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Effects of black carbon and boundary layer interaction on surface ozone in Nanjing, China

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Supplement:

Detailed Methodology

The buoyancy flux parameter (F_B) **Equation A1** is a function of the temperature difference between the air (T_A) and the fire (T_F), the vertical motion of air (v) and the size of the fire, d (here always measured at 1km^2 in this work).

$$F_B = gv\frac{d^2}{4}\left(\frac{T_F - T_A}{T_A}\right)$$

(A1)

The buoyancy flux parameter has been found empirically to demonstrate whether the plume rise is buoyancy or momentum dominated. Under stable atmospheric conditions [Stone and Carlson, 1979], where the atmospheric lapse rate is ($L_A = \frac{\Delta T}{\Delta Z} < -5$), for a buoyancy dominated plume, (defined as where the difference between T_A and T_F is given in **Equation A2b1**), the plume rise height (Δh) is given by **Equation A2b2**, where (U) is the horizontal wind magnitude.

$$(T_F - T_A) > 0.01958 T_F \sqrt{v}$$

(A2b1)

$$\Delta h = 2.4\left(\frac{F_B}{.02U}\right)^{1/3}$$

(A2b2)

Whereas, for a momentum dominated plume (where the difference between T_A and T_F is less than the right hand side of **Equation A2b1)**, the height rise is given by **Equation A2b3**.

$$\Delta h = 1.5\left(\frac{\frac{V^2 d^2 T_A}{4\ T_F}}{\sqrt{.02}U}\right)^{1/3}$$

(A2b3)

On the other hand, under unstable atmospheric conditions (where $L_A > -5$), and where the plume rise is buoyancy dominated, the plume rise height is given by either **Equation A2b4** when $F_B > 55$ or **Equations A2b5, A2b6** when $F_B < 55$ [Woodward, 2010].

$$X^* = 14 {F_B}^{\frac{5}{8}}$$

(A2b4)

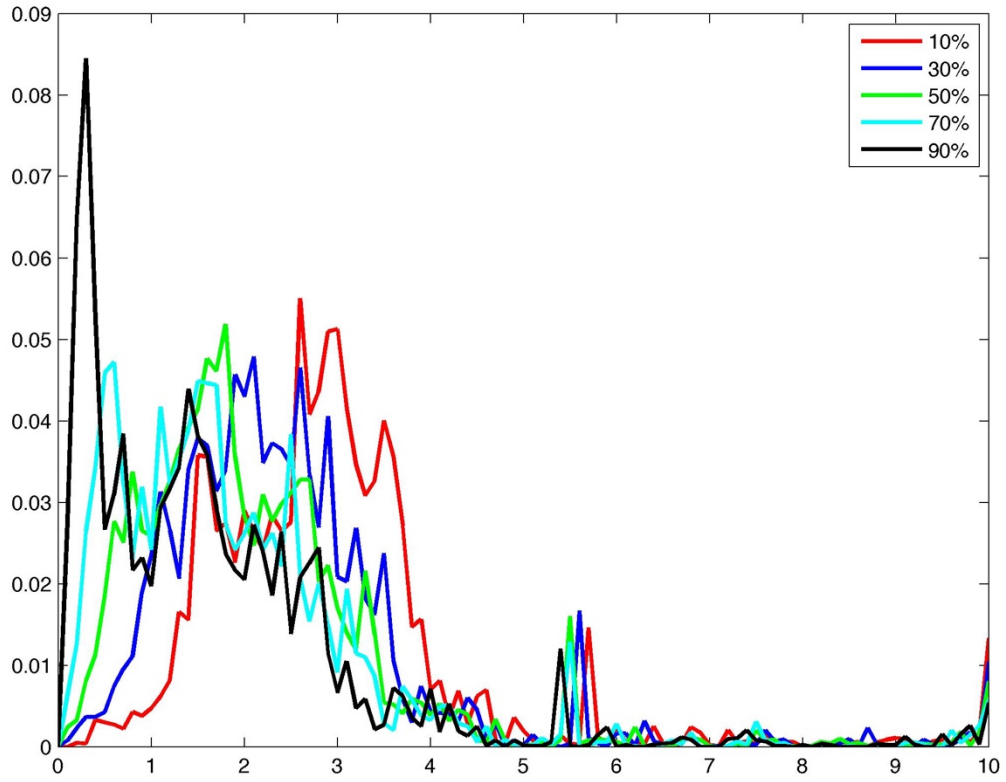
$$X^* = 34 {F_B}^{\frac{2}{5}}$$

(A2b5)

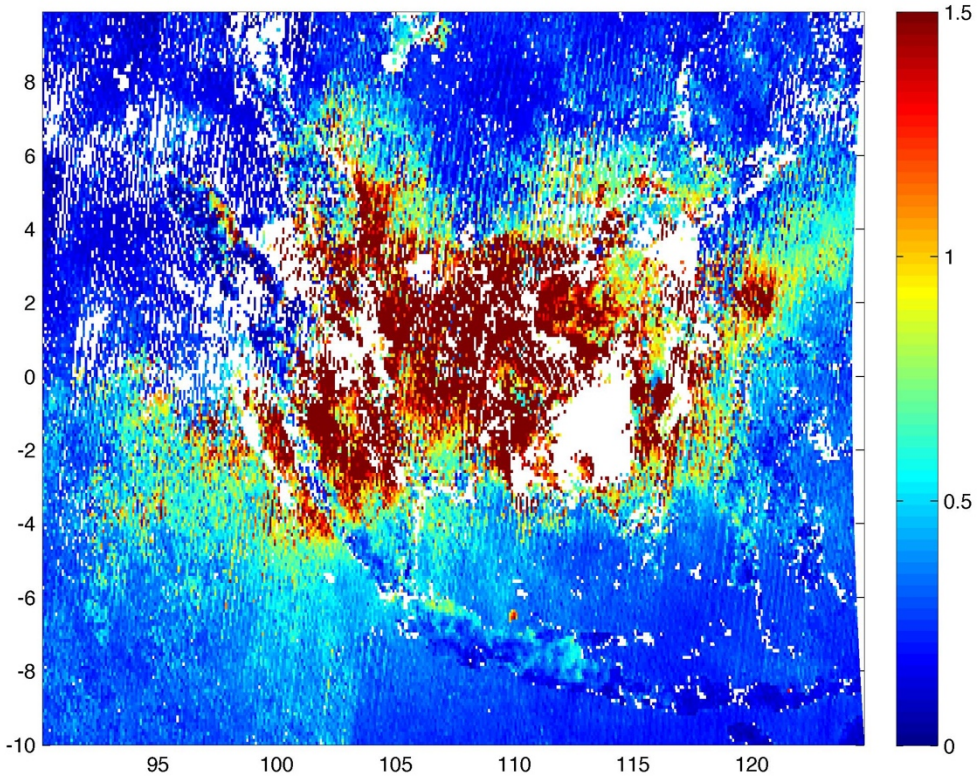
$$\Delta h = 1.6\frac{{F_B}^{\frac{1}{3}}(3.5X^*)^{\frac{2}{3}}}{U}$$

(A2b6)

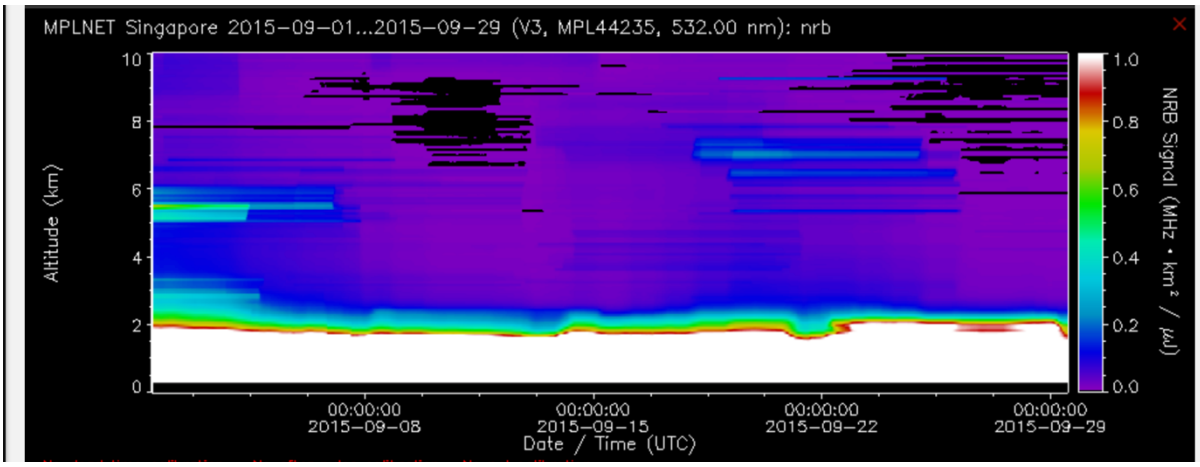
Supplemental Figure 1: PDFs (x-axis is the height in km, and the y-axis is the probability distribution) of the monthly aggregated backscatter heights of the 10% [red] (top), 30% [dark blue], 50% [yellow], 70% [light blue], and 90% [black] levels. Note that there were no measurements on the 10th, 16th, and 20th.

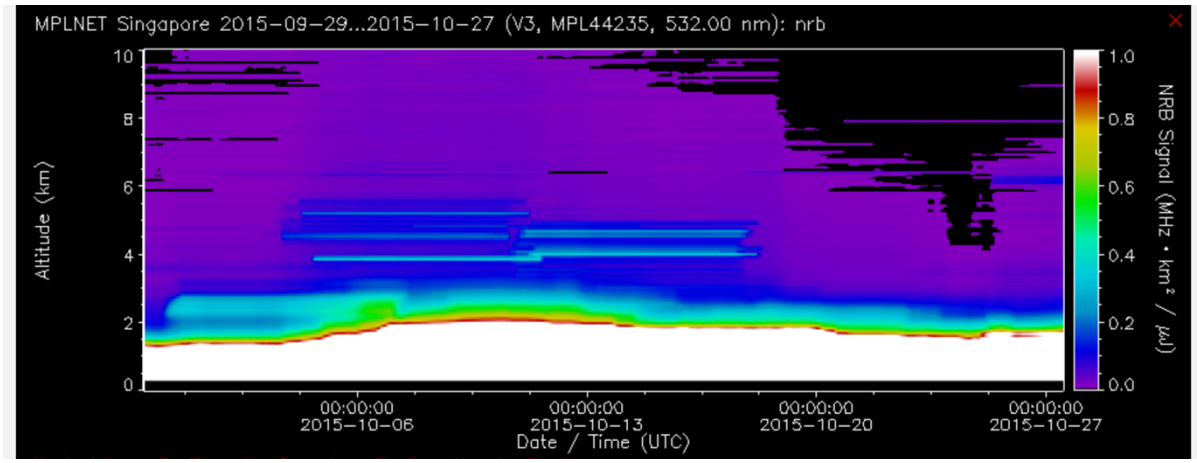


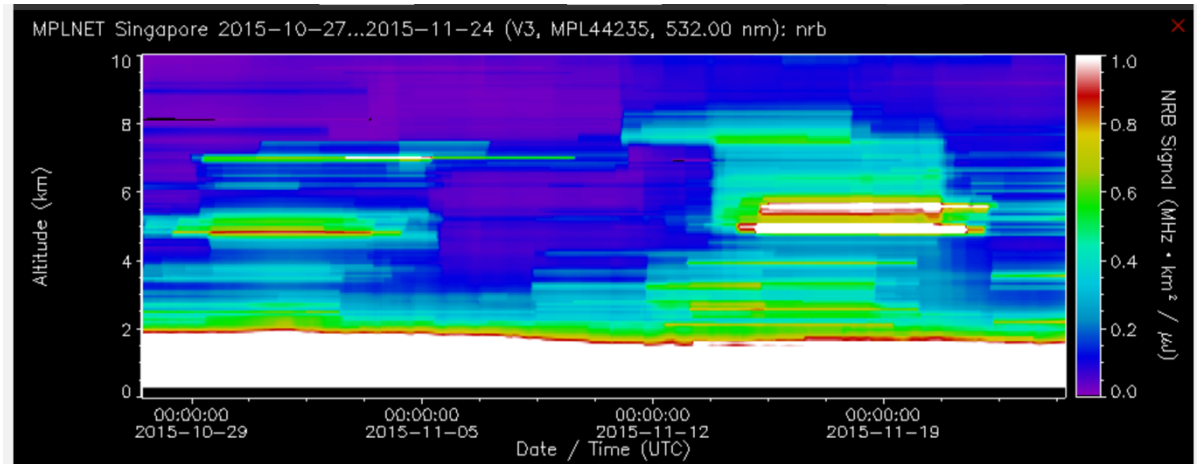
Supplemental Figure 2: Map of the monthly averaged MODIS AOD over the Maritime Continent. The day-to-day statistics are given in **Figure 2**. Regions in white have 0 valid AOD measurements throughout the entire time period, due to cloud cover.



Supplemental Figure 3: Statistical average of the aerosol heights measured by the Singapore MPL station from September 1 to November 30, 2015. This year was chosen since it is another El-Nino influenced high fire year, and has a somewhat similar physical, meteorological, and geographic aerosol extent as 2006.







Supplemental Figure 4: Time Series of Precipitation data from GPCP (dotted line) and AOD (dashed line) from MODIS, averaged on a daily-basis over both the Fire Region (Red) and the No-Fire Region (Blue), from September 1 to November 30.