EMISSION INVENTORIES IN THAILAND FROM INDUSTRIAL AND BIOMASS BURNING SECTOR IN 2011

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Outline

- Objective
- Background
- Methodology
- Results and Discussions
- Conclusions

Objectives

Estimate air pollutants emission from Industrial Sector for 2011

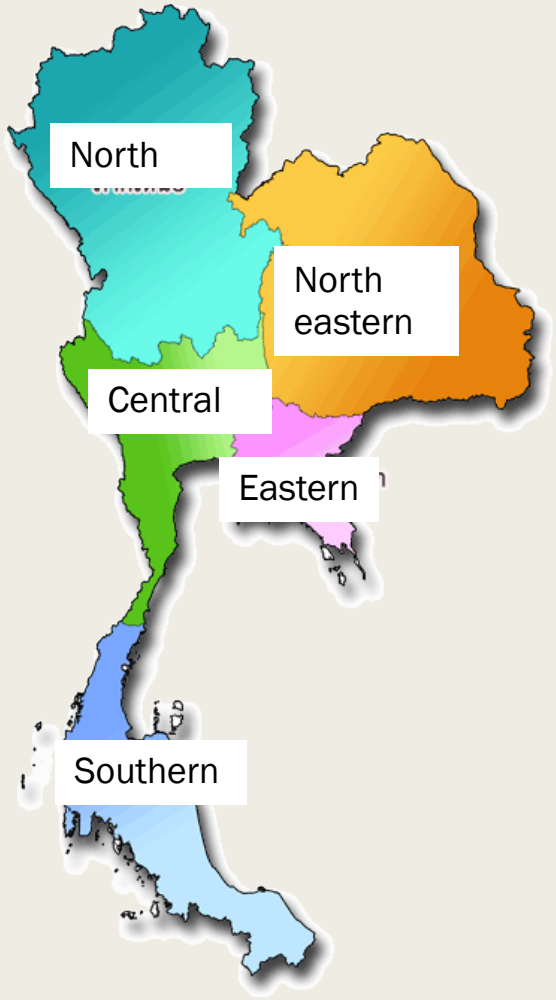
Estimate air pollutants emission from biomass open burning in agricultural and forest area by using the Satellite based and ground report fire data for year 2010-2013

Background

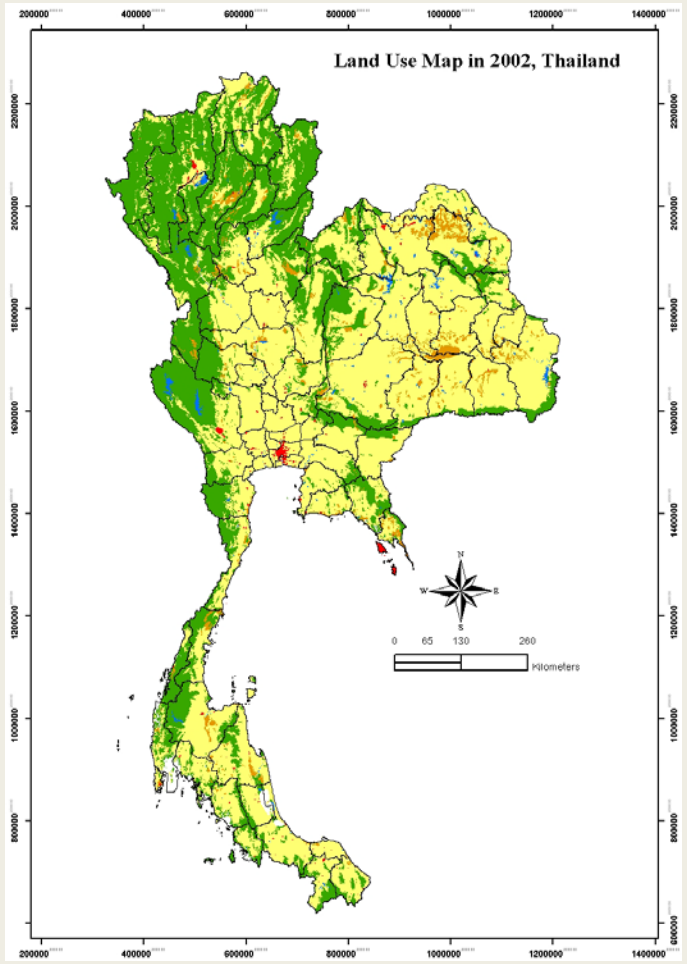
THAILAND

Total Land 514,310 km^2 (5 regions)

- **Forestland 183,899 km^2**
- **Cropland 305,642 km^2**
- **Urban Area 2,957 km^2**
- **Grassland 17,742 km^2**
- **Irrigation Area 4,070 km^2**



Forest Area



Types of Forest

1. Evergreen

1.1 Tropical Rain Forest
1.2 Dry Evergreen Forest
1.3 Hill Evergreen Forest
1.4 Pine Forest
1.5 Swamp Forest
1.6 Mangrove Swamp Forest
1.7 Beach Forest

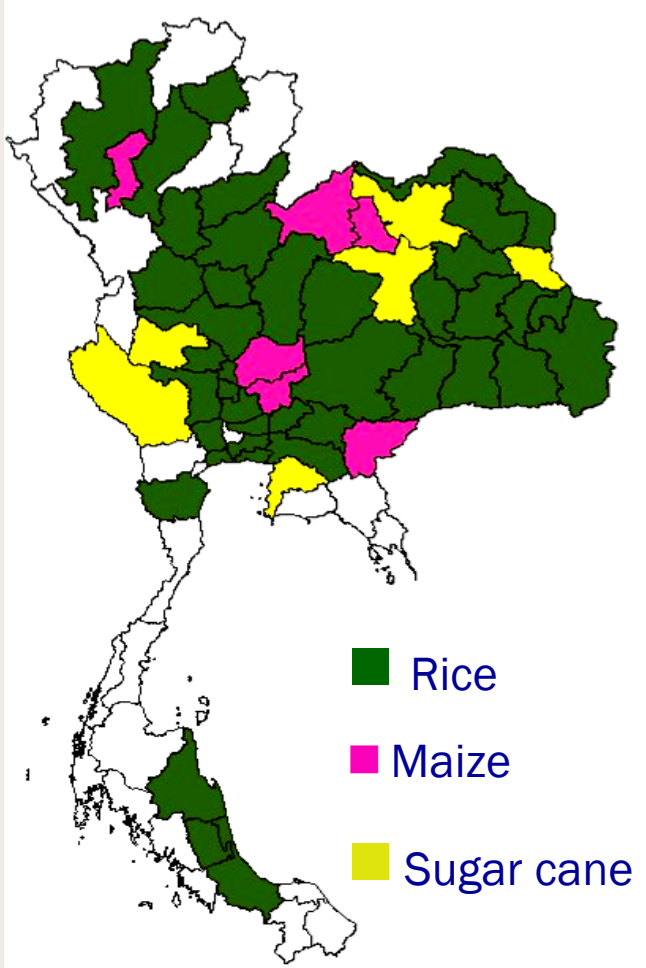
2.Deciduous

2.1 Mixed Deciduous Forest
2.2 Deciduous Dipterocarp Forest
2.3 Grassland

Forest area classified by region in 2013

Region	Region area (km^2)	Forest area (km^2)	Percent
North	171,981	90,054	52.36
North East	167,717	25,302	15.09
Central	67,498	22,132	32.79
East	36,621	8,222	22.45
South	73,813	17,681	23.95
Total	517,630	163,391	31.57

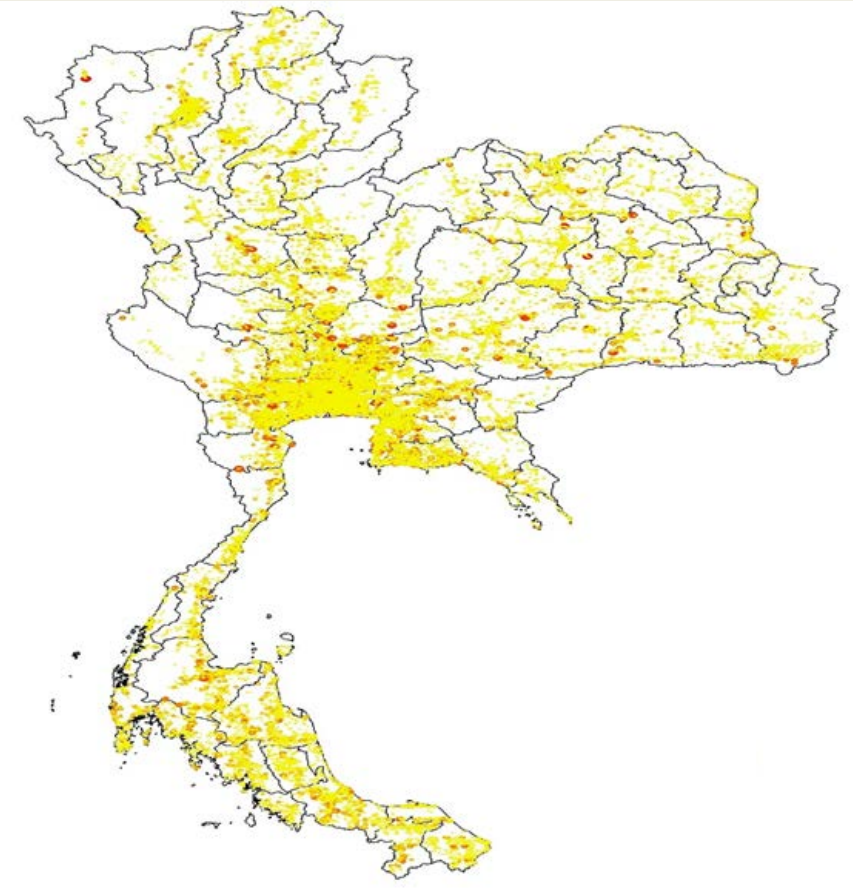
Agriculture Area



Crop type	Production (million tons/year)			
	2010	2011	2012	2013
Rice	34.61	36.08	39.17	36.85
Maize	4.86	5.02	4.97	4.97
Sugarcane	68.81	95.95	98.04	99.6

Region	Region area (km^2)	Agricultural area (km^2)	Percent
North	171,981	48,028	27.94
North East	167,717	76,498	45.61
Central	67,498	26,320	38.99
East	36,621	5,527	15.09
South	73,813	2,372	3.21
Total	517,630	158,745	30.67

Industrial Sector



- There are 93,836 registered factories in 2011.
- Most of factories are located in central and eastern part of country.

Top 5 in number of industries

Type of Industries	Number of factories	percent
Metal Products	9,030	9.6%
Automobile and auto part	6,566	6.9%
Agricultural – Crops & Products	5,942	6.3%
Plastic Product	5,392	5.7%
Non-metal Product	4,743	5.1%

Methodology

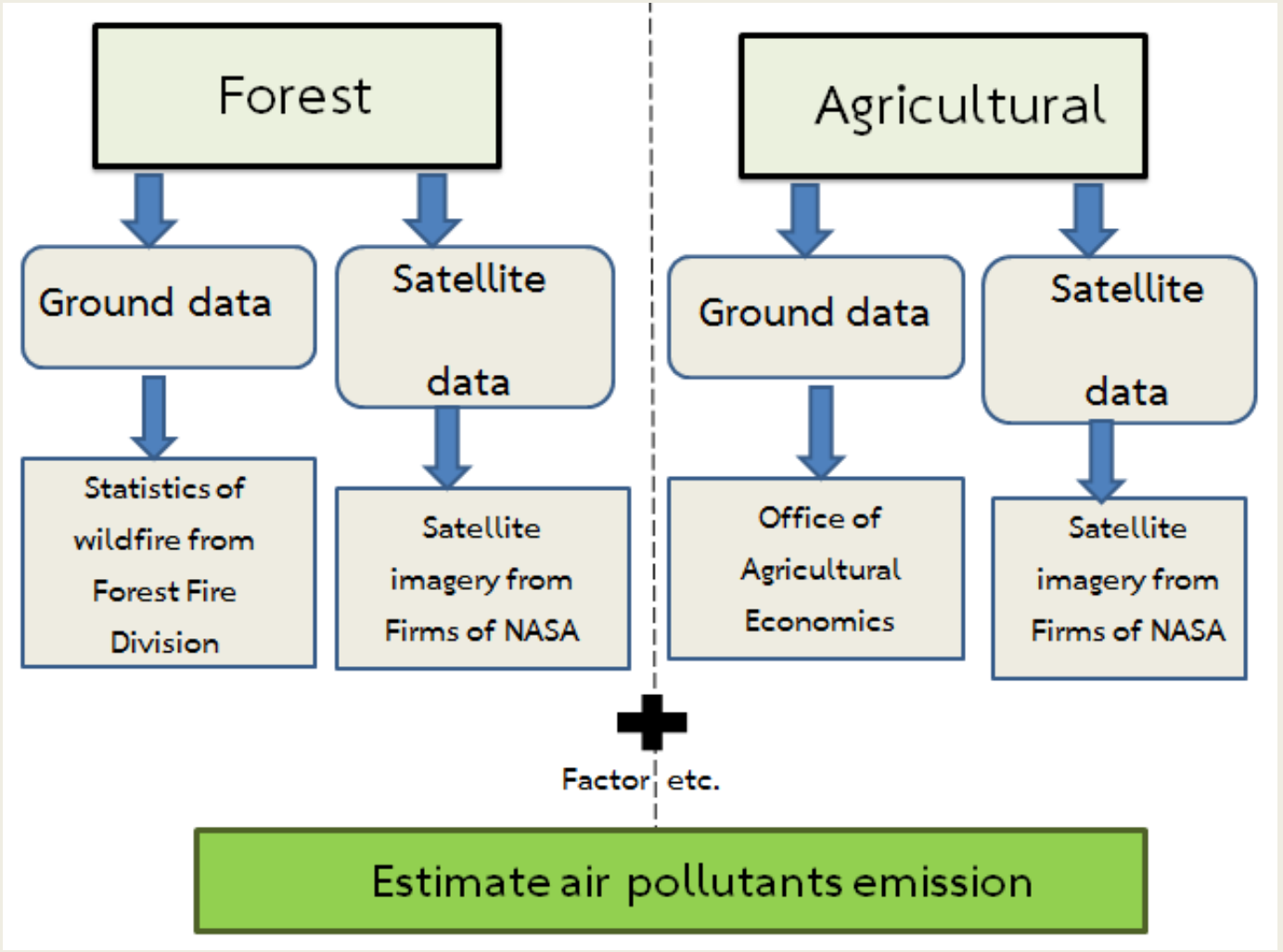
- Emission Factor Technique

$$E_i = M \times EF_i$$

E_i = Emission (g or kg)
M = Amount of biomass burned (kg) or
Energy Usage (TOE, ton of equivalent oil)
EF_i = Emission factor (g/kg of dry biomass or kg/toe)
i = Species of air pollutant

Methodology

Biomass Burning



Methodology

Amount of biomass burned (kg), M

$$M = A \times B \times E \times F$$

A = Burned area (m^2)
B = Dry biomass density (kg/m^2)
E = Combustion efficiency
F = Fraction burned

For Forest Fire

1. Ground report from Forest Fire Control Division
2. Satellite data algorithm MOD14
3. Satellite data algorithm MCD45

For Agricultural burning

1. Satellite data algorithm MOD14
2. Satellite data algorithm MCD45

$$M = P \times D \times \beta \times F \times C$$

P = Annual production of crop (kg)
D = Ratio of residue to crop product
β = Combustion efficiency
F = Fraction burned
C = Burned area percent

For Agricultural burning

Agricultural statistics from Office of Agricultural Economics

Methodology

Emission Factor (EF_i)

Forest Fire

M.O. Andreae et al (2001)

Forest type	Emission factor (g/kg of dry biomass)				
	CO	CO_2	NO_x	TPM	$PM_{2.5}$
Evergreen needleleaf forest	107	1,569	4.60	17.60	13.00
Evergreen broadleaf forest	104	1,580	2.45	9.10	8.50
Deciduous needleleaf forest	107	1,569	4.60	17.60	13.00
Deciduous broadleaf forest	107	1,569	4.60	17.60	13.00
Mixed forest	107	1,569	4.60	17.60	13.00
Woodland	86	1,591	5.29	12.98	9.20
Wooded grassland	65	1,613	5.98	8.36	5.40
Closed shrubland	86	1,591	5.29	12.98	9.20
Open shrubland	65	1,613	5.98	8.36	5.40
Grassland	65	1,613	5.98	8.36	5.40
Cropland	92	1,515	3.83	13.00	3.90

Methodology

Emission Factor (EF_i)

Agricultural Burning

Kanokkanjana K. (2010)

Crop type	Emission factor (g/kg of dry biomass)			
	CO	CO_2	$PM_{2.5}$	BC
Maize	68.11	1,186	8.72	0.55
Rice	133	1,185	28	0.77
Sugarcane	123.76	1,181	20.31	071

Methodology

Industrial Sector

Amount of Energy Usage (TOE), M

- Calculated based on energy usage of 4900 factories that reported to Department of Alternative Energy Department and Efficiency, Ministry of Energy
- Data of 4900 factories were classified according to 107 group according to of Thailand Standard Industrial Classification(TSIC)
- Energy usage of factories in each of 107 group were interpolated from average energy usage(TOE)/ horse power installed of representative of factories in each type
- Total of estimated energy use in Industrial sector were then compared with amount of Energy use in industrial sector that report in Energy Statistics of Thailand. The difference of estimated data and national data is then used to adjusted the estimated data until the discrepancy from national data is less than 5%.

Methodology

Industrial Sector

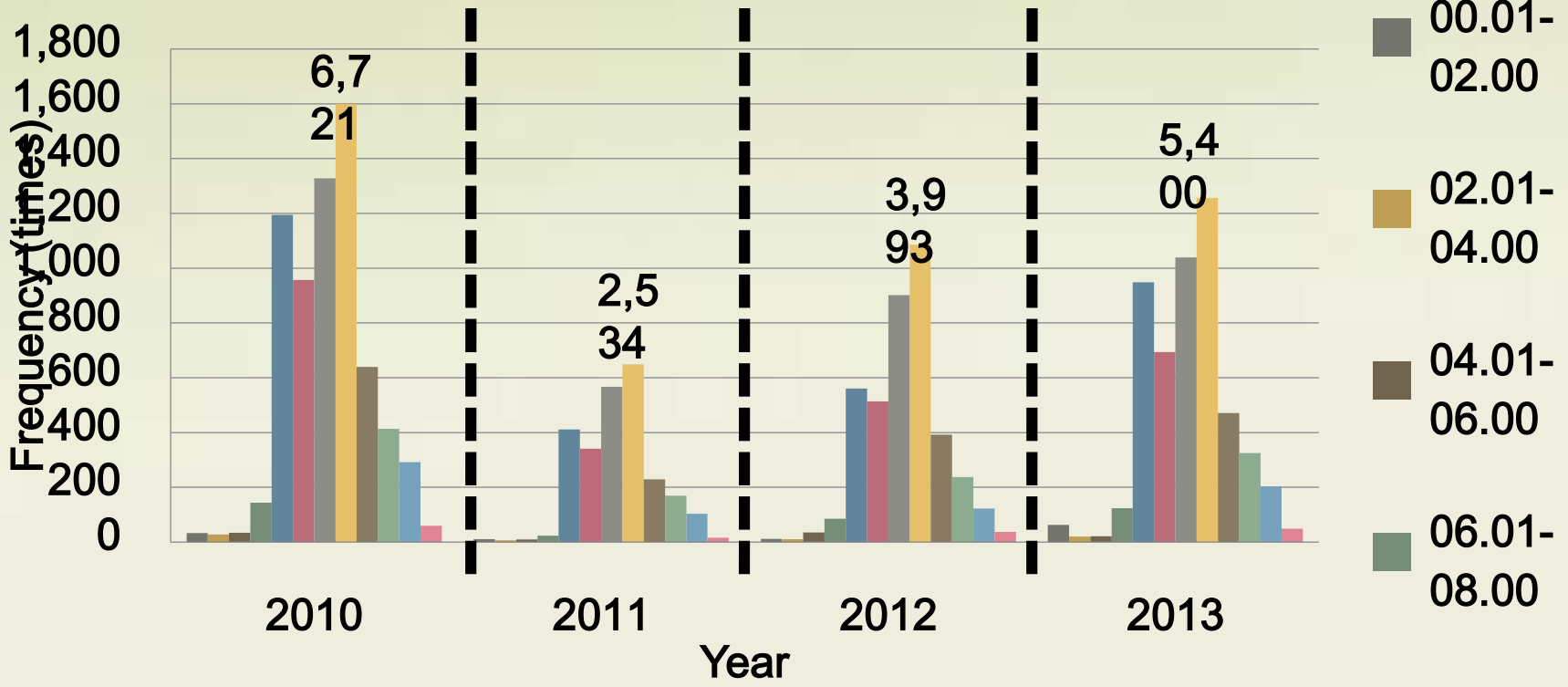
Emission Factor (EF_i)

Fuel types		Coal	Diesel	Kerosene	Fuel oil
Pollutant (lbs/toe)	CO	4.987	37.708	2.126	19.029
	SO_X	59.829	11.511	32.796	171.582
	NO_X	24.707	175.045	10.528	36.142
	VOC	0.315	13.892	0.358	3.057
	PM_{10}	3.372	12.305	1.252	10.348

compiled by ICLEI(local Gevernments for Sustainabilty)

Results and Discussions

- 2 hrs. distribution of Fire frequency in Forest Area of ground data

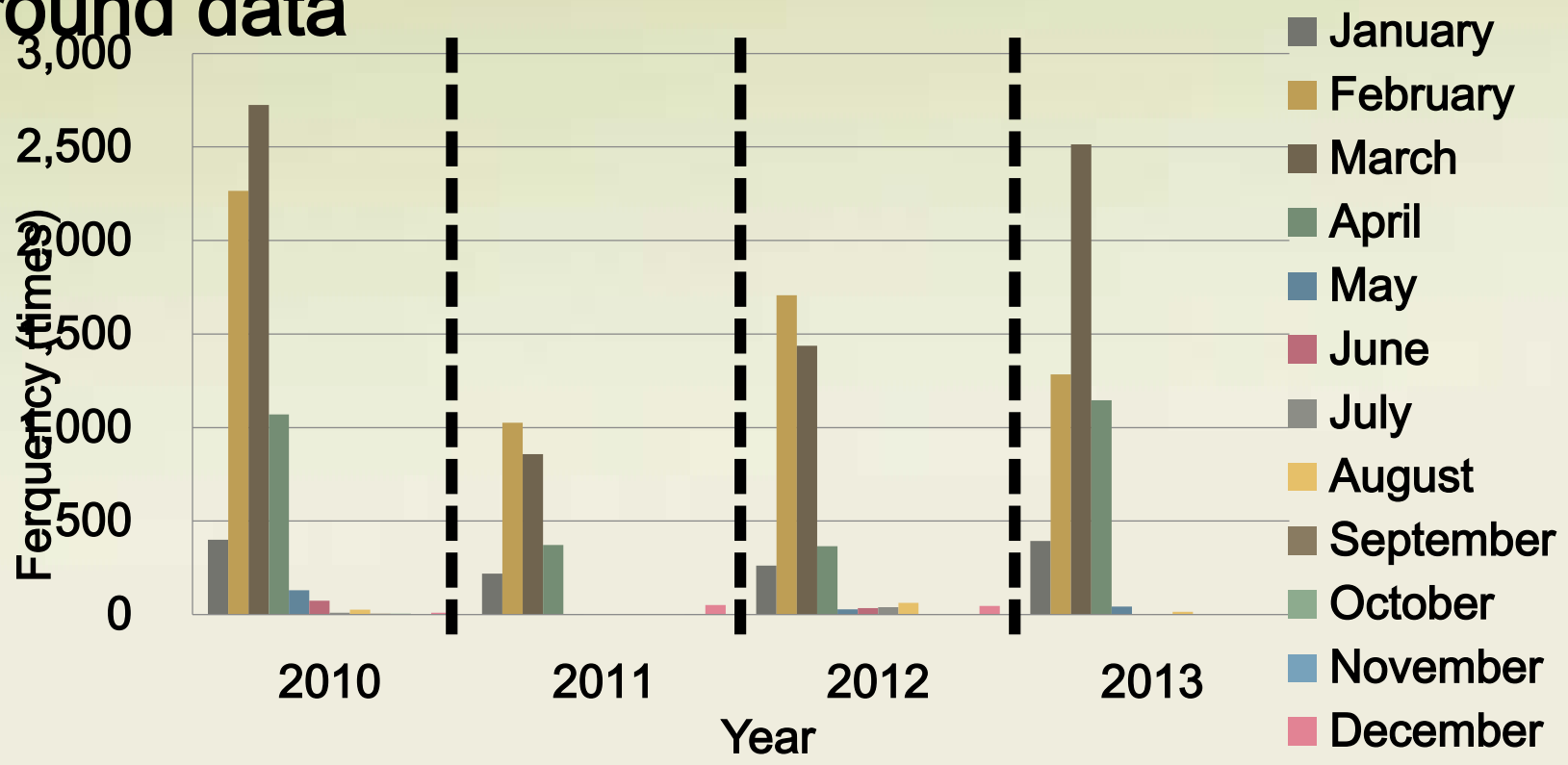


Time : 2 PM – 4 PM ,follow by noon – 2 PM

และ 8 AM – 10 AM

Results and Discussions

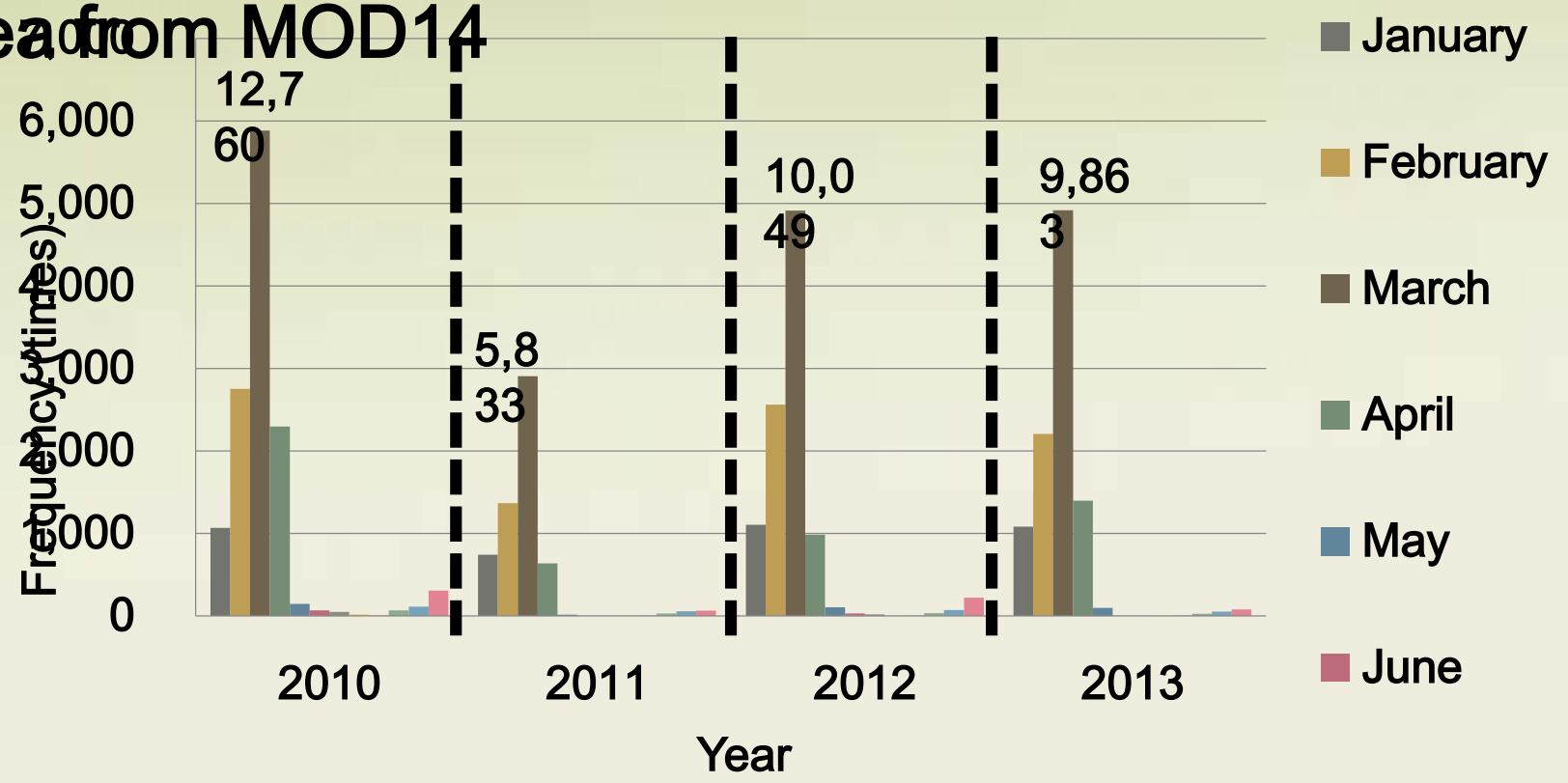
➢ **Monthly distribution of Fire frequency in Forest Area of ground data**



Month : February and March ,follow by April and January

Results and Discussions

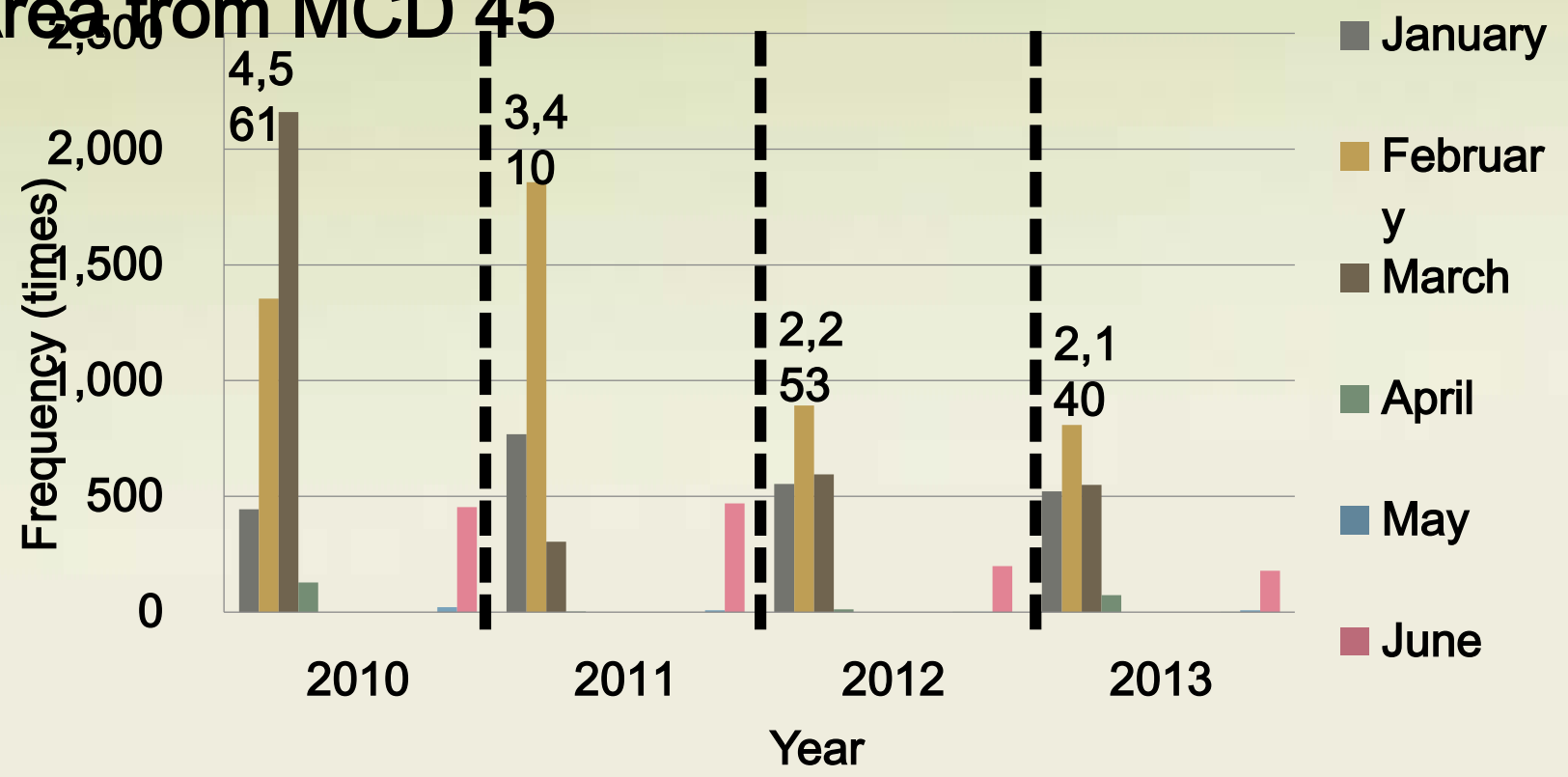
- Monthly distribution of Fire frequency in Forest Area from MOD14



Month : March ,follow by February April and January

Results and Discussions

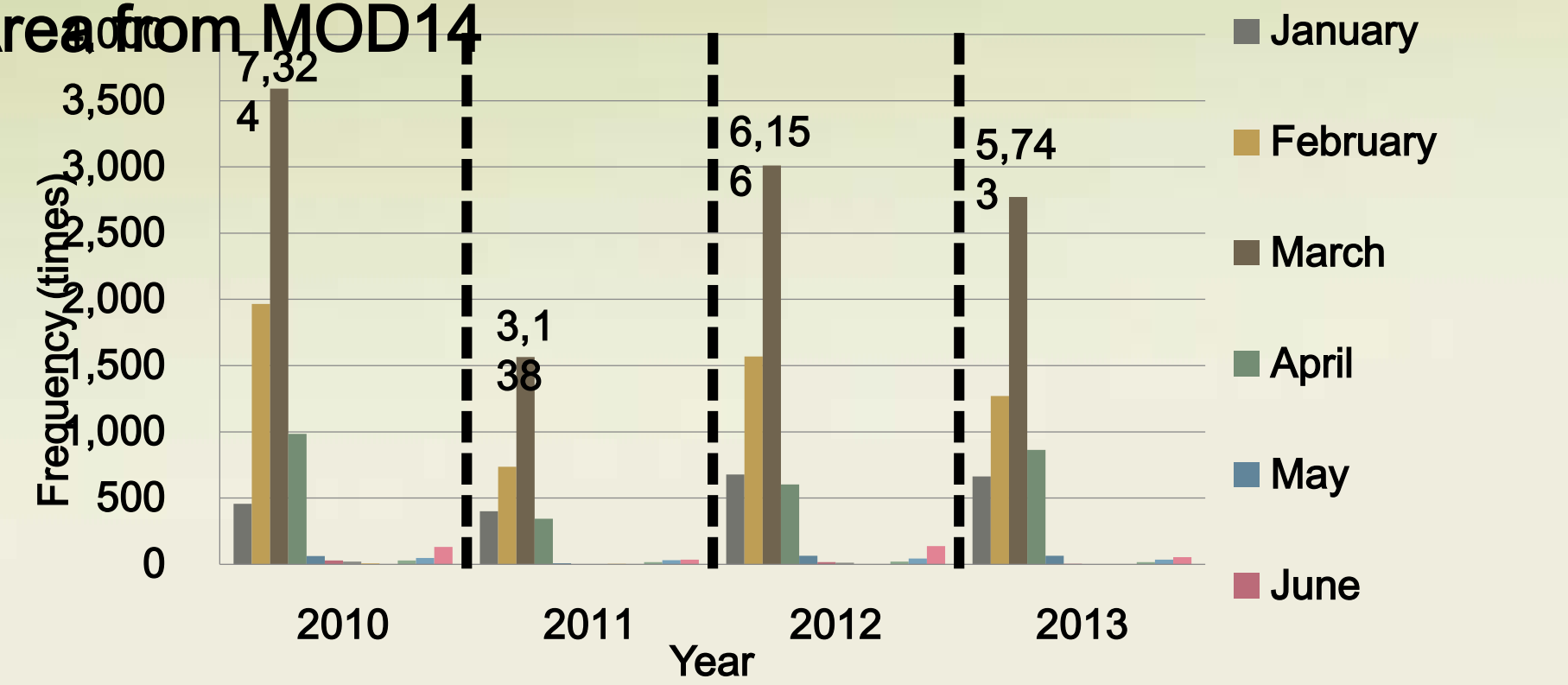
➢Monthly distribution of Fire frequency in Forest Area from MCD 45



Month : February and March ,follow by January and December

Results and Discussions

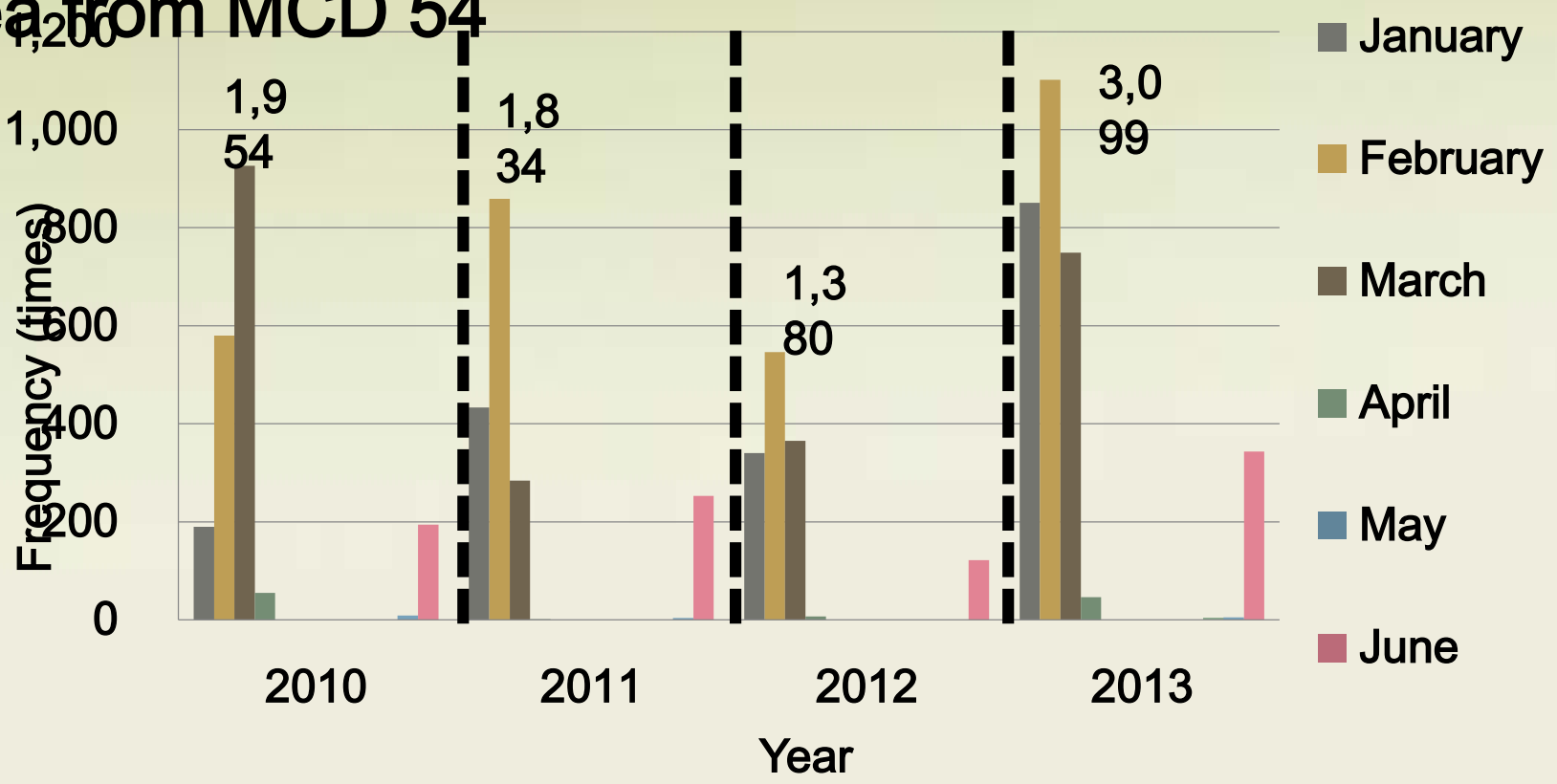
- Monthly distribution of Fire frequency in Agricultura; Area from MOD14



Month : March ,follow by February April and January

Results and Discussions

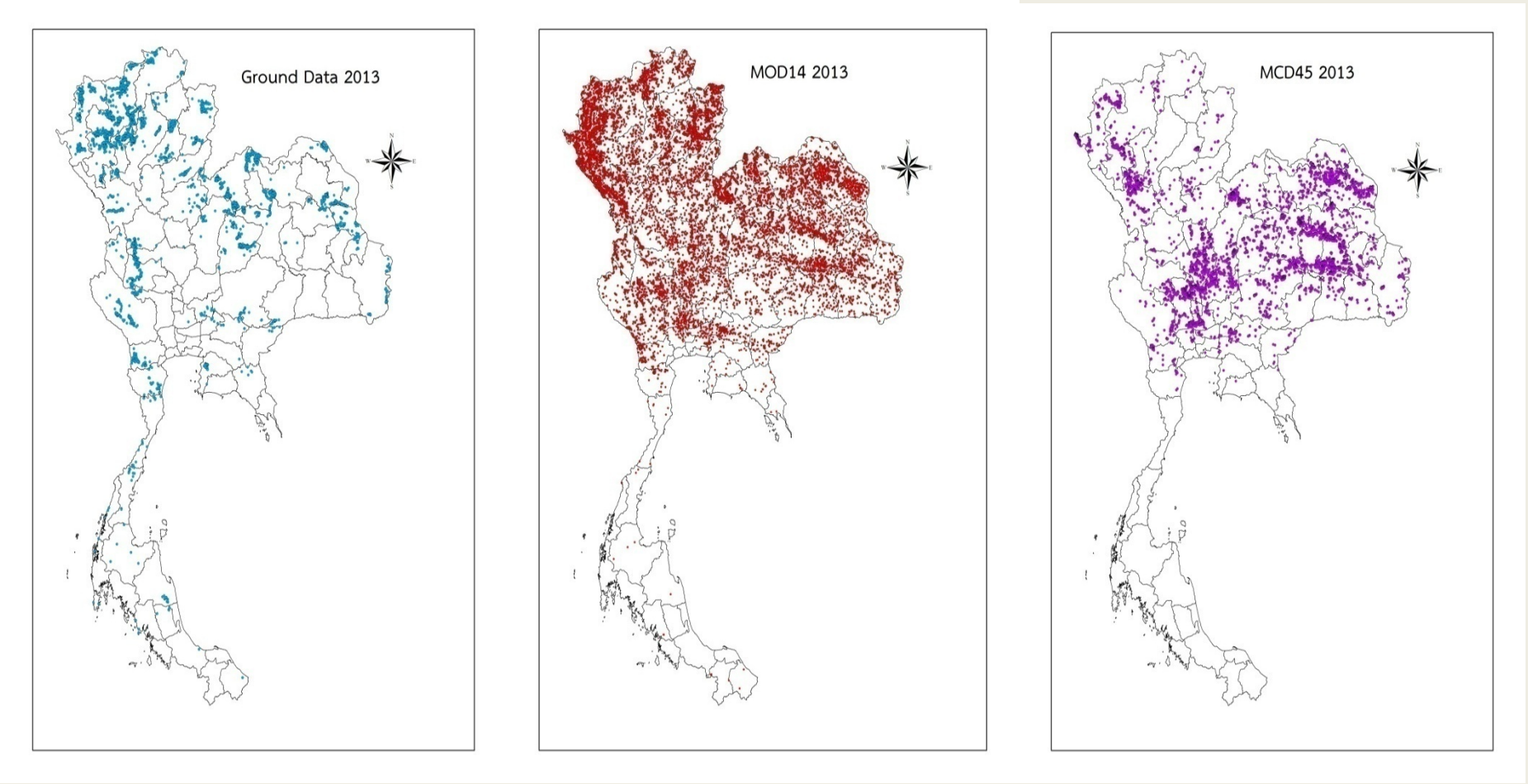
- Monthly distribution of Fire frequency in Agricultura; Area from MCD 54



Month : February and March ,follow by January and December

Results and Discussion

Spatial Distribution of Fire data



Results and Discussion

Table 1 Air pollutants emission in 2010

Vegetable type		Emission (tons)					
		CO	CO_2	NO_x	TPM	$PM_{2.5}$	BC
Forest Fire	Ground data	68,050	1,008,224	2,545	9,684	7,488	-
	MOD14	5,922,002	87,965,519	234,142	881,629	670,750	-
	MCD45	566,927	8,404,517	24,314	91,223	67,676	-
Agricultural Burning	Ground data	1,285,512	11,917,138	-	-	239,245	7,418
	MOD14	447,432	4,759,401	-	-	81,919	2,772
	MCD45	56,054	655,198	-	-	10,158	366

Table 2 Air pollutants emission in 2011

Vegetable type		Emission (tons)					
		CO	CO_2	NO_x	TPM	$PM_{2.5}$	BC
Forest Fire	Ground data	19,909	292,192	847	3,238	2,400	-
	MOD14	1,939,351	28,905,117	80,878	301,110	225,692	-
	MCD45	522,913	7,812,592	22,435	83,740	62,177	-

Results and Discussion

Table 3 Air pollutants emission in 2012

Vegetable type		Emission (tons)					
		CO	CO_2	NO_x	TPM	$PM_{2.5}$	BC
Forest Fire	Ground data	36,063	535,291	1,312	4,988	3,894	-
	MOD14	4,817,853	71,511,766	191,904	723,151	548,762	-
	MCD45	374,870	5,539,171	16,156	60,953	45,104	-
Agricultural Burning	Ground data	1,653,686	15,380,266	-	-	303,418	9,535
	MOD14	374,141	3,886,894	-	-	68,835	2,290
	MCD45	26,695	268,383	-	-	5,147	162

Table 4 Air pollutants emission in 2013

Vegetable type		Emission (tons)					
		CO	CO_2	NO_x	TPM	$PM_{2.5}$	BC
Forest Fire	Ground data	48,477	712,746	1,996	7,697	5,747	-
	MOD14	4,652,430	69,094,906	184,368	694,314	527,828	-
	MCD45	346,009	5,280,949	15,425	54,643	40,481	-

Results and Discussion

- Emissions in Forest Fire Area
  - MOD 14 was the best of the three sources of data due the larger coverage area and similar trend to ground data. However, emissions were systematic overestimated since average of burned area in Thailand is far less than 1 km^2 approximation.
- Emissions in Agricultural Area
  - Ground based data gave more reasonable amount of emissions but lack of spatial and temporal distribution.
  - Satellite Based data, MCD45 was better than MOD 14 from capability to discover peak of fire

Results and Discussions

Emission from Industrial Sector in 2011

Air Pollutants	Emissions (tons/y)
NO_x	361,186
SO_2	268,684
CO	812,180
VOCs	94,033
PM_{10}	64,857

Conclusion

For Biomass Burning

Based on the best dataset for emission estimation

- *Air Pollutants that released from forest fire and agricultural burning is almost at the same rate*

	emissions(tons/yr)		
	CO	CO2	PM2.5
Forest Fire	1,939,351	28,905,117	225,692
Agricultural Burning	1,575,224	14,666,636	287,999

Conclusion

When compare air emissions from Industrial sector and Biomass Burning

- Industrial Sector released released NO_x more than biomass burning and other species such as SO2, VOCs in high amount
- Biomass Burning released CO and PM more than industrial sector

	emissions(tons/yr)						
	CO	CO2	NOx	SO2	PM10	PM2.5	VOCs
Industrial Sector	812,180	-	361,186	268,684	64,857		94,033
Forest Fire	1,939,351	28,905,117	80,878	-		225,692	
Agricultural Burning	1,575,224	14,666,636	-	-		287,999	

Acknowledgement

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