Landscape Fire Smoke - Example Air Quality and Health Impact in LMIC countries

Grosvenor, M., Ardiyani, V., Green, D., Wooster, M.J., Xue, T., Zhang, T., de Jong, M., Geng, G., Li, J., Han, Y., Guo, Q., Kelly, F., Wooster, M., Wang, H., Jiangtulu, B., Duan, X., Wang, B., Zhu, T.

- Global Fire Assimilation System [GFAS] & Air Quality Forecasting
- Example from Indonesian in 2019
- Global Impact on Child Mortality

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Copernicus Atmosphere Monitoring Service (CAMS)

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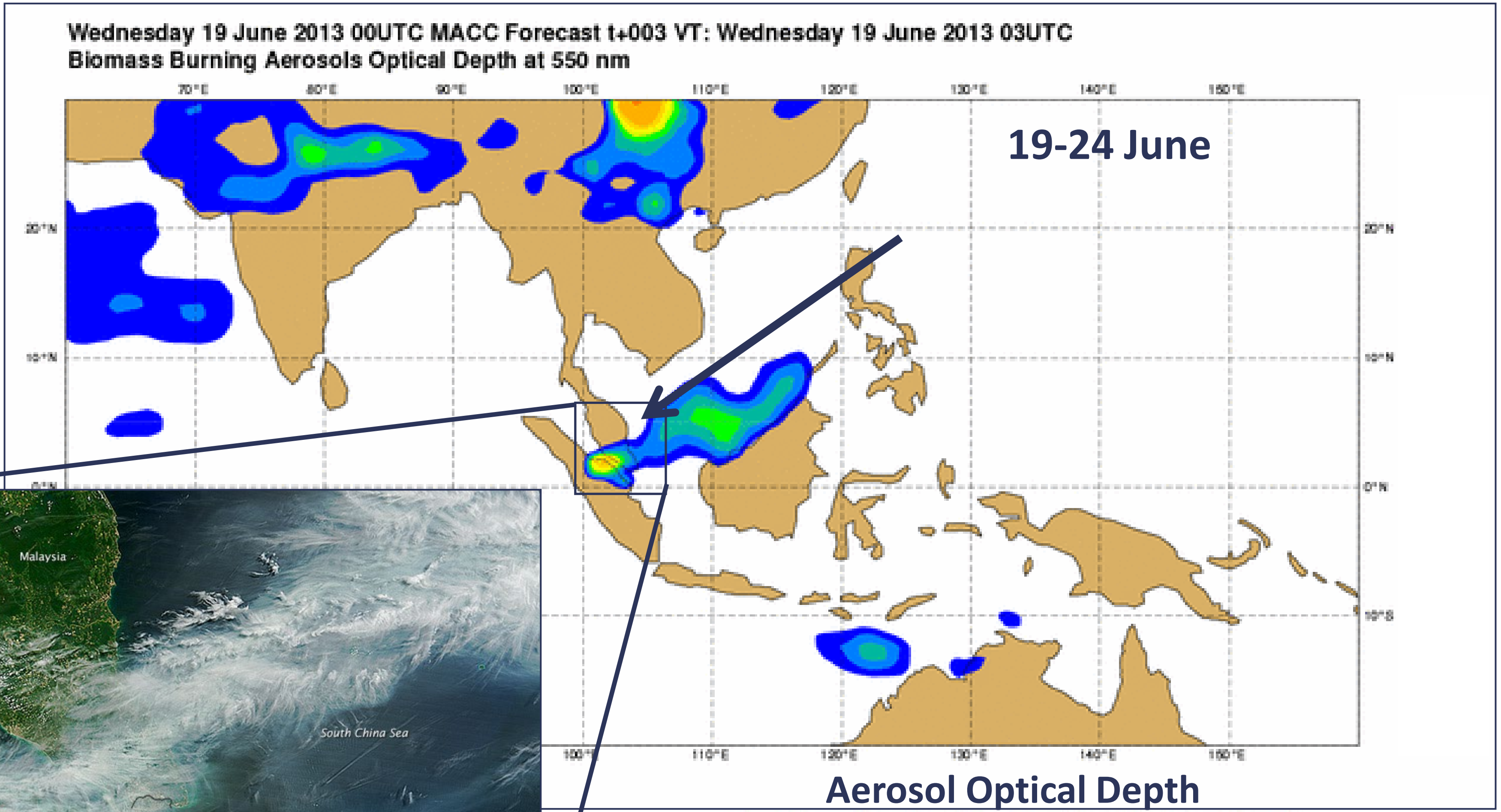
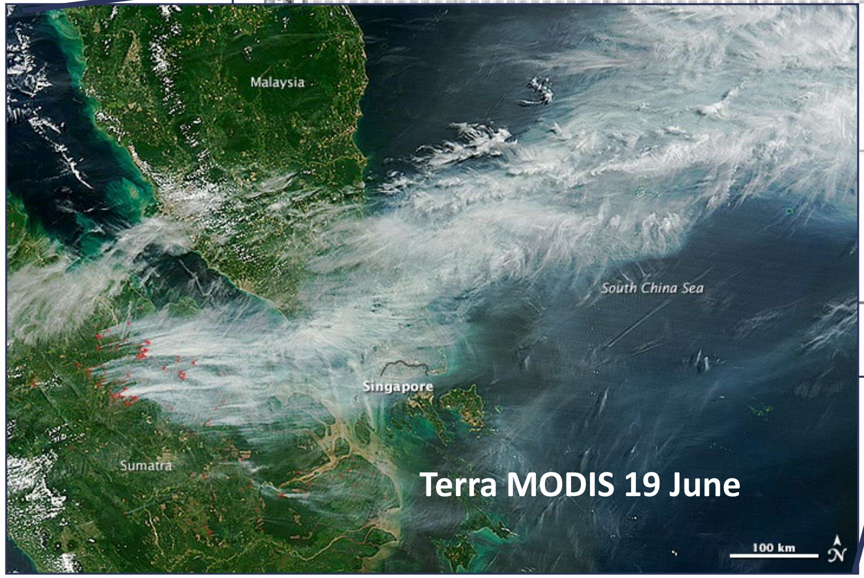
Example from 2013 Sumatran Fires





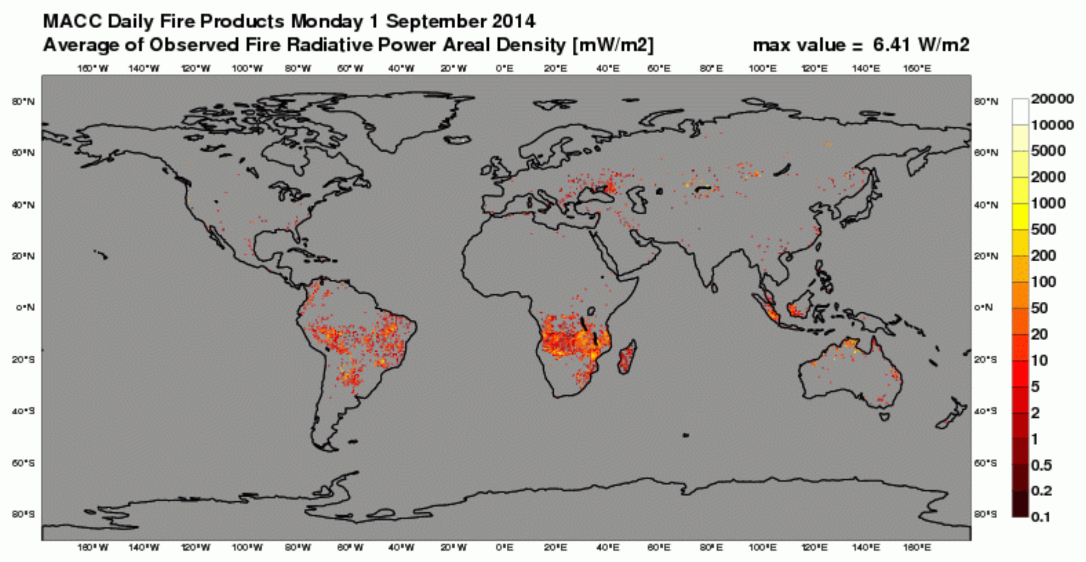
Aerosol Optical Depth

Biomass Burning Aerosol Optical Depth @ 0.55 µm

<u>Now used to generate surface level PM2.5 concentration estimates</u>

Copernicus Atmosphere Monitoring Service (CAMS)

Global Fire Assimilation System (GFAS)



Further developed by consortium of KCL, FMI, JK, IMPA – using more satellites and ultimately improve atmospheric forecast accuracy within CAMS.

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CAMS Surface Level $PM_{2.5}$ Concentration

22 – 25 June 2022

[forecast example in fire affected region]

“Haze” in Kalimantan - 2019

Kalimantan Smoke Plumes

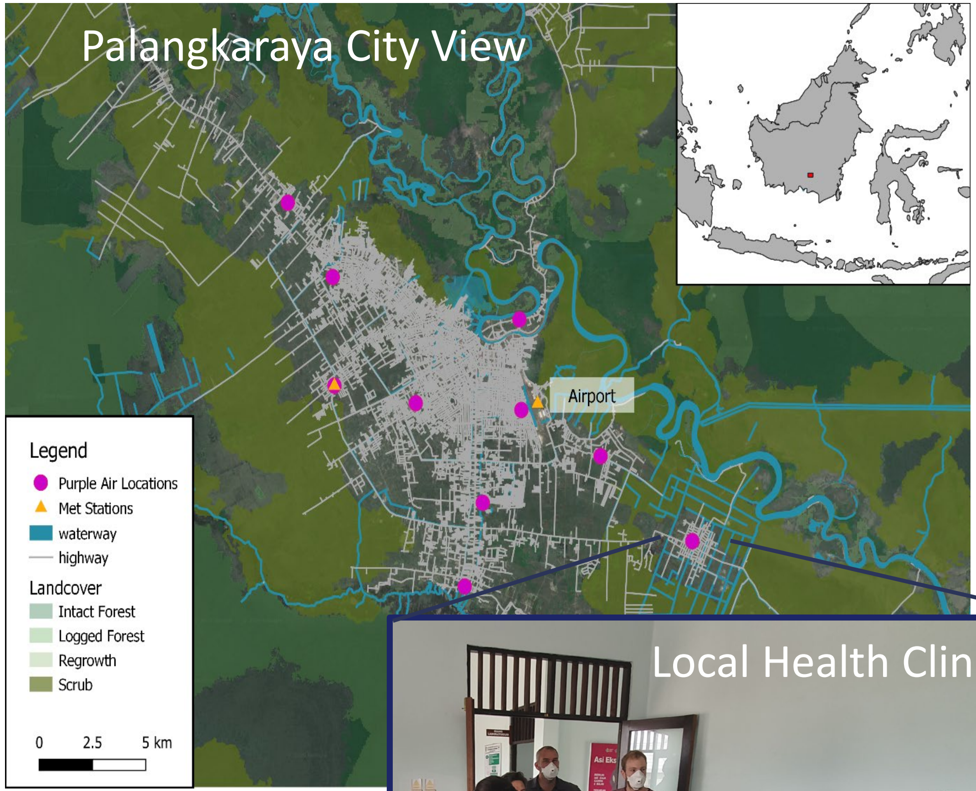
Much of the smoke from peatland fires

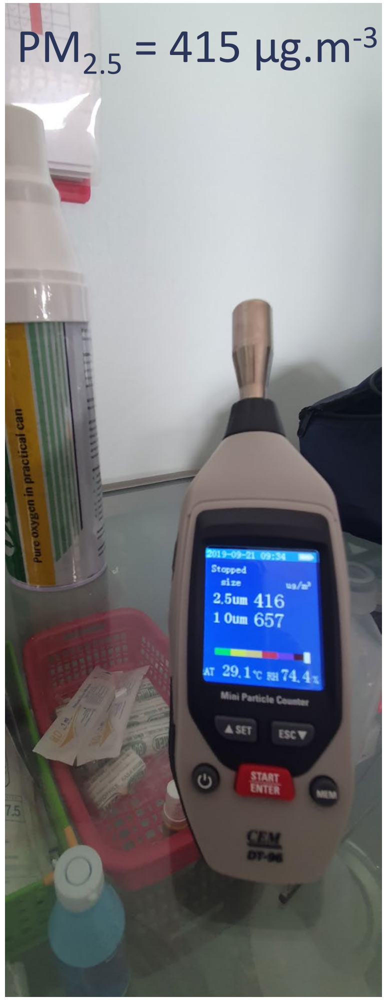
- Highest fuel consumption per unit area worldwide
- Typically smouldering, moving underground.

Palangkaraya City – extreme haze situation
(but virtually zero AQ measurements)

- Understand what AQ impact actually was.
- Use *in situ* measures to help evaluate GFAS & CAMS performance in this extreme fire situation.

In Situ $PM_{2.5}$ Sensors (Purple Air)

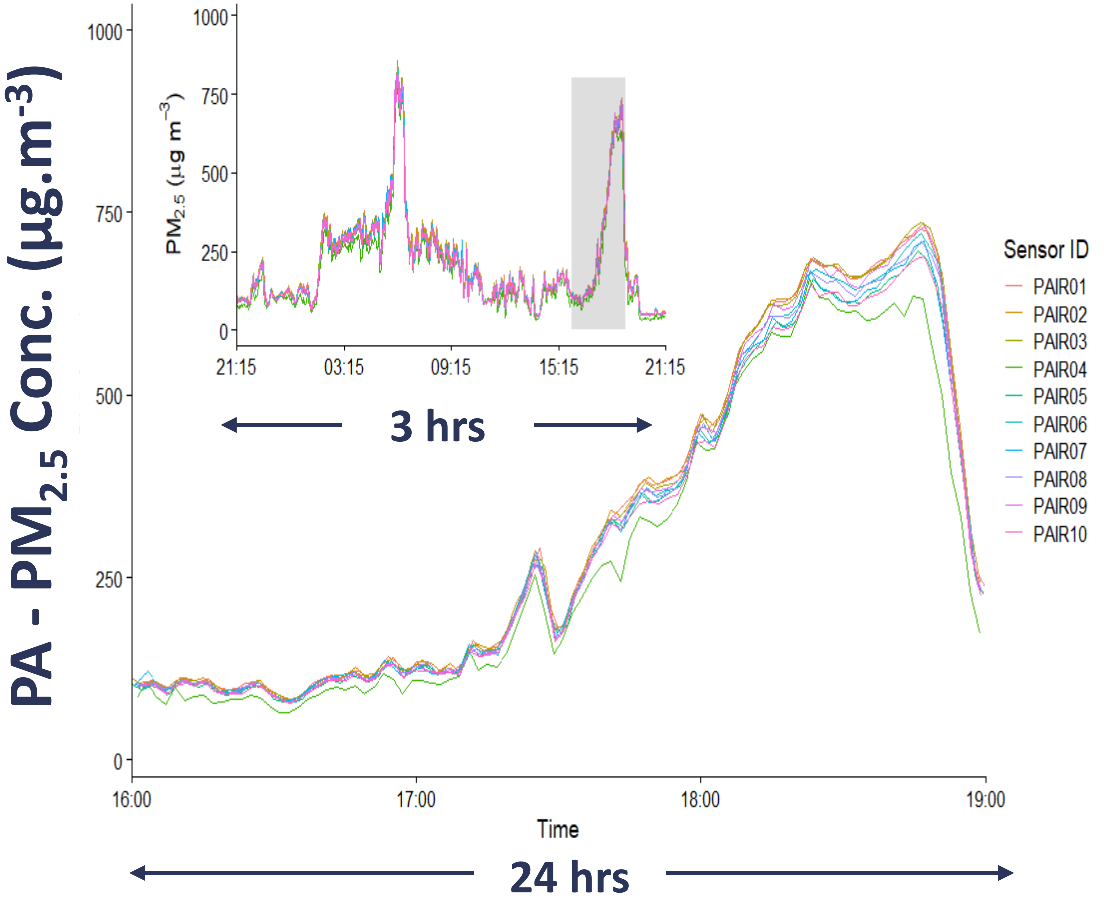




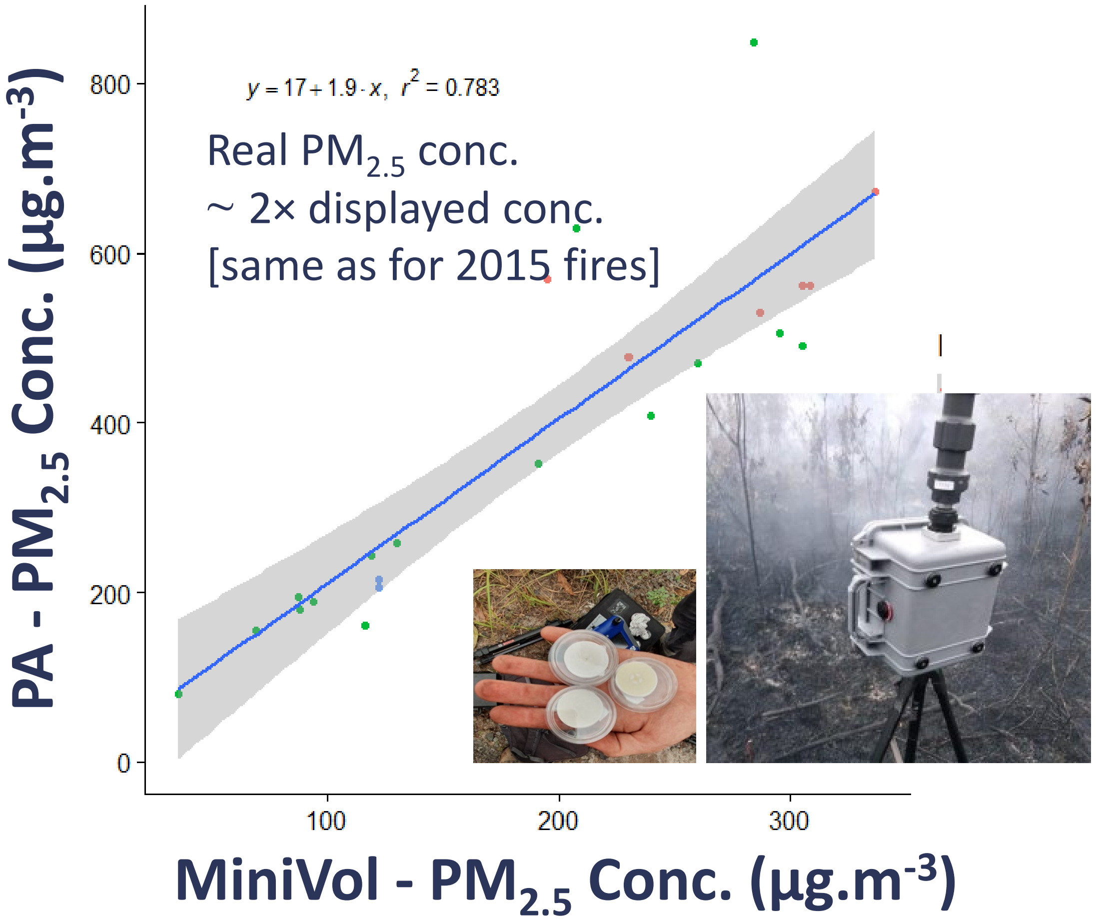
c.f. London (2017-19) mean of 11 to 13 $\mu g.m^{-3}$; New York 7 $\mu g.m^{-3}$
WHO recommended limit 10 $\mu g.m^{-3}$

In Situ $PM_{2.5}$ Sensor Quality Check

10 Sensor Co-location Test



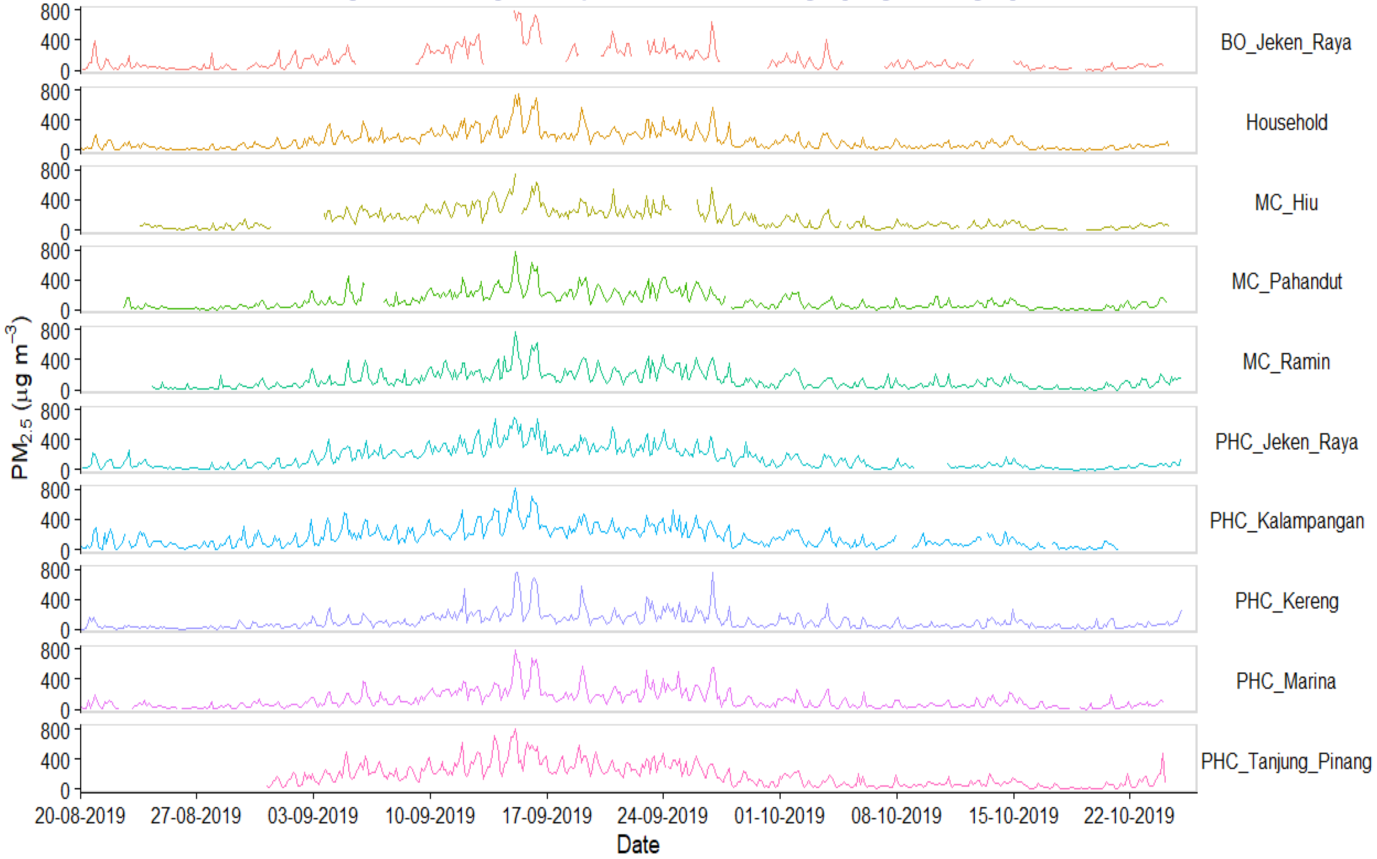
Reference Calibration



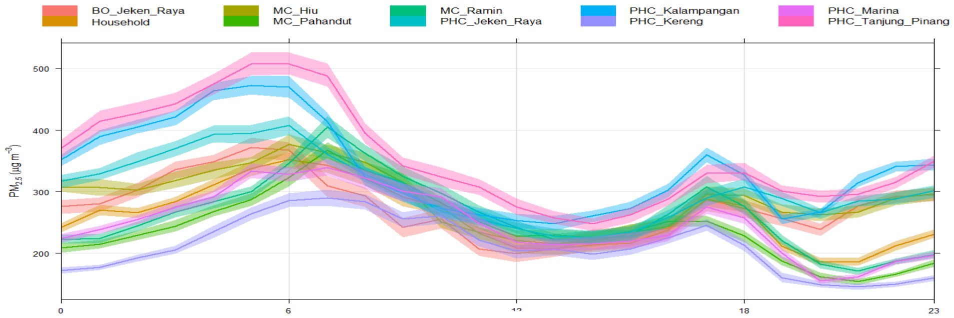
In Situ $PM_{2.5}$ Data

3-Month Timeseries

$PM_{2.5}$ Conc. (µg.m^{-3})



Average $PM_{2.5}$ Diurnal Cycle



24 hrs

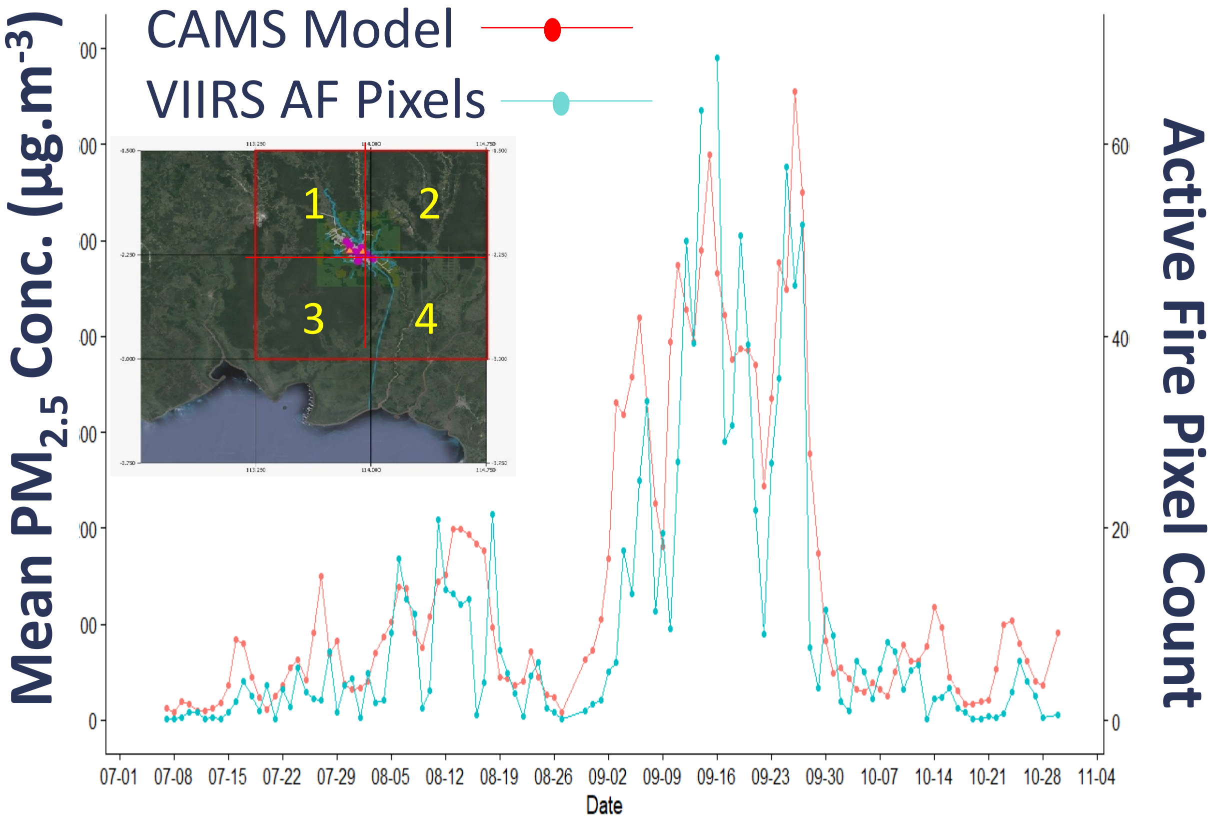
"Haze Free" School Tests

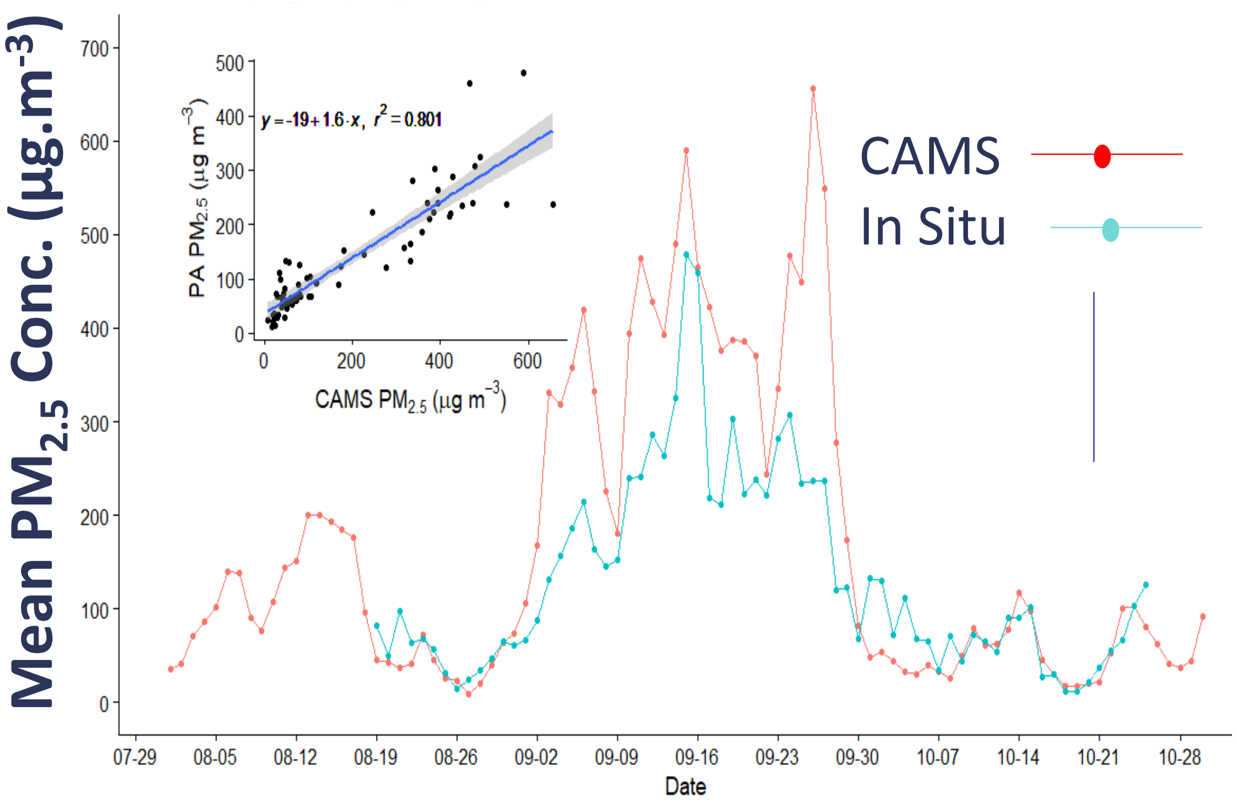
- Fire activity peaks in late afternoon – BUT…
- AQ diurnal cycle shows worse in the early morning – shrinking of boundary layer
- Current strategy of sealing "Haze Free Schools" actually seemed to trap overnight poor AQ

In Situ $PM_{2.5}$ Sensors (Purple Air)

$PM_{2.5}$ & AF Pixel Counts

CAMS model $PM_{2.5}$ vs. *In Situ* $PM_{2.5}$





Air Quality Index from *In Situ* Data

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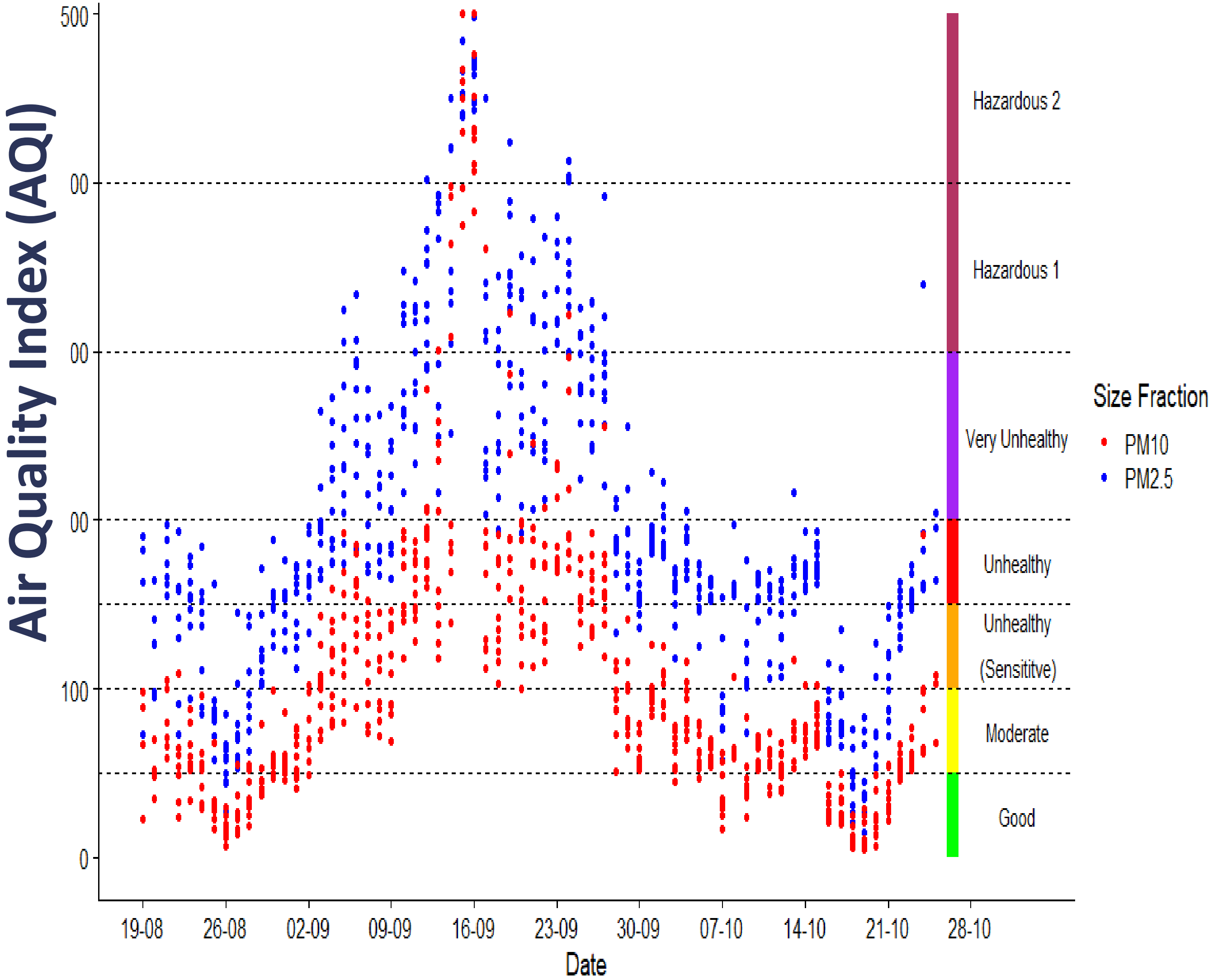
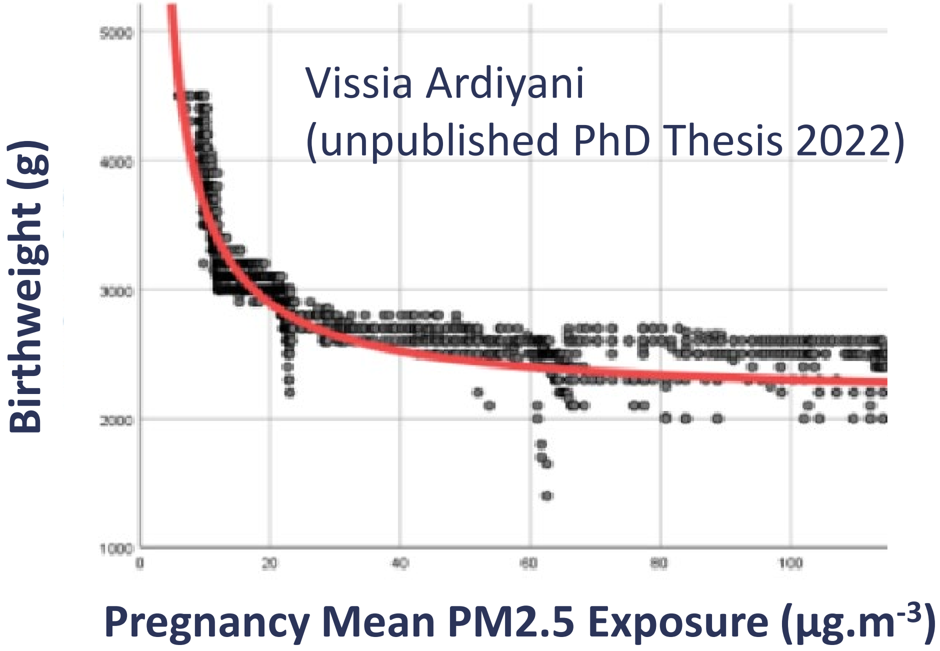
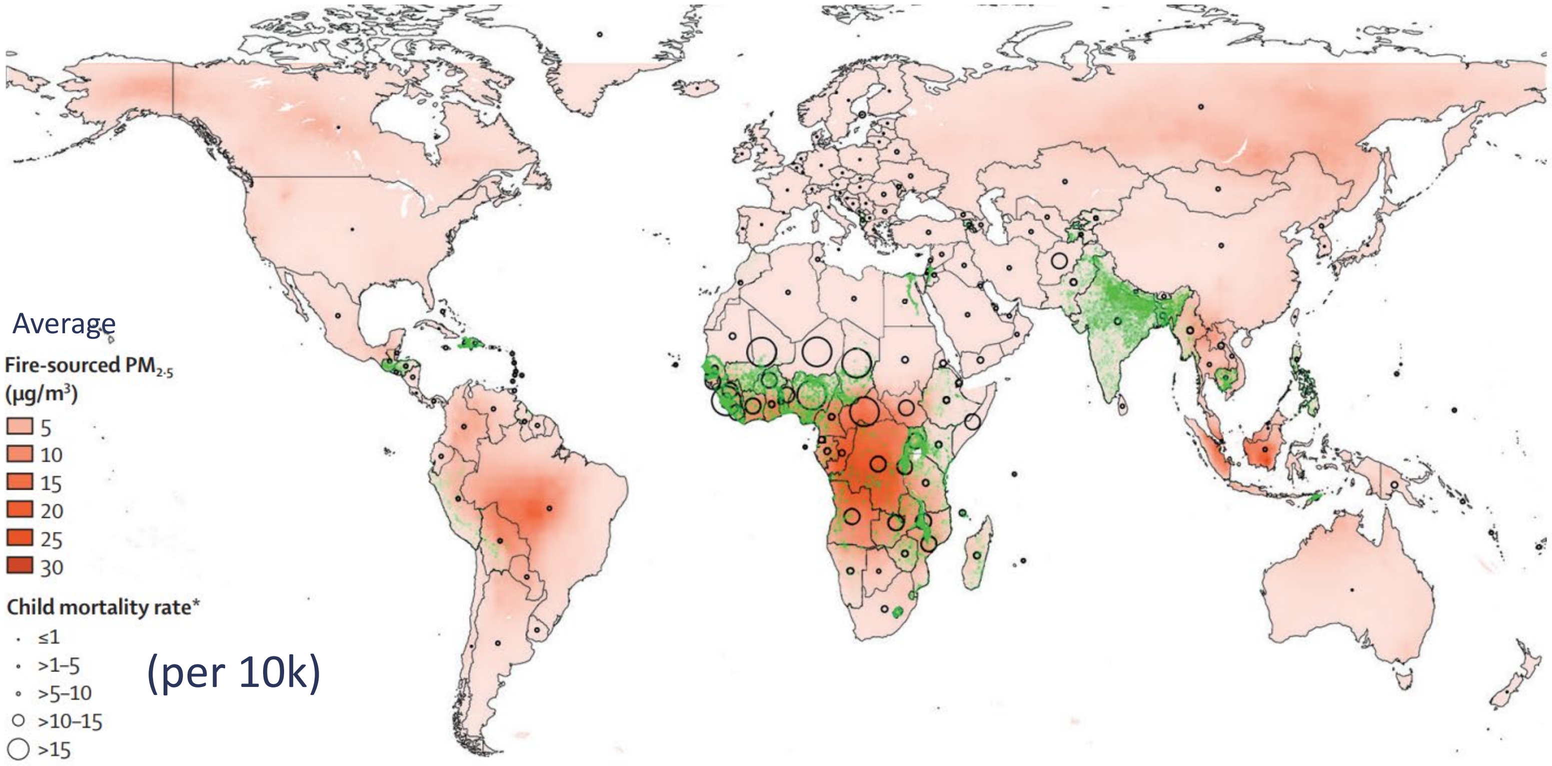
Effect on Quality of Breathable Air



Effect on unborn Children



Global Fire-Sourced $PM_{2.5}$ 'Exposure-Response' Fn.

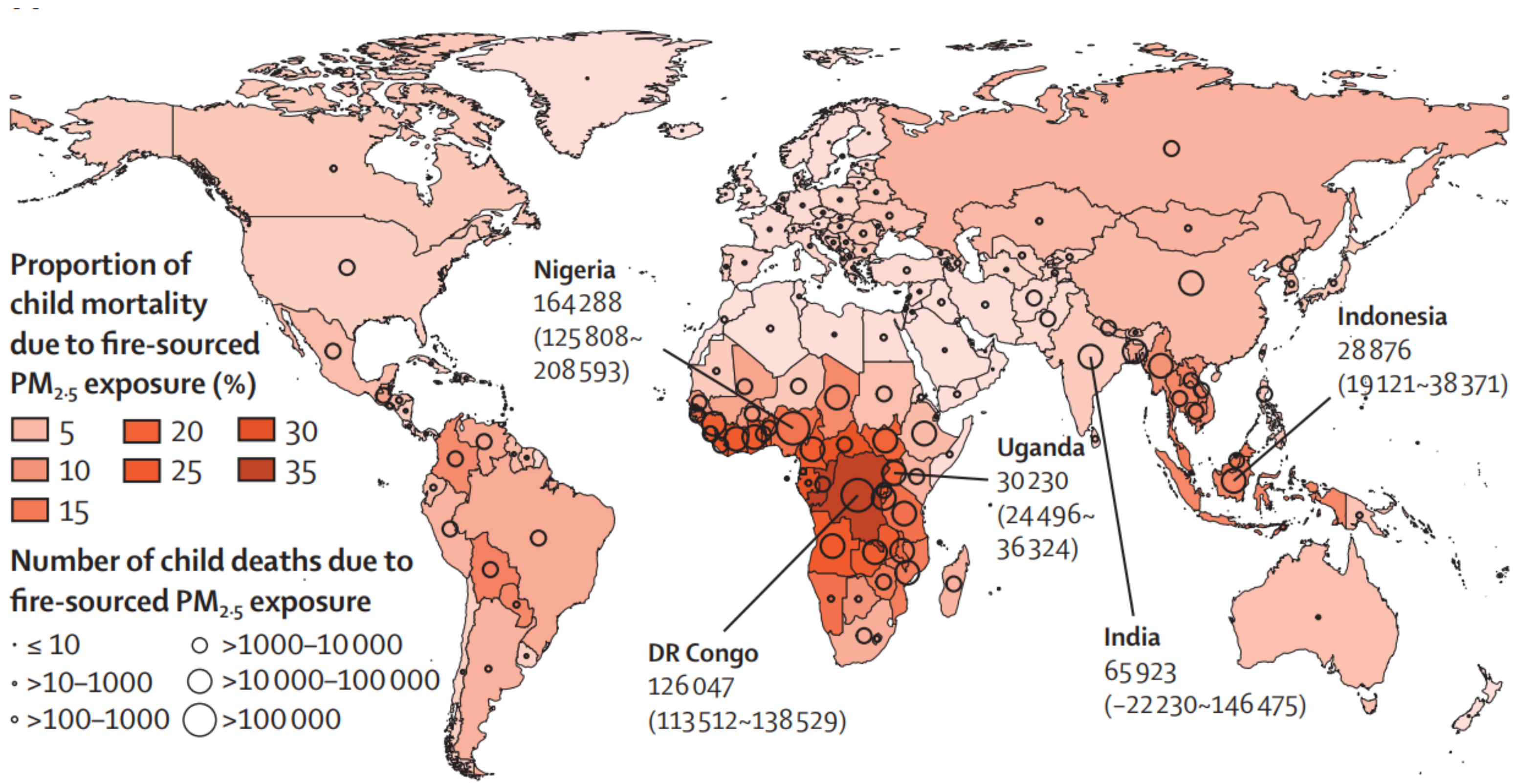


GEOS-Chem Atm Chem Transport Model run with & without fire emissions

Xue et al (2021) Associations between exposure to landscape fire smoke and child mortality in low-income and middle-income countries: a matched case-control study, Lancet Planetary Health, 5, e588-98.

- Epidemiological study based on 550k child health/mortality records of 150k mothers (132 surveys from 55 LMICs).
- Deceased children matched with their sibling(s) and levels of smoke exposure and conditional regression function generated.
- Mean fire-sourced $PM_{2.5}$ exposure in month of death was 4·40 μg.m^{-3}(SD 8·83; IQR 0·24–4·06).
- → 1 μg.m^{-3} increase in monthly exposure to fire-sourced $PM_{2.5}$ → 2·3% increase in child mortality in the under 5's (95% CI 1·50–3·13%).

Global Child Mortality from Landscape Fire Smoke



Xue et al (2021) Associations between exposure to landscape fire smoke and child mortality in low-income and middle-income countries: a matched case-control study, Lancet Planetary Health, 5, e588-98.

- Exposure–resp curve non-linear → only high $PM_{2.5}$ really contributes to increasing child mortality
- In 2000-14, largest number of child deaths from fire-sourced $PM_{2.5}$:
  - Nigeria – 164k deaths.yr^{-1} ; DRC – 126k
  - India – 66k deaths.yr^{-1}; Uganda – 30k
  - Indonesia – 29k deaths.yr^{-1}
- **Almost 1 in 10 child deaths (<5 yrs) worldwide attributable to exposure to landscape fire smoke.**
- **Total 0.75 to 1.0 ×10^{6} deaths.yr^{-1}.**

→ 99% in LMICs, so changing agri-burning practices can save hundreds of thousands of lives per yr.