P1B.3 SEASONAL CHANGES OF THE AIR PARCEL'S TRAJECTORIES ARRIVING AT THE JAPAN AREA

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1. INTRODUCTION

Air quality around the Japan area changes according to the alternation of marine and continental air mass. Basically, a continental air mass has a high concentration of anthropogenic aerosol and dust, while a marine air mass has a low one. As proposed by many researchers, the anthropogenic aerosol may be carried from the Asian continent to the Northwest Pacific Ocean by long-range transport (e.g. Uematsu et al., 1992; Kaneyasu et al., 2000; Jordan et al., 2003). Since a sharp increase in atmospheric air pollutants from Eastern Asia is expected to continue in the near future (van Aardenne et al., 1999; Streets and Waldhoff, 2000), the impacts of anthropogenic aerosol on plants and human health will become more apparent around the Japan area. However, the anthropogenic and natural aerosols are widely distributed with the interannual and seasonal variability around the Japan area. Then it is important to examine the source and transport pathway of the continental and marine air mass arriving at the Japan area.

So far, many researchers have analyzed the air parcel's trajectory to examine the source and transport pathway of polluted air mass observed around the Japan area. For example, Mukai and Suzuki (1996) analyzed the relationship between air parcel's trajectories and aerosol constituents in order to characterize the aerosol transport to the Oki Island for the period of three years. They show that the seasonal changes of aerosol constituents during a given month were related to the variation of the air parcel's trajectories. It is considered that the seasonal variation of atmospheric circulation in East Asia strongly influences the transport process of aerosols arriving at the Japan area. The influence of activity and structure of atmospheric circulation on the seasonal feature of air parcel's trajectories arriving at the Japan area, however, was not well understood in detail. Examining the seasonal changes of air parcel's trajectories arriving at the Japan area, the relationship between atmospheric circulation and the probability distribution of source and transport pathway of the air parcels were investigated.

2. AIR PARCEL'S TRAJECTORY

In this study, air parcel's trajectories were calculated using wind fields in sigma coordinate. We used grid point values of geopotential height and wind component from the NCEP/DOE AMIP-II re-analysis data (Kanamitsu et al., 2002). The wind fields given on a grid with a temporal resolution of 6 hours, a horizontal resolution of 2.5 degrees in longitude and latitude, and a vertical resolution of 17 levels were used. Applying a linear interpolation in time and space, the new position of the air parcel was calculated by an iterative procedure every 1 hour. Sigma vertical velocity was calculated from pressure vertical velocity, surface pressure, and wind component near the surface.

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3. RESULTS

In order to examine the air parcel's trajectories arriving at the Japan area, the seven-day backward air parcel's trajectories arriving at Kyushu (32.5N, 131.0E) and Hokkaido (43.5N, 142.5E) regions were calculated from January to December 2001. The backward trajectories of air parcel started at level of sigma=0.85 (1400-1500m in altitude), and were calculated each day at 00UTC, 06UTC, 12UTC, and 18UTC.

The results show that the air parcel's trajectories arriving at those areas for one year were widely

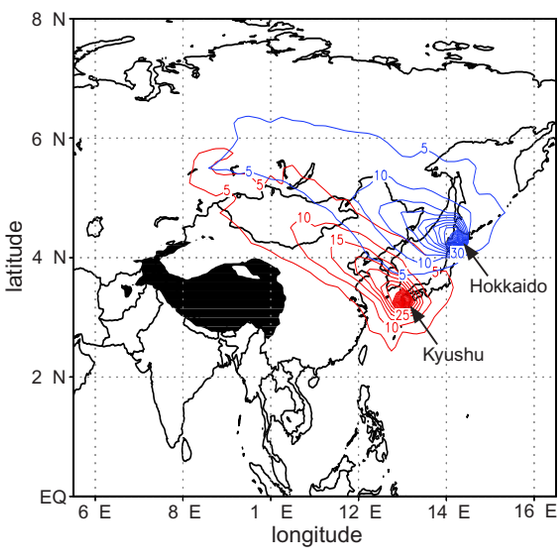

Figure 1. Probability distribution of transport pathway of air parcels arriving at Kyushu (red contour) and Hokkaido (blue contour) from January to December 2001. Contour lines are given at 5% interval. The seven-day backward air parcel's trajectories started at level of sigma=0.85. Black areas indicate elevation higher than 3000m in altitude.

distributed over Eurasia and Pacific Ocean. Few trajectories passed over the area south and west side of the Tibetan Plateau. In order to evaluate the trajectory distribution, the probability distribution of transport pathway of air parcel was investigated. The probability of transport pathway was estimated by counting the trajectories in 2.5 x 2.5 (degree) longitude-latitude columns at a grid.

Figure 1 shows the probability distribution of transport pathway of air parcels arriving at Kyushu and Hokkaido from January to December 2001. The probability of transport pathway of air parcel arriving at those areas was relatively high over the east coast of Asian continent including Japan, north China, Mongolia, and Siberia. This suggested that the transport of air parcels arriving at the Japan area was mainly influenced by westerlies. In order to characterize the transport pathway of air parcel arriving at Japan area, the seasonal features of probability distribution were examined. It was found out that the probability transport pathway of air parcel arriving at those areas was changed with season.

Figure 2 shows the probability distribution of transport pathway of air parcels arriving at Kyushu

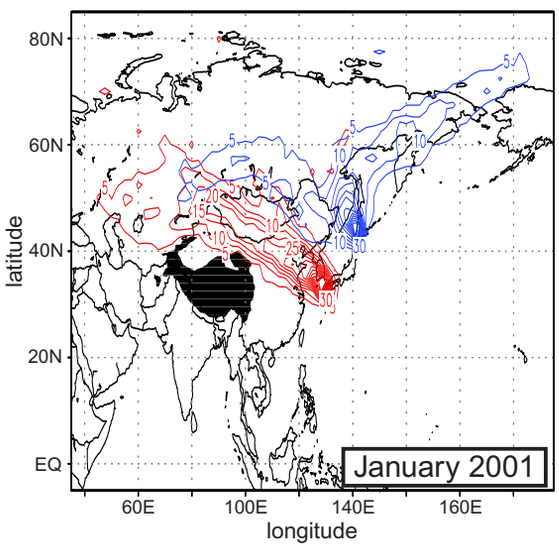

Figure 2. Probability distribution of transport pathway of air parcels arriving at Kyushu (red contour) and Hokkaido (blue contour) in January 2001. The contour interval is 5%. Black areas indicate elevation higher than 3000m in altitude.

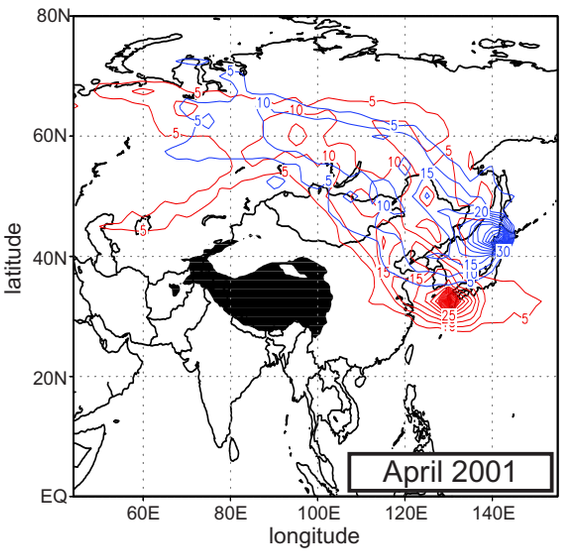

Figure 4. The Same as in Fig. 2, except for April 2001.

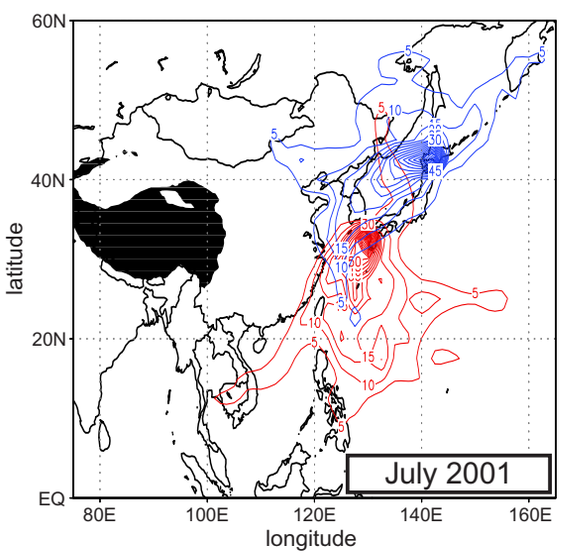

Figure 3. The Same as in Fig. 2, except for July 2001.

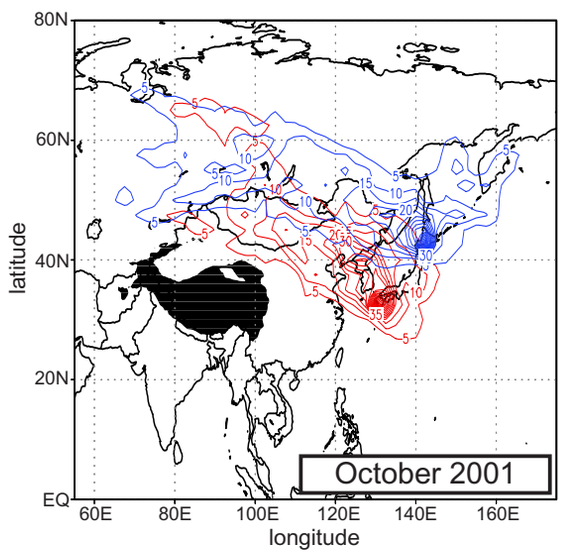

Figure 5. The Same as in Fig. 2, except for October 2001.

and Hokkaido in January 2001. It can be seen that the air parcels arriving at Kyushu were often transported over north and northeast China. The Kyushu region was strongly influenced by continental outflow. Some of the air parcels were descended from higher than about 5000m in altitude. Since major area of seven-day backward position of the air parcels (not shown) were seen around central Asia, atmospheric circulation in which air parcels started from central Asia, moved eastward along the northern boundary of the Tibetan Plateau, and then arrived at the Kyushu region in boundary layer, are considered to prevail in this month. It can be seen, however, that the air parcels arriving at the Hokkaido region passed through the two main courses. In addition to the outflow of Siberian continental air mass, the marine air masses from the Sea of Okhotsk and near Alaska were frequently transported toward the Hokkaido region.

Probability distribution of transport pathway of air parcels arriving at Kyushu and Hokkaido in July is shown in Figure 3. It is found that the probability transport pathway of air parcels arriving at Kyushu was relatively high over East China Sea, Pacific Ocean, and Philippine Sea. The transport of marine air mass toward the Kyushu region was prevailed in this month. On the other hand, high probability transport pathway of air parcels arriving at Hokkaido distributed over the Sea of Japan, Japan, Korea, northeast China, and East China Sea. It is considered from these results that continental air masses from the east coast of Asian continent including Japan and Korea were often transported to the Hokkaido region, though marine air masses from the Sea of Japan and East China Sea were transported toward the Hokkaido region. Since the transport distances were relatively short despite the seven-day backward trajectories, the air parcels moved slowly toward the Hokkaido region. Figure 4 and 5 are same as Fig.2, except for April and October 2001, respectively. These figures indicated that both Kyushu and Hokkaido region were mostly affected by continental air mass. Especially in April 2001, major air parcels arriving at the Kyushu region were transported over Siberia and northeast China, similar to those arriving at the Hokkaido region.

On the basis of above results, it was concluded that the source and transport pathway of air parcel arriving at those areas were greatly different in summer and winter, although the Kyushu region is close to the Hokkaido region from a point view of global scale. Therefore, the findings suggested that, especially in summer and winter, the properties of air parcel arriving at those areas were also different.

In order to understand the influence of atmospheric circulation on air parcel transport, the relationship between the trajectory pattern and the synoptic meteorological condition in East Asia was analyzed. It was suggested that the features of air parcel transport in summer was associated with the activity of the Pacific high and weak westerly flow around the Japan area. It was also suggested that in winter, the effluent of Siberian anticyclone and the passage of trough around the Japan area played an important role in transport of air parcel arriving at the Japan area. It is considered from these findings that the seasonal variability of Pacific and Siberian high pressure systems contributed to the seasonal features of air parcel's trajectories arriving at the Japan area.

4. SUMMARY

The seven-day backward air parcel's trajectories arriving at Kyushu and Hokkaido regions in boundary layer were calculated from January to December 2001. The results showed that the probability transport pathway of air parcels arriving at those areas for one year were high over the east coast of Asian continent including Japan, north China, Mongolia, and Siberia, and the seasonal change occurred. Although the Kyushu region is close to the Hokkaido region from a point view of global scale, the probability distribution of transport pathway of air parcels arriving at those areas was greatly different especially in summer and winter. It is suggested that the seasonal variability of Pacific and Siberian high contributed to the seasonal features of air parcel's trajectories arriving at the Japan area.

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