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Decreases in the Number of Foggy Days in Thailand and Japan, and Possible Causes

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1. Introduction

Fog, defined as moist air with a horizontal visibility of less than 1km, is a litmus test that indicates regional environmental change. It forms due to the cooling of air layers, an increase in the ratio of water vapor supply to air volume, or the mixing of air mass. A decrease in the cooling or the supply of water vapor, for any reason, causes changes in the pattern of fog manifestation; the number of foggy days can decrease, the fog can appear later, or the fog's duration can be reduced. Human activities, such as deforestation or urbanization, affect the thermal conditions and water environments in the air near the ground, which can affect fog appearance, especially in mountain basins that are closed off.

Early studies found that big European cities and North American industrial cities had more foggy days than did countryside areas, due to the rich supply of condensation nuclei (Geiger, 1959: Landsburg, 1980). In Tokyo, the biggest city in Japan, the number of foggy days increased rapidly with industrialization in the 1920s (Yoshino, 1975).

On the other hand, Zhang (1986) studied the influence of deforestation on local climates in Xishuangbanna, a tropical mountainous region with 49 basins in the Southern part of Yunnan Province, China; and pointed out that the number of annual foggy days decreased rapidly during the period of 1954-1980. The decrease in annual foggy days may have been caused by the reduction of evapotranspiration from the tropical forest due to deforestation. The forest coverage in Xishuangbanna was reduced by half in the period from 1949 to 1980; from 69% coverage in 1949 to 30% coverage in 1980. Yoshino (1986) and Nomoto (1995) noticed similar phenomena, though their observation was based only on the record of one meteorological station in Xishuangbanna.

The stretch of Xishuangbanna is located in the tropics. However, as it has a basin topography, it tends to amass chilly air at night, and temperatures can be rather low, especially in the bottoms of the basins during the dry season. When fog forms, the latent heat and radiation from the fog droplets warm the earth's surface and the lowest air layer, arresting the drop in temperature. Therefore, the trees in Xishuangbanna guard themselves against the cold by retaining heat via fog formation. In most places the lowest temperatures are usually at dawn, but in Xishuangbanna it is coldest at midnight, right before the fog forms (Nomoto, et al., 1988: Nomoto, et al., 1990). The seasons of Xishuangbanna are classified into rainy and dry seasons, with the latter running approximately from October to April. There is hardly any precipitation during the dry season; at this time fog is a valuable water source for the trees (Ren, et al., 1985).

In Xishuangbanna, fog plays a significant role as a constituent element in the maintenance of the regional ecosystems. Therefore, the recent decrease in the number of foggy days in Xishuangbanna may add to the further deterioration of the ecosystem that has already been injured by deforestation.

In the area extending from the Southern part of Yunnan Province to Northern Thailand, fog is frequent. Furthermore, a satisfactory meteorological observation network has been established all over Thailand, and the data is relatively easy to acquire.

In Japan, urbanization has recently proceeded to the countryside areas around big cities, and paddy field area, which may add water vapor to the air near the ground, has been drastically reduced in rural areas under the food policy which the Japanese government has pursued since 1969.

This study will examine the number of foggy days in Thailand and Japan, and aim to clarify several properties of the changes.

2. Change in the Number of Foggy Days in Thailand and Deforestation

2.1 Foggy Regions and the Fog Season

The data used in this study, which was provided by the Meteorological Department of Thailand, is comprised mainly of monthly values for the period from 1951 to 1995. The observational network in Thailand is composed of 51 synoptic weather stations (Meteorological Department, 1982), as shown in Figure 1. In terms of climate patterns and geographical conditions, Thailand can be divided into five parts: Northern, Northeastern, Central, Eastern, and the Southern parts (Rungdilokroajn and Nimma, 1990). Most of the areas in the Northern part are hilly and mountainous, and the meteorological stations there are located at the bottoms of deep valleys or basins. The Northeastern part consists of a high level plain called the Northeast Plateau, and the Central part is a large low level plain running along the Chao Phraya River and its tributaries. The Eastern part is adjacent to the Gulf of Thailand, and most of the areas there consist of plains and small hills. The Southern part is located on the peninsula, where the topography is hilly and mountainous because of the long ridge of western mountains extending from the north, that frames the peninsula.

Figure 1 shows a distribution of average annual foggy days (1951-1980) in Thailand. Given the suitable topographical conditions for fog formation and rich forests, as mentioned later, the numbers are higher for the Northern part (100 days at Mae Hong Son, 91 days at Mae Sot, 89 days at Mae Sariang and 87 days at Phrae). With the exception of 94 days at Loei, which is adjacent to the Northern part, the Northeastern part is a less foggy region, and the Central and Eastern parts have hardly any fog. Conversely, the Southern part is considered another foggy region of the country. The numbers amount to 103 days at Surat Thani, the highest value recorded in the country, 69 days at Trang and 51 days at Chumphon.

Figure 2 gives seasonal changes in monthly foggy days and rainfall at selected stations in the Northern, Northeastern, Central and Southern parts. It is well known that the climates of continental Southeast Asia are controlled to a very large extent by the system of Asian Monsoons. May through October is generally the Southwest monsoon season (rainy season) in Thailand, and the monthly foggy days begin to increase obviously at the end of the rainy season, reaching a maximum in the middle of the dry season. In Thailand, the dry season is also the fog season. This suggests a connection between fog formation and evapotranspiration from the forests.

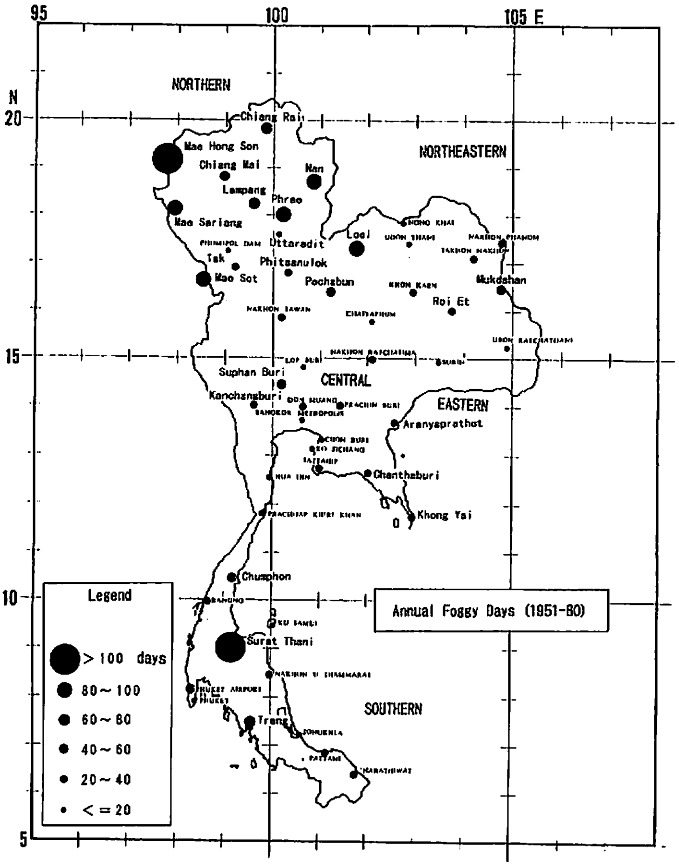


Figure 1 Distribution of Average Annual Foggy Days in Thailand

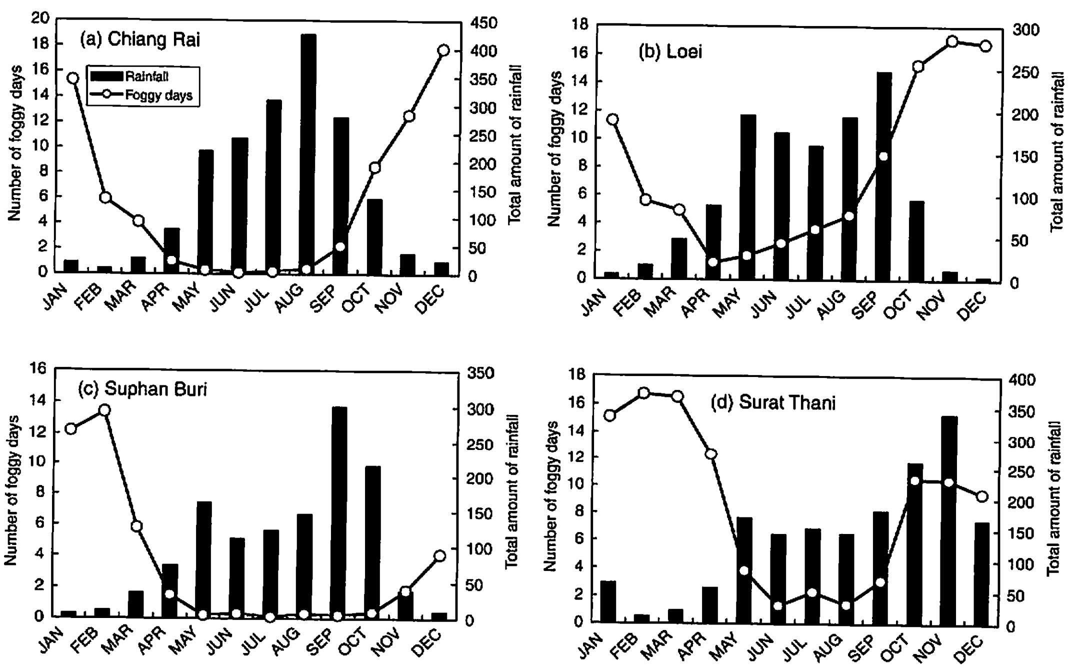
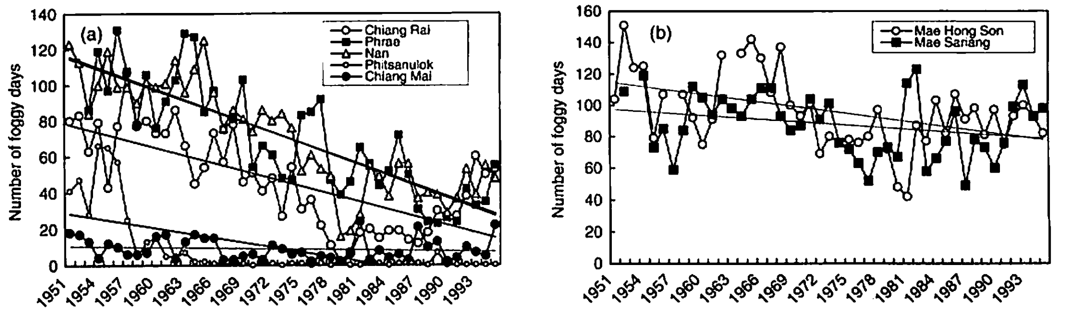


Figure 2 The Fog Season in Thailand

There is one exception to the relationship between the fog season and the dry season, i.e., Surat Thani in the Southern part, as shown in Figure 2(d). There, the number of foggy days per month has two peaks in a year, and increases even in the rainy season. Seasonal changes in the number of foggy days per month are common at stations that frequently observe fog in the Southern part. This leads one to believe that the processes of fog formation are different in the Southern part than in other parts.

2.2 Recent Changes in the Number of Foggy Days in Northern Thailand

Figure 3 shows changes in annual foggy days at selected stations in the Northern part (Northern Thailand) since 1951. As mentioned previously, the meteorological stations in Northern Thailand are located at the bottoms of deep valleys or basins, and fog is frequently observed. The number of foggy days has been decreasing at most stations, especially Chiang Rai, Phrae and Nan, as shown in Figure 3(a). Assuming that the trends in changes are linear, the rate of decrease reached 1.42 days per year at Chiang Rai, 2.01 days/y at Phrae and 1.97 days/y at Nan, respectively. Furthermore, Chiang Mai and Phitsanulok are meteorological stations where hardly any fog is observed. Phitsanulok has had almost no fog since 1965. On the other hand, the trends in changes in the number of foggy days shown in Figure 3(b) are quite different from those in Figure 3(a). The numbers at Mae Hong Son and Mae Sariang have not decreased continuously, but have fluctuated widely throughout the period.



Lines show the trend of changes.

Figure 3 Changes of Annual Foggy Days at Selected Stations in Northern Thailand since 1951

Figure 4 shows the decade-averaged monthly foggy days at Phrae, Chiang Rai, Mae Sariang and Mae Hong Son. The 45-year (1951-1995) period has been divided into five terms, with the last term consisting of just five years. At Phrae and Chiang Rai, where the number of annual foggy days decreased sharply during the period, the decade-averaged monthly foggy days gradually decreased toward the last term of each month throughout the fog season. This tendency is especially clear at Phrae, where the largest rate of decrease of annual foggy days in Northern Thailand, of 2.01 days/y, was recorded. On the other hand, in the cases of Mae Sariang and Mae Hong Son, which showed a slight rate of decrease of annual foggy days, the decrease in the number of monthly foggy days can be confirmed only at the months of the start or at the end of the fog season. As a result, annual foggy days at Mae Sariang have not shown a continuous decrease, whereas a drastic decrease has been observed at Phrae. At Chiang Rai, the number of foggy days increased remarkably in the last term, although the data regarding the cause is inconclusive at present.

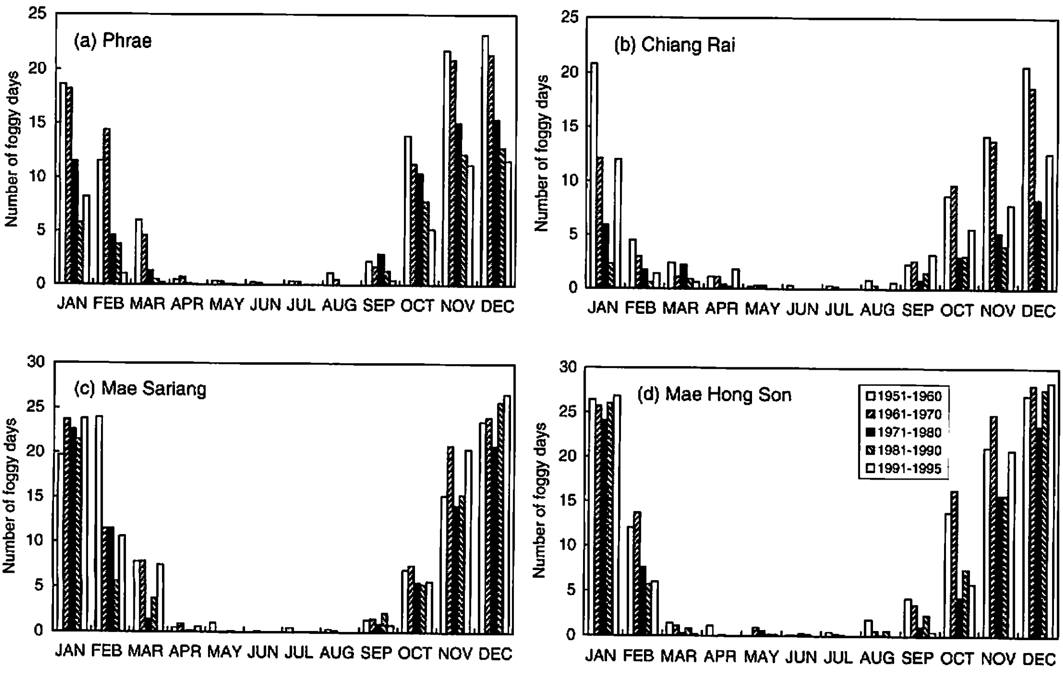


Figure 4 Decade-Averaged Monthly Foggy Days at Selected Stations in Northern Thailand

The number of foggy days has also been decreasing throughout the country (Nomoto, 1999). One sees Phrae type fog, with a recent rapid decrease of foggy days or Phitsanulok type fog with the number of foggy days having fallen and recently disappeared. However, the Mae Sariang type fog with a greater number of foggy days with a slight decrease, was not witnessed in any of these parts. The rates of decrease reached 1.92 days/y at Loei in the Northeastern part and 2.04 days/y at Surat Thani in the Southern part, respectively. The stations in the Eastern part observed almost no fog since 1980.

2.3 Deforestation and Urbanization

Figure 5 shows changes in the forest area rate (ratio of forest area to the whole prefecture area) in selected prefectures in Northern Thailand. Although fog is a phenomenon that takes place on a local scale, data on the forest area rate provides information about the trends in the number of foggy days. Many prefectures in Northern Thailand had rich forests in 1973, but saw the forest area cut by half by 1995. For example, Nan Prefecture had 90.4% forest coverage in 1973, but just 48.9% coverage in 1982 and 41.9% in 1995. Likewise, Phrae Prefecture had 66.2% forest coverage in 1973, but only 37.2% in 1995. Given these changes in the forest area rate, the number of foggy days has been decreasing drastically at most stations in Northern Thailand. One exception is Mae Hong Son Prefecture, which continues to maintain high coverage. Mae Sariang and Mae Hong Son, which are located in the prefecture, did not show the continuous decrease in foggy days. On the other hand, Phisanulok and Pechabun Prefecture had just 42.7% and 39.3% forest coverage, respectively, even in 1973. The stations in both prefectures have seen almost no fog since the middle of the 1960s.

Figure 6 gives the distribution of the forest area rate in Thailand's prefectures in 1973 and 1995, showing that deforestation has taken place all over the country during this period.

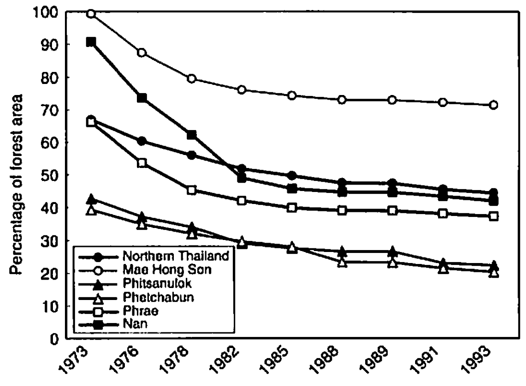
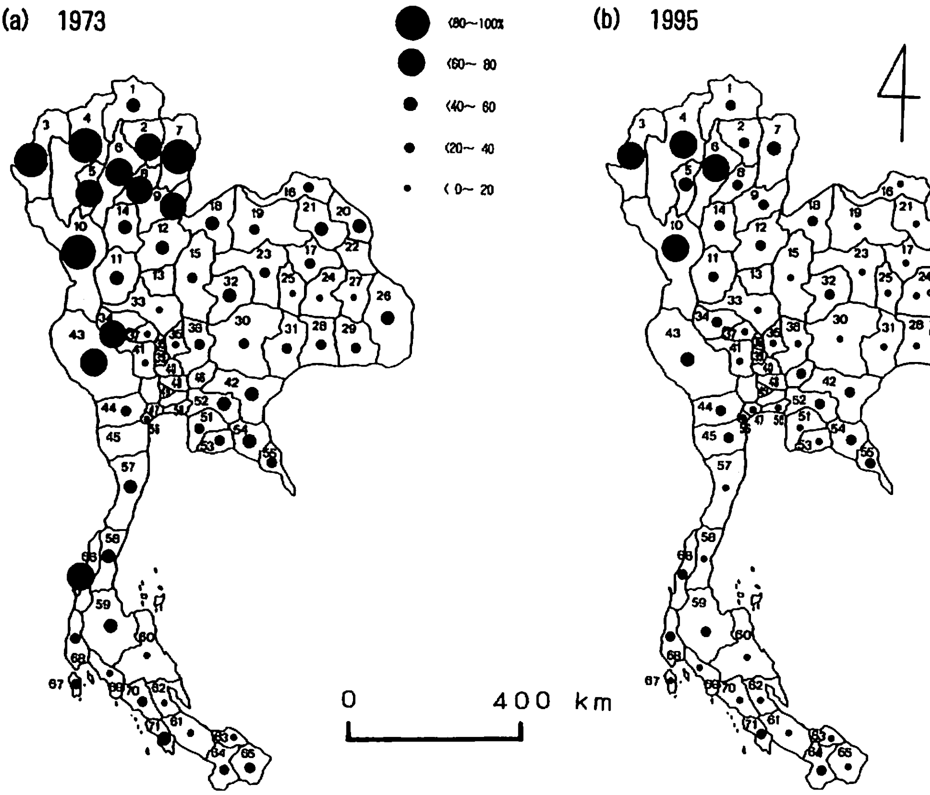


Figure 5 Changes of Forest Area Rate in Selected Prefectures in Northern Thailand

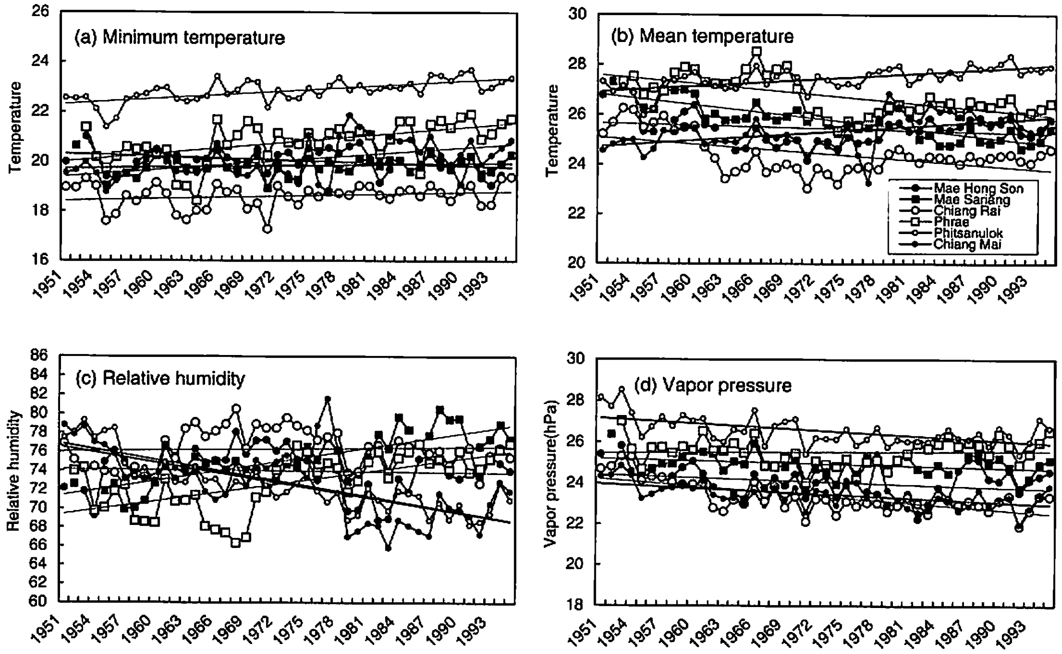


Prefecture No.: 1.Chiang Rai, 2.Payao, 3.Mae Hon Son, 4.Chiang Mai, 5.Lamphun, 6.Lampang, 7.Nan, 8.Phrae, 9.Uttaradit, 10.Tak, 11.Kamphaengphet, 12.Phitsanulok, 13.Phichit, 14.Sukhothai, 15.Phetchabun, 16.Nong Khai, 17.Kalasint, 18.Loei, 19.Udon Thani, 20.Nakhon Phanom, 21.Sakhon Nakhon, 22.Mukudahan, 23.Khon Kaen, 24.Roi Et, 25.Mahasarakham, 26.Ubon Ratchathani, 27.Yasothon, 28.Surin, 29.Suisaket, 30.Nakhon Ratchasima, 31.Burirum, 32.Chaiyaphum, 33.Nakhon Sawan, 34.Uthaithani, 35.Lop Buri, 36.Singburi, 37.Chainat, 38.Saraburi, 39.Anthing, 40.Ayuthaya, 41.Suphan Buri, 42.Prachin Buri, 43.Kanchanaburi, 44.Ratchaburi, 45.Phetchaburi, 46.Nakhon Nayok, 47.Samut Sakhon, 48.Pathumthani, 49.Nonthaburi, 50.Samut Prakan, 51.Chon Buri, 52.Cha Choeng Sao, 53.Rayong, 54.Chanthaburi, 55.Trat, 56.Samut Songkhram, 57.Prachuap Khiri Khan, 58.Chumphon, 59.Surat Thani, 60.Nakhon Si Thammarat, 61.Songkhla, 62.Phathalun, 63.Pattani, 64.Yala, 65.Narathiwat, 66.Ranong, 67.Phuket, 68.Phangna, 69.Krabi, 70.Trang, 71.Stoon

Figure 6 Percentage of Forest Area in Each Prefecture in 1973 and 1995

The prefecture-by-prefecture figures show that the only areas with a forest area rate of more than 60% are the four prefectures which make up Northern Thailand. Therefore, most of the stations in Thailand show either Phrae or Phisanulok type fog.

Among the different meteorological elements, annual mean minimum temperatures may be the most closely related to the trends in the number of foggy days. During the period of 1951-1995, the temperature increased remarkably in Northern Thailand, and there were clear differences between Mae Sariang and Mae Hon Son and other areas, as shown in Figure. 7(a). The rates of increase at Phrae, Chiang Mai and Phitsanulok reached 0.04°C/y, 0.03°C/y and 0.02°C/y for the period, respectively. On the other hand, the rates at Mae Sariang and Mae Hong Son showed zero or even negative values (-0.01°C/y at Mae Hong Son).



Bold lines in (a) show the trends of the changes at Mae Saring and Mae Hon Son and those in (b), (c) and (d), the trends at Phitsanulok and Chiang Mai.

Figure 7 Changes of Annual Mean Meteorological Elements at Selected Stations in Northern Thailand

It is also worthy to note the differences in the changes of meteorological elements between Phitsanulok and Chiang Mai with other areas, as indicated in Figures 7(b) and (c). Contrary to the report in Rungdilokroajn and Nimma (1990), which stated that the annual mean temperature for the period 1951-1989 increased remarkably all over Thailand, a further analysis of temperature during the period of 1951-1995 in this study shows that at the same time it fell in Northern Thailand. Even so, the temperatures at Phitsanulok and Chiang Mai have fallen strikingly, as shown in Figure 7(b). Figure 7(c) shows changes in annual mean relative humidity. In accordance with the changes of annual mean temperature, the humidity has increased, with the exception of two stations, which are, of course, Phitsanulok and Chiang Mai. Humidity in the cities has shown a remarkable decrease, at a rate of 0.18%/y. The changes in annual mean vapor pressure also show a large negative trend in both cities (Figure 7(d)).

Chiang Mai, with a population of 182,000 in 1996, is the largest city in Northern Thailand; Phitsanulok, with a population of 78,000, is the second largest. The rise in temperature there may be evidence of the progress of urbanization. Urbanization may affect the urban heat and humidity, which affect the number of foggy days. Although a city with a population of 180,000 doesn't normally receive recognition as being big, the trends in the number of foggy days in Chiang Mai and Phitsanulok are significantly similar to those in Tokyo and Osaka, Osaka being the second largest city in Japan (Nomoto and Takeyama, 1998). In the tropics, the phenomenon of urbanization has a greater influence on the air near the ground than in other climatic regions, especially in the dry season. It is thought that the recent decreases in the number of foggy days may be the result not only of deforestation, but also of urbanization. The minimum temperature has also been rising sharply, with the vapor pressure decreasing in other parts.

2.4 Deforestation and Monsoon Rainfall in Northern Thailand

Zhang (1986), studying the influence of deforestation on local climates in Xishuangbanna, pointed out that rainfall there had decreased remarkably in the late rainy season, and suggested that it was a result of the reduction of vapor pressure due to the deforestation. Recently, total annual rainfall has deceased all over Thailand (Rungdilokroajn and Nimma, 1990). However, as shown in Figure 8, which indicates the decade-averaged total amount of monthly rainfall at selected stations in Northern Thailand, most of the stations there have observed increasing rainfall in the early half of the rainy season. This increase may have been the result of an increasing Bowen ratio and increasing convective instability due to deforestation. On the other hand, the total amount of monthly rainfall decreased signally in the latter half of the rainy season, at the time of abatement of the SW monsoon, and may have been caused by decreasing evapotranspiration from the decreased forests. Kanae, et al.

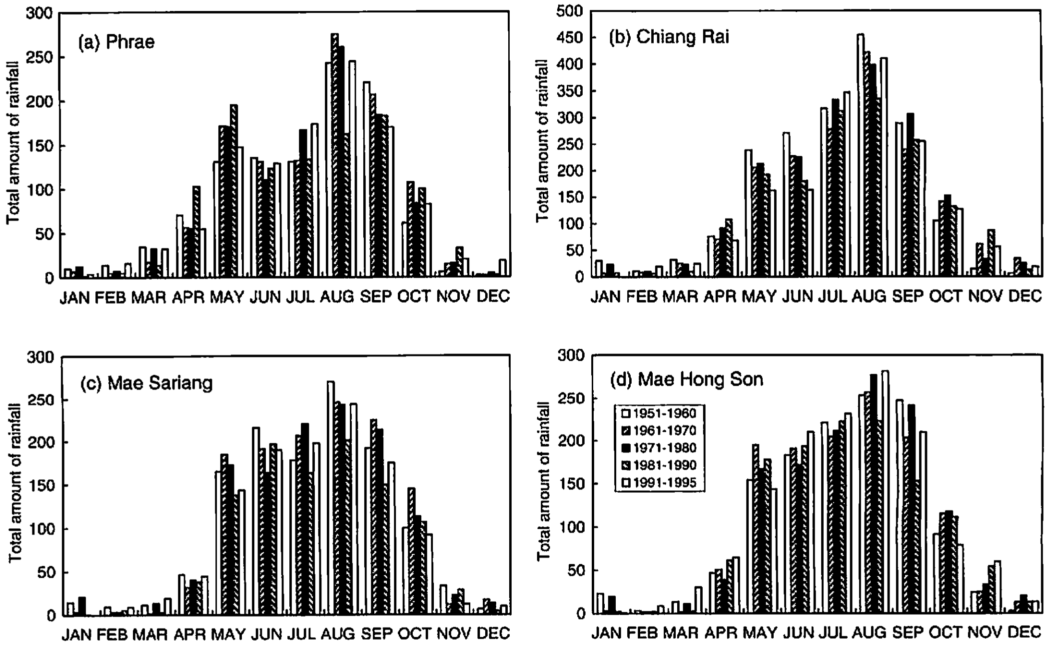


Figure 8 Decade-Averaged Total Monthly Rainfall at Selected Stations in Northern Thailand

(2001) studied the fluctuation of rainfall in and around Thailand in August and September using a numerical simulation, and were able to explain the decrease of rainfall in September by an alteration of the vegetation distribution.

Monsoon rainfall, even in Mae Sariang and Mae Hon Son, clearly demonstrates the effects of deforestation. In the near future, the pattern of foggy days in both stations could change to a Phrae type.

3. Changes in the Number of Foggy Days in Japan and Reduction of Paddy Field Area

3.1 Foggy Regions and Fog Seasons

Figure 9 shows a distribution of average annual foggy days (1961-1990) in Japan. The numbers are high in the inland mountainous region and in areas along the seas, especially those facing the Pacific Ocean. The highest (141 days) is recorded at Karuizawa in the mountainous region of central Japan, where slope fogs typically occur. Advection fogs occur with the most frequency along the Pacific coast of Hokkaido. Numbers there reach 112 days at Kushiro and 113 days at Nemuro. It is well known that radiation fog is typically seen in the inland mountainous basins. The numbers of annual foggy days exceed 100 days at Toyooka and Hitoyoshi.

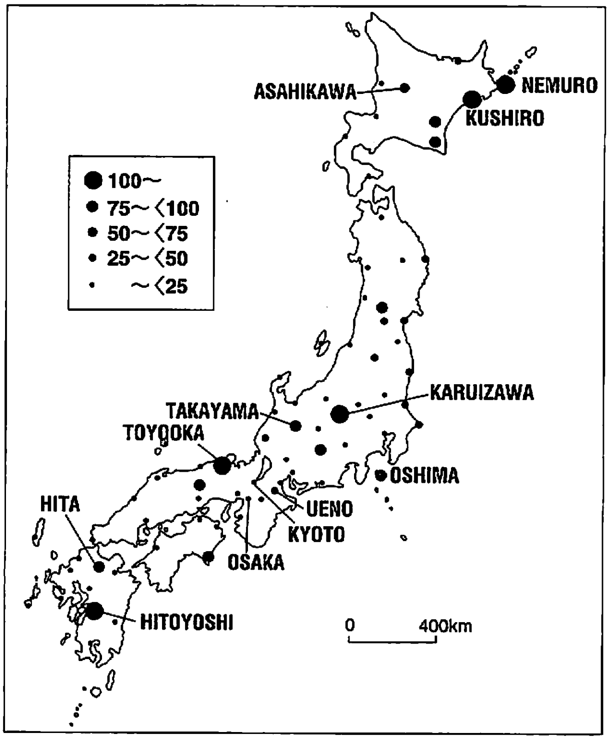


Figure 9 Distribution of Averaged Annual Foggy Days in Japan

The fog seasons in Japan are dependent on the different ways in which cooling affects fog formation. Figure 10 shows time distributions of foggy days. The maximum number of

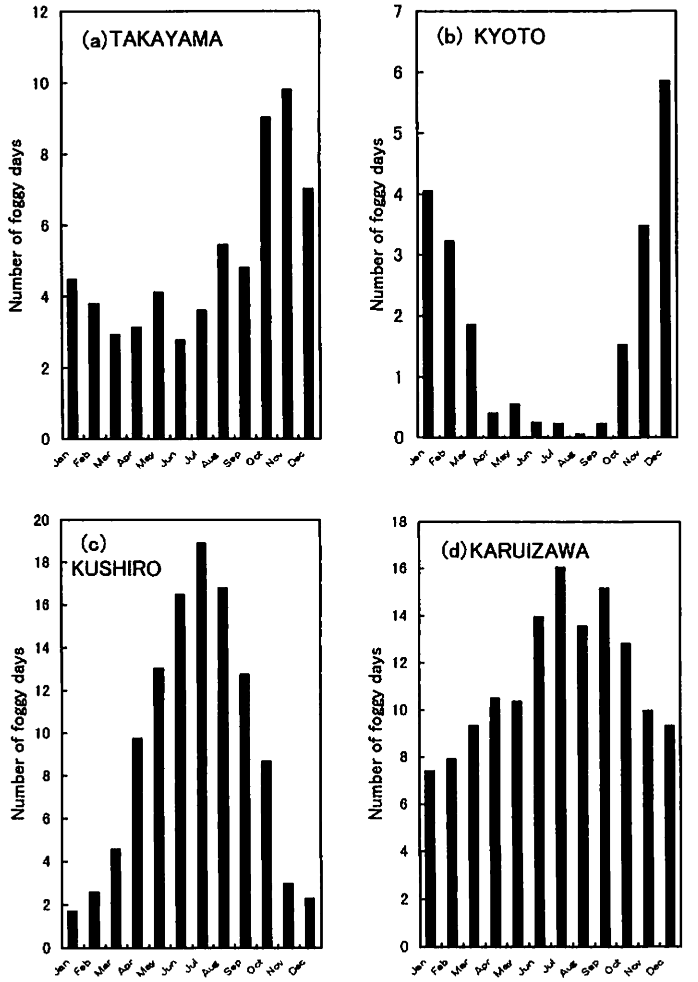


Figure 10 Time Distribution of Foggy Days at Selected Stations

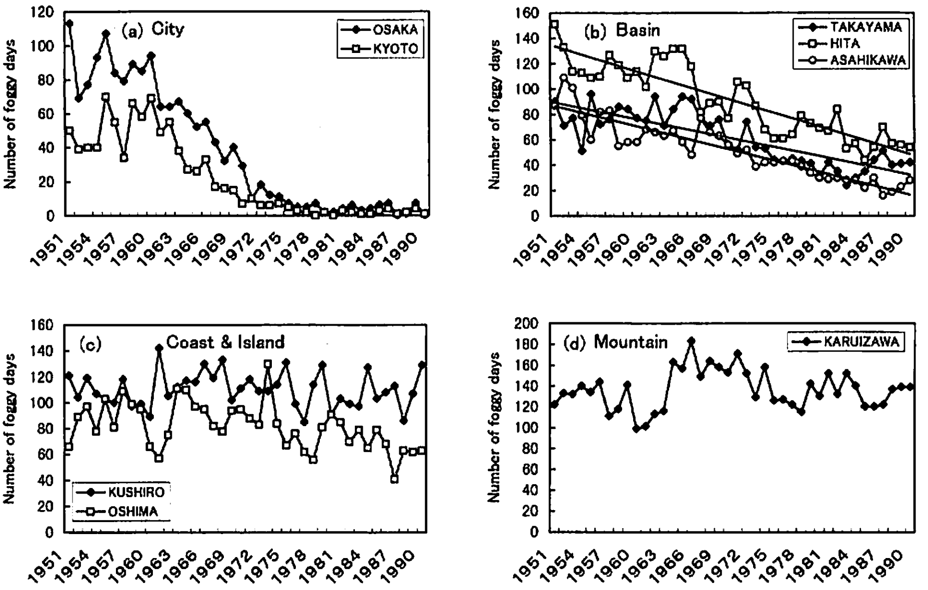
average monthly foggy days (1961-1990) in Takayama, a mountainous basin, was seen in November, because radiative cooling occurs at night due to the dry and stable air typically seen during this month (Figure 10(a)). Although fog occurs frequently there in the cold season, it is important to note the fact that the warm season also sees a small increase in the number of foggy days, which will be mentioned later.

Foggy days in Kyoto, a big city with a population of 1.39 million, shows a remarkable contrast between the cold and warm seasons (Figure 10(b)). Fog frequently appears in the cold season.

When warm air passes over a cold sea surface, advection fog is formed. At Kushiro, which lies on the Pacific coast of Hokkaido, foggy days in the warm season outnumber those in the cold season (Figure 10(c)). The numbers in mountainous regions also show a remarkable increase in the warm season, when warm and moist sub-tropical air advects into Japan (Figure 10(d)).

3.2 Recent Changes in the Number of Foggy Days

Figure 11 shows changes in annual foggy days at selected stations since 1951. Fog has been decreasing rapidly in two major cities (Kyoto and Osaka) since 1960, and there has been almost no fog there since 1970 (Figure 11(a)). Assuming that the trends of its period are linear, the rates of decrease reach 2.90 days per year at Osaka and 1.68 days/y at Kyoto, respectively. Several factors, such as the impermeability of certain areas and heat island phenomena, may affect the urban humidity field, which can control the number of foggy days.



Lines in (b) show the trend of the changes.

Figure 11 Changes of Annual Foggy Days at Selected Stations since 1951

It is also surprising that the number of foggy days decreased constantly in the inland mountainous basins throughout the period (Figure 11(b)). The rates of decrease reached 2.18 days/y at Hita in Kyushu, 1.46 days/y at Takayama, Central Japan and 1.79 days/y at Asahikawa, Hokkaido, respectively. If this trend continues into the future, the number of annual foggy days will hit zero at Hita and Takayama by the year 2013. Although Asahikawa city had a population of 362,000 in 1997, Takayama and Hita are relatively small cities with populations of 62,000 and 63,000. It can be said that the three stations showed especially large rates of decrease, and a similar tendency could be seen at most stations in mountainous basins all over the country.

On the other hand, coastal, island and mountain stations did not show the continuous decrease in annual foggy days (Figures 11(c), (d)). They appeared to fluctuate depending on the general atmospheric circulation.

Monthly foggy days may be a good indicator of annual changes in foggy days. Figure 12 indicates the decade-averaged monthly foggy days, with the 40 years (1951-1990) divided into four terms, at selected stations in the mountainous basins and big cities. Hita and Takayama saw a drastic change between the second and third decades, but only in the warm seasons, a fact that cannot be found out through an analysis of annual foggy days (Figures 12(a), (b)). The number of foggy days during the third decade was fewer than half of those

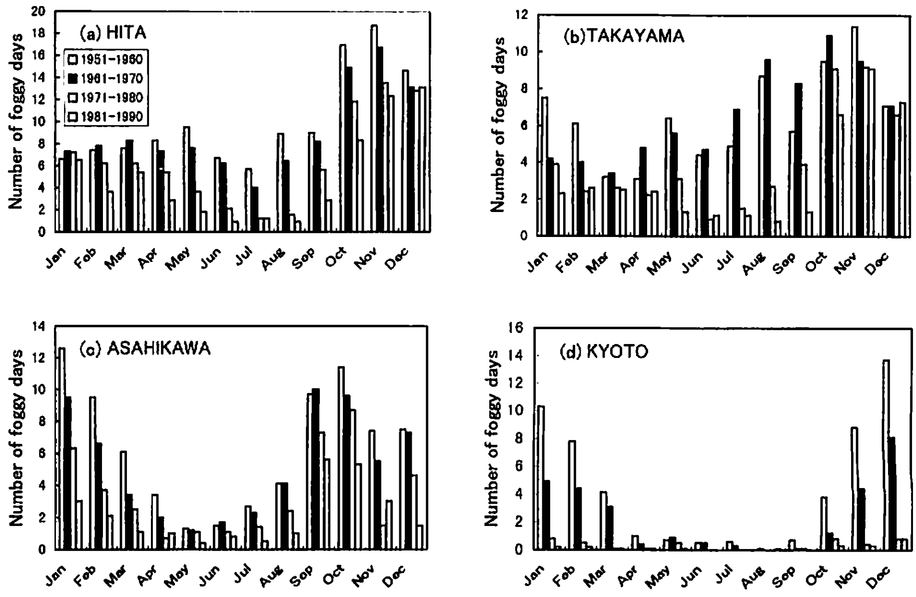


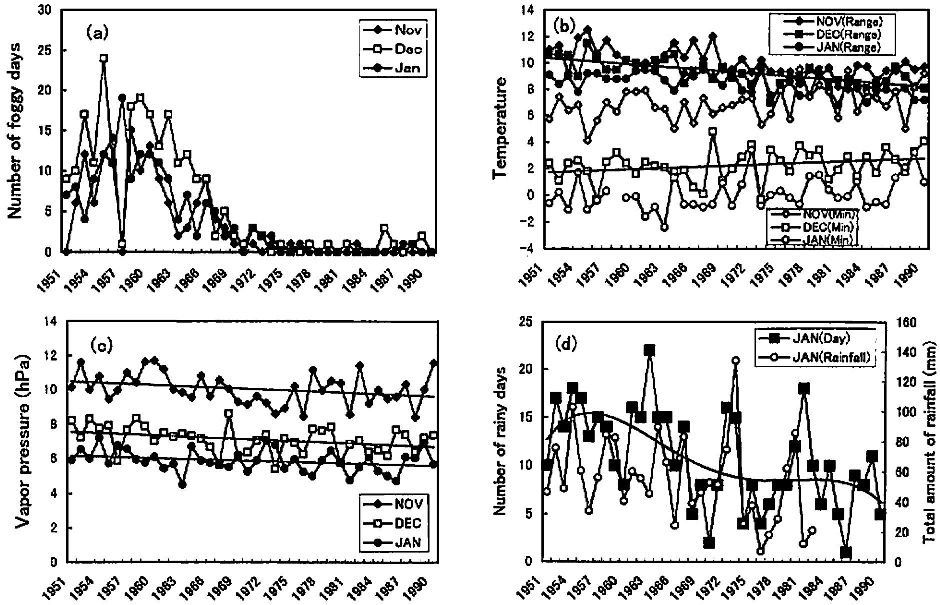
Figure 12 Decade-Averaged Monthly Foggy Days at Selected Stations in Mountainous Basins and Big Cities

of the second decade in the warm season. On the other hand, such changes cannot be seen in the cold season. The drastic decrease in the third decade throughout the warm seasons is also observed at many stations in the inland mountainous basins of Japan.

Asahikawa, which is shown in Figure 12(c), is one exception to the above-mentioned observation. The case of this mountainous basin in northern Japan, where the number of foggy days decreased gradually toward the fourth decade in each month, is different from those of Hita and Takayama. Because of the coarseness of this observational network, we cannot safely judge whether the case of Asahikawa is exceptional or whether this was a common change in the inland mountainous basins in Northern Japan.

As shown in Figure 12(d), the big city had a relatively small number of foggy days in and after the third decade, even in the cold season. It can be said that the environments for fog formation may have changed drastically in the third decade, and this should be witnessed by some meteorological elements.

Figure 13 shows the changes of monthly foggy days, along with some meteorological elements, in Kyoto during November, December and January. These months are in the fog season in Kyoto. The number of monthly foggy days increases at first, and then decreases rapidly (Figure 13(a)). As mentioned above, fog can be formed when the air near the ground is cooled sufficiently, or through the addition of enough water vapor to the air. However, there are no detectable meteorological elements that can explain the change in the number of monthly foggy days. The monthly mean minimum air temperatures rose slightly, while the diurnal ranges of air temperature decreased during the period (Figure 13(b)). The monthly mean vapor pressure in Kyoto decreased gradually during the period (Figure 13(c)). The number of rainy days and total amount of rainfall in January also decreased, although they showed extensive fluctuation throughout the period (Figure 13(d)). It is true that the changes seen in the meteorological data predict fewer foggy days, although the facts do not fit in with the predictions. In the case of city fog, we should take into consideration not only the urban



(a) Number of foggy days, (b) Minimum temperature and diurnal range of air temperature, (c) Vapor pressure and (d) Number of rainy days and total amount of rainfall.

Figure 13 Changes of Monthly Foggy Days and Meteorological Elements in Kyoto in the Cold Season

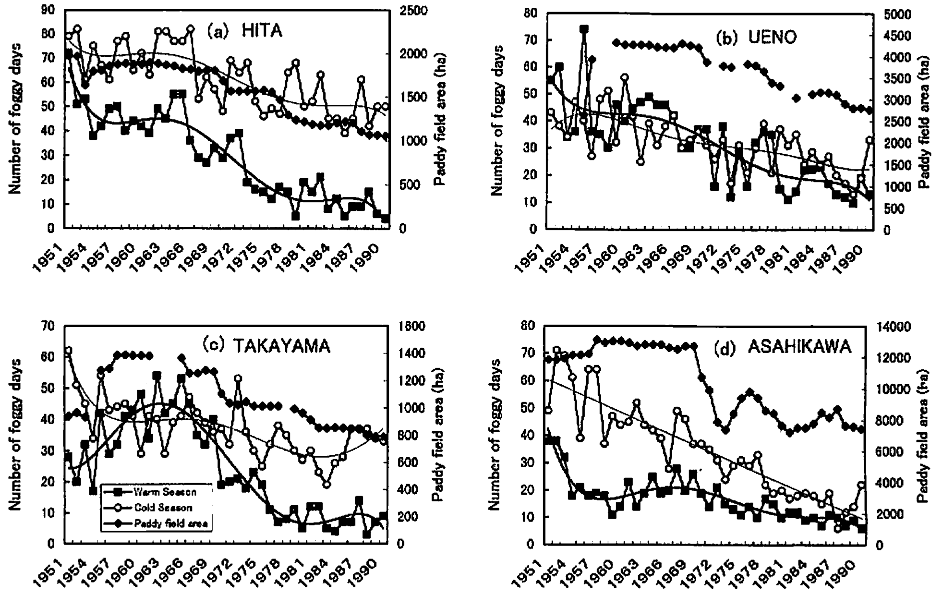
humidity and heat island phenomena, but also other factors such as air pollution.

3.3 Basin Fogs and the Reduction of Paddy Field Area

It can also be seen in the mountainous basins that changes in the monthly mean minimum air temperatures increased slightly, whereas the vapor pressure, number of rainy days and total amount of rainfall in each month decreased during the period. Furthermore, a possible cause for the decrease in the number of foggy days in the mountainous basins can be found.

Figure 14 shows the changes in total number of foggy days in the warm season (April-September), cold season (October-March) and of paddy field area in selected basins. A reduction of rice paddy field area has occurred all over Japan since 1969, following the Japanese government's food policy. The changes in paddy field area correspond well to those in the number of foggy days in the warm season, with the exception of the case of Asahikawa (Figure 14(d)). It is surprising that the correlation coefficients between paddy field area and foggy days in the warm season reach 0.92 for Takayama, 0.86 for Hita and 0.84 for Ueno. During the period, the paddy field area in the Takayama basin first increased (towards the early 1960s) and then decreased (since the middle of the 1960s). The changes in paddy field area strongly affected the number of foggy days in the warm season, which increased towards the early 1960s and have decreased since the middle of the 1960s.

The fact that the paddy field area there fell from 1,400 ha in the first half of the 1960s to 800 ha in 1990 indicates the loss of a vast amount of water vapor supply to the basin air.



Bold lines show the trend in the number of foggy days in the warm season and thin lines, those in the cold season.

Figure 14 Changes in Total Amount of Foggy Days in the Warm Season (April-September) and in the Cold Season (October-March) and of Paddy Field Areas

4. Conclusion

From this study, we can draw the following conclusions on recent changes in the number of foggy days in Thailand and Japan.

In Thailand, the number of foggy days begins to increase at the end of the rainy season, reaching a maximum in the middle of the dry season. The dry season is also considered the fog season.

During the period of 1951-1995, the number of annual foggy days decreased throughout Thailand. The rates of decrease reached 2.01 days per year at Phrae and 2.04 days/y at Surat Thani. In Northern Thailand, the trends of foggy days can be classified into three types. In the Mae Sariang type, the decrease in foggy days could be confirmed only at the months of the start or the end of the fog season. On the other hand, in the Phrae type, it was observed in each month throughout the fog season. Most of the stations in Thailand showed either Phrae or Phitsanulok type fog.

Among some meteorological elements, the minimum temperature and the vapor pressure may give us information concerning the decrease of foggy days. The minimum temperature has been increasing drastically all over Thailand during the period and its tendencies have relationship with the magnitude of decreasing foggy days. The author cannot safely judge why the minimum temperature has been increasing rapidly and the vapor pressure decreasing all over the country. In Northern Thailand, the high increase of the minimum temperature and the high decrease of the vapor pressure are observed in big cities, which may be caused by urbanization.

Although fog is a local phenomenon, data on the forest area rate (by prefecture) is informative of the tendency of the number of foggy days. Many prefectures in Northern

Thailand had rich forests in 1973, but saw the area halve by 1995. Even so, Mae Hong Son Prefecture has retained high coverage to date. Mae Sariang and Mae Hong Son, which are located in the prefecture, did not show a continuous decrease of foggy days. Further research on the local forest area and land use will aid in understanding the decrease in foggy days in Thailand.

In Japan, the number of annual foggy days has also fallen strikingly in the mountainous basins and big cities in recent years. The decrease rate reached 2.90 days per year at Osaka and 2.18 days/y at Hita.

At many stations in the mountainous basins, the number of foggy days decreased in the warm season. On the other hand, those in big cities decreased throughout the year, with fog being rare since 1970.

A reduction of paddy field area may affect the number of foggy days in the warm season. Correlation coefficients between the changes of paddy field area and foggy days in the warm season reached 0.92 at Takayama, 0.86 at Hita and 0.84 at Ueno. In order to carry this work further, it is essential to take into consideration detailed observations of the basins and to conduct numerical simulations.

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