Regional Environmental Monitoring

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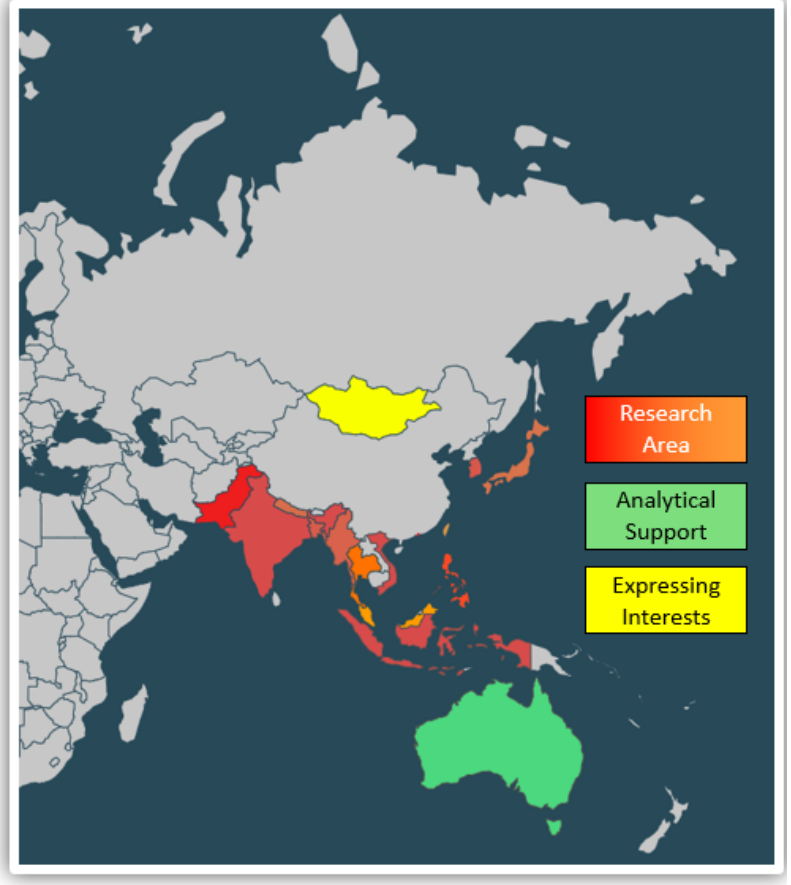
Presentation Outline

- Introduction
- Biomass Burning
- Haze Episode
- Low Cost Sensor
- Trajectory Model
- Chemical Mass Balance
- Source Apportionment

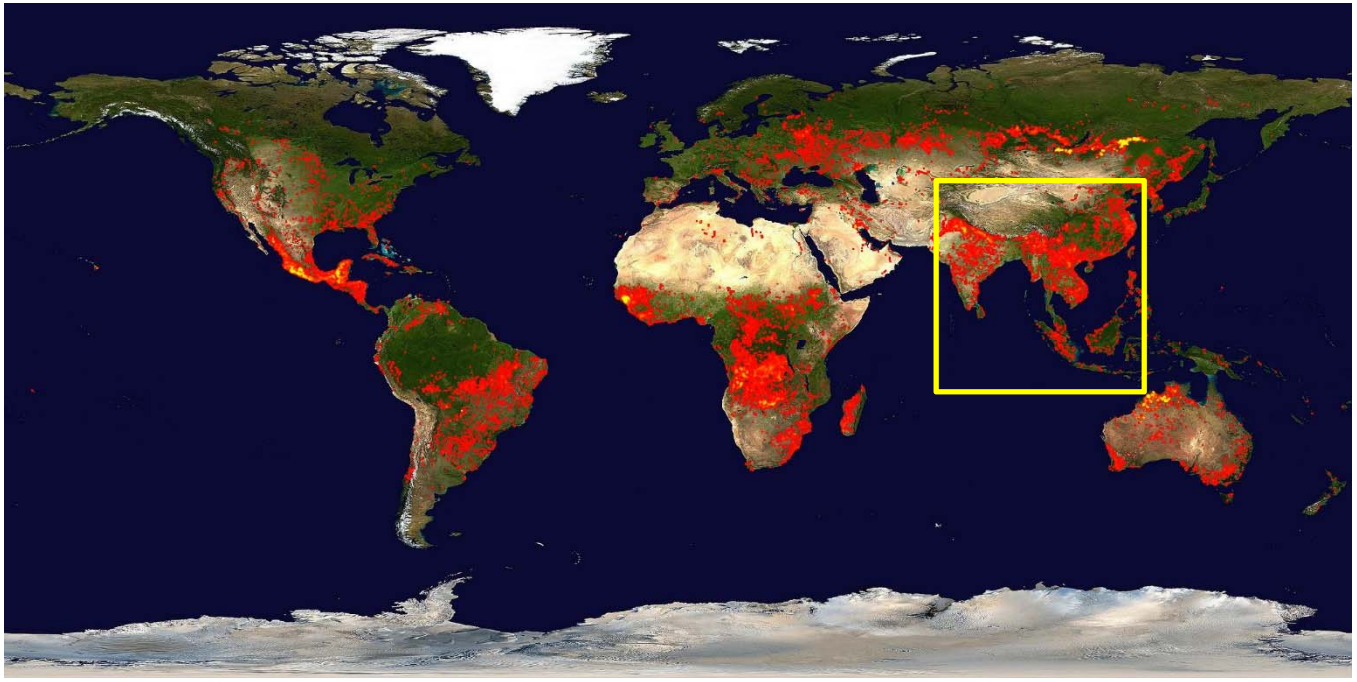
Introduction

- Southeast Asia or Southeastern Asia is a sub-region of Asia, consisting of the countries that are geographically south of China, east of India, west of New Guinea and north of Australia
- This region usually affected by biomass burning episode due to hot weather condition

Introduction



Southeast Asian and Biomass Burning



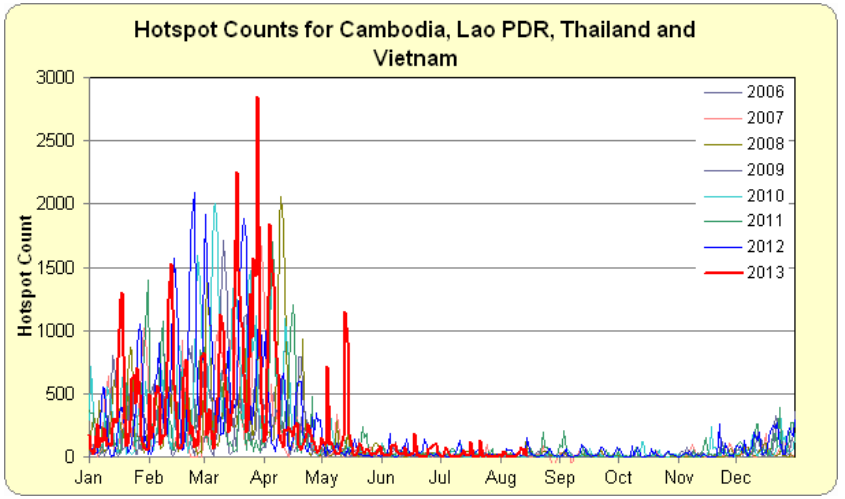
Ichoku and Kahn (2012)

Air Pollution in Southeast Asia

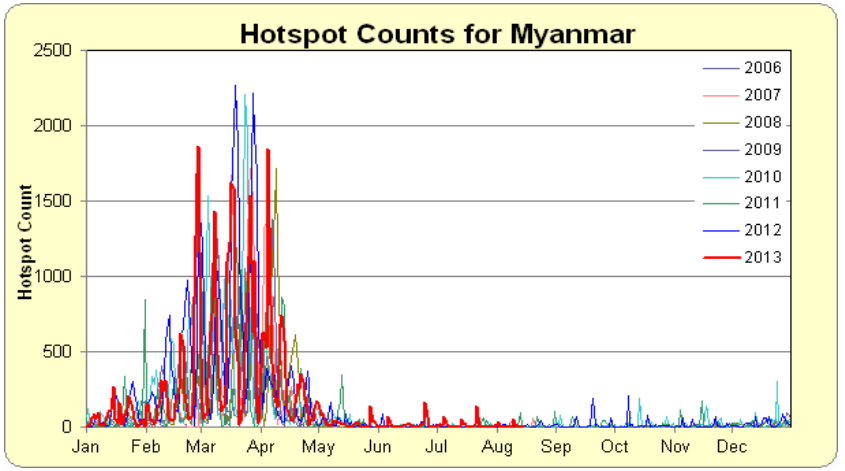
- Air pollution in Southeast Asia cause by several factors from natural and anthropogenic sources
- Biomass burning, volcanic eruption, sea spray are example of natural sources
- Motor vehicles, industrial activities, power plant are example of anthropogenic sources

DIFFERENT TYPES OF BIOMASS BURNING

Two Different Seasons

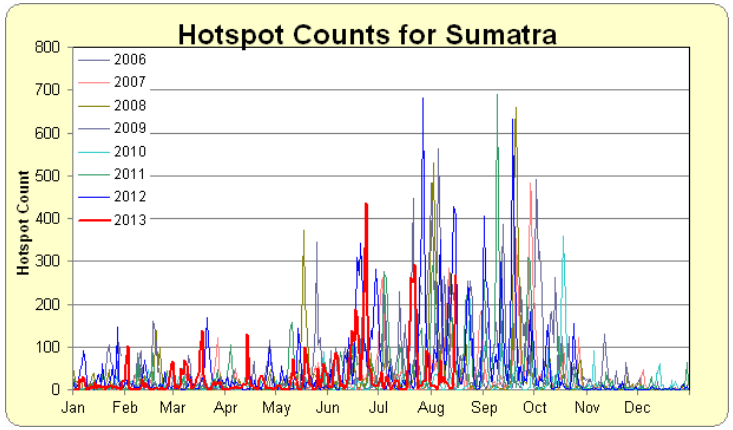


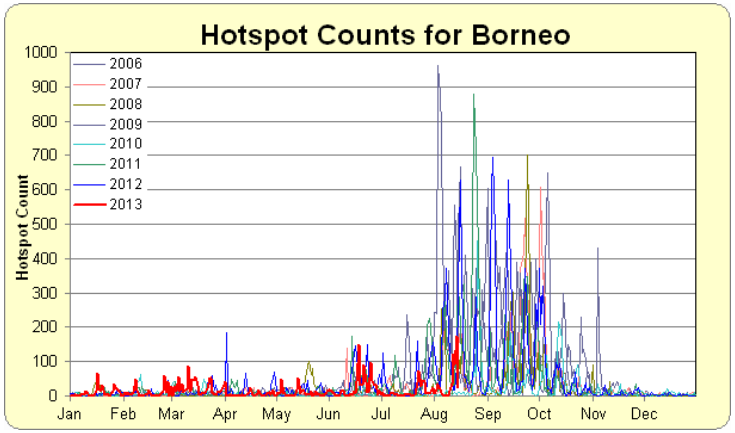
Indochina - Jan to May



Source: ASMC (2013)

Two Different Seasons

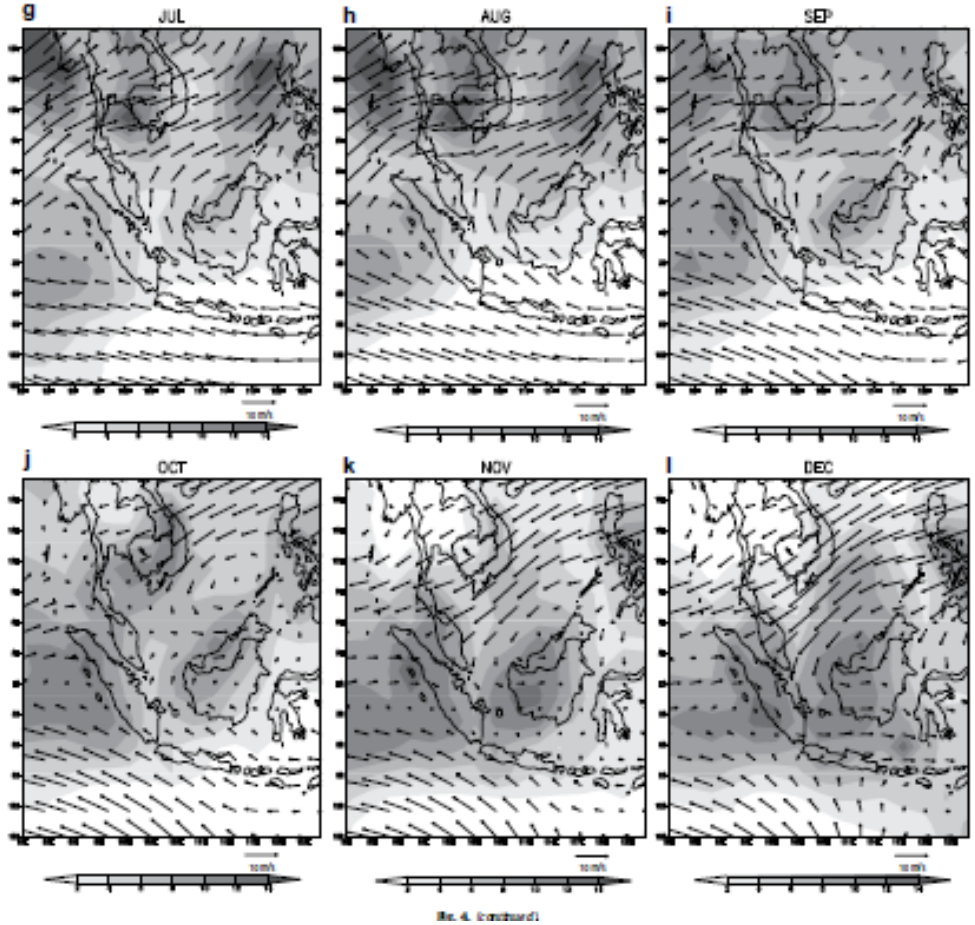




Sumatra, Peninsular Malaysia and Borneo
June to September

Source:
ASMC (2013)

Wind Pattern



June to September
Southwest monsoon

Sumatra-Peninsular Malaysia - Borneo

Biomass Burning from Peat Soil Combustion

Indochina-Thailand-Myanmar

Objectives

1. Applying low-cost sensing devices to assess ambient $PM_{2.5}$ levels for comparison with exposure levels
2. Applying low-cost sensing devices in communities to quantify community/local source contribution
3. Establishing a network of low-cost sensing devices to monitor ambient levels and to evaluate regional pollution transport

LOW COST SENSOR

Low Cost Sensor ($PM_{2.5}$)

- The type of $PM_{2.5}$ sensor such as AS-LUNG which is currently used in several research groups
- Any type of low cost sensor ($PM_{2.5}$ and gases) with good quality also could be used in this study.
- The evaluation of sensors needs be conducted prior to the application.
- The QA/QC data from low cost censor need to be compared with established instrument.

AS-Lung Sensor

($PM_{2.5}$)

Hatyai, Thailand

Monitoring at Continuous Air Quality Monitoring System (CAQM)

Chiang Mai, Thailand

Putrajaya, Malaysia

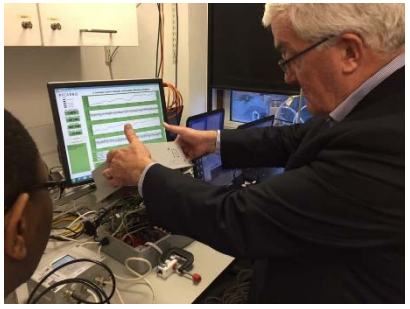
QA/QC

- Comparison between the data collected from low cost sensor and established air quality monitoring instrument

  (e.g. AS-Lung with Grimm spectrometer)
- Gaseous sensors with good quality could be added to this research activity
- The QA/QC for gases follows the procedures of $PM_{2.5}$ (comparison with established instrument)

Correlation between PM2.5 using sensor and TEOM

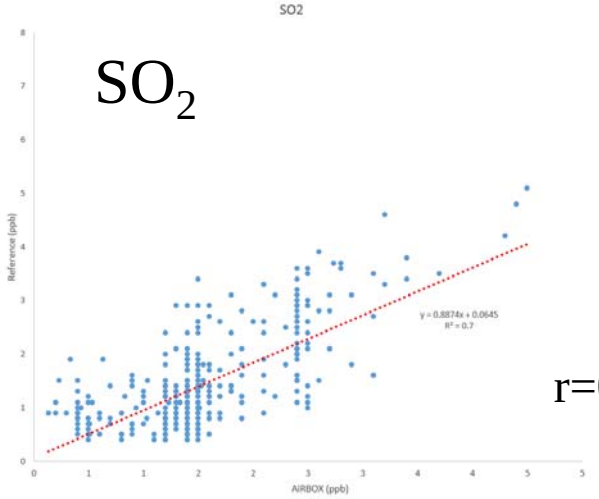
Example of Low Cost Air Quality Sensor for Gases



Technical specification

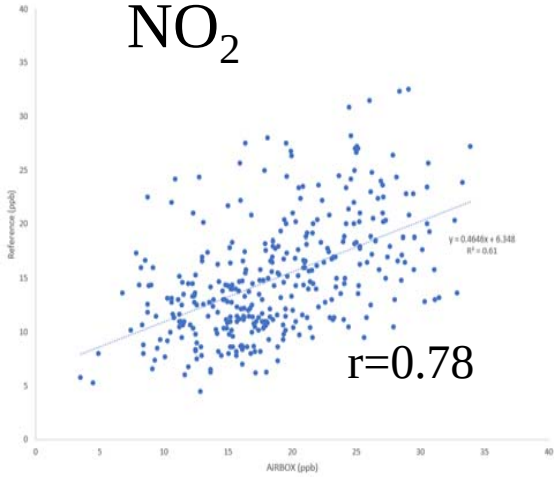
Parameters	Sensors	Range	Detection limit	correlation	Resolution	Accuracy
PM_1, $PM_{2.5}$ & PM_{10}	Alphasense OPC	0-1200 μgm^{-3}	1 μgm^{-3}	r=0.75	1 μgm^{-3}	~<± 5 μgm^{-3}
Nitrogen Dioxide	Alphasense EC	0- 5 ppb	2 ppb	r=0.82	1 ppb	~<± 5 ppb
Carbon Monoxide	Alphasense EC	0-30 ppm	0.02 ppm	r=0.88	0.02 ppm	~± 5 ppb
Sulphur Dioxide	Alphasense EC	0-200 ppb	0.2 ppb	r=0.88	1 ppb	~<± 5 ppb
Ozone	Alphasense EC	0-200 ppb	2 ppb	r=0.82	1 ppb	~<± 5 ppb

SO_2



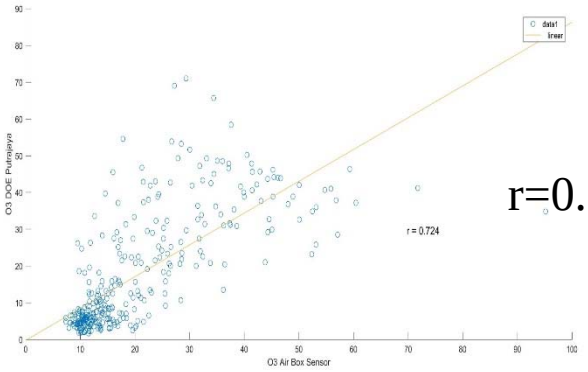
r=0.84

NO_2



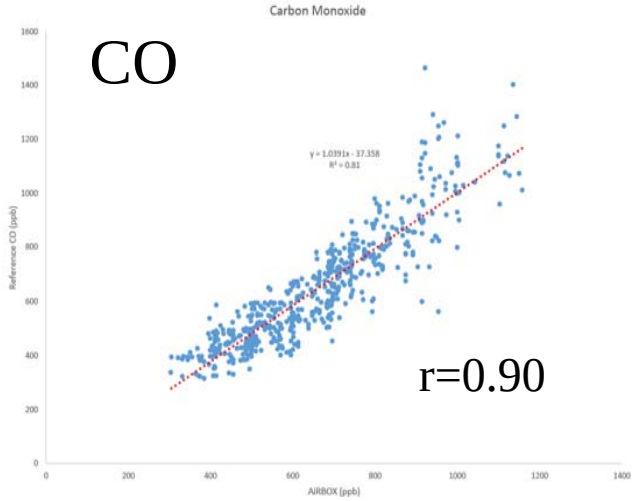
r=0.78

O_3



r=0.72

CO

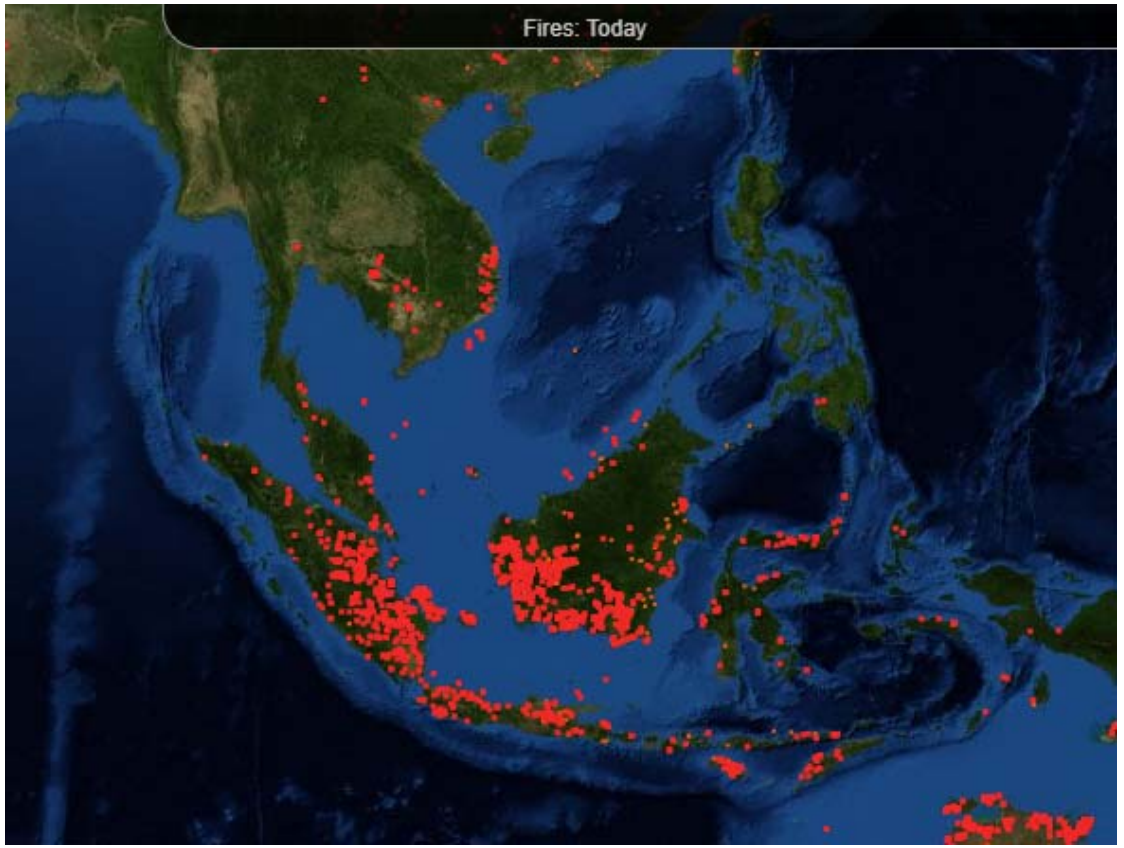


r=0.90

Suggested Location for Regional Sampling

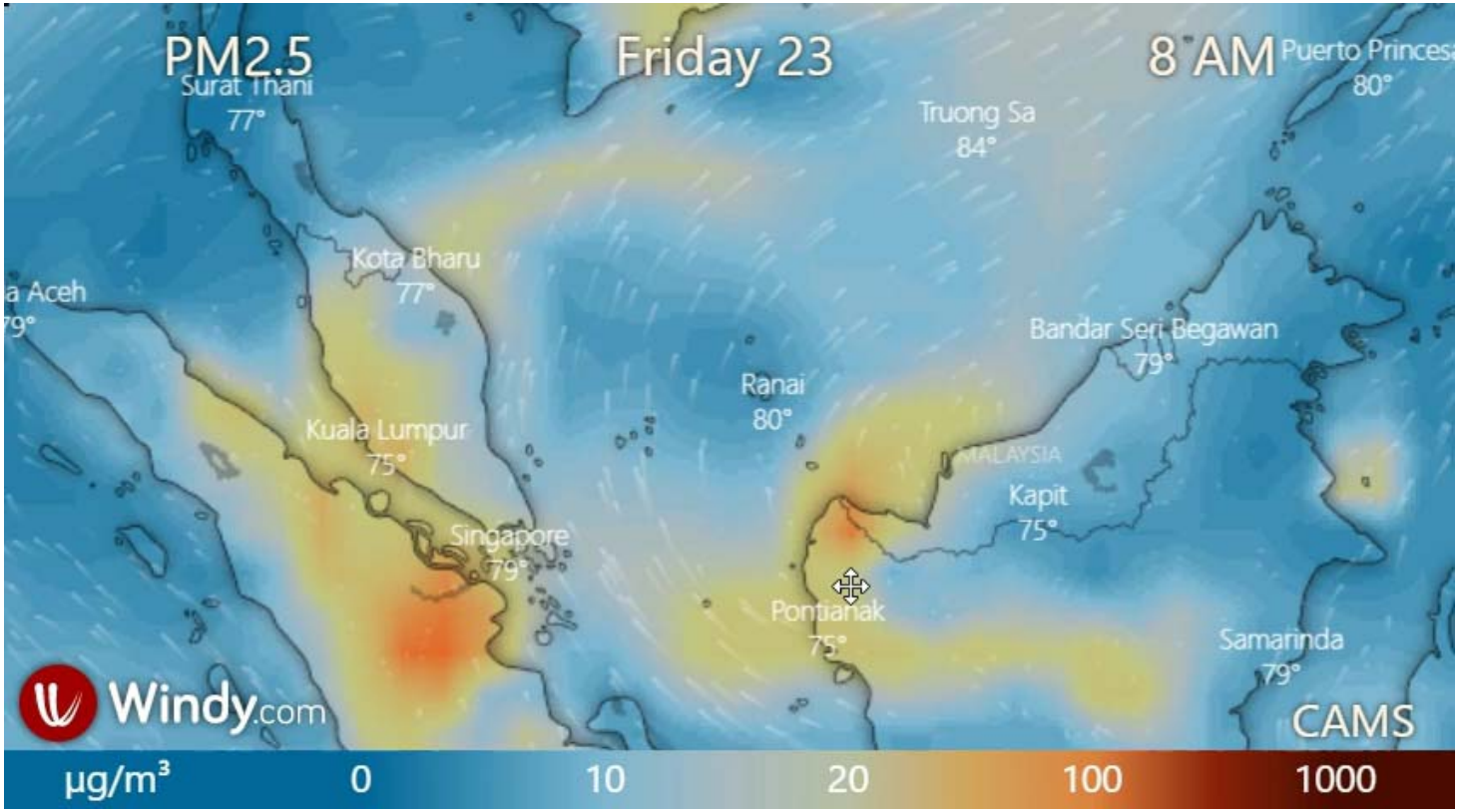
- Represent large area monitoring
- Manage to determine transboundary sources
  (Mainly from forest fire and agricultural burning)
- Rooftop/Tower/Air Quality Stations
- Within or near to Meteorological/Air Quality Station
- Less influence from local sources (e.g. traffic emission or industrial sources)

Information on Forest Fire



https://firms.modaps.eosdis.nasa.gov/map/

Information on Haze Episode/$PM_{2.5}$ and Wind Direction



https://www.windy.com/-NO2-no2?cams,no2,3.008,101.772,5

Other Parameters

Meteorology

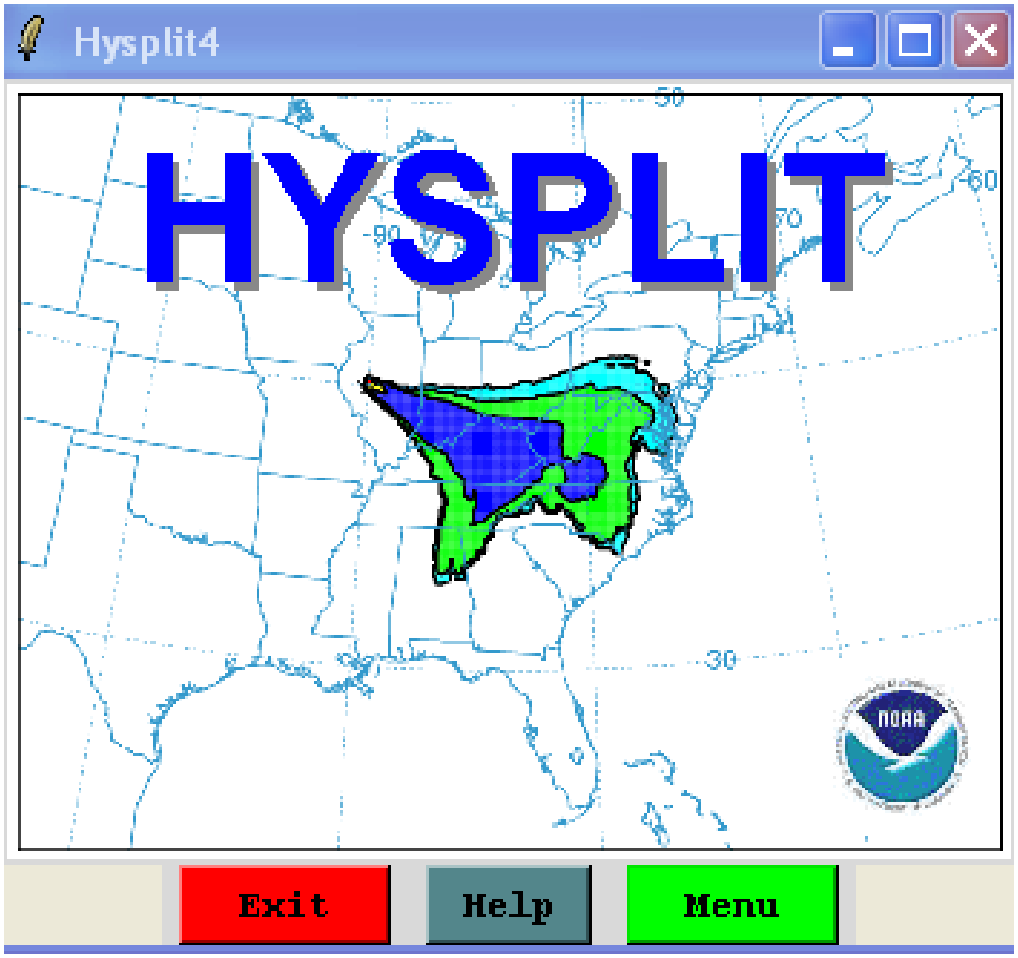
- Relative Humidity
- Temperature
- Wind Speed
- Wind Direction
- Visibility
- Etc.

Air Pollutants

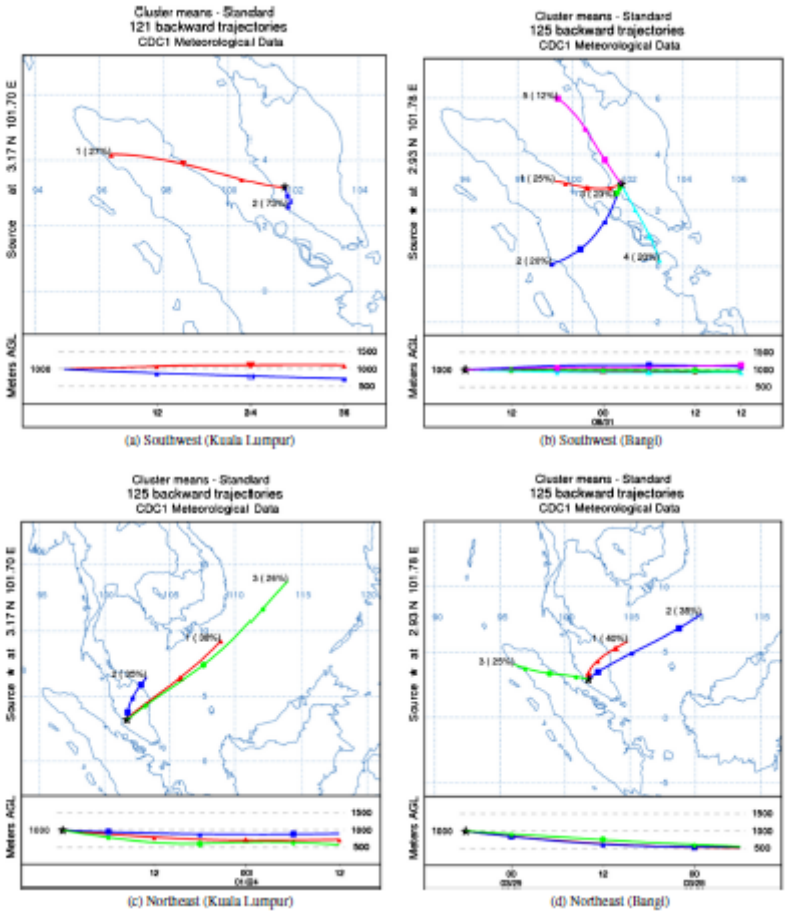
- Carbon monoxide (CO)
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Surface ozone (O_3)
- Etc.

TRAJECTORY ANALYSIS

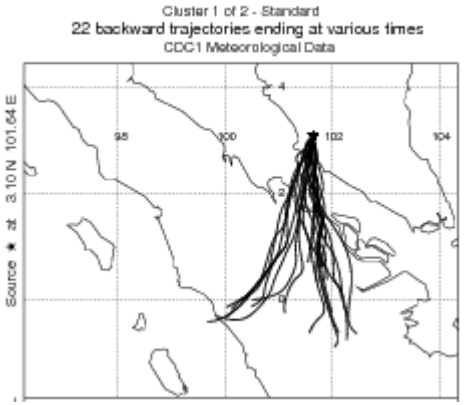
HYSPLIT BACKWARD TRAJECTORIES MODEL

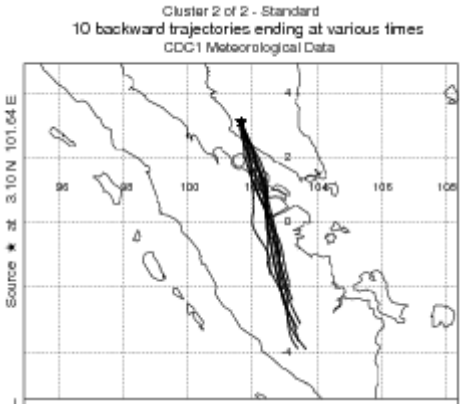


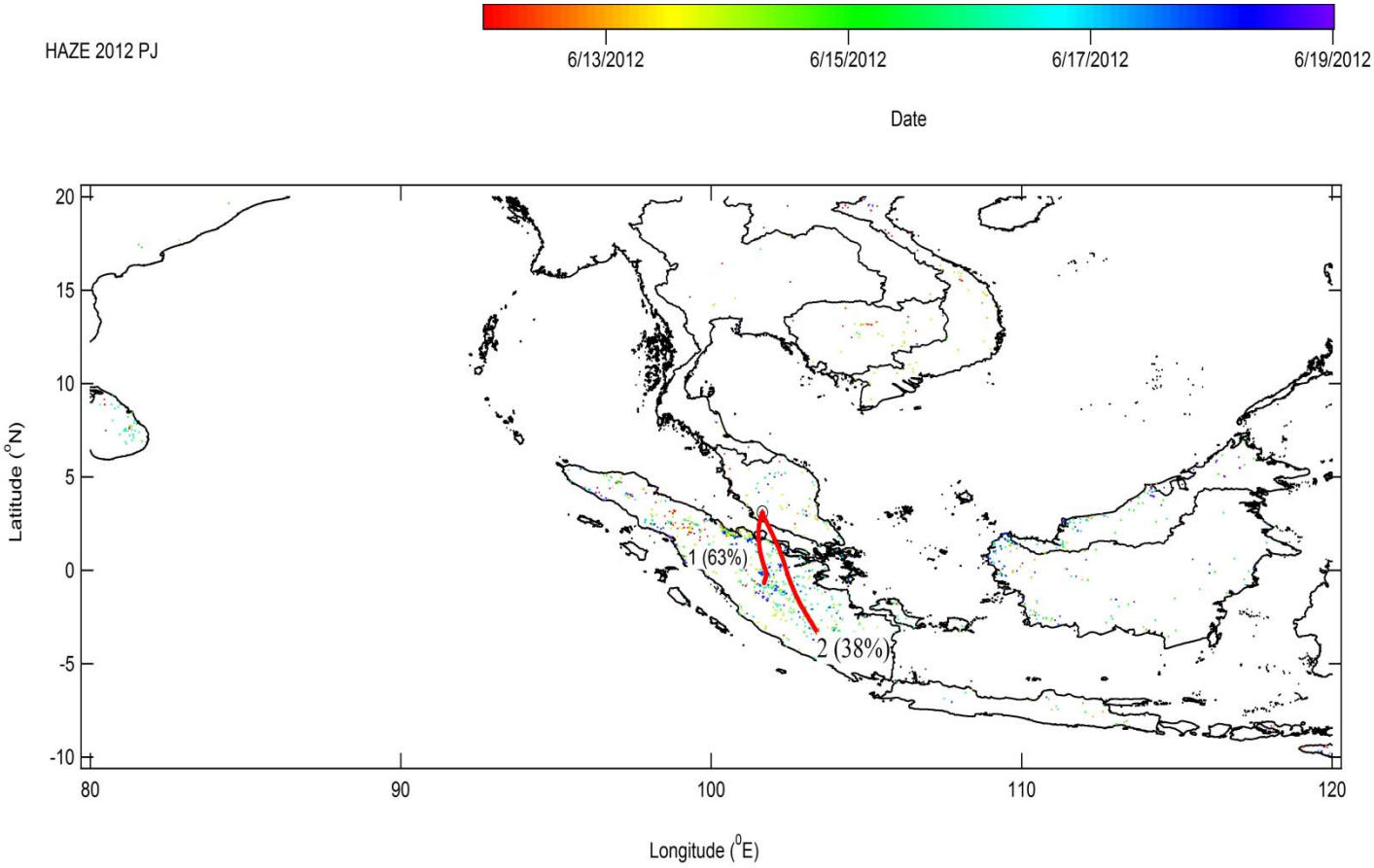
HYSPLIT BACKWARD TRAJECTORIES MODEL



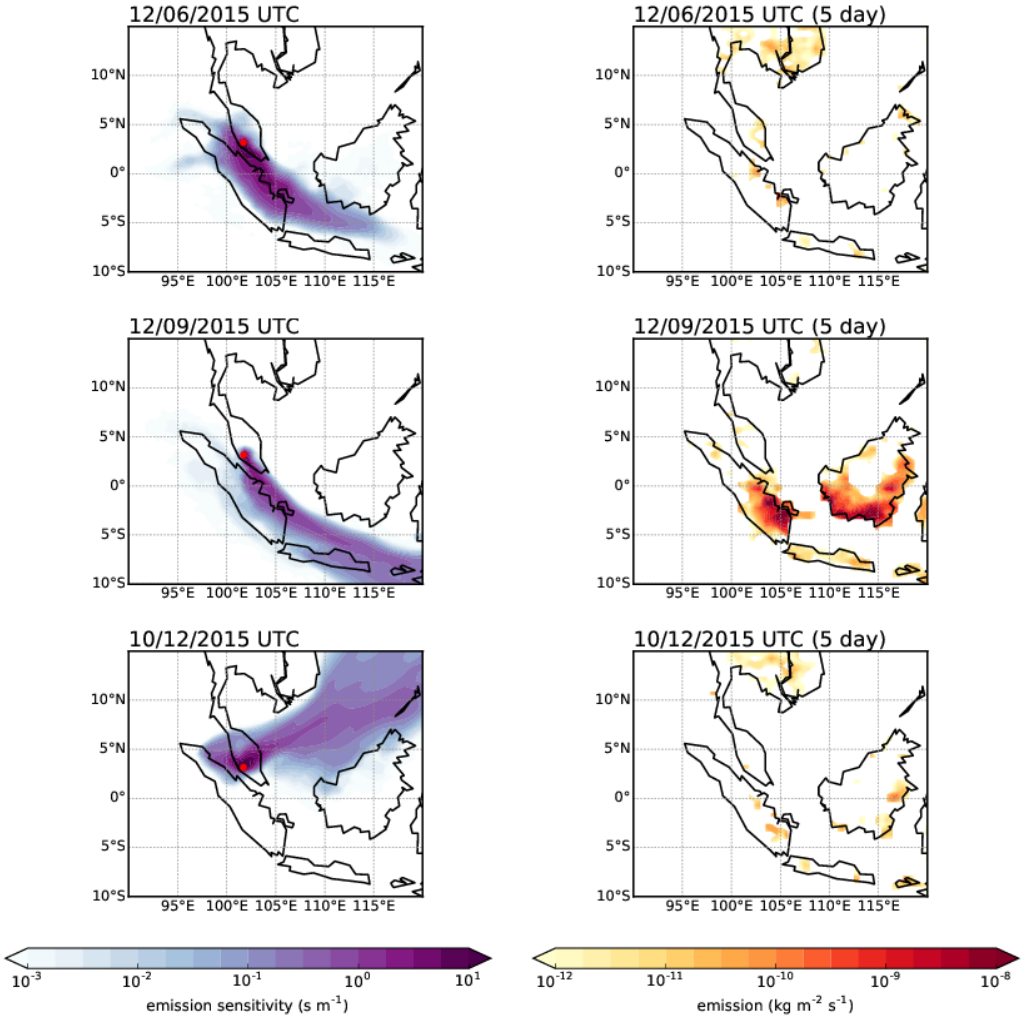
HYSPLIT BACKWARD TRAJECTORIES FOR HAZE







Emission Sensitivity and Emission



Numerical Atmospheric-dispersion Modelling Environment (NAME) Model

(Sulong et al., 2016)

CHEMICAL COMPOSITION

$PM_{2.5}$ Sampling (High Volume Sampler, HVS)

- HVS $PM_{2.5}$
- Flowrate of 1.13 m^3 min^{-1}
- 24 h sampling/filter
- Quartz filter [Whatman QM-A; 8’ X 10’]
- June 2015– January 2016
- Nine samples per month

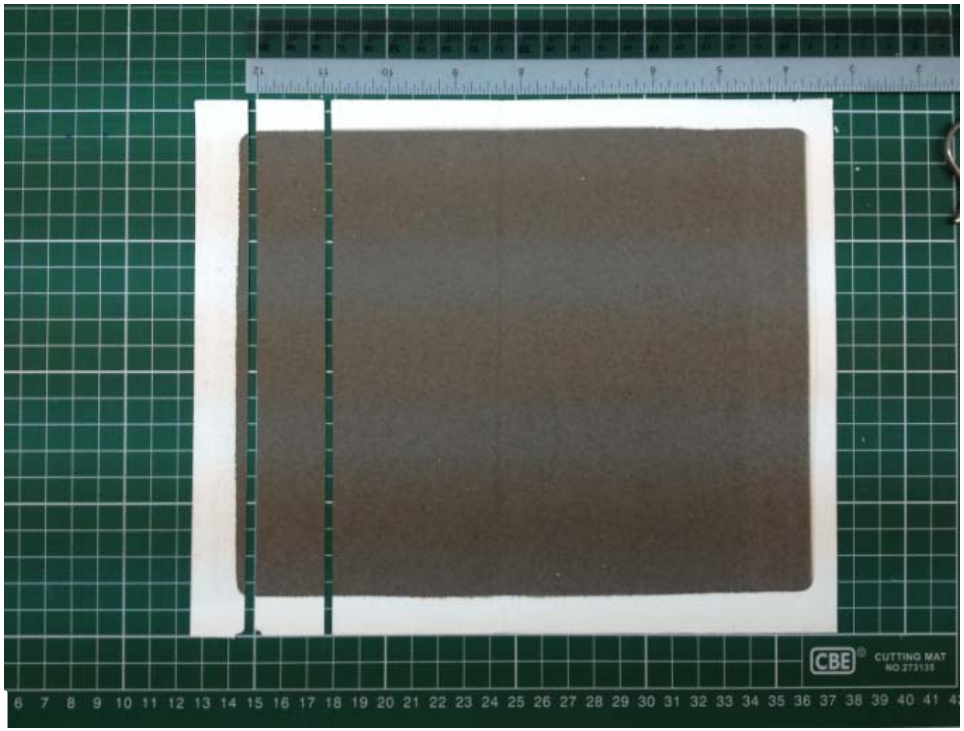
$PM_{2.5}$ Sampling (Low Volume Sampler, LVS)

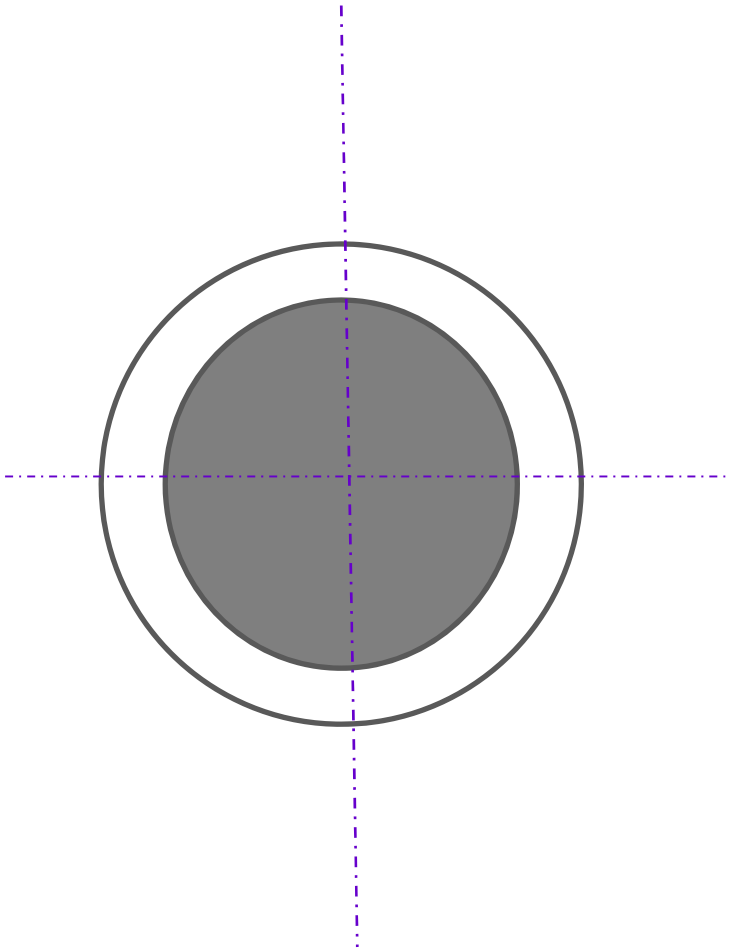
- Flowrate of 5 L min^{-1}
- 8 h and 24 h sampling
- Position to be more than 1 m above the ground
- 47 mm filter, type of filter paper is based on element to be determined
- Pre-weighed and pre-desiccated filter paper for sampling

Sampling Frequency and Duration

- 8 samples per month, or
- Every 4 days
- Weekdays and weekend
- 4 seasons (Inter Monsoon 1, Northeast Monsoon, Inter Monsoon II and Southwest Monsoon)
- Autumn, Winter, Spring, Summer

Chemical Composition





Sample from HVS

Sample from LVS

Sample Digestion

Inorganic Composition

Ions

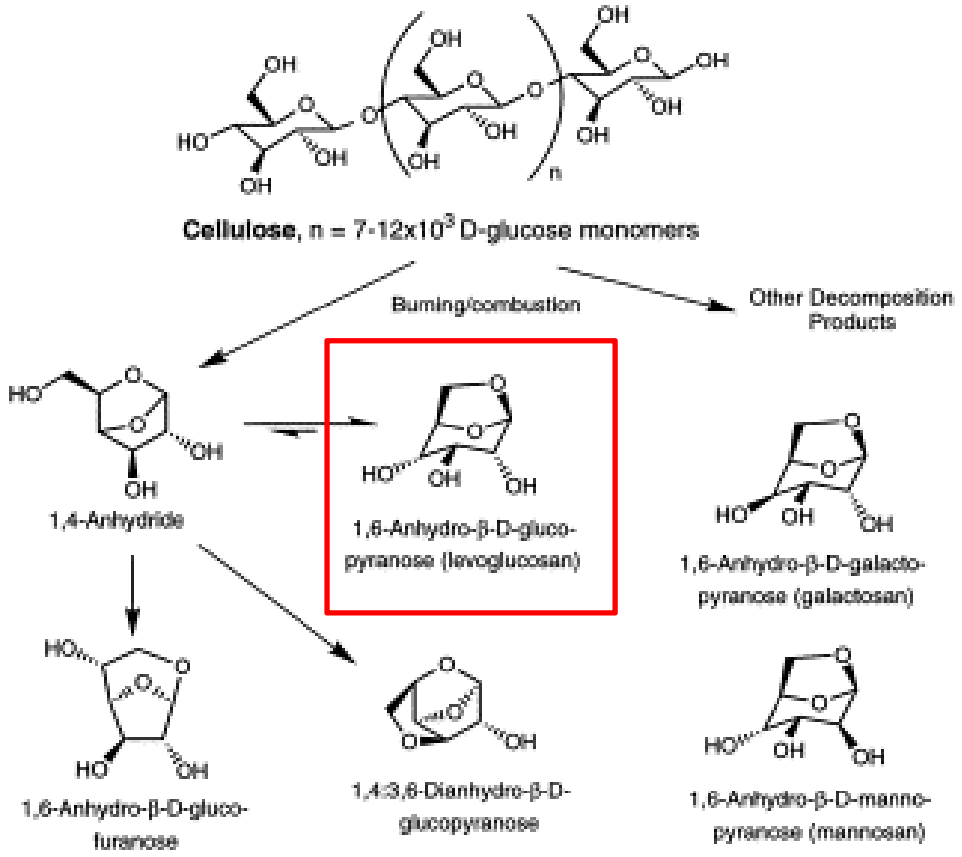
- SO_4^{2-}
- NO_3^-
- Cl^-
- NH_4^+
- Ca^{2+}
- Mg^{2+}
- K^+
- Na^+
- Etc

Trace Metals

- Pb
- Zn
- Cd
- Cu
- Fe
- Cr
- Mn
- Etc.

Black Carbon - Smokestain Reflectometer

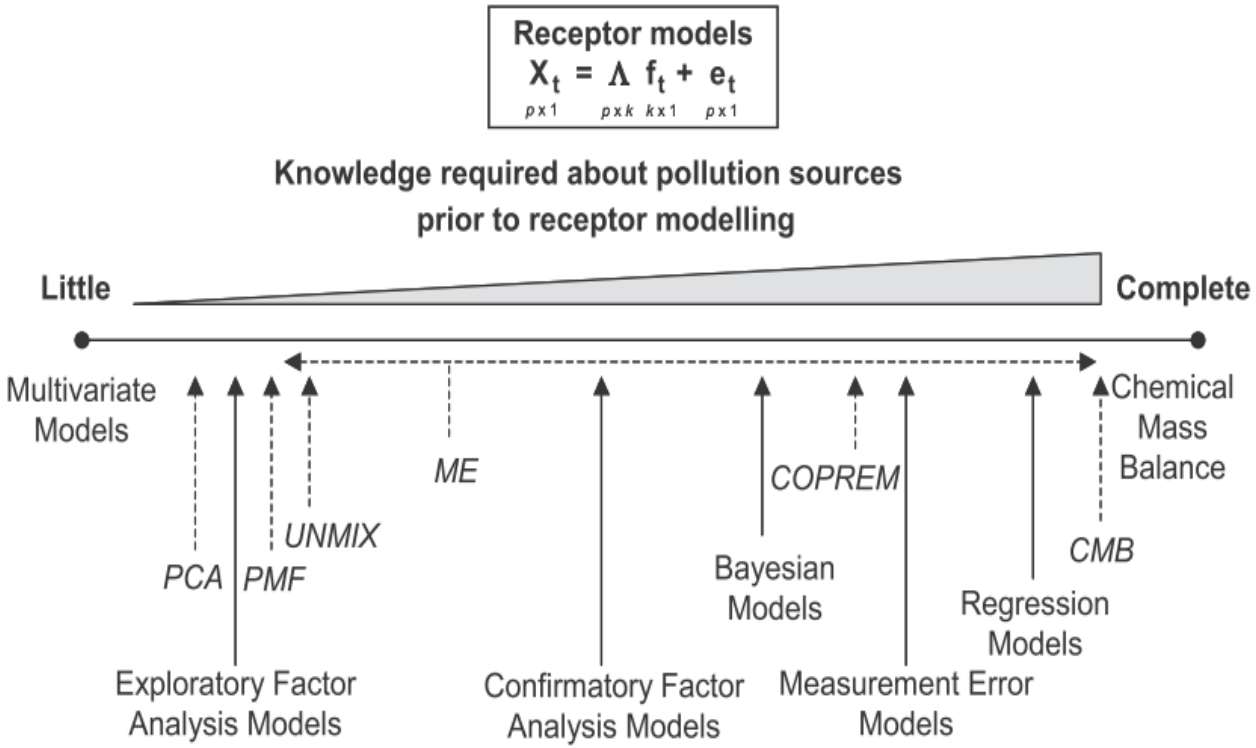
Organic biomarkers



Determination using Gas-Chromatography (optional)

SOURCE APPORTIONMENT

Receptor Model









Source-compositions

Monitor
(receptor)
Receptor models
(e.g., PMF, CMB, PCA)

Chemical Mass Closure (CMC)

$$[PM_{2.5}] = [\text{Sea salt}] + [\text{Dust}] + [\text{SIA}] + [\text{TE}] + [\text{BC}] + [K^+] + [\text{Unidentified}]$$

where, $[\text{Sea salt}] = [Na^+] + [Cl^-] + [Mg^{2+}] + [\text{ss-}K^+] + [\text{ss-}Ca^{2+}] + [\text{ss-}SO_4^{2-}]$;

with $[\text{ss-}K^+] = 0.036 \times [Na^+]$; $[\text{ss-}Ca^{2+}] = 0.038 \times [Na^+]$; and

$[\text{ss-}SO_4^{2-}] = 0.252 \times [Na^+]$

$[\text{Dust}] = [\text{nss-}Ca^{2+}] / 0.11$

$[\text{SIA}] = [\text{nss-}SO_4^{2-}] + [NO_3^-] + [NH_4^+]$; with $[\text{nss-}SO_4^{2-}] = [SO_4^{2-}] - [\text{ss-}SO_4^{2-}]$;

"nss-" standing for "non-sea salt"

Source Apportionment: Positive Matric Factorisation

- **US EPA Models, Tools and Databases for Air Research**

  http://www.epa.gov/air-research/models-tools-and-databases-air-research

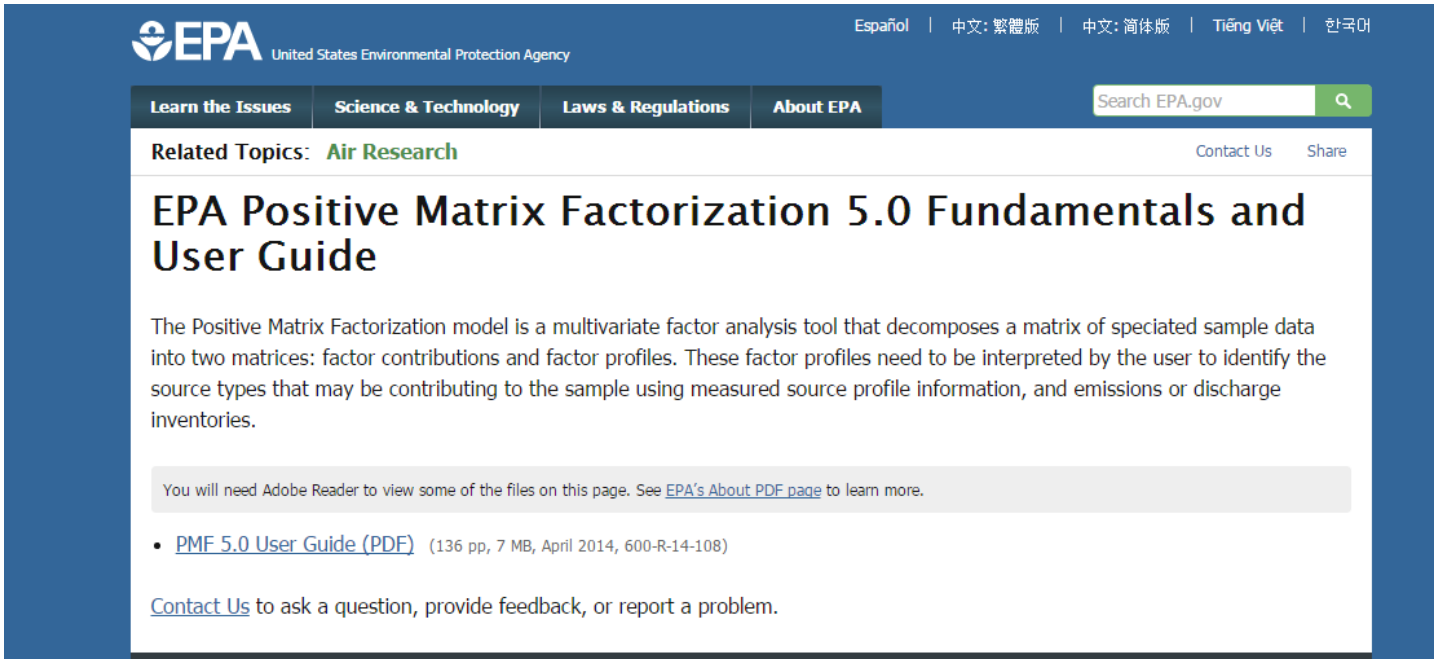
- Positive Matrix Factorization Model for environmental data analyses

  http://www.epa.gov/air-research/positive-matrix-factorization-model-environmental-data-analyses

- Download PMF 5.0

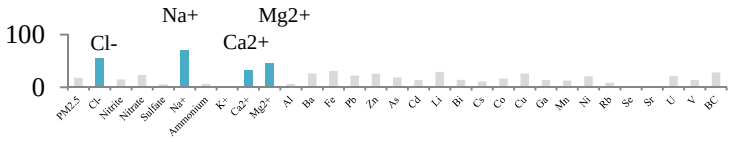
  http://www.epa.gov/sites/production/files/2015-03/epa_pmf_5.0_setup.exe

Read User Guide

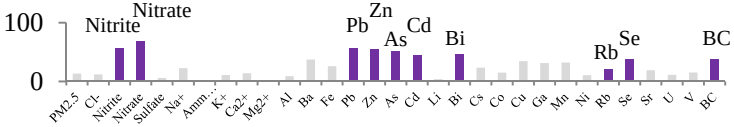


PMF-MLR SOURCE APPORTIONMENT: PM2.5 CHEMICAL COMPOSITION (INORGANIC & BC)

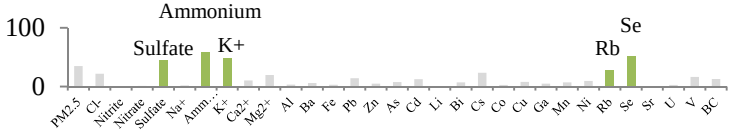
F5: Sea salt



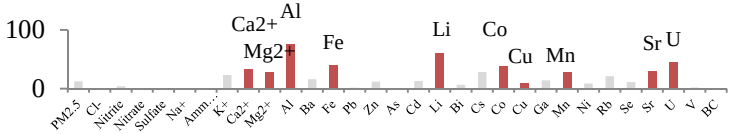
F4: Mixed traffic & industrial



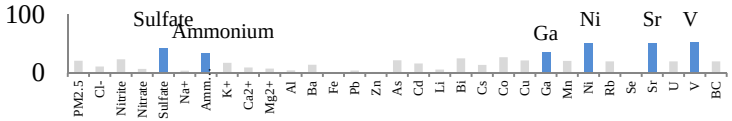
F3: Mixed SIA & biomass burning

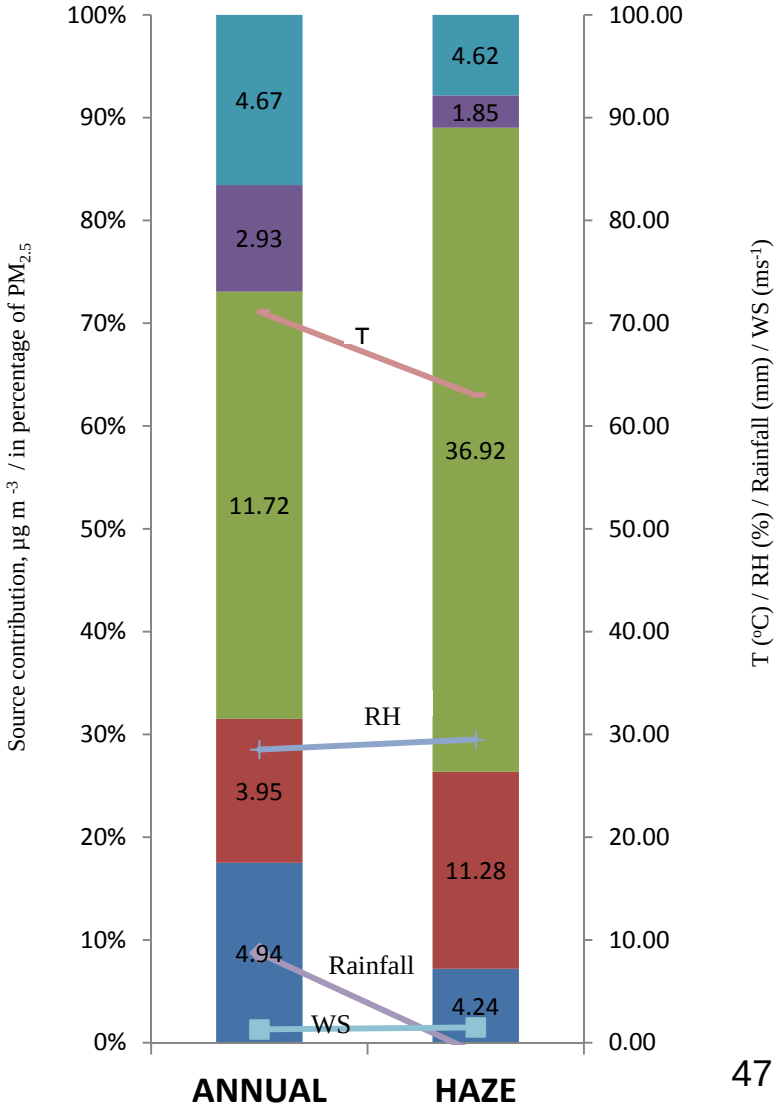


F2: Mineral dust



F1: Combustion of engine oil





Regional Networking

Location/Country	Low Cost Sensor	PM Monitoring
Chiang Mai (Thailand)	/	/
Hatyai (Thailand)	/	/
Putrajaya (Malaysia)	/	/
Batu Pahat (Malaysia)	/	
Kuching (Malaysia)	/	

Other potential locations?

THANK YOU