Impacts of springtime carbonaceous aerosols in northern peninsular Southeast Asia and the western North Pacific: An overview

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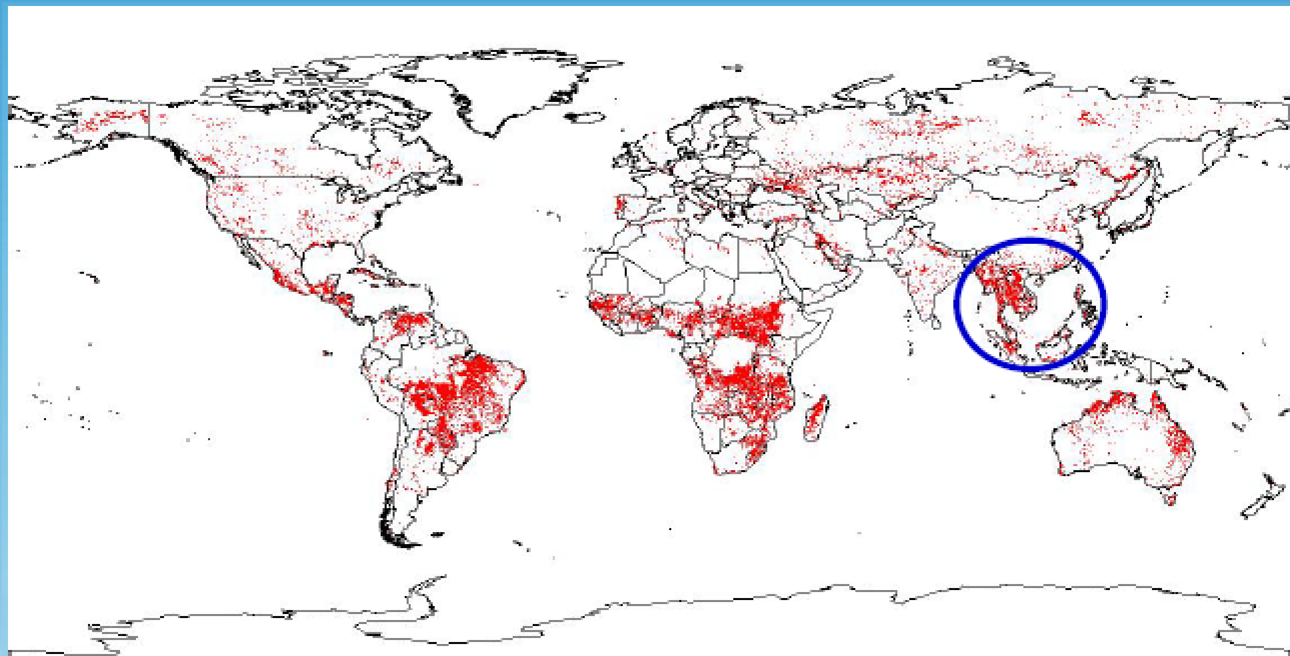
International Meeting on Air Pollution in Asia

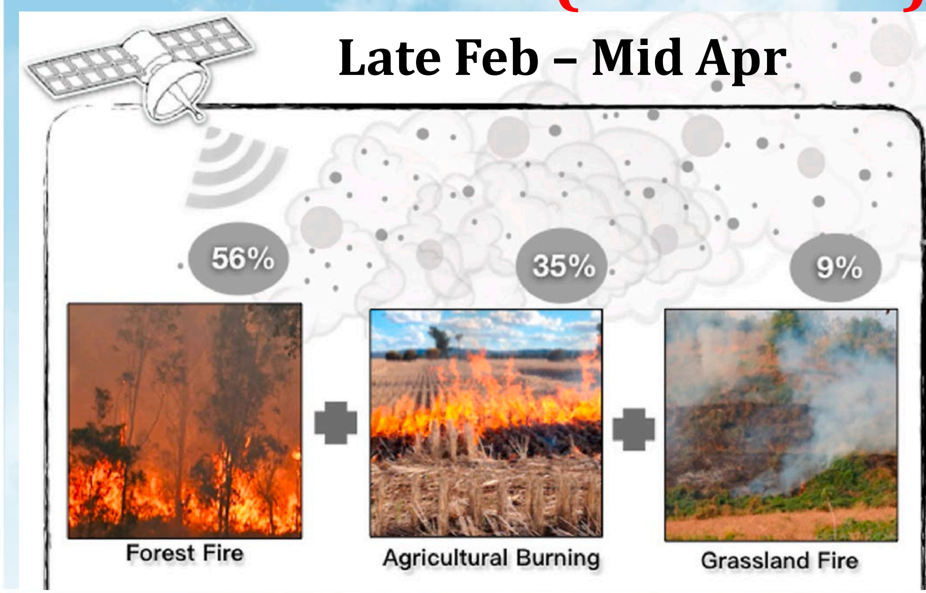
3rd February, 2023 **Hanoi, Vietnam**

Biomass-burning in Southeast Asia (SEA)



Peninsular SEA (Indochina)

Late Feb – Mid Apr

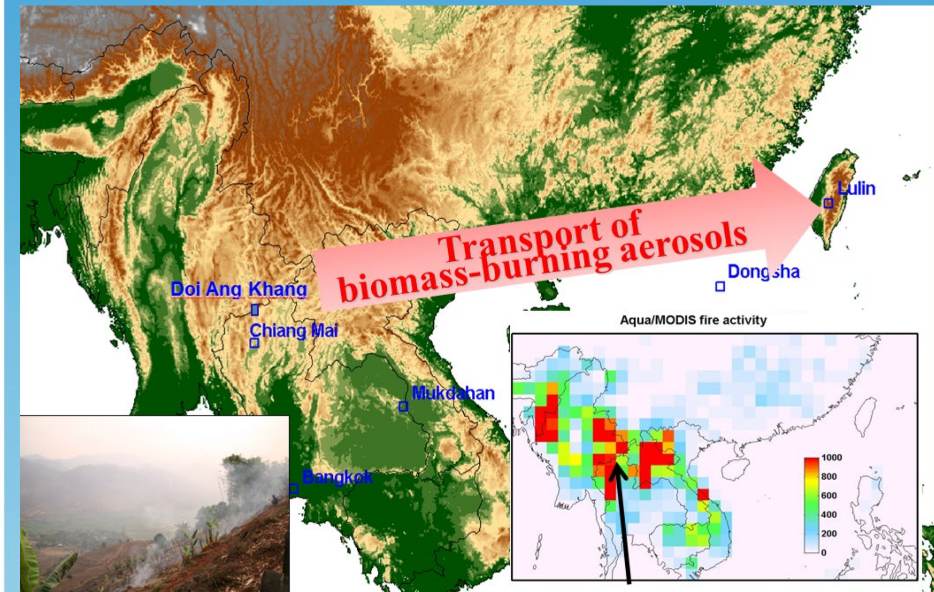


Insular SEA (Maritime)

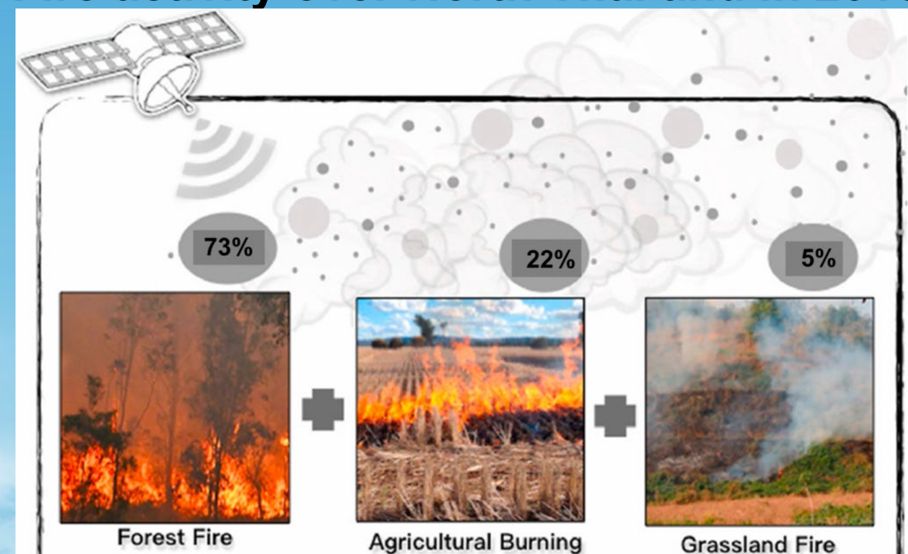
Late Aug – Oct

Peat burning

Overview of biomass-burning over northern peninsular Southeast Asia



Fire activity over North Thailand in 2016



Punsompong, Pani et al. (2021); Atmos. Environ.

hardwood + softwood

flaming + smoldering

Warming or Cooling?

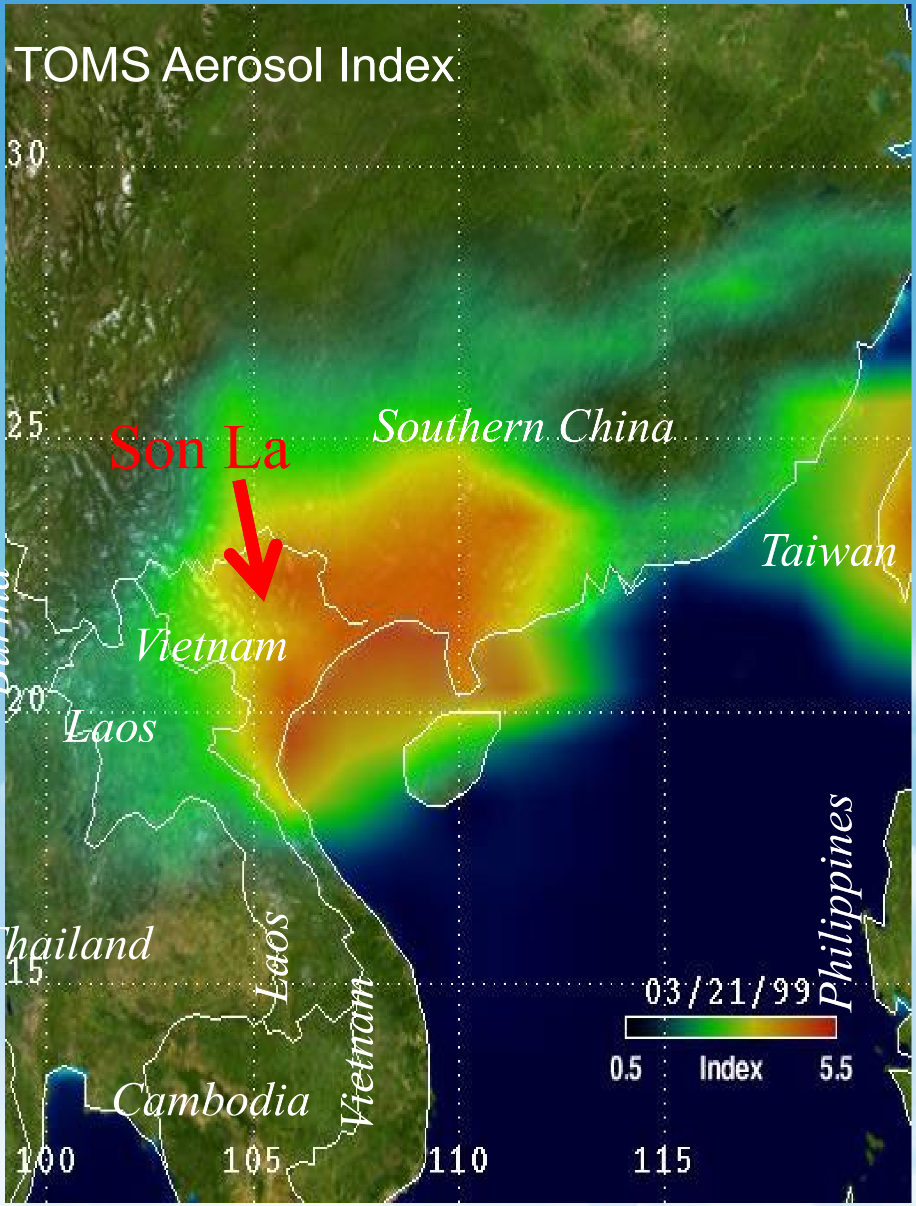
absorb/scatter

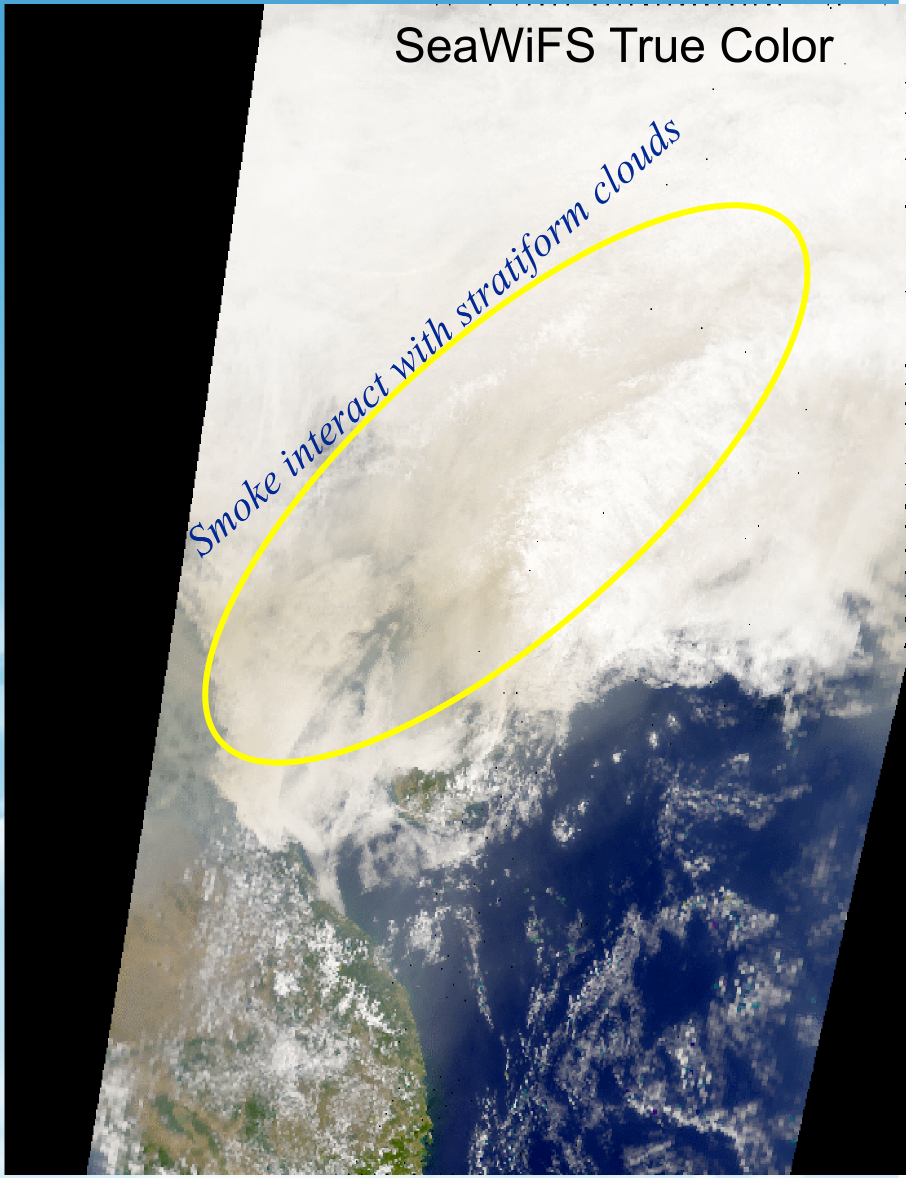
OC (organic carbon), BC (black carbon) → strongly absorb

K^+, Na^+, Ca^{2+}, Mg^{2+}, NH_4^+, H^+, Cl^-, H_2SO_4, HSO_4^-, SO_4^{2-}, and NO_3^-

Adverse Environmental/Climatic Impacts

Aerosol and cloud interaction: a case study



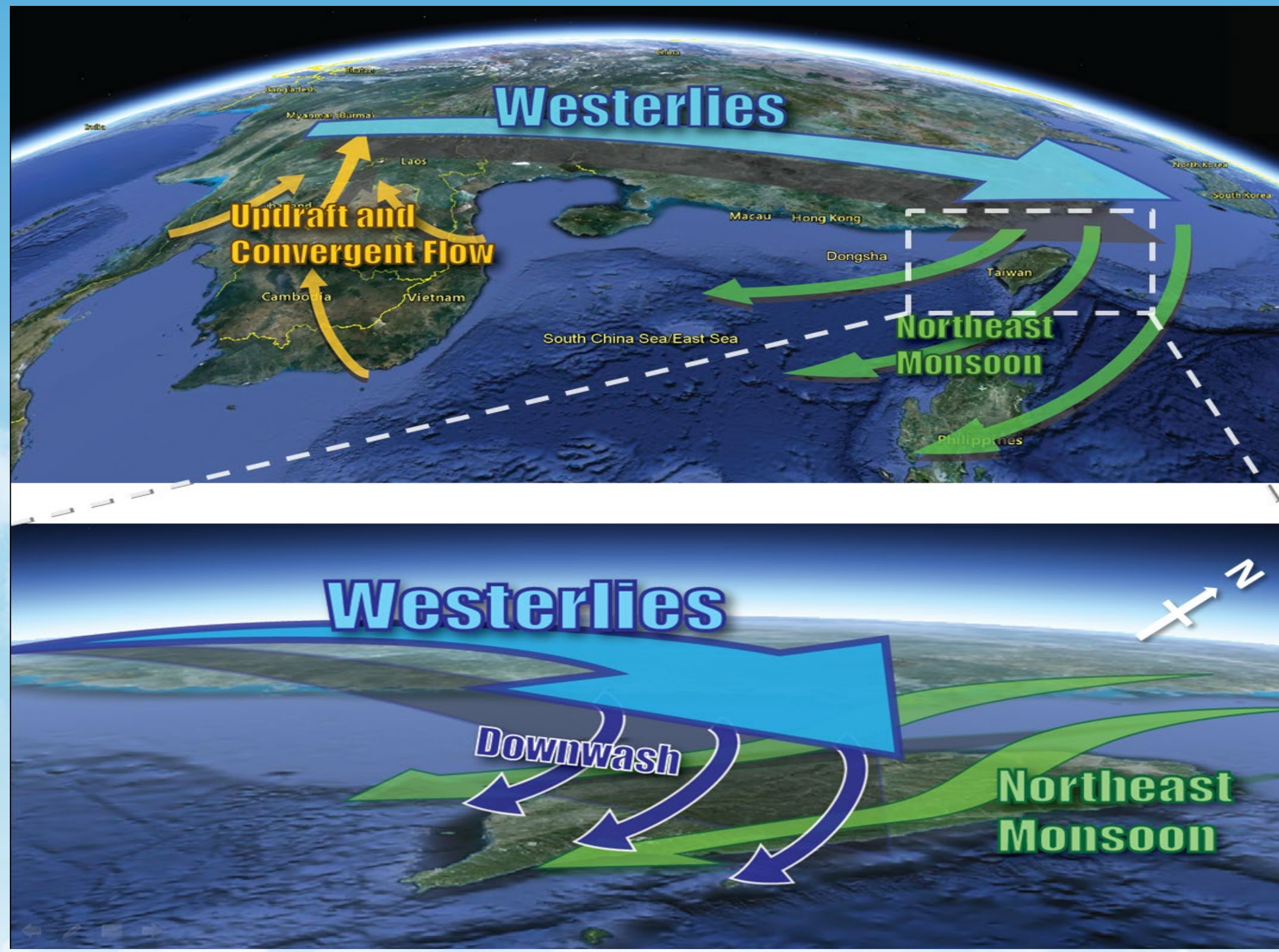


Event on 21 March 1999

(Courtesy: Christina Hsu, NASA)

7-SEAS/Dongsha experiment
March-June, 2010

Seven SouthEast Asian Studies (7-SEAS) project



Transport mechanism of springtime smoke from Southeast Asia to downwind Oceanic regions (Lin et al., 2013, **Atmos. Environ.**)

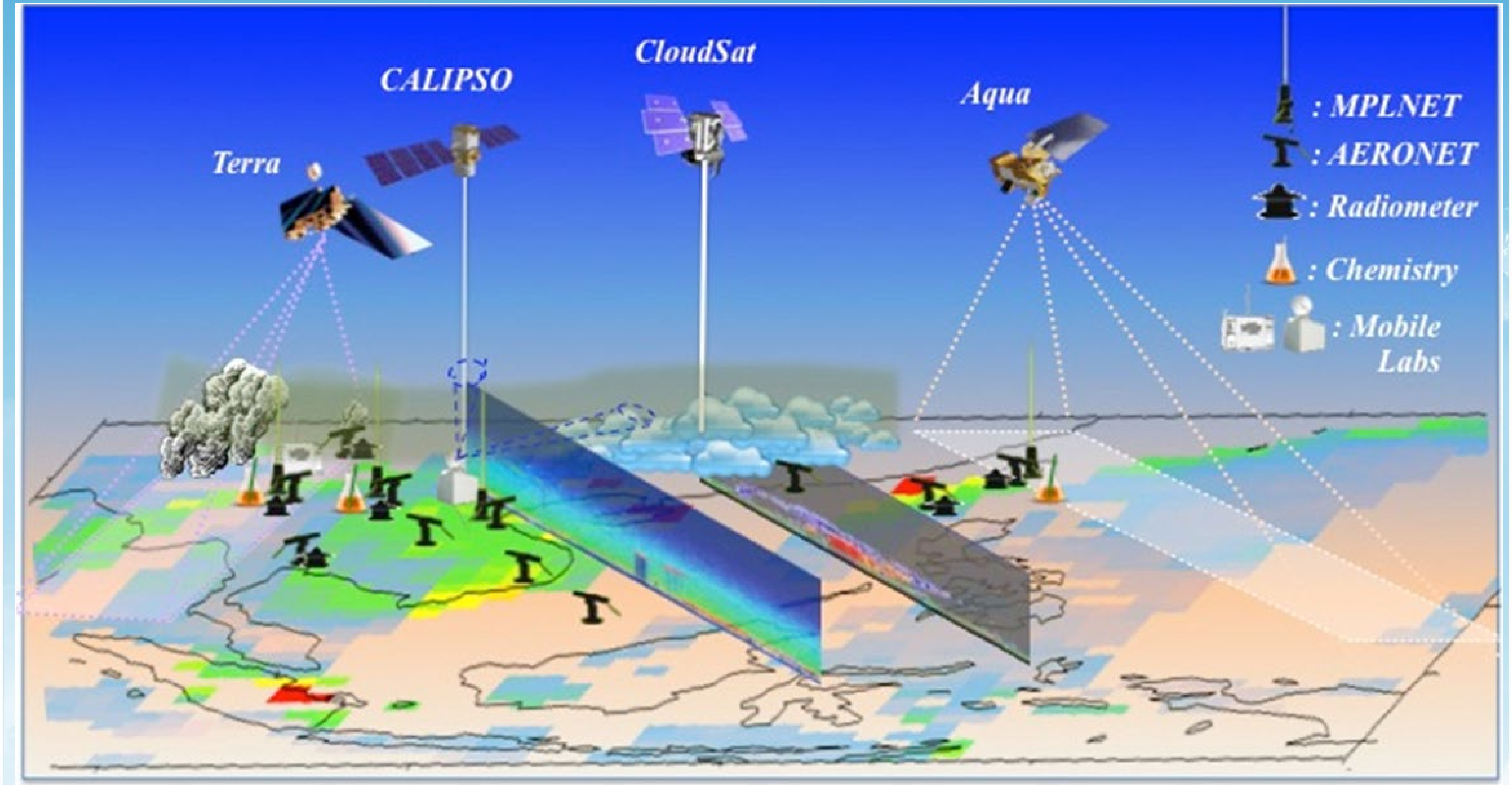
7-SEAS/BASELInE 2013-2015 spring campaigns

Biomass-Burning
Aerosols &
Stratocumulus
Environment:
Lifecycles and
Interactions
Experiment

Scientific Issues:

A. BB characterization at near-source region in SEA
B. Lifecycle of BB aerosols from source to receptor regions
C. Aerosol-radiation interactions
D. Aerosol-cloud interactions

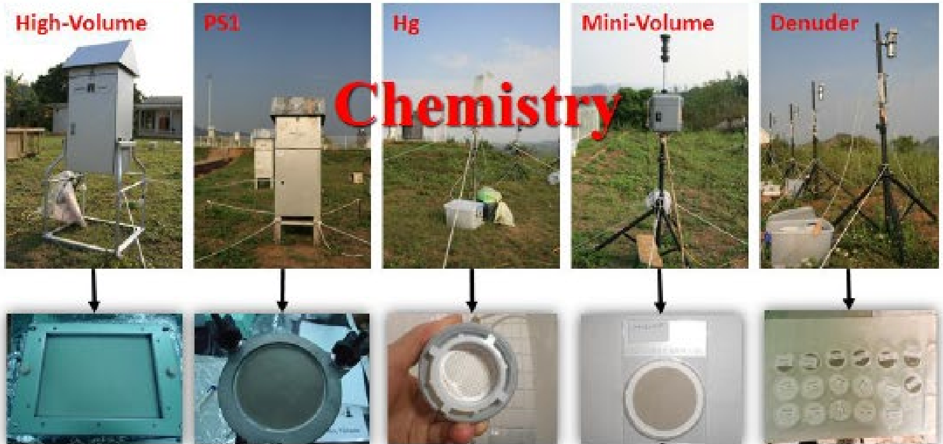
Synergistic 7-SEAS/BASELInE deployments of AERONET/MPLNET, SMARTLabs mobile laboratories, and regional contributing instruments along the "river of smoke aerosols"



Tsay et al. (2016), AAQR


Doi Ang Khang supersite (DAK)
1,534 m MSL
northern Thailand
Radiation
Air quality and aerosol in-situ
Chemistry sampling

7-SEAS 2010-2015 *in-situ* instrumentation

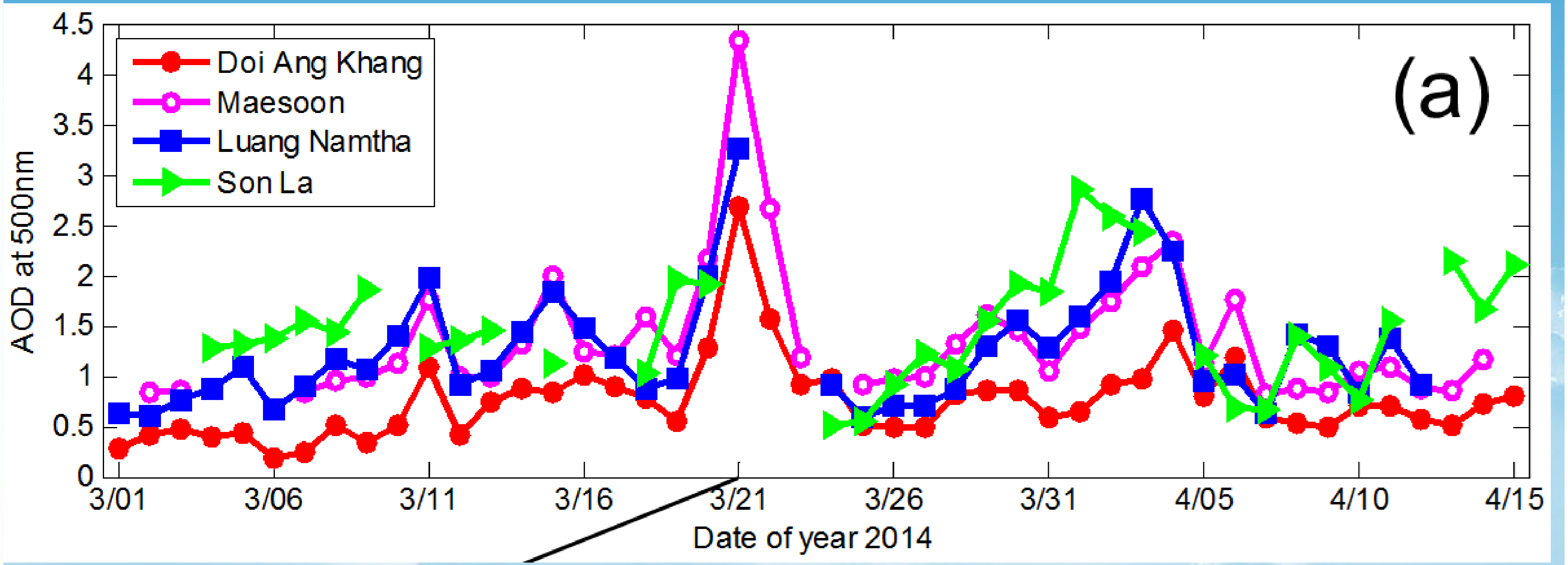


Toxin Chemistry
- ❑ mass concentration
- ❑ Dioxin
- ❑ Metal
- ❑ PAHs

Mercury Chemistry
- ❑ mass concentration
- ❑ gaseous mercury
- ❑ particulate mercury

Aerosol Chemistry
- ❑ mass concentration
- ❑ water soluble ions
- ❑ carbon composition
- ❑ levoglucosan

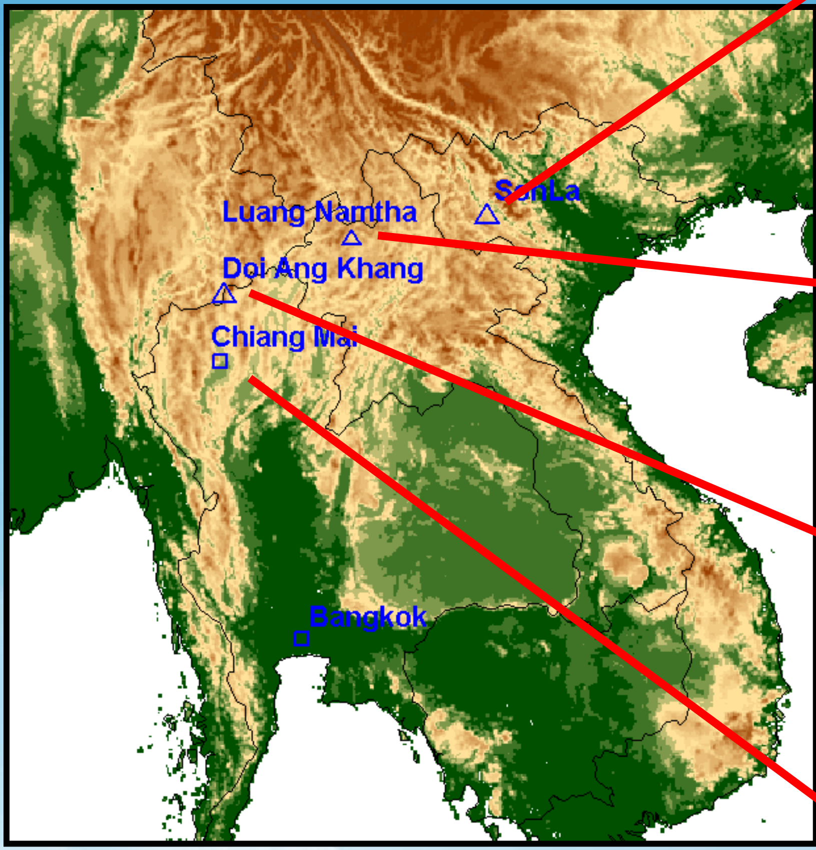
Severe BB aerosol loading over Peninsular SEA

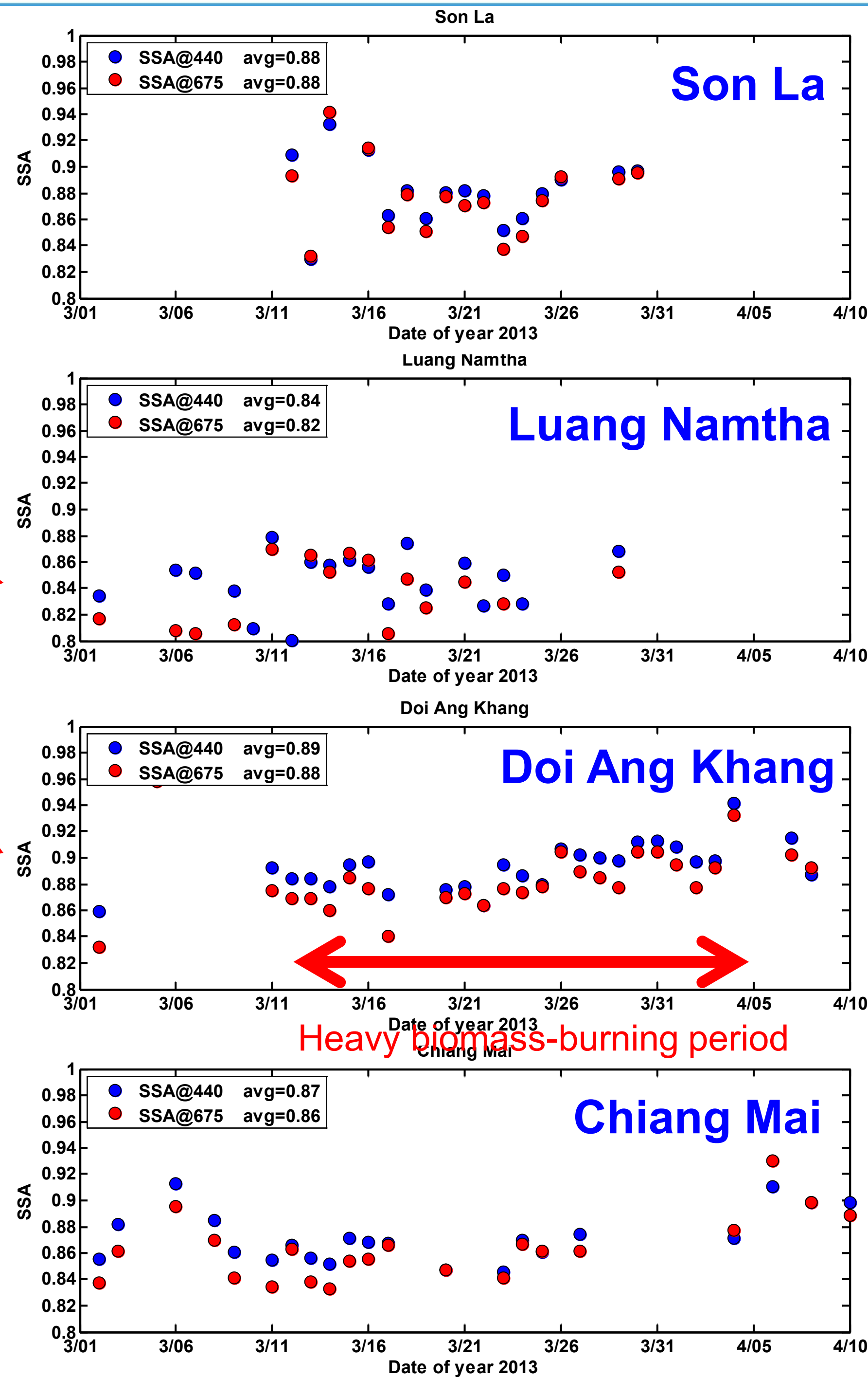


7-SEAS/BASELInE 2014 Campaign

Wang et al. (2015), AAQR

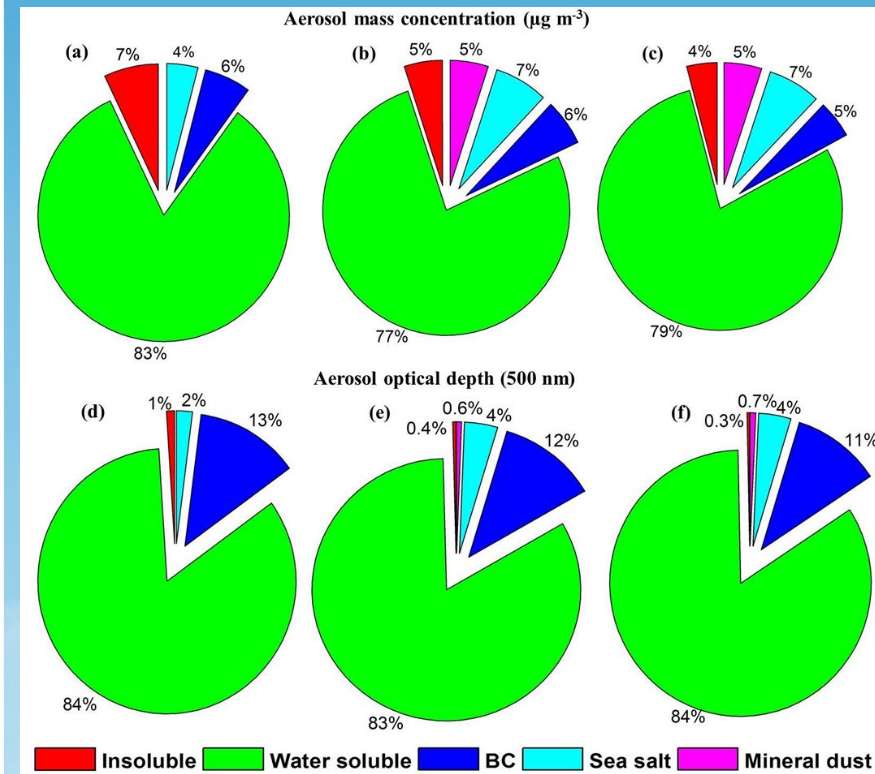
Time-series of SSA (single-scattering albedo)

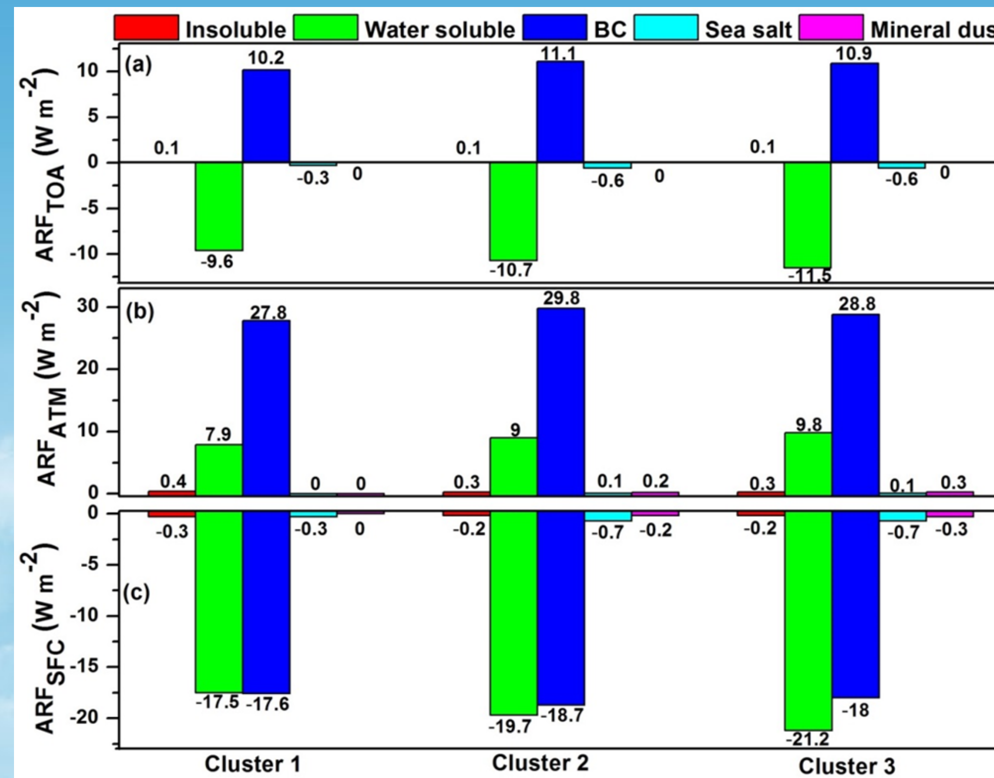




7-SEAS/BASELInE 2013 Campaign

Contribution of chemical components to aerosol loading and radiative forcing at Doi Ang Khang





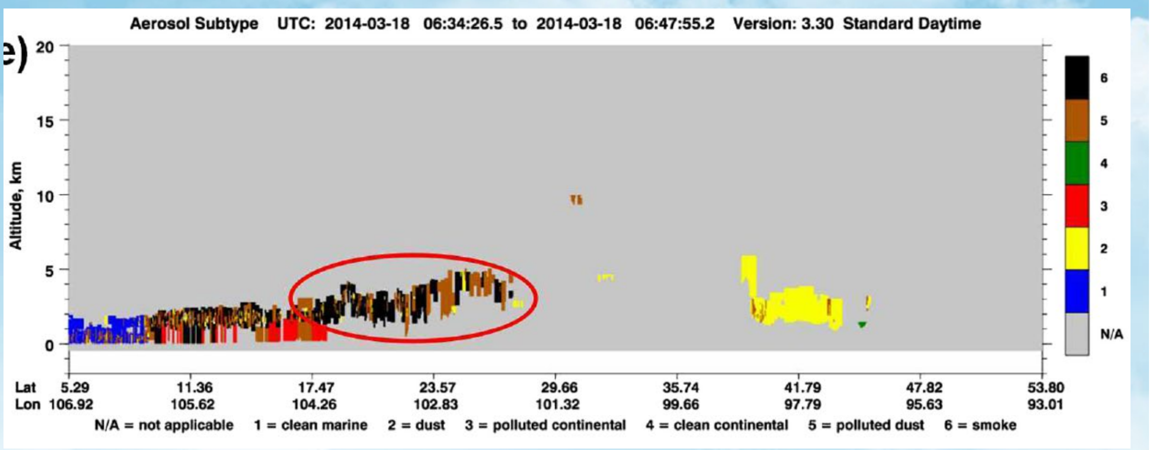
BC contributed ~6% to ambient $PM_{2.5}$; its contribution to AOD was ~12%; ~75% to the atmospheric forcing due to composite aerosols

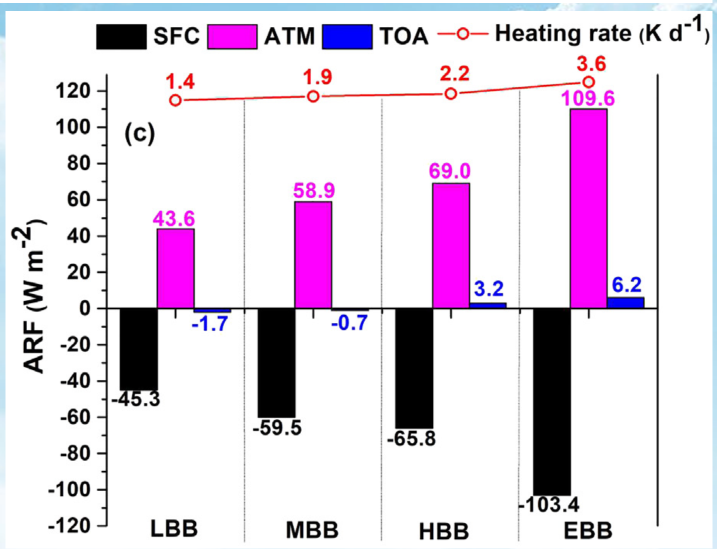
7-SEAS/BASELInE 2013 Campaign

Pani et al. (2016b); Aerosol Air Qual. Res.

Radiative response of BB aerosol over Chiang Mai

	Low-BB	Mild-BB	High-BB	Extreme-BB
LG (Levoglucosan; μg m^{-3})	0.6 ± 0.2	1.1 ± 0.5	2.0 ± 0.4	3.5
OC (μg m^{-3})	22.5 ± 4.3	29.2 ± 8.3	41.3 ± 7.8	72.0
EC (μg m^{-3})	4.3 ± 0.8	5.5 ± 1.5	7.6 ± 1.4	13.3
OC_{BB} to OC (%)	42 ± 10	60 ± 14	77 ± 0	79
OC_{ANTHRO} to OC (%)	58 ± 10	40 ± 14	23 ± 0	21
EC_{BB} to EC (%)	39 ± 9	57 ± 15	75	77
EC_{ANTHRO} to EC (%)	61 ± 9	43 ± 15	25 ± 0	23
BB to $PM_{2.5}$ (%)	52 ± 16	54 ± 14	63 ± 0	79



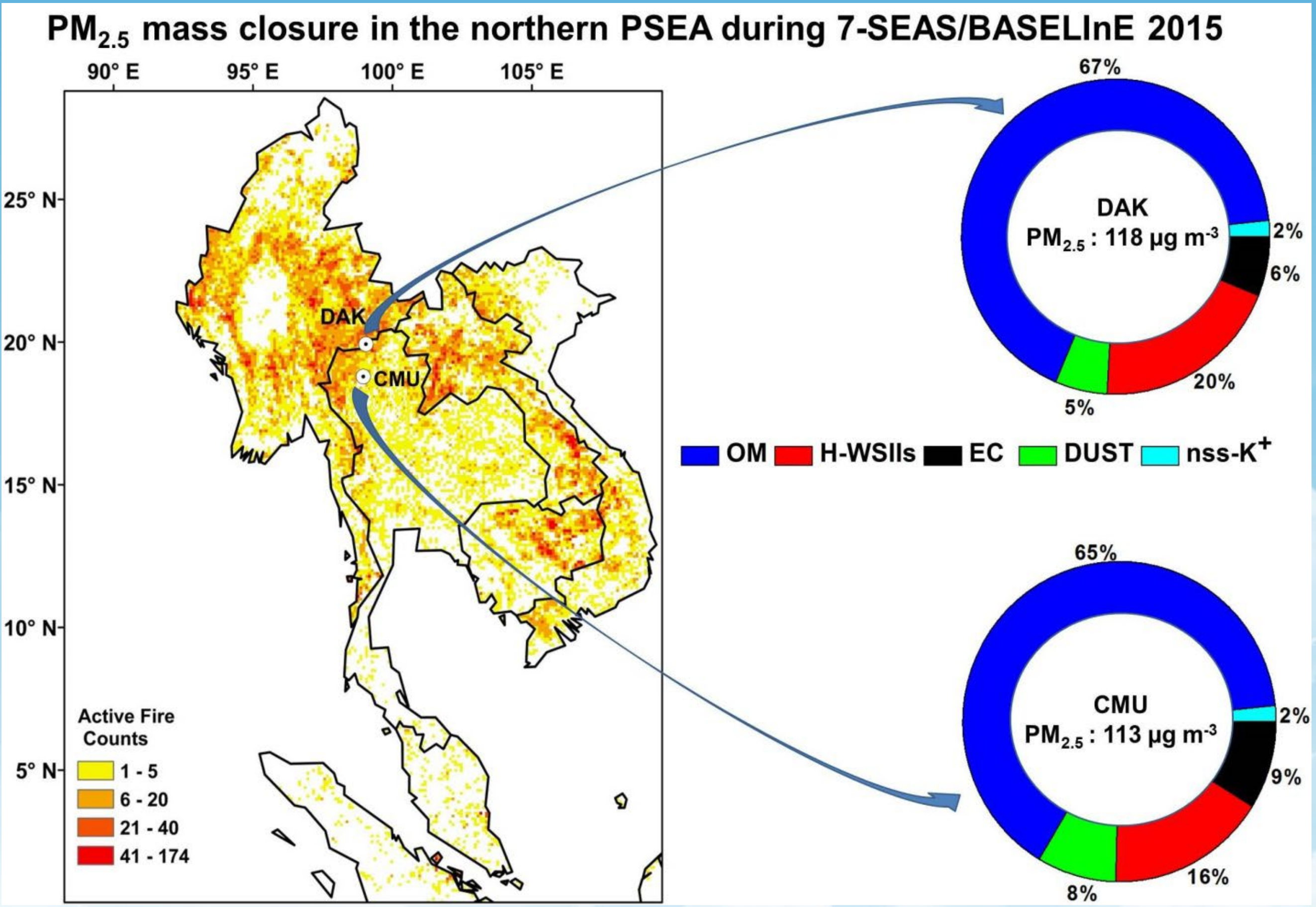


7-SEAS/BASELInE 2014 Campaign

Pani et al. (2018); Sci. Total Environ.

Chemical profile of BB-induced aerosols in northern peninsular SEA

Doi Ang Khang (DAK; mountain; near-source of BB) *vs* Chiang Mai University (CMU; foothill; urban)

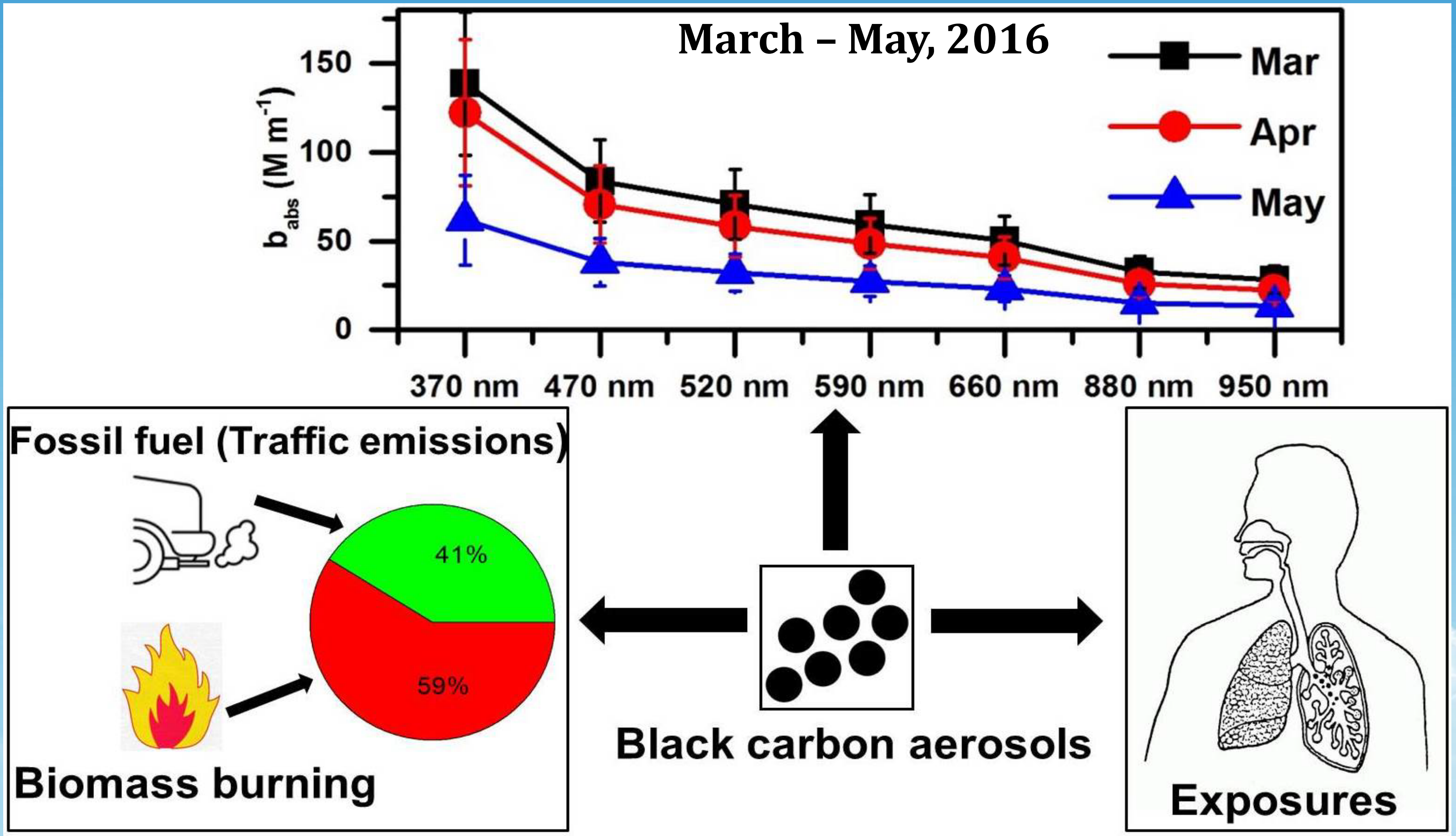


- **Organic matter** (OM) was the most abundant
- OM/OC ratio were **1.7 ± 0.3 for DAK** and **1.6 ± 0.3 for CMU**.
- **EC & dust** (%) were higher at CMU due to addition of traffic sources with BB.

7-SEAS/BASELInE 2015 Campaign

Pani et al. (2019); Atmos. Res.

Black carbon over Chiang Mai



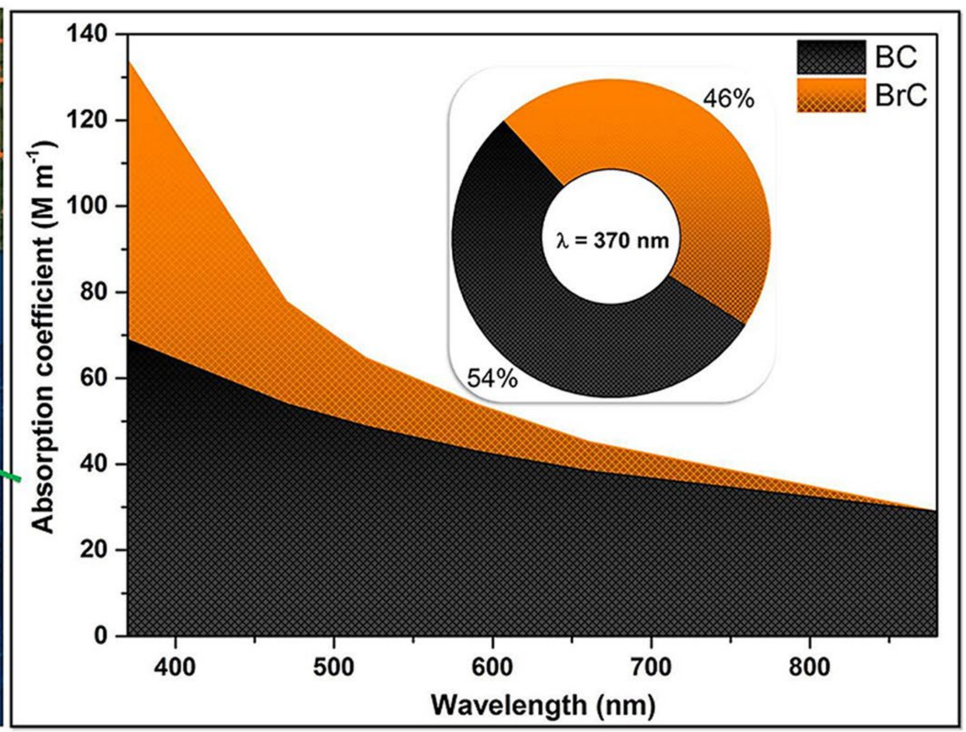
- Mean MAC (mass absorption cross-section) of BC was 9.3 m^2 g^{-1} at 880 nm
- BB contributed as high as 92% to daily BC concentration (59% on average).
- Health risk of BC was estimated to be as high as 11 number of passively smoked cigarettes per day in March.

Follow-up spring campaign 2016

Pani et al. (2020); Environ. Poll.

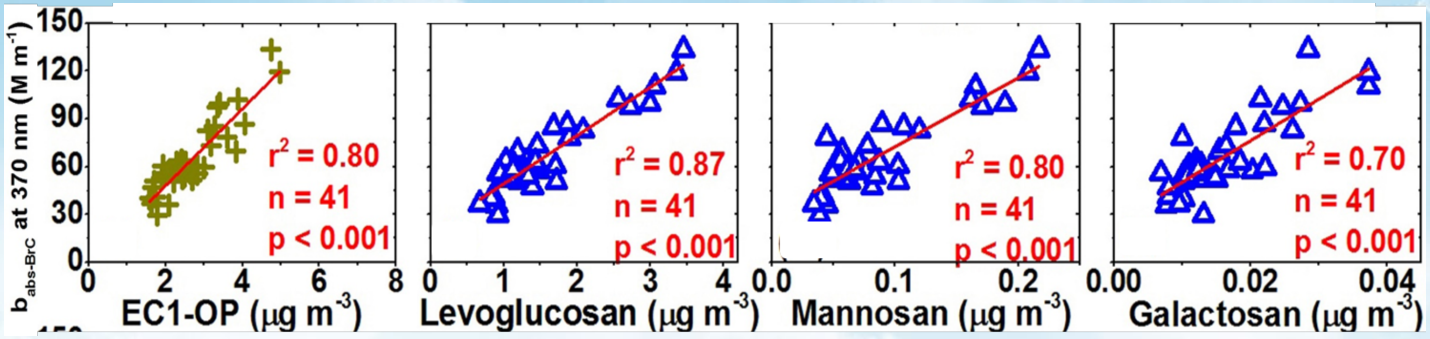
Brown carbon light absorption over Chiang Mai

Fires over northern PSEA in March-April, 2016
Courtesy: NASA's FIRMS



Light absorption of carbonaceous aerosols over Chiang Mai, Thailand

- Median MAC value of BrC was 2.4 $m^2\ g^{-1}$ at 370 nm



Strong associations with BB tracers

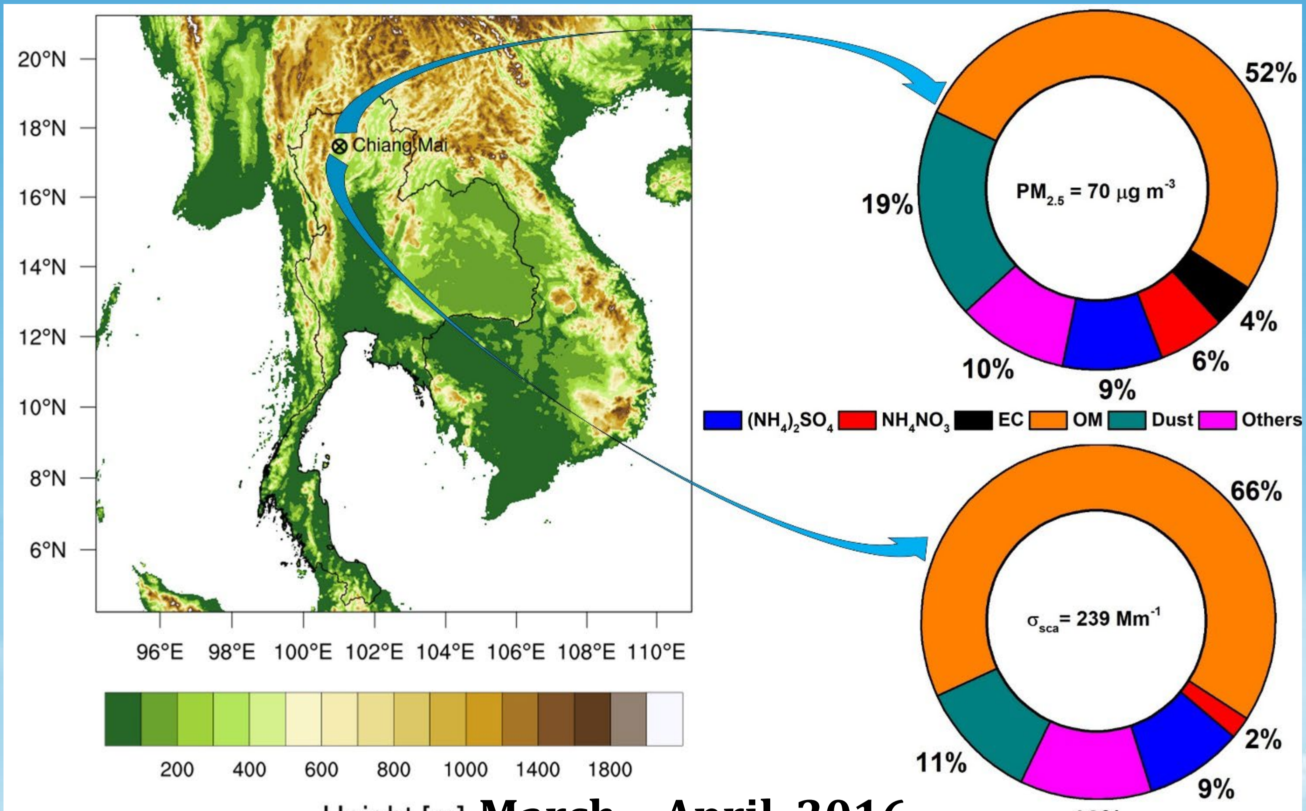
Follow-up spring campaign 2016

Pani et al. (2021); Environ. Poll.

Aerosol light scattering over Chiang Mai

Knowledge of mass scattering cross section (MSC) is also important in addition to MAC .

$$[PM_{2.5}] = [(NH_4)_2SO_4] + [NH_4NO_3] + [Dust] + [Others] + [EC] + [OM]$$



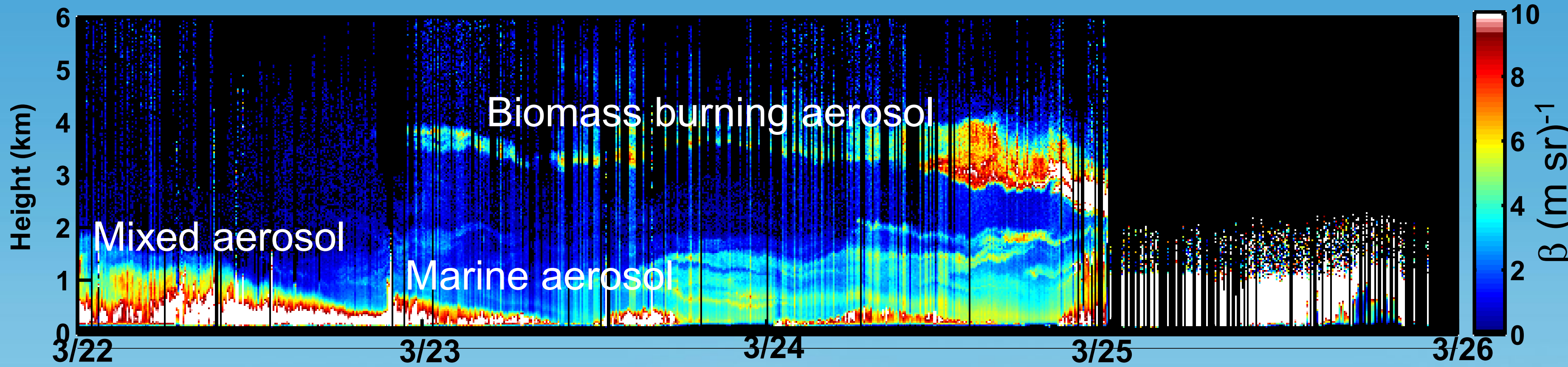
March – April, 2016

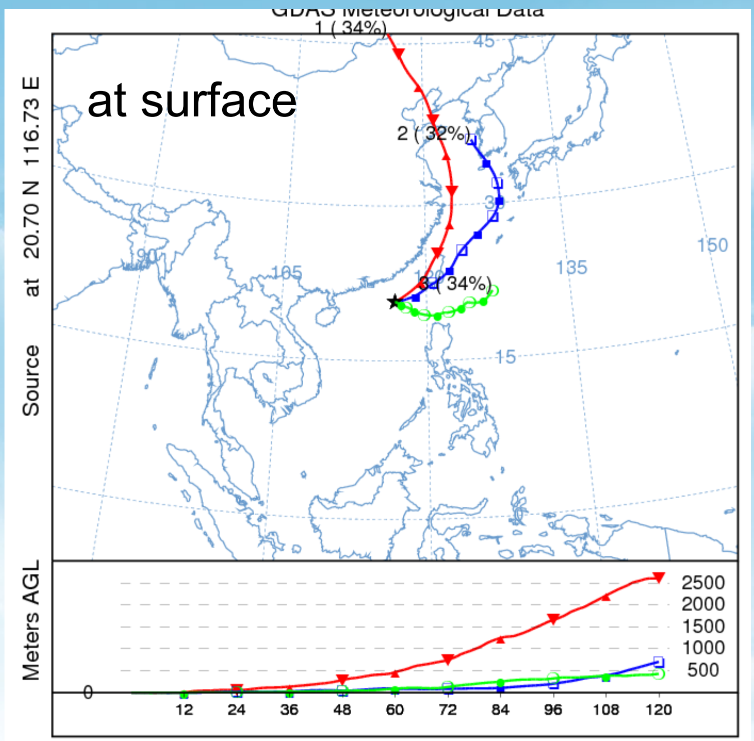
- Site-specific MSC of **$(NH_4)_2SO_4$, NH_4NO_3, OM, Dust, and Others** are **4.0, 2.4, 4.5, 2.5, and 4.1 $m^2\ g^{-1}$** at Chiang Mai.

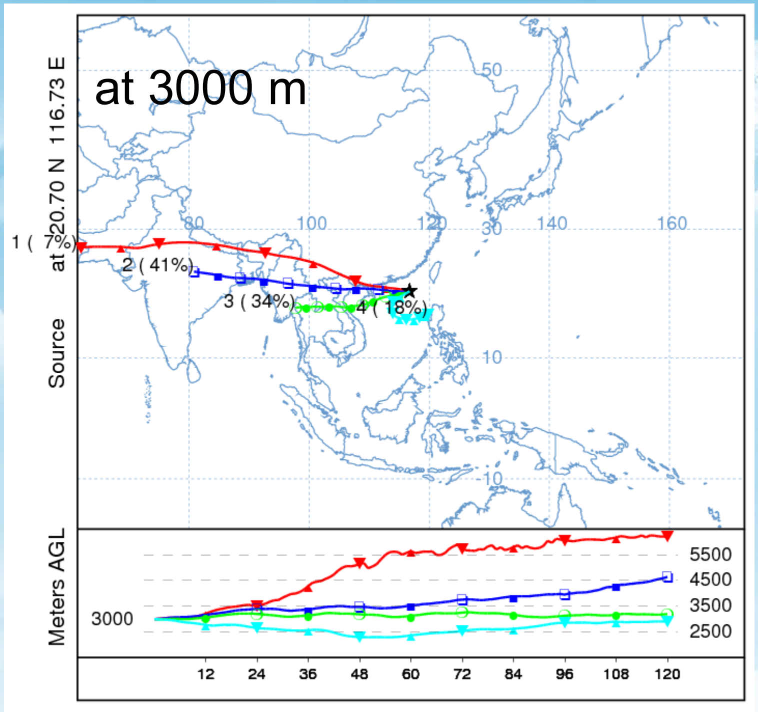
Follow-up spring campaign 2016

Pani et al. (2023); Sci. Total Environ.

Two-layer aerosol transport over South China Sea

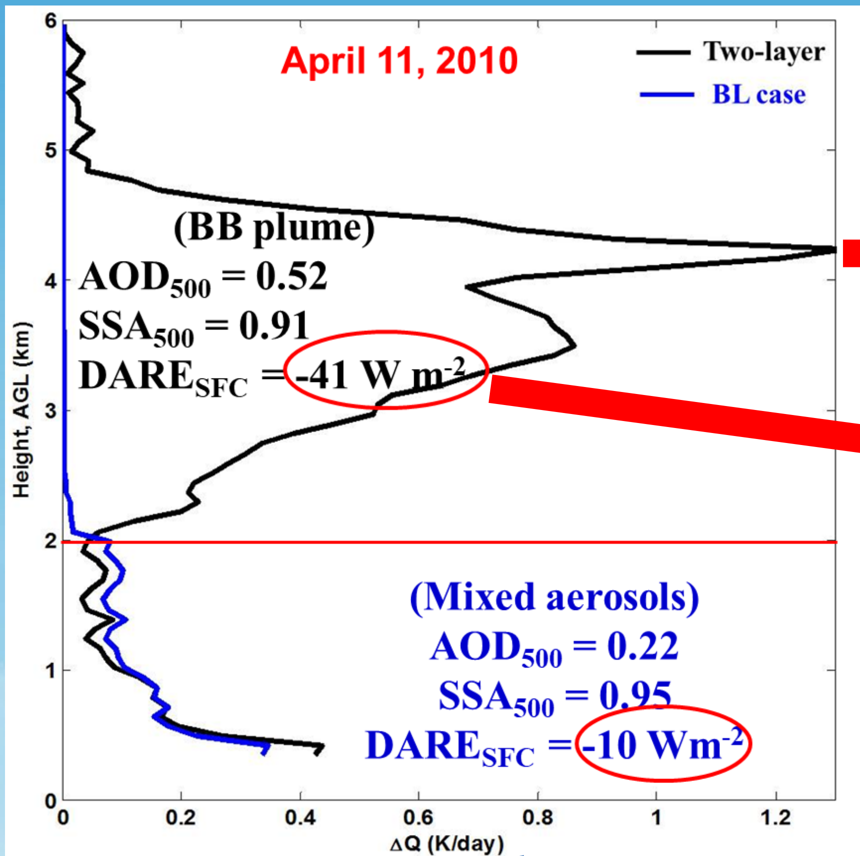






Wang et al. (2013), Atmos. Environ.

Aerosol radiative effect for two-layer aerosol transport over South China Sea



Significant Atmospheric Warming

Significant Surface Cooling

mostly happen in every spring

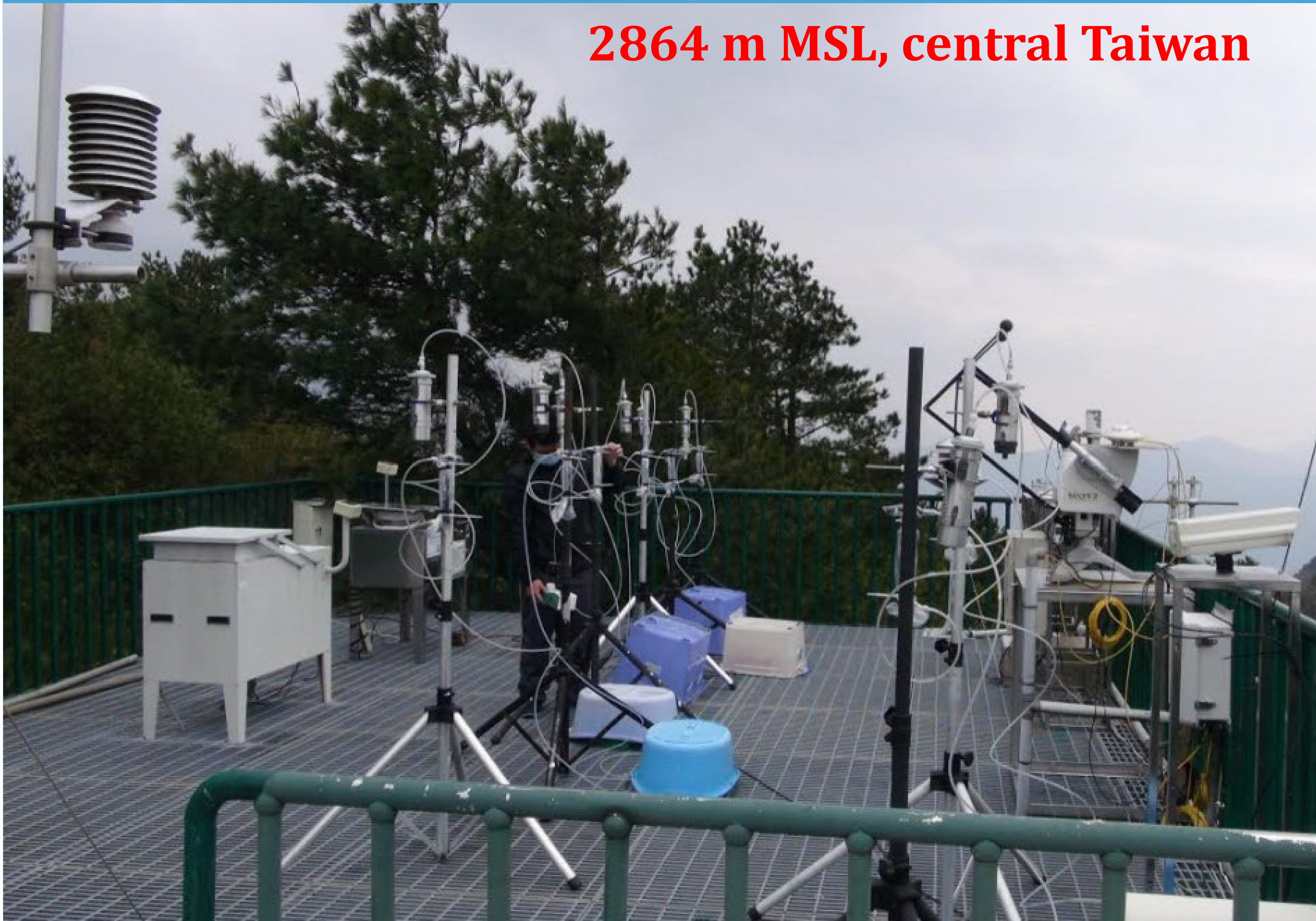
Heating Rate (Kelvin per day)

AOD: Aerosol Optical Depth; SSA: Single Scattering Albedo;
$DARE_{SFC}$: Direct Aerosol Radiative Effects at Surface

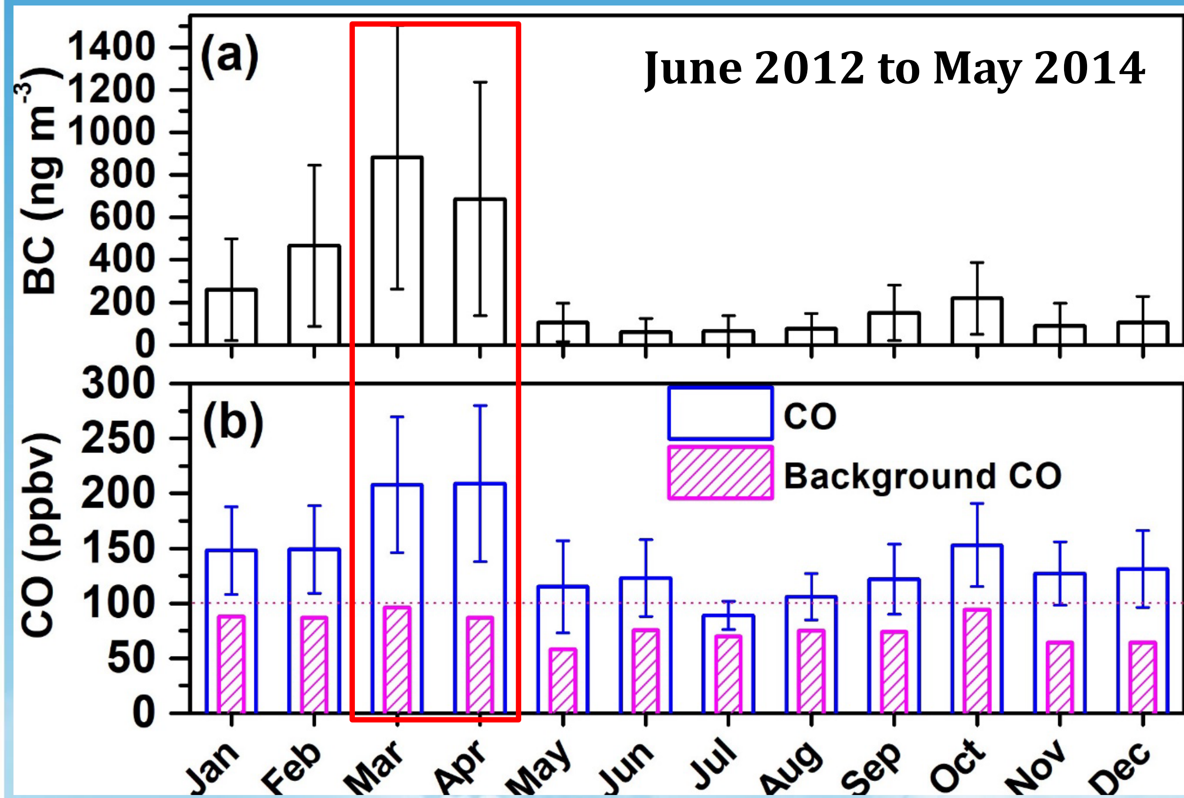
7-SEAS/Dongsha Experiment 2010

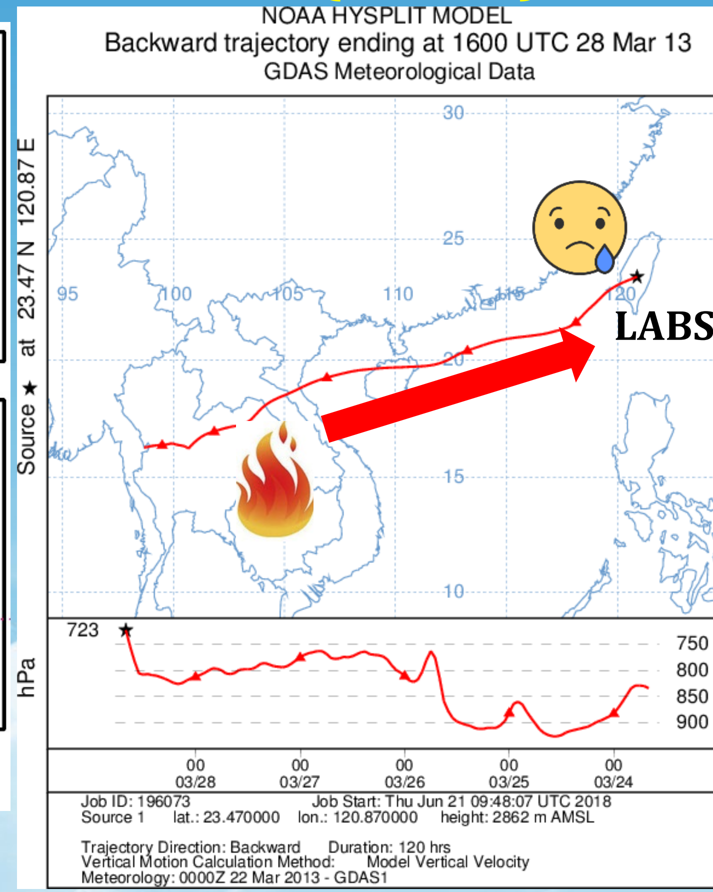
Pani et al. (2016a); JGR-Atmosphere

Lulin Atmospheric Background Station (LABS)



Transport efficiency of BC from northern PSEA to Lulin Atmospheric Background Station (LABS)





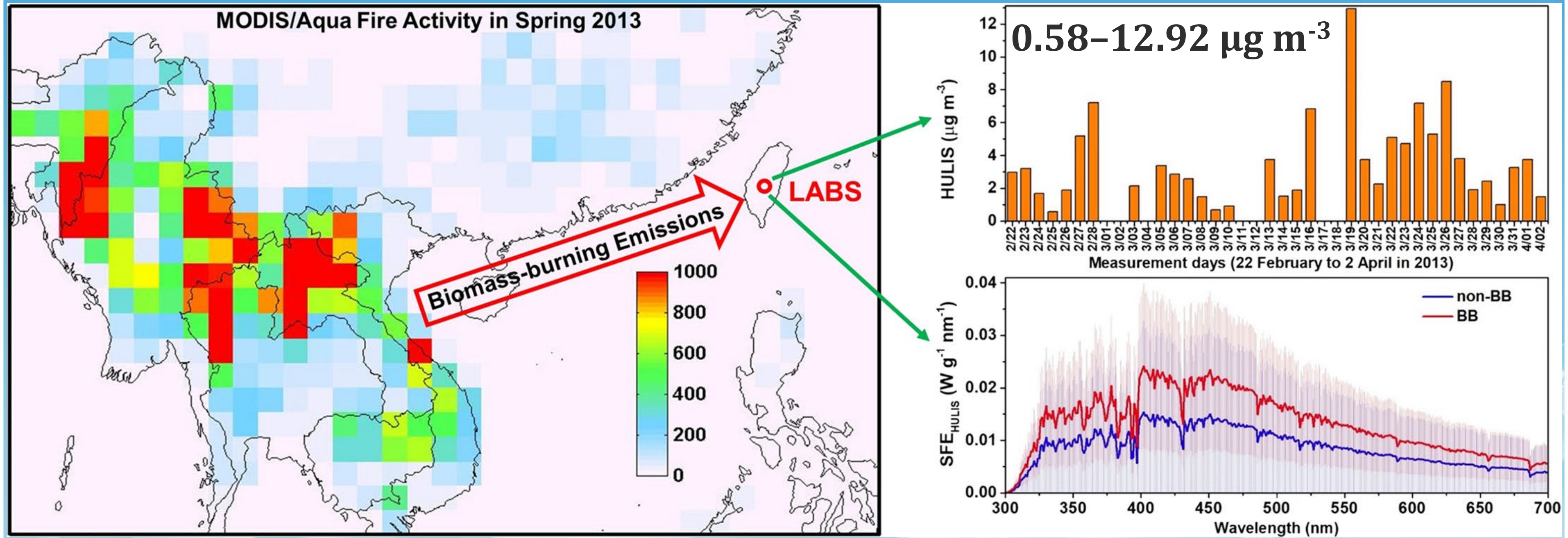
Transport efficiency of BC from PSEA to LABS = 68%

~32% loss in BC (6.4% loss per day) was estimated for the atmospheric transport of BB emissions from PSEA to LABS (Taiwan).

7-SEAS/BASELInE 2013 Campaign

Pani et al. (2019); Atmos. Environ.

Humic-like substances (HULIS) in springtime PM_{10} at LABS: Abundance and light-absorption

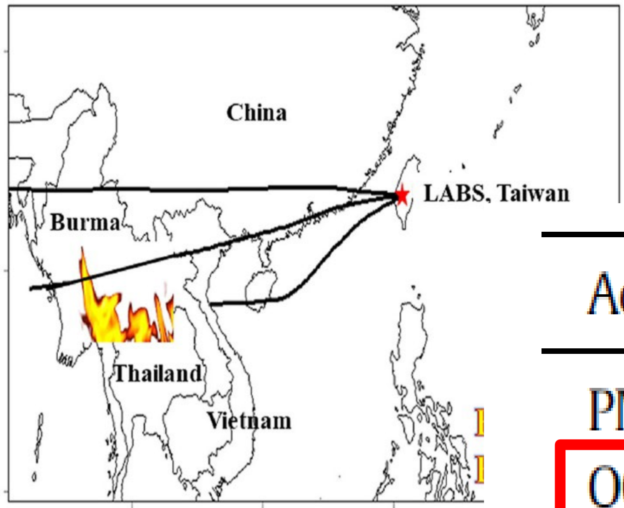


- HULIS at LABS was mostly attributed to both primary and secondary sources.
- BB was the dominating factor of HULIS abundance at LABS
- MAC_{HULIS} was 1.16 ± 0.75 $m^2\ g^{-1}$ at 370 nm during BB-dominated period.
- SFE_{HULIS} (the amount of energy added to the Earth-atmosphere system by a given aerosol mass in the atmosphere) was 4.16 W g^{-1} during BB-dominated period.

7-SEAS/BASELInE 2013 Campaign

Pani et al. (2022); Sci. Total Environ.

Aerosol component trends at Mt. Lulin



OC, EC, and nss-K^+ exhibited a decreasing trend.

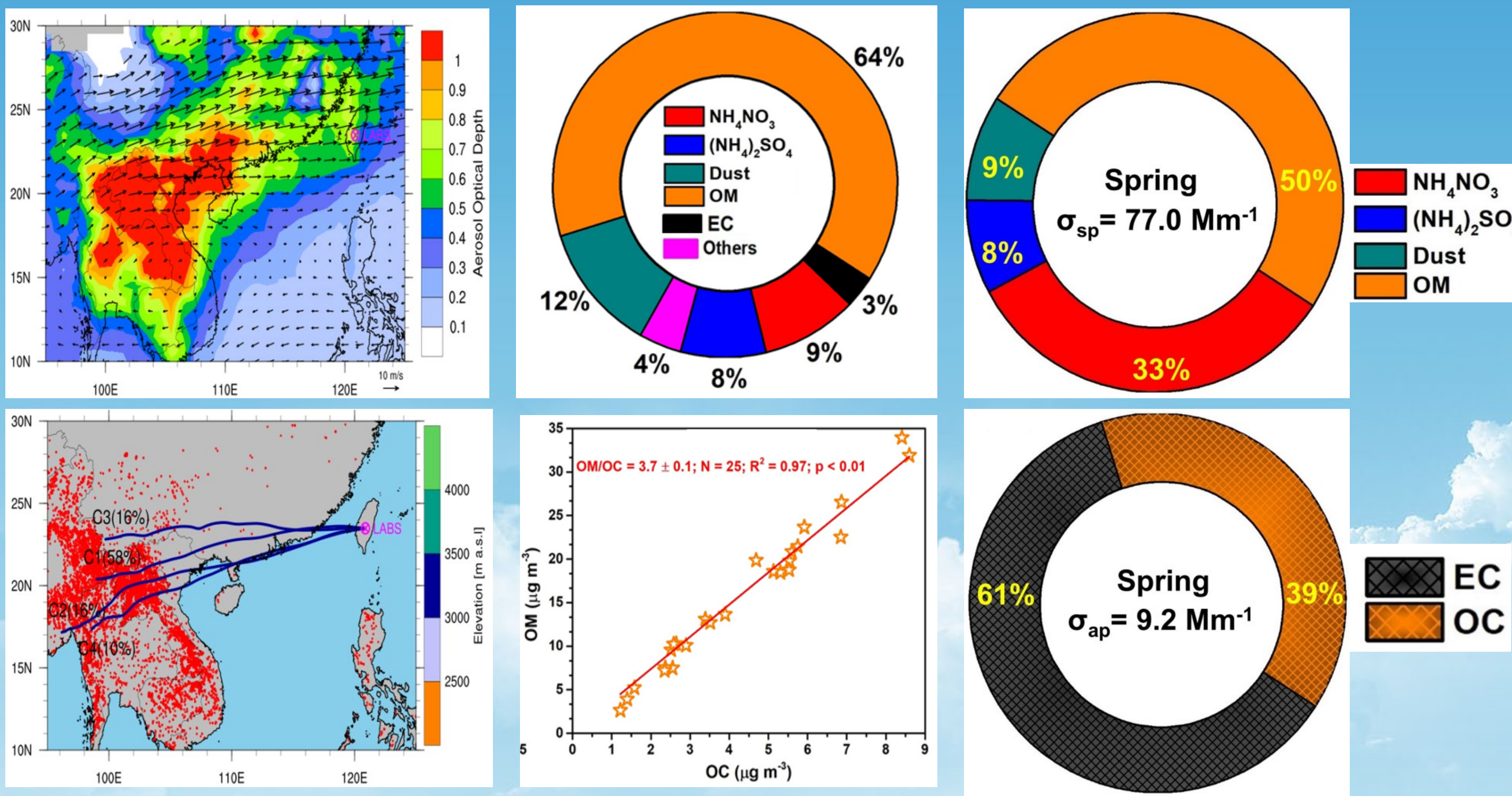
Aerosol component	Sen's slope (yr^{-1})	Trend (% yr^{-1})
$PM_{2.5}$ ($\mu g\ m^{-3}$)	−0.0011	−0.27
OC ($ng\ m^{-3}$)	−0.7410	−0.67[a]
EC ($ng\ m^{-3}$)	−0.1330	−0.48
nss-K^+ ($ng\ m^{-3}$)	−0.0325	−0.71[a]
Levoglucosan ($ng\ m^{-3}$)	0.0004	0.07
NO_3^- ($ng\ m^{-3}$)	0.0790	0.64[a]
nss-SO_4^{2-} ($ng\ m^{-3}$)	−0.0690	−0.08
$AOD_{500\ nm}$	−0.0001	−1.04[b]
Total rainfall (mm)	−0.0672	−0.34

[a] Trends are significant at $p < 0.05$ level.
[b] Trend is significant at $p < 0.01$ level.

Long-term (2003–2018)

Singh et al. (2020), Environ. Poll.

Linking of chemical composition and optical properties of BB influenced aerosols at LABS



- Estimated dry MSCs of $(NH_4)_2SO_4$, NH_4NO_3, OM, and Dust were 3.20, 12.58, 2.54, and 2.12 m^2 g^{-1}, respectively. Likewise, estimated dry MACs of **EC and OC** were **7.30 and 0.83 m^2 g^{-1}**, respectively.

Data included: 2020 March

Pani et al. (2022); Sci. Total Environ.

Questions Please?

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