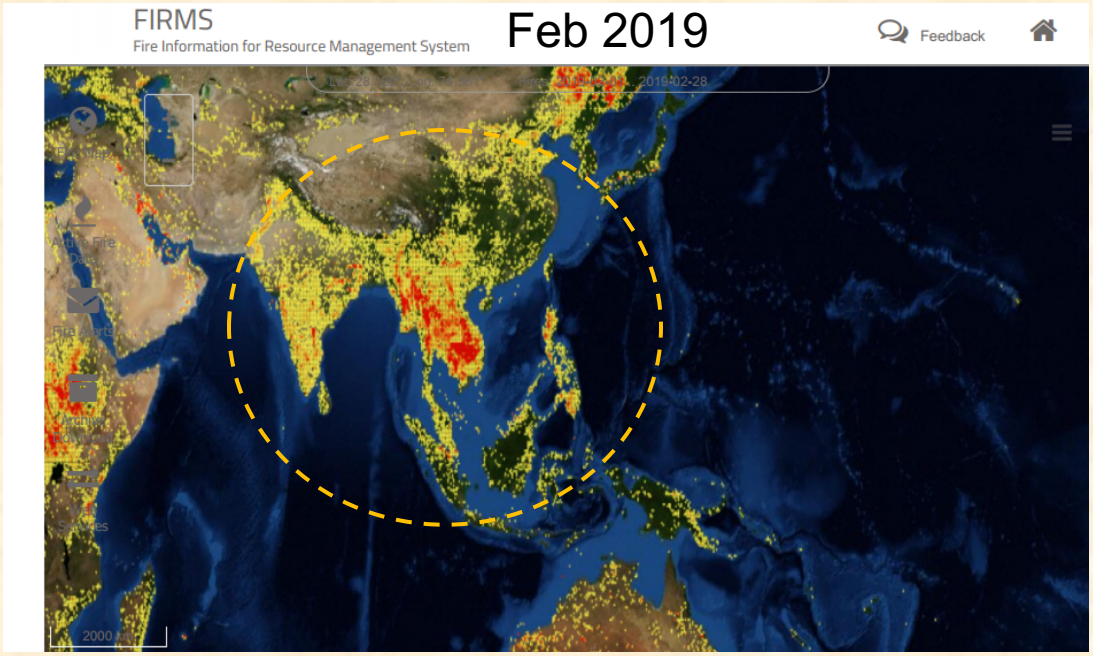
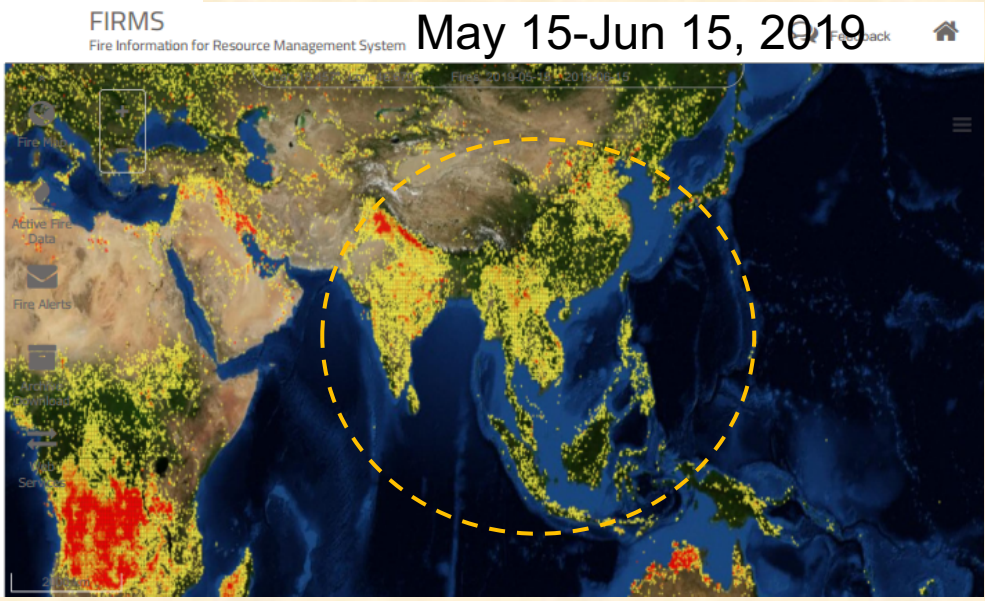
Crop residue open burning: implication on air quality and climate forcing in Asian Monsoon Region

Prof. Kim Oanh N. T.
EEM/SERD, AIT
kimoanh@ait.ac.th

3 min-video : https://www.youtube.com/watch?v=XL8QWefAop0&t=44s



Biomass open burning: region and season



Source: FIRMS (NASA)

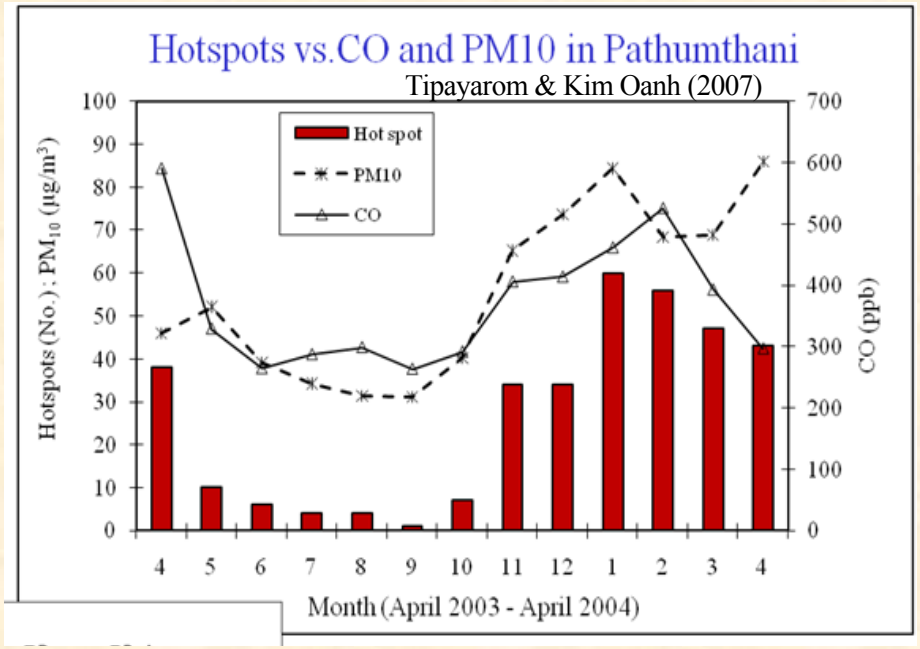
Contents

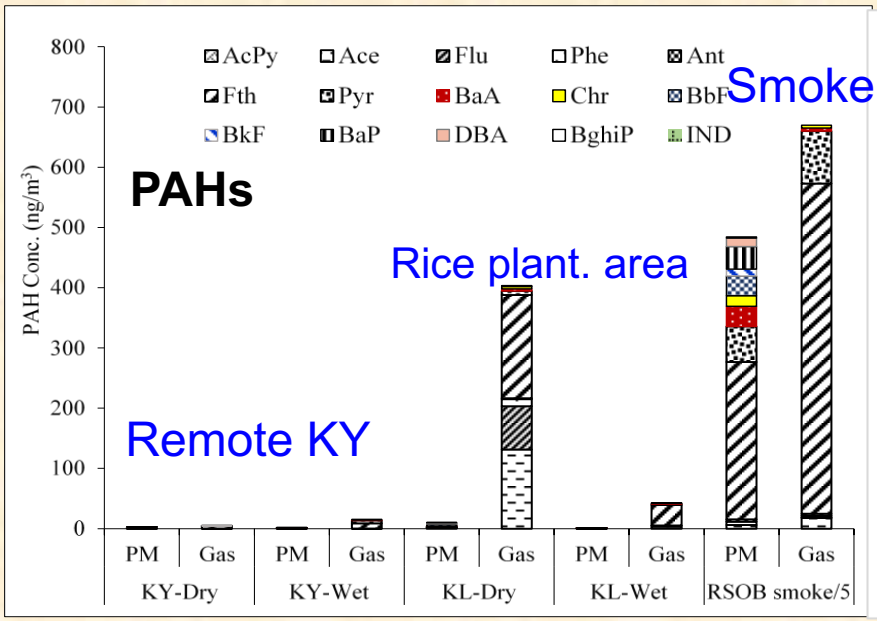
- Crop residue open burning (CROB) and local air quality
- Southeast Asia CROB emissions
- Modeling impacts: scenarios
- Non-open burning alternatives

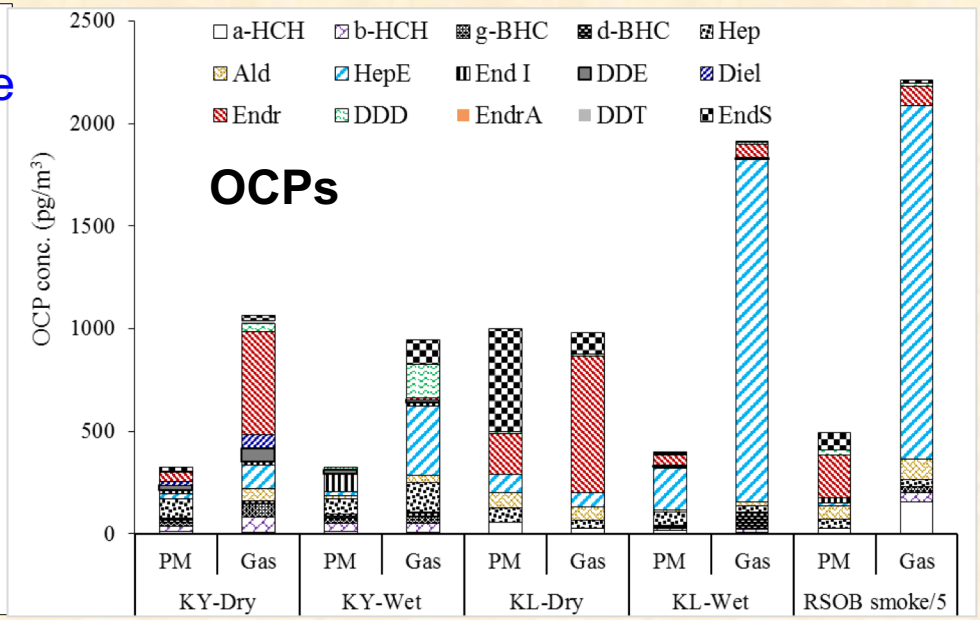
(1) Crop residue open burning

- Widely practiced in Asia and is projected to increase in the short- and medium term
- Huge emissions
  - ✓ Toxic pollutants: gases, PM, PAHs, dioxins
  - ✓ Short-lived climate pollutants (BC, VOC, OC)
  - ✓ Ozone precursors (VOC, NOx, CO)
- CROB: intensive in dry & harvesting season
  - Effects on air quality ➔ health, crops, ecosystems
  - Effects on the atmosphere and climate

Rice straw field burning and air quality in Thailand



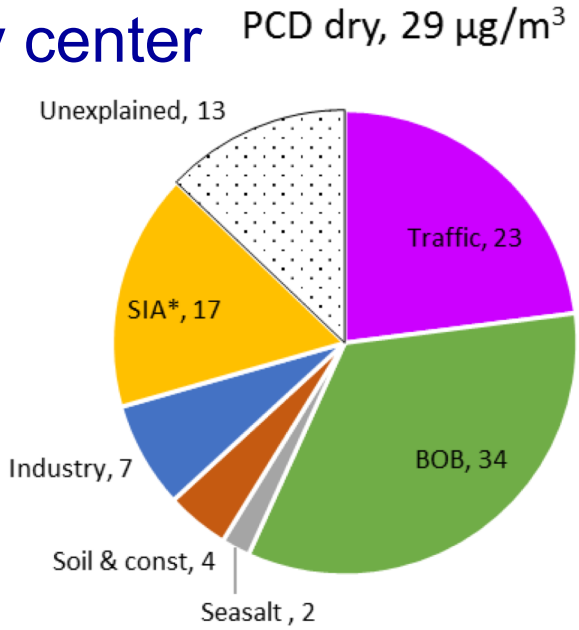




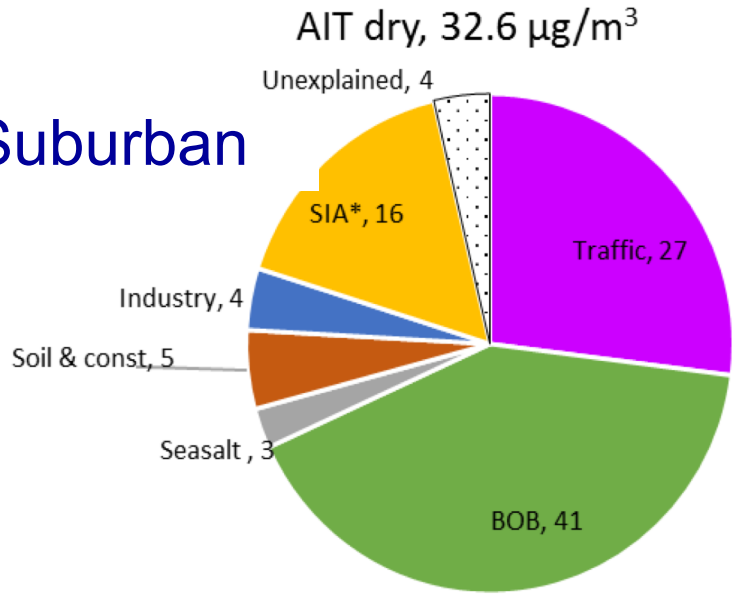
Klinmalee and Kim Oanh, 2018

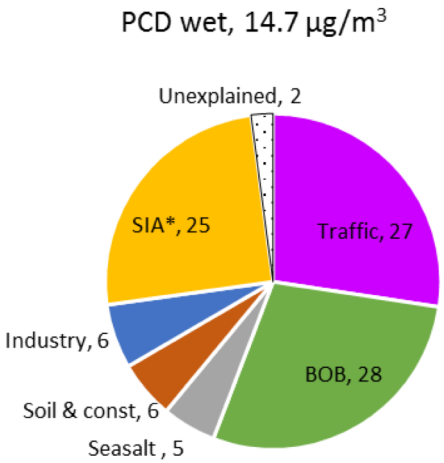
Source apportionment: Bangkok MR, 2016-2017

City center

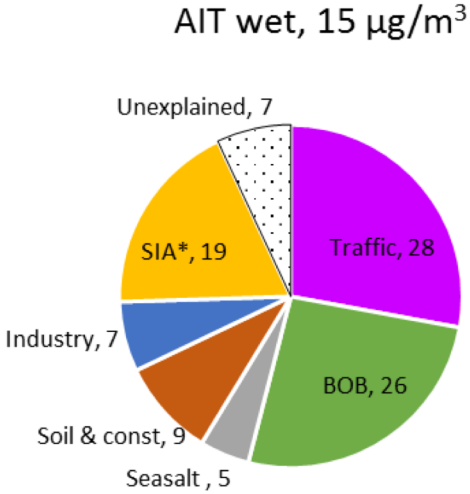


Suburban

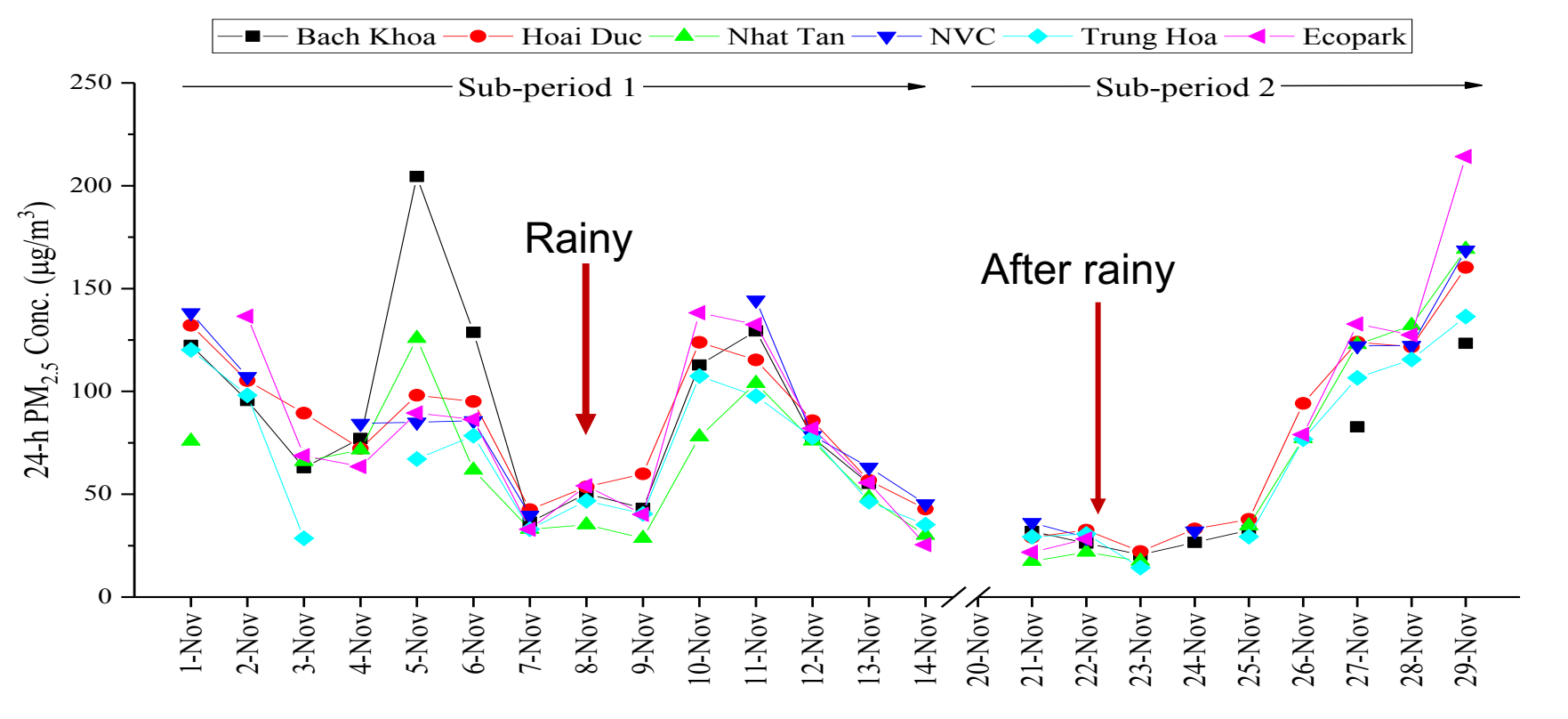




Traffic, biomass (RSOB), industry, etc.



Rice straw OB & $PM_{2.5}$ in Hanoi, 2017: effects of rain



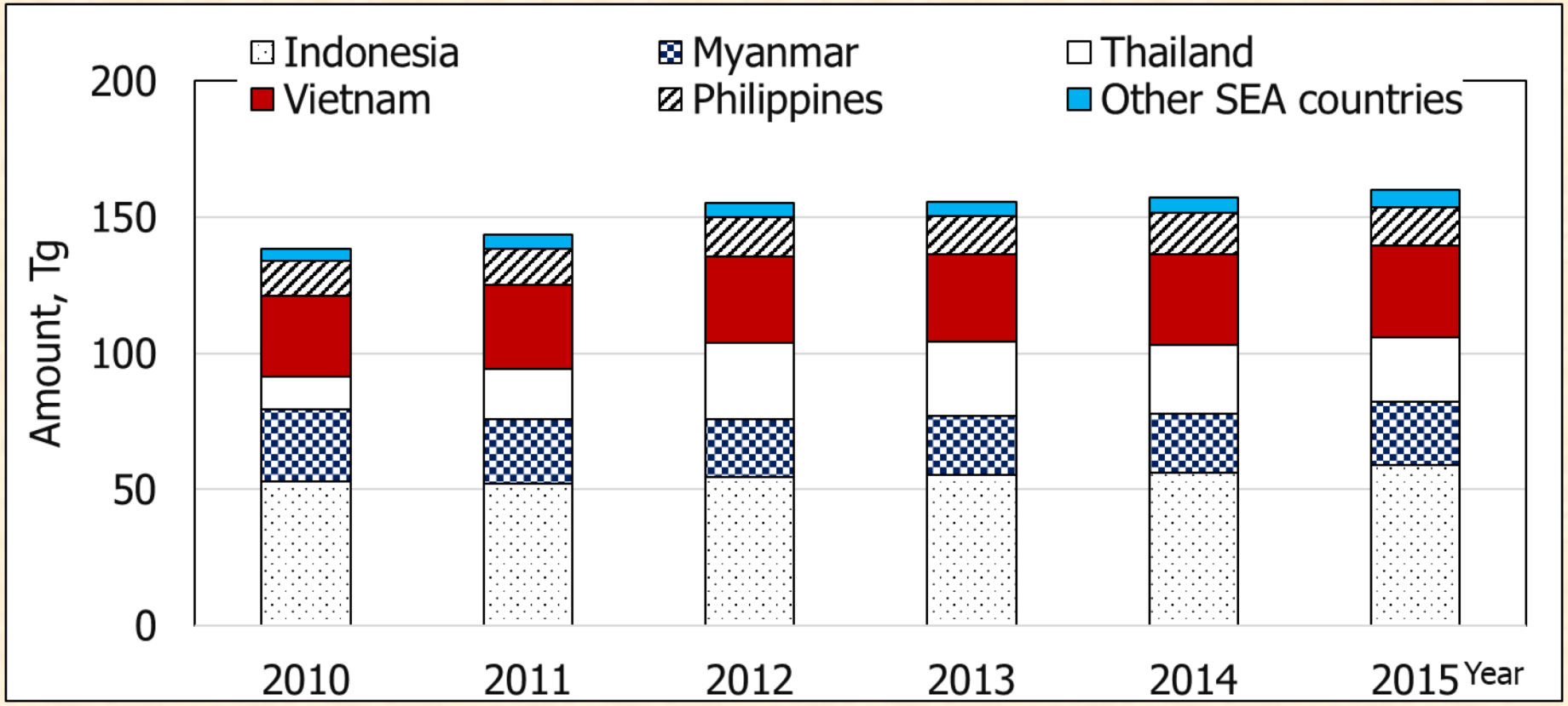
Ambient levels	Rainy (3 days)	After rain (4 days)	Rest of period
$PM_{2.5}$, µg/m³	42 ± 9	26 ± 6	98 ± 37
BC, µg/m³	3.1 ± 0.4	2.2 ± 0.5	5.4 ± 1.6
Exceedance NAAQS*	25%	0%	92.5%

***NAAQS for 24h $PM_{2.5}$: 50 µg/m³**

Source: Monitoring report to CAA, 2018

(2) SEA CROB emissions

Annual amounts of crop residues biomass subjected to open burning (M_k) in SEA, Tg/yr

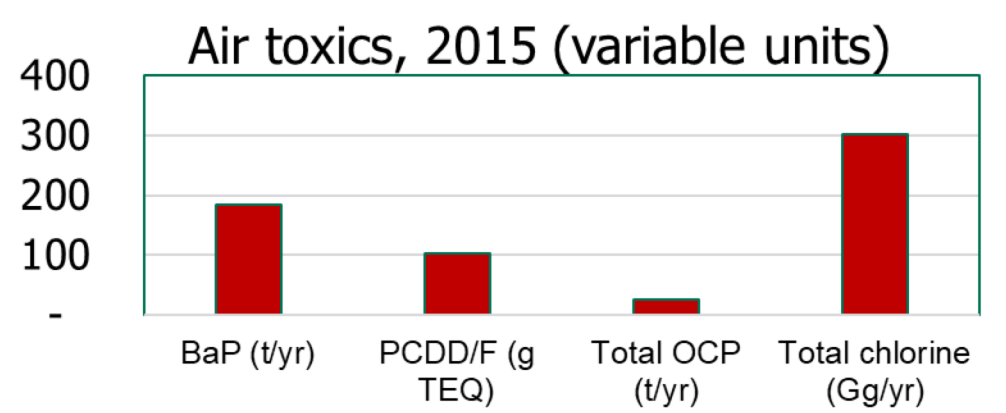


SEA annual average: 152 Tg/yr

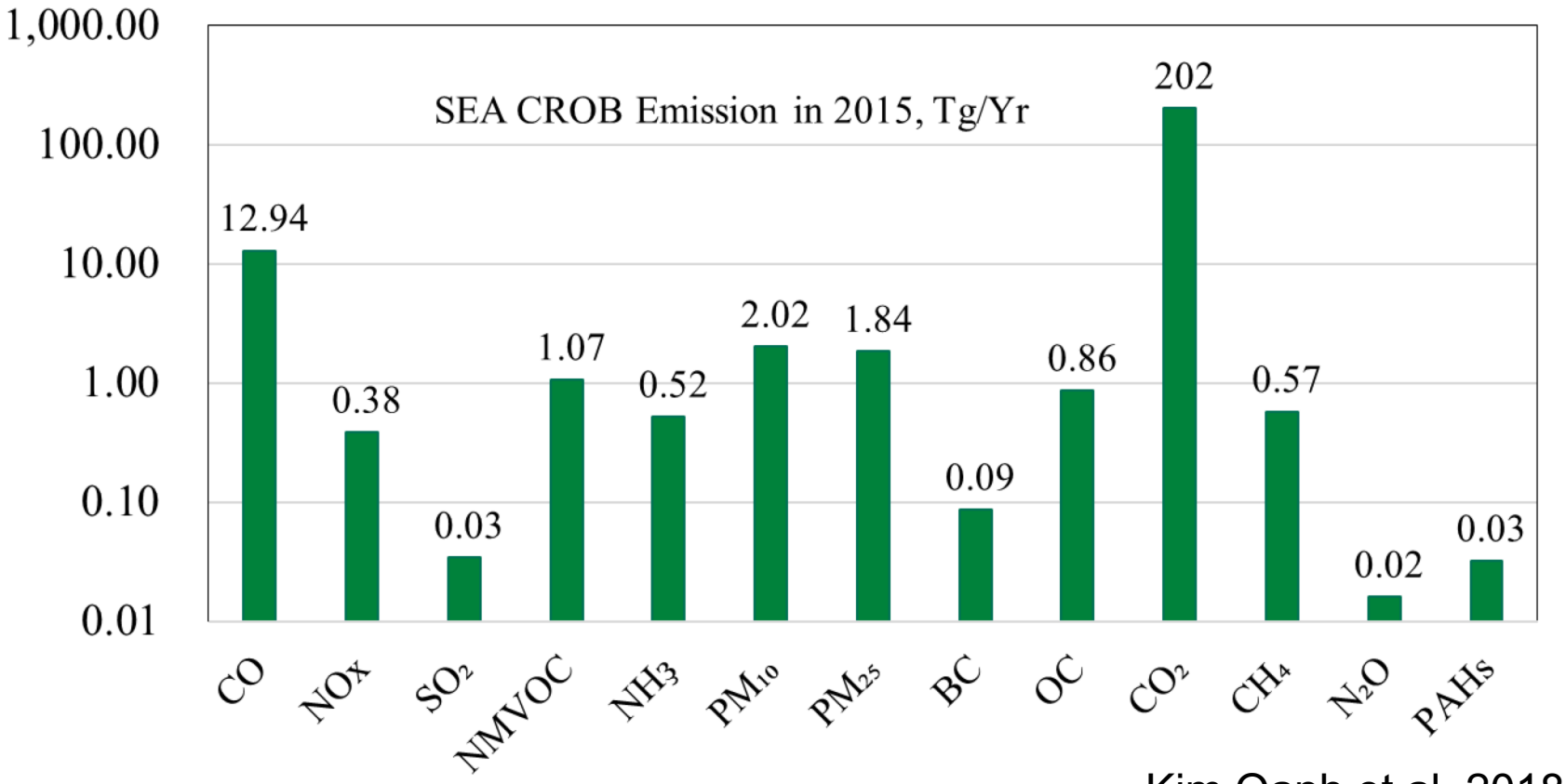
Rice straw: largest share (>75% M_k)

Kim Oanh et al., 2018

SEA CROB Emission in 2015

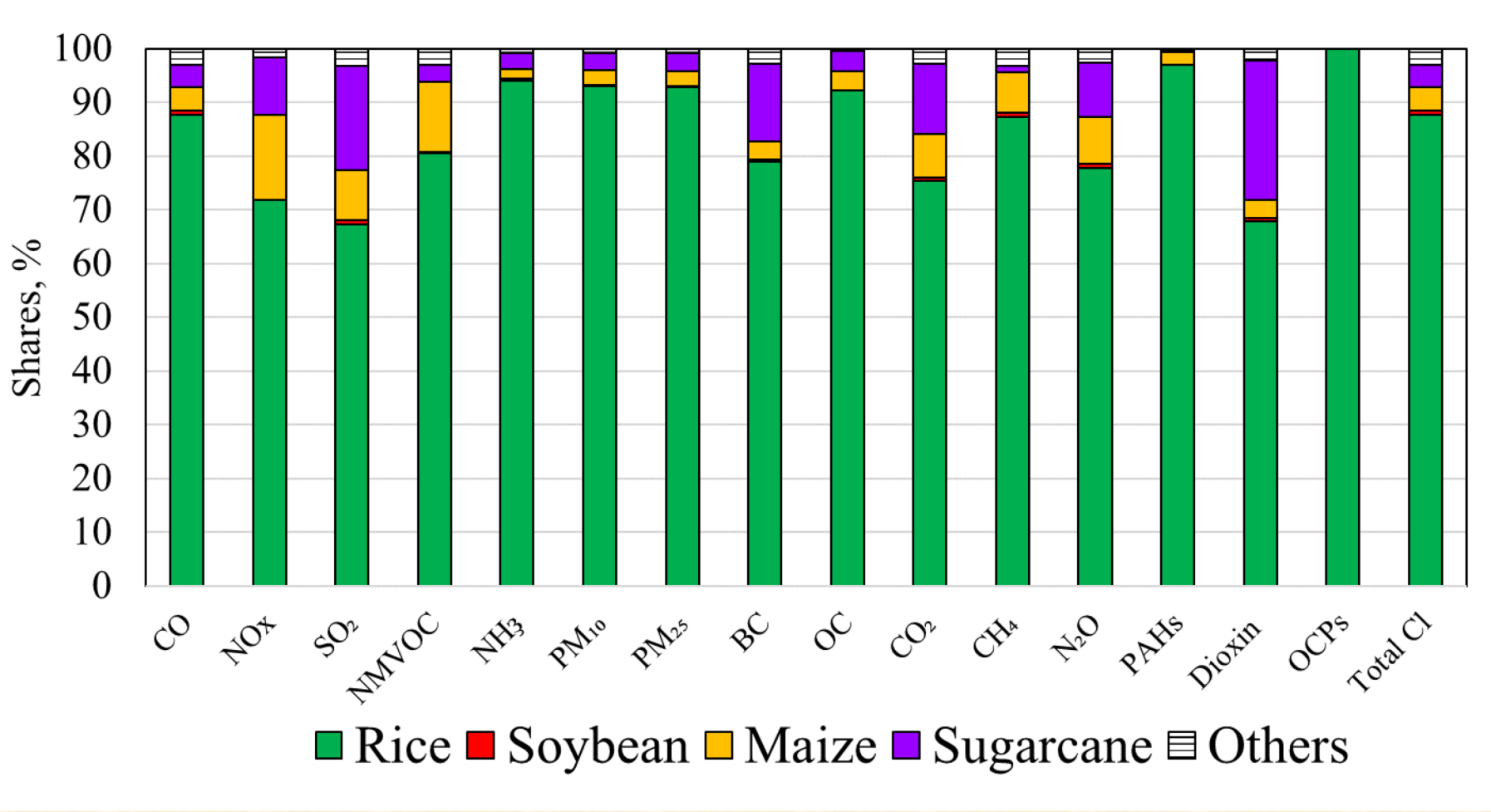


Tg/Yr



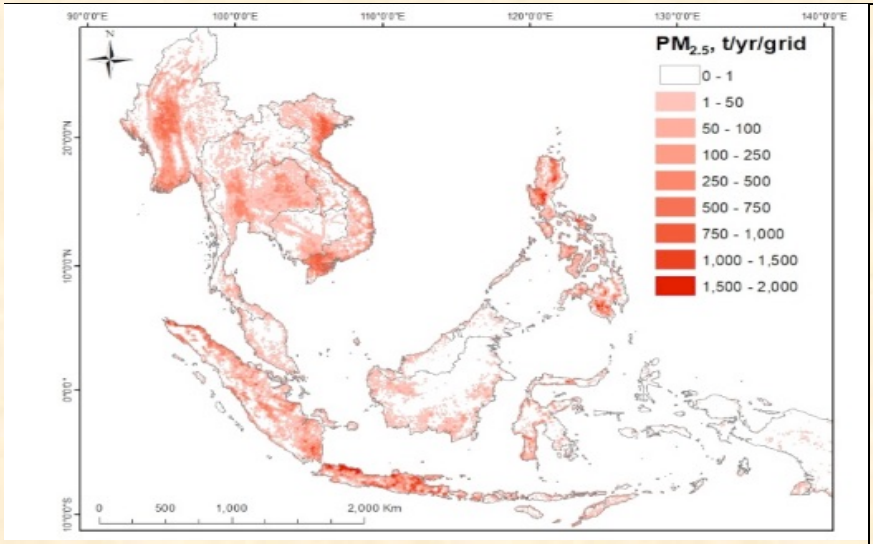
Kim Oanh et al, 2018

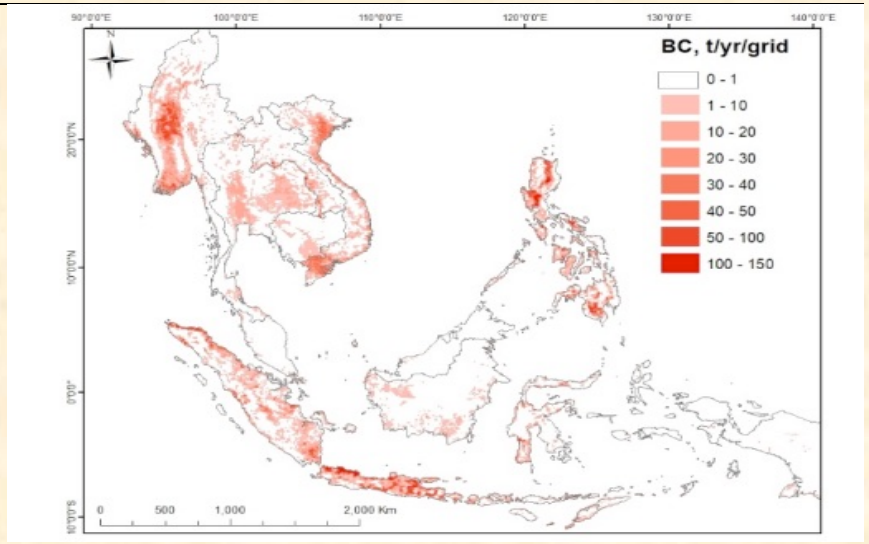
Emission per crop type, average 2010-2015

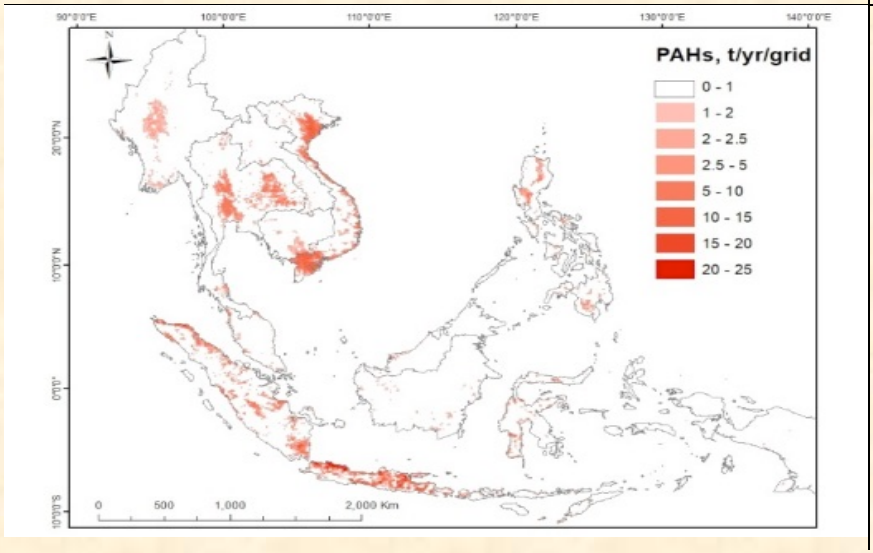


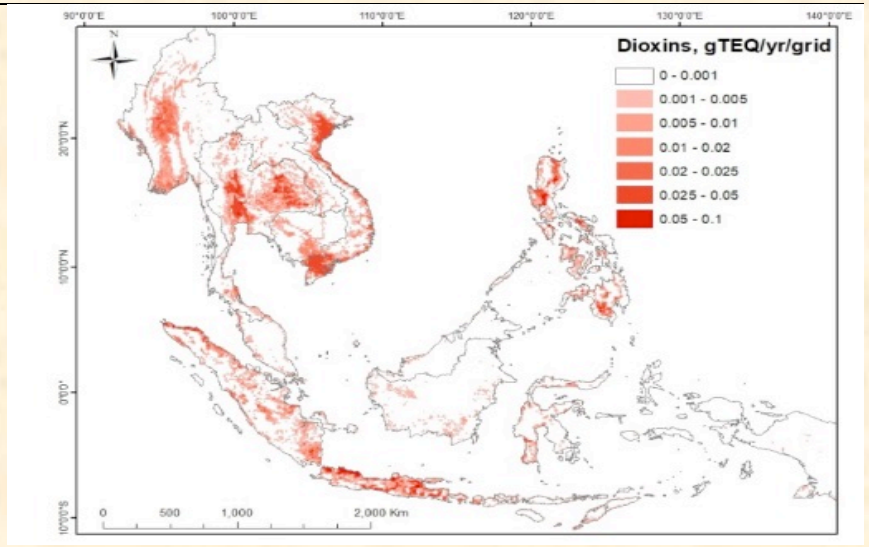
Rice straw open burning: major shares (70 to above 95% of the total SEA CROB)

SEA gridded emissions (0.1°x0.1°): **Emissions higher over rice plantation areas, in CROB-harvesting months**



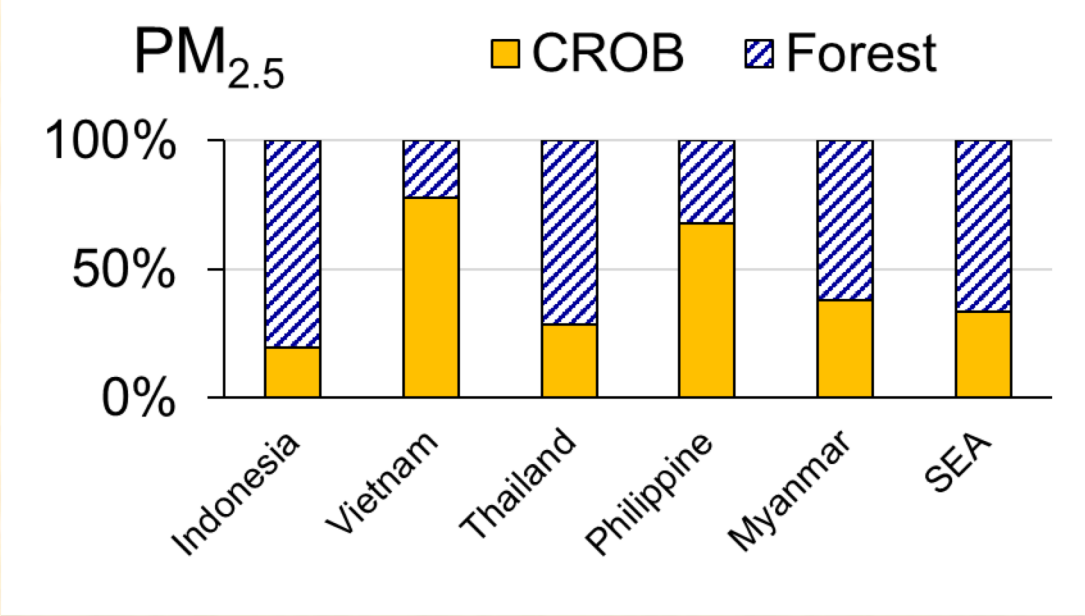


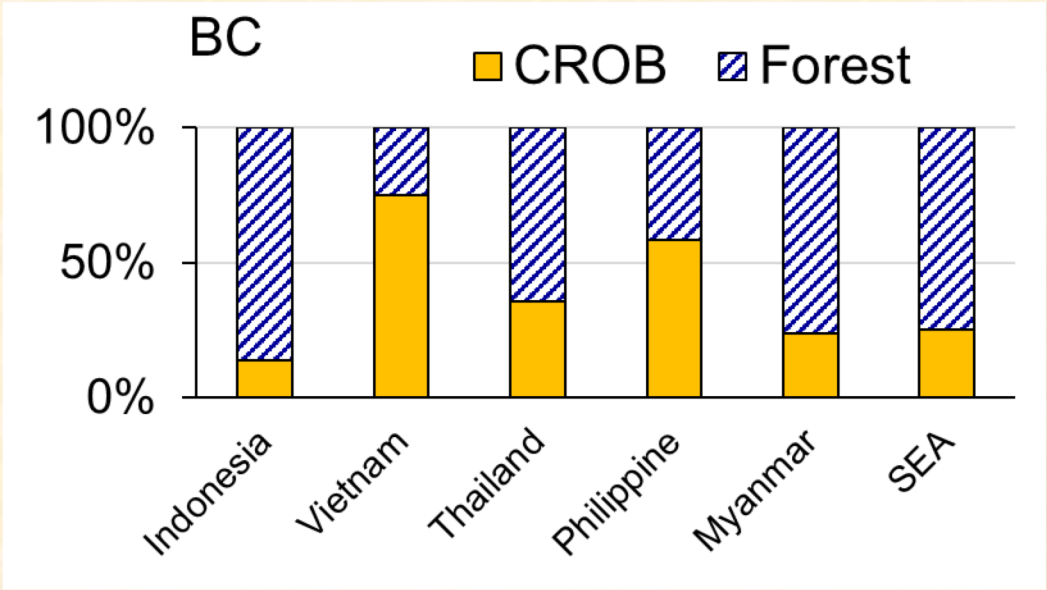




Source: Kim Oanh et al. 2018

CROB vs. forest fire (GFED) emissions



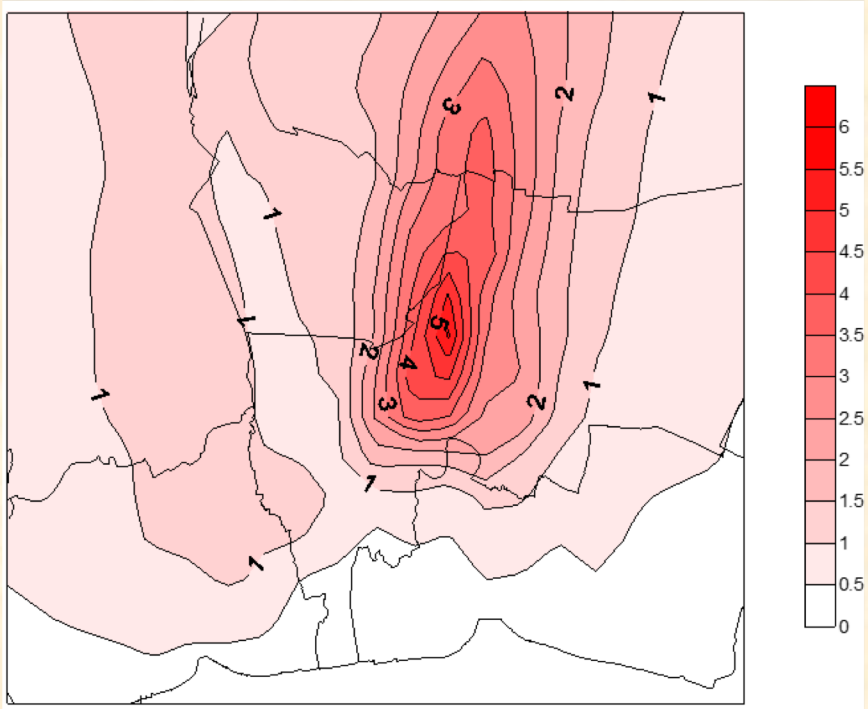


- CROB contributes 12-45% of the total SEA OB emission of different species
- Compare to forest fires: CROB emissions are higher in Vietnam and Philippines, and lower in Indonesia, Thailand, Myanmar
- CROB happens daily over extended period and where people live ➔ serious health risks

(3) Modeling impacts: zero RSOB scenario and reduction in PM and ozone in BMR

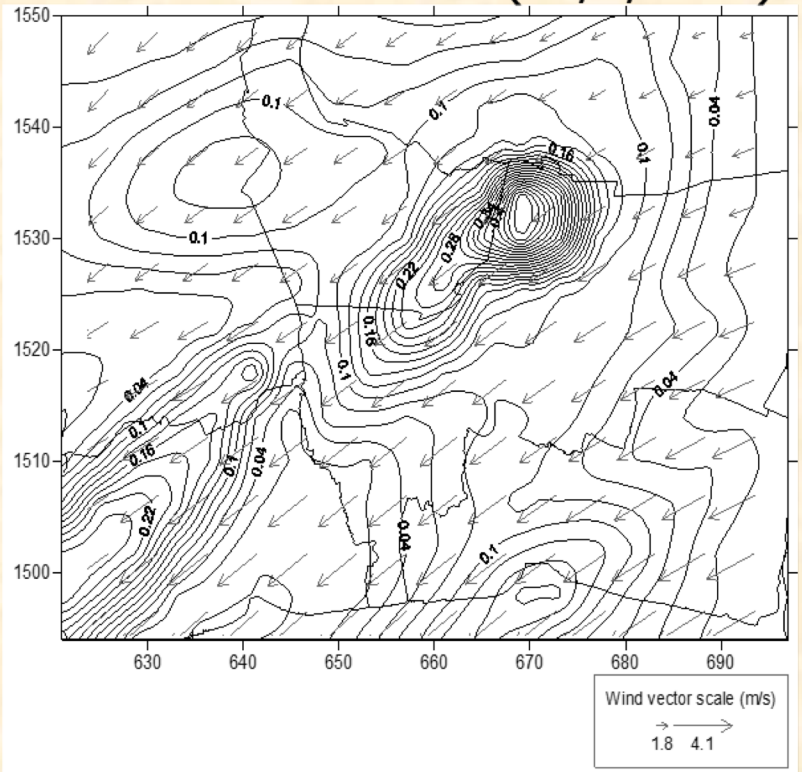
(CAMx-MM5 results)

Monthly PM_{10} reduction



Monthly (Feb. 2007) average of PM_{10} reduction (μg/m^3): maximum by 6 μg/m^3 (Thongchai, 2011)

1h Ozone reduction (27/1/2004)

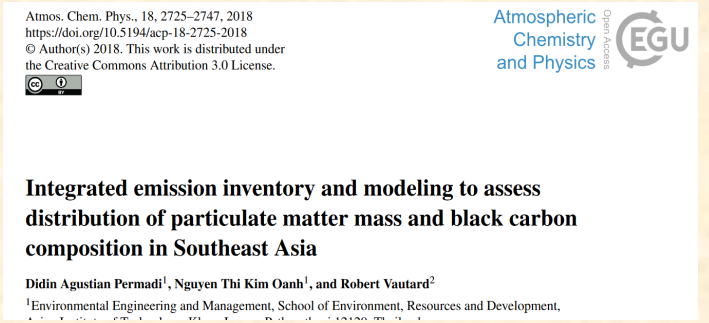


1h O_3 reduced on average by 4 ppb at Rangsit, max in March (Phuong, 2007)

SEA: Modeling to Assess Emission Reduction Scenarios on BC Radiative Forcing and Health

- Development of refined EI in SEA for 2007 to assess **WRF-CHIMERE** performance (Permadi et al., 2018a) for PM and BC

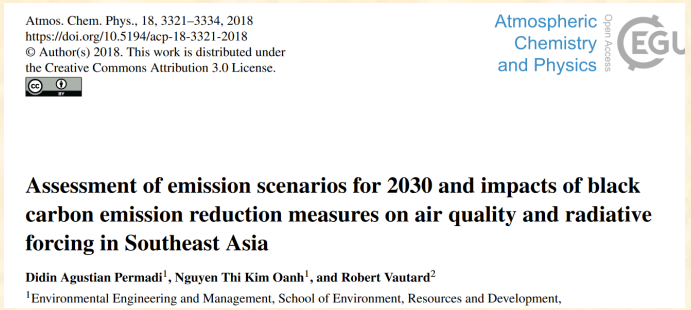
- Projection under BAU2030 and RED2030 for BC emission sources (Indonesia and Thailand) and assess impacts on human health and climate (Permadi et al., 2018b).


Atmos. Chem. Phys., 18, 2725–2747, 2018
https://doi.org/10.5194/acp-18-2725-2018

Atmospheric Chemistry and Physics

Integrated emission inventory and modeling to assess distribution of particulate matter mass and black carbon composition in Southeast Asia

Didin Agustian Permadi[1], Nguyen Thi Kim Oanh[1], and Robert Vautard[2]
[1]Environmental Engineering and Management, School of Environment, Resources and Development,


Atmos. Chem. Phys., 18, 3321–3334, 2018
https://doi.org/10.5194/acp-18-3321-2018

Atmospheric Chemistry and Physics

Assessment of emission scenarios for 2030 and impacts of black carbon emission reduction measures on air quality and radiative forcing in Southeast Asia

Didin Agustian Permadi[1], Nguyen Thi Kim Oanh[1], and Robert Vautard[2]
[1]Environmental Engineering and Management, School of Environment, Resources and Development,

Source sector	**Measures** (RED2030)
Residential	Fuel switching, improved cookstoves
Transport	Emission standard, cleaner fuel
Industry	Control for key sectors, technology and fuel
Open burning	Law enforcement/Master plan

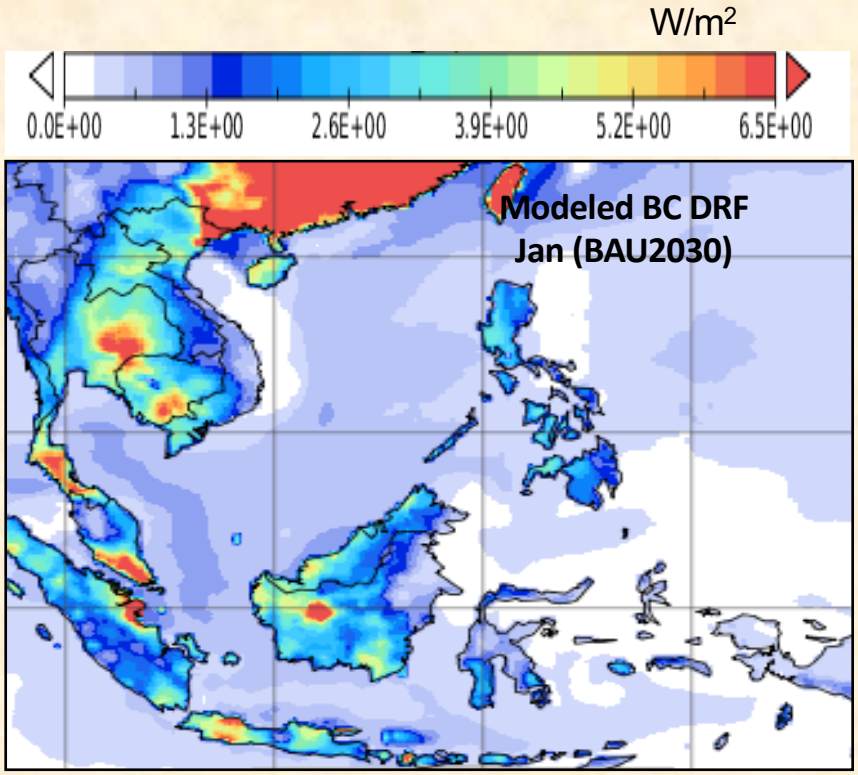
RED2030 measures follow the master plans of Thailand and Indonesia

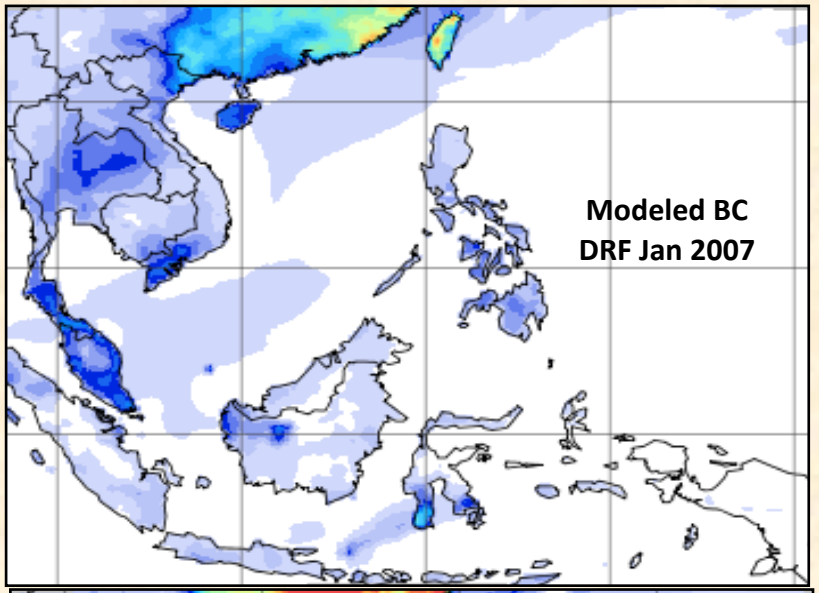
Climate impacts: BC direct radiative forcing (DRF)

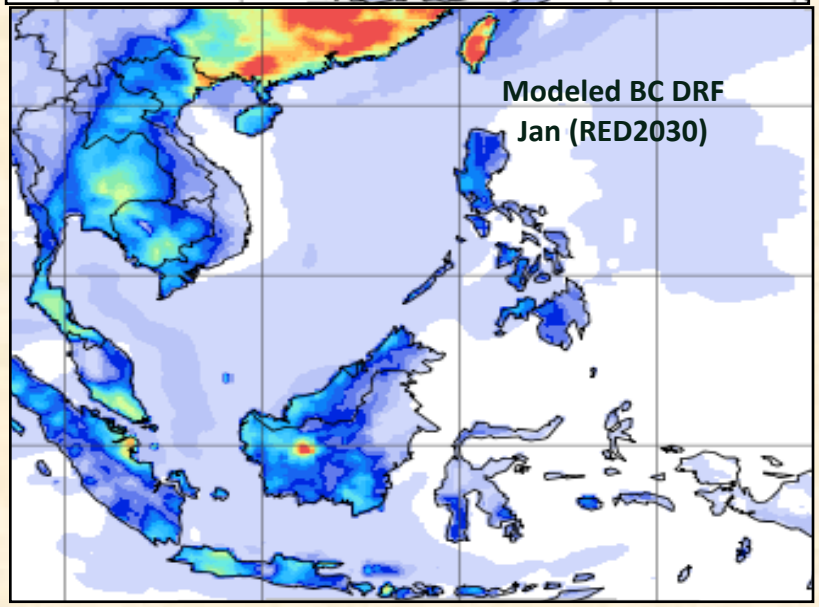
Max Annual in SEA domain:

BAU2030: 2.0 W/m^2

RED2030: 1.4 W/m^2







Avoided deaths (BAU2030 - RED2030)	Indonesia	Thailand
Mortality per 100,000 pop. (this study)	49	36
Shindell et al. (2011) with more measures	74	68

(4) Crop residue management: emission reduction

- Non-burning alternatives: mushroom growing, gardening, on-site treatment, used as fuel and for **fuel production**
- Challenges: RS collection/transport, market, characteristics (high Si, low energy content)
- Management: ban? burning only when it is dry and good dispersion?

➔ Enforcement issue

Turning RS into cooking fuels

Policy Brief

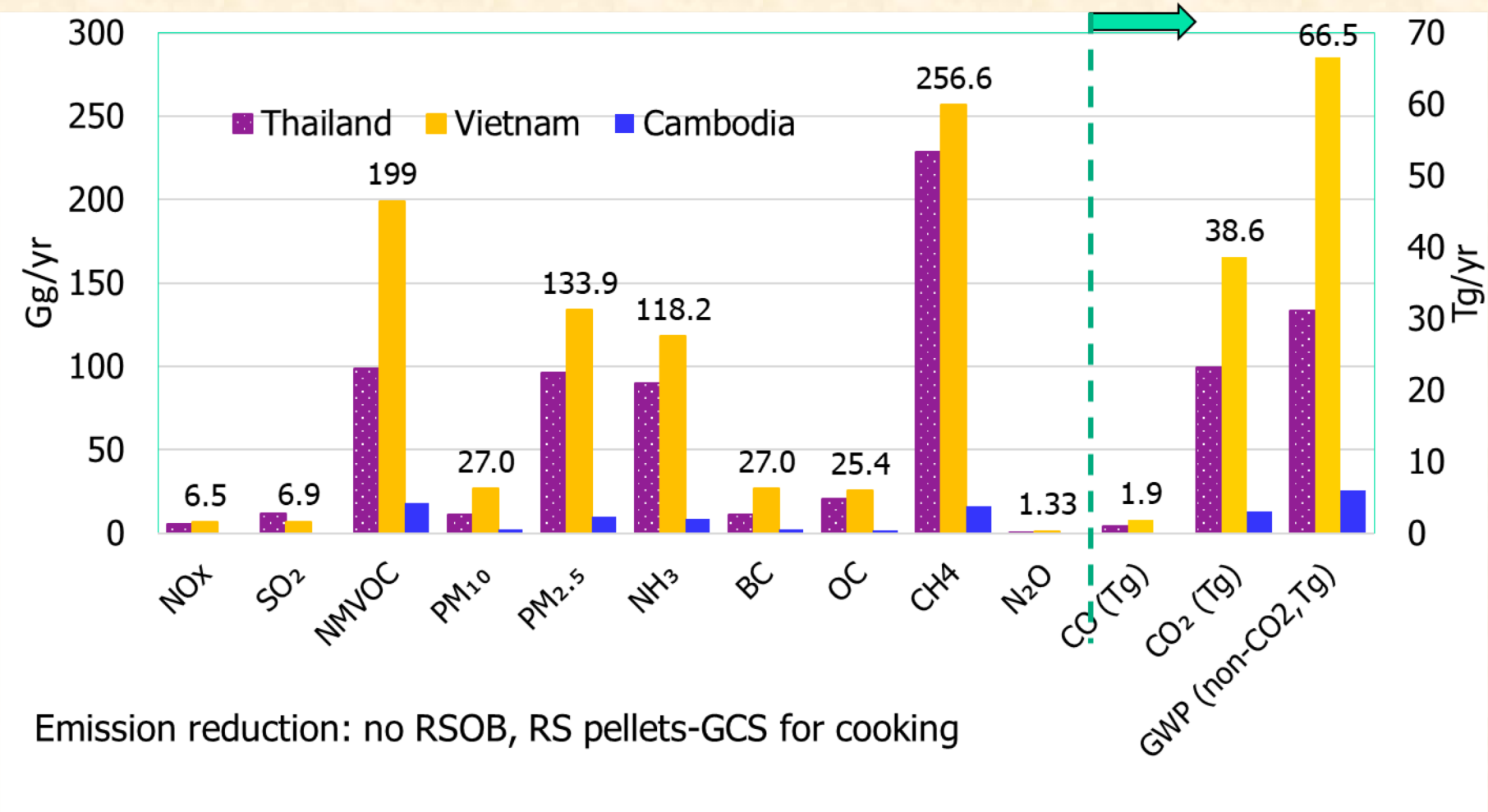
Policy recommendations:

1. Raise awareness of the adverse health effects of RS open burning
2. Strengthen enforcement of the existing open burning related policies
3. Provide a subsidy for development of a pilot-scale business model for producing RS pellets
4. Provide a subsidy to farmers for improved gasifier-cookstoves
5. Incorporate the alternative of RS-pelletizing into crop residue management strategies

We acknowledge the funding supports from PEER (USAID: NSF) and SUMERNET (SEI-Sida)

Author contact: Prof. Nguyen Thi Kim Oanh kimoanh@ait.ac.th
Tel. +66 02 524 5641

Emission reduction: air quality and climate benefits of replacing solid cooking fuels (wood, coal, charcoal) with Pellet-GCS



GWP (non-CO_2) in CO_2 eq., 20 yr: CO_2 is not included in the GWP value

Summary

- Open burning of crop residue contributes substantial emissions, higher than forest fires in some SEA countries
- Intensive emissions in dry and harvesting season contribute to AP episodes and high exposure risks
- Non-OB alternatives provide multiple benefits

Say No to Rice Straw OPEN BURNING !

3 min-video : https://www.youtube.com/watch?v=XL8QWefAop0&t=44s