emission factors. Perhaps these differences cancel each other out. In Korea, there are no emission factor data available, and we employed the European emission factors. In Europe, NH_3 emissions from pigs, cattle, poultry, and fertilizer applications account for over 93% of total NH_3 emissions. Only NH_3 emissions from pigs, cattle, poultry, and fertilizer applications were considered in this report. Domestic animal population data was collected by prefecture and apportioned to grid cells based on the prefectural area in each grid cell (1° latitude × 1° longitude).

We used Information Related to Livestock Improvement (pub. Ministry of Agriculture, Forestry and Fisheries, Livestock Industry Bureau Animal Production Division, 1992) and the Data Book on Livestock of Hokkaido '92 (pub. Hokkaido 1992). For fertilizer NH_3 emissions, we assumed a 10% ammonium nitrogen evaporation rate for ammonium sulfate, urea, and other nitrogen-containing fertilizers. Since Japanese prefectural fertilizer data were not available, total fertilizer usage for Japan was apportioned to prefectures based on cultivated area. We used the Yearbook of Fertilizer (pub. The Association of Fertilizer, 1992) and the Statistics Table on Agriculture of Hokkaido (pub. Hokkaido, 1992). For the calculation of Korean NH_3 emission fluxes, we used the Statistical Yearbook of Agriculture, Forestry & Fisheries (1992) as a data base.

4. Results and Discussion

The NH_3 emission fluxes from pigs are shown in Figs. 1. The 5 largest NH_3 emission fluxes from pigs ranged from 2,740 to 4,740 tonnes NH_3/grid/y from grids in the central part of Korea (2 grids), Kanto (2 grid), and southern Kyushu (1 grid). The 5 largest NH_3 emission fluxes by dairy cows ranged from 2,010 to 4,740 tonnes NH_3/grid/y from grids in the central part of Korea (1 grid), Hokkaido (3 grids), and northern Kanto (1 grid). The 5 largest NH_3 emission fluxes by beef cattle ranged from 3,550 to 4,600 tonnes NH_3/grid/y and were located in the central part of Korea (4 grids) and in southern Kyushu (1 grid). The 5 largest NH_3 emission fluxes by poultry ranged from 2,950 to 5,180 tonnes NH_3/grid/y from grids in the central part of Korea (1 grid), in Tohoku (1 grid) and in Kyushu (3 grids). The highest total emission fluxes from livestock including pigs, dairy cows, beef cattle, and poultry, 14,900 tonnes NH_3/grid/y was observed for the central part of Korea and the second highest value of 13,100 tonnes NH_3/grid/y was observed for southern Kyushu. Fluxes larger than 10,000 tonnes NH_3/grid/y were estimated for the central part of Korea (2 grids), Kanto (1 grid), and southern Kyushu (2 grids)(Fig. 2).

The NH_3 emission fluxes calculated for fertilizers applications were extremely high for Korea. There were 9 grids in Korea exceeding the maximum NH_3 emission fluxes (2,070 tonnes NH_3/grid/y) for Japan. There are no grids in Japan with fertilizer emission fluxes larger than 2,500 tonnes NH_3/grid/y (Fig. 3) and the differences between grids were small. However, relatively high emission fluxes were calculated for Hokkaido, Kanto, and northern

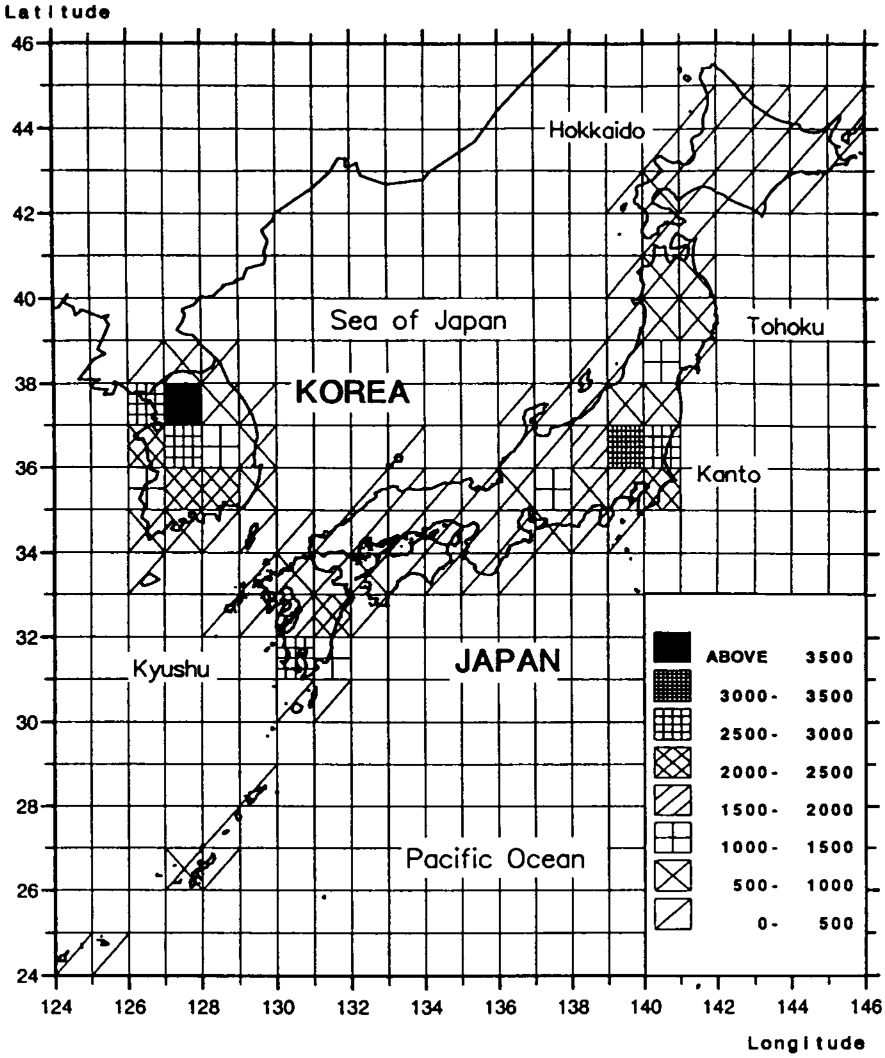

Fig. 1. Gridded NH_3 emission fluxes from pigs in Japan and Korea (tonnes NH_3/grid/y)

Kyushu. The 5 largest combined NH_3 emission fluxes from both livestock and fertilizer applications ranged from 13,200 to 18,100 tonnes NH_3/grid/y and were located in the central part of Korea (3 grids), in northern Kanto (1 grid), and in southern Kyushu (1 grid)(Fig. 4).

Total NH_3 emissions in Japan were 4.41, 4.61, 6.02, 7.77, and 5.02×10^4 tonnes NH_3/y from pigs, dairy cows, beef cattle, poultry, and fertilizer applications, respectively. The overall total NH_3 emission from livestock and fertilizer applications was 27.8×10^4 tonnes NH_3/y. The total domestic emissions in Korea were 2.41, 1.15, 3.71, 1.92, and 5.20×10^4 tonnes NH_3/y from pigs, dairy cows, beef cattle, poultry, and fertilizer applications, respectively. The overall total NH_3 emission from livestock and fertilizer applications was 14.4×10^4 tonnes NH_3/y. Zhao and Wang[6] estimated the NH_3 emissions from Japan and Korea as follows: 14.3 (livestock without poultry), 10.7 (poultry), and 9.66 (fertilizer applications) $\times 10^4$ tonnes NH_3/y for Japan and 3.10 (livestock without poultry), 1.66 (poultry), and 4.23 (fertilizer applications) $\times 10^4$ tonnes NH_3/y for Korea. From the comparison of our data to those calculated from Zhao and Wang, our estimates of livestock (without poultry) emissions are double of those of Zhao and Wang and those of emissions from fertilizer applications is about half those of Zhao and Wang. Other estimates are within error estimates.

A comparison of our data to those for other countries[2] indicates that the emission flux due

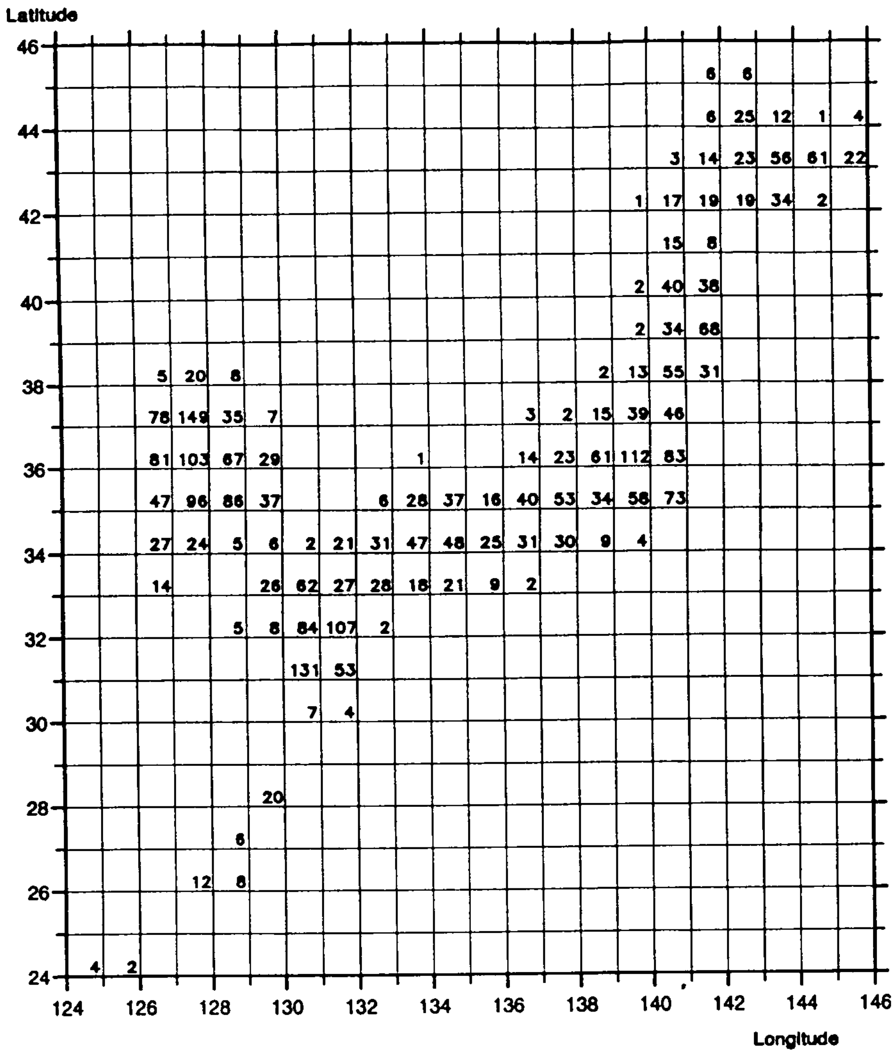

Fig. 2. Gridded NH_3 emission fluxes from pigs, cattle, and poultry in Japan and Korea (100 tonnes NH_3／grid／y)

to fertilizer applications in Japan is similar to those in the former West Germany and the United Kingdom, however, the NH_3 emission fluxes from cattle in the former West Germany and in the UK are larger than that in Japan. The total national NH_3 emission by Japan is small compared to those of most European countries.

We compared the total NH_3 emission amount to the total NH_4^+ deposition in Japan. Acid deposition monitoring throughout the year was conducted in Japan from 1983 to 1987 with bulk samplers[4]. The results indicate that the average deposition rates are 22×10^4 tonnes NH_3／y. Hence the average deposition is about 20% smaller than the total annual NH_3 emissions.

International Cooperation

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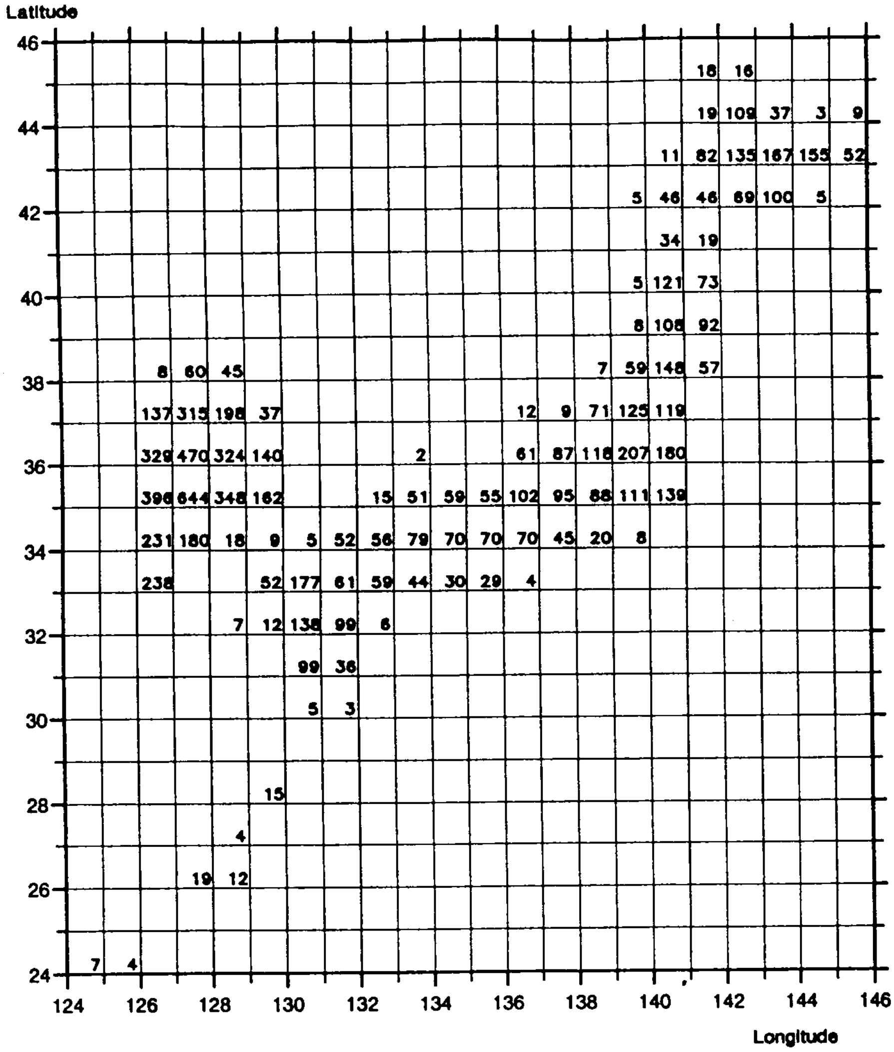

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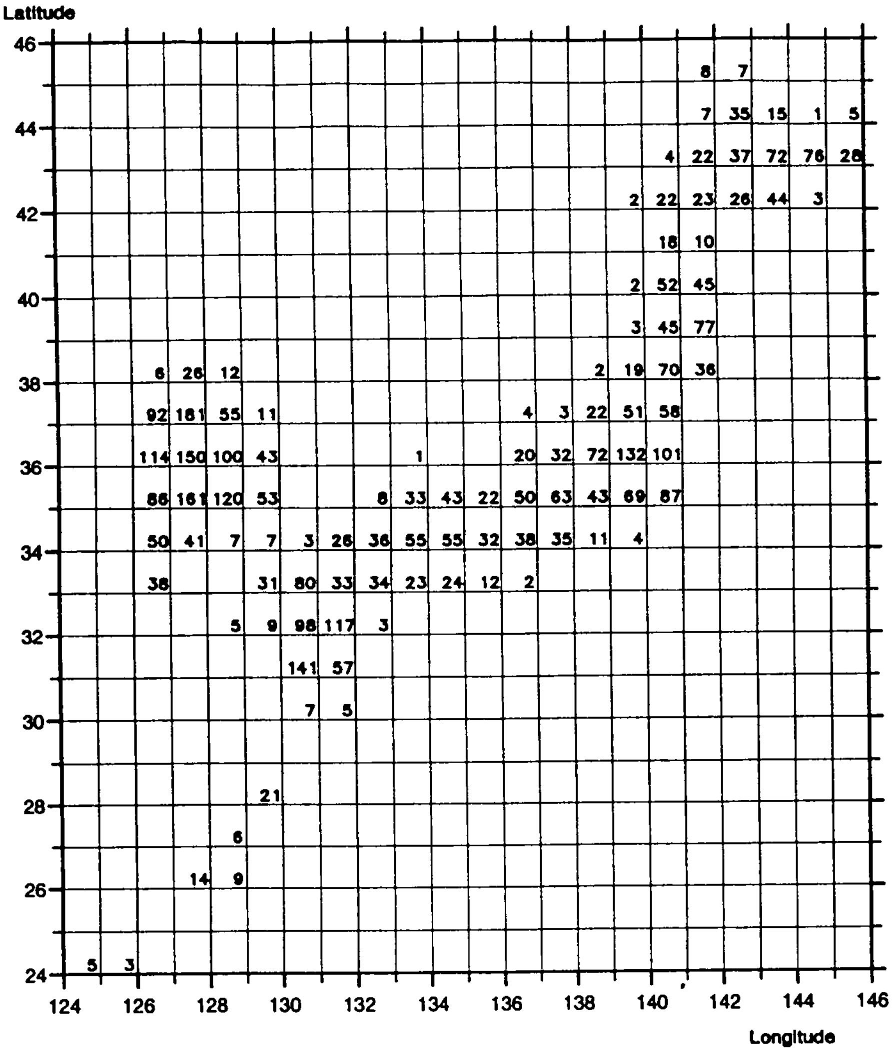

Fig. 4. Gridded NH_3 combined emission fluxes from livestock and fertilizer applications in Japan and Korea (100 tonnes NH_3/grid/y)

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