Cross-boundary aerosols: a case study of aerosol problem in Bangkok during January-February, 2019

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Abstract. The event of high concentration of aerosols in Bangkok and its suburb during January-February, 2019 was investigated using ground and satellite-based data. The Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) was also used for the investigation. The results from the investigation implied that the presence of high concentration of aerosols in Bangkok and its suburb during that period was likely due to the cross-boundary aerosols produced from biomass-burning in Cambodia.

Keyword: Bangkok, Biomass-burning, Cross-boundary aerosols

1. Introduction
Southeast Asia is one of the fast-economic growing areas in the world [1]. In these areas, industrial activities and urbanization expand rapidly. Due to the increase in land and natural resource demands, deforestation and biomass-burning occur frequently in many parts of these areas and large amount of aerosols are released from these activities to the atmosphere. These aerosols are sometimes transported by wind across political boundary from one country to other countries. These aerosols are usually called cross-boundary aerosols [2]. The cross-boundary aerosols from biomass-burning often create events of high concentration of aerosols in many countries such as Singapore and Thailand [3]. In this study, the event of high concentration of aerosols occurred in Bangkok during January to February 2019 was investigated by using ground and satellite-based information. In addition, modelling approach was also employed for the investigation.

2. Methodology
For the ground-based approach, data on aerosol size distribution from a sunphotometer of AERONET at Nakhon Pathom (13.82°N, 100.04°E, suburb of Bangkok) were collected during the period: January to February, 2019 (Figure 1). A new sunphotometer was installed in Bangkok (Figure 2) and it has operated since January, 2019. The sunphotometer becomes part of AERONET and the data from this newly-installed sunphotometer were also collected. For the data on the vertical profile distribution of the amount of aerosols, they were acquired from a Light Detection and Ranging (Lidar) of MPLNET installed at Nakhon Pathom (Figure 3). Wind distribution maps at 925 hPa provided by the Thai Meteorological Department during that period were gathered.

For the satellite approach, fire spot data in Thailand and its neighboring countries from Moderate Resolution Imaging Spectroradiometer (MODIS) were collected for the analysis of the event. In terms
of modelling approach, the HYSPLIT was ran to investigate the trajectory of aerosols. Then all data were interpreted to obtain the results. Based on these results, a conceptual model of the event of the high concentration aerosols was proposed.

**Figure 1.** Sunphotometer installed at Silpakorn University in Nakhon Pathom.

**Figure 2.** Sunphotometer installed in Bangkok.

**Figure 3.** Lidar of MPLNET installed at Silpakorn University in Nakhon Pathom.
3. Results and discussions
Data obtained from instruments and agencies mentioned above were collected during January to February. For most days during this period, the data from MODIS reveal high density of fire spots in Cambodia and there was wind blowing from Cambodia to Thailand at the height of about 800-900 m from the ground and the data from LIDAR show that the boundary layer of the atmosphere is about 1.0-1.5 km from the ground. In addition, data on aerosol size distribution from the sunphotometers show two peaks with the domination of fine mode aerosols. Results from HYSPLIT indicate that most of aerosols appeared in Bangkok came from areas of high density of fire spots in Cambodia. The typical results are shown in Figure 4-7.

Figure 4. Fire spot from MODIS on 15 January 2019.

Figure 5. Wind map at 925 hPa on 15 January 2019 from the Thai Meteorological Department.
Figure 6. Boundary layer of the atmosphere from LIDAR.

Figure 7. Aerosol size distribution from the sunphotometer on 15 January 2019.

Figure 8. Back trajectory on 15 January 2019, obtained from HYSPLIT.
The interpretation of the results from the sunphotometers and the wind maps together with results from HYSPLIT implies that most of the aerosols appeared in Bangkok and its suburb were biomass-burning aerosols and they were transported from Cambodia by the high level wind. The results from LIDAR imply that the concentration of aerosols in that period was high due to the low level of the boundary layer.

From these results, a conceptual model for the high aerosol concentration event is proposed as follows (Figure 9). The aerosols from biomass-burning in Cambodia were transported by wind to the central part of Thailand, where Bangkok is located. As this part of Thailand is situated in a low altitude area surrounded by ranges of mountains in the West and the North, and the high land plateau in the Northeast of the country, the speed of the aerosols transported by the wind was reduced when it arrived this part of the country, causing the falling of the aerosols. In addition, solar radiation was also reduced by these transported aerosols, making the reduction of air temperature near the ground. The height of the boundary layer was reduced by this reduction, making additional high concentration of aerosols near the ground.

Figure 9. Conceptual model of the event of high concentration aerosols transported by wind

4. Conclusions
The event of high concentration of aerosols in Bangkok and its suburb during January-February, 2019 has been investigated using ground-based, satellite-based and model-based approaches. The results from these approaches imply that this event is likely caused by the cross-boundary aerosols from Cambodia to Thailand. Further analysis using more measurements and analytical models is recommended for future investigation.

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