DISTRIBUTION OF AIR POLLUTANTS IN NORTHEAST ASIA ACCORDING TO SYNOPTIC METEOROLOGY IN MAY 1999

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1. INTRODUCTION

Northeast Asia is one of the most densely populated areas in the world. The rate of economic development in this area is among the World's fastest. Huge amount of air pollutants emitted in the area transports to the east along with prevailing westerlies (Jaffe et al., 1999).

In spring of Northeast Asia, migratory anticyclones are frequent. Transport and distribution of air pollutants can be substantially altered according to the locations of anticyclones.

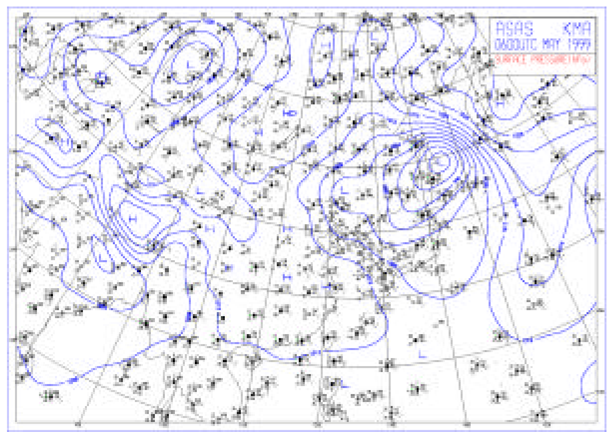
In this work, two different synoptic meteorological conditions associated with different locations of anticyclones in May 1999 were identified. The characteristics of pollutant distribution in these meteorological conditions were predicted and compared. Models-3/CMAQ (Models-3/Community Multi-scale Air Quality; USEPA, 1999) and MM5 (PSU/NCAR Mesoscale Modeling System; Dudhia et al., 1999) were used to predict air quality and meteorology, respectively.

2.0 MODELING

2.1 Target domain and period

The modeling domain was 5,184 km × 3,456 km centering on the Korean Peninsula (130^{o} N, 40^{o} E). The grid size was 108 km × 108 km and the number of grids was 48 in the west-east direction and 32 in the south-north direction. The number of layers in the vertical direction was six to the height of 500 hPa. The Lambert Conformal projection was used for the map.

The modeling started at 00:00 GMT (Greenwich Mean Time) on May 3 and lasted till 18:00 GMT on May 12, 1999. The two periods of May 6-7 and May 11-12 were selected to analyze the transport and distribution of pollutants (Figure 1). In the former case, a strong cyclone was



<May 6, 00:00 GMT>

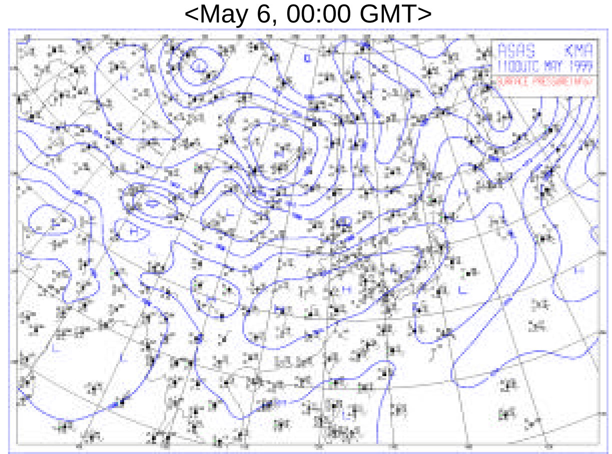


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Fig. 1 Synoptic meteorological fields for selected episodes.

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located on the east side of the Korean Peninsula and a weak anticyclone located on the west side. As a result, the isobars were arranged the south-north direction over the Korean Peninsula. In the latter case, a weak anticyclone was broadly located from the southern China to the Korean Peninsula. It was expected that wind blown out anticyclonically over the Korean Peninsula.

2.2 Input data

The emission data were taken from Carmichael (2002) prepared for ACE-Asia (Asian Pacific Regional Aerosol Characterization Experiment) (Figure 2). Diurnal variation of the emissions was assumed constant for 24 hours. The default data set provided with MM5 was used as the landuse data. Sample data provided for the test run of Models-3 (probably clean air conditions) were used for initial and boundary conditions. The first 39 hours were devoted to a spin-up period in order to minimize the influence of assumed homogeneous initial conditions. The GDAPS (Global Data Assimilation and Prediction System) data of six-hour interval were used for initial and boundary conditions of MM5.

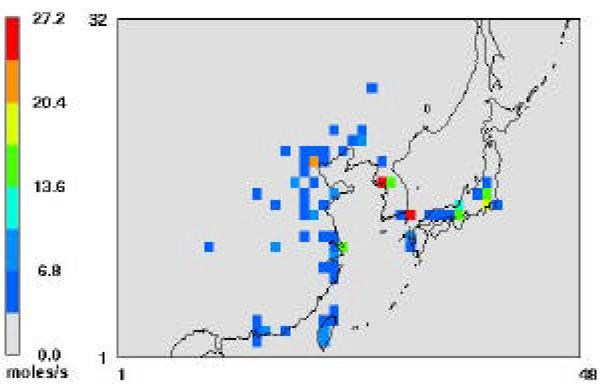

Fig. 2 Distribution of NO_2 emissions.

3.0 RESULTS AND DISCUSSION

3.1 Comparison with observation

Ozone, NO_2, and SO_2 concentrations predicted in Seoul, Korea are compared with observed ones in Figure 3. The range of variations in predicted ozone concentration is similar to that of observed ones. However, ozone concentration is somewhat overpredicted for the latter two days. The diurnal variations of NO_2 and SO_2 predictions are larger than those of the observed ones.

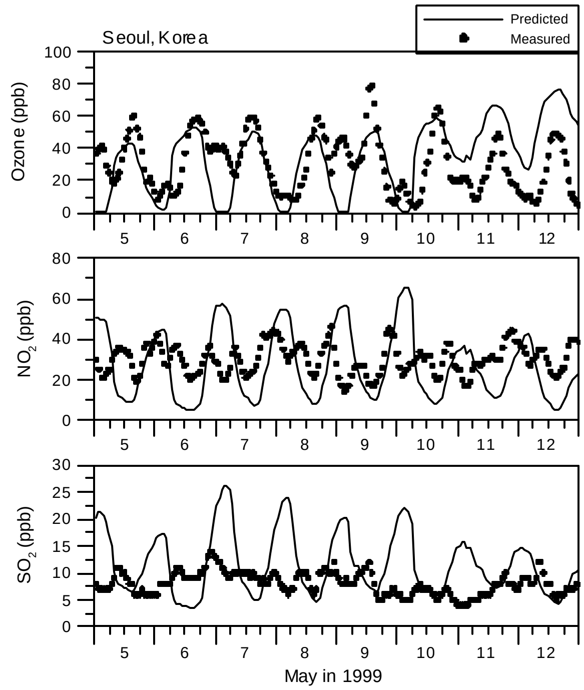

Fig. 3 Comparison of predicted and observed concentrations in Seoul, Korea.

3.2 Episode I – May 6, 1999

Wind field at 00:00 GMT on May 6 is shown in Figure 4. Easterlies persist over the southern China. Winds blow upward to the north in the inland area of China and blow to the west from the northeast of China to the north of Japan. On the other hand, northerlies and north-easterlies are prevailing in the southern part of the Korean Peninsula, southern Japan, and Taiwan.

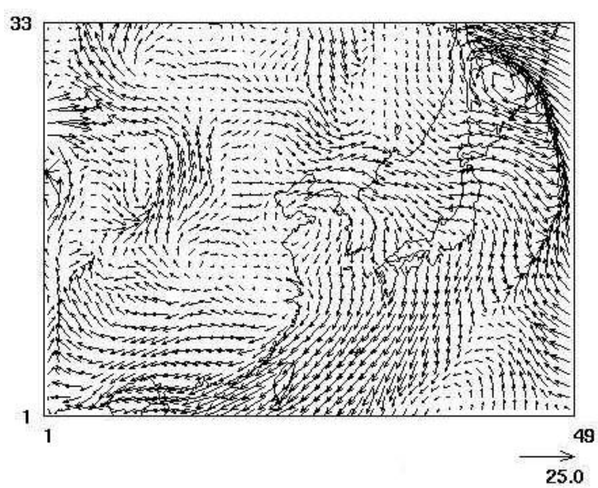

Fig. 4 Wind field at 00:00 GMT on May 6, 1999.

NO$_2$ did not show a characteristic of long rang transport. Instead, it showed high concentration near emission sources, especially at nighttime when the mixing height was low. However, this high concentration near the emission sources could be exaggerated because a constant emission rate without diurnal variation was assumed.

Figure 5 shows the distribution of ozone concentration at 06:00 GMT on May 7. The peak concentration appears on the eastern coast of China where emission is high. The time of 06:00 GMT corresponds to 2 to 3 pm LST in this area. Ozone concentration is higher than 50 ppb in most areas including the ocean. It means that most areas of the northeast Asia is under the influence of anthropogenic emissions.

It is interesting to note that ozone concentration to the south of the Korean Peninsula including Jeju Island is higher than that in the greater Seoul area (in the middle of the Korean Peninsula). In reality, not only predicted concentrations of ozone, CO, and PAN but also observed concentrations of ozone and CO (PAN was not measured) at Gosan in Jeju Island increased from May 5 to 7. It can be surmised that the duration of northerly winds over the Korean peninsula transported pollutants emitted in the Korean Peninsula to the south of Korean peninsula and Jeju island.

PAN may serve as a useful indicator of photochemical air pollution caused by long-range transport (Finlayson-Pitts and Pitts, 1986). Near the emission sources where ozone concentration is high, PAN concentration is also high. But high concentration of PAN appears at the inland area of China where emission is very low. This was due to long-range transport of pollutants caused by continuing westerlies in the southern part of China (Figure 6).

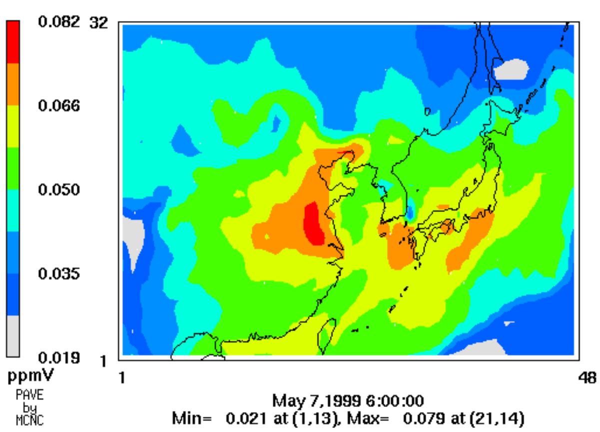

Fig. 5 Distribution of ozone concentration at 06:00 GMT on May 7, 1999.

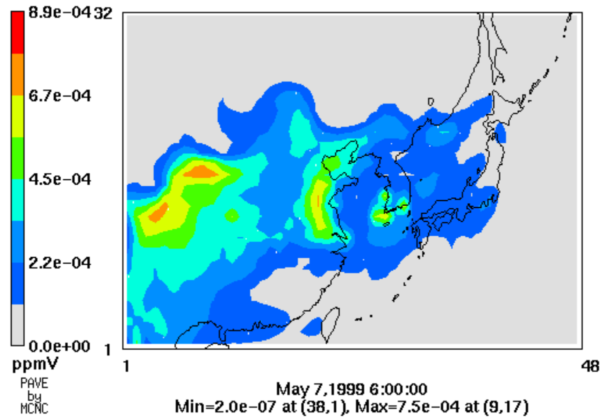

Fig. 6 Distribution of PAN concentration at 06:00 GMT on May 7, 1999.

3.2 Episode II – May 11, 1999

Wind field at 18:00 GMT on May 11 is shown in Figure 7. Westerlies are prevailing over the northestern China, Korean peninsula and Japan.

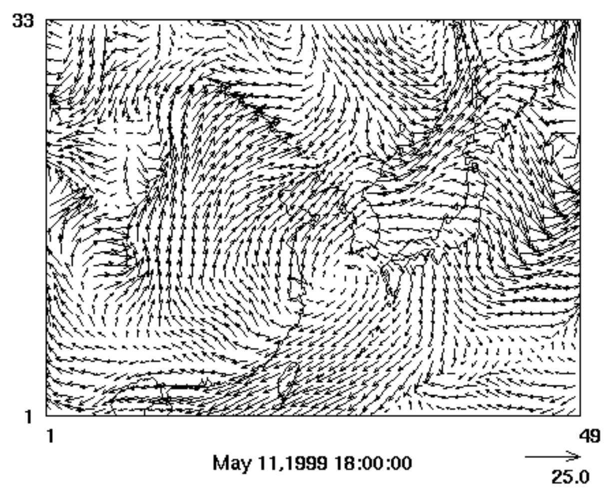

Fig. 7 Wind field at 18:00 GMT on May 11, 1999.

As shown in Figure 8, high concentration of ozone is expanded to the east of China with strong westerlies at 06:00 GMT on May 12, 12 hours later from Figure 7. As a result, it resides over a wide area centering on the Korean Peninsula. PAN distribution more clearly shows the eastward transport of high concentration cloud of photochemical pollutants from the Yellow Sea to Japan (Figure 9).

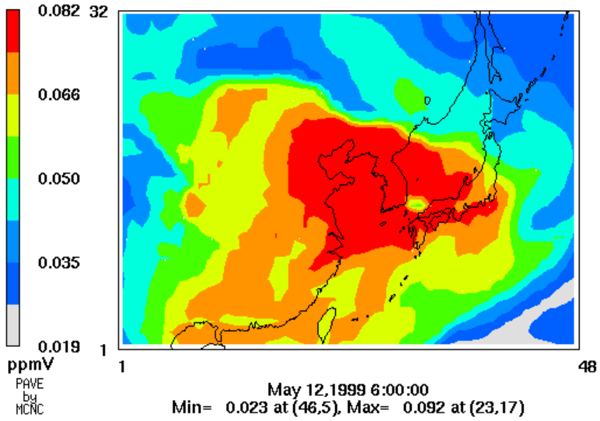

Fig. 8 Distribution of ozone concentration at 06:00 GMT on May 12, 1999.

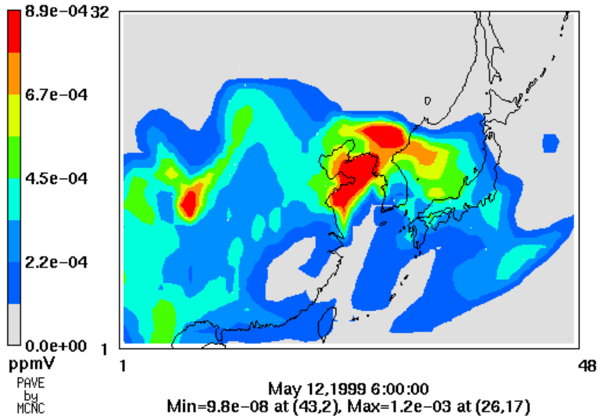

Fig. 9 Distribution of PAN concentration at 06:00 GMT on May 12, 1999.

4.0 ACKNOWLEDGEMENTS

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