Biomass burning in Thailand

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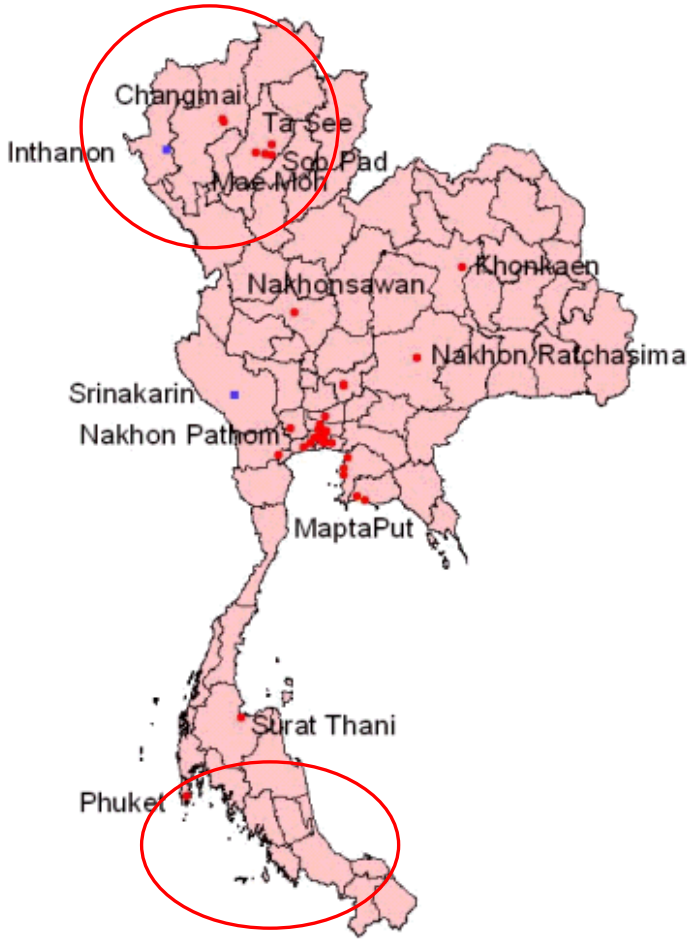
Inventory, Modeling and Climate Impacts of Greenhouse Gas emissions (GHG's) and Aerosols in the Asian Region, 26-28 June 2013, Tsukuba, Japan

Outline

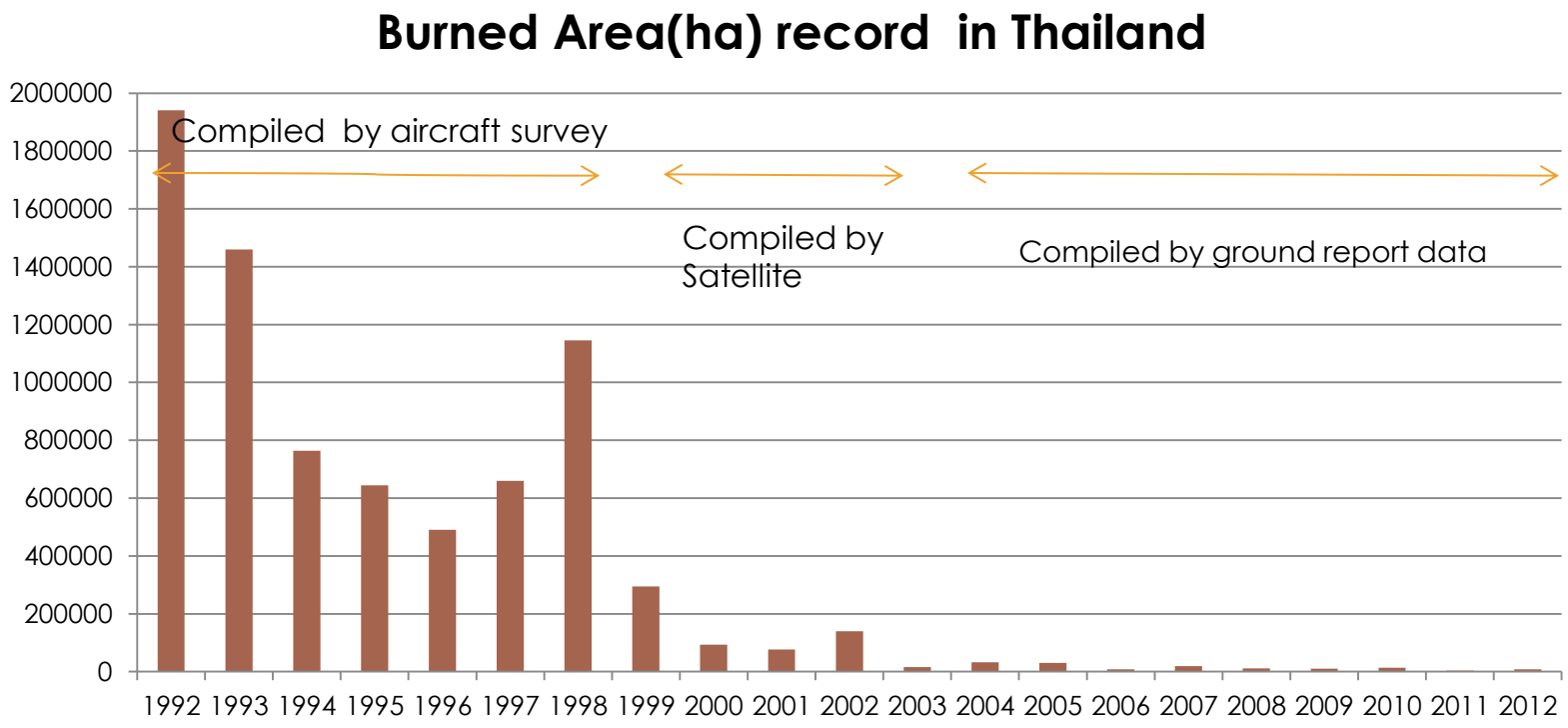
- Introduction
- Crop Residue Burning
- Forest Fire situation 2013
- THailand Emission Modeling System

Air Pollution episodes from Biomass burning



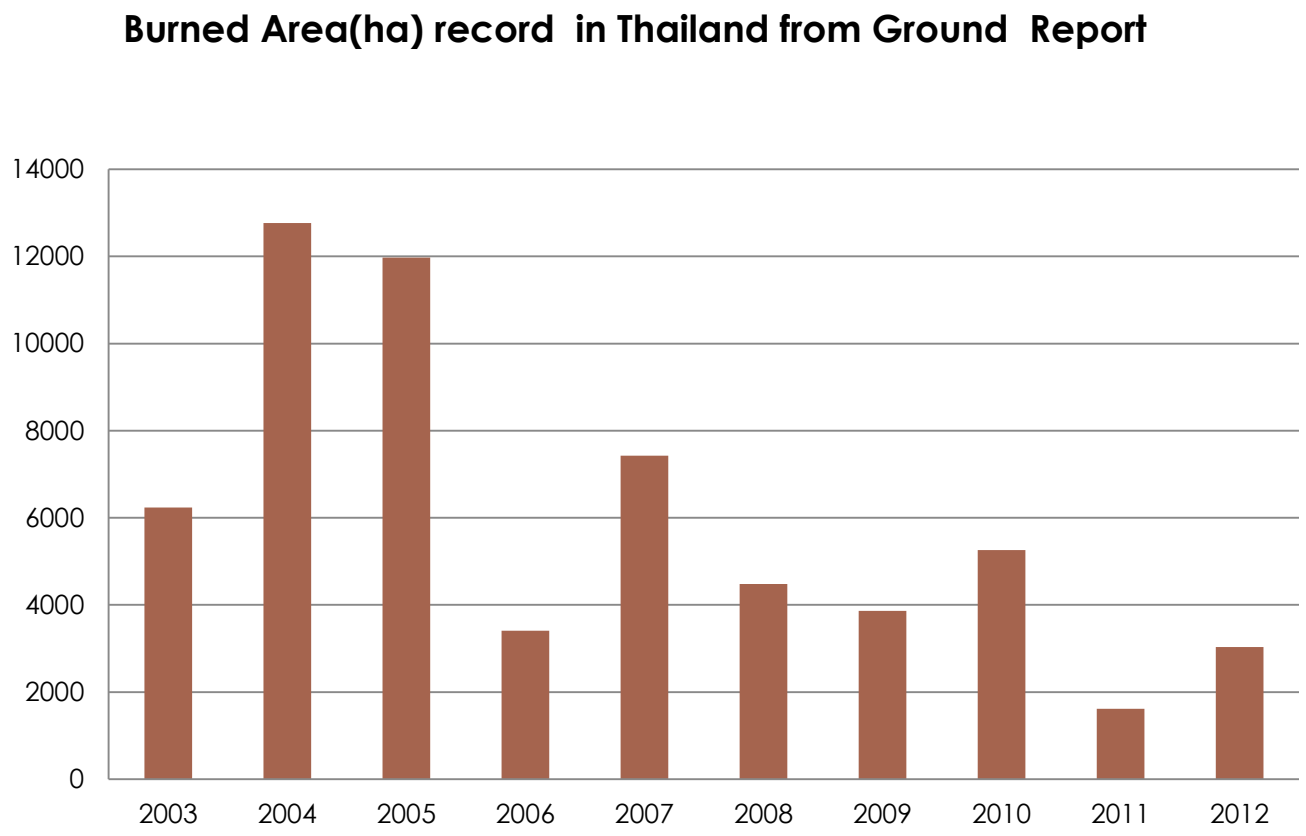
- First episode of high PM_{10} concentration in southern province in Oct-Nov, 1997 due to forest fire in Indonesia.
- Severe haze problem in northern part of Thailand during 2007 due to open burning in Thailand and neighbor countries.

Forest Fire Record in Thailand



Source: Forest Fire Control Division, National Park, Wildlife, and Park conservation dept, Thailand

Forest Fire Record in Thailand



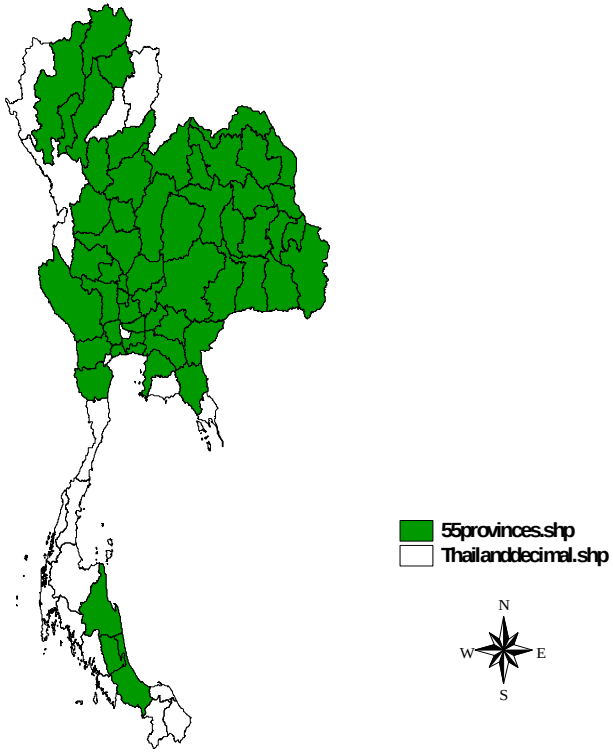
Source: Forest Fire Control Division, National Park, Wildlife, and Park conservation dept, Thailand

Biomass Burning in Thailand

There are three majors biomass burning activities

- Garbage/Junkyard Burning
  - Only in Rural area/city without garbage collection system
- Crop Residue Burning
- Forest Fire

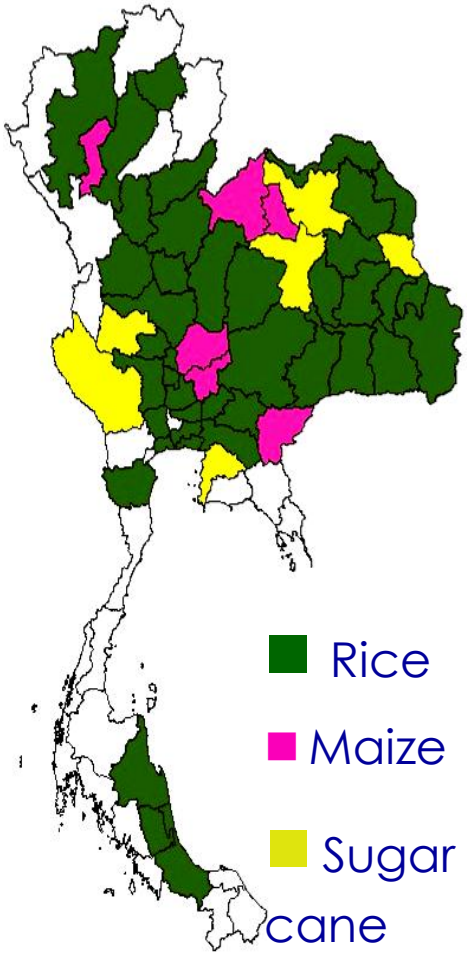
Crop Residue Burning



- The assessment of crop residue burning in Thailand during 2006
- A project under a TOR of Pollution Control Department
- A collaboration project of 4 universities in Thailand
  - Chiang Mai Univ(North)
  - KMITL & KMUTT(Central)
  - Khonkaen Univ(Northeast)
  - Prince of Songkla University (South)

Crop Residue Burning

The assessment of crop residue burning in Thailand during 2006



Objectives

- to assess the crop residue burning of three major crops, i.e., rice, sugar cane, and maize in 55 provinces
- to find relationship between farming practices and crop residue burning
- how to manage and prevent crop residue burning

Why Crop Residue burning is so important?

Thailand is a major rice exporter in the world. The more rice production -> more crop residue -> burning crop residue -> increase of carbon, aerosols and etc to our atmosphere.

Crop Residue Burning

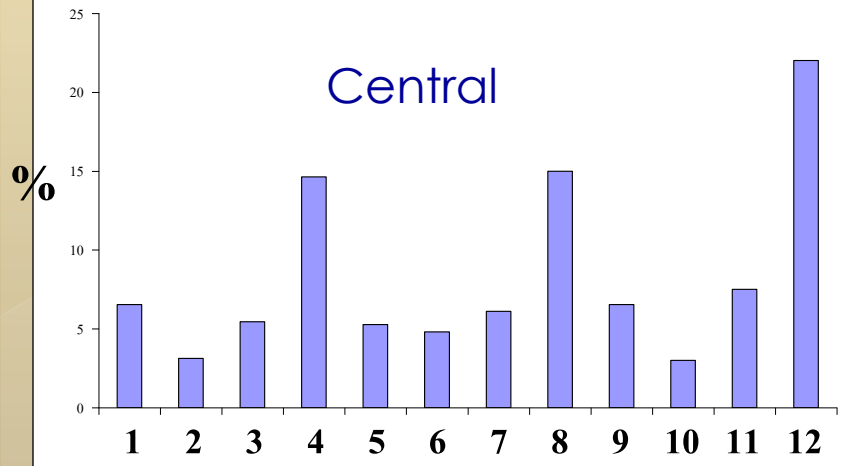
The assessment of crop residue burning in Thailand during 2006

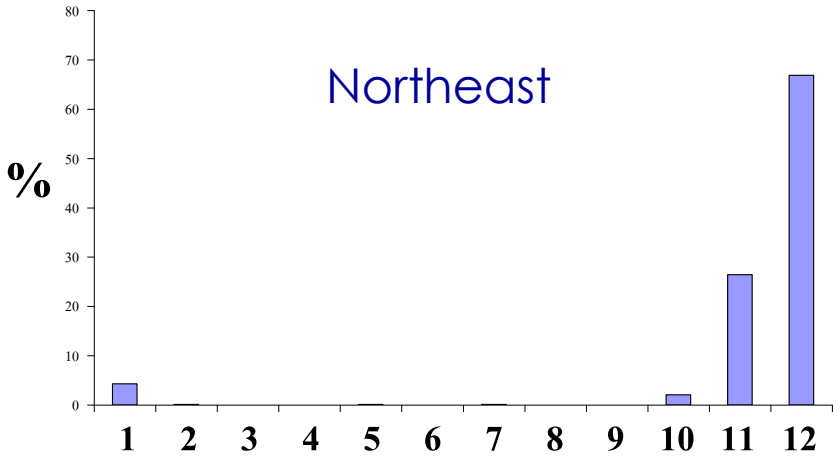
Methodology

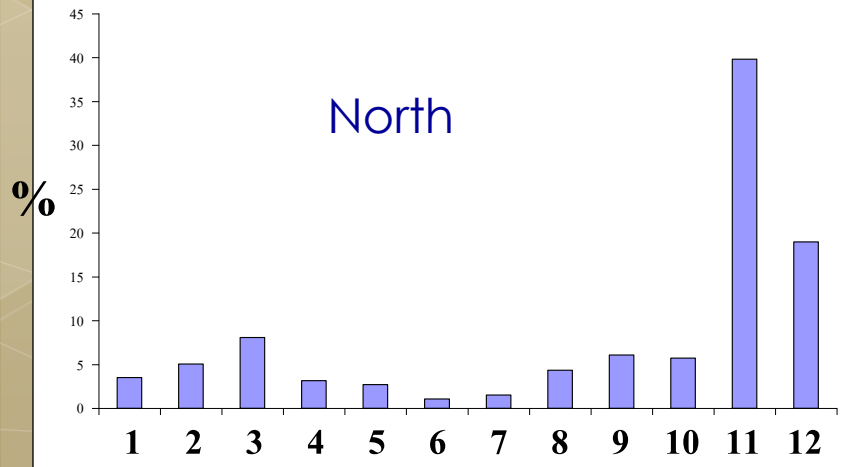
- visit and interview farmers in 55 province(sampling about 50 farmers in each provinces)
- Collect crop residue for further analysis in a lab

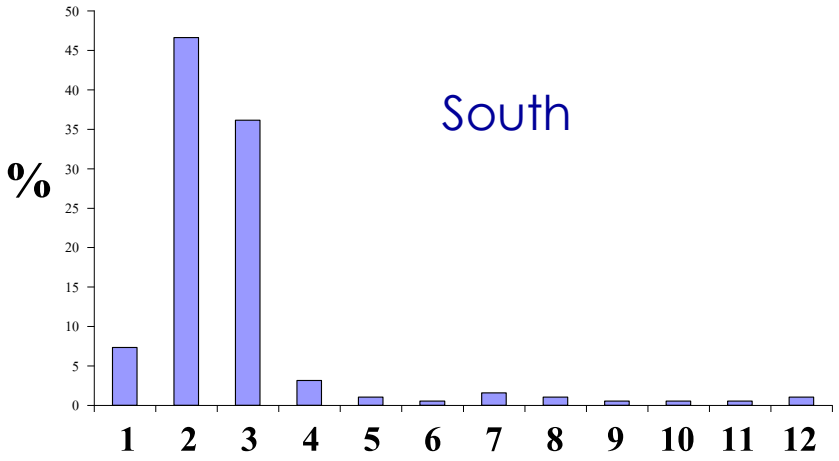
Results

Rice: Harvesting Months



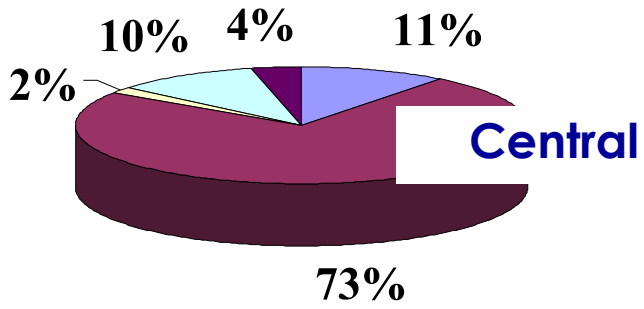


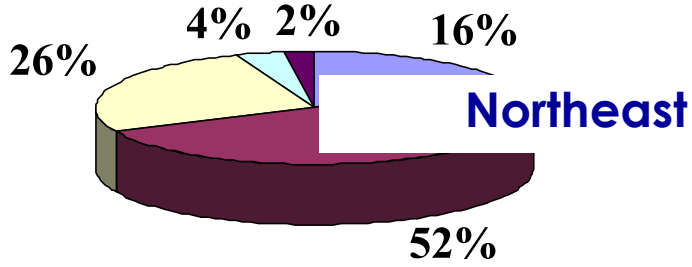




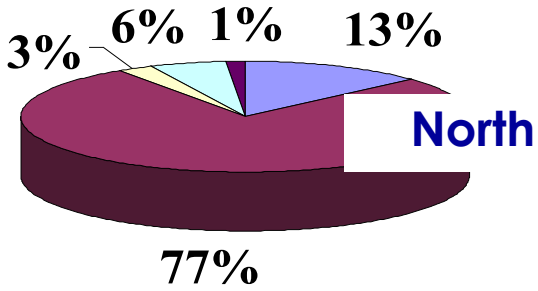
Results

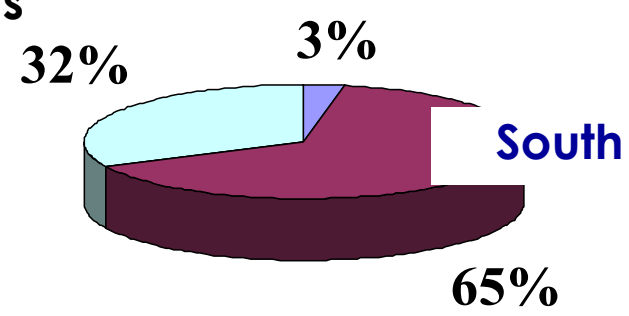
Rice: Timing for crop residue burning





Results

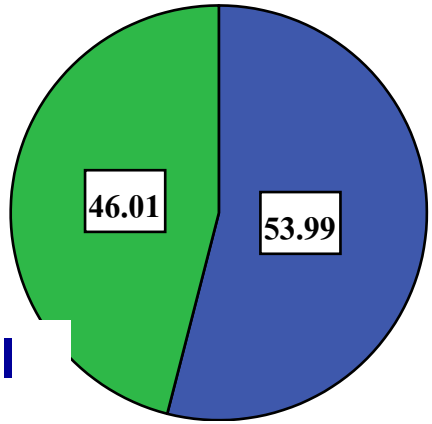




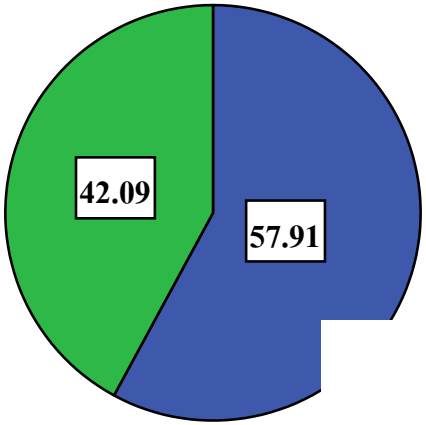
Morning | Afternoon | Night time | Calm wind | others

Results

Rice: fraction of burning crop residue in field



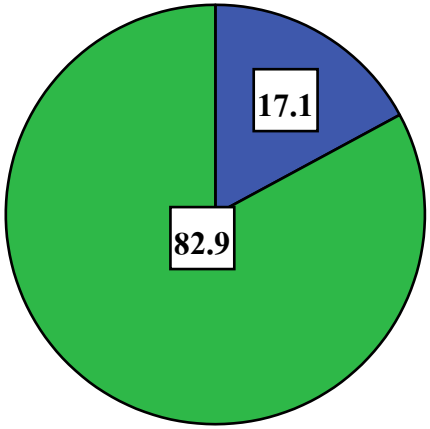
Central



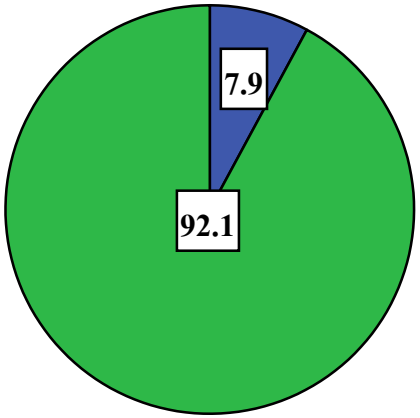
Northeast

Not burned

burned



North



South

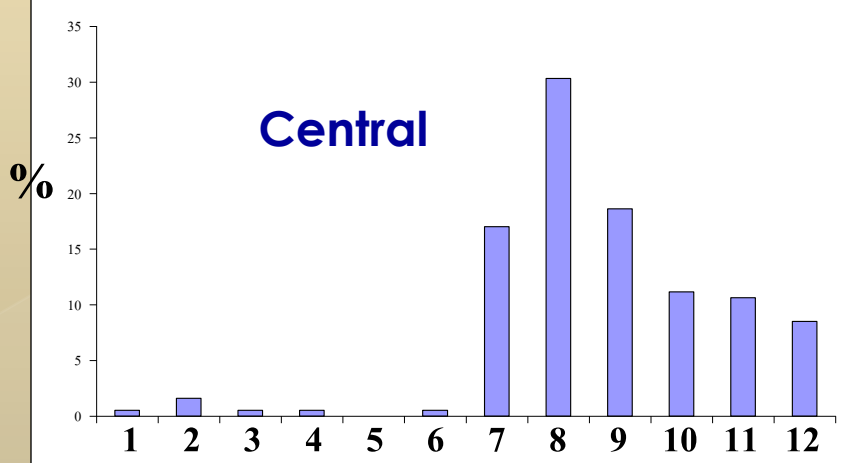
Results

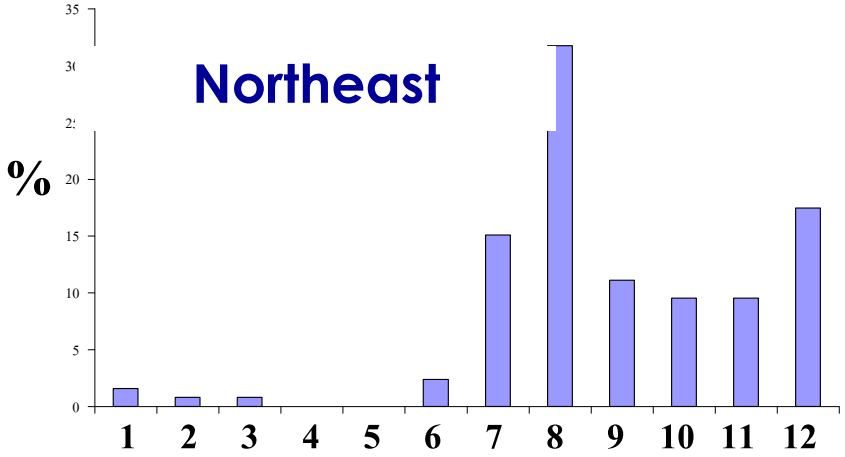
Rice: Summaries

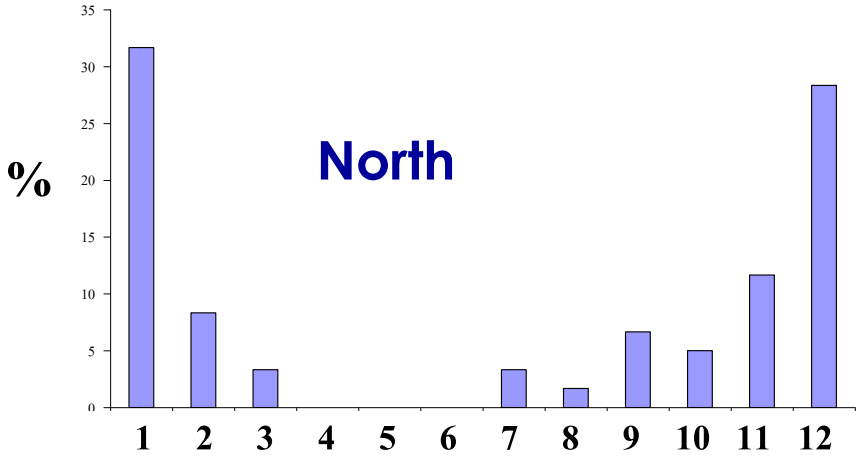
- North and northeastern region using rainwater as water source while Central and Southern using water from irrigation canal.
- Timing for Harvesting are November and December for North and northeastern region, February and March for Southern region, April, August, and December for Central.
- Timing for crop residue burning is afternoon.
- Fraction burn of crop residue in field, Northeastern region = 57.91%, Central= 54%, North = 17.1%, South =7.9%
- Farmer realized the affect of crop residue to air quality and climate change but did not have a quick solution to get rid of residue in field.

Results

Maize: Harvesting Months

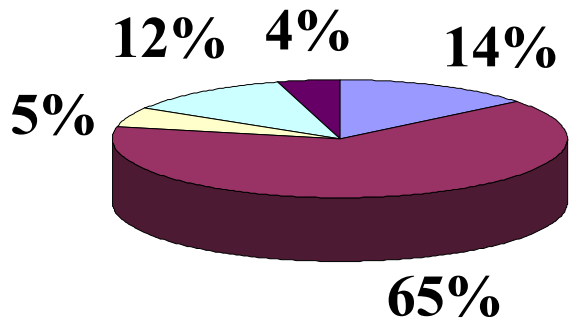




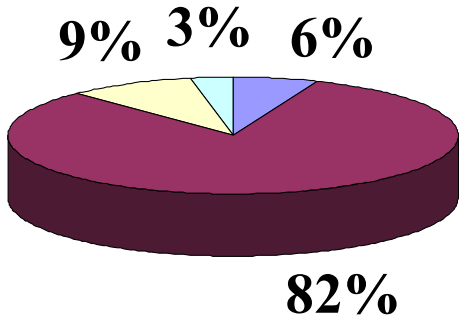


Results

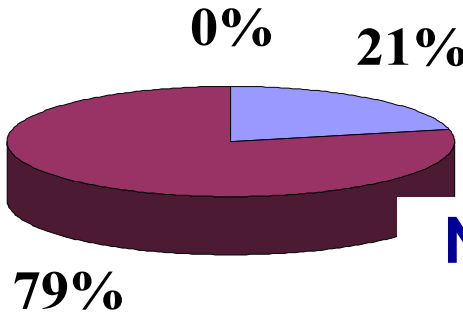
Maize: Timing for crop residue burning



central



Northeast



North

Morning

Afternoon

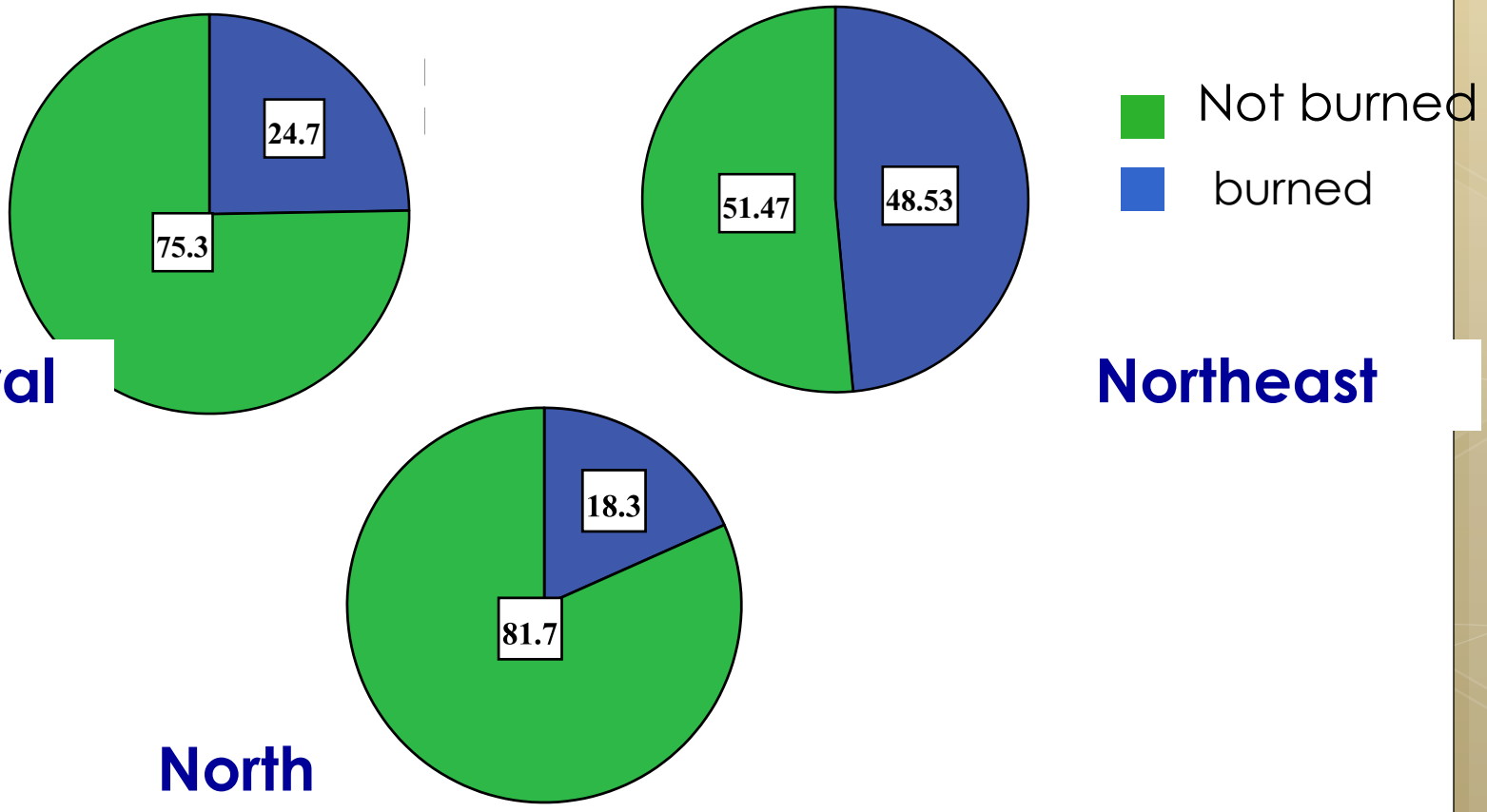
Night time

Calm wind

others

Results

Maize: fraction of burning crop residue in field



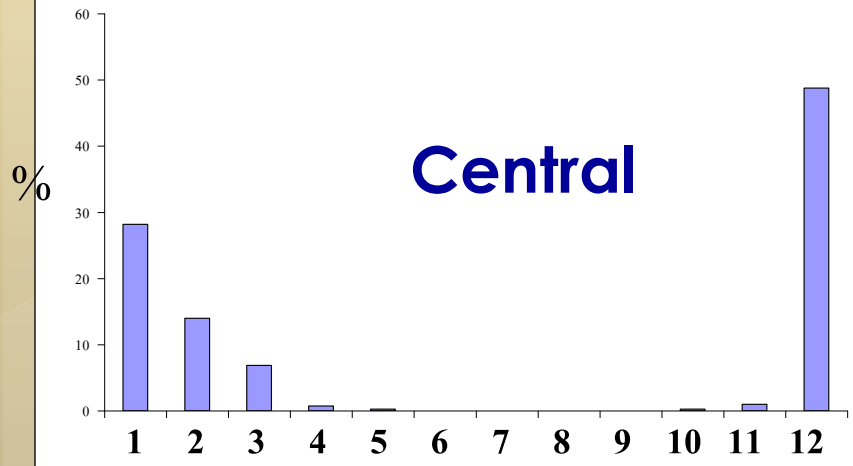
Results

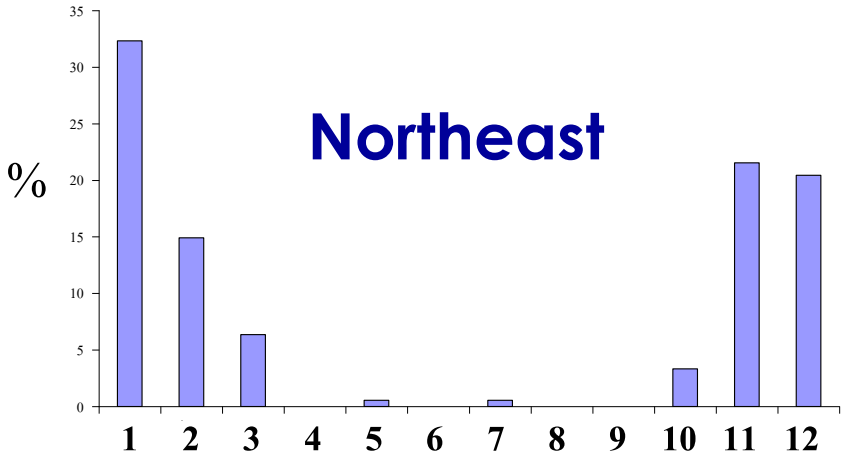
Maize: Summaries

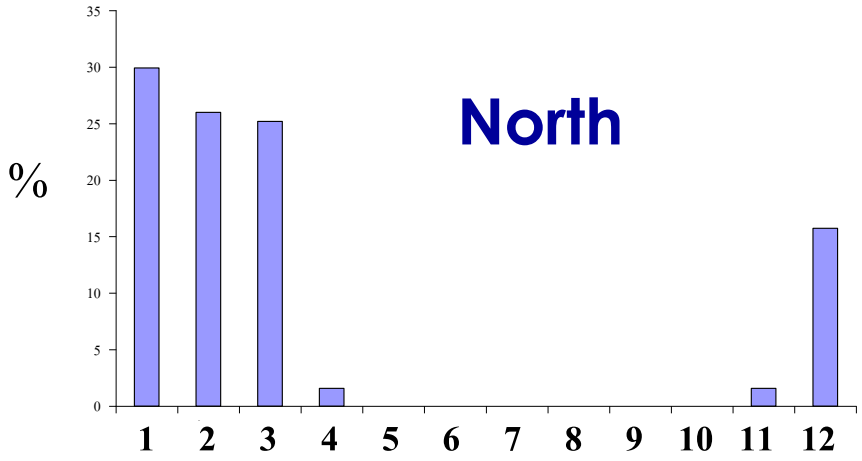
- Farmer in three regions using rainwater as a source of water.
- Harvesting time for Central and Northeastern are July-December while Northern are September-February.
- Timing for crop residue burning is afternoon
- Northeastern has a largest fraction burned at 48.53% while fraction of Central and North are 24.7% and 18.3%, respectively.
- Farmer realized the affect of crop residue to air quality and climate change but did not have a quick solution to get rid of residue in field

Results

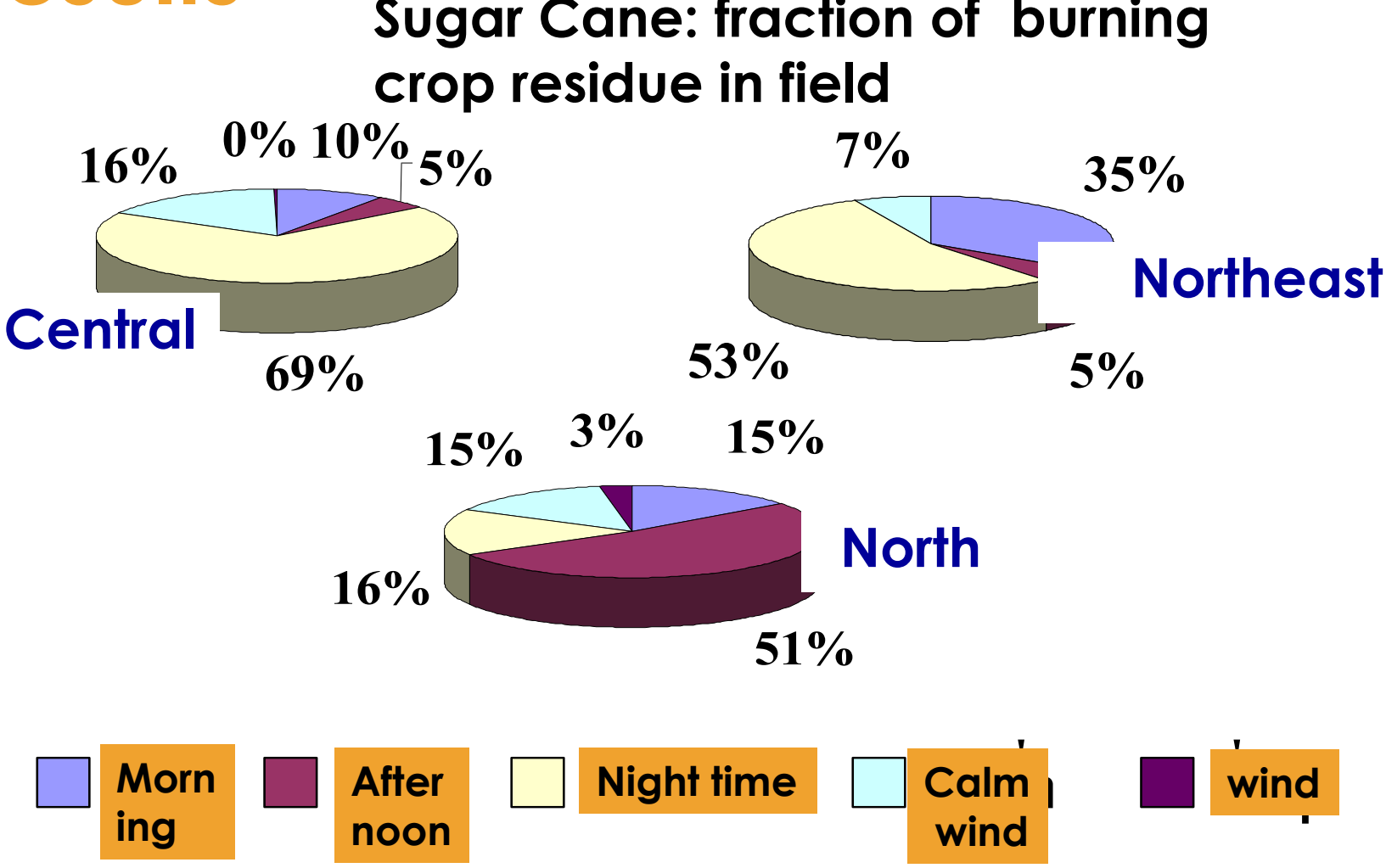
Sugar cane: Harvesting Months





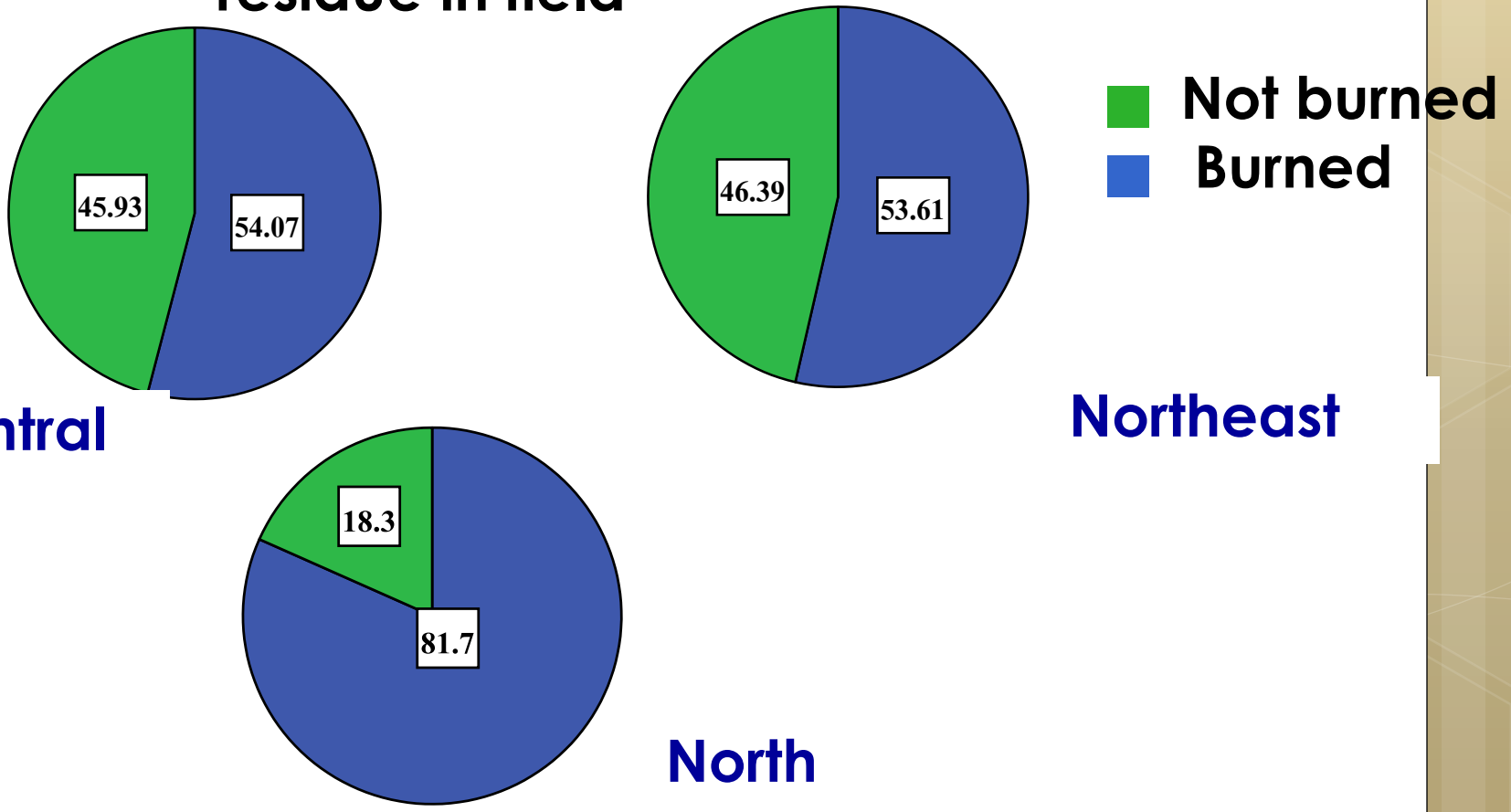


Results


Sugar Cane: fraction of burning crop residue in field
16%
0%
10%
5%
Central
69%
7%
35%
Northeast
53%
5%
15%
3%
15%
North
16%
51%
Morn ing
After noon
Night time
Calm wind
wind

Results

Sugar cane: fraction of burning crop residue in field



Results

Sugar Cane: Summaries

- Farmer in three regions using rainwater as a source of water.
- Harvesting time for all regions are November-March.
- Timing for crop residue burning in Central and Northeast is night time while afternoon for Northern region.
- Northern has a largest fraction burned at 81.7% while fraction of Central and Northeastern are 54.07% and 53.6%, respectively.
- Farmer realized the affect of crop residue to air quality and climate change but did not have a quick solution to get rid of residue in field

National Fire and Haze Control Plan of Action for 2013

Committee

- National level
  - National Disaster Management Committee chaired by Prime Minister
  - National Committee on Fire and Haze Control: chaired by Minister of Natural Resources and Environment
- Provincial level
  - Provincial Committee on Fire and Haze Control for 8 Fire-prone Provinces in the Northern Part of Thailand: Chaired by the Governors

National Fire and Haze Control Plan of Action for 2013

Measures

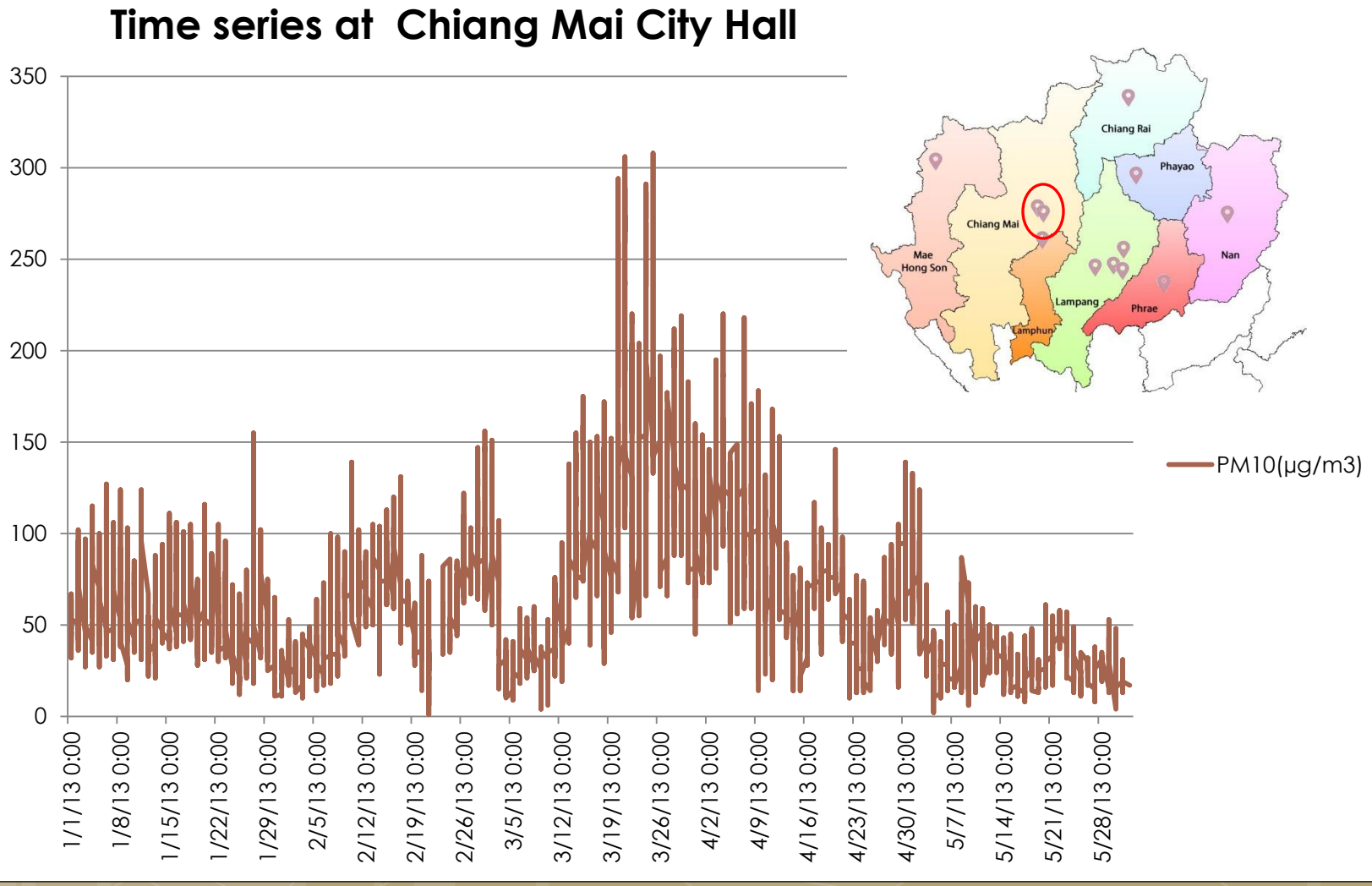
- Strictly prohibited burning in forest areas, communities, agricultural areas and roadside areas during *Jan – Apr 2013*
- Zoning of Agricultural areas
  - Limited areas and time for burning
- Supporting Zero Burning Villages in the Northern Thailand

Forest Fire situation:2013

Air Quality Monitoring Network in the Northern Thailand

	Location
13 Stations	Chiang Mai (2), Lumpang (4), Chiang Rai (2) Maehongsorn Lumpoon Nan Payao Prae

Forest Fire situation:2013



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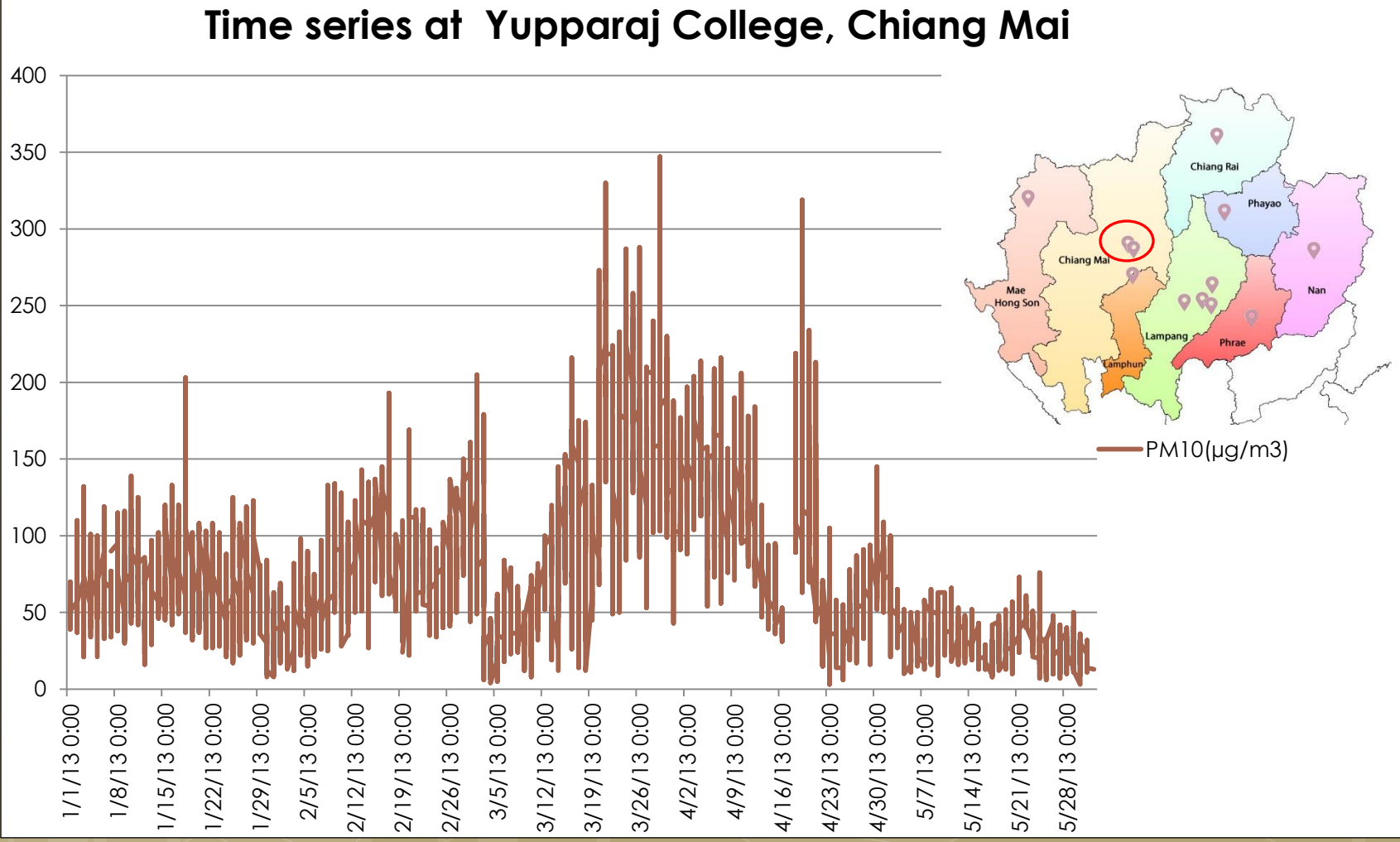
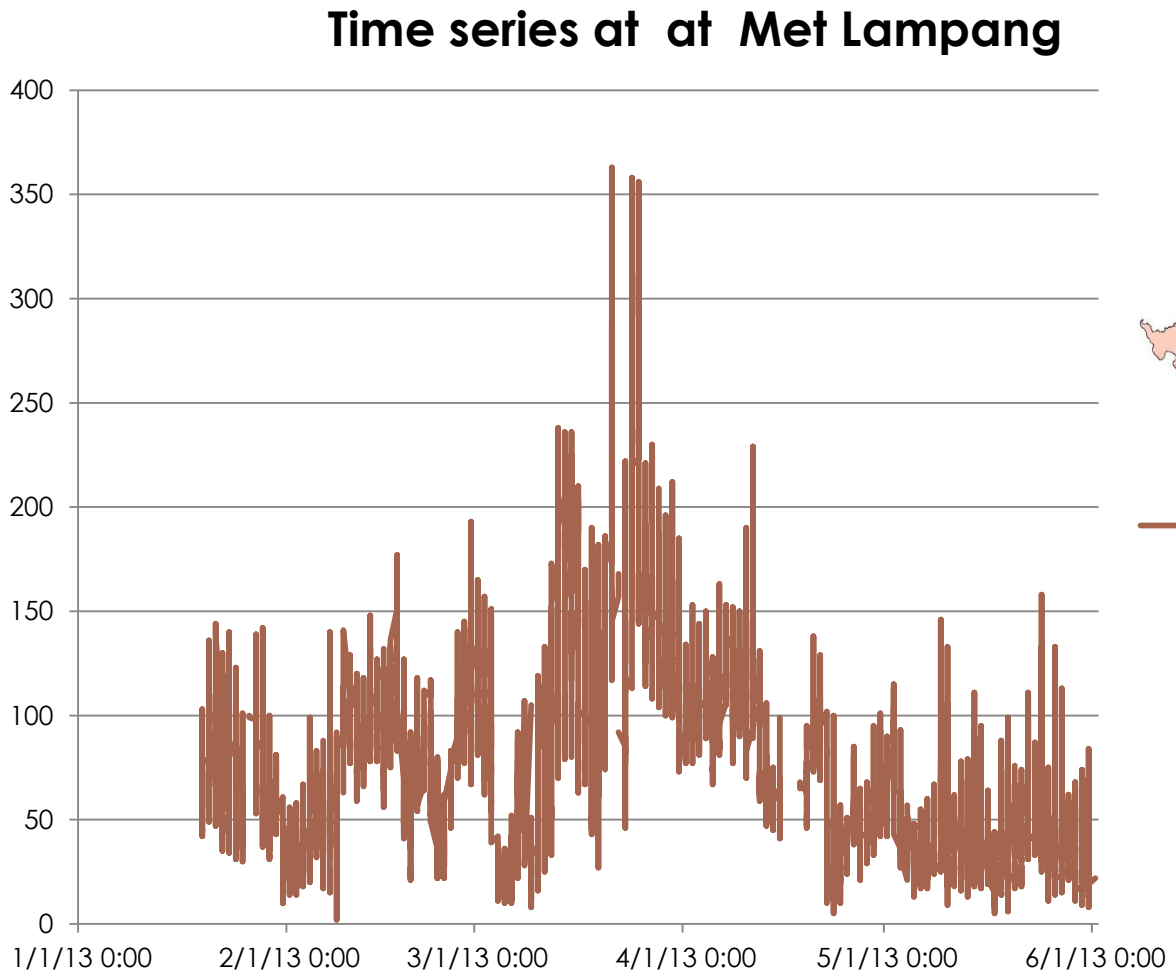
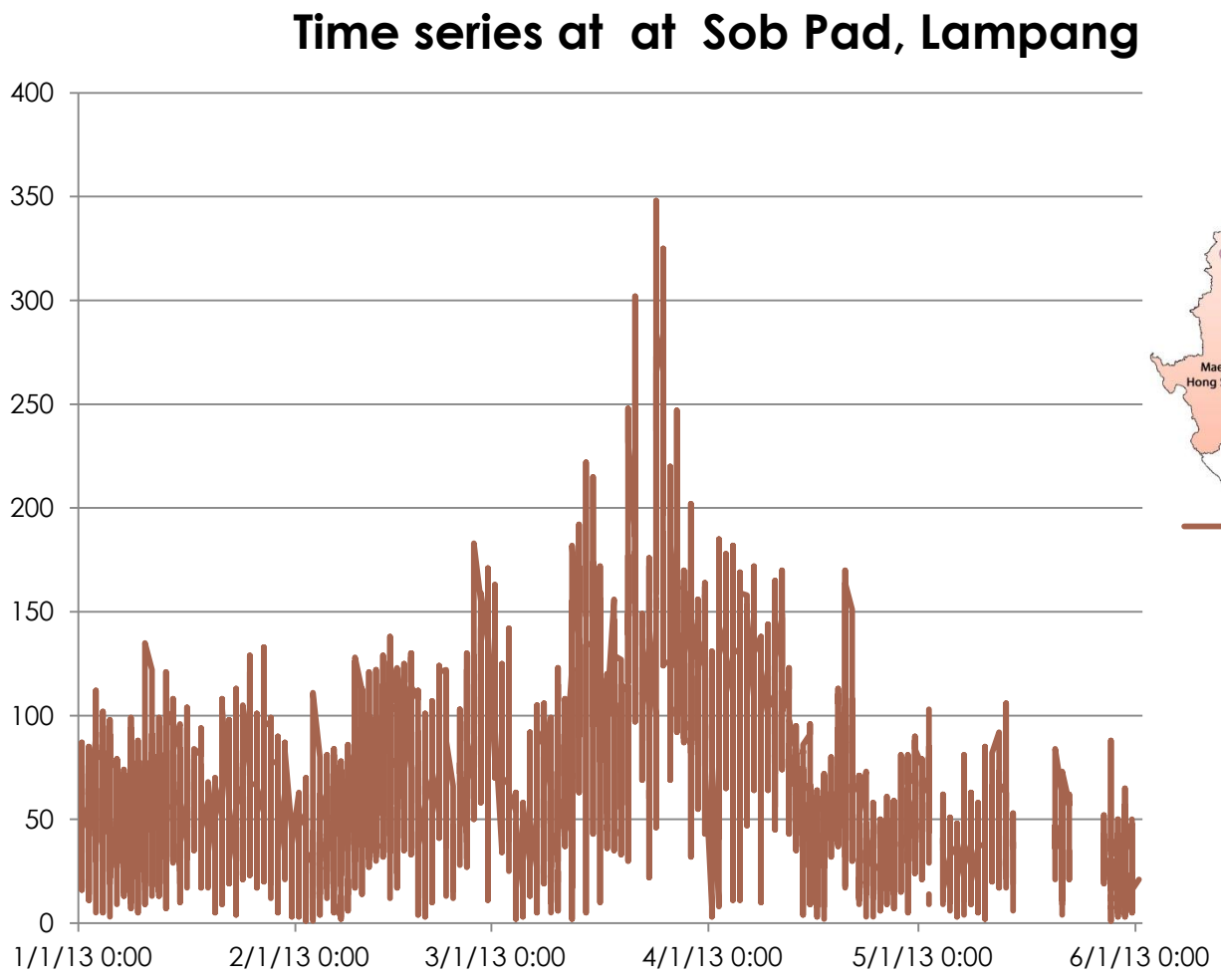


Forest Fire situation:2013



Forest Fire situation:2013



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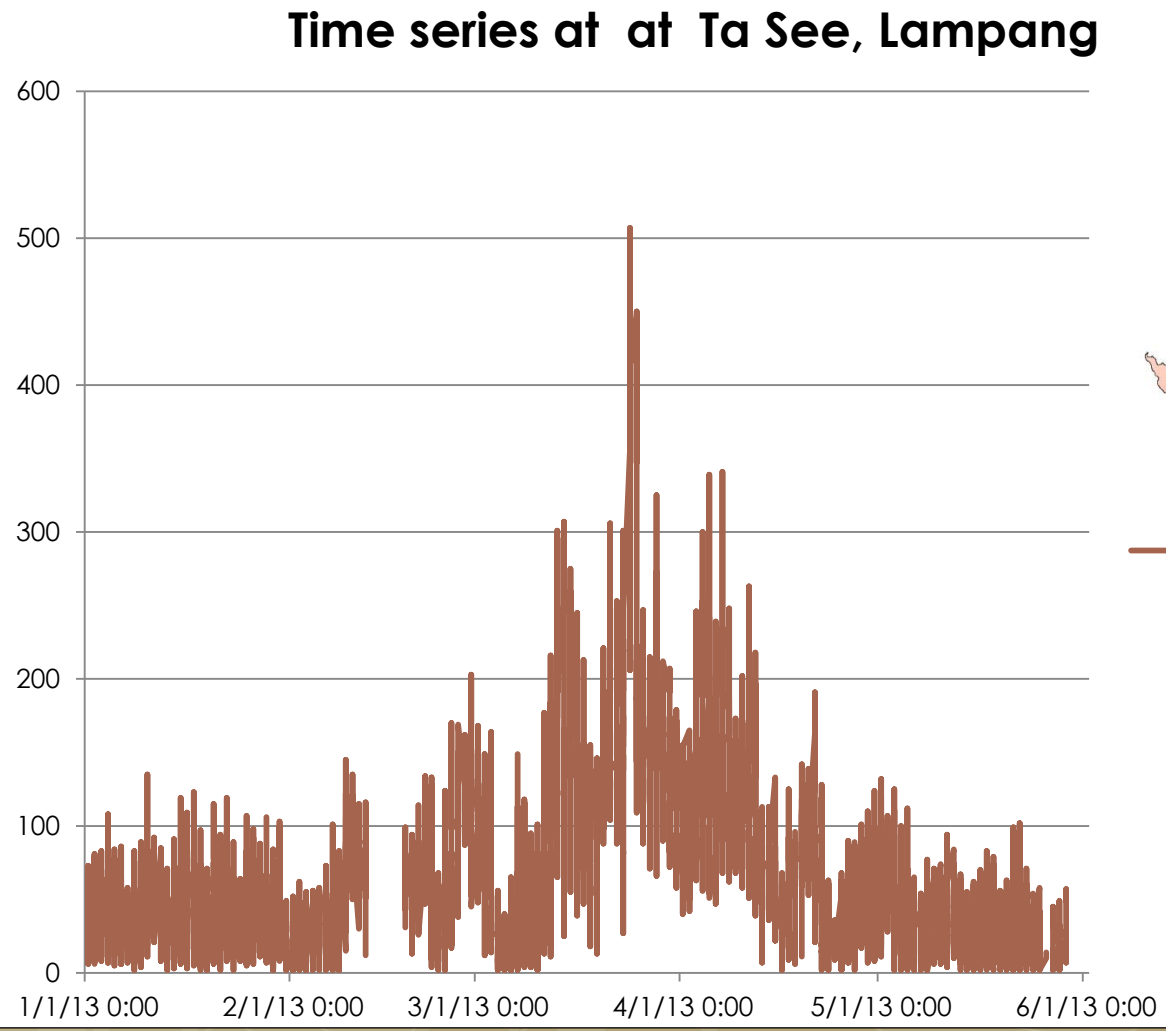

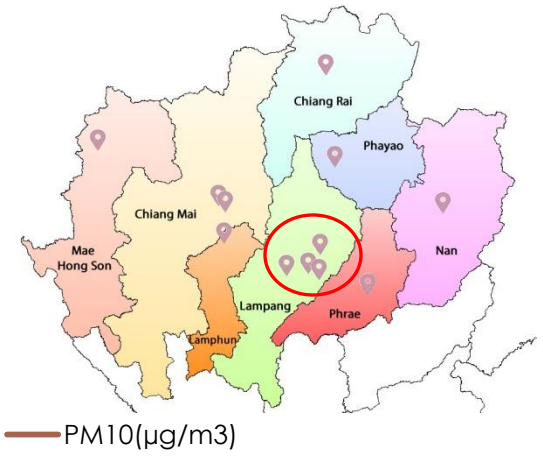

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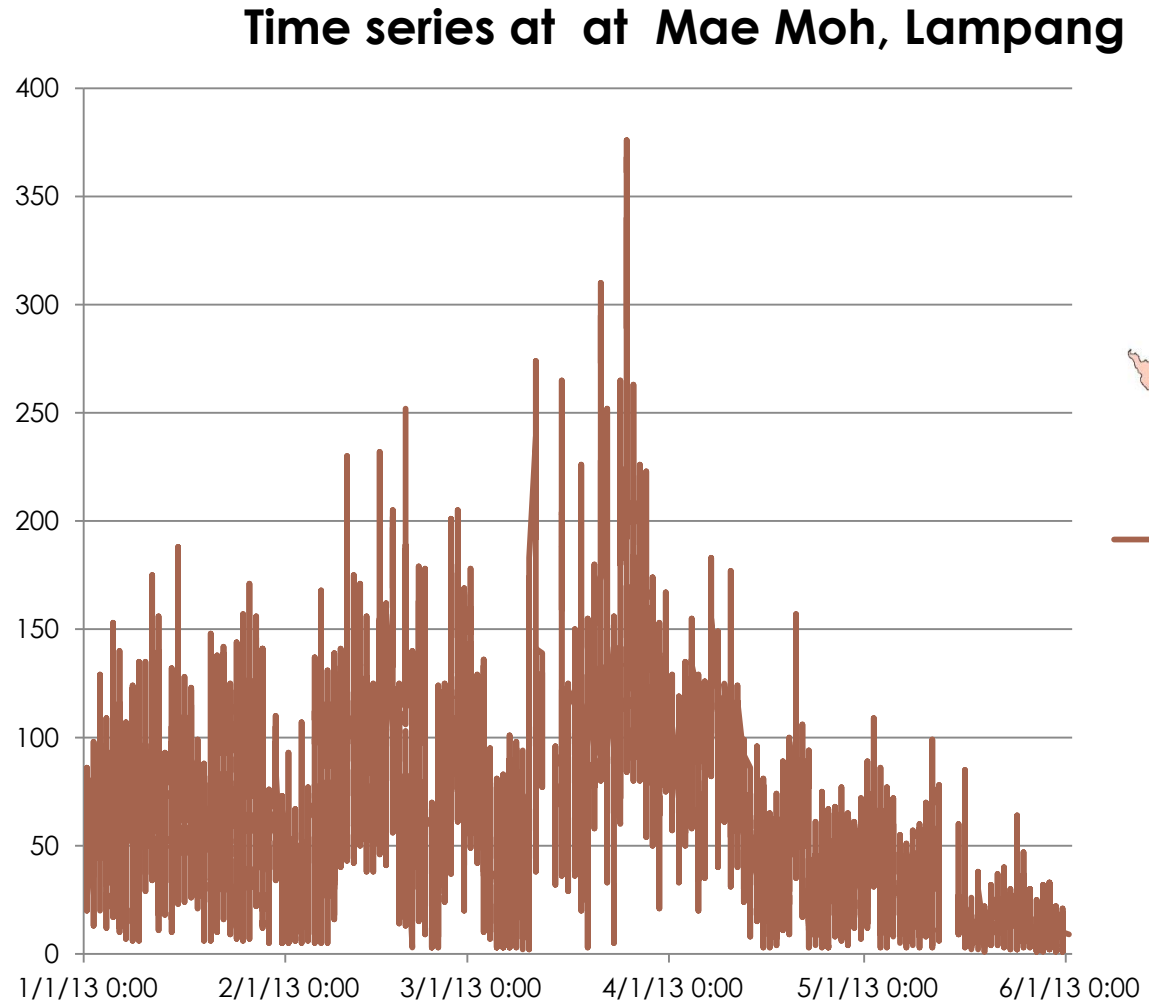

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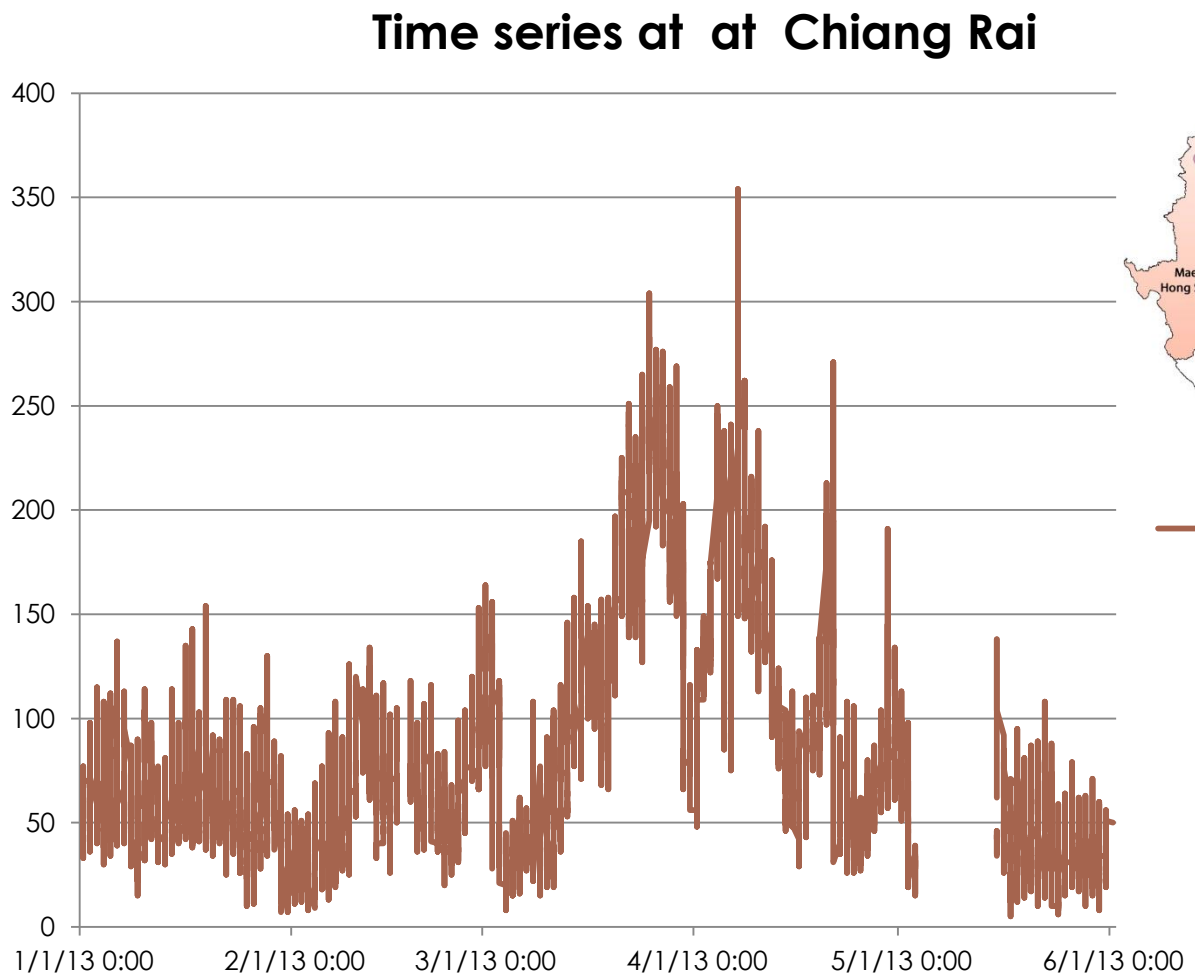
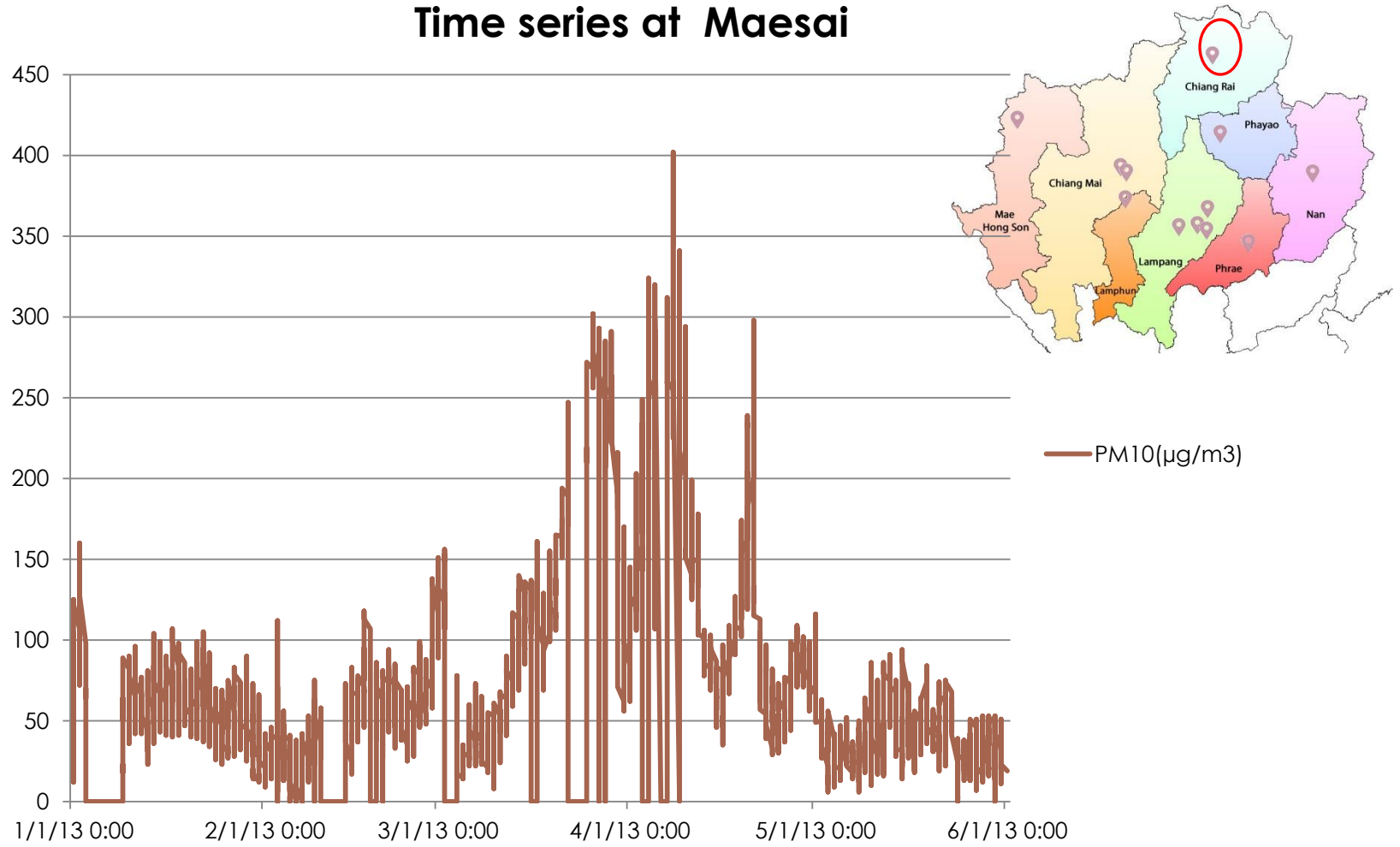


PM10(µg/m3)

Forest Fire situation:2013



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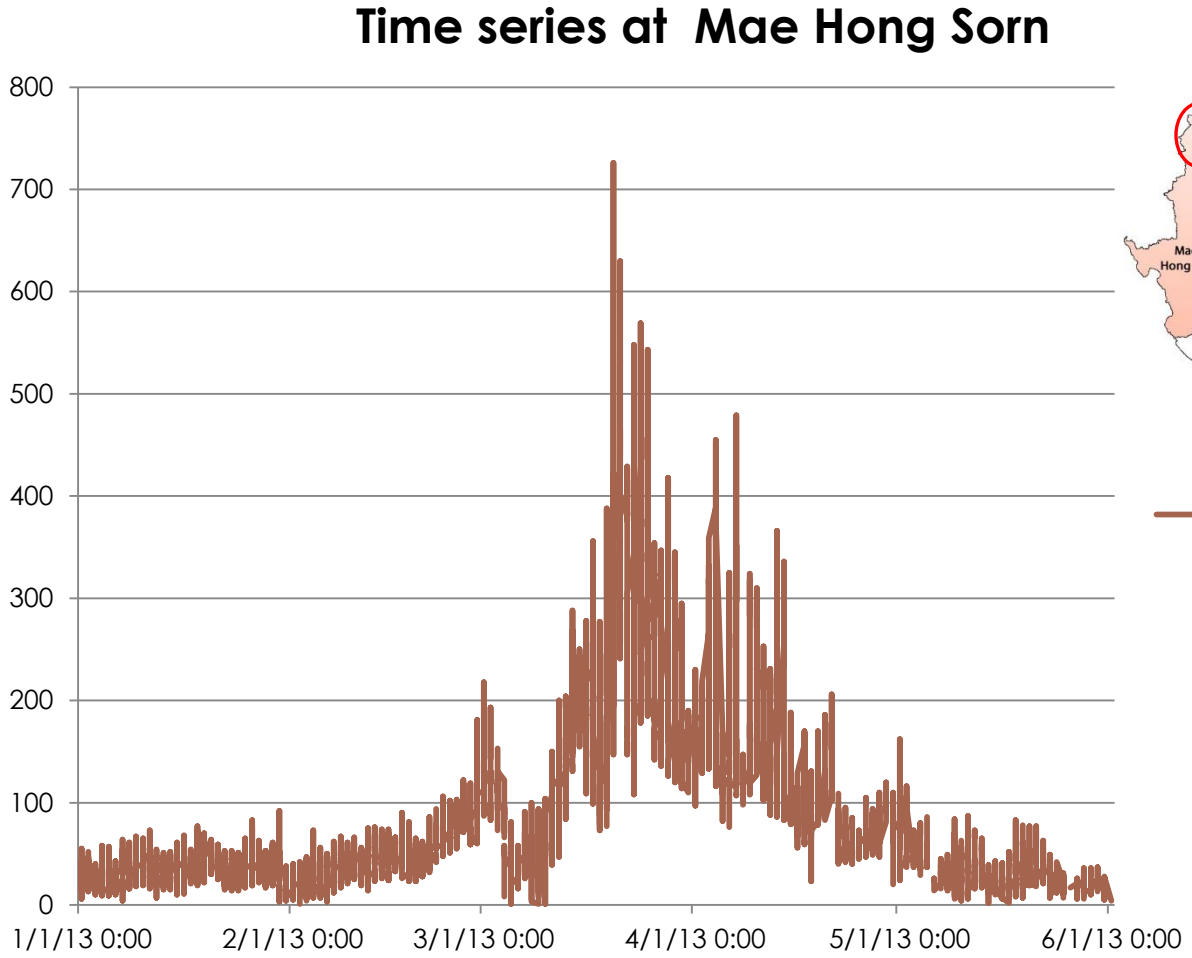
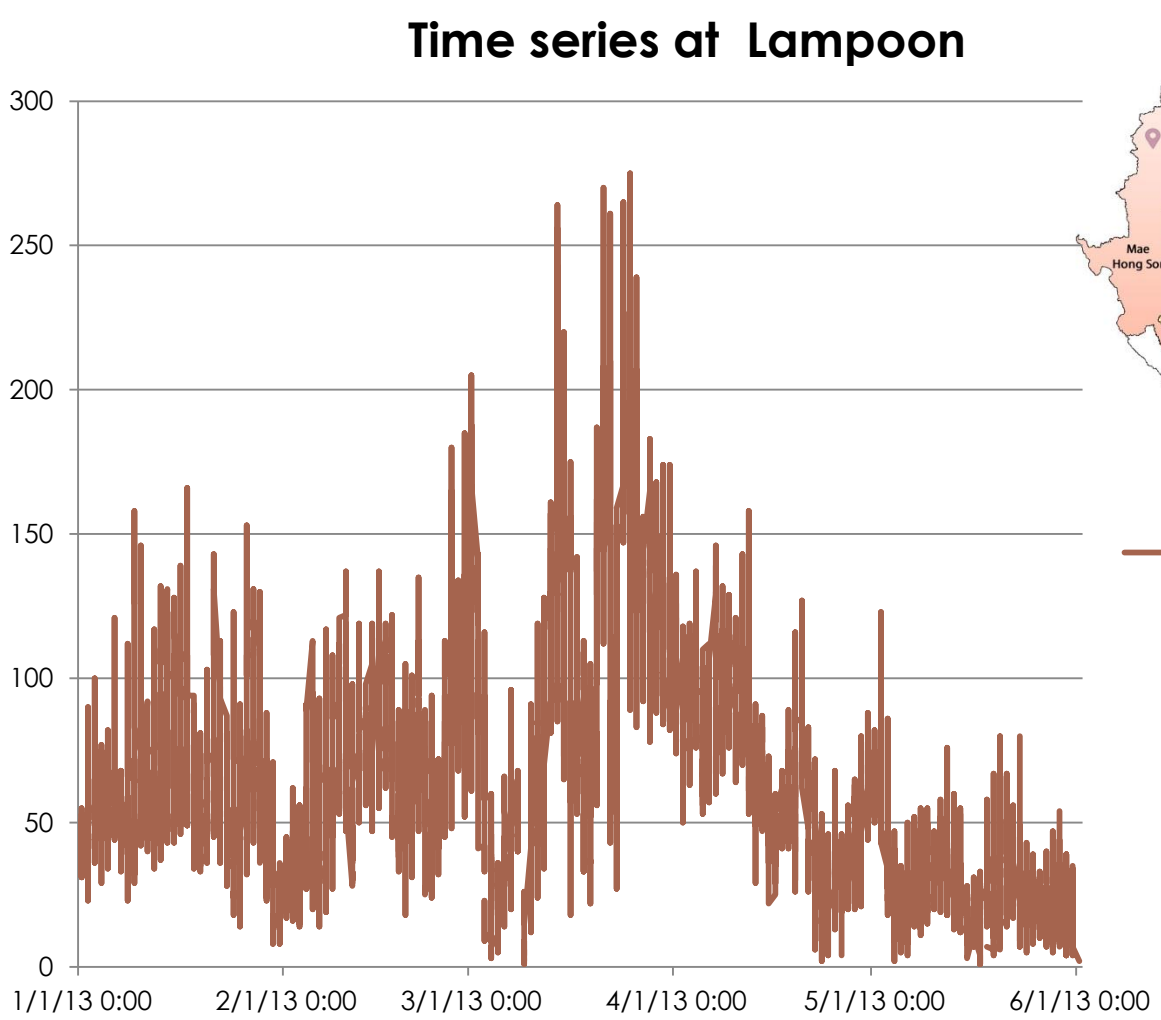


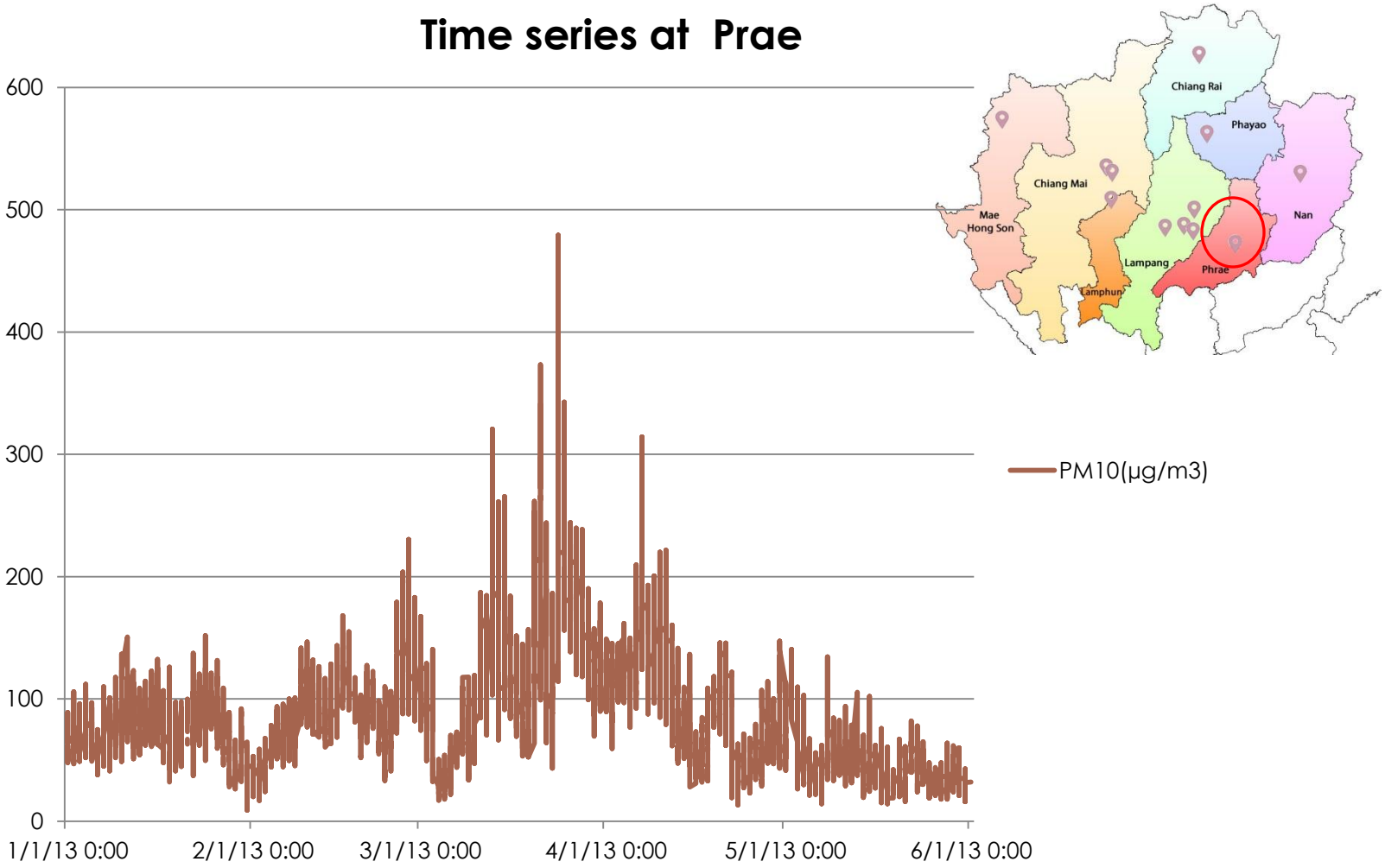
PM10(µg/m3)

Mae Hong Sorn has a nick name as a city with three Seasons Fog.
Fog in winter due to cold weather, summer due to forest fire, and Rainny season due to Rain.

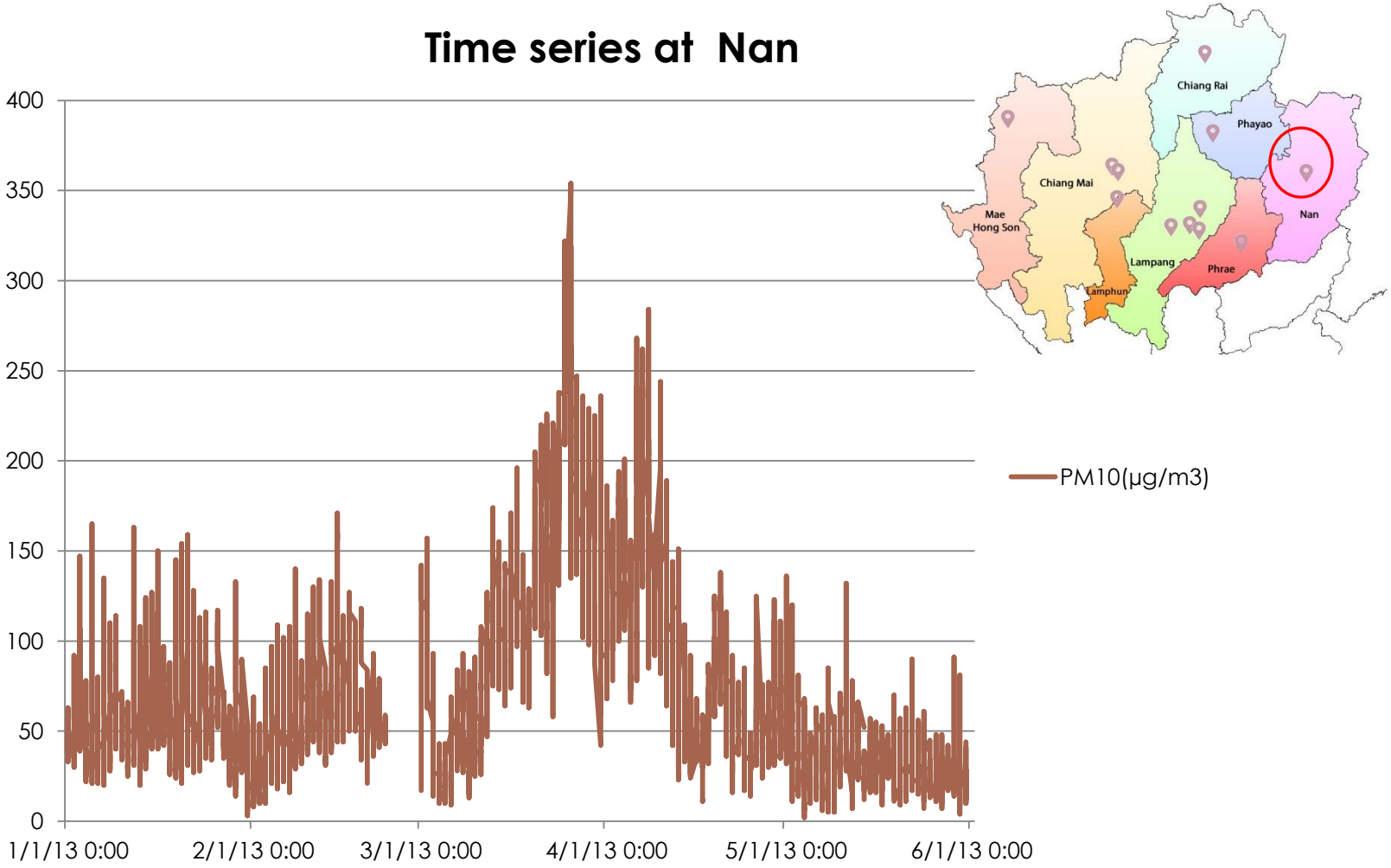
Forest Fire situation:2013



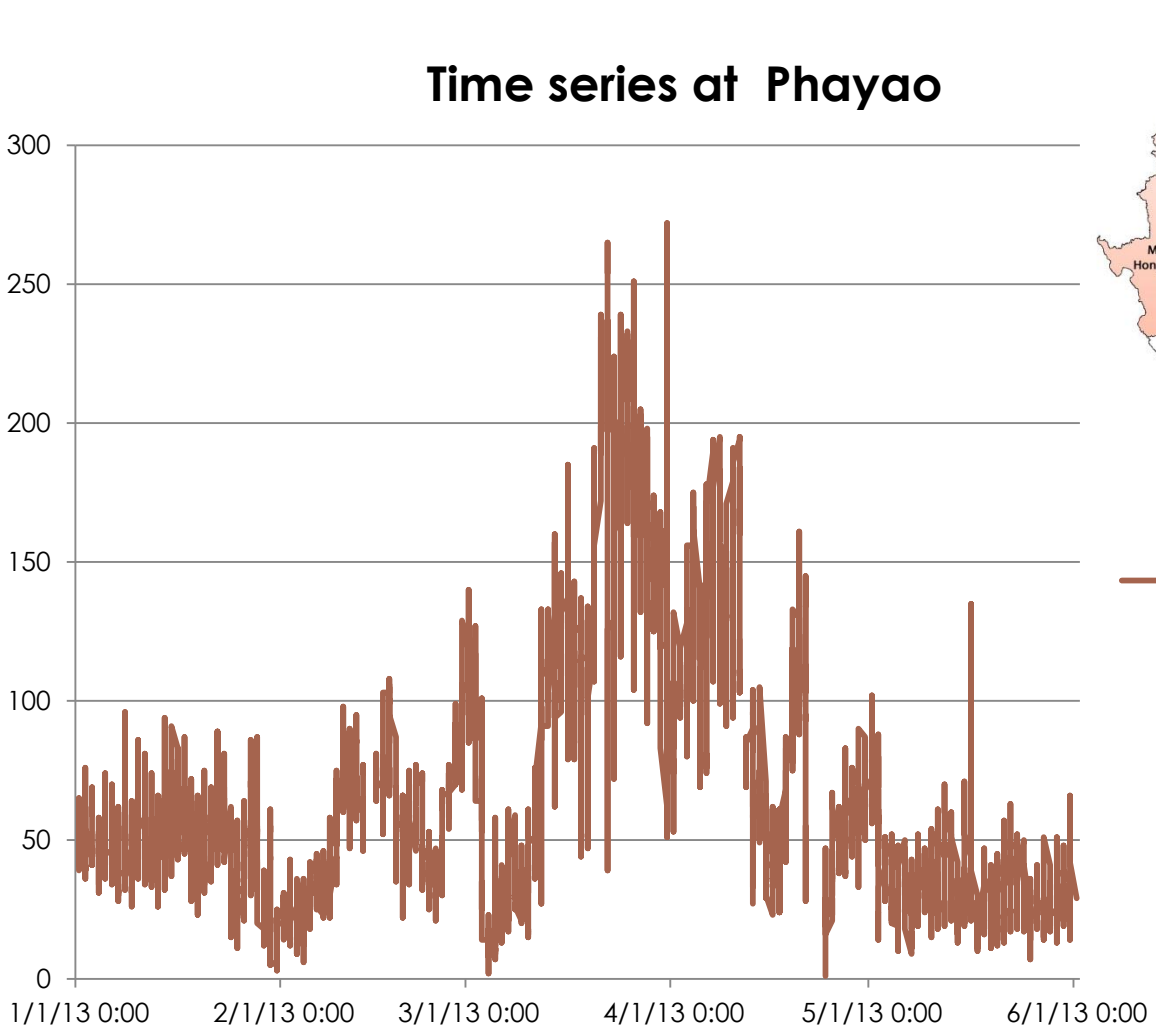
Forest Fire situation:2013



Forest Fire situation:2013

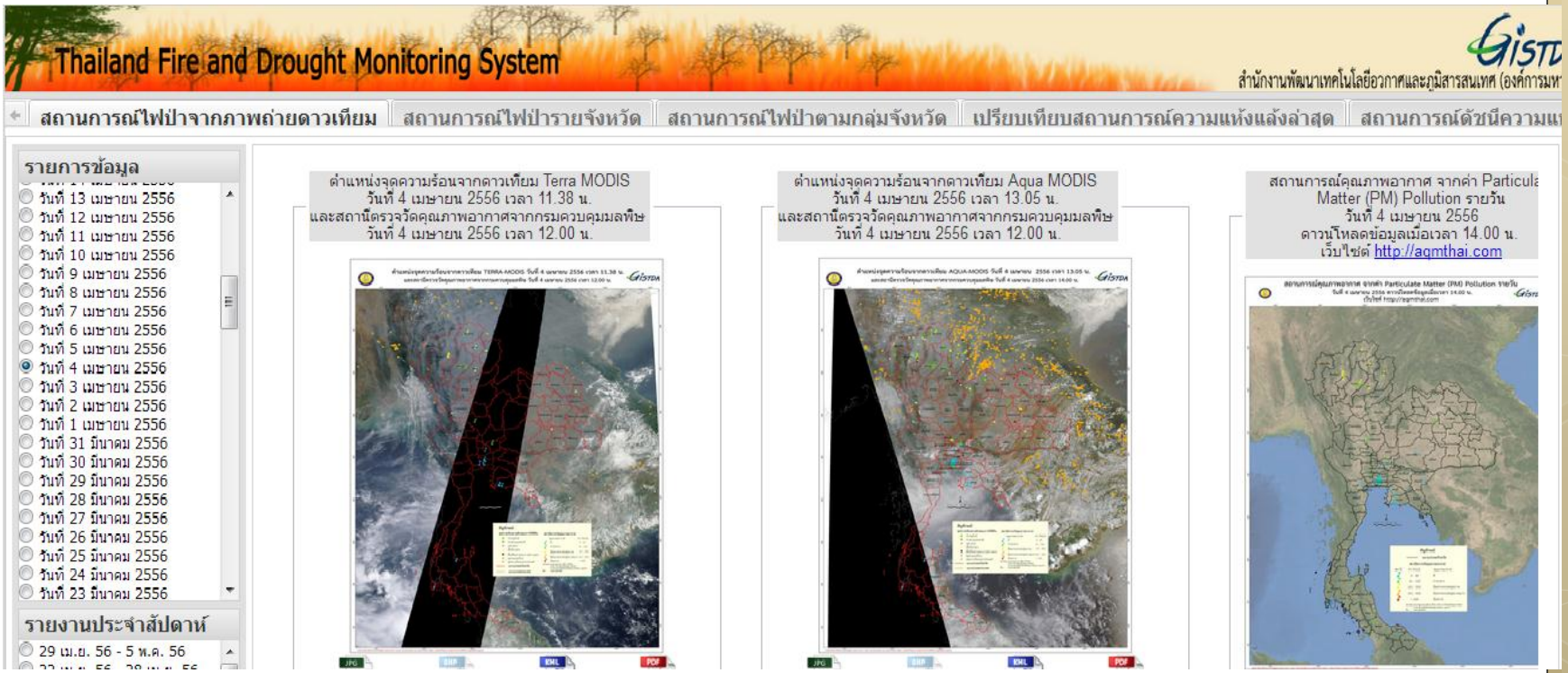


Forest Fire situation:2013



Forest Fire Situation: 2013

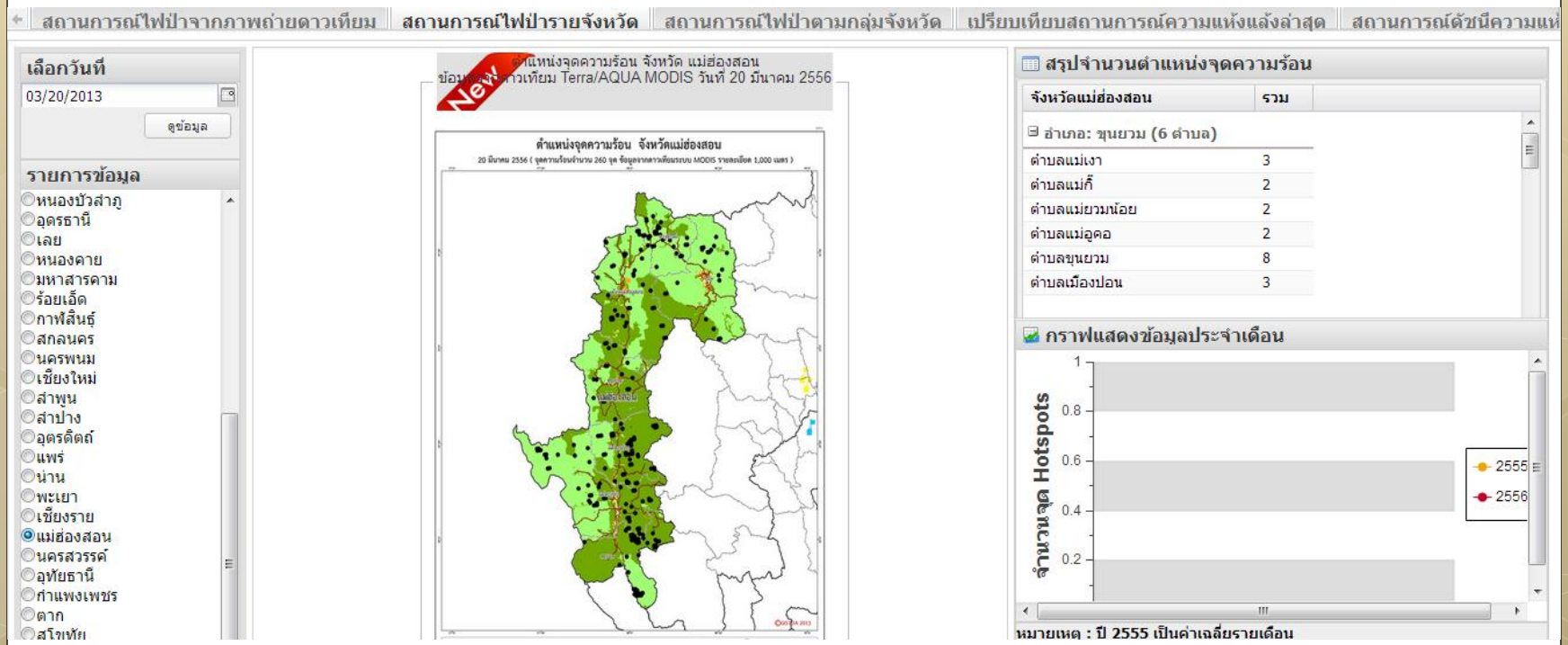
Thailand Fire and Drought Monitoring System



http://fire.gistda.or.th/

Forest Fire Situation: 2013

Thailand Fire and Drought Monitoring System



Conclusions

- Thai Government have tried several measures to prevent biomass burning but it didn't work well.
- To solve problems about biomass burning is not an easy task. The zero burning policy didn't work well with the tradition practice
- The public awareness is need to be done to make people realize the consequence of his/her action on biomass burning.
- Government need to invest more in both research and build public awareness.

THailand Emission Modeling System

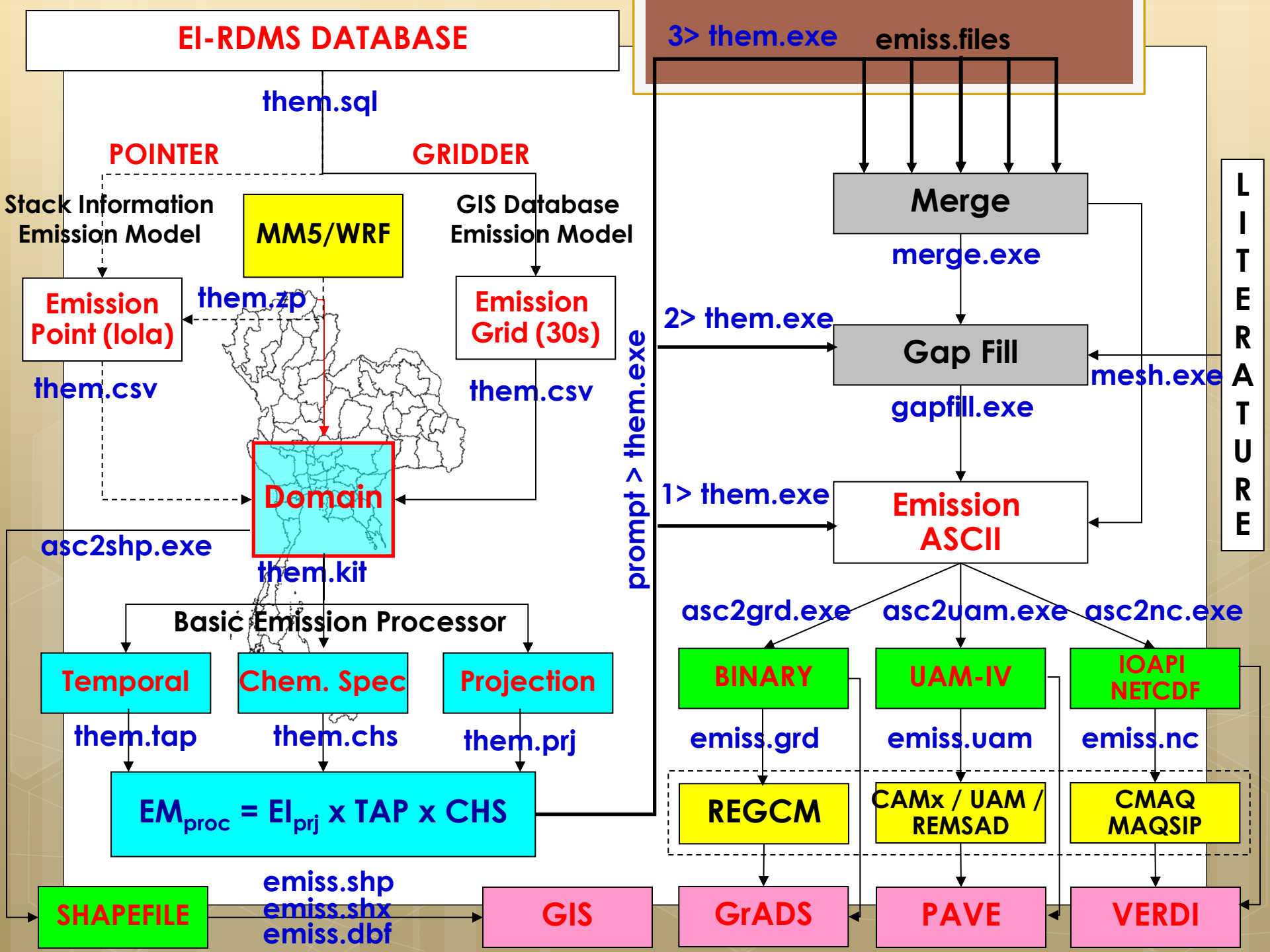
THEM

THEM: Capabilities

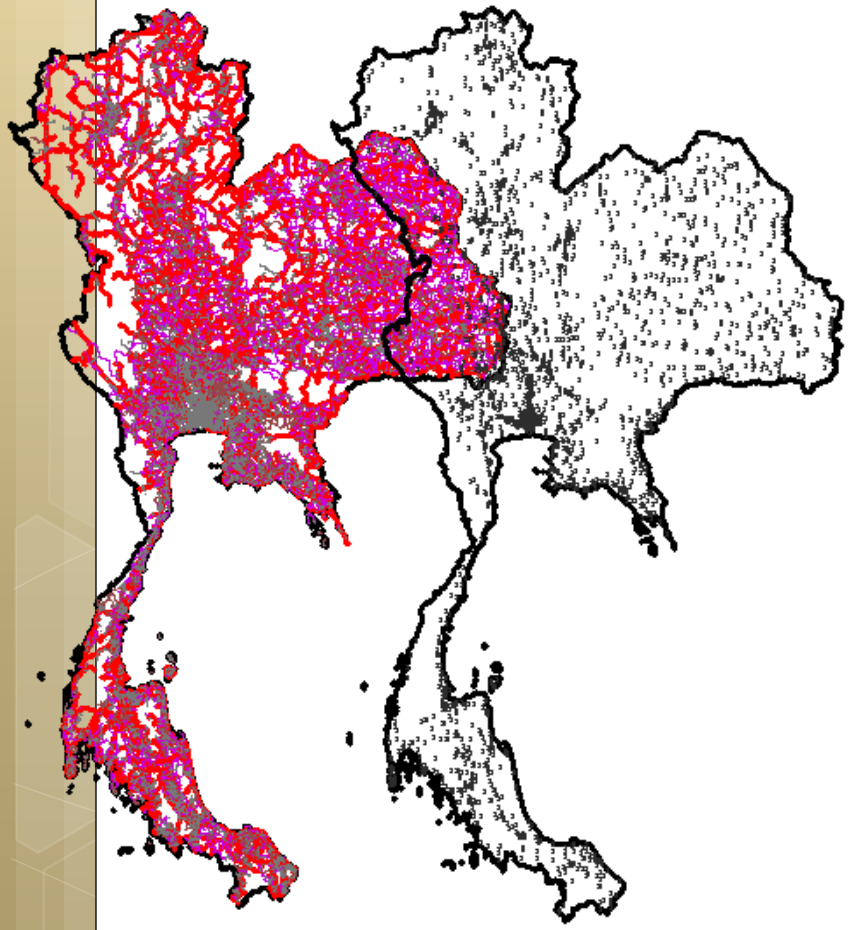
- **Emission Processors**
  - 2D GRID Emission Model: Shape-like Area / Line / Point Source (GRIDDER)
  - 3D POINT Emission Model: Elevated Large Point Source (POINTER)

- **Emission Models**
  - On-road Traffic Emission Model:
    Deterministic Road & Intersection for Vehicular Emission Rate (DRIVER)
  - Fugitive Dust Emission Model:
    Behavior of LOwer Wind ERosion (BLOWER) &
    Seasalt Particle Reaction from Aquatic laYER (SPRAYER)
  - Firing & Burning Emission Model
    Forestry Inflamed Response to Emission Release (FIRER) &
    Biomass burning Under Residues Nearby to Emission Release (BURNER)
  - CEMS Emission Model:
    Continuous Emission Monitoring System to Emission Rate (CEMSER)

  - Model of Emissions of Gases and Aerosols from Nature: MEGAN (Guenther, 2006)
    Project (NATURER)
  - Nonroad Emission Model: NONROAD (EPA, 2008)


EI-RDMS DATABASE
them.sql
POINTER
GRIDDER
Stack Information Emission Model
MM5/WRF
GIS Database Emission Model
Emission Point (lola)
them.zp
Emission Grid (30s)
them.csv
them.csv
Domain
asc2shp.exe
them.kit
Basic Emission Processor
Temporal
Chem. Spec
Projection
them.tap
them.chs
them.prj
EMproc = EIprj x TAP x CHS
emiss.shp
emiss.shx
emiss.dbf
SHAPEFILE
GIS
prompt > them.exe
3> them.exe
emiss.files
Merge
merge.exe
2> them.exe
Gap Fill
mesh.exe
gapfill.exe
1> them.exe
Emission ASCII
asc2grd.exe
asc2uam.exe
asc2nc.exe
BINARY
UAM-IV
IOAPI NETCDF
emiss.grd
emiss.uam
emiss.nc
REGCM
CAMx / UAM / REMSAD
CMAQ MAQSIP
GrADS
PAVE
VERDI
LITERATURE

On-Road Traffic Emission Model: DRIVER

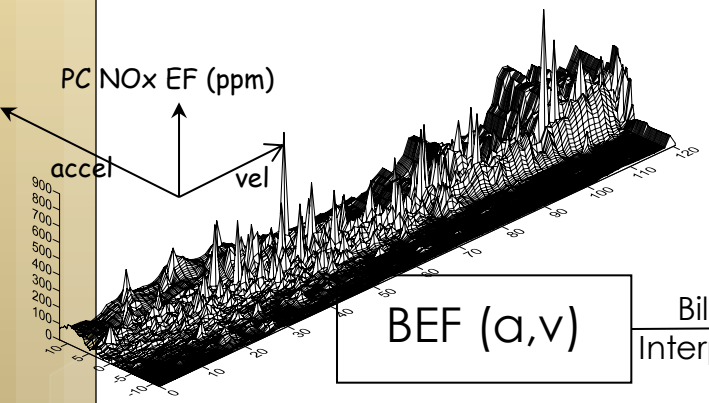


Thai Road Link Network (Left) & Traffic Intersection (Right)

180+ PCD Lab Test Sampling

No.	Vehicle Class	Fuel	Size	Age	Sample Sizes	จำนวนที่ได้รับ	จำนวนที่ขาด	หมายเหตุ
1	Motorcycle	Gasoline	All	0-5 Yrs	10	7 คัน	3 คัน	
2	Motorcycle	Gasoline	All	5-10 Yrs	10	7 คัน	3 คัน	
3	Motorcycle	Gasoline	All	> 10 Yrs	10	10 คัน	-	
4	Personal Car (Light Duty Gasoline Vehicle)	Gasoline	All	0-5 Yrs	10	10 คัน	-	
5	Personal Car (Light Duty Gasoline Vehicle)	Gasoline	All	5-10 Yrs	10	10 คัน	-	
6	Personal Car (Light Duty Gasoline Vehicle)	Gasoline	All	> 10 Yrs	10	12 คัน	-	
7	Personal Car (Light Duty CNG Vehicle)	CNG	All	0-5 Yrs	10	5 คัน	5 คัน	
8	Personal Car (Light Duty CNG Vehicle)	CNG	All	5-10 Yrs	10	4 คัน	6 คัน	
9	Personal Car (Light Duty CNG Vehicle)	CNG	All	> 10 Yrs	10	2 คัน	8 คัน	
10	Pick-Up (Light Duty Diesel Vehicle)	Diesel	All	0-5 Yrs	10	6 คัน	4 คัน	
11	Pick-Up (Light Duty Diesel Vehicle)	Diesel	All	5-10 Yrs	10	28 คัน	-	
12	Pick-Up (Light Duty Diesel Vehicle)	Diesel	All	> 10 Yrs	10	8 คัน	2 คัน	
13	Truck (Heavy Duty Vehcile)	Diesel and CNG	6 Wheels	0-5 Yrs	10	-	10 คัน	
14	Truck (Heavy Duty Vehcile)	Diesel and CNG	6 Wheels	5-10 Yrs	10	7 คัน	3 คัน	
15	Truck (Heavy Duty Vehcile)	Diesel and CNG	6 Wheels	> 10 Yrs	10	รวมกัน 34 คัน	รวมขาด 36 คัน	ไม่ได้ระบุจำนวนล้อ
16	Truck (Heavy Duty Vehcile)	Diesel and CNG	10 Wheels	0-5 Yrs	10			
17	Truck (Heavy Duty Vehcile)	Diesel and CNG	10 Wheels	5-10 Yrs	10			
18	Truck (Heavy Duty Vehcile)	Diesel and CNG	10 Wheels	> 10 Yrs	10			
19	Truck (Heavy Duty Vehcile)	Diesel and CNG	> 10 Wheels	0-5 Yrs	10			
20	Truck (Heavy Duty Vehcile)	Diesel and CNG	> 10 Wheels	5-10 Yrs	10			
21	Truck (Heavy Duty Vehcile)	Diesel and CNG	> 10 Wheels	> 10 Yrs	10			
22	BUS (Heavy Duty Vehicle)	Diesel and CNG	All	0-5 Yrs	10	-	10 คัน	
23	BUS (Heavy Duty Vehicle)	Diesel and CNG	All	5-10 Yrs	10	-	10 คัน	
24	BUS (Heavy Duty Vehicle)	Diesel and CNG	All	> 10 Yrs	10	25 คัน	-	
25	Personal Car (Light Duty LPG Vehicle)	LPG	All	5-10 Yrs	-	7 คัน	-	Other Fuel

DRIVER Concept & Run



Traffic Information

drive.in

BEF (a,v)

bef.csv

Bilinear Interpolation

DRIVER

drive.out

Output

- Hourly Emission
- Unit Conversion
- Traffic Data
- Driving Pattern
- Driving Time
- Amb. Temp
- Day of the week

POINT	FROM	TO	BIKE	MC	PC	PU	BUS1	BUS2	BUS3	HDV1	HDV2	HDV3	HDV4	HDV5	ELSE
A1	0.00	0.15	0	2	8	0	0	0	0	4	0	0	0	0	0
A1	0.15	0.30	0	5	3	0	0	0	0	0	0	0	0	0	0
A1	0.30	0.45	0	6	5	1	0	0	0	4	0	0	0	0	0
A1	0.45	1.00	0	0	5	1	0	0	0	2	0	0	0	0	0
A1	1.00	1.15	0	1	8	2	0	0	0	2	0	0	0	0	0
A1	1.15	1.30	0	5	4	0	0	0	0	3	0	0	0	0	0
A1	1.30	1.45	0	0	3	0	0	0	0	1	0	0	0	0	0
A1	1.45	2.00	0	1	1	0	0	0	0	2	0	0	0	0	0
A1	2.00	2.15	1	1	0	0	0	0	0	3	0	0	0	0	0
A1	2.15	2.30	0	1	4	0	0	0	0	4	0	0	0	0	0
A1	2.30	2.45	0	2	3	0	0	0	0	1	0	0	0	0	0
A1	2.45	3.00	0	2	1	0	0	0	0	0	0	0	0	0	0
A1	3.00	3.15	0	1	0	1	0	0	0	2	1	0	0	0	0
A1	3.15	3.30	0	1	0	0	0	0	0	0	1	0	0	0	0
A1	3.30	3.45	0	2	2	0	0	0	0	2	1	0	0	0	0
A1	3.45	4.00	0	3	1	0	0	0	0	1	0	0	0	0	0
A1	4.00	4.15	0	0	3	1	0	0	0	0	0	0	0	0	0
A1	4.15	4.30	0	1	1	0	0	0	0	1	0	0	0	0	0
A1	4.30	4.45	0	4	1	1	0	0	0	4	1	0	0	0	0
A1	4.45	5.00	0	6	3	1	0	0	0	2	0	0	0	0	0
A1	5.00	5.15	0	6	0	0	0	0	0	1	0	0	0	0	0
A1	5.15	5.30	0	6	2	0	0	0	0	3	0	0	0	0	0
A1	5.30	5.45	0	6	5	1	1	0	0	2	0	0	0	0	0
A1	5.45	6.00	0	5	1	1	0	0	0	4	1	0	0	0	0
A1	6.00	6.15	0	7	5	3	3	0	0	7	0	0	0	0	0
A1	6.15	6.30	0	0	0	3	0	0	0	0	2	0	0	0	0
A1	6.30	6.45	0	3	1	0	0	0	0	9	0	0	0	0	0
A1	6.45	7.00	0	14	4	3	1	0	0	4	0	0	0	0	0
A1	7.00	7.15	0	12	8	0	0	0	0	2	1	0	0	0	0
A1	7.15	7.30	0	8	9	0	0	0	0	5	0	1	0	0	0
A1	7.30	7.45	0	9	11	1	2	0	0	3	0	1	0	0	0
A1	7.45	8.00	0	20	4	0	0	0	0	10	0	0	0	0	0

POINT	FROM	TO	NOX	THC	CO	CO2
A1	0.00	1.00	4.76	243.60	110.64	99.25
A1	1.00	2.00	3.60	133.03	60.55	71.67
A1	2.00	3.00	3.10	114.15	52.97	59.86
A1	3.00	4.00	2.31	130.17	59.29	46.42
A1	4.00	5.00	3.34	204.34	92.86	69.13
A1	5.00	6.00	4.64	423.21	191.99	104.00
A1	6.00	7.00	8.60	447.06	203.56	168.26
A1	7.00	8.00	10.48	903.72	409.82	237.28
A1	8.00	9.00	11.66	1031.69	467.98	262.79
A1	9.00	10.00	10.09	849.19	384.96	228.70
A1	10.00	11.00	14.68	1253.95	568.73	329.40
A1	11.00	12.00	14.28	1145.14	519.34	316.94
A1	12.00	13.00	15.10	911.60	414.31	317.21
A1	13.00	14.00	12.09	762.35	346.13	258.19
A1	14.00	15.00	13.33	890.57	405.30	282.92
A1	15.00	16.00	11.63	617.50	280.36	243.43
A1	16.00	17.00	15.16	966.00	438.61	321.34
A1	17.00	18.00	15.46	1094.04	496.16	339.29
A1	18.00	19.00	15.72	1779.65	806.42	379.36
A1	19.00	20.00	15.36	1273.45	577.63	343.69
A1	20.00	21.00	13.07	961.94	436.66	283.21
A1	21.00	22.00	11.95	1051.05	477.55	270.37
A1	22.00	23.00	10.16	704.02	319.66	217.51
A1	23.00	0.00	8.45	521.06	236.58	180.16

Other Emission Models

- Biomass Burning Emission Model
  - Emission: MODIS Hotspot (Giglio), LDD Landuse (LDD) & EF_{local}
  - Model: GFEDv3 (Giglio et al., 2010)
- CEMS Emission Model
  - Emission: CEMS Data Networks (EGAT)
  - Model: CEMScan of SMOKE (EPA)
- Nonroad Emission Model
  - Emission: NSO Survey & Local EF
  - Model: NONROAD (EPA, 2008)
- Biogenic Emission Model:
  - Emission: Local LDD Landuse (LDD)
  - Model: BIOME / BEIS (Pierce, 2002), MEGAN (Guenther, 2006)

Air Emission Inventory for Thailand

Industrial Sector

	NO_x	SO_2	CO	NH_3	NMVOC	PM_{10}	$PM_{2.5}$	BC	OC	CO2	CH4
Power Generation	**150,644**	**12,381**	**77,038**	**4,027**	**13,424**	**6,465**	**2,861**	**1,265**	**744**	**119,863,909**	**-**
EGAT/IPP	109,595	3,007	68,791	3,394	11,314	3,931	1,739	769	452	103,505,091	-
SPP/VSPP	41,049	9,374	8,247	633	2,110	2,534	1,121	496	292	16,358,819	-
Industrial Facilities	**55,506**	**268,269**	**672,018**	**880**	**17,123**	**249,516**	**-**	**49,453**	**62,995**	**-**	**-**
Industrial Process	**74,637**	**301,391**	**118,108**	**898**	**16,641**	**153,045**	**-**	**47,112**	**64,956**	**-**	**-**
Offshore facilities	**321**	**40**	**436**	**-**	**-**	**47,153**	**-**	**-**	**-**	**3,076,132**	**-**
Total	**281,107**	**582,082**	**867,600**	**5,804**	**47,188**	**456,179**	**2,861**	**97,829**	**128,695**	**122,940,041**	**-**

Air Emission Inventory for Thailand

Transportation Sector

	NO_x	SO_2	CO	NH_3	NMVOC	PM_{10}	$PM_{2.5}$	BC	OC	CO_2	CH_4
On-road	**436,990**	-	**3,880,687**	-	**1,268,941**	**268,369**	-	-	-	**62,988,799**	-
Roads / Highways	402,035	N/A	3,546,732	-	1,101,997	259,819	-	-	-	60,639,910	-
Intersection	34,955	N/A	333,955	-	166,944	8,550	-	-	-	2,348,889	-
Non-road	**18,011**	**935**	**14,933**	-	**8,391**	**317**	**201**	-	-	**3,038,049**	**684**
Aviation	13,591	935	13,533	-	6,614	-	-	-	-	2,955,649	563
Locomotives	3,469	N/A	880	-	224	103	-	-	-	82,400	-
Navigation	951	N/A	521	-	1,553	214	201	-	-	N/A	121
Total	**455,001**	**935**	**3,895,621**	-	**1,277,332**	**268,686**	**201**	-	-	**66,026,848**	**684**

Air Emission Inventory for Thailand

Domestic Sector

	NO_x	SO_2	CO	NH_3	NMVOC	PM_{10}	$PM_{2.5}$	BC	OC	CO_2	CH_4
Household	**9,151**	**-**	**3,337**	**16,595**	**1,053**	**782**	**70**	**-**	**-**	**18,210,765**	**-**
Cooking	9,082	-	1,233		324	259	-	-	-	8,693,125	-
Human & Pets	-	-	-	16,436	-	-	-	-	-	9,326,694	-
Smoking	69		2,104	158	728	522	70	-	-	190,947	-
Incinerator	**1,203**	**1,565**	**4,913**	**-**	**923**	**1,797**	**22**	**-**	**-**	**266,575**	**-**
Crematoria	968	703	3,527	-	828	1,414	17	-	-	238,595	-
Municiple Solid Waste	211	842	1,306	-	72	345	4	-	-	23,512	-
Total	**10,354**	**1,565**	**8,250**	**16,595**	**1,976**	**2,579**	**92**	-	-	**18,477,341**	-

Air Emission Inventory for Thailand

Agricultural Sector

	NO_x	SO_2	CO	NH_3	NMVOC	PM_{10}	$PM_{2.5}$	BC	OC	CO_2	CH_4
Biomass Burning	192,748	26,720	5,044,870	78,952	286,188	595,268	299,557	36,856	255,169	58,540,020	456,142
Farm Machinery	5,810	-	3,381	1	1,541	896	843	-	-	108,936	-
Livestock	1,253	-	-	286,797	-	-	-	-	-	11,891,083	950,960
Fertilizer	-	-	-	66,998	-	-	-	-	-	-	-
Crops	-	-	-		588,844	-	-	-	-	-	148,317
Total	199,811	26,720	5,048,251	432,749	876,574	596,163	300,401	36,856	255,169	70,540,039	1,555,418

Air Emission Inventory for Thailand

Natural Sector

	NO_x	SO_2	CO	NH_3	NMVOC	PM_{10}	$PM_{2.5}$	BC	OC	CO_2	CH_4
Biogenics	-	-	-	195,543	907,807	-	-	-	-	-	108,994
Vegetation	-	-	-		907,807	-	-	-	-	N/A	-
Soil	-	-	-	195,543		-	-	-	-	N/A	-
Termite	-	-	-			-	-	-	-		108,994
Non-biogenics	1,202	-	-	-	-	-	-	-	-	-	-
Lightning	1,202	-	-	-	-	-	-	-	-	-	-
Oceanic	-	-	-	-	-	N/A	N/A	-	-	-	-
total	1,202	-	-	195,543	907,807	-	-	-	-	N/A	108,994

Summary of Air Emission Inventory for Thailand

Result

	NO_x	SO_2	CO	NH_3	NMVOC	PM_{10}	$PM_{2.5}$	BC	OC	CO_2	CH_4
ANTHROPOGENIC	946,273	611,303	9,819,722	455,148	2,203,069	1,323,607	303,554	134,685	383,864	277,984,269	1,556,102
NATURAL	1,202	-	-	195,543	907,807	-	-	-	-	N/A	108,994
Total	947,475	611,303	9,819,722	650,691	3,110,876	1,323,607	303,554	134,685	383,864	**277,984,269**	1,665,096

Comparison with REAS 2008