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Sect.4 #51

# Gridded Ammonia Emission Fluxes in Japan

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**Abstract.** In order to fully understand the acidification of precipitation, it is essential to determine ammonia emissions. Detailed gridded emission fluxes of $NH_3$ have been compiled in Europe. In East Asia they have been determined on a national basis(Zhao and Wang, 1994). In Japan we have calculated $NH_3$ emission fluxes on a 1° latitude x 1° longitude basis for livestock and the application of fertilizer. Livestock emission factors developed by W.A.H. Asman(Asman, 1992) for Europe were used 23.04 and 5.36 kg $NH_3$/animal/yr. for cattle (dairy cows and beef), and pigs, respectively. Domestic animal population data was collected by prefecture and apportioned to grid cells based on the prefectural area in each grid cell. For fertilizer emissions, $NH_3$ emission were calculated assuming a 10% ammonium nitrogen evaporation rate for ammonium sulfate, urea, and other nitrogen-containing fertilizers. Since prefectural fertilizer data were not available, total fertilizer usage for Japan was distributed to prefectures based on cultivated area. The maximum calculated $NH_3$ emission fluxes for each of the three animal categories were as follows: Dairy cows, 4730 (Hokkaido), beef cattle, 4540 (Kyushu) and pigs, 3480 (Kanto) tonnes $NH_3$/grid/yr. The total $NH_3$ emissions due to livestock in Japan were 4.6, 6.0 and 4.4 x $10^4$ tonnes $NH_3$/yr. from dairy cows, beef cattle and pigs, respectively. The overall total $NH_3$ emission from livestock and the application of fertilizer was 2.0 x $10^5$ tonnes $NH_3$/yr. The $NH_3$ emission by Japan is small compared to those of most European countries.

**Key Words**: Emission inventory, ammonia, Japan, livestock, application of fertilizers.

## 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 two hydrogen ions to the soil. Hence $NH_3$ is considered to be an air pollutant which is harmful to the soil. Detailed gridded emission fluxes of $NH_3$ from livestock and the application of fertilizer have been compiled for Europe (Buijsman et al., 1987, Asman et al., 1988, Asman, 1992).

When we evaluate the total deposition of chemicals to the environment in Europe, North America and Japan, the amounts of $SO_4^{2-}$ and $NO_3^-$ deposition are similar, however, the $NH_4^+$ deposition in Japan is larger than that in the other regions (Interim Assessment, The Causes and Effects of Acidic Deposition, Tamaki et al., 1991). In order to understand the characteristics of acid deposition in Japan, $NH_3$ emission fluxes must be determined. In the near future, the transboundary air pollution among east Asian countries will be evaluated with an emission, transport, conversion and deposition model. The detailed gridded emission flux map of $SO_2$ and NOx has been compiled for Asia (Akimoto and Narita, 1994) as the basic data on model run. It is essential to establish an $NH_3$ emission flux map to conduct a simulation model of air pollutants among east Asian countries. The East Asian $NH_3$ emission fluxes have been determined by Zhao(Zhao and Wang, 1994), however, they are on a national basis. We have calculated $NH_3$ emissions from livestock and the application of fertilizer for Japan on a 1° latitude x 1° longitude grid.

## 2. Methods

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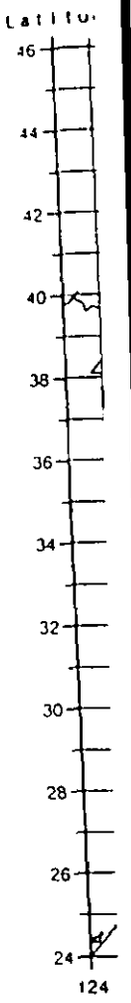
Detailed $NH_3$ emission fluxes for Europe have been compiled in order to run air pollution simulation models among European countries. Only livestock and the application of fertilizer have been taken into account to obtain $NH_3$ emission fluxes. We used the animal emission factors developed by W.A.H. Asman(Asman, 1992) for Europe 23.04 and 5.36 kg $NH_3$/animal/yr. for cattle(dairy cows and beef) and pigs, respectively. In Japan we generally have much more rainfall and the average ambient temperature is higher compared to European countries. Thus the former may actually make emission factors be lower in Japan and the latter may make emission factors be higher than those factors for Europe. Perhaps these differences cancel each other. In Europe, $NH_3$ emissions from cattle and pigs cover 84% of the $NH_3$ emission from livestock. Only $NH_3$ emissions from cattle and pigs 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 x 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 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).

### 3. Results and Discussion

The $NH_3$ emission fluxes from pigs are shown in Fig. 1. The $NH_3$ emission fluxes calculated for Northern Kanto were between 2,500 and 3,500 tonnes $NH_3$/grid/yr. Those for Southern Kanto were greater than 2,000 tonnes $NH_3$/grid/yr. In Kyushu there is one grid showing between 3,000 and 2,500 tonnes $NH_3$/grid/yr. The maximum calculated $NH_3$ emission fluxes for each of the three animal categories were as follows: Dairy cows, 4730 (Hokkaido), beef cattle, 4540 (Kyushu) and pigs, 3480 (Kanto) tonnes $NH_3$/grid/yr. The five largest $NH_3$ emission fluxes by dairy cows ranged from 4,730 to 1,920 tonnes $NH_3$/grid/yr. and were situated in Hokkaido (4 grids) and in northern Kanto (1 grid). The five largest $NH_3$ emission fluxes by beef cattle ranged from 4,540 to 2,350 tonnes $NH_3$/grid/yr. and were located in Kyushu (3 grids), in northern Kanto (1 grid) and in Tohoku (1 grid). The highest total emission flux from livestock including dairy cows, beef cattle and pigs of 8,490 tonnes $NH_3$/grid/yr. was observed for northern Kanto and the second highest value of 7,880 tonnes $NH_3$/grid/yr. was observed for southern Kyushu (Fig. 2). Grids with emission fluxes larger than 5,000 tonnes $NH_3$/grid/yr. exist in Hokkaido (2), Kanto (2) and southern Kyushu (3), respectively.

There are no grids with fertilizer emission fluxes larger than 2,500 tonnes $NH_3$/grid/yr. (Fig. 3) and differences between grids are small. However, relatively high emission fluxes were calculated for Hokkaido, Kanto and northern Kyushu. The maximum combined emission flux from both livestock and the application of fertilizer calculated for the northern part of Kanto was 10,600 tonnes $NH_3$/grid/yr. (Fig. 4). High emission fluxes of 7,000 to 9,000 tonnes $NH_3$/grid/yr. were calculated for eastern part of Hokkaido, the Kanto plain and Kyushu.

Total livestock $NH_3$ emissions in Japan were 4.6, 6.0 and 4.4 x $10^4$ tonnes $NH_3$/yr. from dairy

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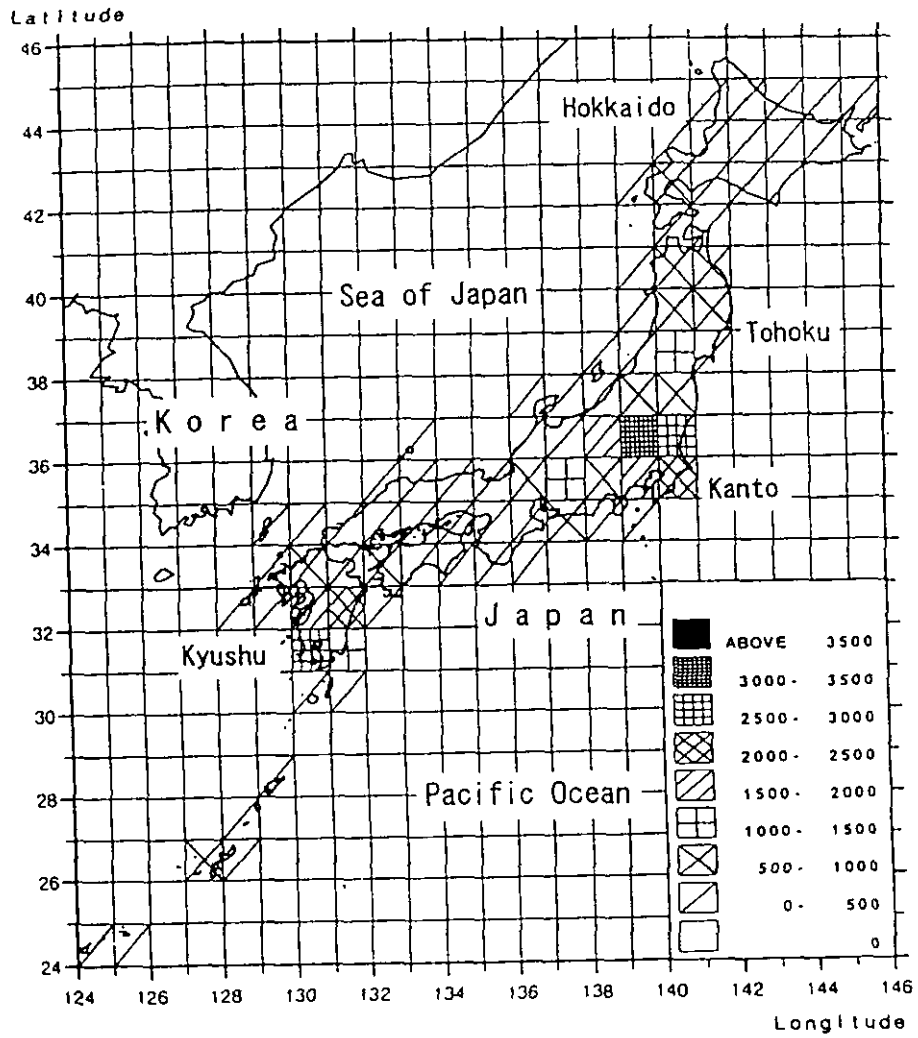


Fig.1. Gridded $NH_3$ emission fluxes from pigs in Japan(tonnes $NH_3$/grid/yr.)

cows, beef cattle and pigs, respectively. The total domestic emission from the application of fertilizer was $5.0 \times 10^4$ tonnes $NH_3$/yr. The overall total $NH_3$ emission from livestock (cattle and pigs) and the application of fertilizer was $2.0 \times 10^5$ tonnes $NH_3$/yr. The Japanese $NH_3$ emission due to livestock (without poultry) and the application of fertilizer were estimated to be 14 and $9.7 \times 10^4$ tonnes $NH_3$/yr.(Zhao and Wang, 1994), respectively. Those estimates are within 10% difference of our calculation for livestock, however, our calculation of the emission due to the application of fertilizer is approximately 50% smaller. A comparison of our data to those for other countries indicates that the emission flux due to the application of fertilizer in Japan is similar to those in the former West Germany and the United Kingdom, however, the $NH_3$ emission flux from cattle is larger in the former West Germany and in the UK compared to that in Japan. The total national $NH_3$

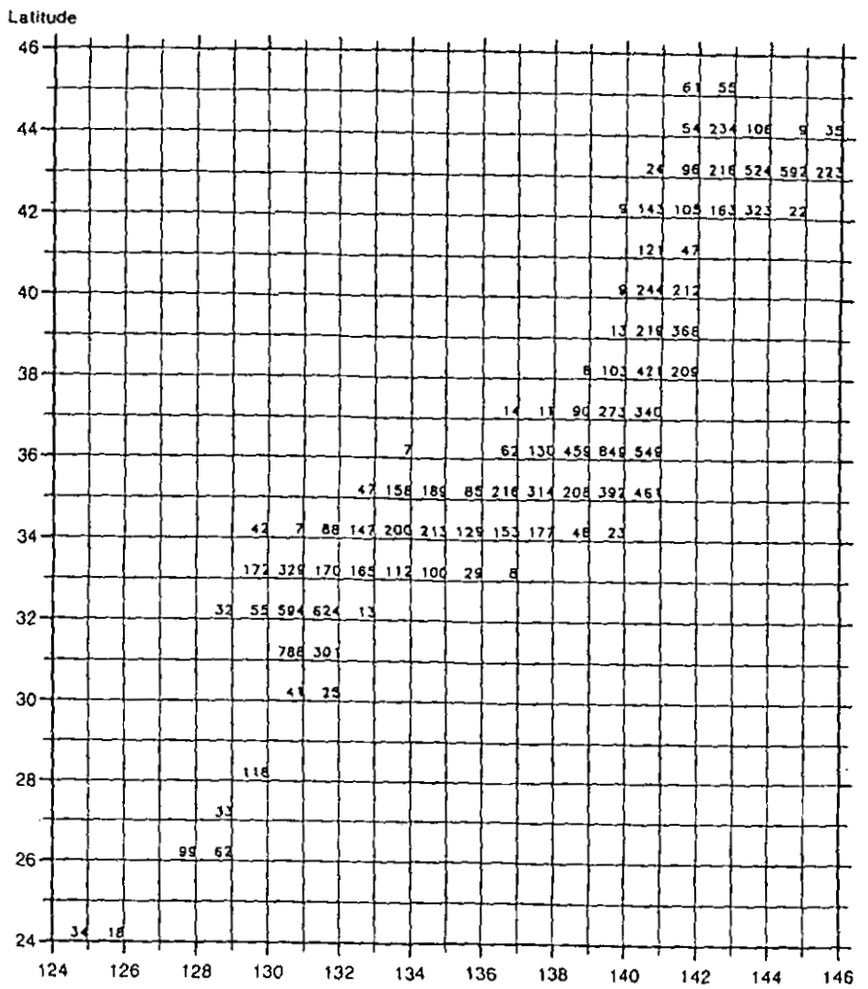


Fig. 2. Gridded $NH_3$ emission fluxes from cattle and pigs in Japan(10 tonnes $NH_3$/grid/yr)

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 (Tamaki et al., 1991). The results indicate that the minimum, average andmaximum deposition rates are 11, 24 and 61 x $10^4$ tonnes $NH_3$/yr. Hence the average deposition is about 20% larger than the total annual $NH_3$ emission.

## 4. Conclusion

In Asia, gridded emission fluxes of $SO_2$ and NOx were compiled, however, there was no gridded emission fluxes of $NH_3$. We have calculated $NH_3$ emission fluxes on a 1° latitude x 1° longitude basis for livestock and the application of fertilizer in Japan using emission factors developed in


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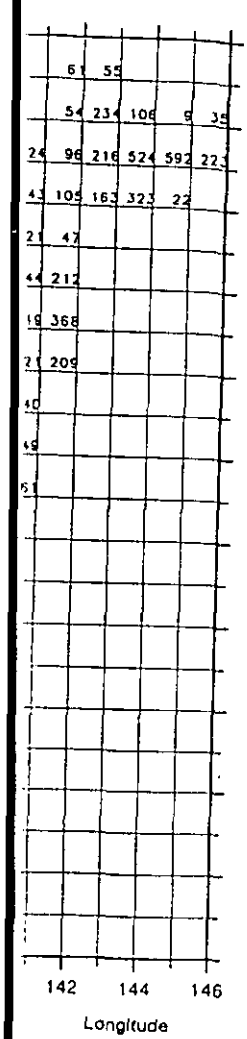


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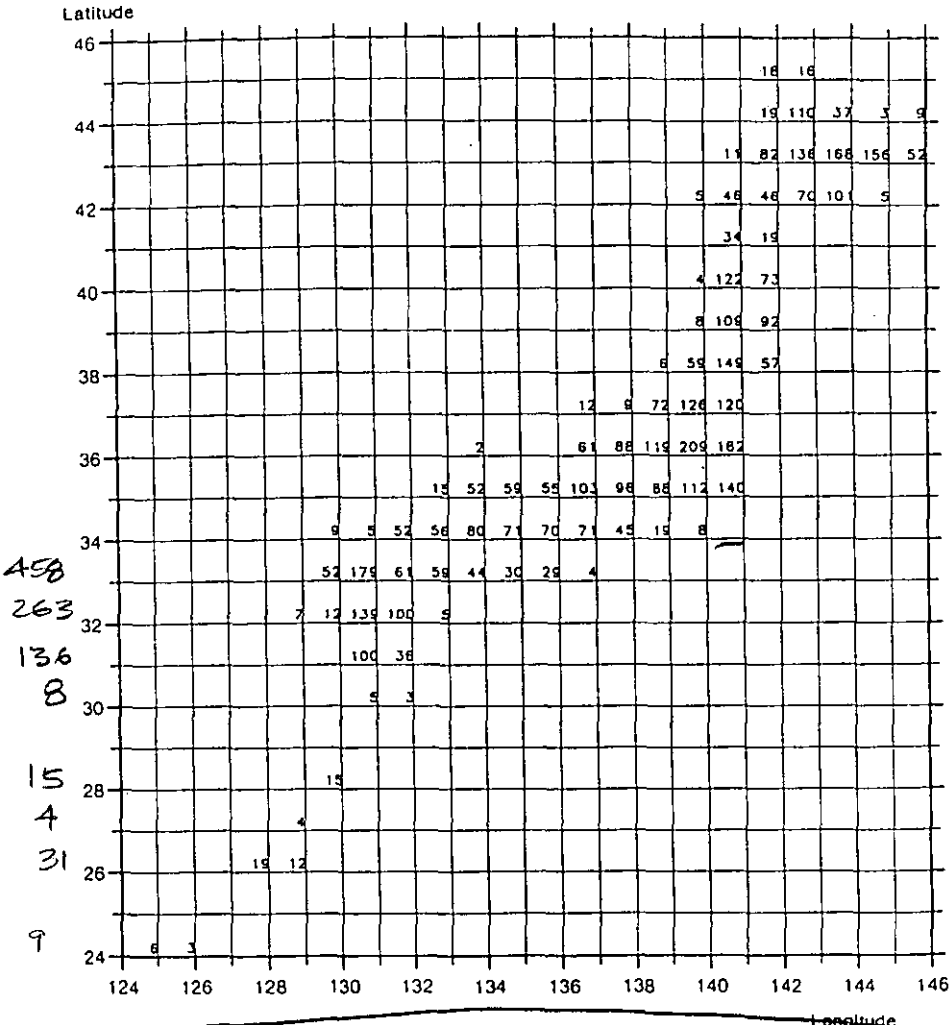


Fig. 3. Gridded $NH_3$ emission fluxes from the application of fertilizer in Japan(10 tonnes $NH_3$/grid/yr.)

Europe. The total $NH_3$ emissions due to livestock in Japan were 4.6, 6.0 and 4.4 x $10^4$ tonnes $NH_3$/yr. from dairy cows, beef cattle and pigs, respectively. The overall total $NH_3$ emission from domestic animals and the application of fertilizers was 2.0 x $10^5$ tonnes $NH_3$/yr. The larger emission fluxes from domestic animals and the application of fertilizers were observed in Hokkaido, Kanto and Kyushu districts The most dominant contributorin each category is beef cattle. The $NH_3$ emissions in Japan are small compared to those of most European countries.

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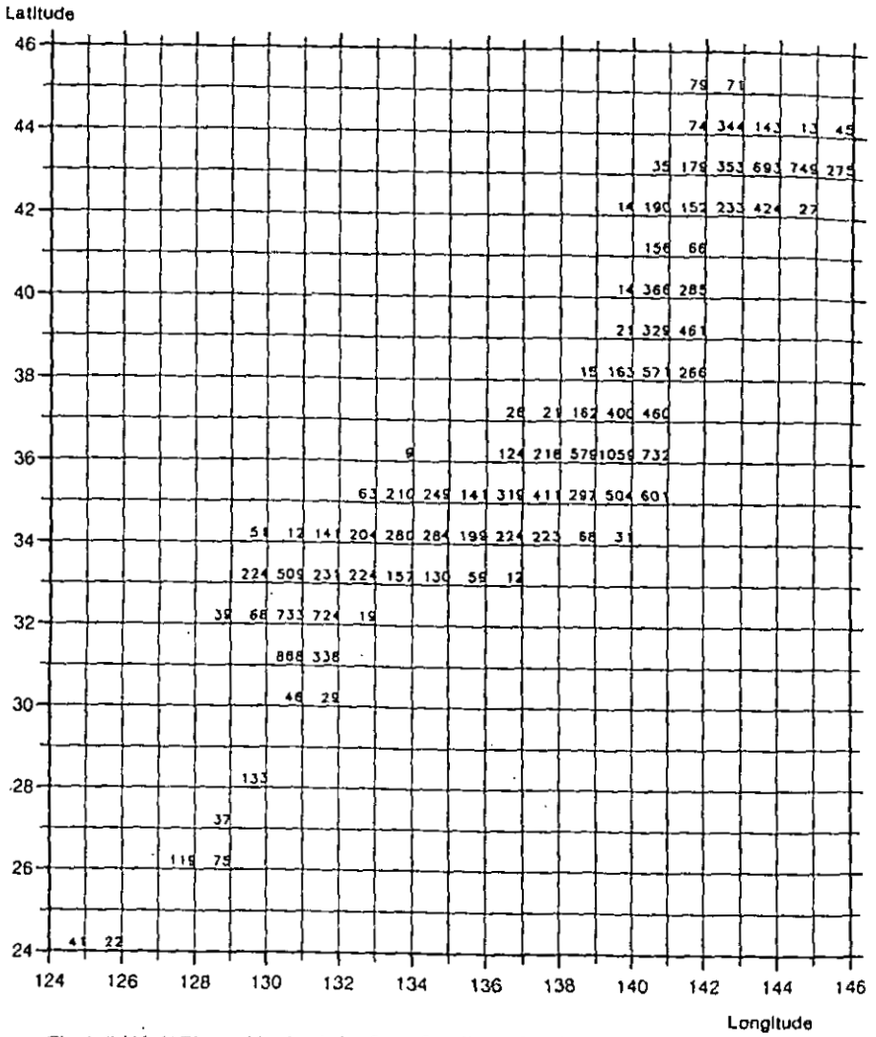


Fig. 4. Gridded $NH_3$ combined emission fluxes from livestock and the application of fertilizer in Japan (10 tonnes $NH_3$/grid/yr.)

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