Supplementary Information:

S1: Study Period and location

The trend of PM$_{2.5}$ Concentration ($\mu$g/m$^3$) in a few continuous air quality monitoring stations (CAQMS) in the west peninsular Malaysia which are located at:

a) Sek. Keb. TTDI Jaya, Shah Alam (CA20B)

![Trend of PM$_{2.5}$ concentration (µg/m$^3$)](image)


![Trend of PM$_{2.5}$ concentration (µg/m$^3$)](image)

Fig. S1. Hourly trend of PM$_{2.5}$ concentration at west Peninsular Malaysia

S2: MERRA- 2 Reanalysis Data

The PM$_{2.5}$ concentration were obtained based on the data of aerosol subtype of BC, OC, SO$_4^{2-}$, dust and sea salt in the MERRA-2 reanalysis. The equation that used to compute the PM$_{2.5}$ concentration was shown in the equation 1.
\[ PM_{2.5} = \text{DUSMASS25} + \text{OCSMASS} + \text{BCSMASS} + \text{SSSMASS25} + \text{SO4SMASS} \times \left(\frac{132.14}{96.06}\right) \]  

Equation 1

Where the DUSMASS25 = dust column mass concentration - PM$_{2.5}$ (kg m$^{-3}$), OCSMASS = organic carbon column mass concentration (kg m$^{-3}$), BCSMASS = black carbon column mass concentration (kg m$^{-3}$), SSSMASS25 = sea salt column mass concentration - PM$_{2.5}$ (kg m$^{-3}$), SO4SMASS = SO$_4$ surface mass concentration (kg m$^{-3}$) and 132.14/96.06 multiplication factor for sulfate ion.

The MERRA-2 reanalysis data were evaluated based on the performance indicator in term of error measure and accuracy measure. The mean fractional bias (MFB) and mean fraction error (MFE) were used to measure the error of the model data on predicting the PM$_{2.5}$ concentration with the acceptable standard are within -0.35 < x < 0.35 and x < 0.55, respectively. Meanwhile, correlation coefficient was used to measure the accuracy of the model data with the acceptable standard for PM$_{2.5}$ concentration is x > 0.5. The mathematical equation of error and accuracy measure were shown in equation 2 to equation 4.

\[
\text{Mean fractional bias (MFB)} = \frac{1}{N} \sum_{i=1}^{N} \frac{M_i - O_i}{(M_i - O_i)/2} \quad \text{Equation 2}
\]

\[
\text{Mean fractional error (MFE)} = \frac{1}{N} \sum_{i=1}^{N} \frac{|M_i - O_i|}{(M_i - O_i)/2} \quad \text{Equation 3}
\]

\[
\text{Correlation coefficient (R)} = \frac{1}{N - 1} \sum_{i=1}^{N} \left[ \frac{(M_i - \bar{M})(O_i - \bar{O})}{Stdev_M \cdot Stdev_O} \right] \quad \text{Equation 4}
\]

Where, the N = total number of data, $M_i$ = the predicted values, $\bar{M}$ = mean predicted values, $O_i$ = the observed values, $\bar{O}$ = mean observed values, Stdev$_M$ = standard deviation of predicted values and Stdev$_O$ = standard deviation of observed values.

The evaluation result of MERRA-2 reanalysis data on predicting the PM$_{2.5}$ concentration at ECPM regions based on mean fractional bias (MFB), mean fraction error (MFE) and correlation coefficient (R) for three different CAQMS that involved in this study.
### Table S1. The MERRA-2 reanalysis data evaluation result

<table>
<thead>
<tr>
<th>Location</th>
<th>Performance Evaluation</th>
<th></th>
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<tr>
<td></td>
<td></td>
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<td>MFE</td>
<td>R</td>
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<td></td>
</tr>
</tbody>
</table>

![Image a) showing a scatter plot with R^2 linear = 0.524](image1)

![Image b) showing a scatter plot with R^2 linear = 0.141](image2)
Fig. S2. Scatter plot of predicted PM$_{2.5}$ concentration (µg/m$^3$) against observed PM$_{2.5}$ concentration (µg/m$^3$) for MERRA-2 reanalysis data model at a) Terengganu, b) Kelantan and c) Pahang.

Some outliers were detected for all three CAQMS especially during the peak PM$_{2.5}$ concentration in the MERRA-2 data.
Fig. S3. Daily trend of average PM$_{2.5}$ concentration in the ECPM regions a) Terengganu, b) Kelantan and c) Pahang.

The meteorological parameters from MERRA-2 reanalysis (M2I6) were used to obtain meteorological behavior of zonal and meridional wind speed, wind direction and sea level pressure in the ECPM regions as to observed how the transboundary smoke of BB can travel and affect the ECPM regions air quality during HP1, HP2 and LP1.

Fig. S4. The meteorological condition of wind speed, wind direction and sea level pressure during (a-b) HP1, (c-d) HP2, (e-f) LP1 and (g-h) LP2 at MC.
S3: Identification of the origin of aerosols through HYSPLIT model

HYSPLIT backward trajectories analysis has run three days continuously to trace the sources of pollutants during HP1, HP2, LP1 and LP2. The trajectories analysis for one day before and after having shown in Fig. S5 and Fig. S6.

**Fig. S5.** Backward Trajectories Analysis at (a, c) 0-1000 m and (b, d) 1500-2000 m for HP1 while (e, g) 0-1000 m and (f, h) 1500-2000 m for HP2 on three consecutive days. Grey dotted line A (daytime) and A’ (nighttime) are present as a swath of CALIOP.
Fig. S6. Same as Fig. S5 but (a-d) for LP1 while (e-h) for LP2.