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Factors influencing the variations of PM10 aerosol dust in Klang Valley, Malaysia during the summer

Liew Juneng*, Mohd Talib Latif, Fredolin Tangang

School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor Darul Ehsan, Malaysia

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A B S T R A C T

The associations between the variations of PM10 concentration during summer monsoon dry seasons over the Klang Valley, Malaysia and the local meteorological factors, synoptic weather conditions as well as the regional hotspots number were examined based on simple multiple linear regression analysis. The regressive relationships established, suggest that the variation of PM10 in Klang Valley was governed significantly by all of the examined factors. Local meteorological conditions are among those factors which governed the largest day-to-day variations of PM10 concentration in the Klang Valley areas during the dry season. When augmented by synoptic meteorological variables and foreign emission sources, a remarkable increase in the explained variance was apparent. On the other hand, domestic burning sources only had a minimal impact on PM10 fluctuations. Important synoptic weather patterns which influence the air pollution variations were also identified. These synoptic conditions include the strengthening of the summer monsoon southwesterly winds over the equatorial area. In addition, the formation of cyclonic circulation, associated with typhoon formation over the north-west Pacific and the South China Sea as well as over the Bay of Bengal, are found to have had a profound impact on PM10 variations over the Malaysian region through the modulation of regional moisture distributions.

1. Introduction

Particulate matter with an aerodynamic diameter of less than 10 μm (PM10) has been identified as an important atmospheric pollutant in major cities in Southeast Asia, particularly the Klang Valley, Malaysia (Afroz et al., 2003; Abas et al., 2004; Azmi et al., 2010). It is believed to have an effect on the human respiratory system which in turn may result in chronic obstructive pulmonary disease and asthma (Mott et al., 2005). In Malaysia, PM10 is one of the major air pollutants and is decisive in the computation of Malaysian Air Pollution Index (MAPI) (Afroz et al., 2003). Hence, a comprehensive understanding of the sources, distributions and dispersive characteristics of PM10 over a given area is crucial if effective management and mitigation of the associated air pollution impacts are to be achieved.

In Southeast Asia, biomass burning is a major regional source of particulate matter in the atmosphere, most notably during the dry seasons (June to September) (Khandekar et al., 2000; Abas et al., 2004; Anwar et al., 2010; Hyer and Chew, 2010). The burning of peat soil and plant residue in Sumatra, Indonesia and Indochina releases vast quantities of smoke, consisting of a high quantity of particulate matter, into the atmosphere (Lin et al., 2009; Hyer and Chew, 2010). Over the Klang Valley, the concentration of PM10 during the summer monsoon dry season is particularly high due to the contribution of smoke from biomass burning from regional sources. (Awang et al., 2000; Juneng et al., 2009). In addition, variations of PM10 may be governed by neighboring precursory emissions which occur as a result of local societal and industrial development. In the case of the Klang Valley, PM10 concentrations have been reported to be higher over the urban traffic stations compared with those of quieter and more rural stations (Awang et al., 2000).

Apart from emission sources, ambient air quality can be strongly influenced by meteorological factors via complex interactions between various processes – emissions, transport, chemical transformation as well as wet and dry deposition, etc (Seinfeld and Pandis, 1998; Demuzere et al., 2009). Hence, it is clearly understood that air quality depends not only on emission sources, but also more crucially, on the weather elements with multifaceted characteristics over various spatio-temporal scales. Locally, biogenic and dust emissions, in addition to certain chemical processes, are controlled by local weather elements such as temperature, relative humidity, solar radiation flux and cloudiness. From a regional perspective, short and long-range transport of pollutants depends

* Corresponding author. Tel.: +60389215870; fax: +60389253357.
E-mail address: juneng@ukm.my (L. Juneng).

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on the characteristic of the boundary layer turbulence and synoptic atmospheric circulations (Demuzere et al., 2009).

Although the characteristics and variations of PM10 concentrations over the Klang Valley have been addressed by many previous studies (e.g Afroz et al., 2003; Abas et al., 2004; Keywood et al., 2003; Md Yusof et al., 2010), a comprehensive attempt to link these variations to weather elements, particularly from the synoptic perspective, has yet to be undertaken. This knowledge is potentially of great use in the construction of skillful air pollution prediction tools to foster better air quality management for the local authority. The aim of this paper therefore is to establish statistical relationships between the summer monsoon PM10 concentrations and that of the weather elements, both on local and synoptic scales. The next section will provide a general overview of the data sets and statistical methods used. The results and discussion are provided in Section 3, whereby Section 4 concludes and summarizes the study.

2. Data and methods

2.1. Data sets

2.1.1. Air quality data

The PM10 concentration data used in the study was recorded as part of a Malaysian Continuous Air Quality Monitoring (CAQM) program, using the β-ray attenuation mass monitor (BAM-1020) as manufactured by Met One Instruments Inc. The monitoring network was installed, operated and maintained by Alam Sekitar Malaysia Sdn Bhd (ASMA) on behalf of the Malaysian Department of the Environment (Afroz et al., 2003). The network currently comprises of 51 monitoring stations, with some having been established as early as 1996. These are distributed over the Malaysian Peninsular and the eastern Malaysia regions. However, for the sake of this study, the collection of PM10 data was only undertaken at six monitoring stations in the Klang Valley area. The geographical locations of the

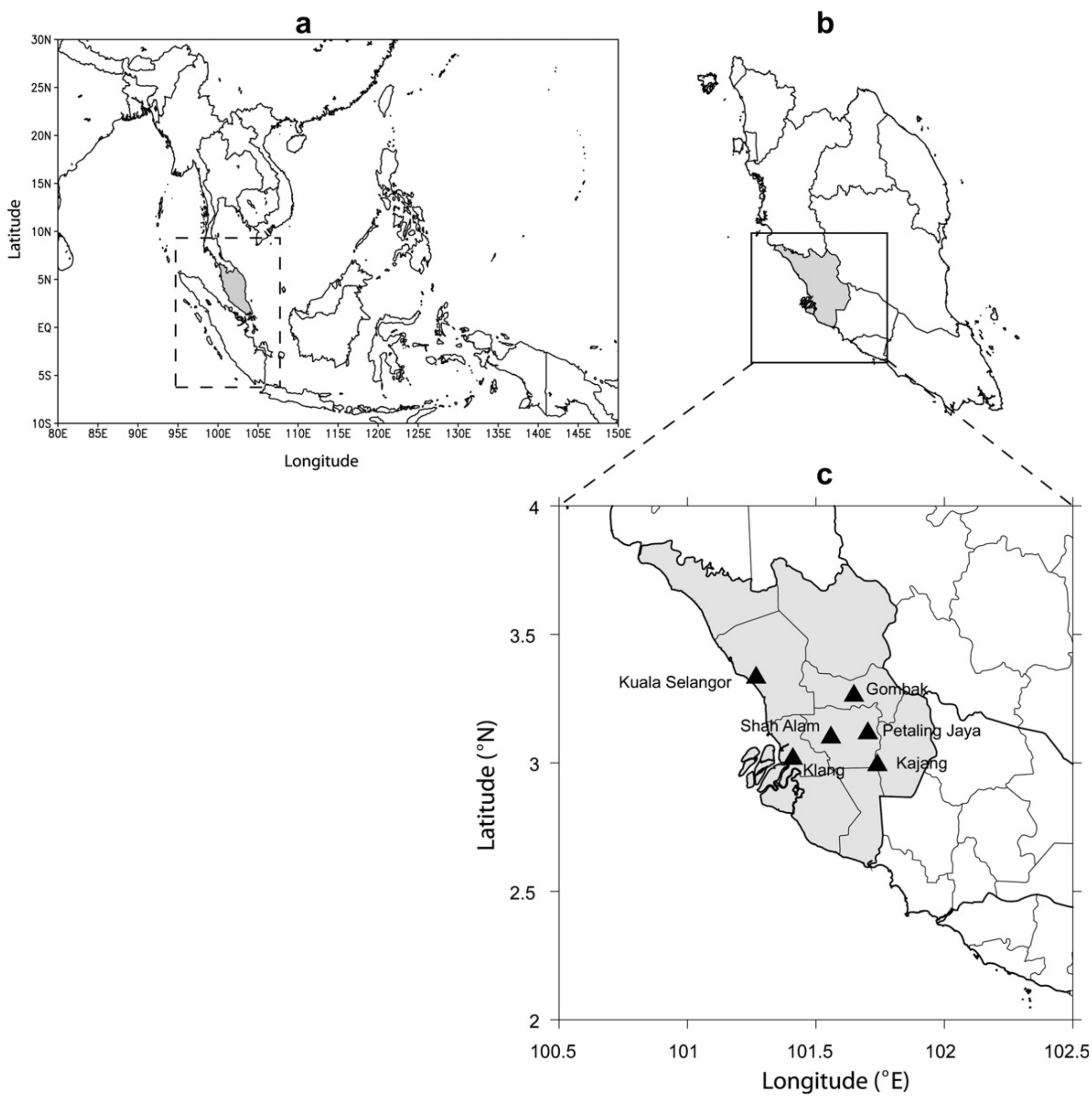

Fig. 1. (a) The domain where the NCEP data used in the study is defined. The box with the dotted boundaries is the area where the MODIS hotspots data is used (refer to text). The shaded region shows the Malaysian Peninsular. (b) The Klang Valley areas (shaded) in the Malaysian Peninsular. (c) The locations of the six stations within the Klang Valley used in the study.