26. Study on Distribution of NO_2 and SO_2 Concentration Over Jakarta Area, Indonesia

ジャワ島西部の局地風がジャカルタの大気汚染に与え得る影響

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ABSTRACT: We conducted field observation for air quality over Jakarta city using a number of passive samplers for NO_2 and SO_2 in August 2004 in dry season and for NO_2 , NO_x, SO_2 and O_3 in March 2006 in rainy season. Observed values show that local field has effected air pollution distribution both horizontal and vertical. The sea breeze circulation that was stronger in August (dry season) caused air pollutant concentration in northern part of Jakarta has become lower than March (rainy season). In August vertical structure has more become complex caused the vertical distribution of concentration more not uniform than March.

KEYWORDS: Jakarta, air pollution, local flow, sea breeze

1. Introduction

For planning of long term better air quality, we conducted field observation for air quality over Jakarta city using a number of passive samplers for NO_2 and SO_2 in August 2004 in dry season and for NO_2 , NO_x, SO_2 and O_3 in March 2006 in rainy season. The samplers were distributed in 50 locations to measure 1 week averaged concentration distribution. The observed values, contours of air pollutants were plotted. This paper reports comparison of air pollution between dry and wet (rainy) season.

2. Meteorological Condition of Jakarta in dry and rainy seasons

Climate in Indonesia is classified roughly into two types in a year, one in the "rainy" season from November to March, and the other in the "dry" season from May to September. A few weeks in April and October are the transition periods between the dry and wet seasons.

We performed numerical simulation over western Java area using the MM5 due to investigate the characteristics and the development mechanism of complex local flows during dry and rainy season in some typical days. The simulations were done for the typical days of rainy season on 8-13 February 2001 and for typical days of dry season on 6-19 August 2004. Latitude and longitude at the southwest and northeast corners of the outermost domain were 8^0 S and 105^0 E, and 5^0 S and 109^0 E, respectively. The domain system used in this calculation is a triply nested two-way interacting mesh.

Figure 1a shows calculated nocturnal flow event under typical synoptic wind flow on 9 August

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2004 at 0100 LST in dry season over Western Java Island. The southeasterly synoptic scale wind is blocked near surface level by the mountains along the south coast of Western Java Island, leading to induced local flow phenomena such as upstream blocking and streamlines dividing.

The local flow over Jakarta in the morning is characterized by weak surface wind. The sea breeze was formed over Jakarta, started at 1300 LST. With continued heating, the sea-breeze over Jakarta strengthens throughout the day. At around 1800 LST (Fig. 2a) the strength of the sea breeze reaches a maximum (about 5 ms^{-1}) penetrated further inland till 50 km far. By 1900 LST (not shown) the sea-breeze circulations gradually decay due to the decreased surface-heating rate. During the transition period, the northerly sea-breeze circulation is still present over the Jakarta area until 2000 LST. By 2100 LST the sea breeze is stop and the area characterized by weak wind.

(a) (b)

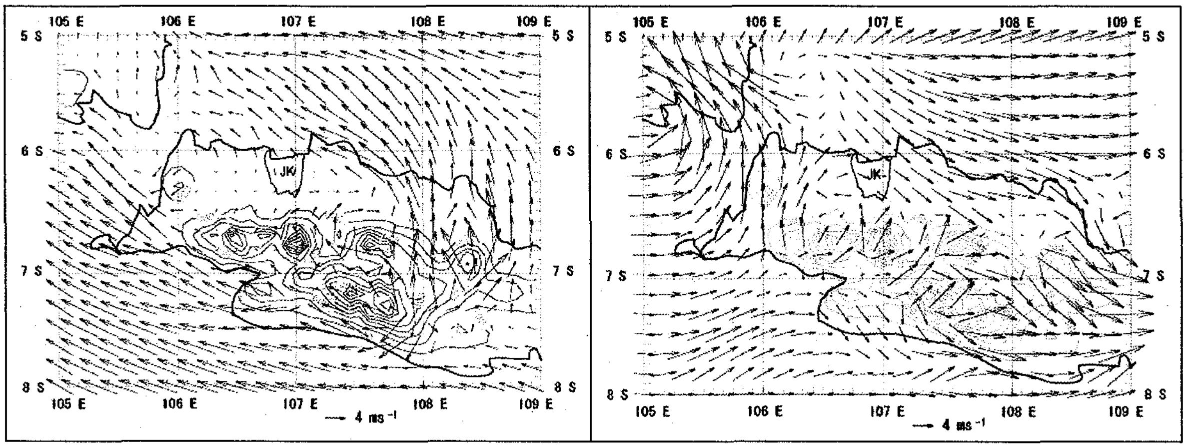

Fig.1. Calculated near-surface wind field over the Java Island (a) in dry season on 9 Aug 2004 at 0100 LST (b) in rainy season on 9 Feb 2001 at 0100 LST.

(a) (b)

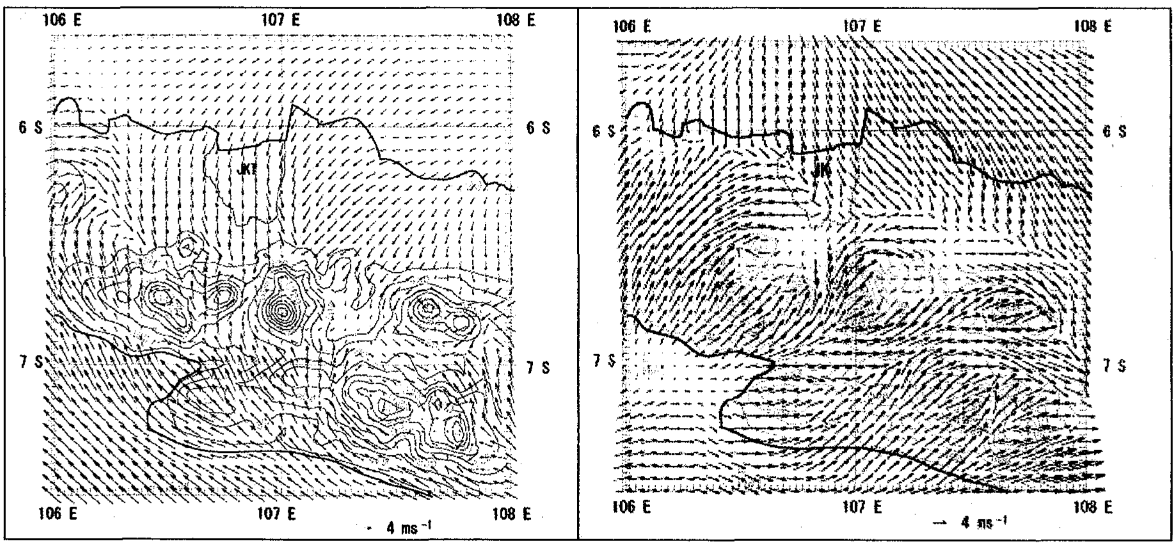

Fig.2. Calculated near-surface wind field over the Jakarta area (a) in dry season on 9 Aug 2004 at 1800 LST (b) in rainy season on 8 Feb 2001 at 1300 LST.

Figure 1b shows calculated nocturnal flow event typical of synoptic wind flow on 9 February 2001 at 0100 LST in rainy season over Western Java Island. On sunny day, i.e. on 9 Feb, land sea temperature difference is about 5 K during the daytime, and about 1 K during the nighttime. Hence sea breeze probably can be developed. However, on cloudy day, i.e. on 10 Feb (see Fig. 2b), sea breeze can not develop long time and can not reach further inland.

As shown in Fig. 2a, in dry season, the sea breeze developed on 9 August which penetrated to around 50 km from the coast of Jakarta and reach maximum penetration at 1800 LST. However, in rainy season, as shown in Fig. 2b, the weak sea breeze arrived between 1200 and 1300 LST, which penetrated to around 20 km from the coast of Jakarta. In this season, over Java area a synoptic scale convergence line is formed by WSW and NW winds (see Fig. 3). This synoptic WSW wind blowing over Java tends to prohibit inlandward further advancement of the sea breeze. Depth of the sea breeze in rainy season is also deeper than dry season. In rainy season, the subsidence behind the convergence line by the synoptic WSW wind and the sea breeze from Java sea causes upper part of the sea breeze layer was warmed after 1500 LST and thus the depth of the sea breeze was suppressed. In rainy season, Jakarta area is divided into two regions which are be separated by a convergence line (a convection line); there are the eastern part that be affected by marine air and the western part that not be affected.

The wind speed in August was lower than March; the monthly average wind speed in August and March were 2.5 ms^{-1} and 2.9 ms^{-1}, respectively. Therefore, the surface temperature in August was higher than March; the monthly average surface temperature in August and March were 27.5 ^{0}C and 27.1 ^{0}C, respectively.

3. Comparison of Air Pollution Concentration in Rainy and Dry Season in Jakarta

We conducted field observation for air quality over Jakarta city using a number of passive samplers for NO_2 and SO_2 in August 2004 in dry season and for NO_2 , NO_x, SO_2 and O_3 in March 2006 in rainy season. The samplers were distributed in 50 locations to measure 1 week averaged concentration distribution. The observed values, contours of air pollutants were plotted.

As described above, in Jakarta, the sea breeze in August penetrated longer further inland than in March. As a result, SO_2 concentration in northern part of Jakarta in August (Fig. 3a) was lower than in March (Fig. 3b). In March (Fig. 3b), westerly wind speed was higher than August, consequently, SO_2 concentration in western part of Jakarta was lower than August. However, average SO_2 concentration in March 2006 was higher than August 2004 because economic activity has increased about 1.3 times. The average SO_2 concentration in March and August were 3.72 ppb and 2.97 ppb, respectively.

Local flow field, i.e. sea breeze, also affected distribution concentration of NO_2. Thus, NO_2 concentration in northern part of Jakarta in August (Fig. 4a) was lower than in March (Fig. 4b).

Therefore, average NO_2 concentration in March 2006 higher than August 2004 because economic activity has increased about 1.3 times. The average NO_2 concentration in March and August were 28.2 and 17.6 ppb, respectively.

(a) August 2004 (b) March 2006

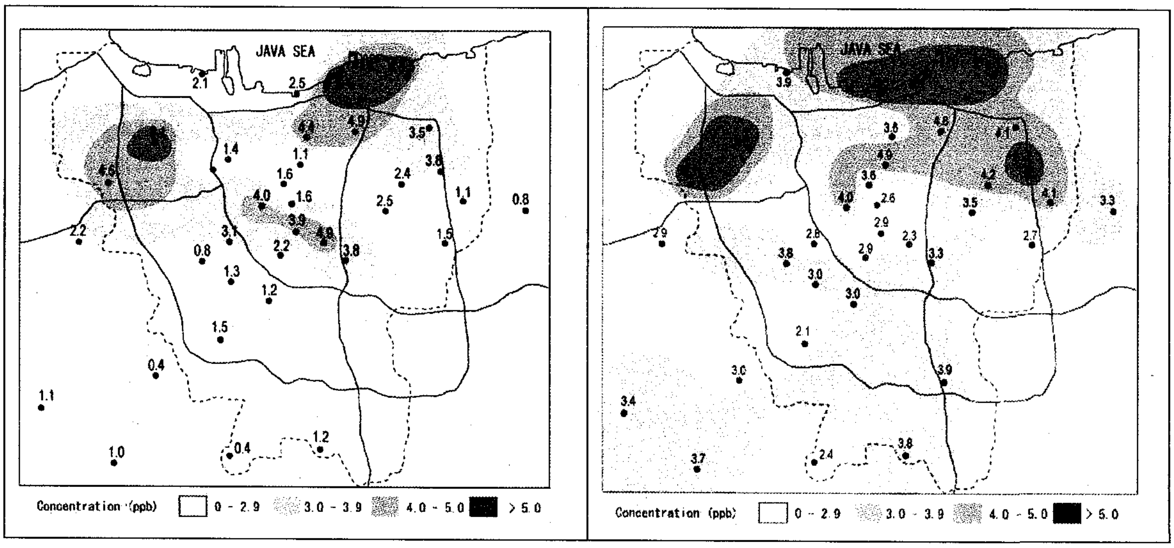

Fig. 3 Observed spatial distribution of SO_2; measured with 50 passive samplers distributed over the greater Jakarta during 1 week measurements in (a) August 2004 and (b) March 2006.

(a) August 2004 (b) March 2006

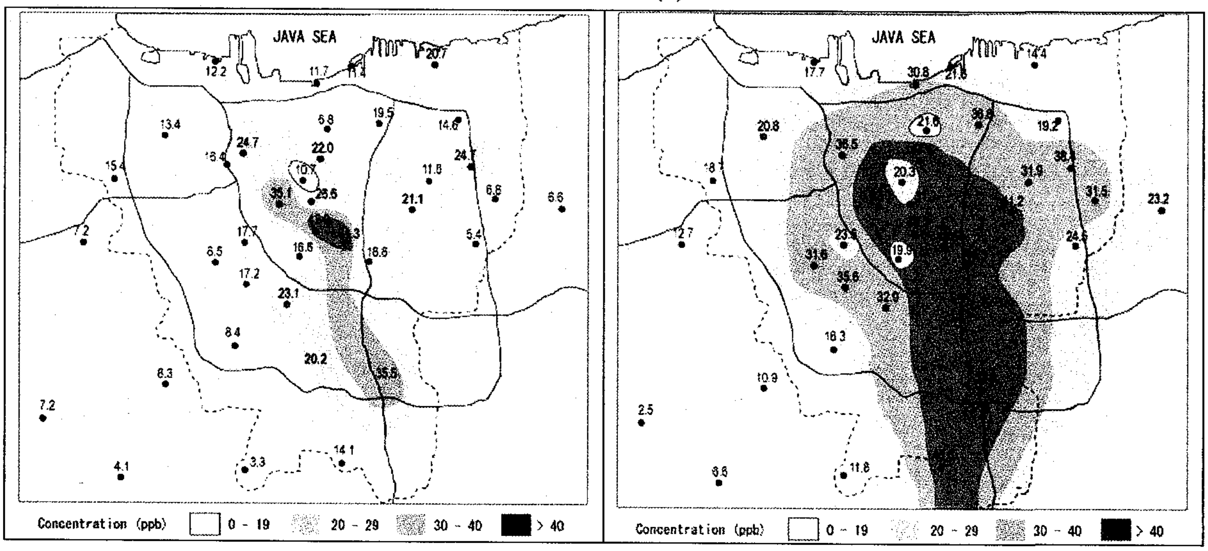

Fig. 4 Same as Fig. 3, but for NO_2.

Fig. 5 shows observation result for NOx and O_3 on March (rainy season) and Fig. 6 shows vertical distribution of NO_2, SO_2, NOx and O_3 in center city of Jakarta. In Fig. 6a, vertical profile of NO_2 in March was more uniform than August because in August has stronger mechanical turbulence. Therefore sea breeze circulation in August caused the vertical structure more become complex.

(a) NOx (b) O3

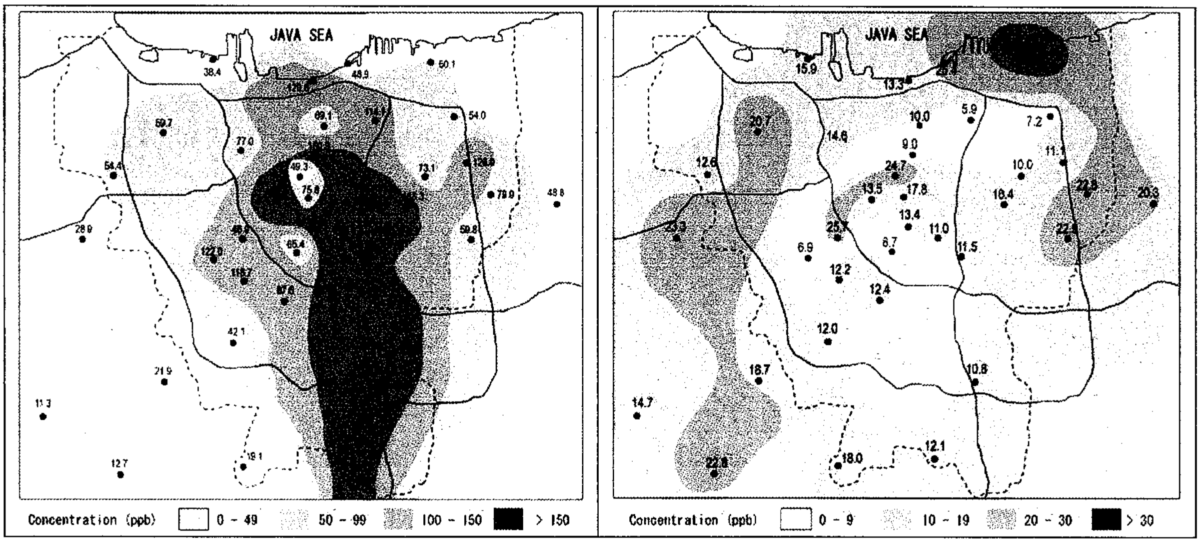

Fig. 5 Observed spatial distribution of (a) NOx and (b) O3; measured with 50 passive samplers distributed over the greater Jakarta during 1 week measurements in March 2006.

(a) (b)

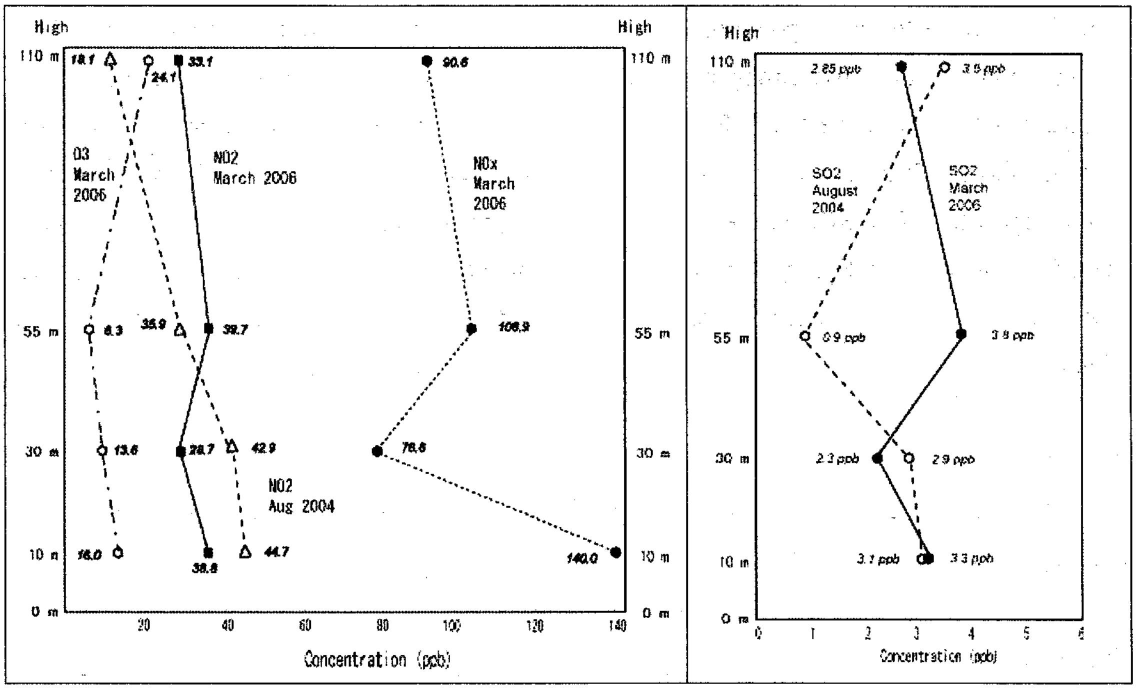

Fig. 6 Observed vertical concentration of (a) NO_2 August (open triangles), NO_2 March (solid rectangulars), NOx March (solid cycles), O_3 March (open cycles), and (b) SO_2 August (open cycles), and SO_2 March (solid cycles).

To know chemical reaction we performed numerical simulation of CTM (chemical transport model). The model includes 58 chemical species and a system of 130 chemical reactions (Kitada, 2003). In Fig. 7a shows calculated concentration on one typical day on August and March at sunny day. The O_3 production in March is higher than August since the solar radiation in March is higher than August; i.e. with initial value of O_3 40 ppb, in March and August maximum O_3 production are 66 ppb and 54 ppb, respectively (Fig. 7a). However, in March is usually cloudy. In Fig 7b shows cloudiness have significant effect to O_3 production.

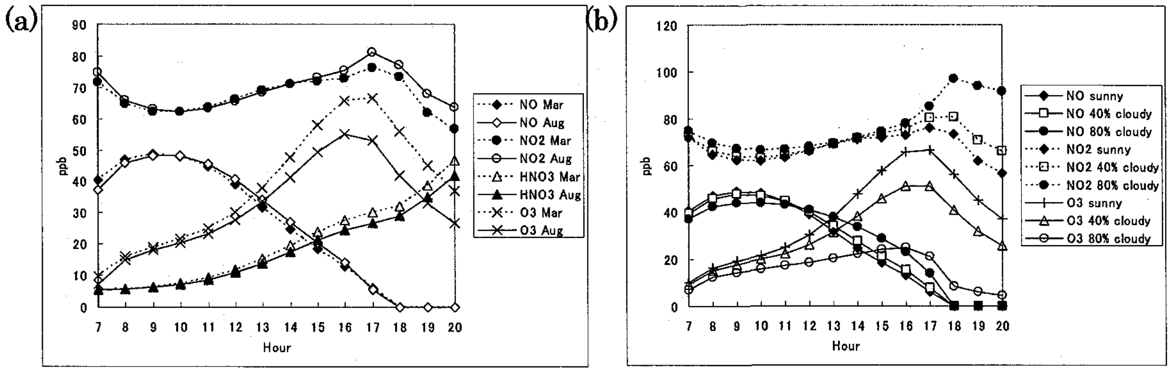

Fig. 7 (a) Calculated concentration in August and March at one typical sunny day (without cloud), (b) calculated concentration in Mach in various cloud condition.

4. Conclusion

Local field has effected air pollution distribution both horizontal and vertical in Jakarta city. The sea breeze circulation that was stronger in August caused air pollutant concentration in northern part of Jakarta has become lower than March. In August vertical structure has more become complex caused the vertical distribution more not uniform than March. At sunny day, the O_3 production in March is higher than August since the solar radiation in March is higher than August; i.e. with initial value of O_3 40 ppb, in March and August maximum O_3 production are 63 ppb and 51 ppb, respectively. However, in March is usually cloudy and cloudiness have significant effect to O_3 production.

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