VEGETATION FIRES IN INDONESIA AND METEOROLOGICAL DRIVERS

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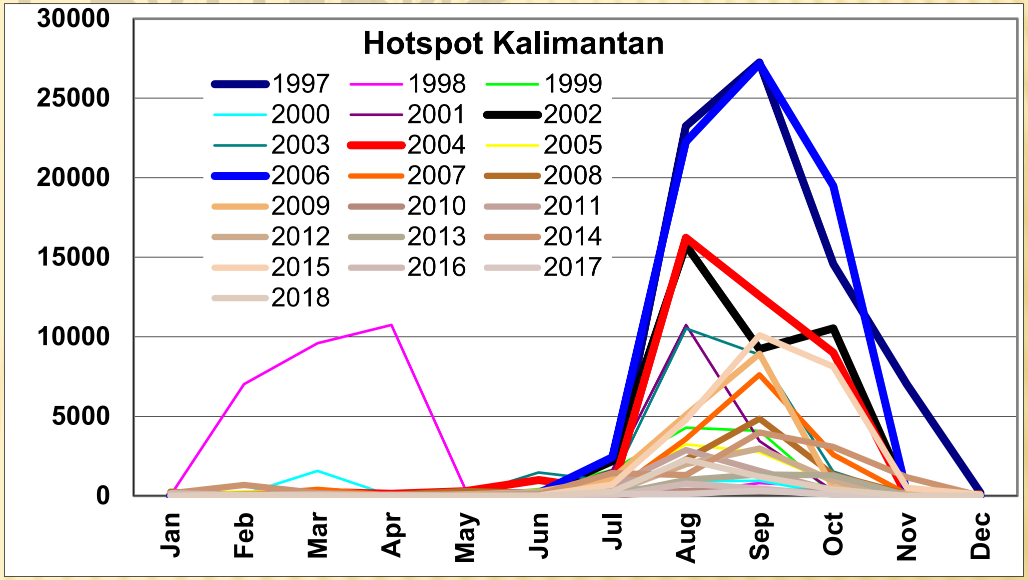
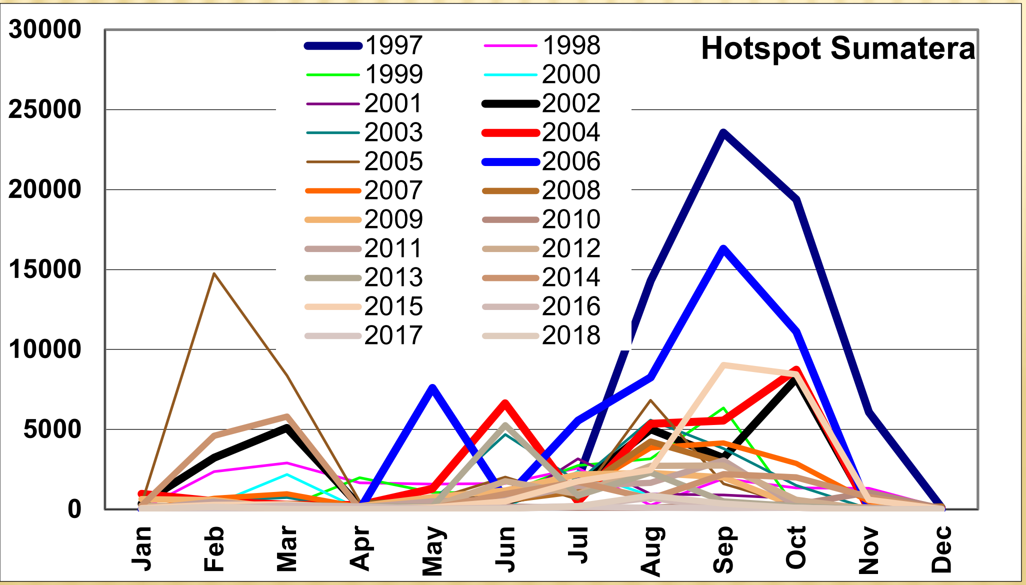
PRESENTATION OUTLINE

- Historical annual and long term pattern of forest fire, annual pattern
- Forest fire in Riau 2013
- Forest fire in Palangkaraya (central Kalimantan) 2012 - 2014
- Forest fire in Jambi 2014
- Aeronet 3, aerosol optical and radiative properties
- Why was the sky red during forest fire

HISTORICAL ANNUAL PATTERNS

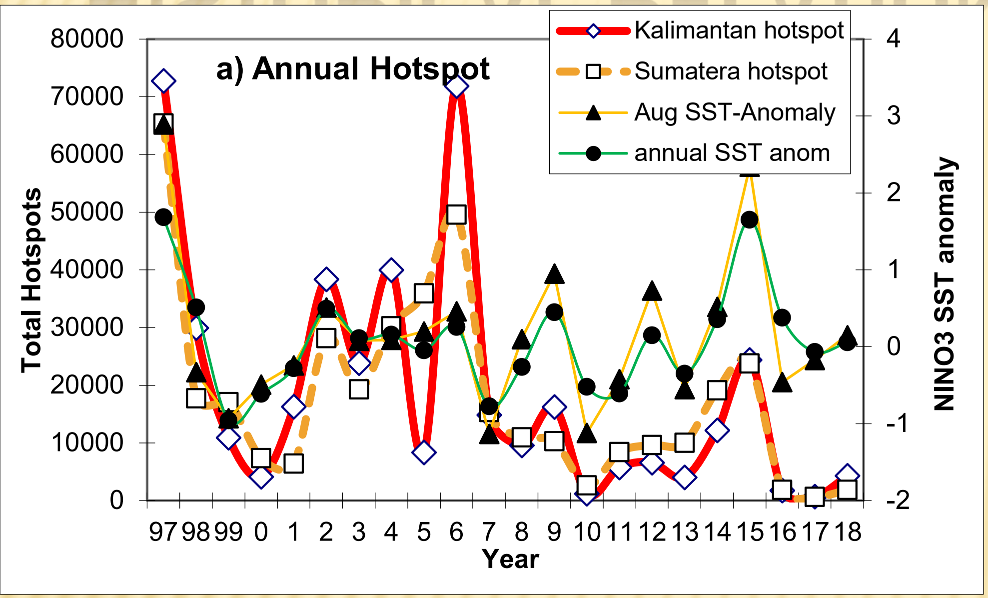
Data from 1997 to 2018 show most fire occur during August Sept and October due to the dry condition. There was a fire episode in Feb March that occur once.

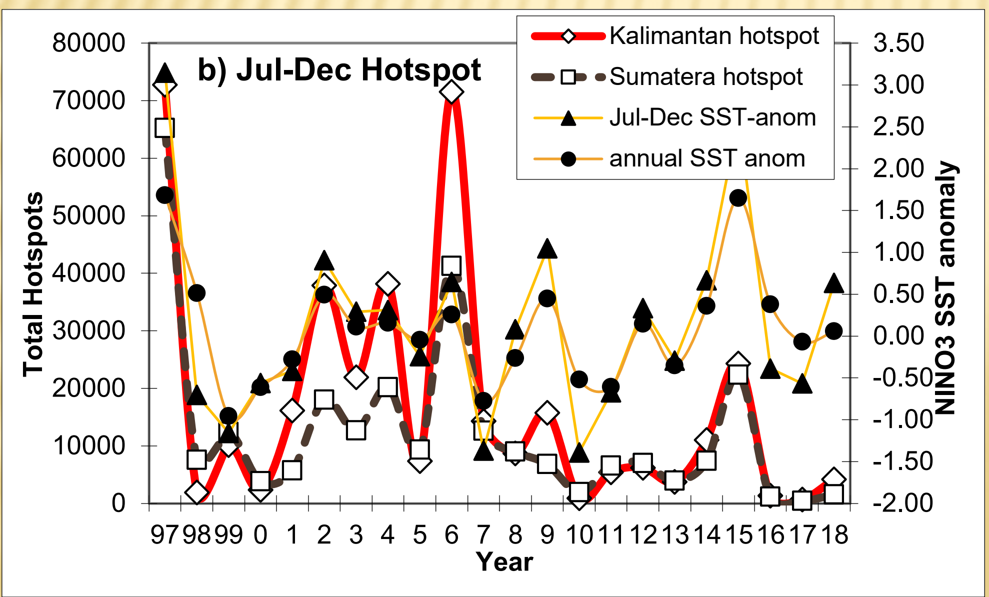




The fire episode in Sumatera is a bit different with basically two peaks in August September October and during the early time of the year. The first due to dry condition and the early time due to cold surge that bring dry condition temporary in early year.

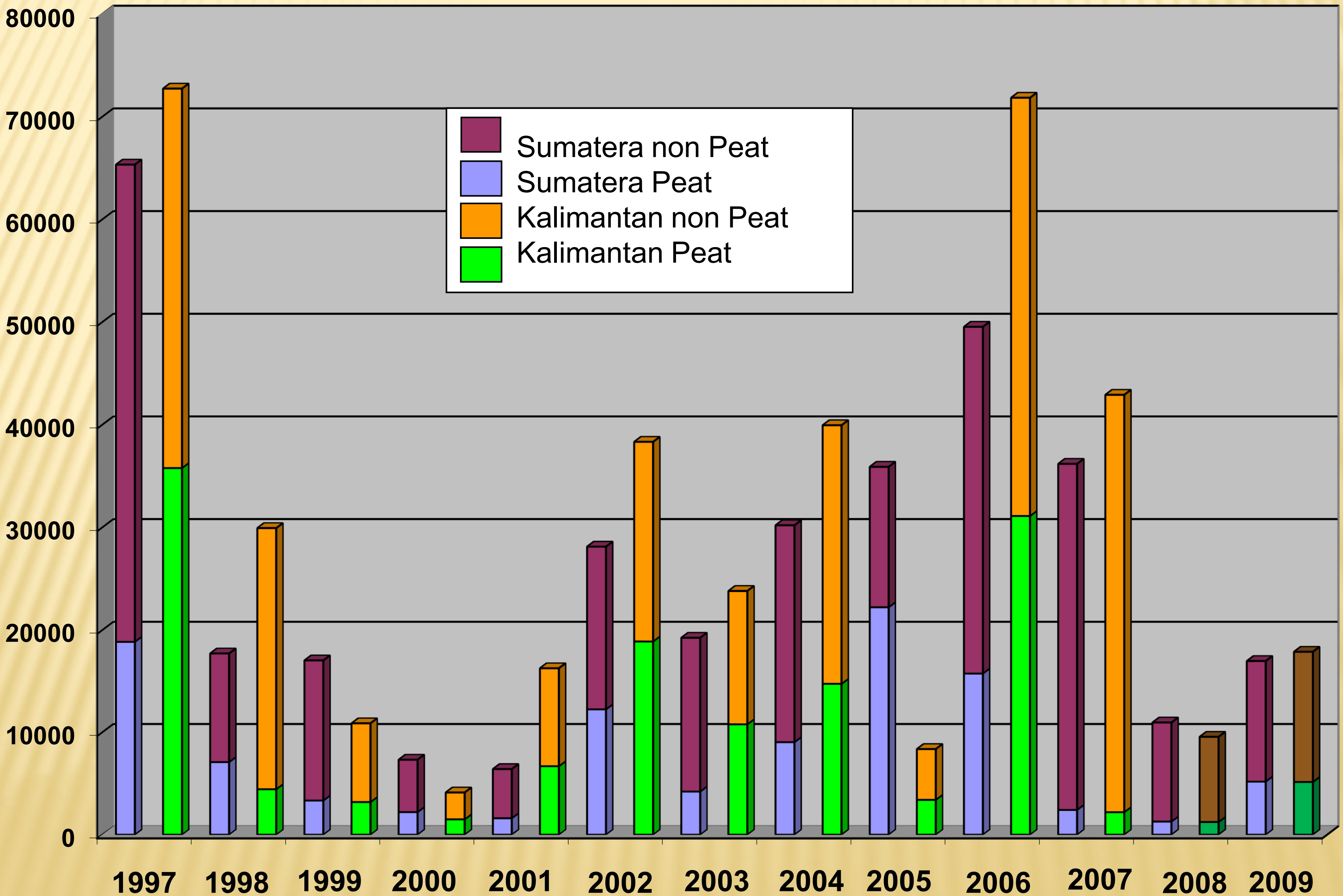
HISTORICAL RELATIONSHIP WITH CLIMATE





the empirical relationship between number of hotspot in Sumatera and Kalimantan against the SST anomalies over the Pacific. The SST anomalies over the ENSO3 region represent the ENSO activities. NINO3 is as an area in between 5N-5S, 150W-90W. According to data of NINO3, there were the highest SST anomaly in NINO3 that reached 3.62 in December 1997 and followed by 2.63 in November 2015. From this empirical relationship, it is clear that those forest fire events that occur in Sumatera and Kalimantan have been induced or forced by the event over the Pacific. This relationship fails after 2007 due to human intervention.

MINERAL AND PEATLAND SOIL



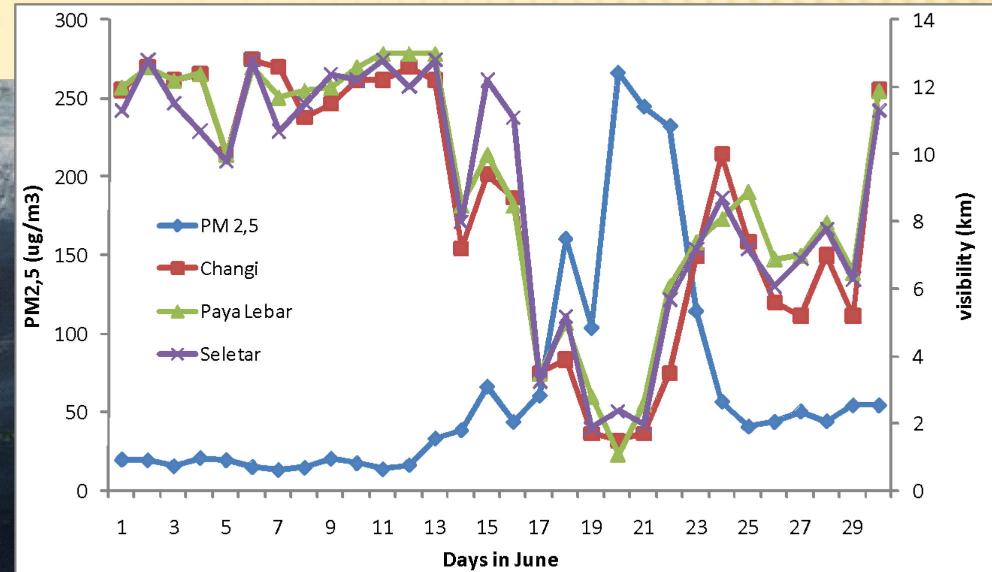
ESTIMATED CARBON EMISSION DUE TO FIRE

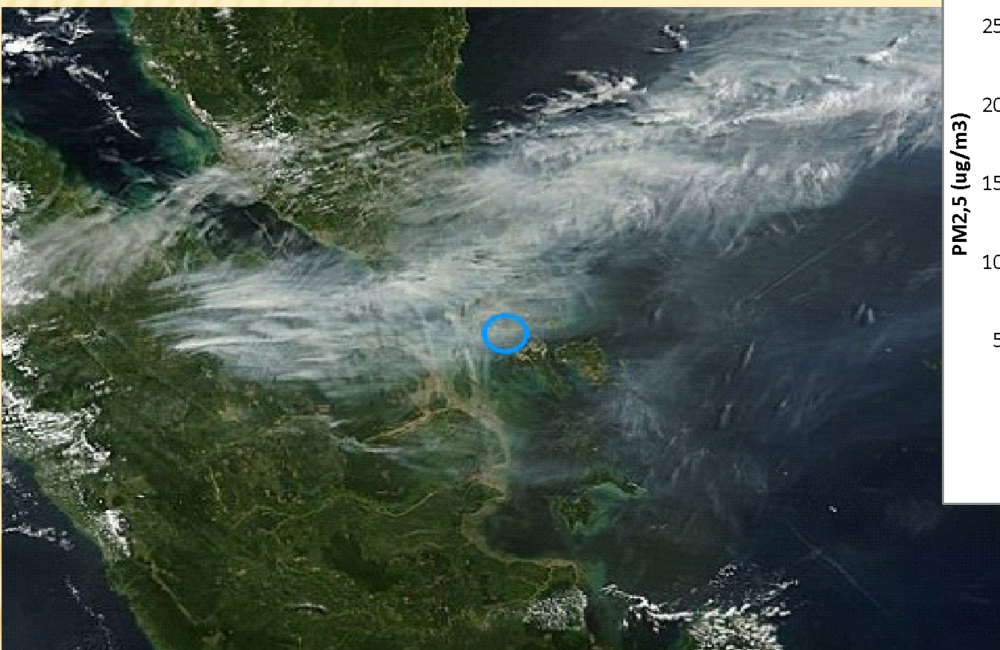
C emission (Tg carbon)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Heil et. al 2007	1098	289	167	81	172	588	318	509	452	951	150	94	235
Levine 1999	245	64	37	18	38	131	71	114	101	212	33	21	52
Page et. al 2002a	810	213	123	60	127	434	234	376	334	702	111	70	173
Page et. al 2002b	2570	676	390	190	403	1377	743	1192	1058	2226	351	221	550
Duncan 2003	700	184	106	52	110	375	203	325	288	606	96	60	150

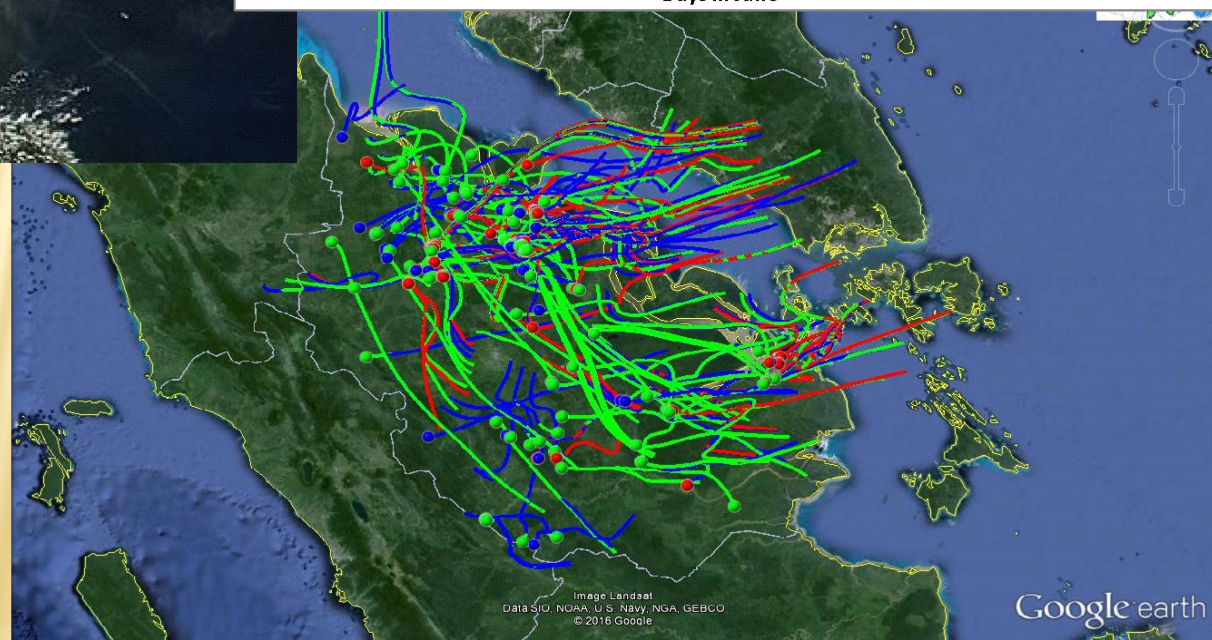
Using data of peat and non peat burning area we can calculate the total emission due to fire with some calculation according to some paper suggested for the emission calculation.

FIRE IN RIAU 2013

Riau PSI in 5 monitoring sites (Rumbai, Minas, Duri Camp, Duri Field, and Dumai) vs hotspots (b).

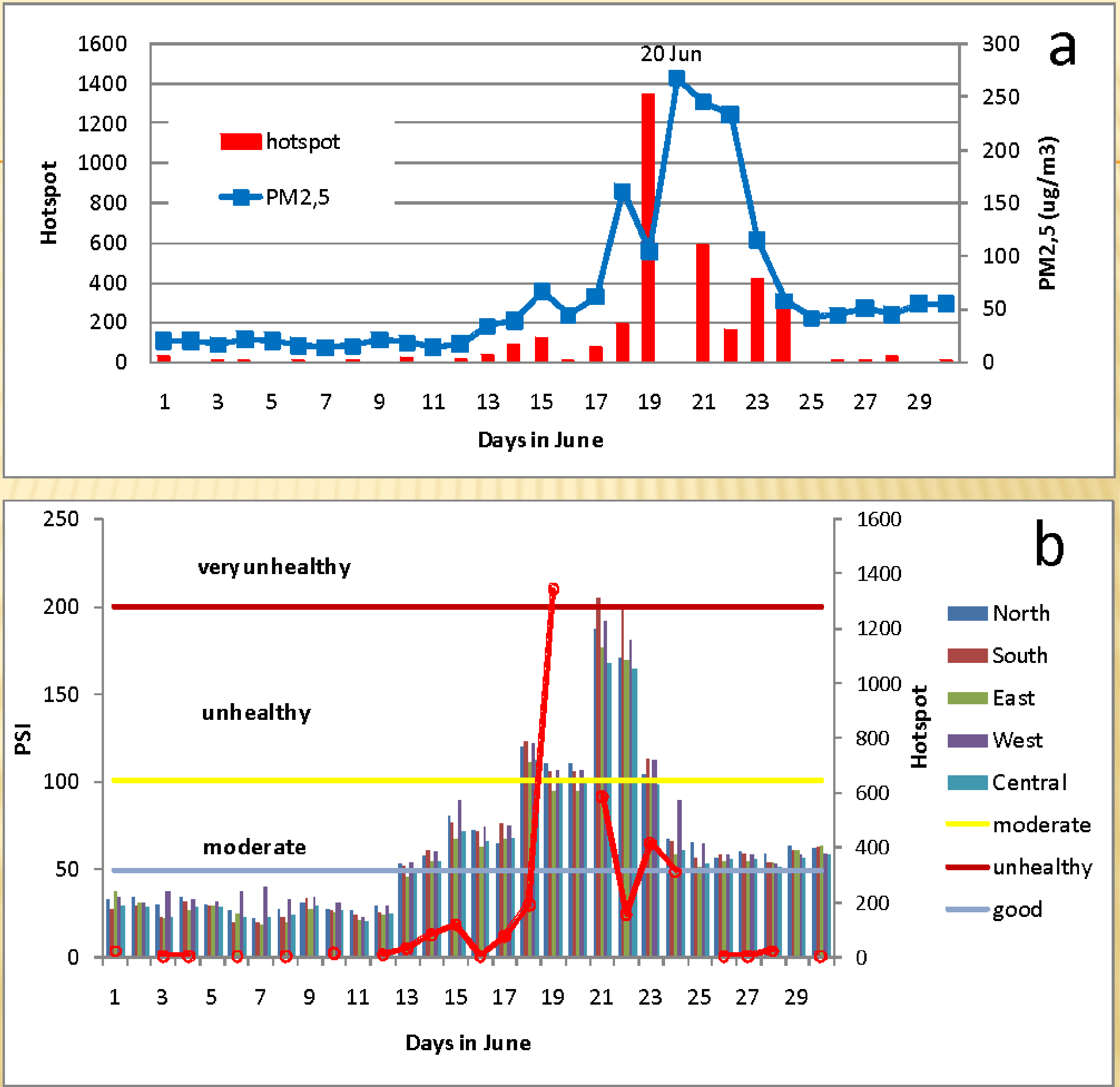




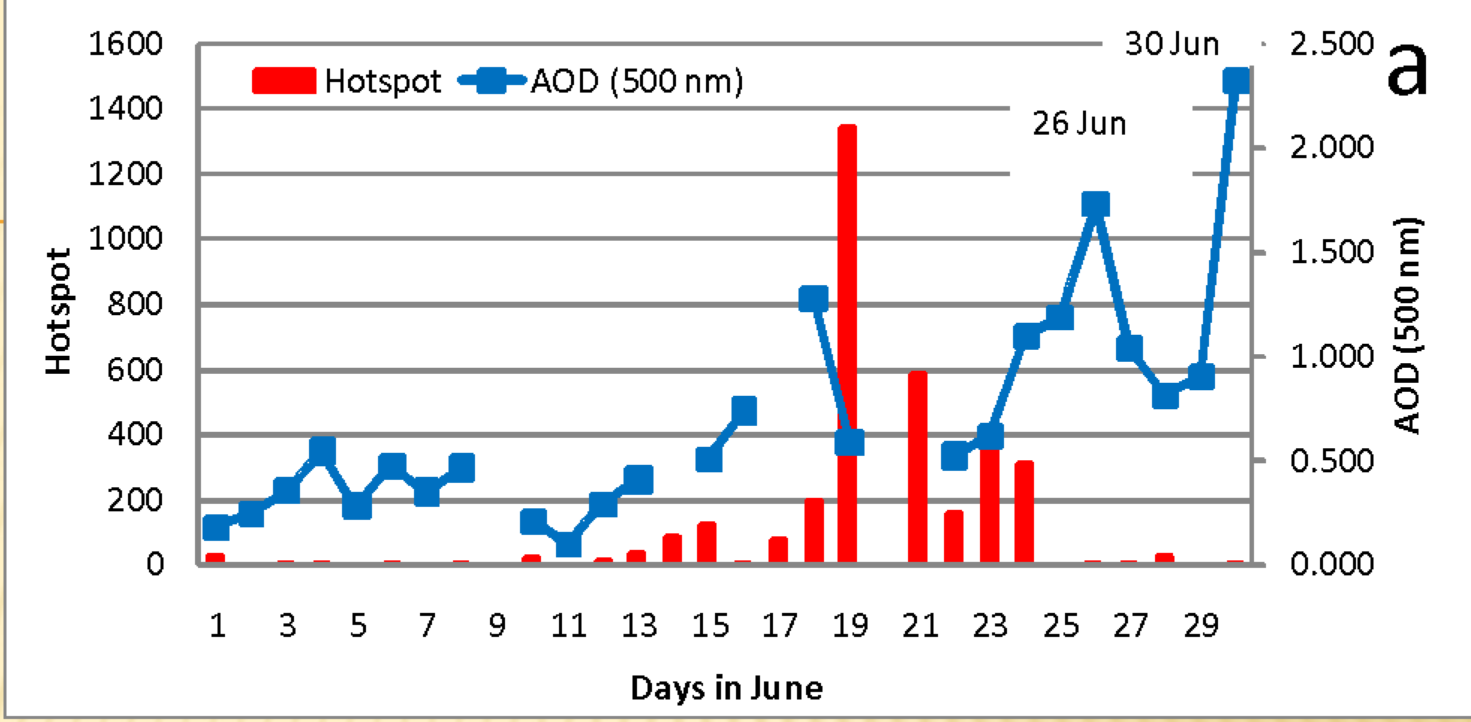


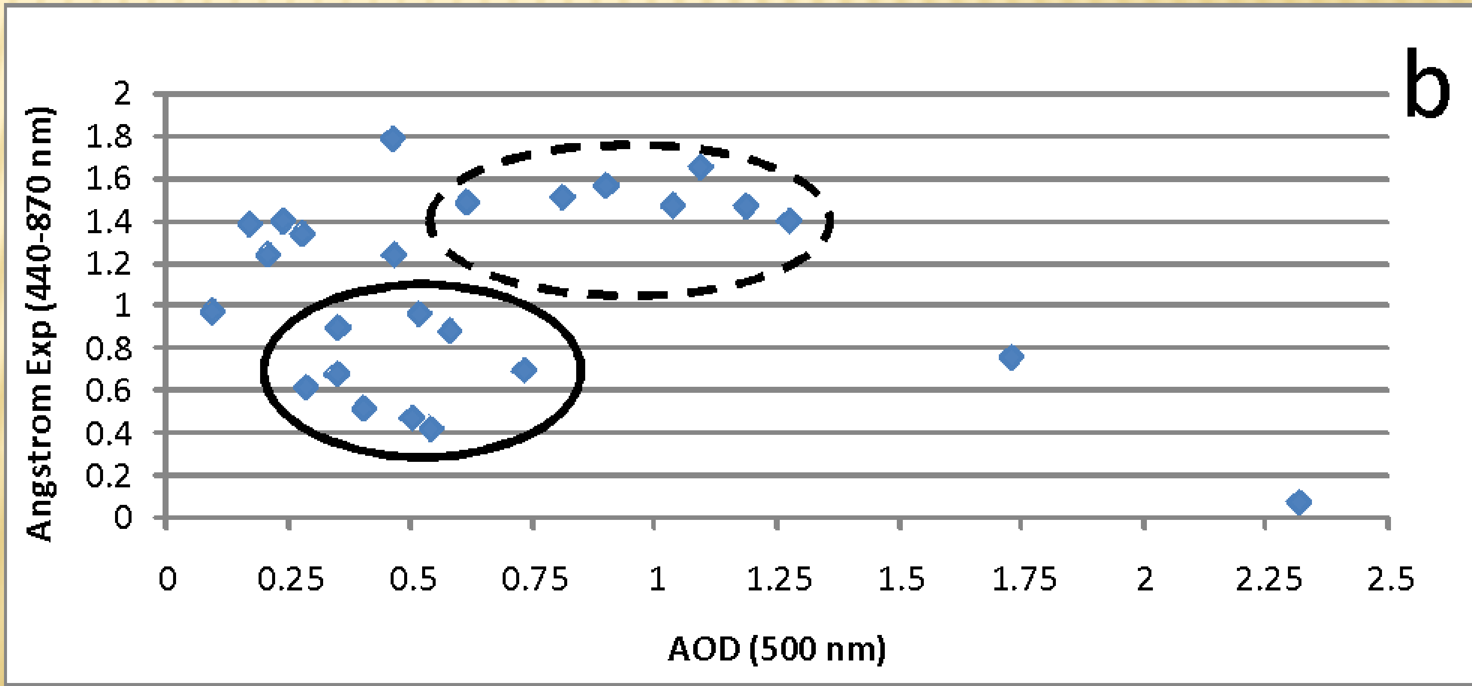
Aqua MODIS satellite imagery on June 19th, 2013 (a); Hysplit forward trajectory model ran 24 h for June 2013 from hotspot in Riau (b).

PM2.5 concentration (a) and PSI in Singapore (b) vs hotspot detection in Riau Province in June 2013.

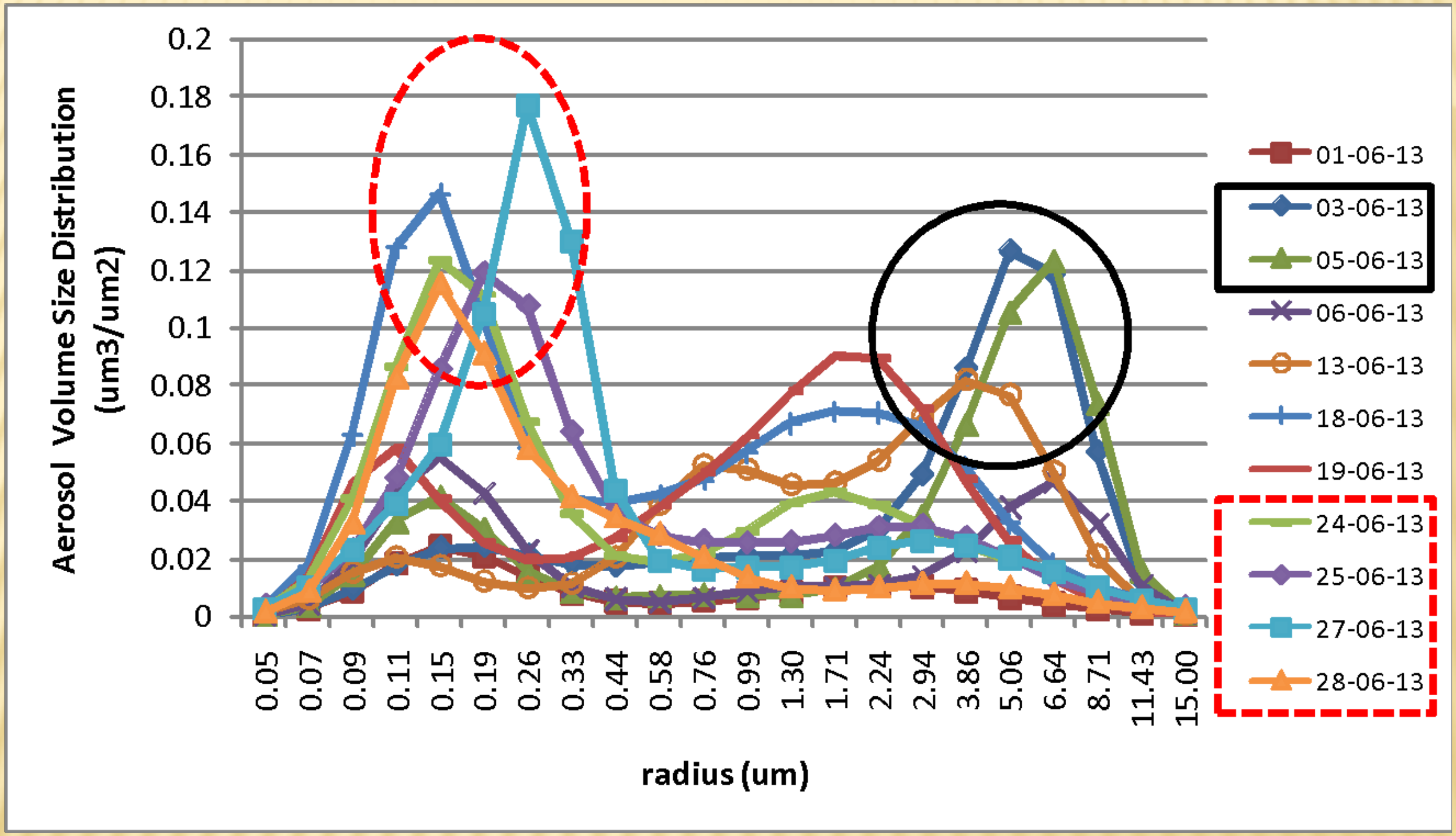


Daily AOD at wavelength 500 nm and daily hotspot number in June 2013 (a) and scatter plot of AOD versus AE (440–870 nm) (b). AE was determined using 440–870 nm, which are indicative of the general size distribution and the relative dominance of fine versus coarse mode particles.





2013 FIRE FROM SINGAPORE AERONET

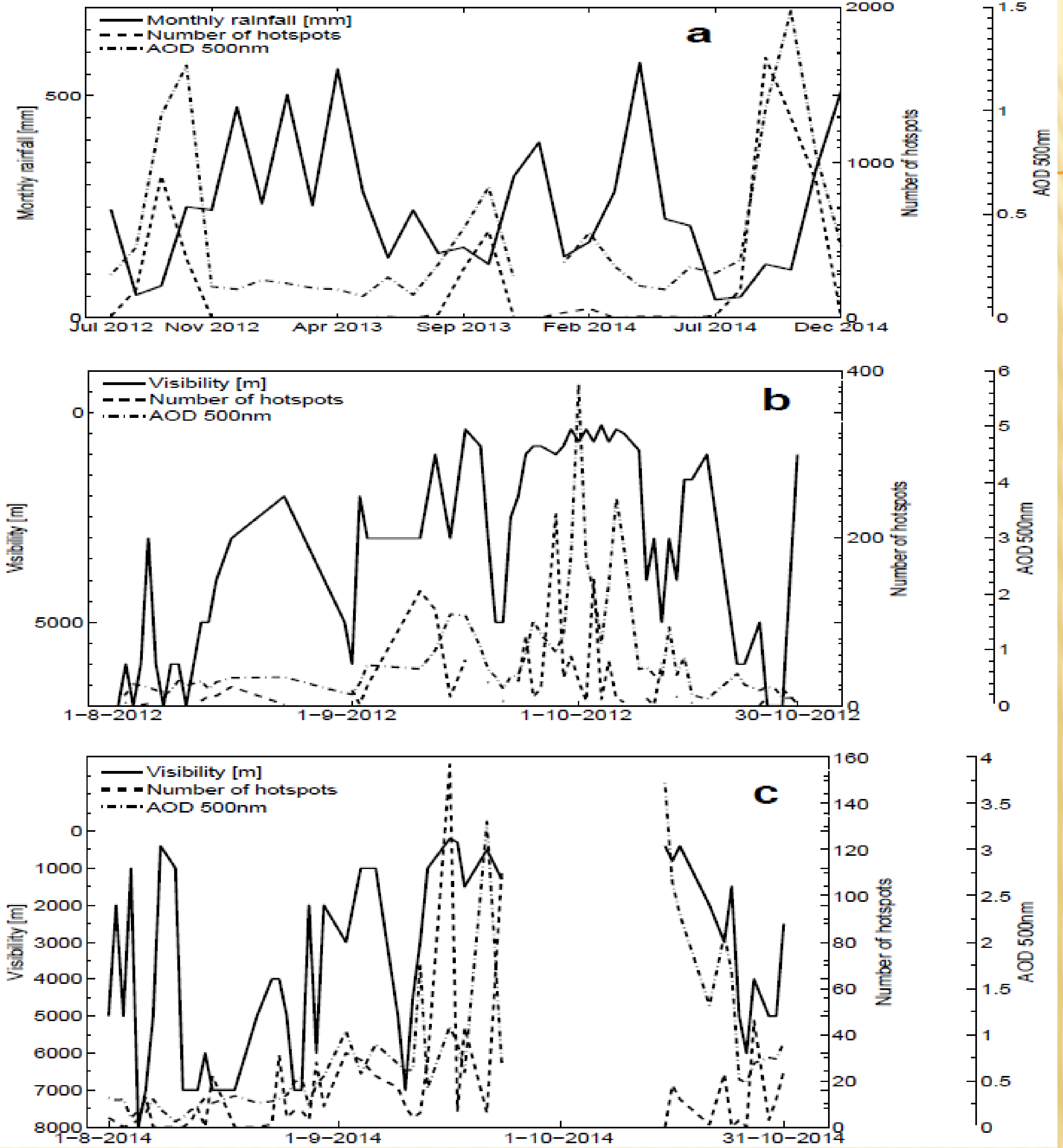


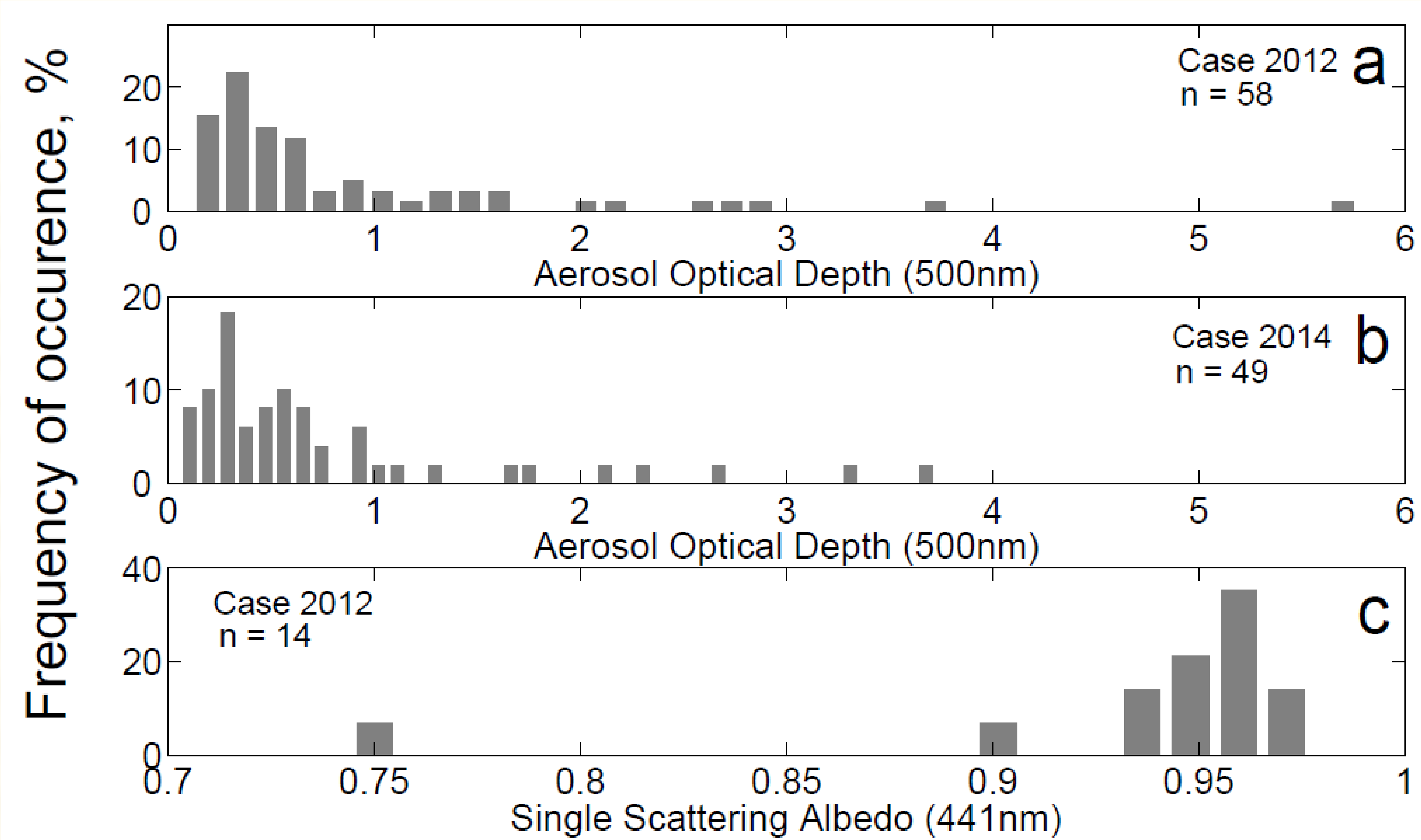
Aerosol size distribution during June 2013 from Singapore AERONET site. There is significant shift between size distribution before the fire episode (solid rectangular/circle) and during fire episode (dashed rectangular/circle).

FOREST FIRE IN PALANGKARAYA KALIMANTAN AEROSOL INSTRUMENT TO OBSERVE AEROSOL

The sun photometer installed on the roof of the Tjilik Riwut Meteorology Station at Tjilik Riwut Airport Palangkaraya, Central Kalimantan – Indonesia

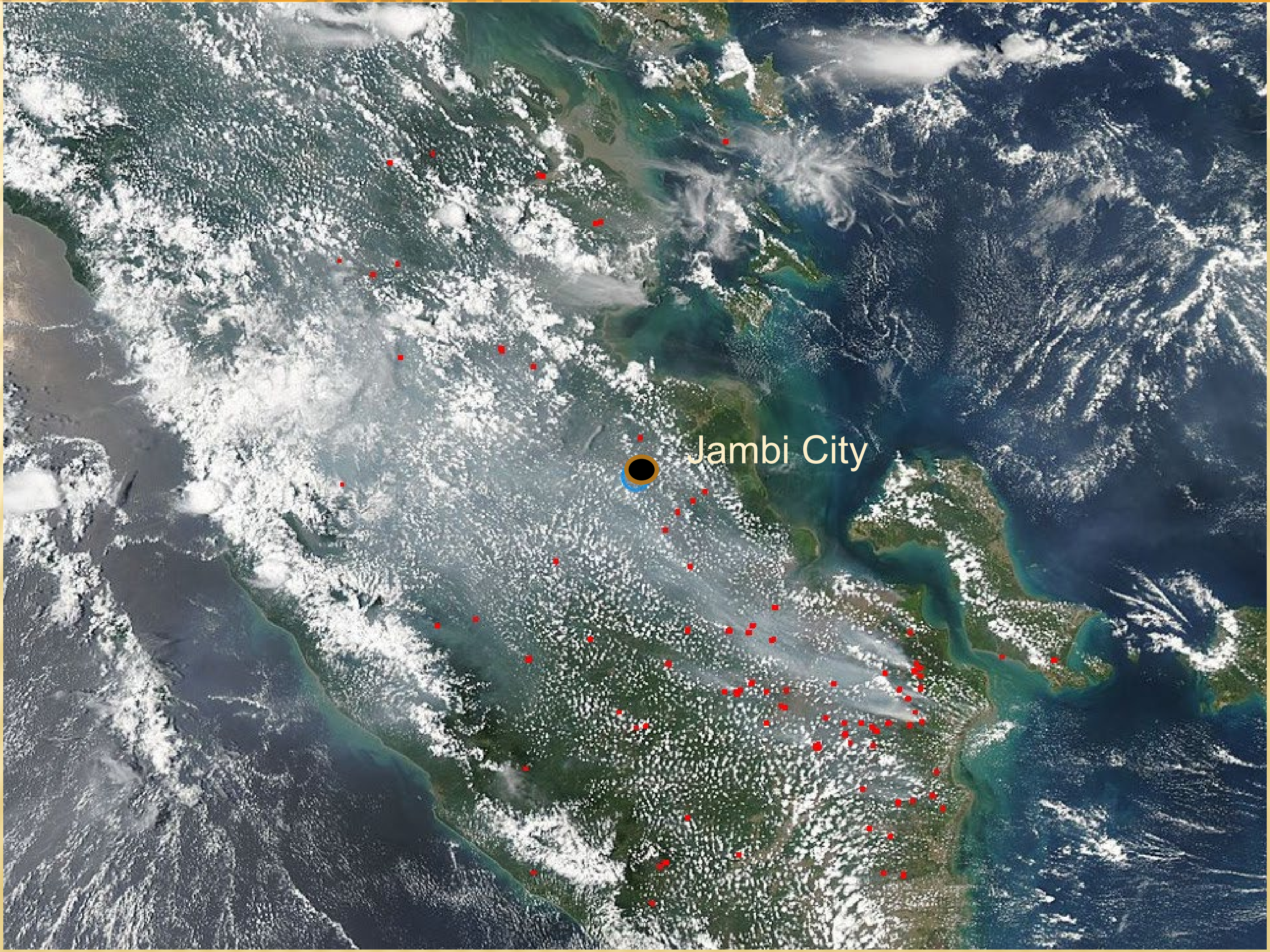
Monthly AOD, hotspot and rainfall relationship. AOD at wavelength 500 nm (a) and Visibility versus AOD and hotspot in 2012 (b) and 2014 fire episodes (c),



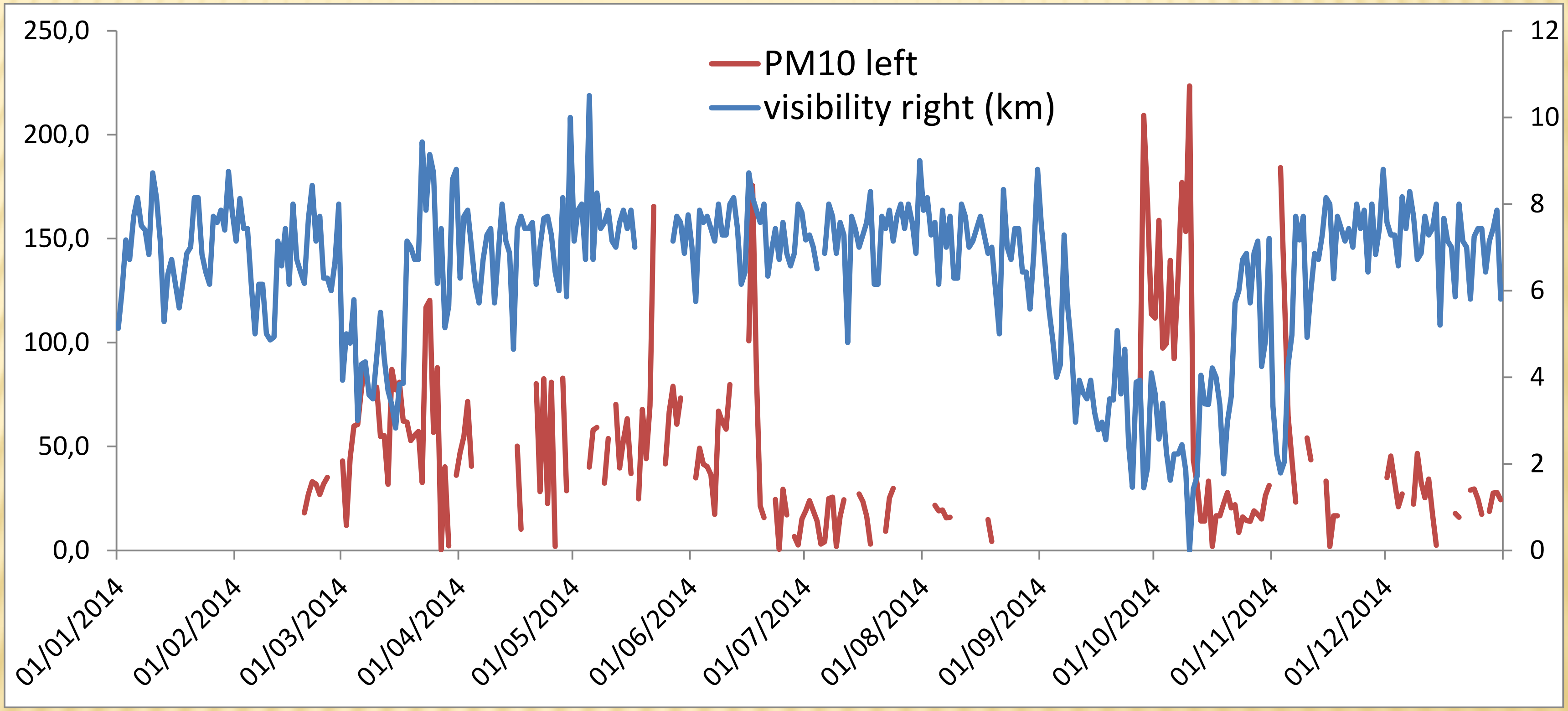


Histogram of AOD during fire episode 2012 and 2014 (a, b) and Histogram of SSA (c),

FOREST FIRE IN JAMBI PROVINCE SUMATERA HOTSPOT IN SUMATERA 1 OCTOBER 2014

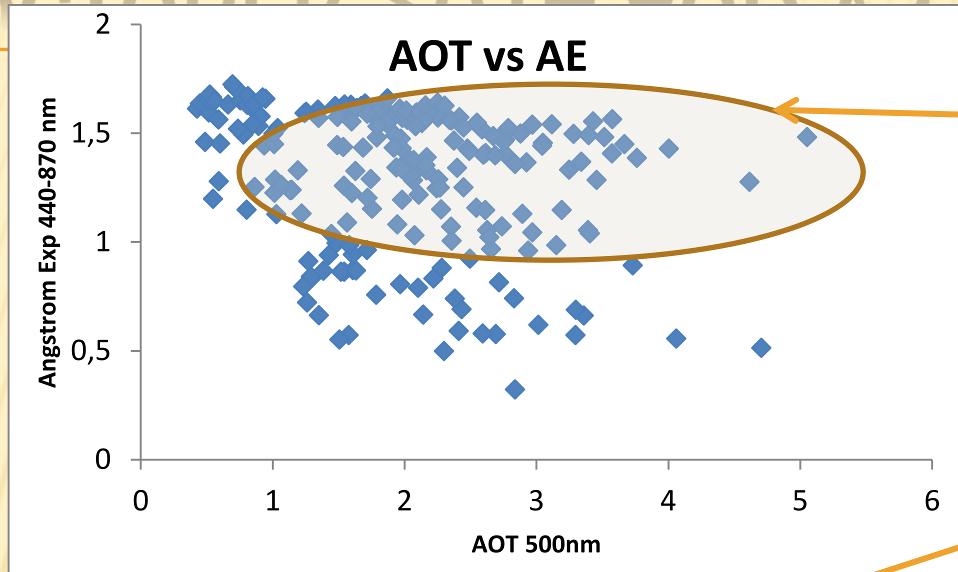


PARTICULATE (PM10) VS VISIBILITY DURING FIRE EPISODE OCTOBER 2014



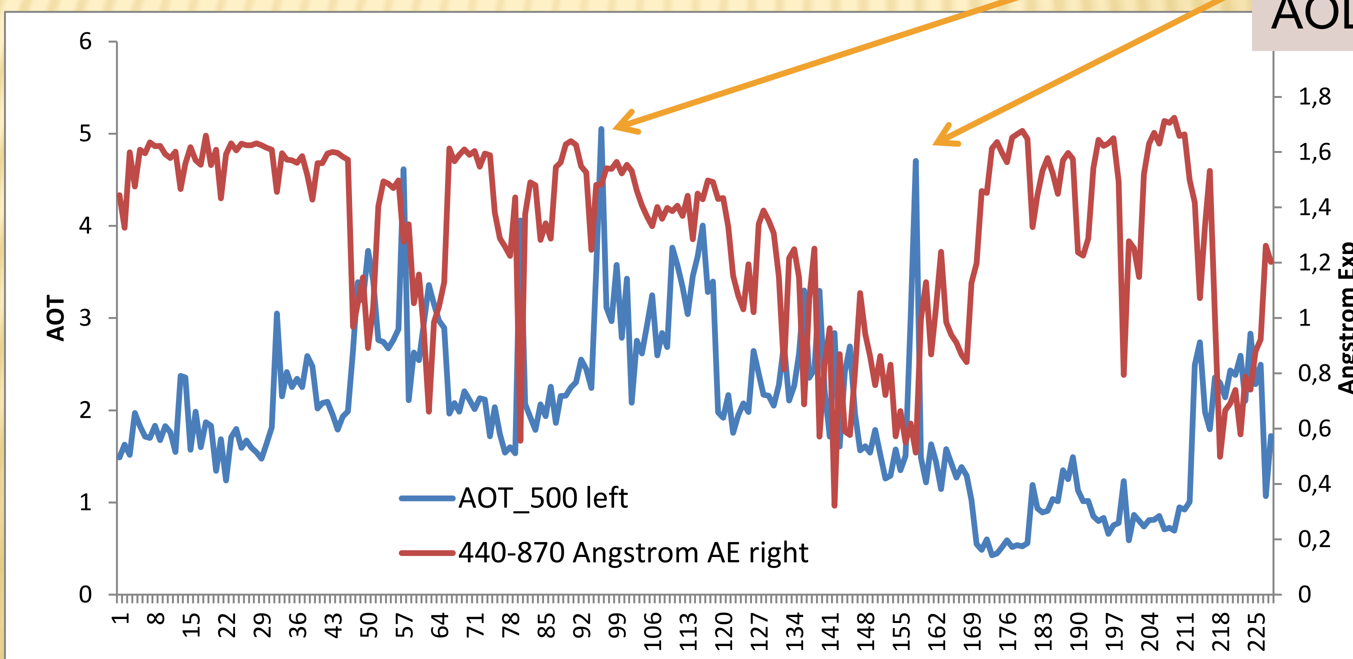
Certainly there is a clear relationship between particulate concentration and visibility, however, some reduction of visibility is due to fire in some other parts outside Jambi

OCTOBER 2014 AOD VS AE

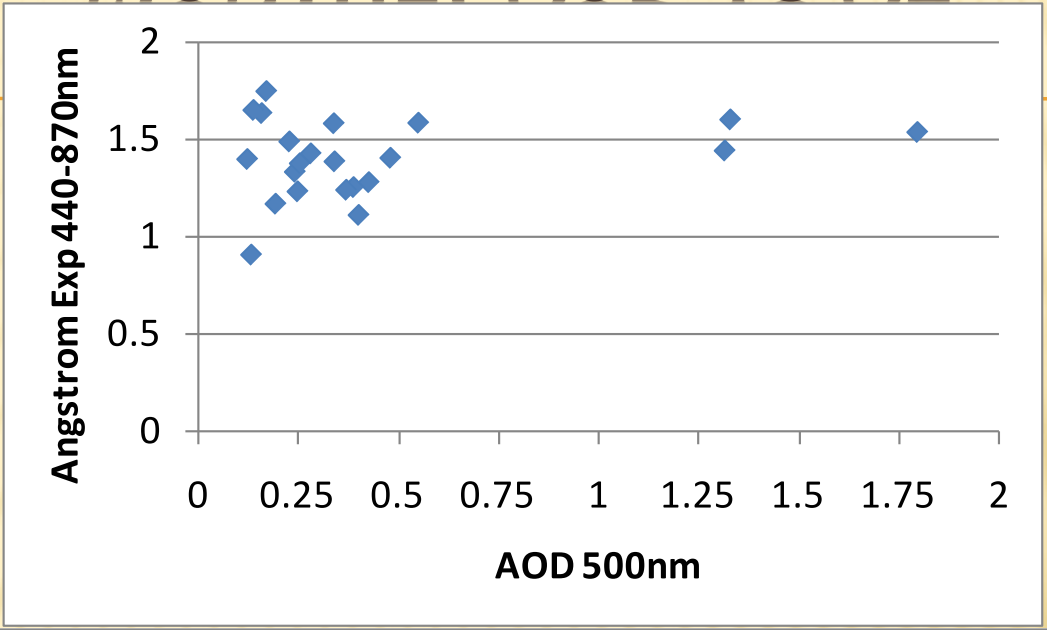


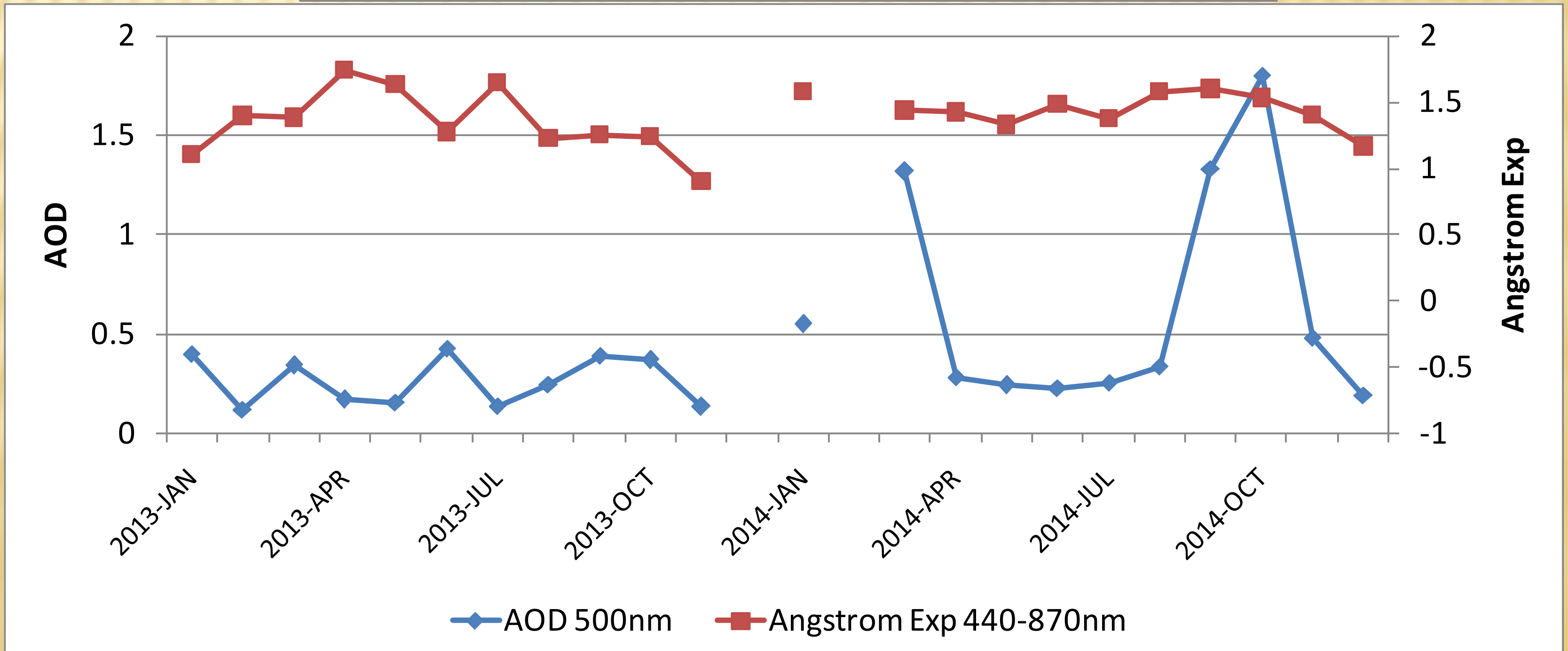
Small size aerosol from forest fire

Peatland source aerosol with high AOD above 4.5



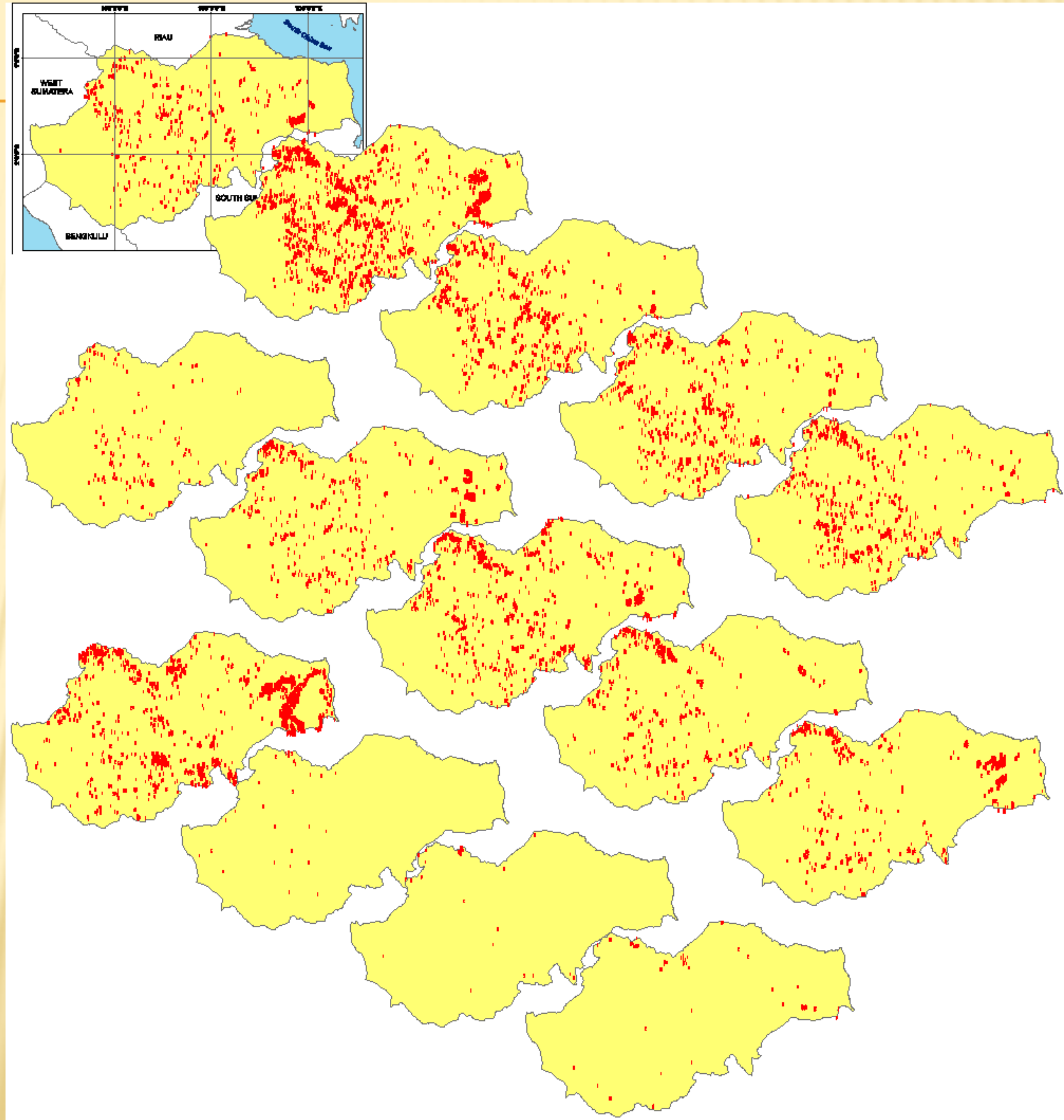
MONTHLY AOD VS AE



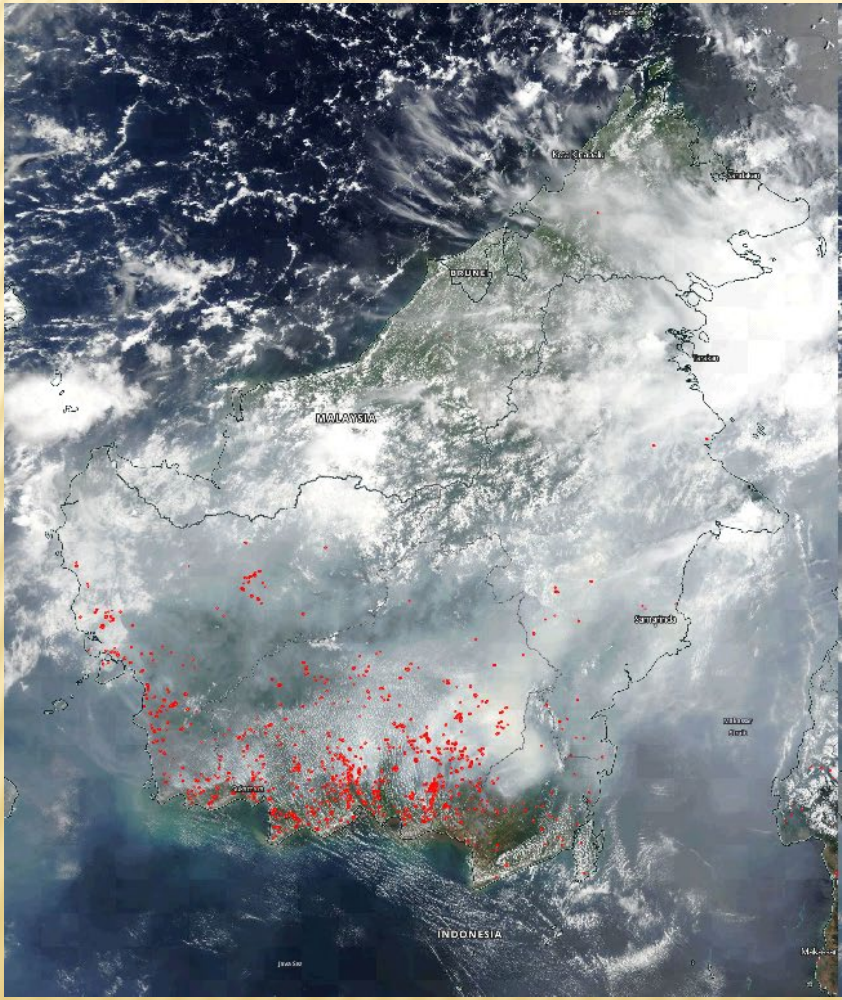


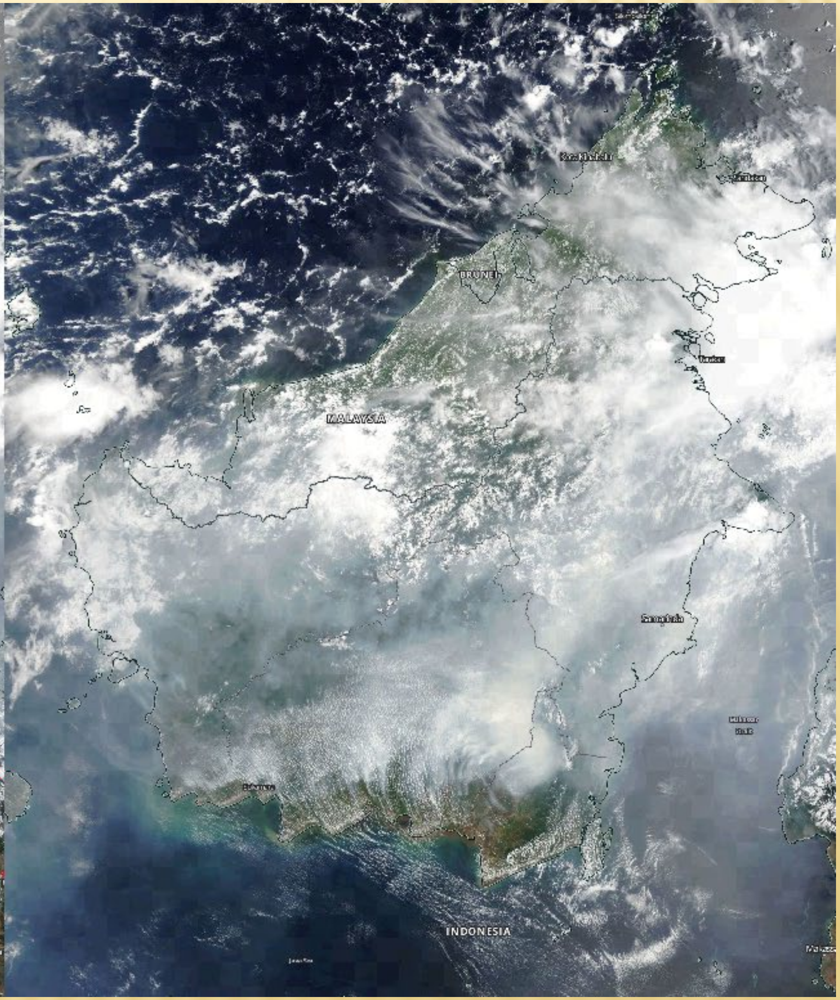
JAMBI FIRE

Fire episodes in Jambi province in the middle of Sumatera from 2005 (upper left) down to 2017. Actually there was the trace of succesfull human intervention in reducing the cause of fire with the last largest episode during 2015 El Nino.

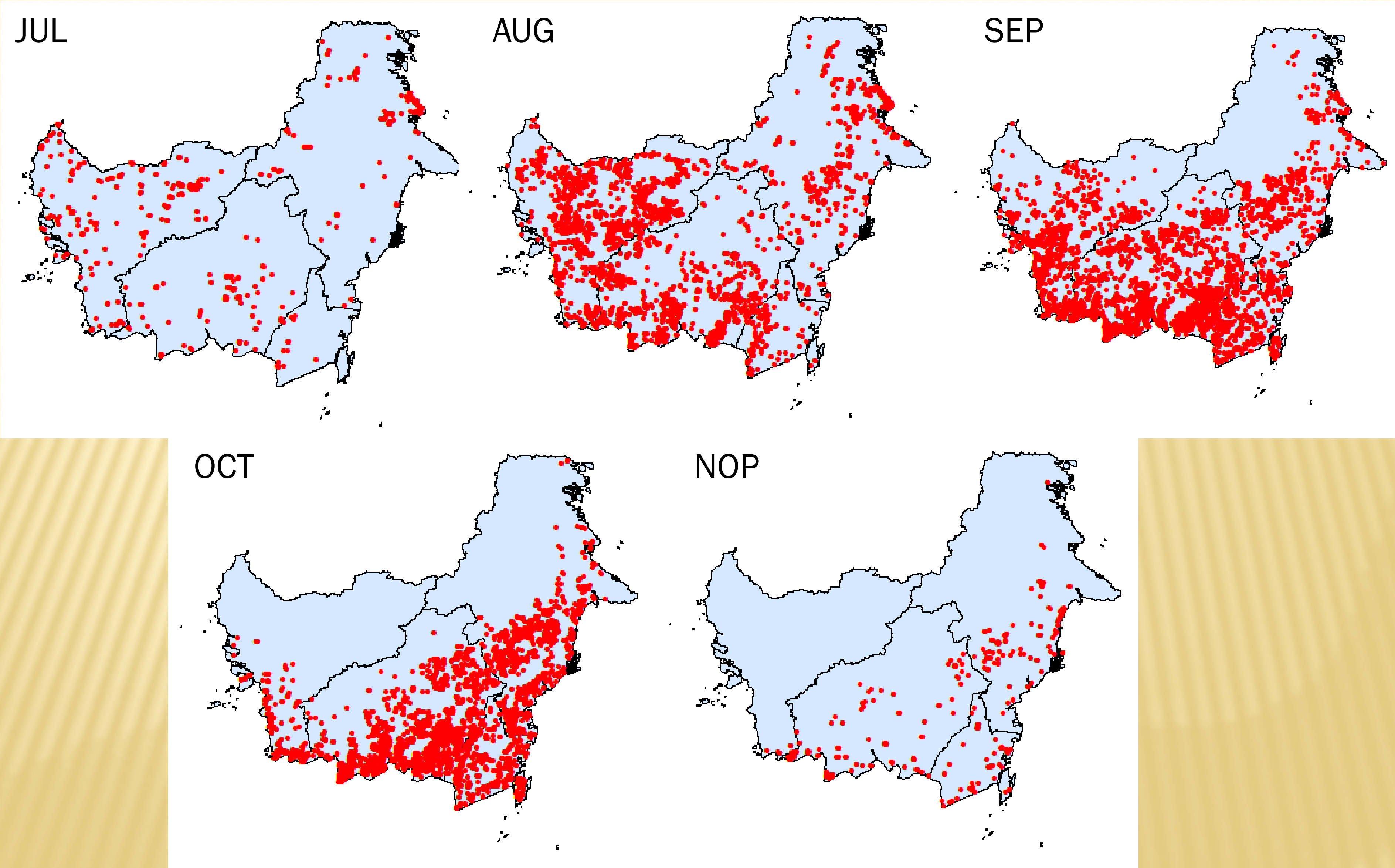


KALIMANTAN 2015 (21 SEPT 2015)



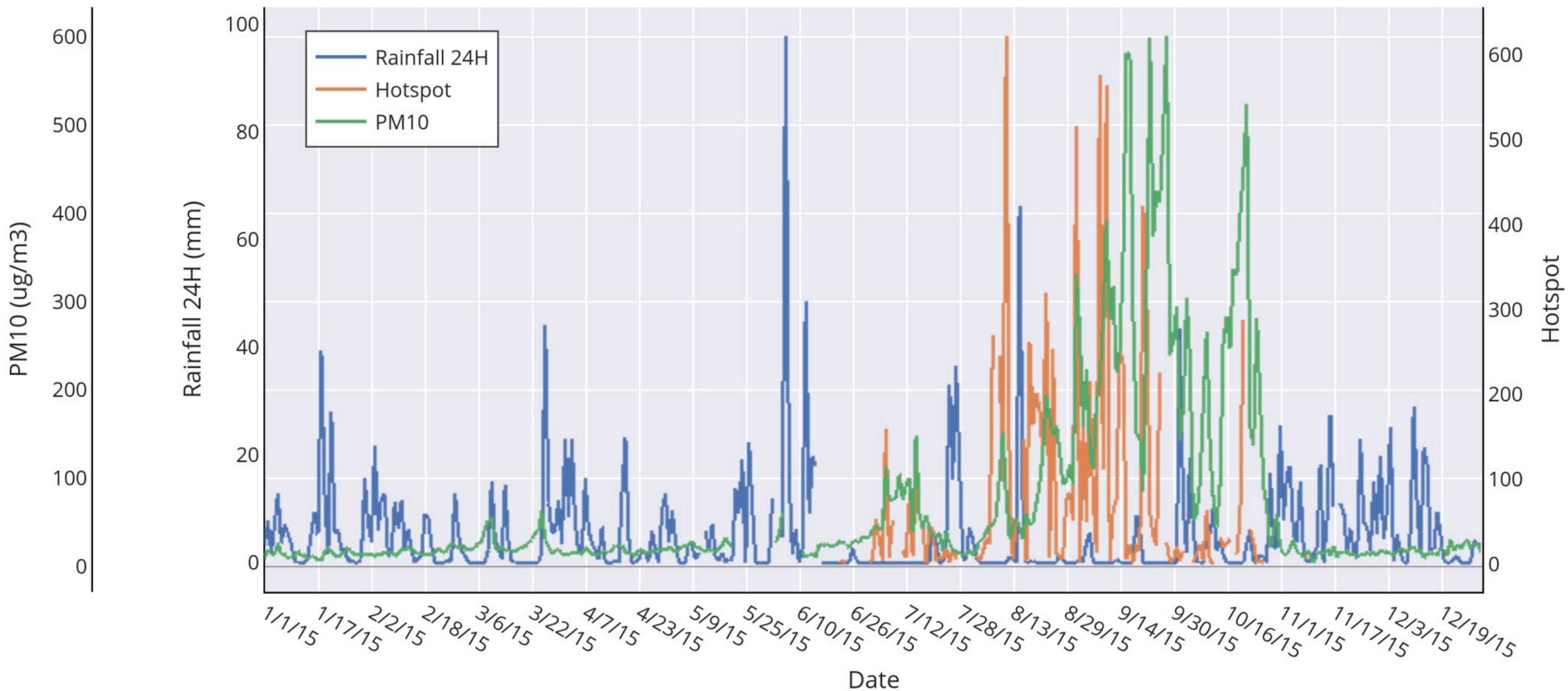


KALIMANTAN 2015



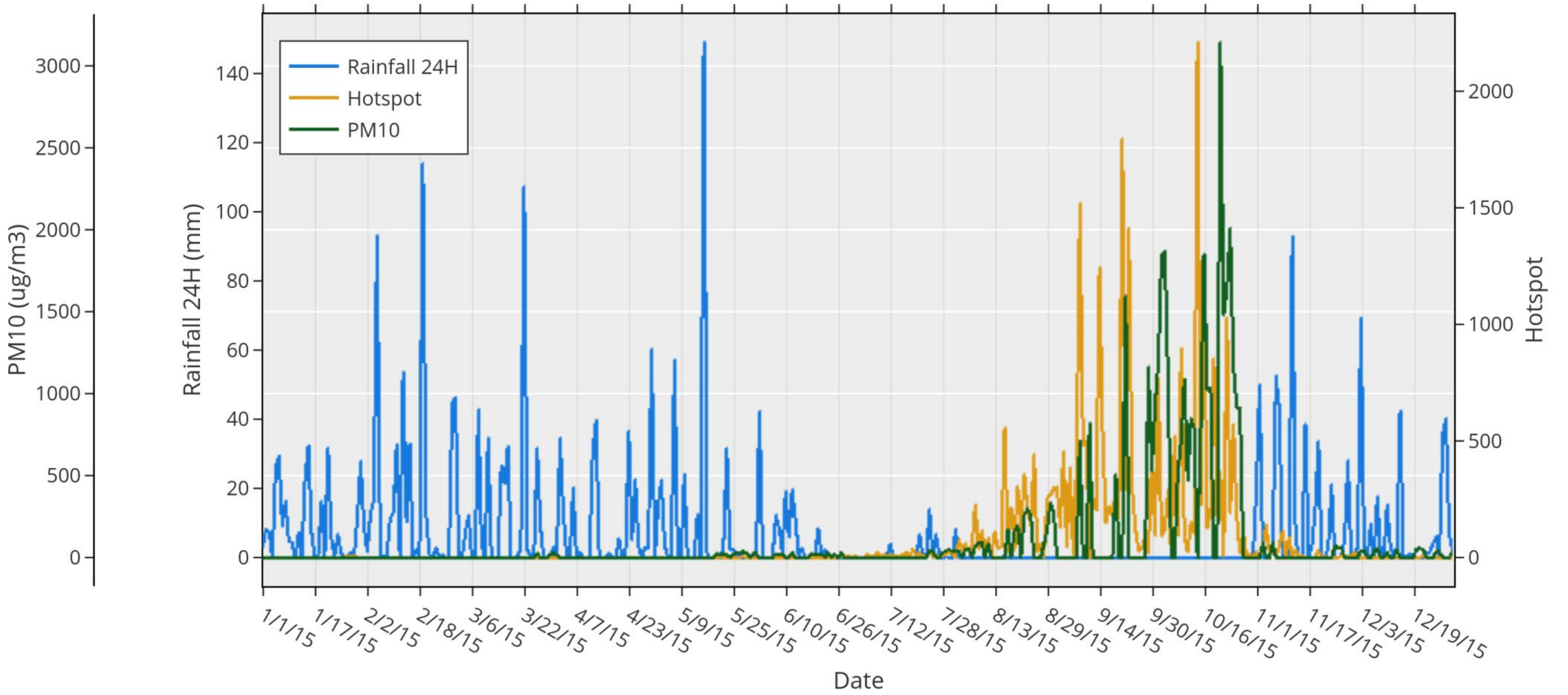
KALIMANTAN 2015

The relation between rainfall, hotspot and PM10 in central Kalimantan



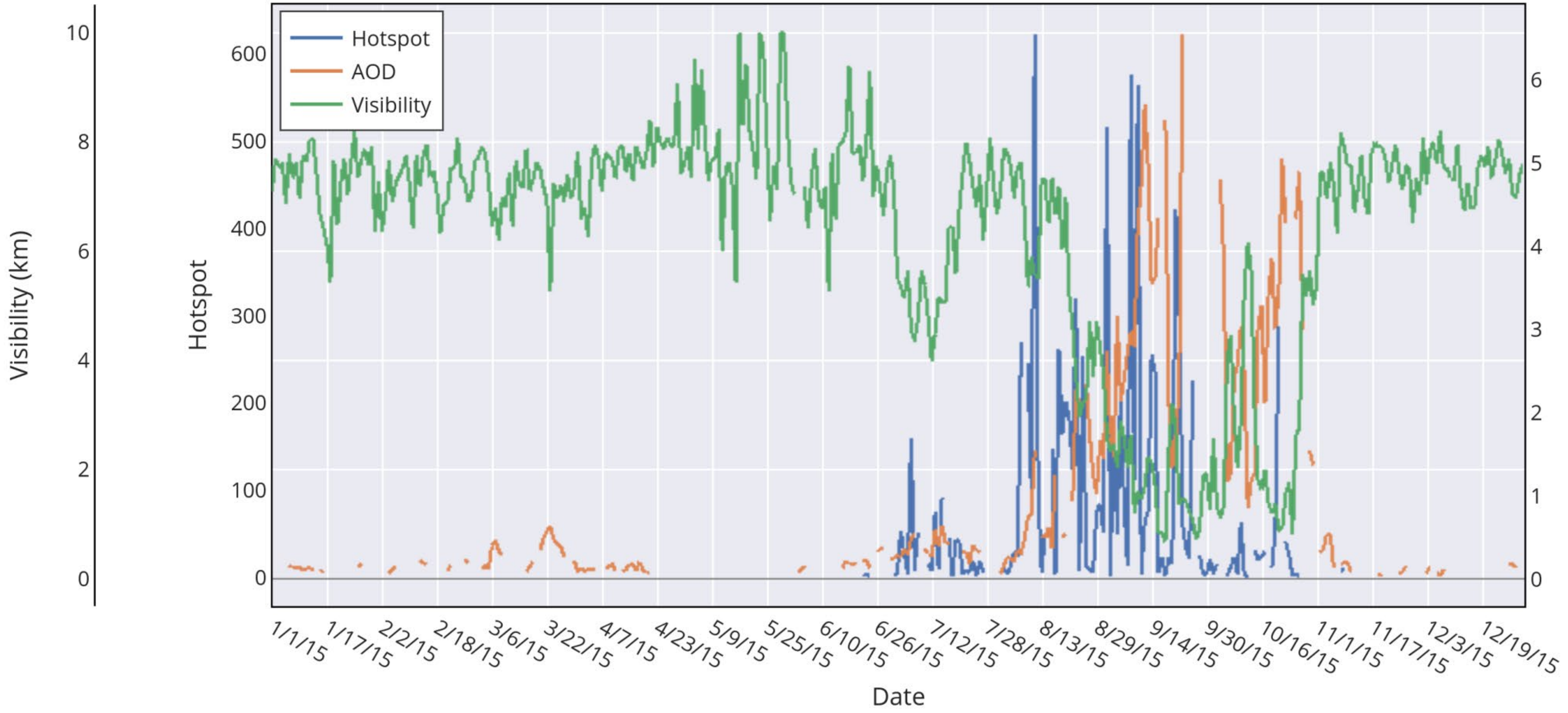
KALIMANTAN 2015

The relationship between rainfall, hotspot and PM10 in West Kalimantan



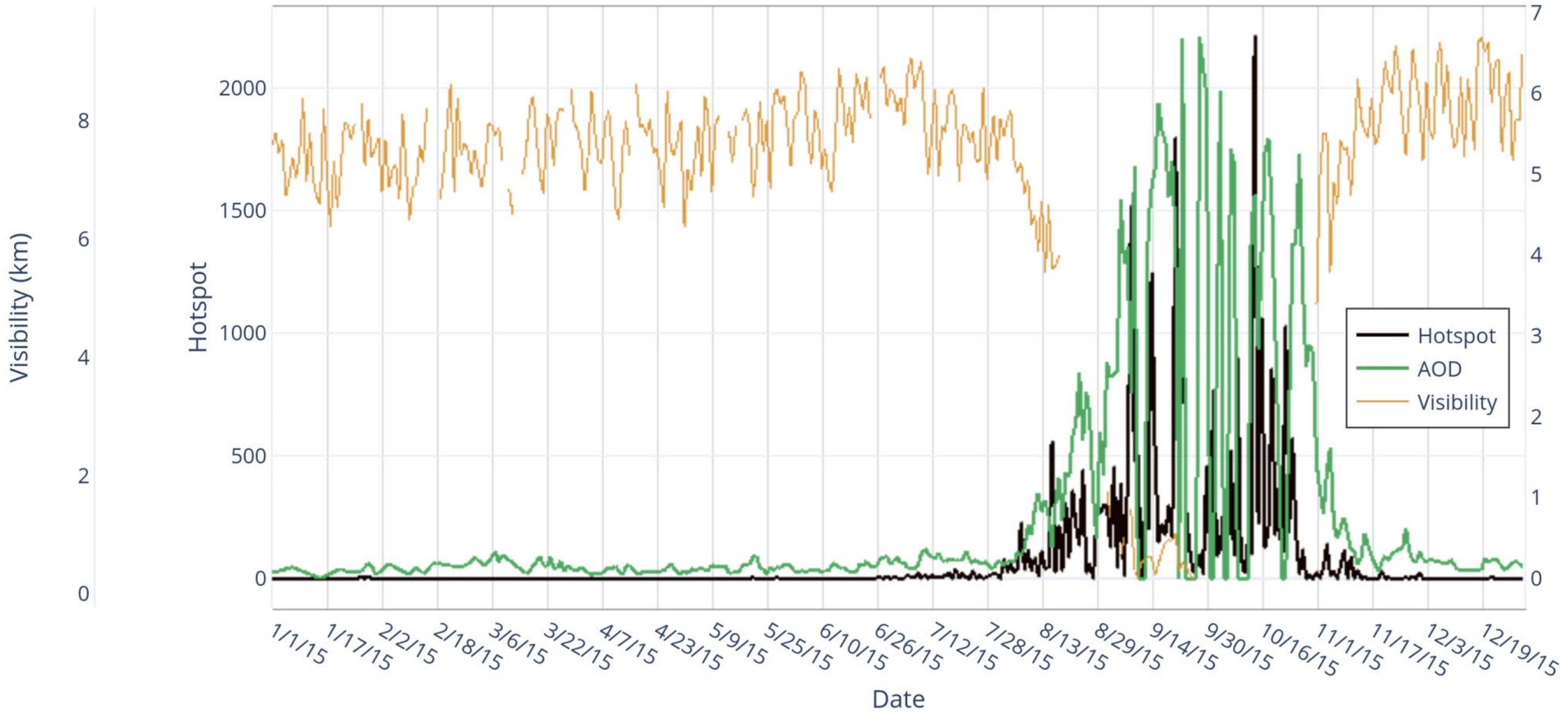
KALIMANTAN 2015

The relationship between hotspot, AOD and visibility in west Kalimantan



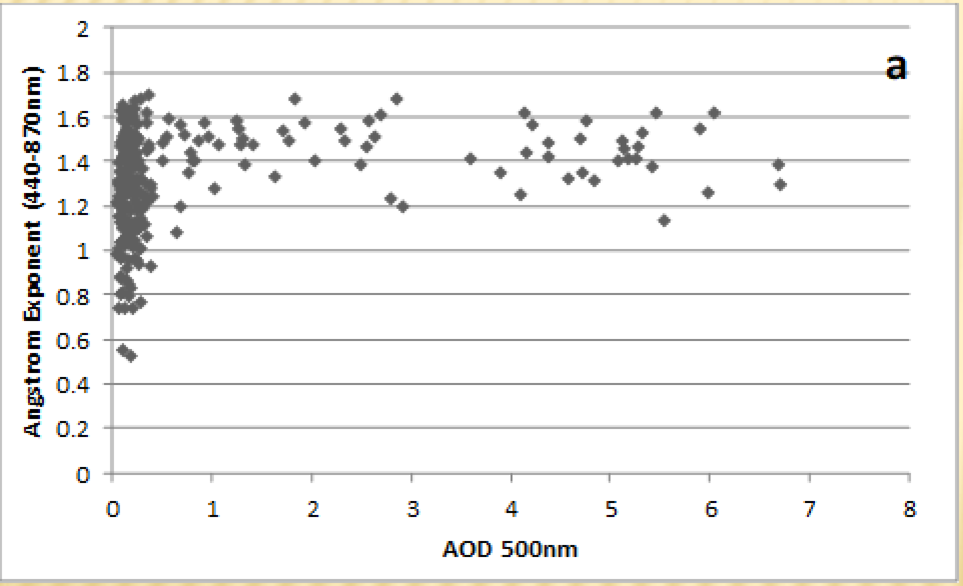
KALIMANTAN 2015

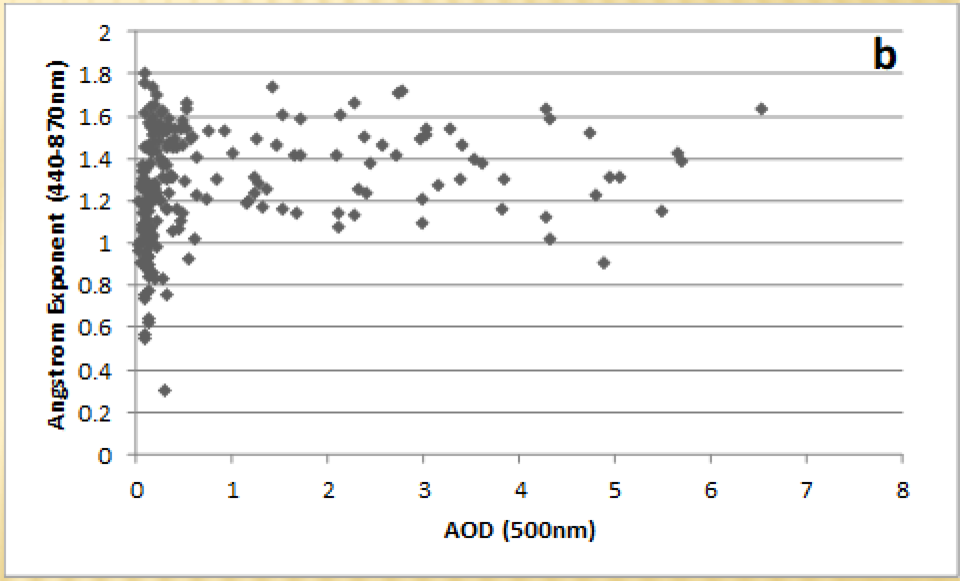
The relationship between hotspot, AOD and visibility in central Kalimantan



KALIMANTAN 2015

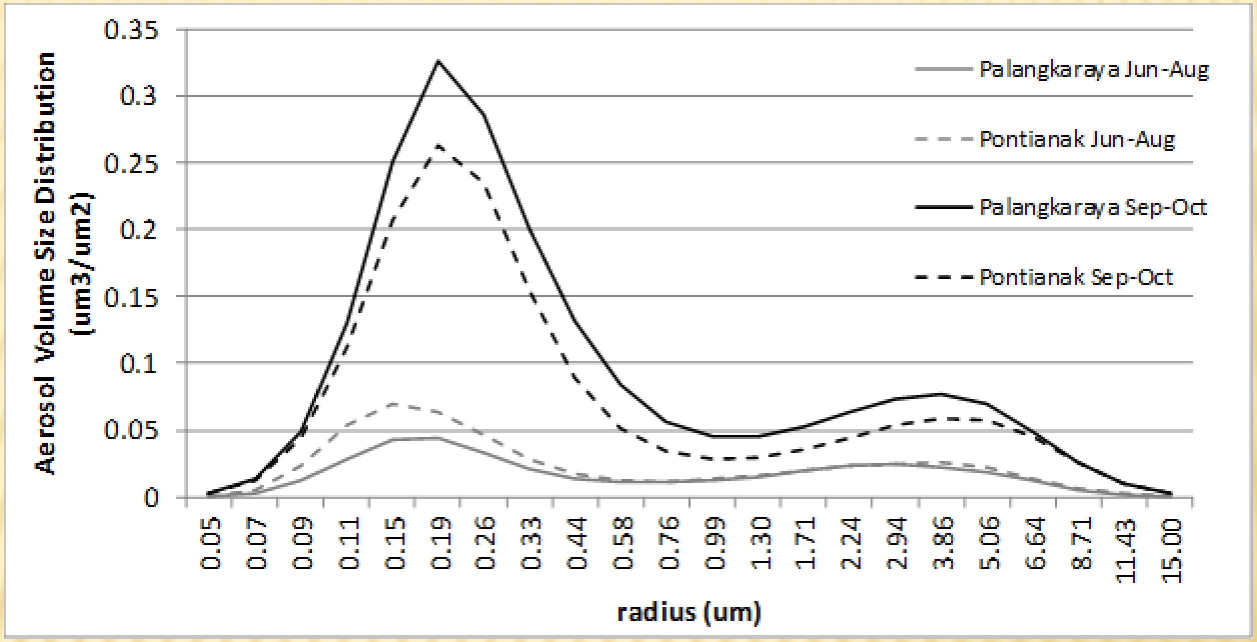
AOD characteristics in Central and west Kalimantan during the fire episode. This is the indication of small particle originated from smoke. As studied by Holben *et al.* 2001 and Salinas *et al.* 2009 α > 1 indicates the presence of fine aerosol (radius < 2.5 μm) associated with urban pollution and biomass burning emissions.





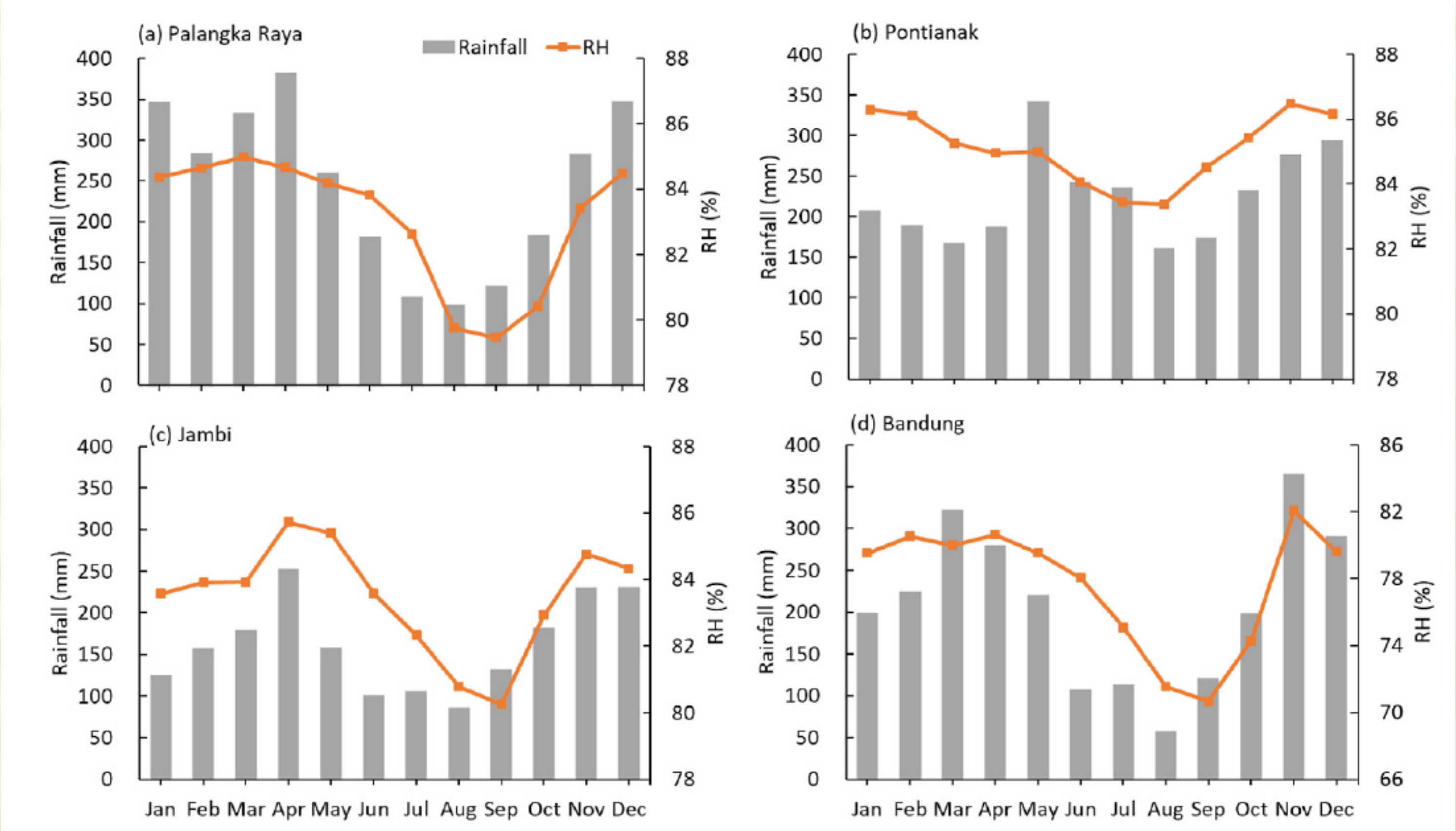
the AOD value below 0.2 with 0.5 < α < 2 indicate the presence of marine aerosol

KALIMANTAN 2015



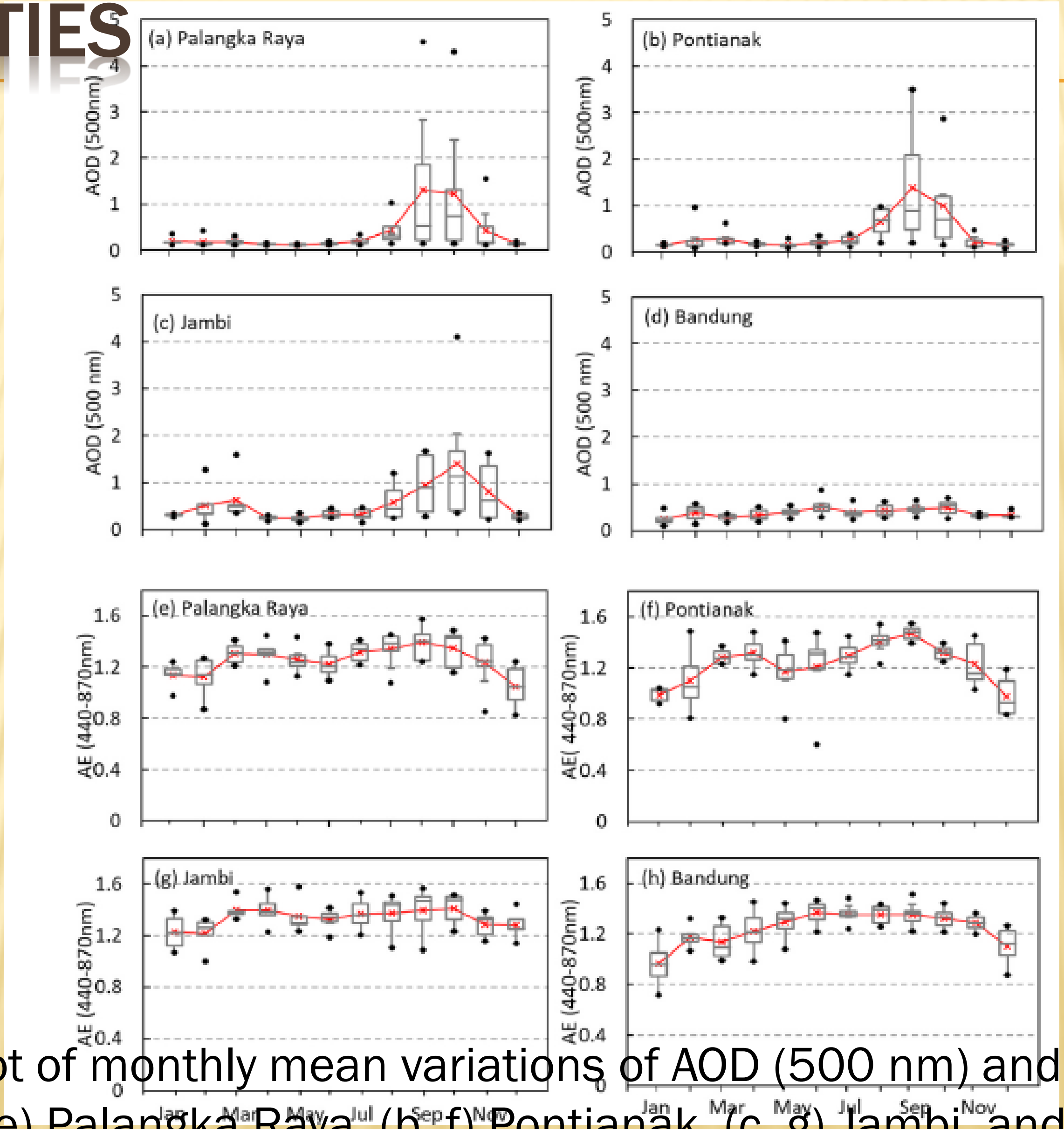
The aerosol size distribution during peak of burning season in September to October and pre-burning season in June to August both in Palangkaraya (Central) and Pontianak (West Kalimantan). These aerosol volume size distributions show bimodal distribution with maximum volume concentrations for fine mode particles with radii ranged between 0.14 and 0.26 μm and 2.24 to 6.64 μm for coarse-mode particles in both location during burning period. As can be seen from Fig. 8 that prior to burning season, fine and coarse mode aerosol were well evenly distributed in Palangkaraya and very slightly higher in Pontianak. We postulate that the source of these higher fine and coarse particulate were due to agriculture activity.

AERONET 3, AEROSOL OPTICAL AND RADIATIVE PROPERTIES



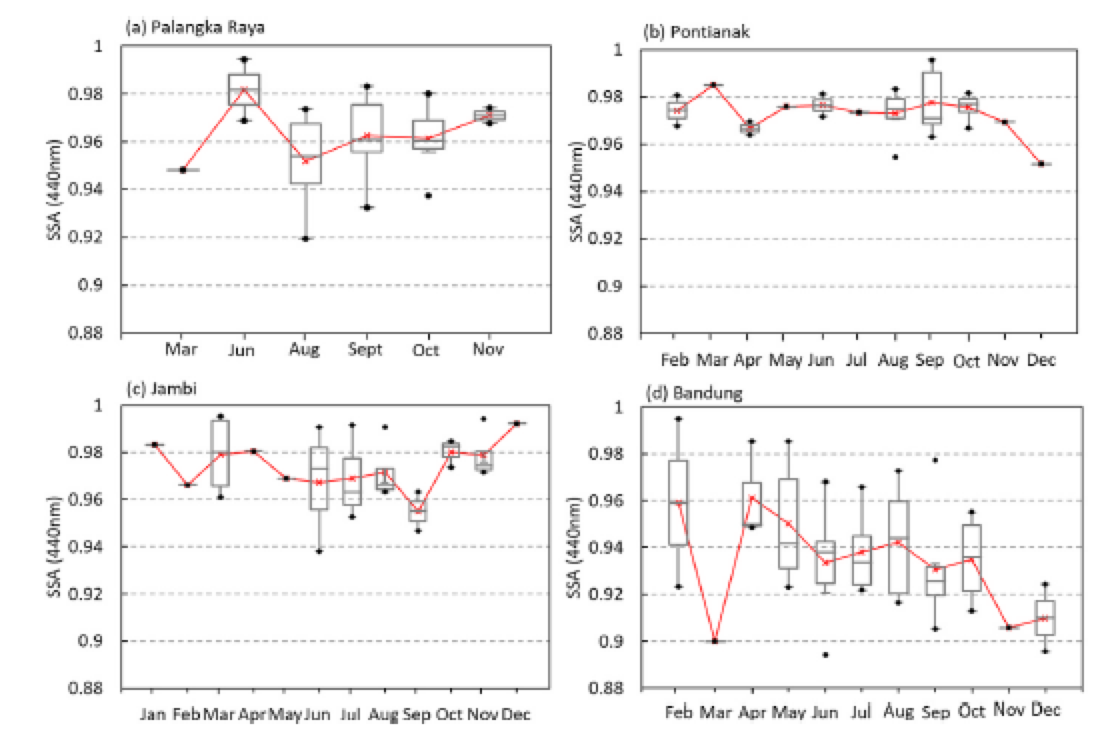
The monthly mean variations of meteorological parameters observed in (a) Palangka Raya, (b) Pontianak, (c) Jambi, and (d) Bandung during the study period 2009 - 2020.

AERONET 3, AEROSOL OPTICAL AND RADIATIVE PROPERTIES

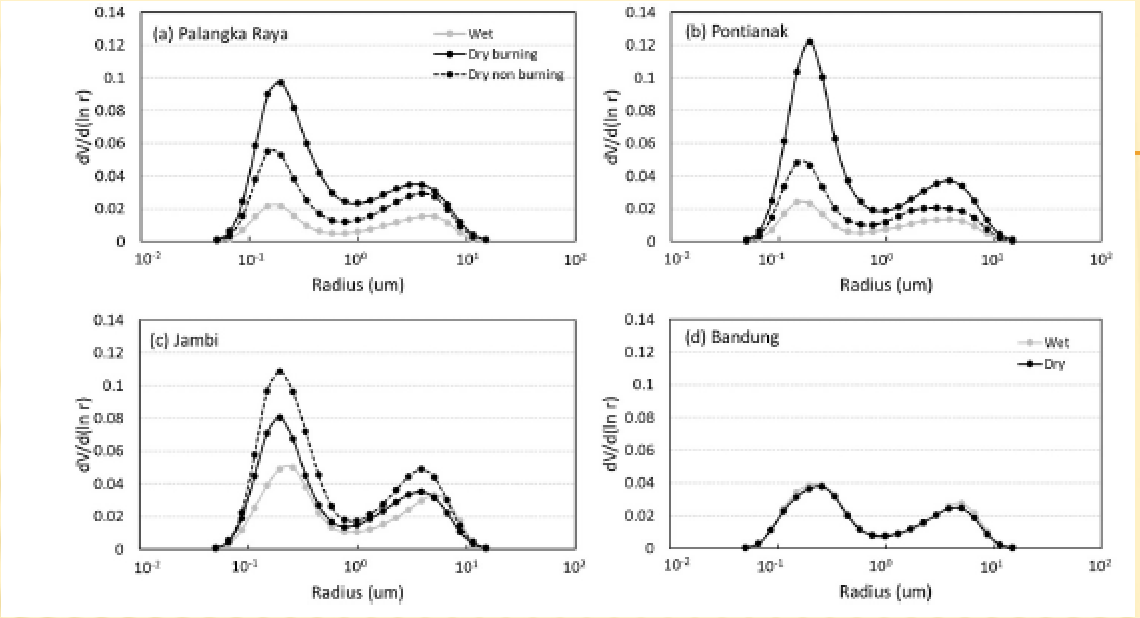


Box whisker plot of monthly mean variations of AOD (500 nm) and AE (440–870 nm) in (a, e) Palangka Raya, (b, f) Pontianak, (c, g) Jambi, and (d, h) Bandung.

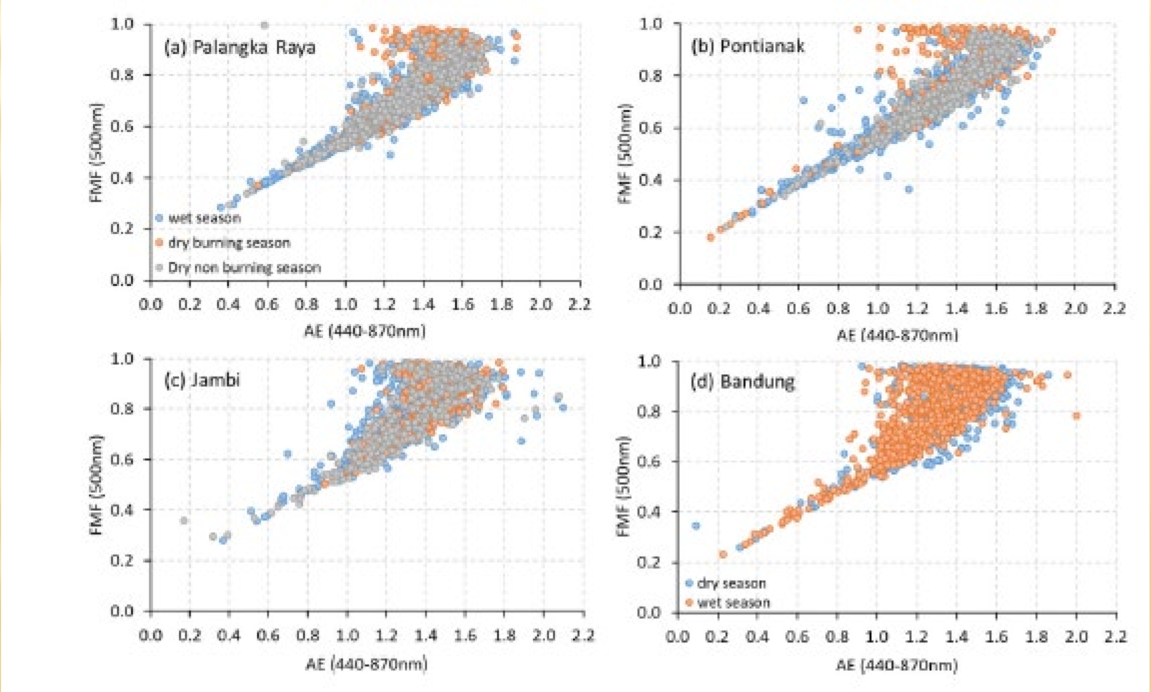
AERONET 3, AEROSOL OPTICAL AND RADIATIVE PROPERTIES



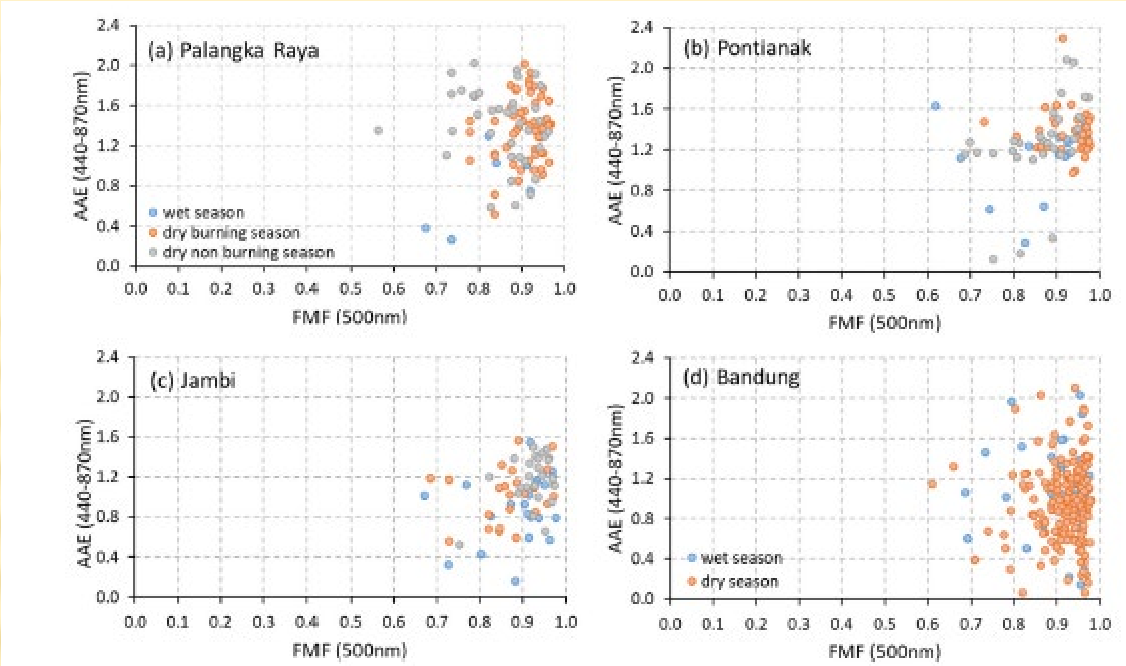
SSA at wavelength 440 nm in (a) Palangka Raya, (b) Pontianak, (c) Jambi, and (d) Bandung



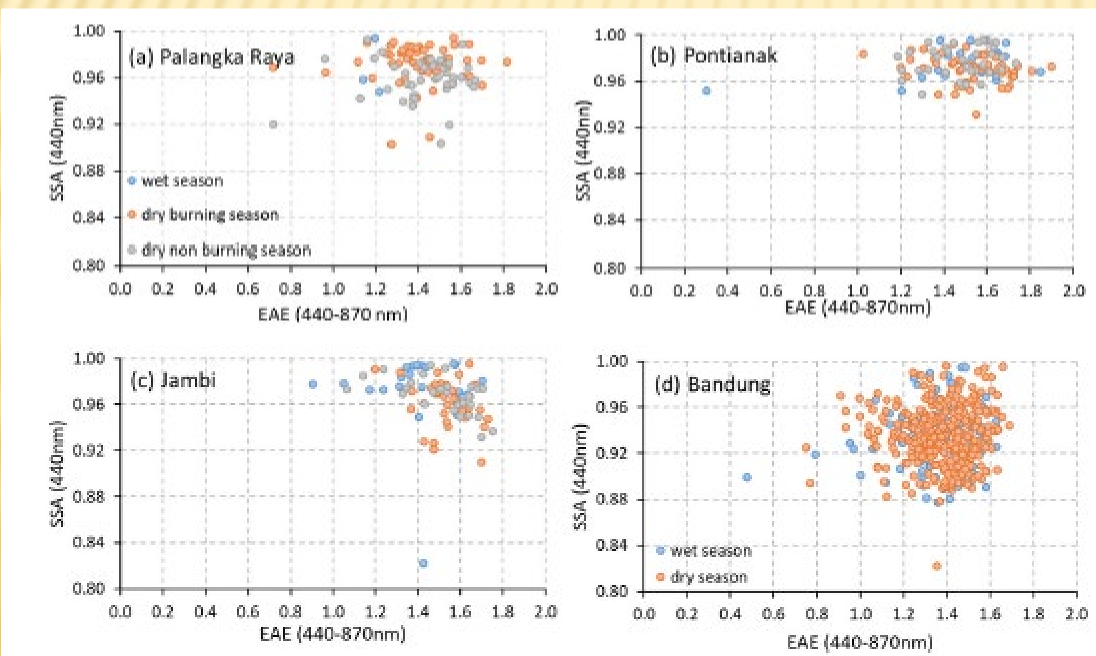
Particle size distribution during wet and dry (burning and non-burning season) in (a) Palangka Raya, (b) Pontianak, (c) Jambi, and (d) Bandung



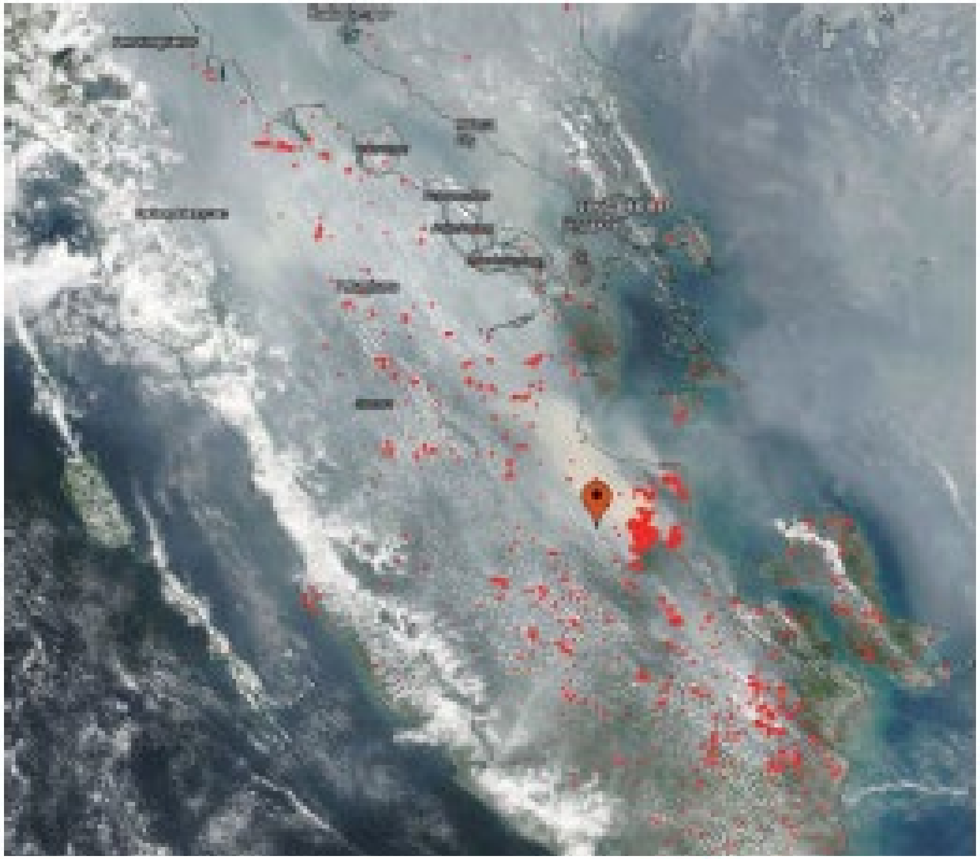
Relationships between FMF and AE during wet and dry (burning and non-burning season) in (a) Palangka Raya, (b) Pontianak, (c) Jambi, and (d) Bandung



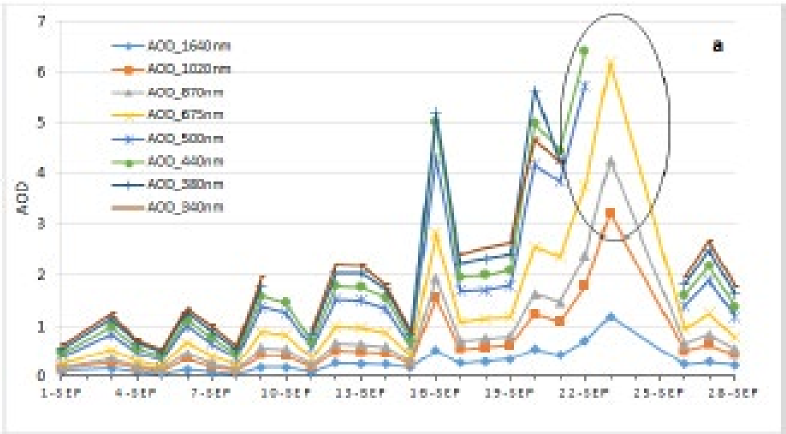
Relationships between AAE (440–870 nm) and FMF (500 nm) during wet and dry (burning and non-burning season) in (a) Palangka Raya, (b) Pontianak, (c) Jambi, and (d) Bandung.

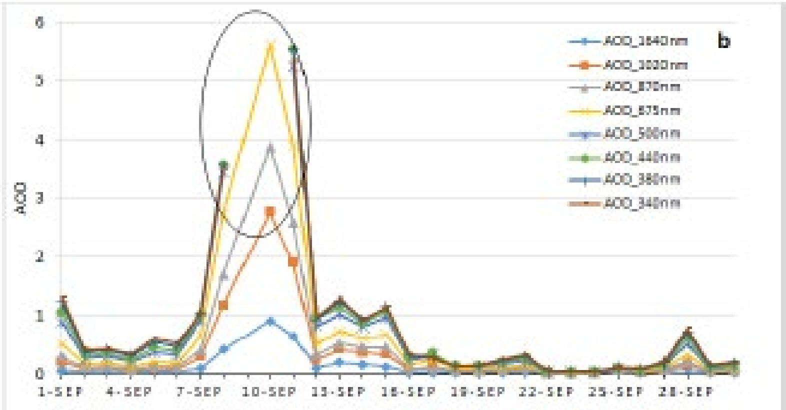


Relationships between SSA (440 nm) and FMF (500 nm) during wet and dry (burning and non-burning season) in (a) Palangka Raya, (b) Pontianak, (c) Jambi, and (d) Bandung

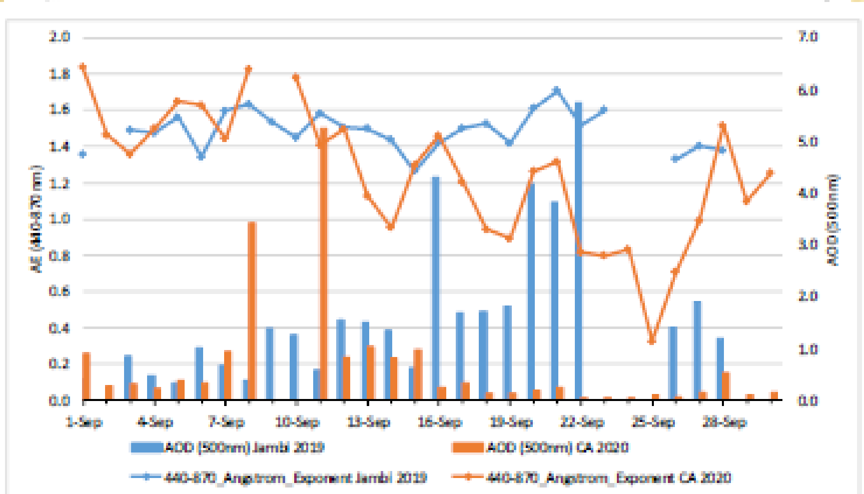


WHY THE SKY WAS RED DURING FOREST FIRE





AOD level 2 measured in different wavelengths during September 2019 in Jambi, Sumatera, Indonesia (a) and AOD level 1.5 during September 2020 in Monterey, California, The United States of America (USA) (b). The black circle indicates the period of red sky.



Comparison of level 2 AOD (500 nm) and Angstrom Exponent (440 and 870 nm) during smoke fires period at Jambi site September 2019 and Monterey site September 2020.

THE STUDY FOUND THAT THE RED SKY OCCURRENCE IN JAMBI IS EXPLAINED

1. Very high AOD (500 nm) with the domination of fine-mode particle (indicated from $\alpha > 1$) ranged from 0.34 to 5.74 during the peak of fires and a day before the red sky.

2. Only longer wavelengths of AOD were recorded and retained at 675, 870, 1020, and 1640 nm, while AOD in shorter wavelengths cannot be retrieved due to complete attenuation.

3. Very high SSA near one which indicates purely or dominant of aerosol scattering with characteristics coagulated fine-mode particles or aged smoke due to high relative humidity

CONCLUSIONS

1. Fire climate relationship is detected from historical record, however the recent finding shows the decrease of this relationship due to human intervension mostly due to some legal action.
2. PM10 and AOD during fire episodes increase significantly and eventually reduce visibility and homogen size create red sky
3. Significantly high AOD number above 6.0 in Kalimantan and above 5.0 in Jambi may related to peat fires in the eastern coast of Sumatera
4. The long-term average statistics demonstrated a clear seasonal pattern of AOD at all sites, except for Bandung.
5. Annual trend detection demonstrated a decreasing tendency of AOD at all sites except Bandung. Bandung shows persistent aerosol emission for the whole seasons driven primarily by the anthropogenic activities
6. The SSA did not indicate any significant seasonal patterns at the four analyzed sites. Biomass burning sites appeared to have a higher SSA annual mean (~0.97) compared to urban/industrial site (~0.93) owing to different chemical compositions and aerosol sources.

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