7 South East Asian Studies

- Overview of 2010-2016 spring campaigns in northern SEA

George Lin, National Central U.,

Si-Chee Tsay, Brent Holben, Christina Hsu, NASA/GSFC

Jeff Reid, Naval Research Lab,

7-SEAS team of TH/TW/VN

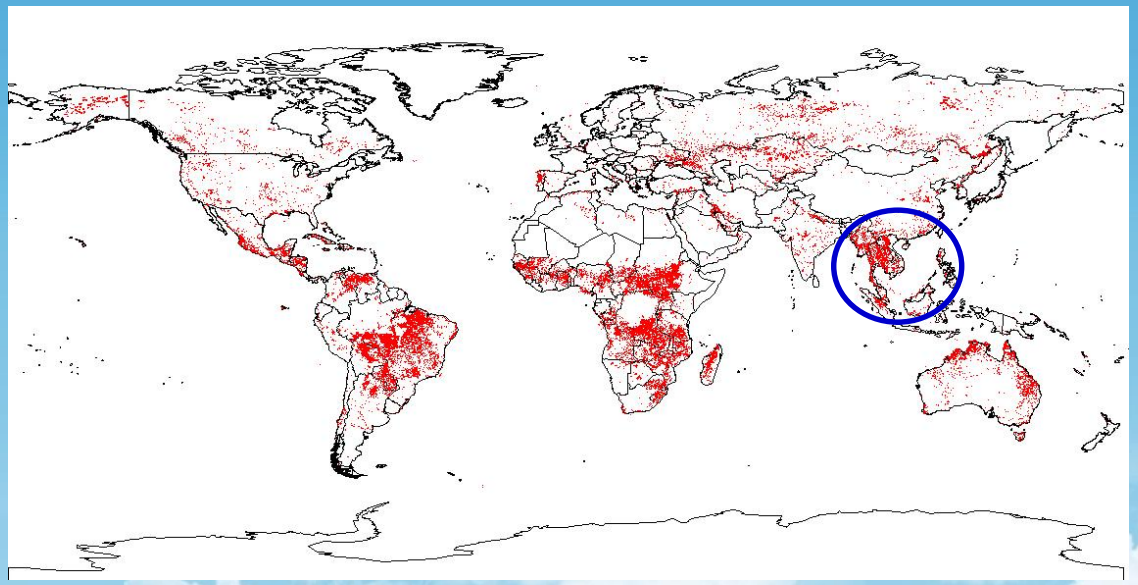
Biomass Burning (BB) in SE Asia

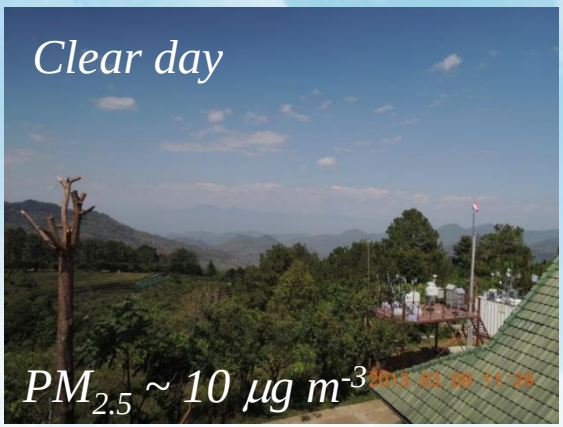
7 South East Asia Studies (7-SEAS)

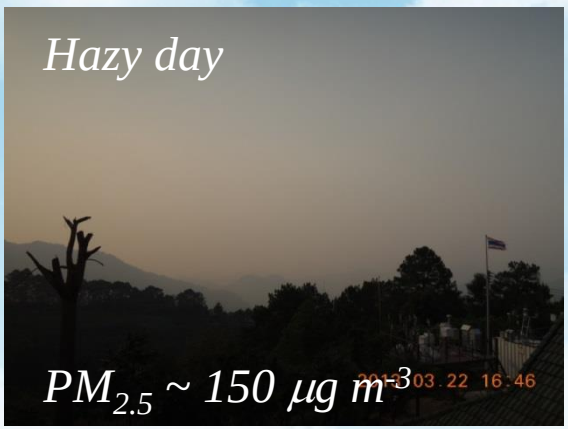
7-SEAS spring campaigns

Future plan

Biomass-burning haze in SEA





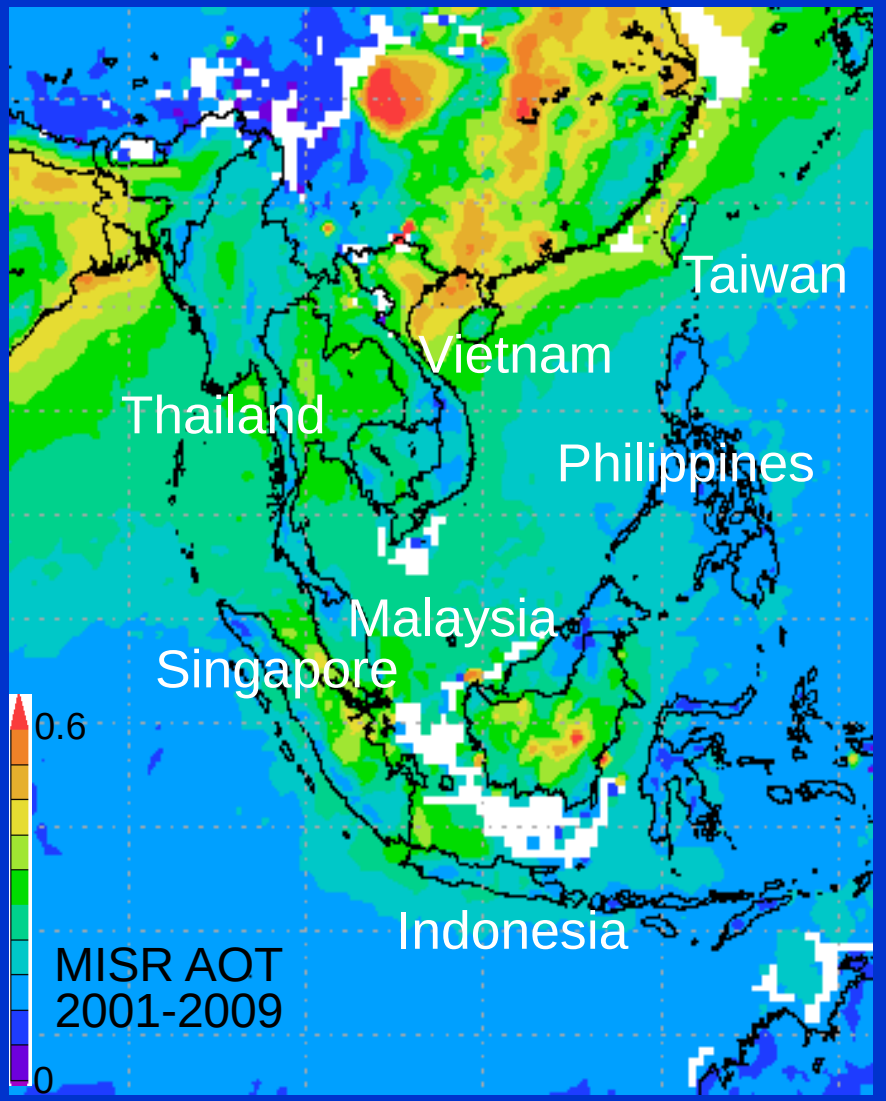


Seven South East Asian Studies
7-SEAS

Investigate the impacts of aerosol particles on *weather and the total SE Asian environment*

In order to do this, we need input from seven science areas:

- Aerosol lifecycle and air quality
- Tropical meteorology
- Radiation and heat balance
- Clouds and precipitation
- Land processes and fire
- Oceanography (phys. and bio.)
- Verification, analysis and prediction



What are the scientific issues of biomass-burning aerosol and related pollutants in SE Asia we concern about, particularly for Springs?

- Source/receptor BB characterization
- Environment and climate impact
- Health effects

7-SEAS activities since 2007

- 10 workshops and training courses
- 2007 VBBE (Virtual BB Experiment)
- 2012 Cruise mission in southern SEA

In-situ Experiments in northern SE Asia:

Phase I (2010-2012)

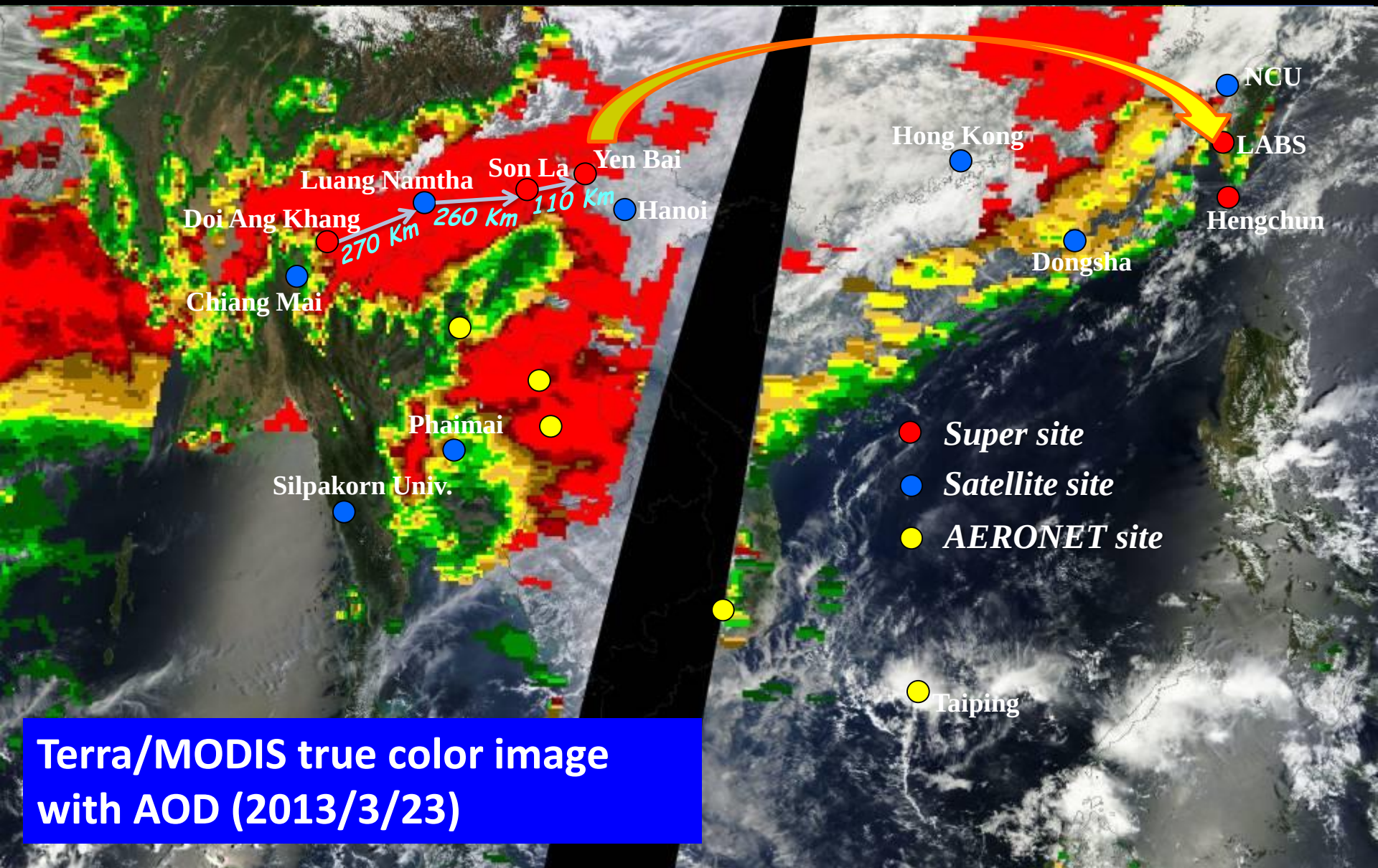
- 2010 Dongsha Experiment
- 2011 Son La Campaign I
- 2012 Son-La Campaign II

Phase II (2013-2015)

- 2013 BASELInE I
- 2014 BASELnE II
- 2015 BASELInE III

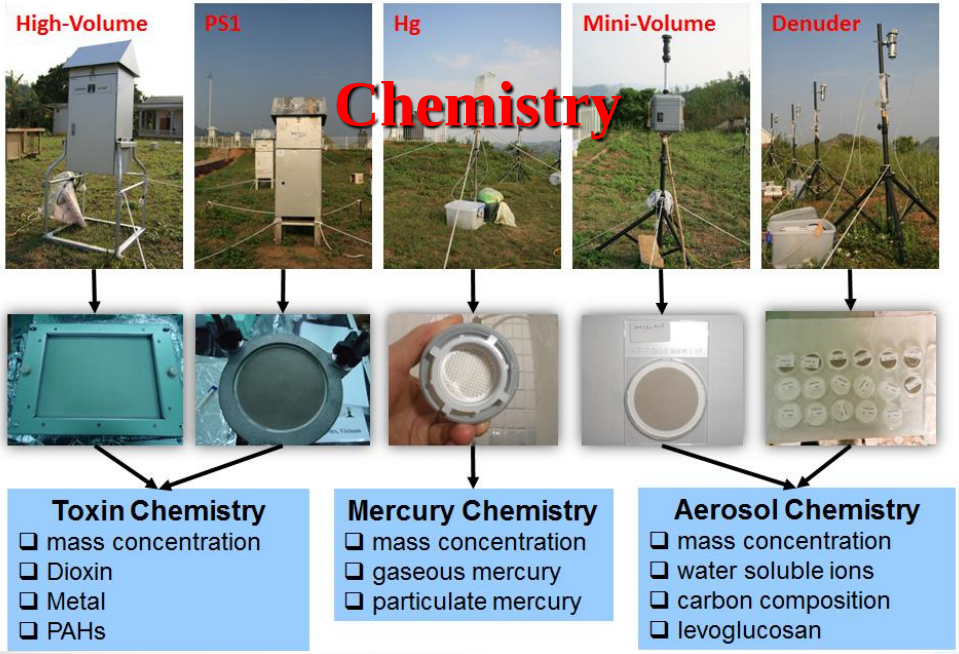
Phase III (2016-2018): Data and network

7-SEAS Spring field campaigns



Terra/MODIS true color image with AOD (2013/3/23)

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

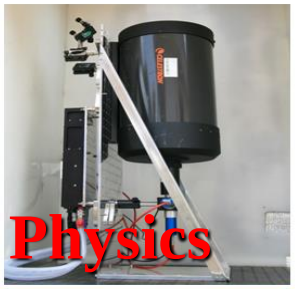


Toxin Chemistry
- ❑ mass concentration
- ❑ Dioxin
- ❑ Metal
- ❑ PAHs

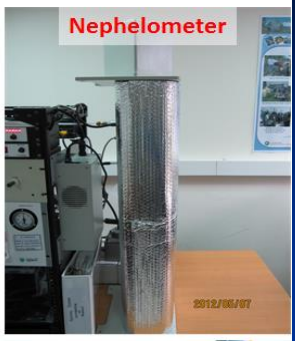
Mercury Chemistry
- ❑ mass concentration
- ❑ gaseous mercury
- ❑ particulate mercury

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

CCN



Lidar



Meteorological data

AOD、Radiation

氣膠吸光及散光係數

NASA COMMIT- Dongsha, Son La

NASA ACHIEVE Yen Bai

NCU mobile 1 - Doi Ang Khang

NCU mobile 2 – Hengchun

NCU Mt. Lulin Dongsha supersites

Air quality mobile - Hengchun

Surface measurements at sites: chemical

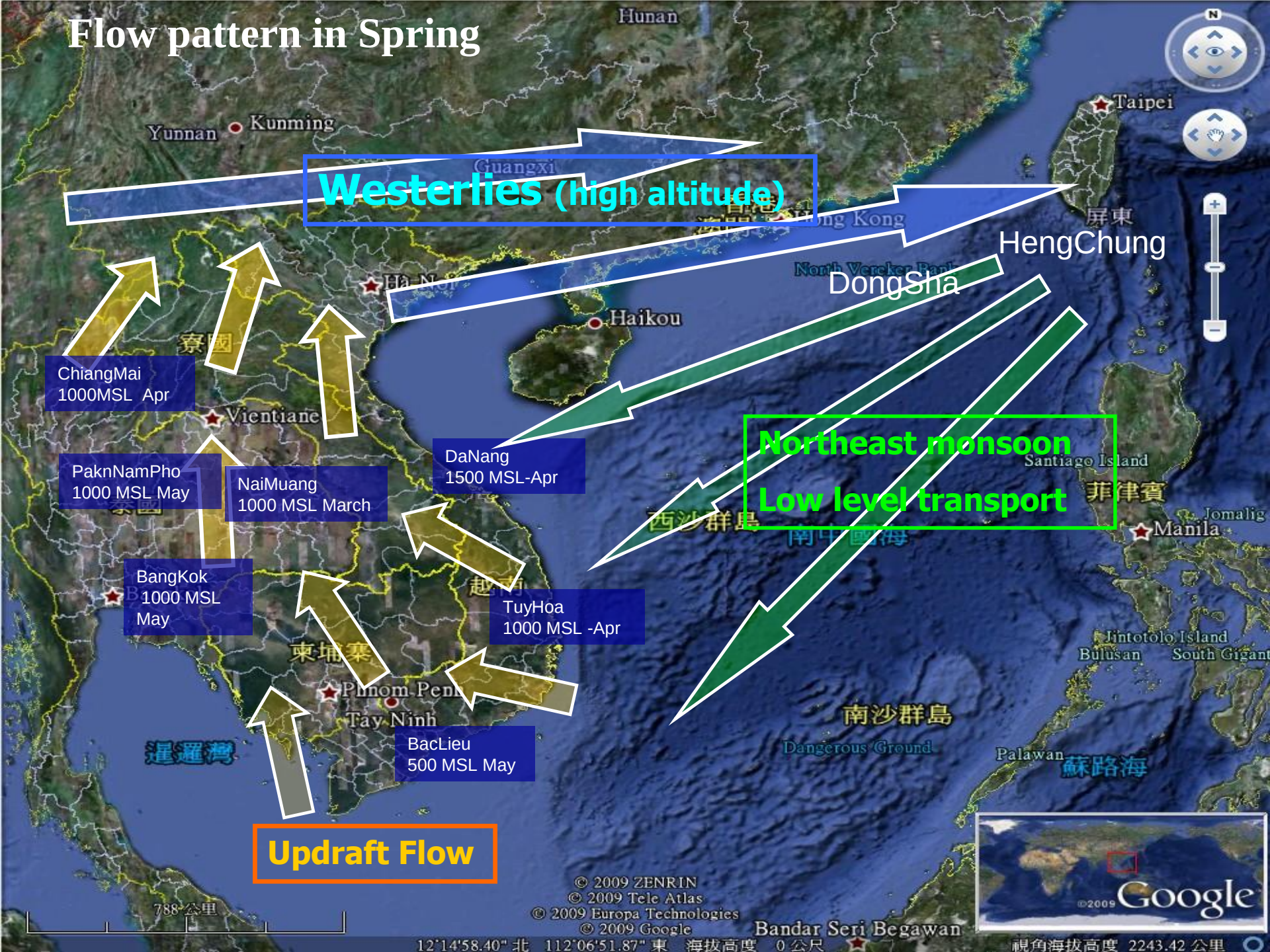
- **Air quality: continuous PM, O_3, CO, SO_2, etc.**
- **Aerosol chemistry – $PM_{2.5}$/PM_{10} for mass, ions, metals and OC/BC, organic acids**
- **Segmented aerosol chemistry**
- **Hg, Dioxins and PAHs**
- **VOCs**

Surface measurements at sites: physical

- **Meteorological data**
- **AOD**
- **Radiation**
- **Lidar**
- **CCN, aerosol size spectrum**
- **Continuous BC mass concentrations**
- **Aerosol absorption and scattering**

2010 Dongsha Experiment

- A pre-study of 7-SEAS
- Capacity building
- To characterize aerosol chemistry and physics over BB source/receptor sites in northern SE Asia: TH-VN-TW


Flow pattern in Spring
Hunan
Yunnan
Kunming
Guangxi
Taipei
Westerlies (high altitude)
HengChung
DongSha
Haikou
ChiangMai
1000MSL Apr
Vientiane
PaknNamPho
1000 MSL May
NaiMuang
1000 MSL March
DaNang
1500 MSL-Apr
Northeast monsoon
Low level transport
Santiago Island
Manila
BangKok
1000 MSL
May
TuyHoa
1000 MSL -Apr
Phnom Penh
Tay Ninh
BacLieu
500 MSL May
南沙群島
Dangerous Ground
Palawan
Updraft Flow
© 2009 ZENRIN
© 2009 Tele Atlas
© 2009 Europa Technologies
© 2009 Google
Bandar Seri Begawan
Google

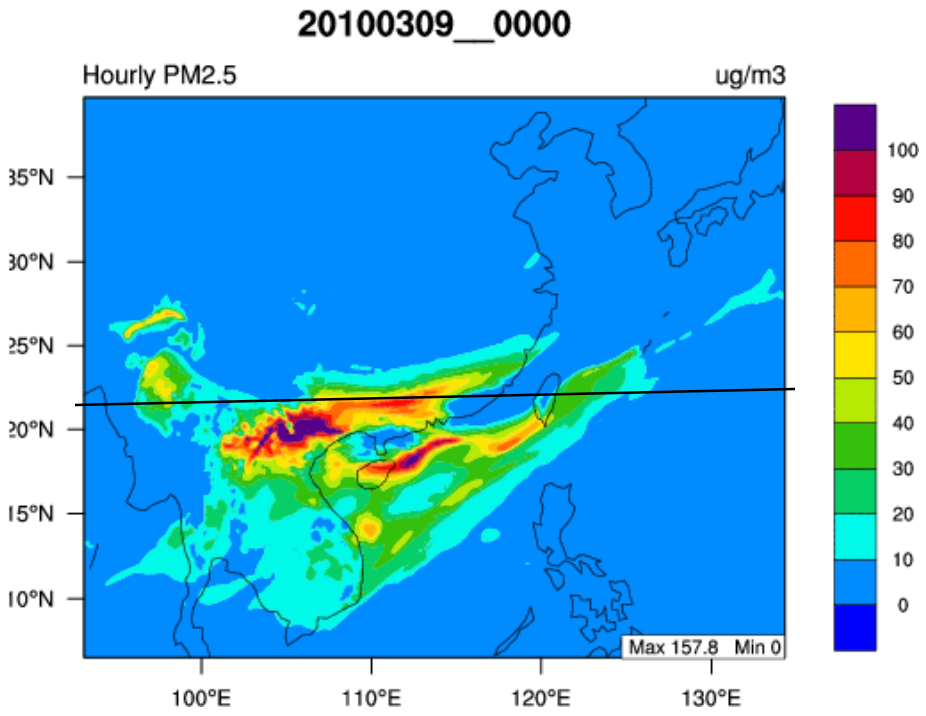

LABS
ChiangMai
Dongsha Island
HengChung
DaNang
Ocean
Researcher
No.1
Hunan
Yunnan
Kunming
Guangxi
Taipei
香港
澳門
Hong Kong
Ha Noi
Haikou
寮國
Vientiane
泰國
西沙群島
南中國海
Santiago Island
菲律賓
Manila
Jomalig
Bangkok
越南
柬埔寨
Phnom Penh
Tay Ninh
暹邏灣
南沙群島
Dangerous Ground
Palawan
蘇路海
Jintotolo Island
Bulusan
South Gigant
Bandar Seri Begawan
© 2009 ZENRIN
© 2009 Tele Atlas
© 2009 Europa Technologies
© 2009 Google
788 公里
12°14'58.40" 北 112°06'51.87" 東 海拔高度 0 公尺
視角海拔高度 2243.42 公里
Google

Transport of $PM_{2.5}$ – WRF/CMAQ simulation

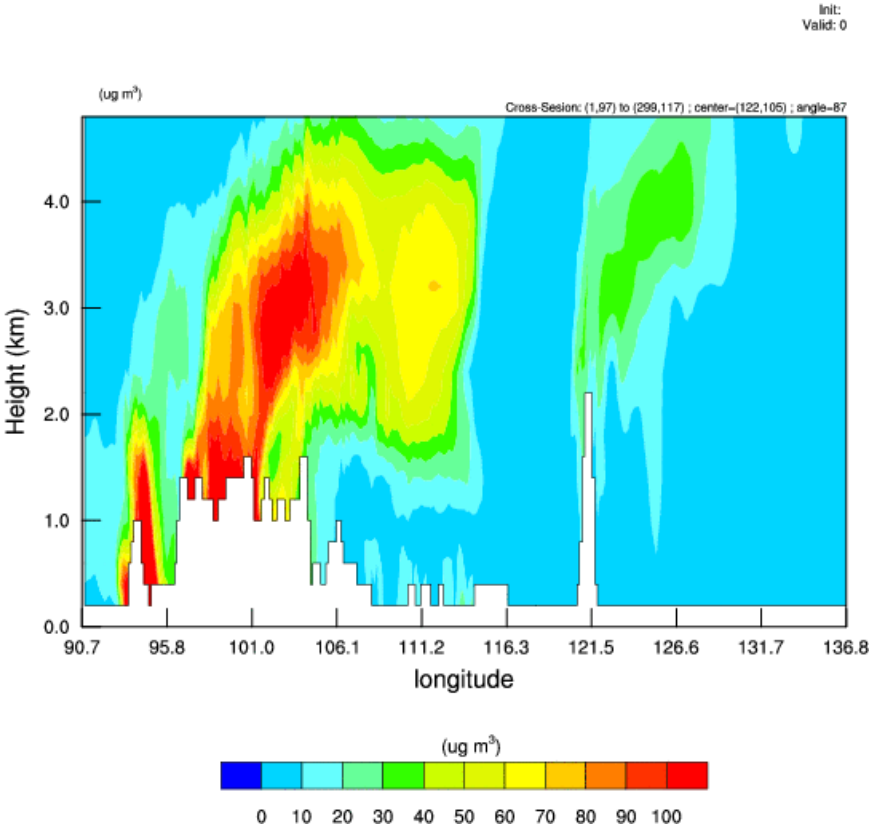
(contributed by MT Chuang)

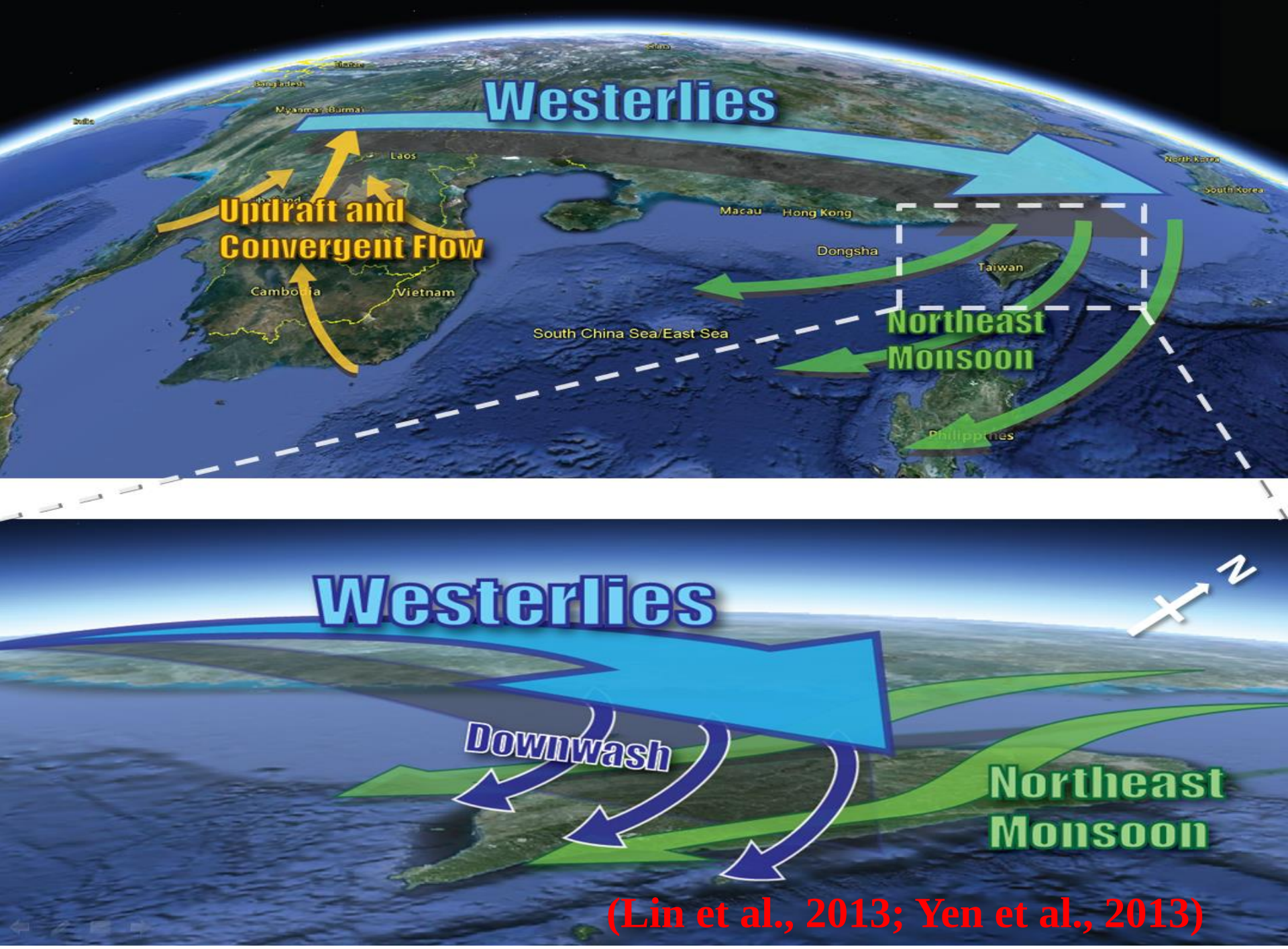
3/9-3/10 2010 Dongsha Experiment

3 km, horizontal



Cross-sectional transport



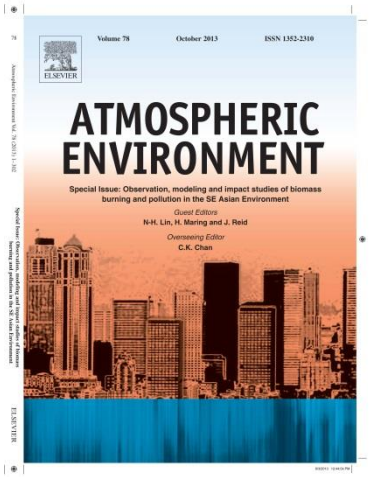


(Lin et al., 2013; Yen et al., 2013)

Atmospheric Environment

2013 Nov (78) special issue on:

"Observation, Modeling and Impact Studies of Biomass Burning and Pollution in the SE Asian Environment – From BASE-ASIA and Dongsha Experiment to 7-SEAS"



Guest Editors:

George Lin, NCU (nhlin@cc.ncu.edu.tw)

Hal Maring, NASA

Jeff Reid, NRL

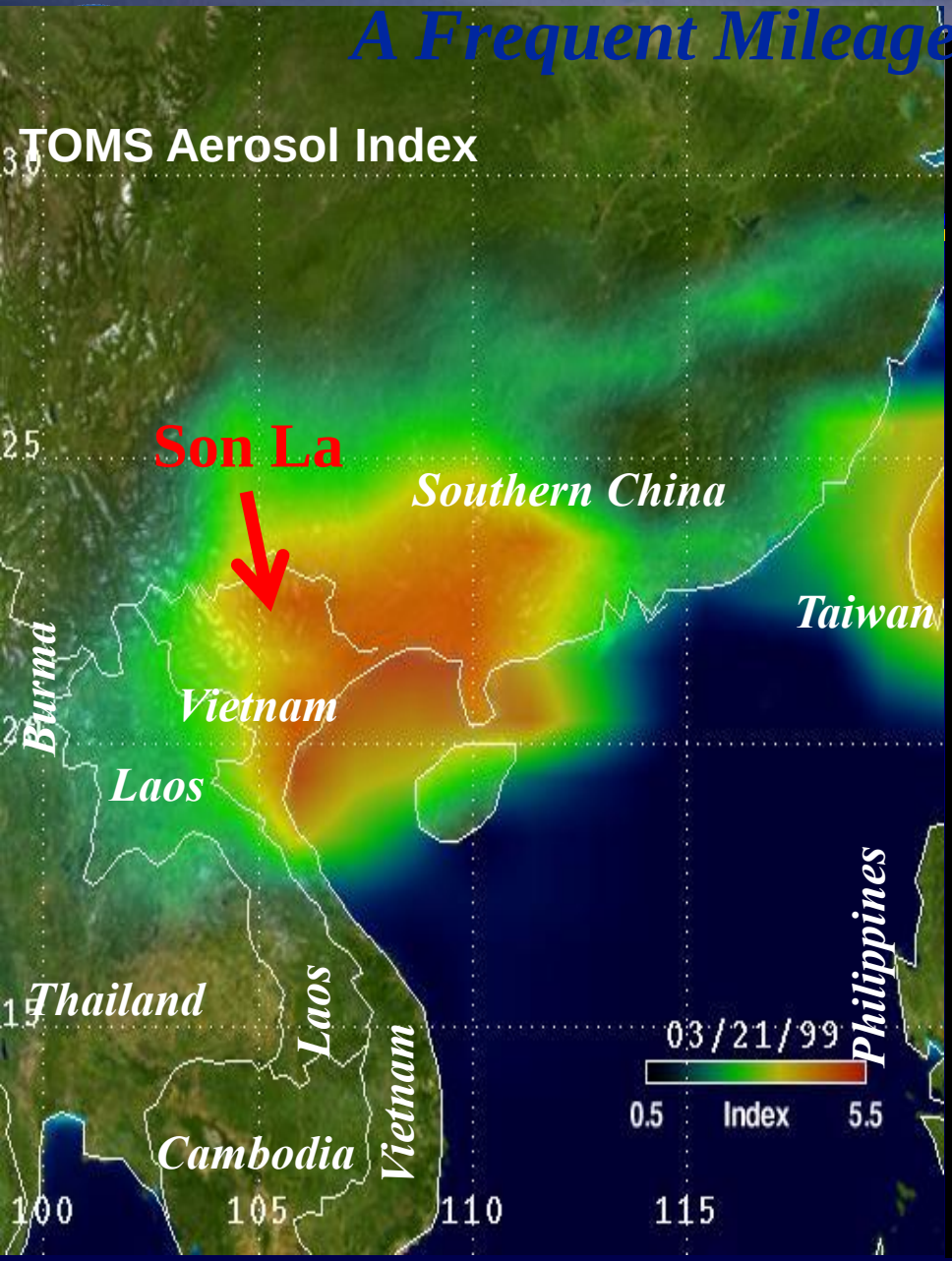
28 papers – overview, aerosols/gases/toxics, remote sensing, modeling and impact studies.

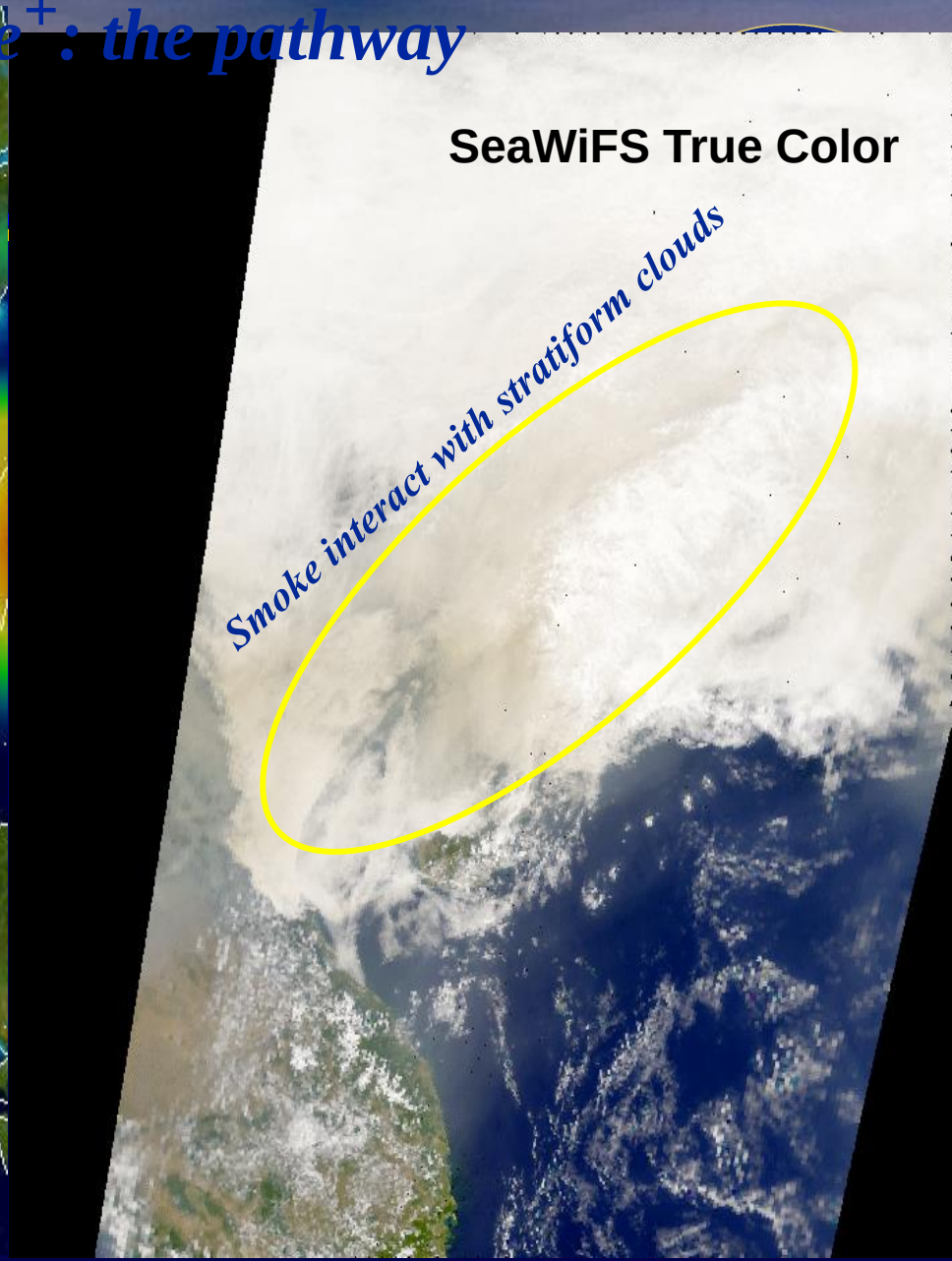
7-SEAS/Son La Experiments in northern Vietnam

- **2011 3/18-4/6: A pilot study of aerosol chemistry near biomass-burning source regions in northern Vietnam**

- **2012 3/13-4/9: Comprehensive *in-situ* and vertical profiling measurements**

A Frequent Mileage^{+} : the pathway





Event on 21 March 1999

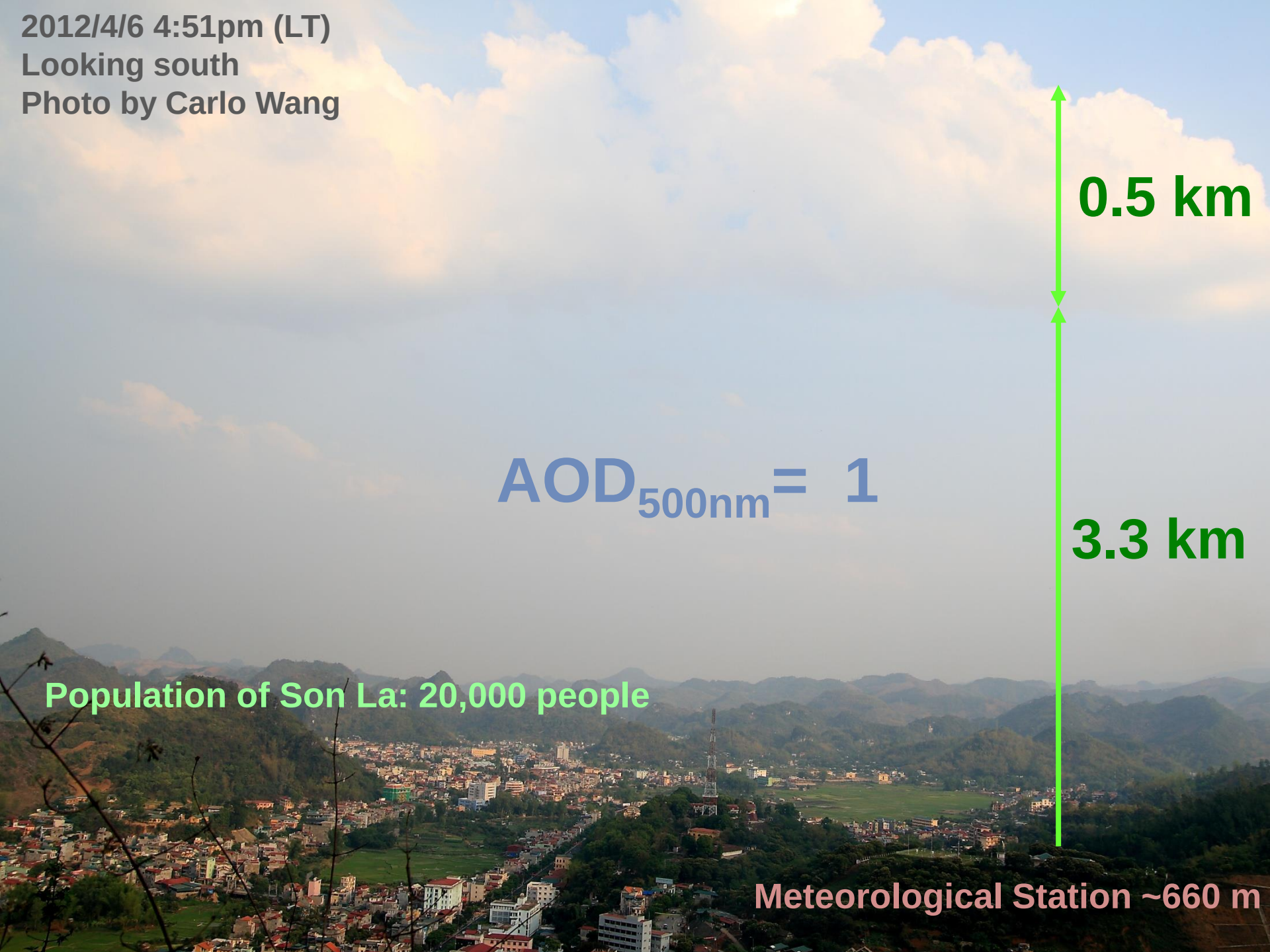
(Provided by Christina Hsu, NASA)

Son La, Vietnam

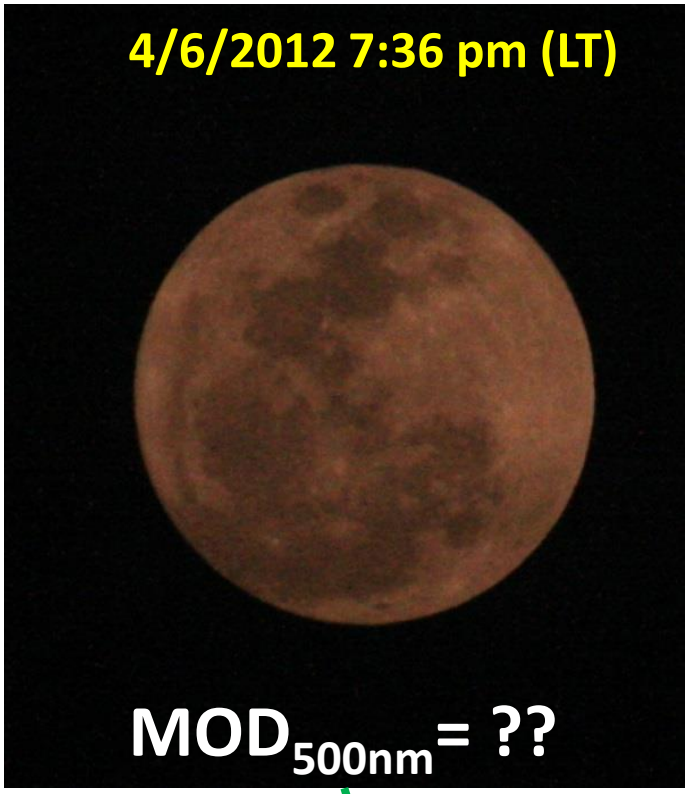
Samplers

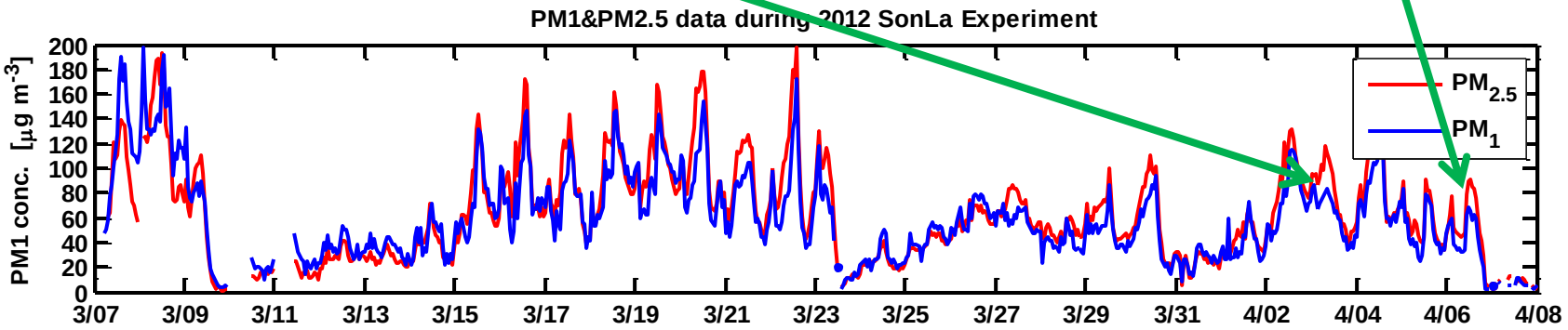
Lidar

NASA/COMMIT


2012/4/6 4:51pm (LT)
Looking south
Photo by Carlo Wang
0.5 km
AOD500nm= 1
3.3 km
Population of Son La: 20,000 people
Meteorological Station ~660 m

Son La, Vietnam (2012)



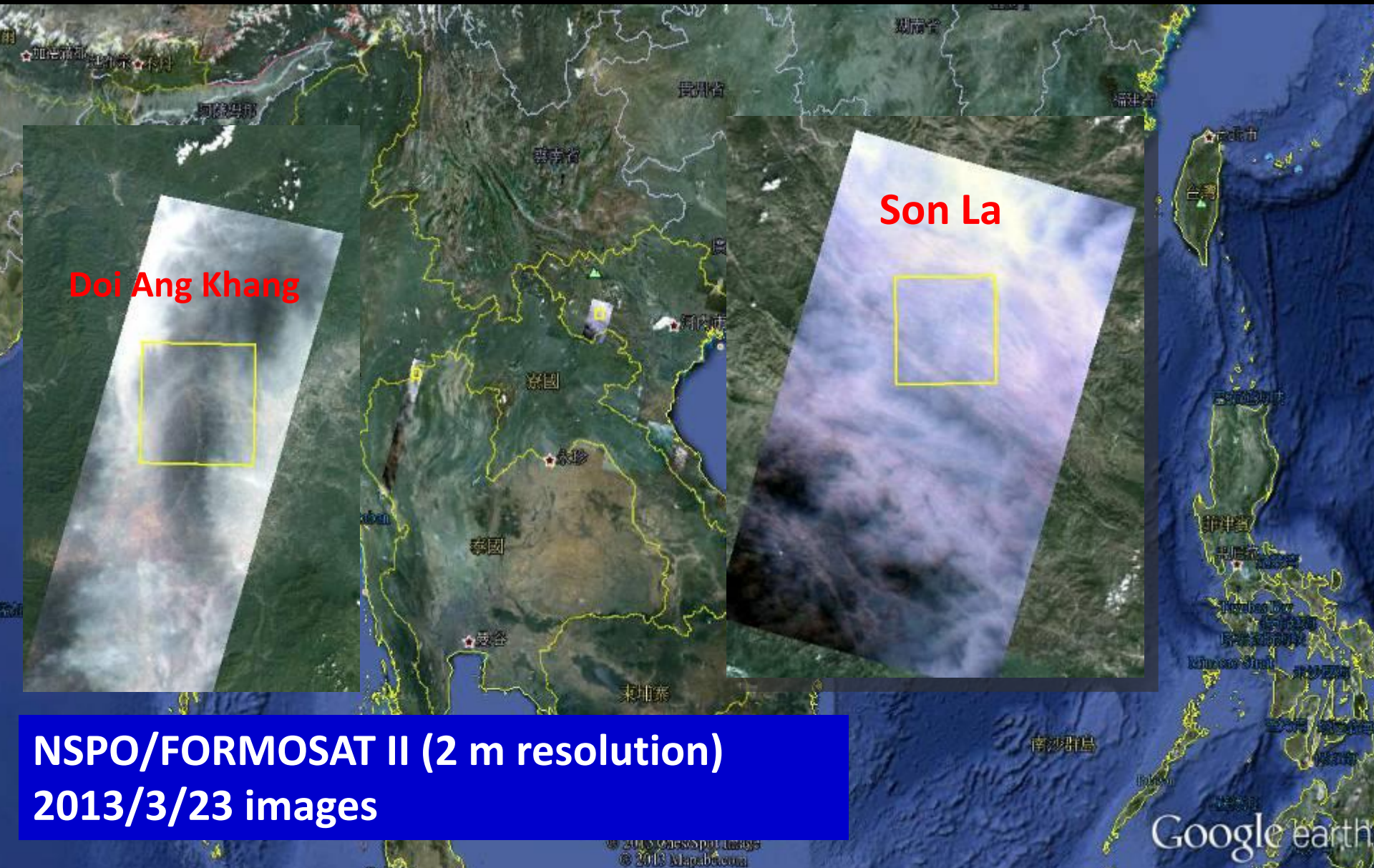


Phase II: 2013-2015 7-SEAS/BASELInE

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

- **Lifecycle of biomass-burning aerosols from source to receptor regions in springtime northern SE Asia**
- **Aerosol-cloud interaction**

7-SEAS/BASELInE spring campaigns



NSPO/FORMOSAT II (2 m resolution)
2013/3/23 images

Doi Ang Khang supersite (DAK)

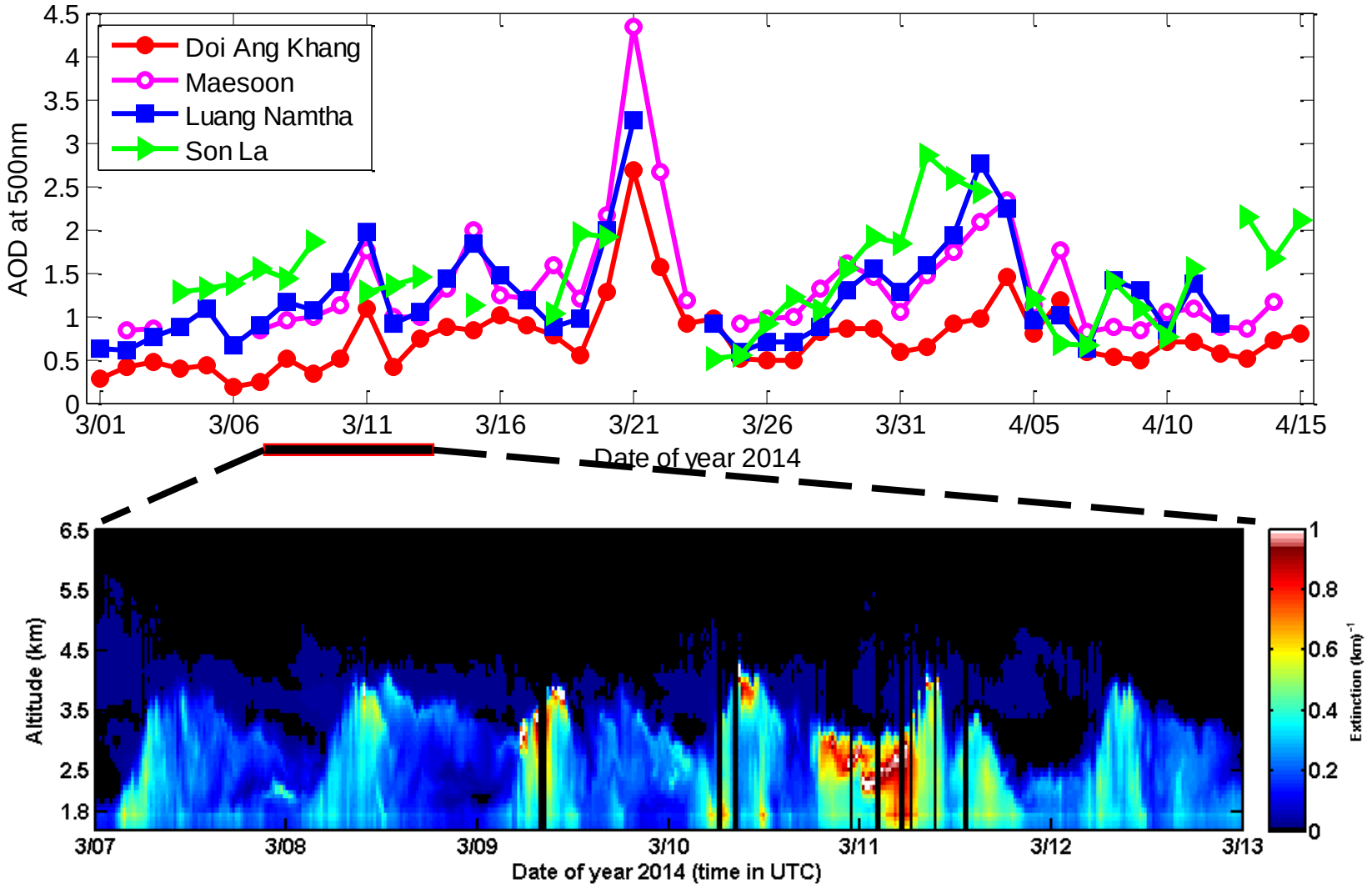
1,534 m MSL
northern Thailand

Radiation

Air quality and aerosol in-situ

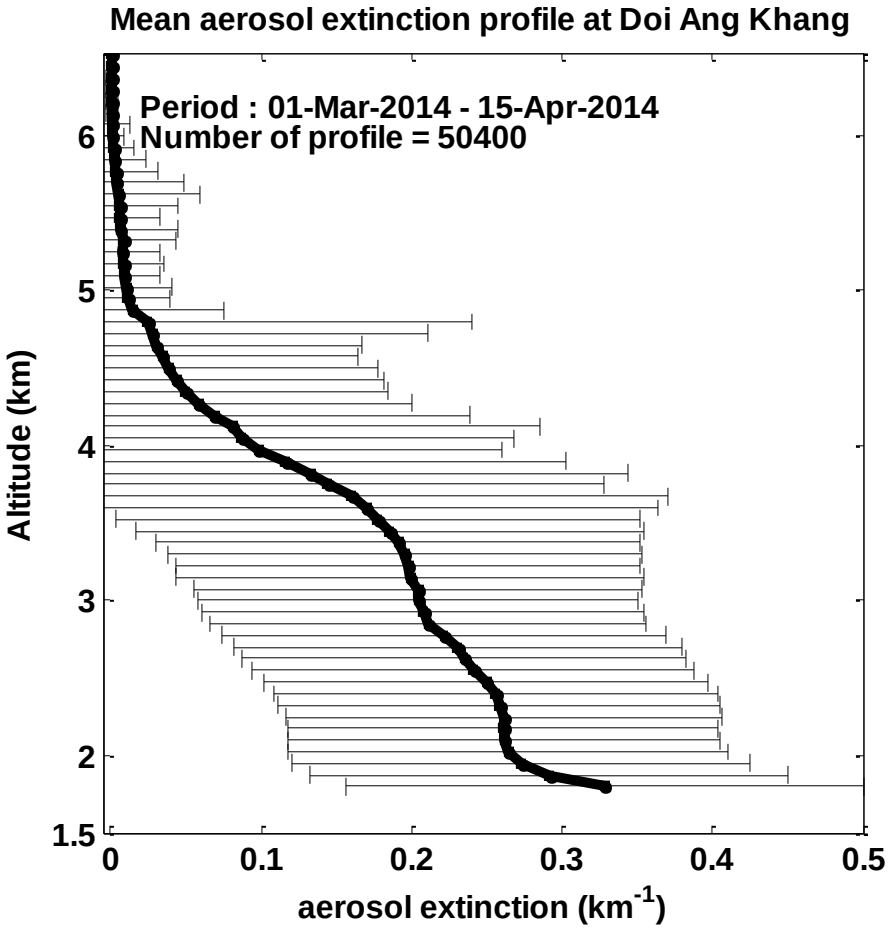
Chemistry sampling

Regional biomass-burning smoke haze

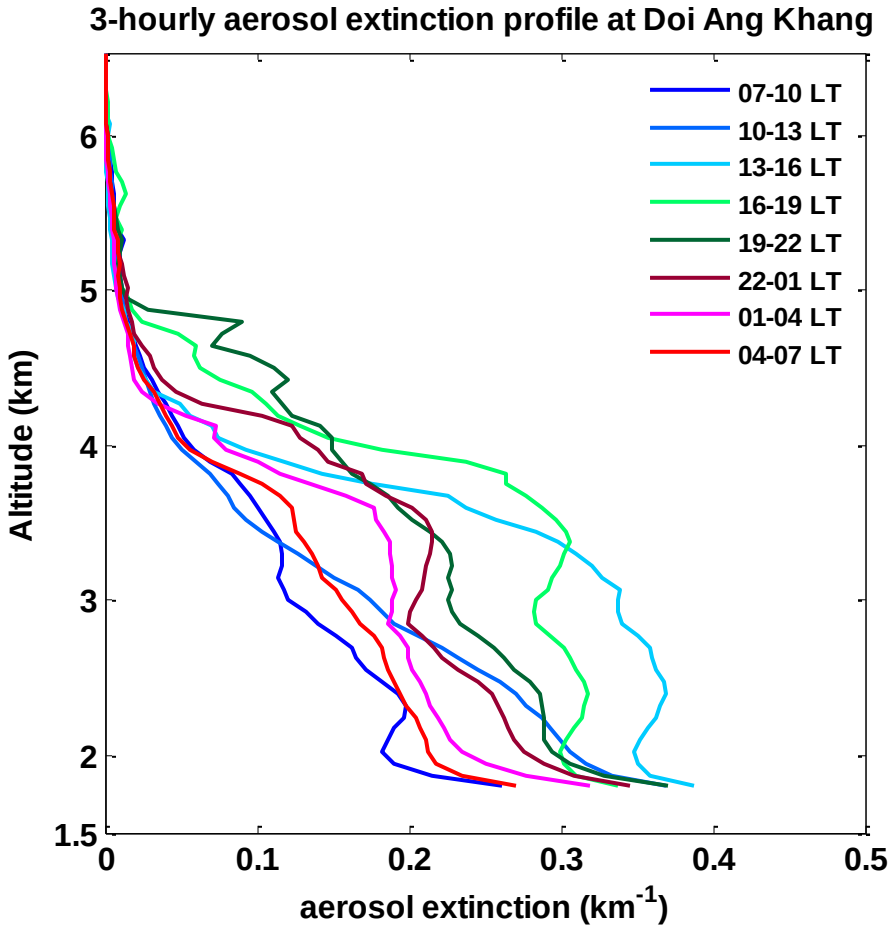


Aerosol extinction profiles at Doi Ang Khang (DAK) in spring 2014

(a) mean profile



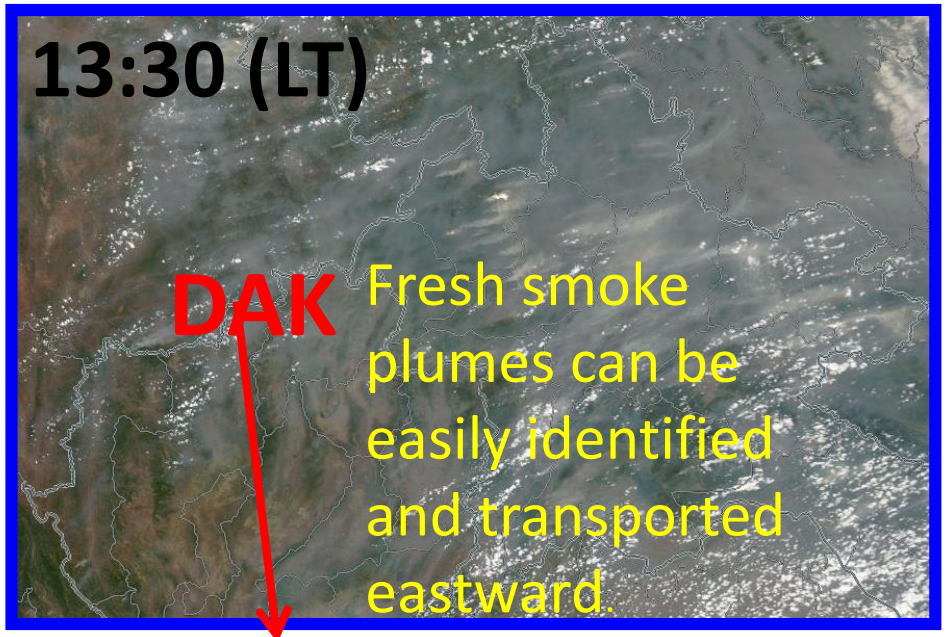
(b) 3-hourly mean profile



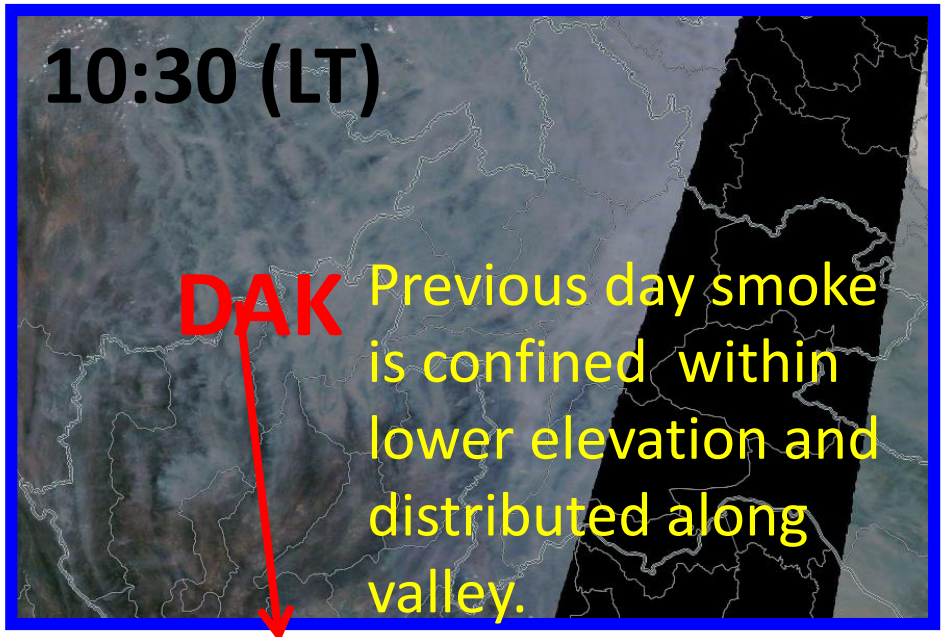
PBL development *plays a vital role on the distribution*

Fresh and aged smoke from MODIS imagery

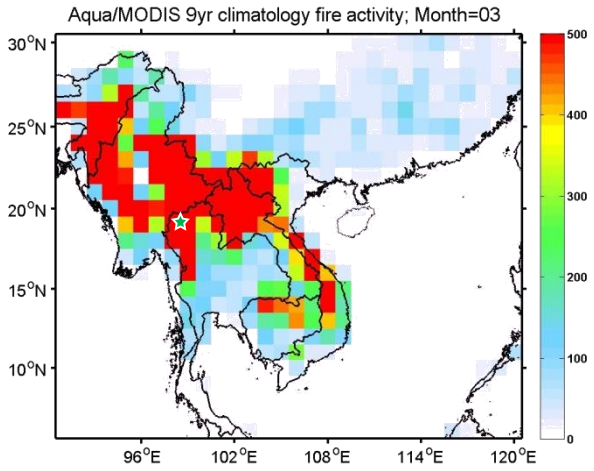
(a) 2014/3/30 Aqua true color image



(b) 2014/3/31 Terra true color image



Cloud Condensation Nuclei (CCN)



Biomass Burning ⇨ Potential Source as CCN ⇨ Characteristics of BB-CCN

- CCN – Cloud Condensation Nuclei
  Particles that can activate at a given supersaturation are definded as Cloud Condensation Nuclei for this supersaturation.
- CN – Condensation Nuclei
  Particle that form droplets at supersaturations (≥400%). (John H. Seinfeld, 1998)

$$\text{Activation Ratio} = \frac{N_{CCN}}{N_{CN}} \times 100\%$$

Aerosol micro-physical measurements at Doi Ang Khang

NCU instruments

- PSAP (Radiance Research, BC)
- SMPS (TSI 3936, 0.3 lpm, fine PSD)

- CCNC (DMT 100, 0.5 lpm, CCN conc.)

S.S.: 0.15%, 0.3%, 0.45%, 0.6%, 0.75%

$$\frac{N_{CCN}}{N_{CN}} \times 100\%$$

- CPC (TSI, 3010, 1.0 lpm, CN conc.)

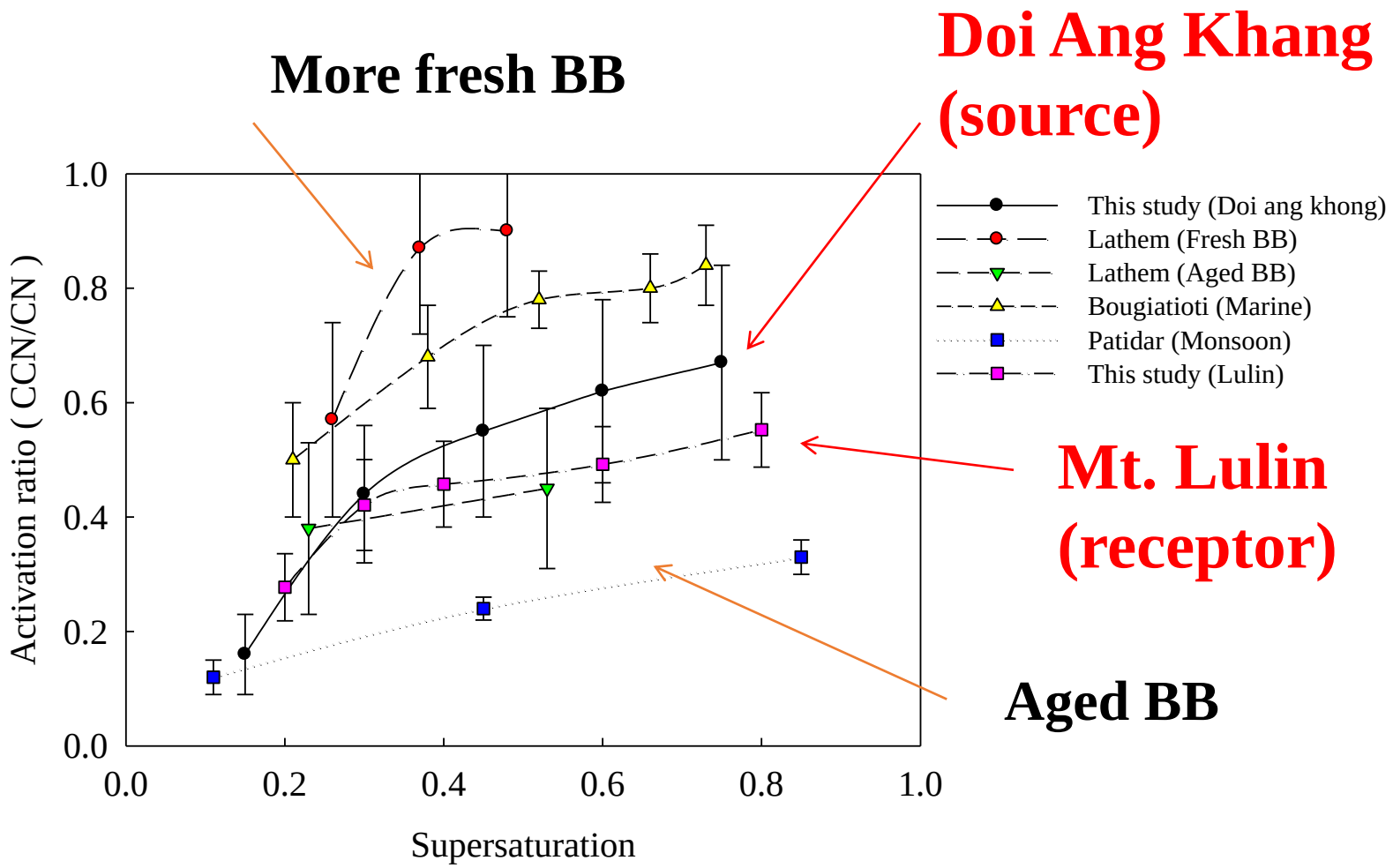
- Aerotrak (TSI 9000, 2.5 lpm, Alv. S.A. conc.)

- Aerosol Inlet
  - APS (TSI 3321, 5.0 lpm, course PSD)

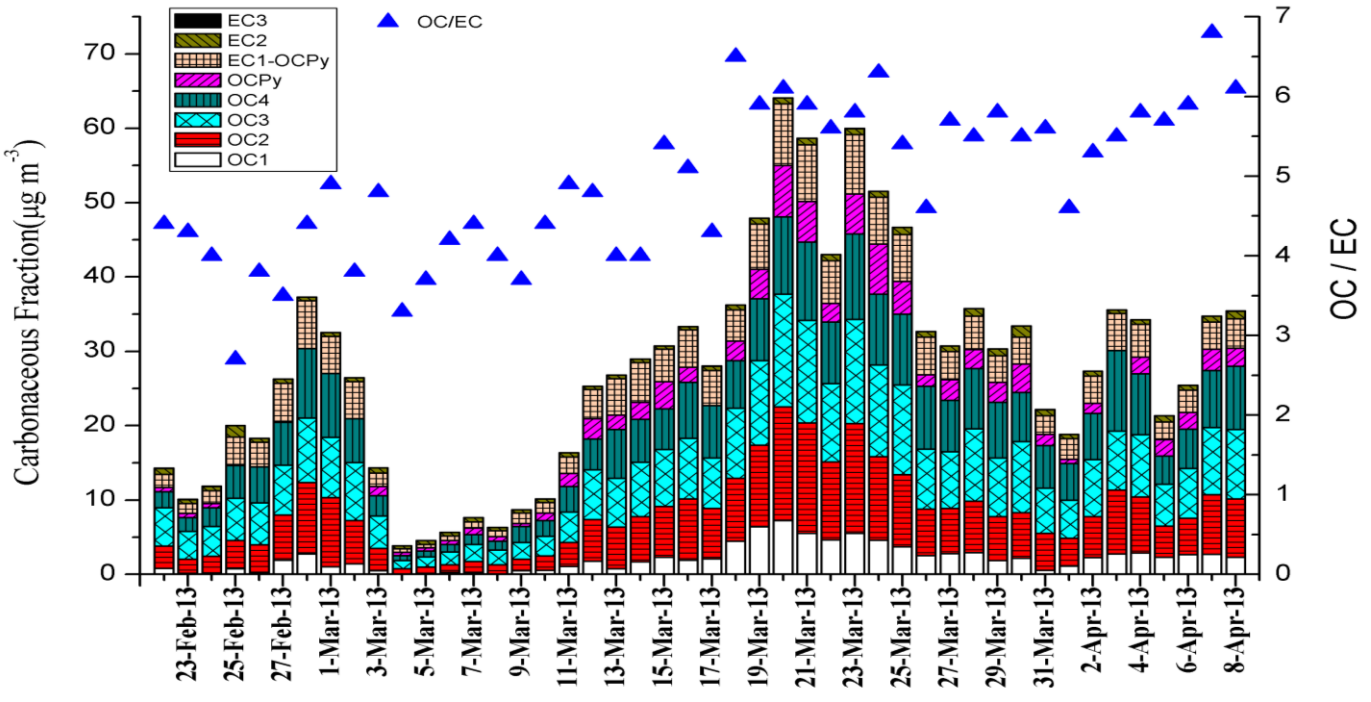
- Aerosol Inlet ($d_{p,a}$<2.5μm)
  - TEOM (RP 1400, 16.7 lpm, PM2.5 mass conc.)

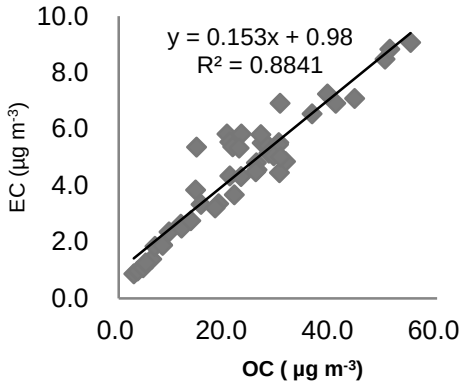
(TC Hsiao)

CCN Activation Ratio Summary



$PM_{2.5}$ – OC/EC at Doi Ang Khang





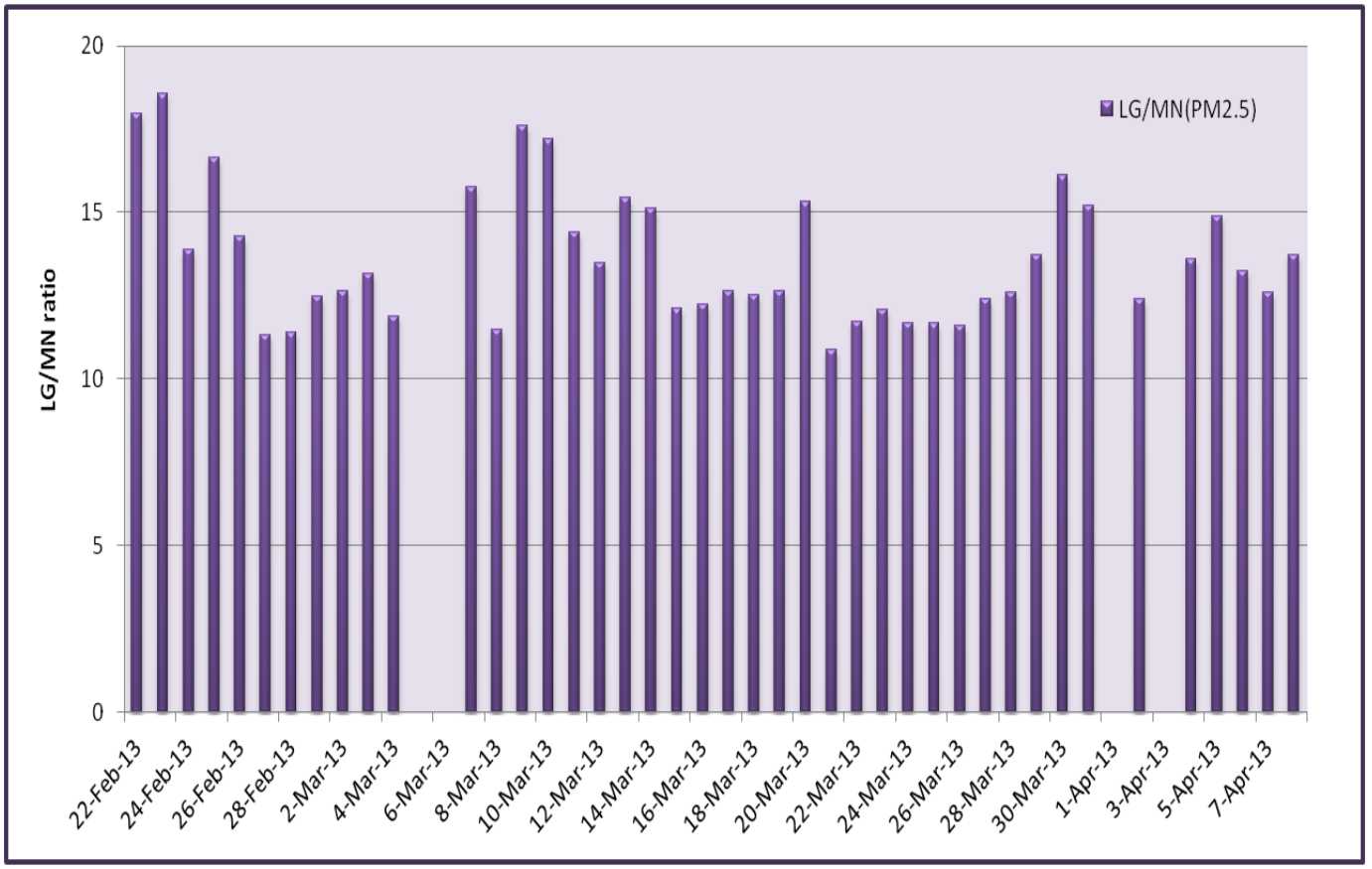
OC (μg m^{-3})	23.2 ± 12.9
EC (μg m^{-3})	4.5 ± 2.1
TC (μg m^{-3})	27.7 ± 14.9
OC/EC	**4.9 ± 0.9**

- **OC/EC can be used to identify sources** (Chow et al., 2004; Cao et al., 2005), for instance, 1.1 for mobile source and 2.7 for coal burning (Watson et al., 2001), **5.1 for forest fire** in (Pio et al., 2008).
- OC and EC are highly correlated with R^2=0.88.

(Provided by CT Lee)

Ambient Aerosol Composition

Anhydrosugar Ratios at Doi Ang Khang



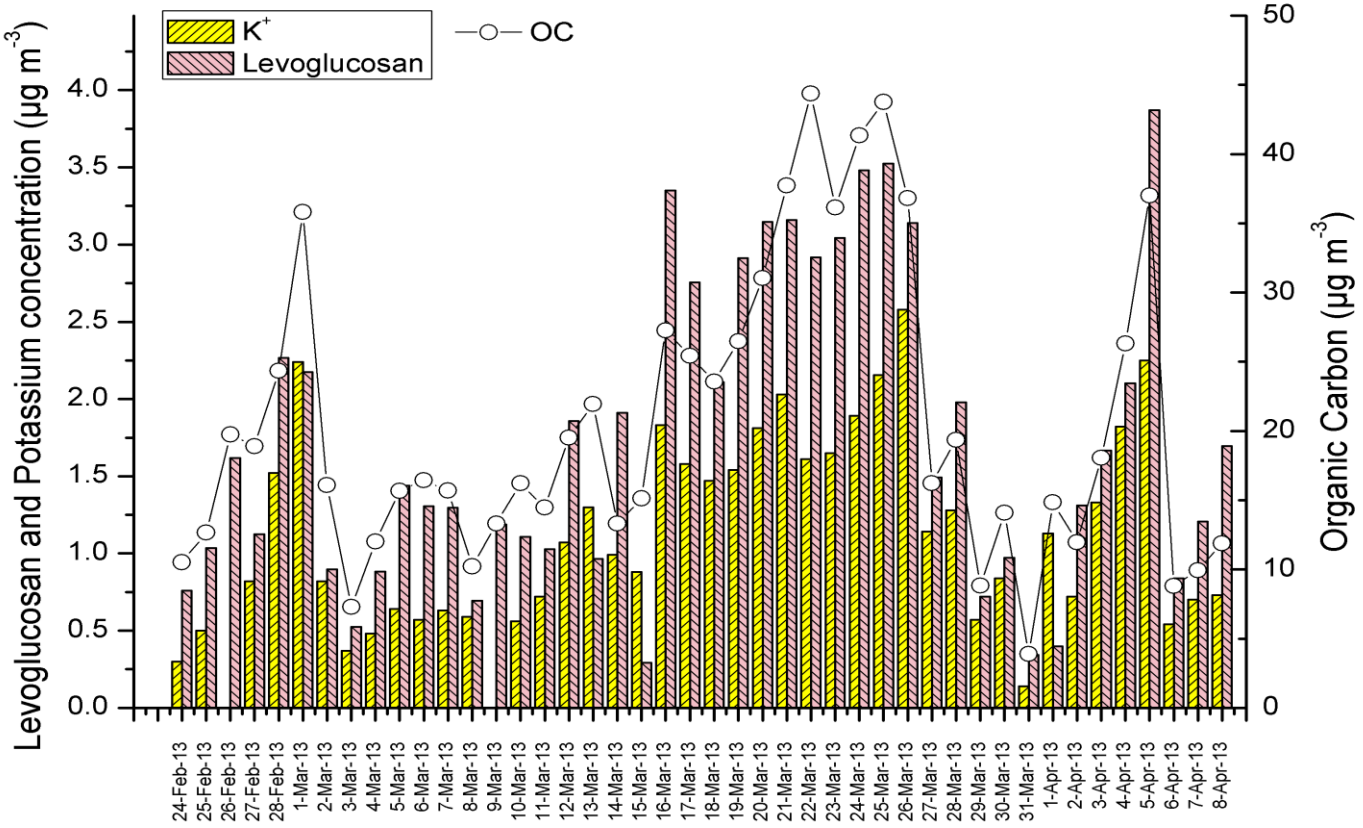
- Consistent levoglucosan/mannosan **(LG/MN) ratio (~15)**

→ **Mixed types of biomass fuel, including**

agricultural residues and hard wood (G. Engling)

Molecular Tracer Measurement

Biomass Burning Tracer Concentrations at Son La, 2013

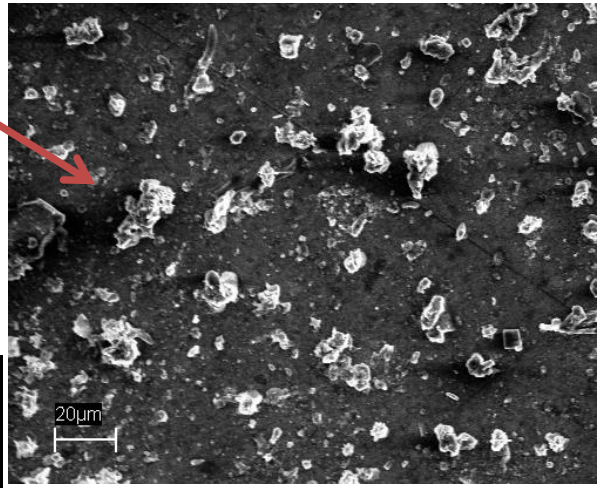


K^+/levoglucosan ratio: average at 0.77±0.54 in 2013.

Low ratios indicate smoldering burning phase was predominant.

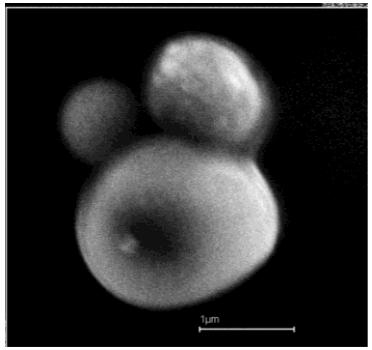
STRUCTURE of SMOKE

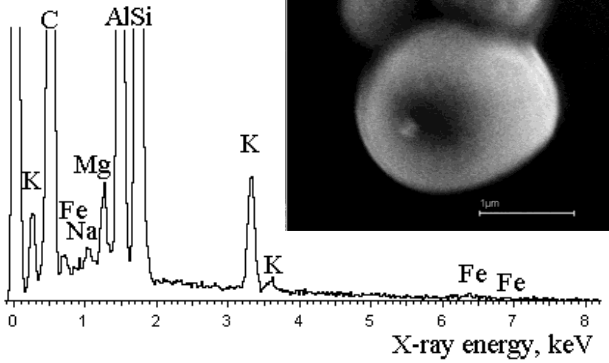
SEM/EDX INDIVIDUAL PARTICLE ANALYSIS



Olga

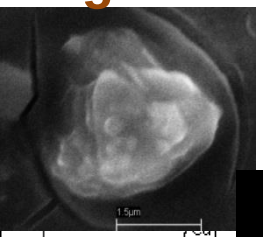
Dust/Soil



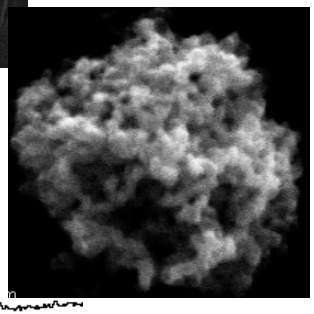


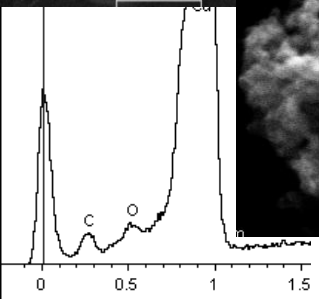
aluminum silicates mixed with K, Fe

Organic/tar



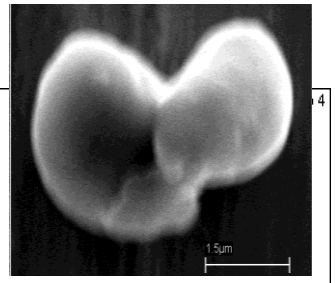
soot

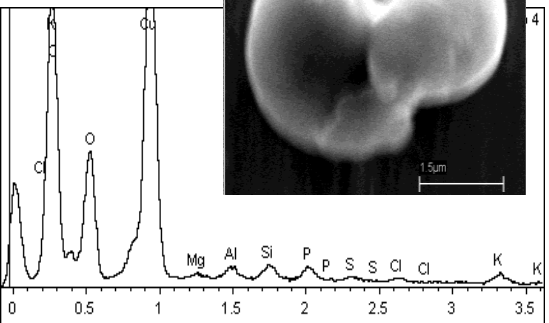




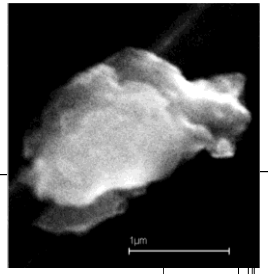
Fly Ash

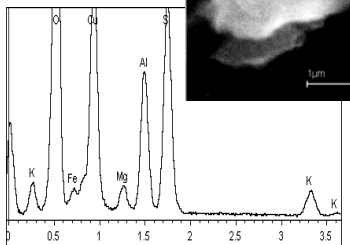
K chlorides



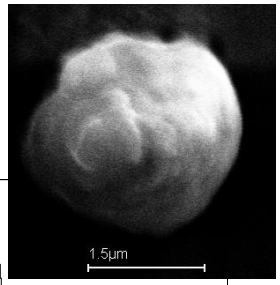


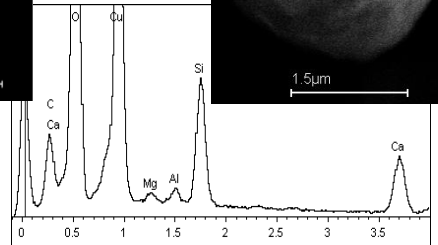
Fe - rich



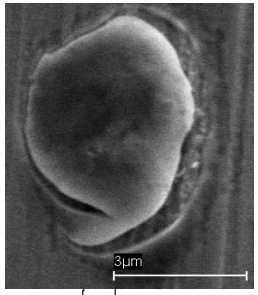


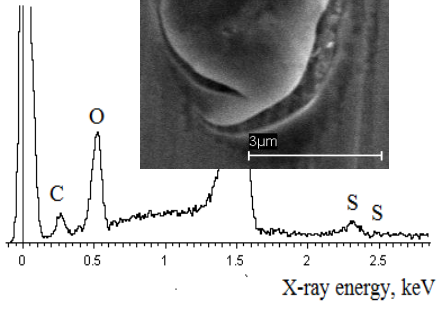
Ca - rich





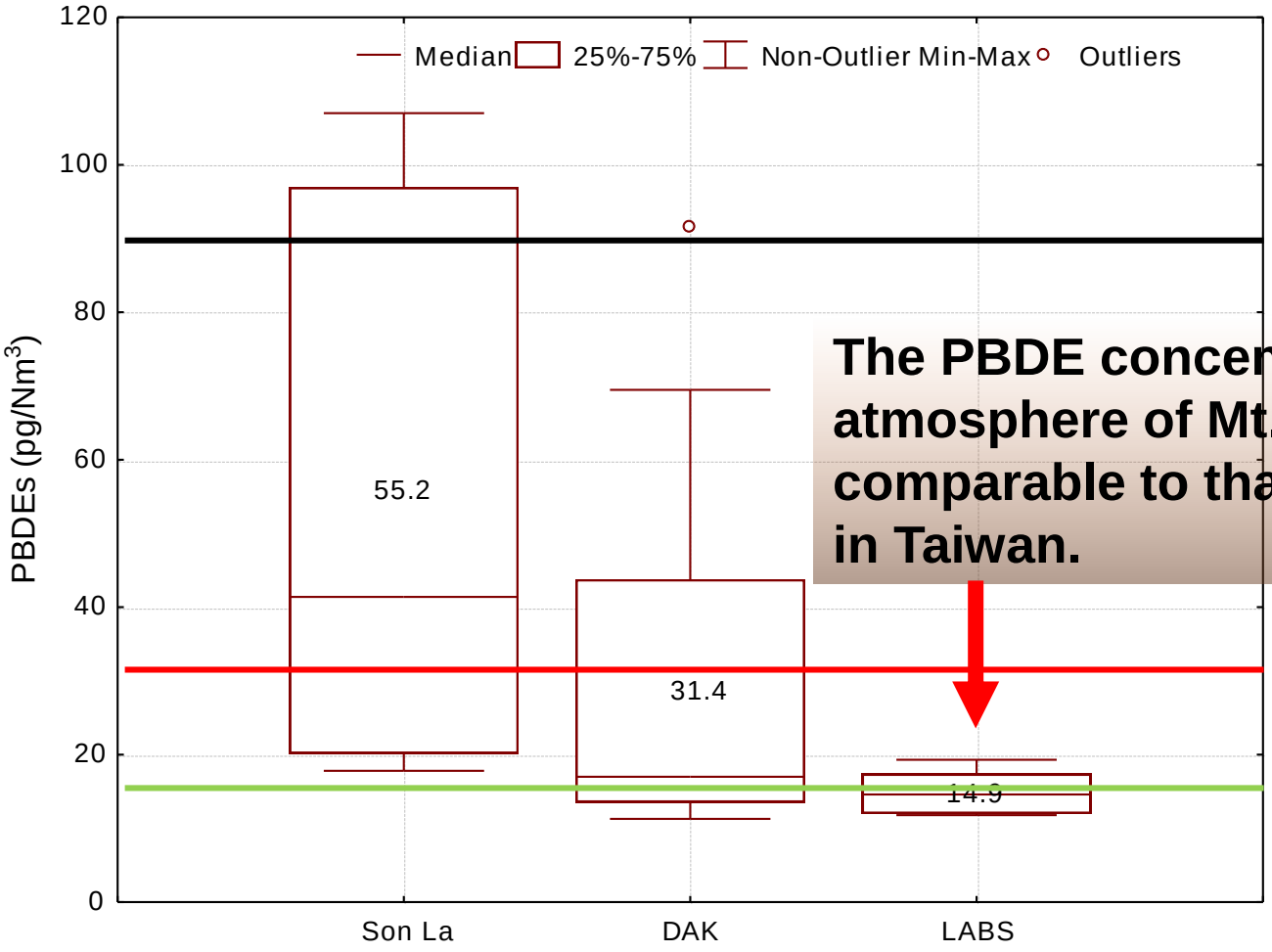
Sulfates





Dioxins measurements

2013 7-SEAS/BASELInE



Metals Complex Areas
90.7 pg/Nm^3

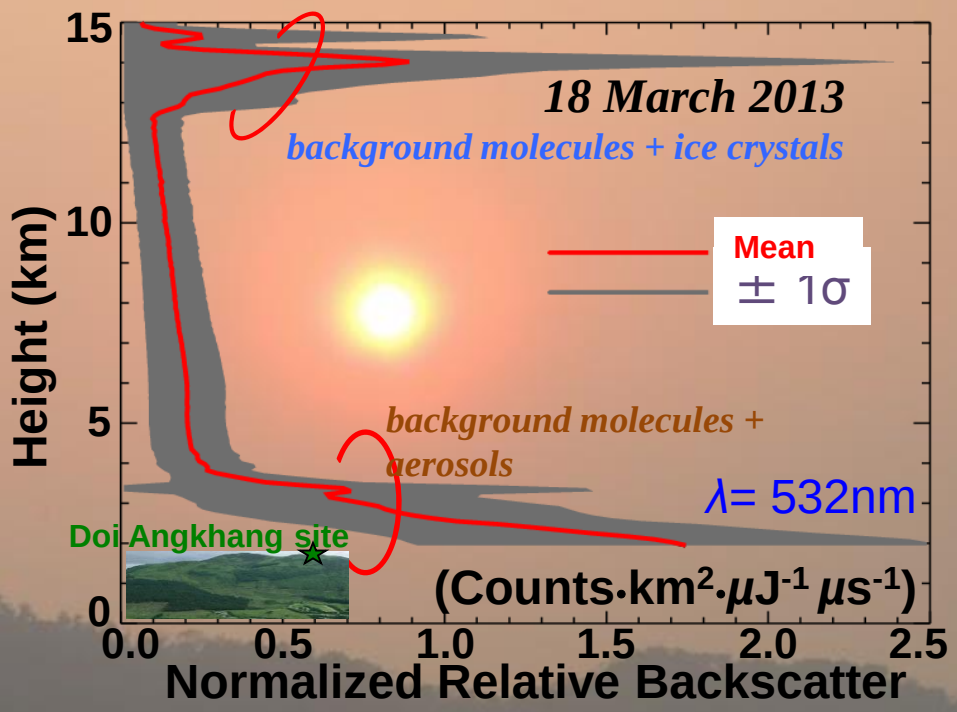
The PBDE concentrations in the atmosphere of Mt. Lulin were comparable to that of the Rural Area in Taiwan.

Urban Areas
31.7 pg/Nm^3

Rural Areas
15.9 pg/Nm^3

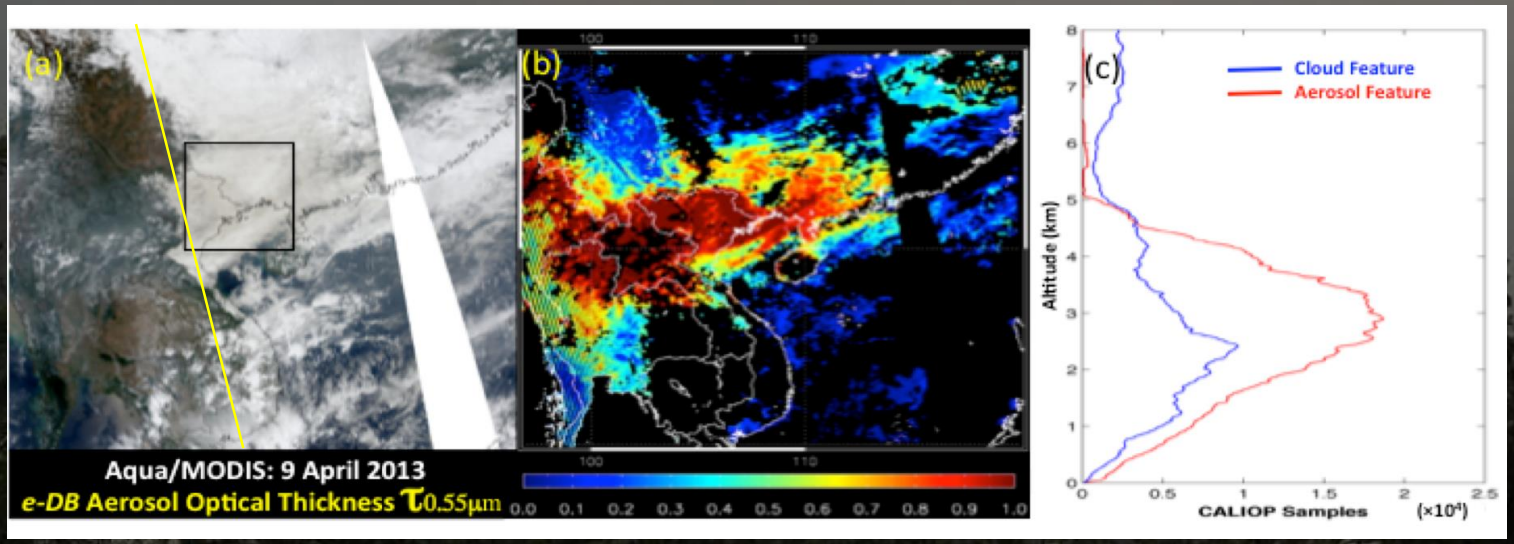
(LC Wang)

Biomass-burning
Aerosols &
Stratocumulus
Environment:
Lifecycles &
Interactions
Experiment



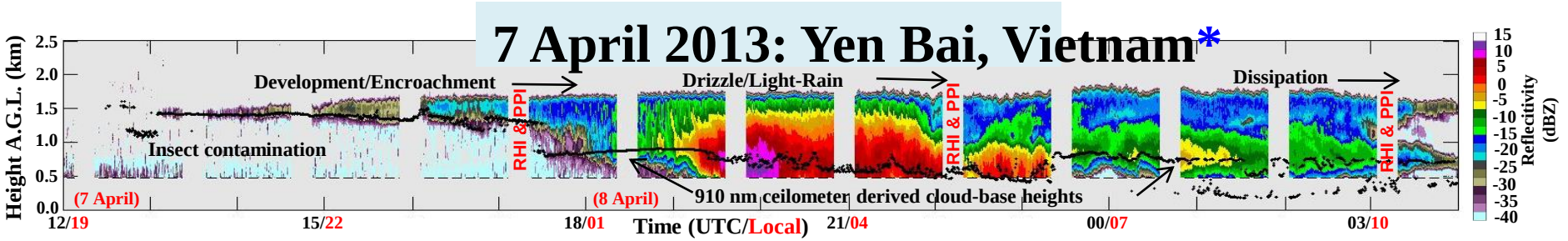
BASELInE: Overview and Follow-on

NASA:
Taiwan:
Thailand:
Vietnam:



Physical processes of aerosol-cloud interaction:

- *Climatologically important cloud formation and precipitation regime*
- *Clouds embedded in a heavy aerosol laden environment*
- *High vertical-temporal resolution radar/lidar measurements*



- ✓ *Permit better understanding of the cloud system lifecycle*
- ✓ *Simulate well the initial coupling of the aerosol and cloud layer*
- ✓ *Aid in estimations of precipitation on aerosol washout effect*

- ➢ ***Require efficient yet critical in-situ profiling (e.g., UAVs) of the boundary layer for validating remote sensing/retrievals and for initializing regional transport/chemical and cloud ensemble models***
- ➢ ***Ongoing project to improve assessment of aerosol-cloud interactions***

**Loftus, et al., 2016, AAQR, doi:10.4209/aaqr.2015.11.0631.*

Aerosol and Air Quality Research

2nd special issue on:

"Aerosol Impact on Physical, Chemical and Biological Processes in Southeast Asia and the Maritime Continent"

Guest Editors:

James Campbell, NRL

Guey-Rong Sheu, NCU

Somporn Chantara, CMU

To be published in Jan 2017

~27 papers in press

7-SEAS/BASELInE Data Products

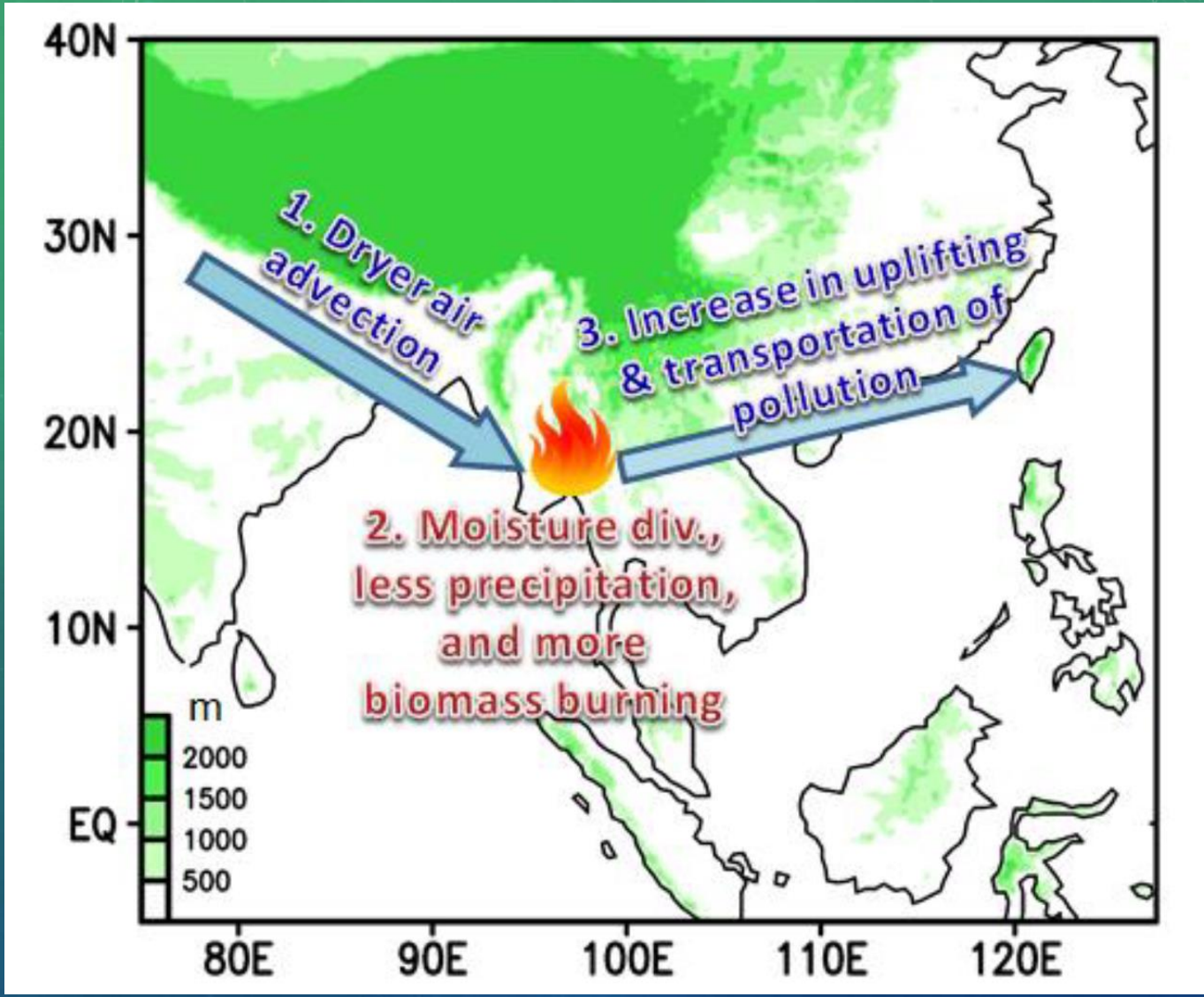
SMARTLabs/AERONET/MPLNET	Regional Instrumentation
Trace Gas – Column: O_3, NO_2, SO_2, HCHO, CO, H_2O; – ***Surface***: CO, CO_2, O_3, SO_2, NO, NOx/NOy; – ***Profile***: NO_2, (O_3 in progress)	***Organic Carbon*** (OC): OC_1 (120°C), OC_2 (280°C), OC_3 (480°C), OC_4 (580°C), OP (pyrolyzed organic carbon, e.g., anhydrosugars, dicarboxylic acids)
Aerosol Optical Thickness: multi-spectral from UV to shortwave-IR, dust at longwave-IR, and extinction profile	***Elemental Carbon*** (EC): EC_1 (580°C – OP), EC_2 (740°C), EC_3 (840°C)
Aerosol Microphysics/Chemistry: size, mass, type, CCN, hygroscopicity, scattering/absorption/extinction	***Water soluble ions***: Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-}, nss-SO_4^{2-}, NO^{2-}, F^-
Cloud Optical Thickness: multi-spectral from visible to longwave-IR	***Toxic***: Mercury, PCDD/Fs (dioxin)
Cloud Microphysics: size, liquid-/ice-water content, cloud-base/top/height, thermodynamic phase, Doppler fall-velocity, depolarization and reflectivity profiles	***Metal***: Ti, Mn, Co, Ni, Cu, Zn, Mo, Ag, Cd, Sn, Sb, Tl, Pb, V, Cr, As, Y, Se, Zr, Nb, Ge, Rb, Cs, Ga, La, Ce, Pr, Nd, Sm, Eu, Gd
Radiation Flux: surface solar and terrestrial irradiance	***UV radiation:*** spectral UV (erythemal) irradiance
Meteorology: P, T, RH, wind, mixed-layer height, precipitation, visibility	***Supplementary data***: sounding profile, sky image, particle spectroscopy/morphology, rainfall amount

Summary

- **BB aerosol chemical, microphysical and radiative properties over Indochina region have been first characterized.**
- **Transport pattern of BB plumes from Indochina region is described and verified by in-situ measurements.**
- **BB types in our sites nearby source region are identified.**
- **More to be studied…**

7-SEAS Phase III for N. Region

- 2016-2018
- Data analysis and modeling
- Regional network for long-term studies
- Incorporation with 2018 NASA flight missions of SW monsoon studies in SE Asia



Schematic diagram for illustrating how an intensified India-Burma Trough modulates the occurrence of biomass burning in northern Indochina and its downwind impact on Taiwan **(Huang et al., 2016 JGR).**

Summary of sites and measurements in 2016

Taiwan - receptor

Sites	Aerosol chemistry	Aerosol in situ	Trace gases	Cimel	MPL
Mt. Lulin	PAHs, Ions, Metals, EC/OC	mass, size, optics	CO, O_3,…	V	
Alishan				V	V
Chaiyi				V	
NCU				V	V

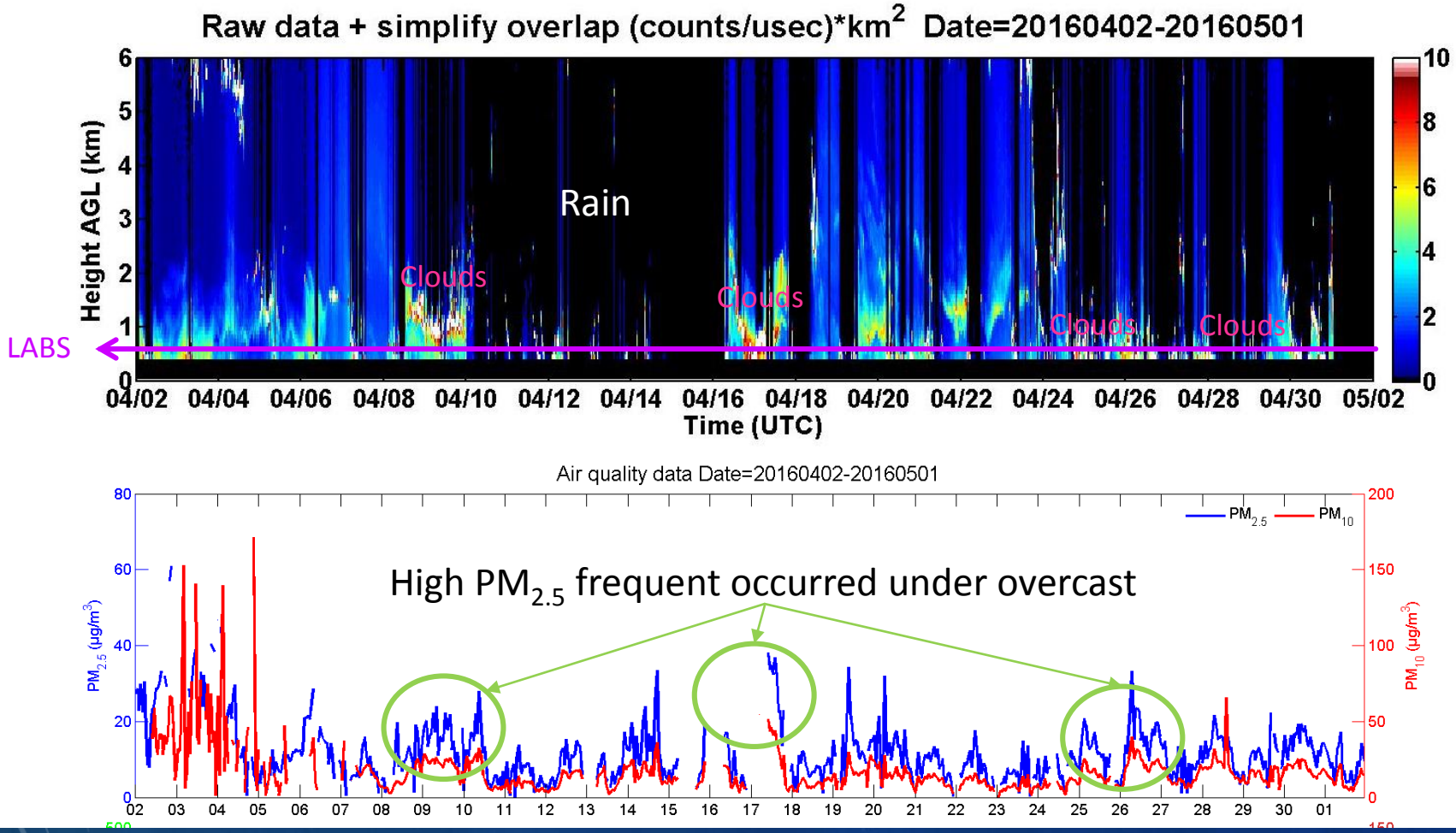
Thailand - source

Sites	Aerosol chemistry	Aerosol in situ	Trace gases	Cimel	MPL
CMU	PAHs, Ions, Metals, EC/OC	mass, optics			
Chiang Mai Met station				V	
Omkoi				V	V

Aerosol vertical distribution and transports

Experiment	Period
Yushan experiment	2013 Aug. – 2014 Aug.
Douliu experiment	2015 Sep. – 2015 Oct.
Alishan experiment	2016 Apr. – 2016 May

Lidar profiles from Alishan (2416m) in 2016



According to lidar signal, the BB plume can reach to as high as 4.5 km a.s.l

Aerosol Sampling Site (CMU)

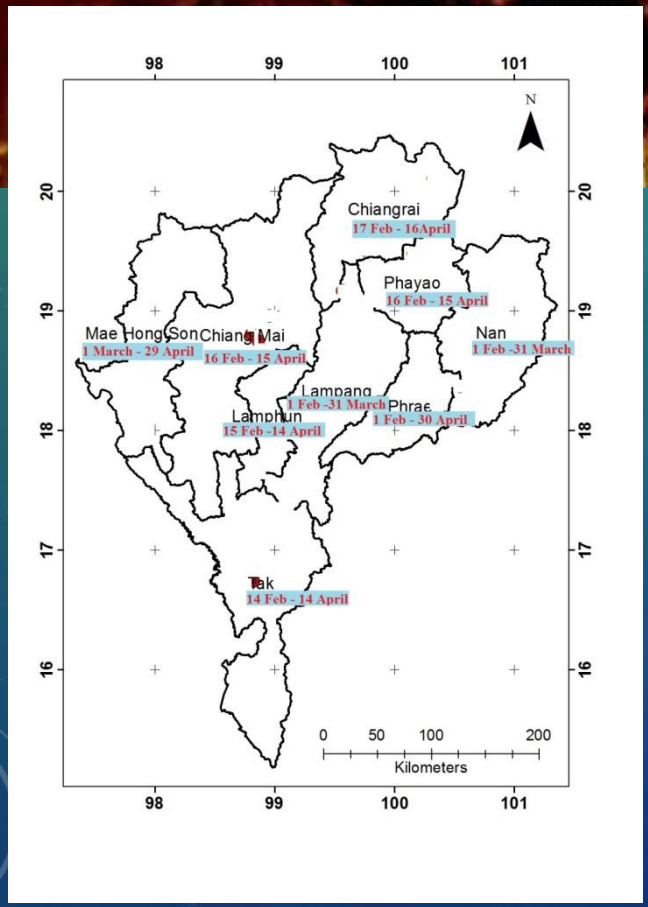
การป้องกันและแก้ไขปัญหาหมอกควันภาคเหนือ

60 วัน ห้ามเผา

กุมภาพันธ์ - เมษายน

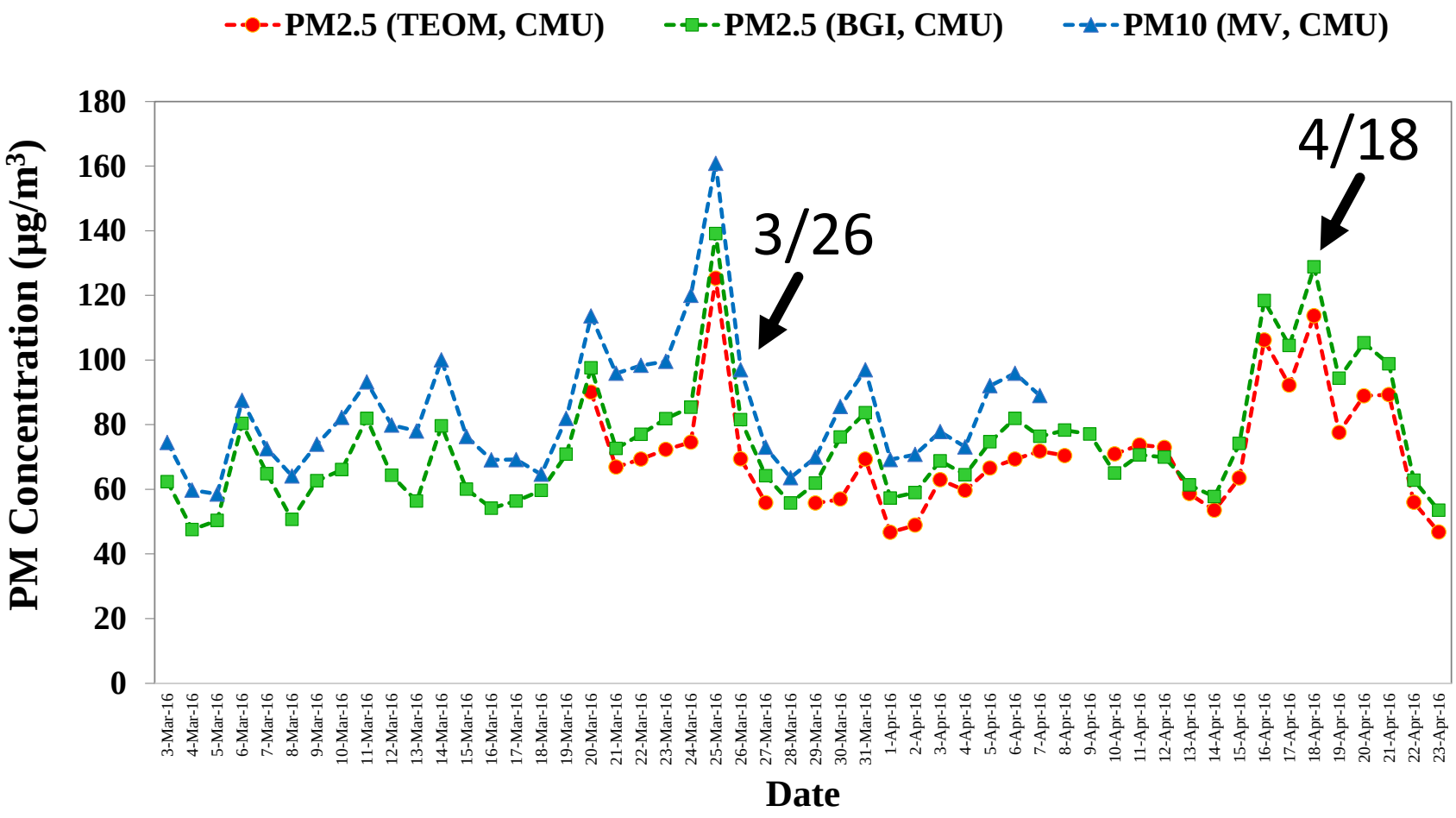
ห้ามเผาป่า ห้ามเผาใบไม้ ห้ามเผาไร่นา
ฝ่าฝืนมีโทษ ทั้งจำคุกและโทษปรับ

ห้ามเผา



Province	Feb	March	April
Chiang Rai	← 17 Feb – 16 April →		
Chiang Mai	← 16 Feb – 15 April →		
Lamphun	← 15 Feb – 14 April →		
Lampang	← 1Feb – 31 March →		
Phrae	← 1Feb – 30 April →		
Nan	← 1Feb – 31 March →		
Phayao	← 16 Feb – 15 April →		
Mae Hong Son		← 1 March – 29 April →	
Tak	← 14 Feb – 14 April →		

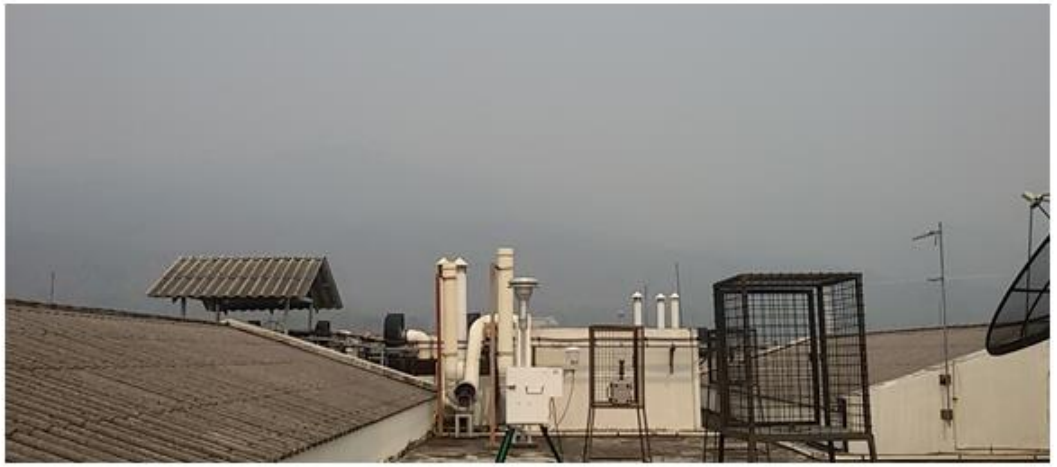
Daily Average of PM concentrations



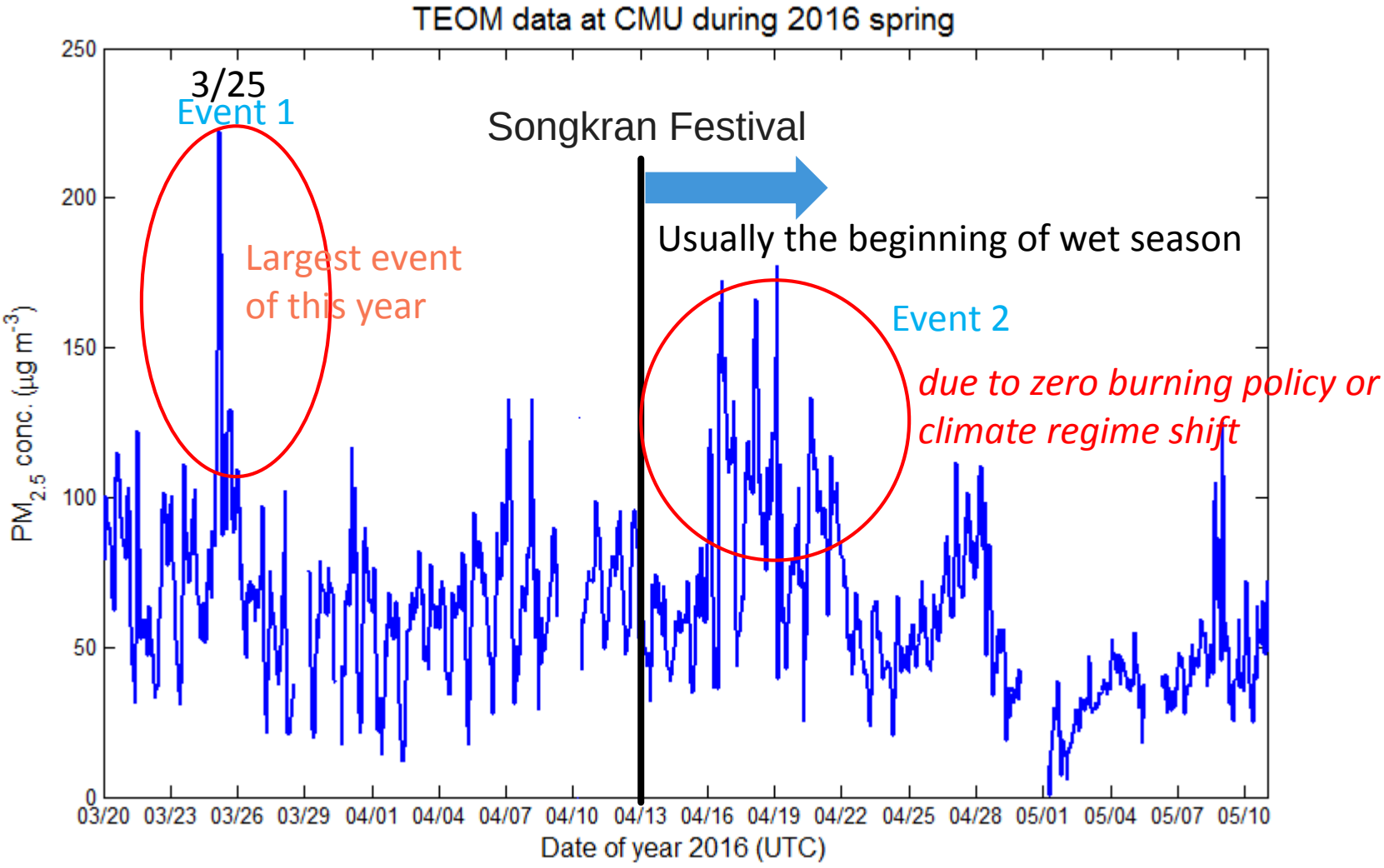
Clear sky, rainy season

$PM_{2.5}$ 80 μg/m^3
26 March, 2016 (3:30 UTC)

$PM_{2.5}$ 150 μg/m^3
18 April, 2016 (3:30 UTC)

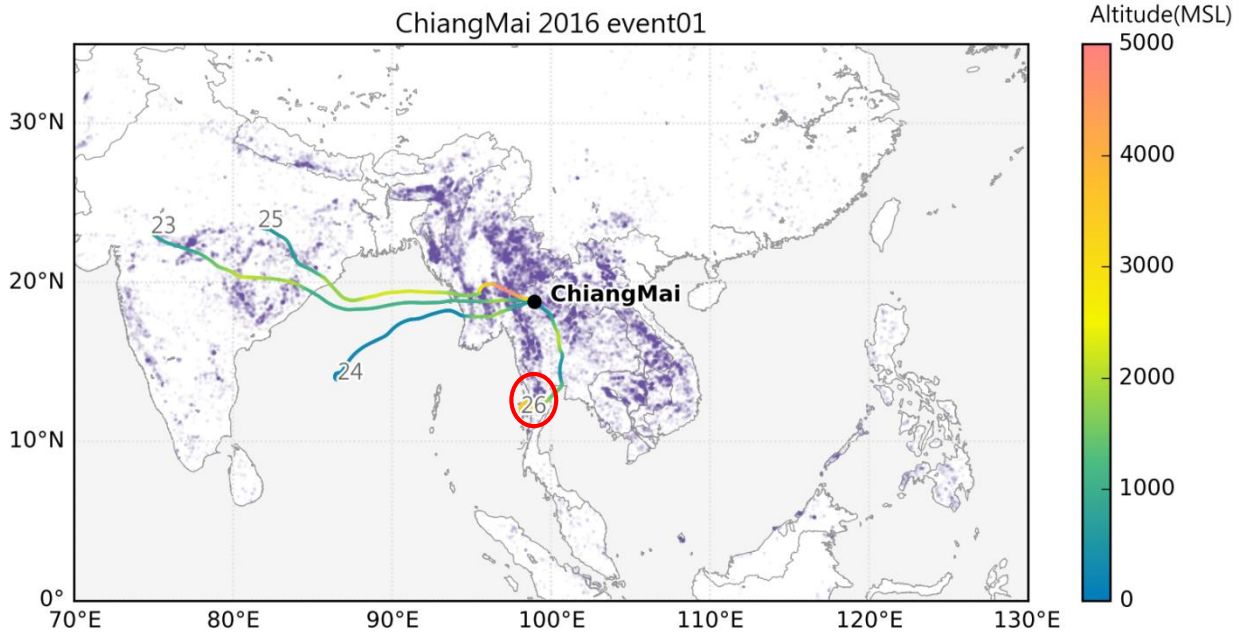


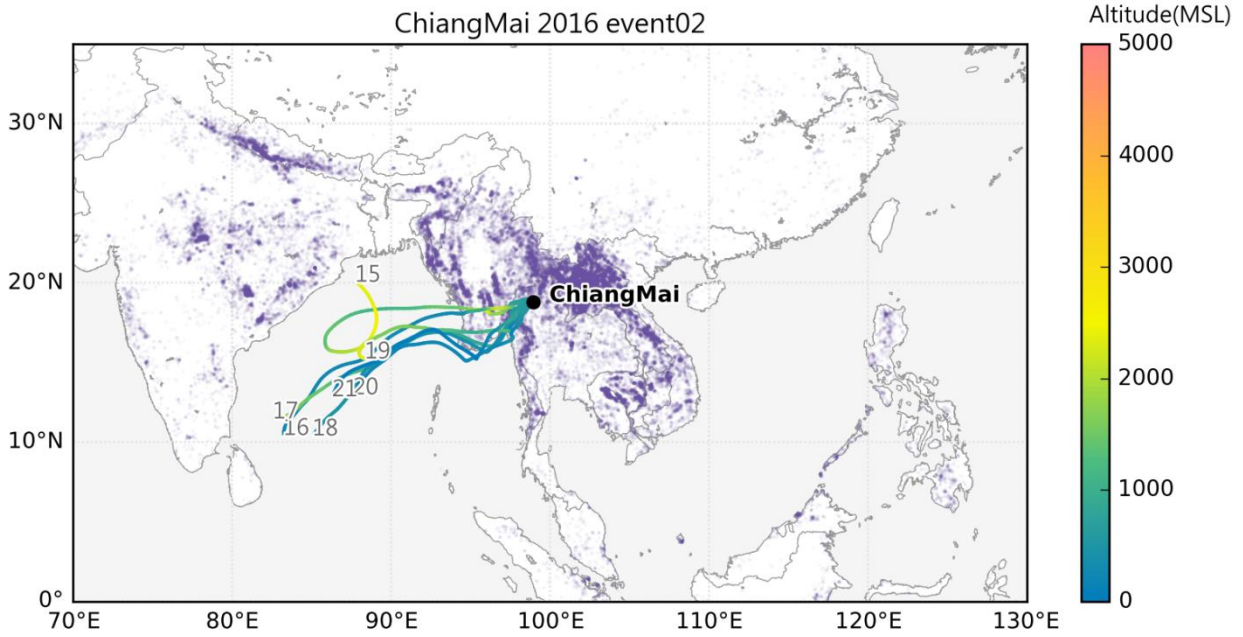
Hourly PM2.5 concentration at CMU during 2016



Event 1:
3/23-3/26

Event 2:
4/15-4/21

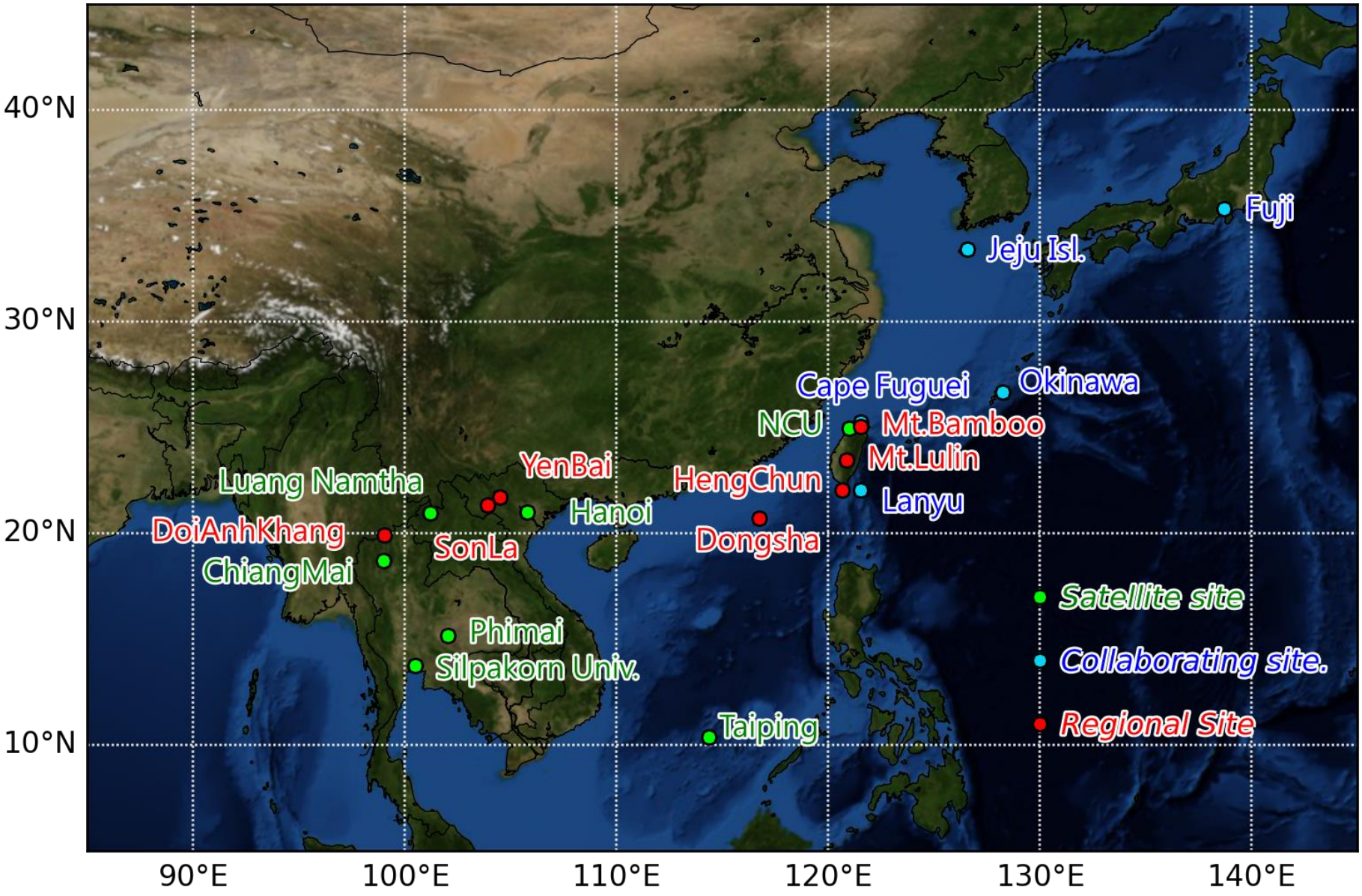




Cloud-Aerosol-Monsoon Philippines Experiment (CAMPEx)

The purpose of this mission is to investigate the role of anthropogenic and natural aerosol emissions in modulating the frequency and amount of precipitation in the Philippines during the southwest monsoon.

Regional networks for ACP studies in SEA and EA



34

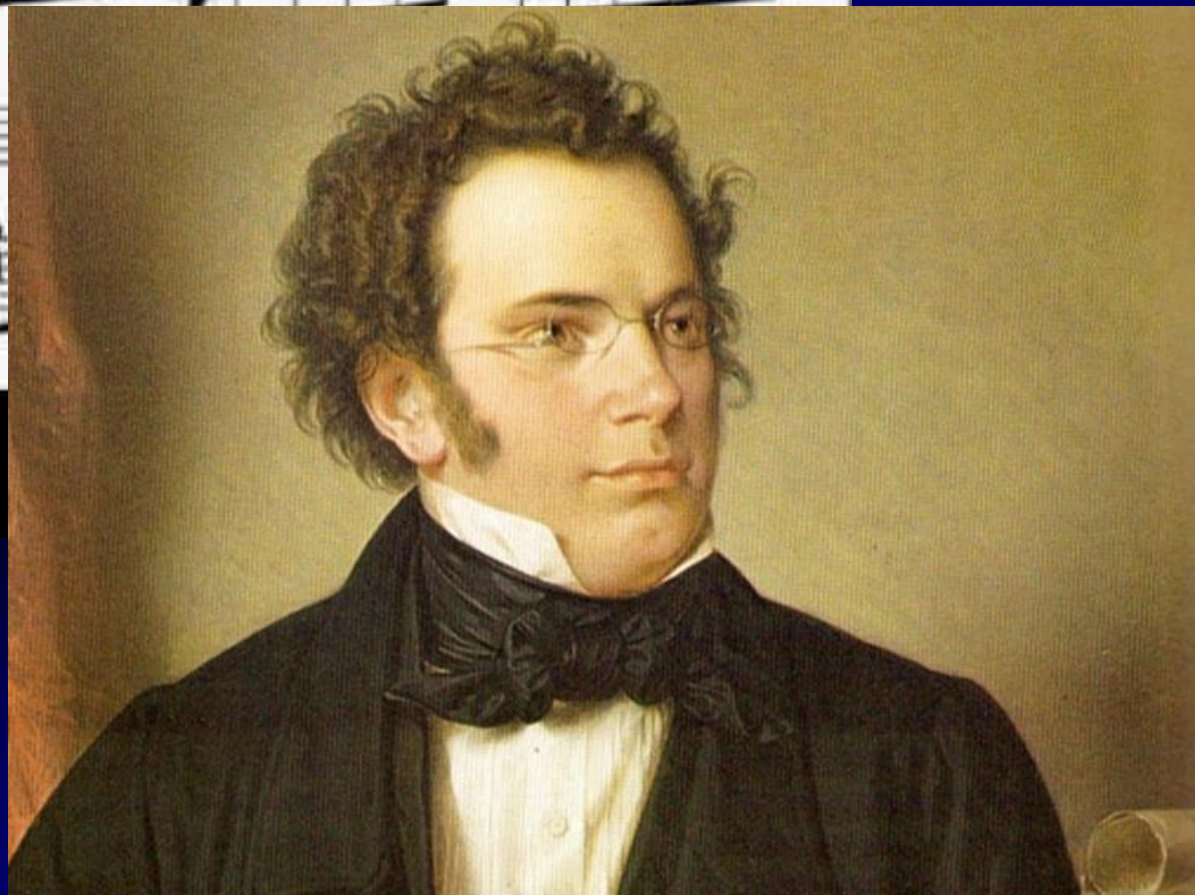
Grade II

The Unfinished Symphony

(theme)

Franz Schubert
(1797-1828)

Allegro moderato



THANK YOU!

Contact:
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http://aerosol.atm.ncu.edu.tw