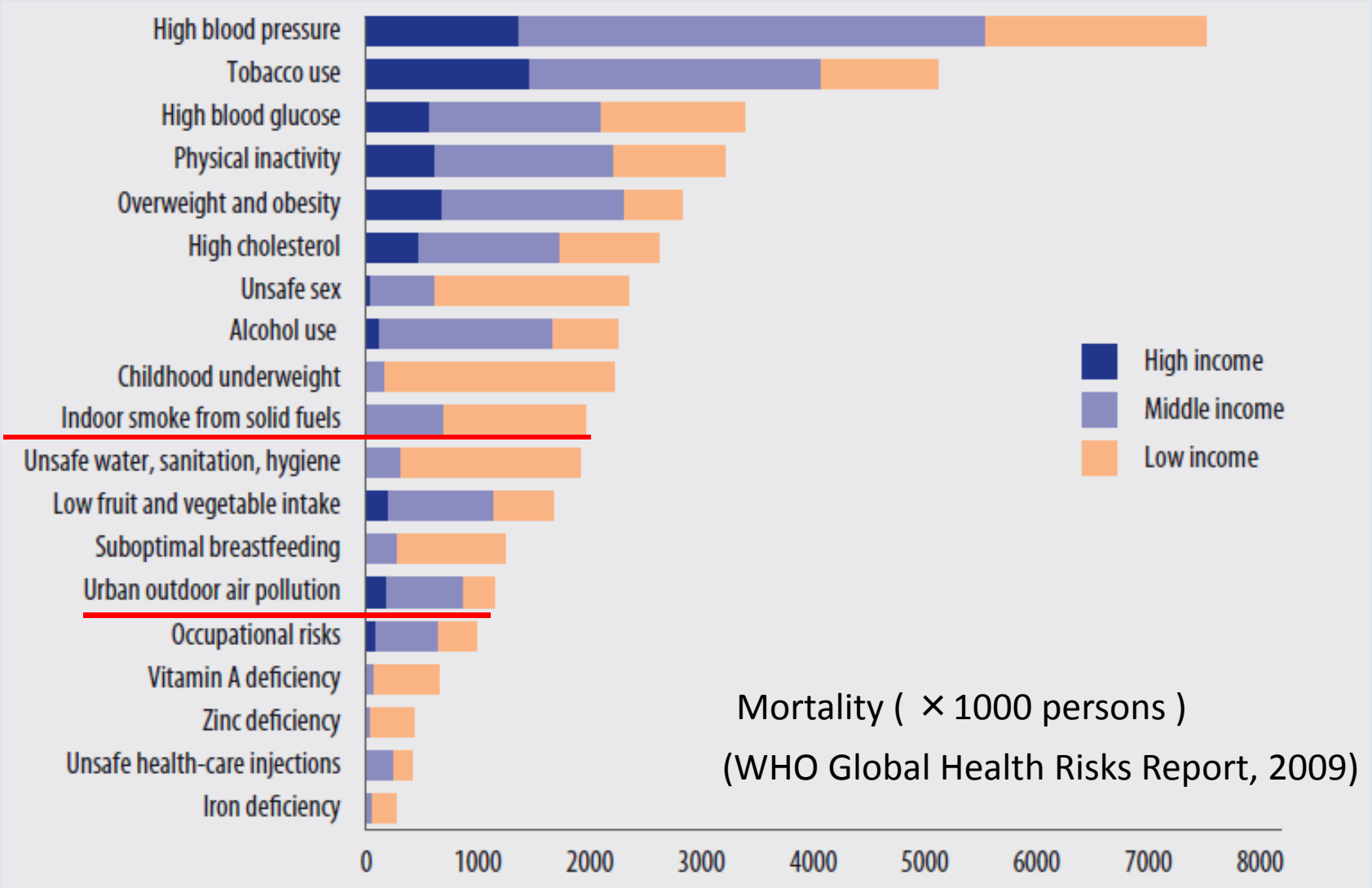
18th AIM International Workshop
14th – 16th December, 2012
NIES, Tsukuba, JAPAN

# Recent Progress on the Model development of Air Quality and co-benefits

Kyoto University Gakuji KURATA

# Background (1)

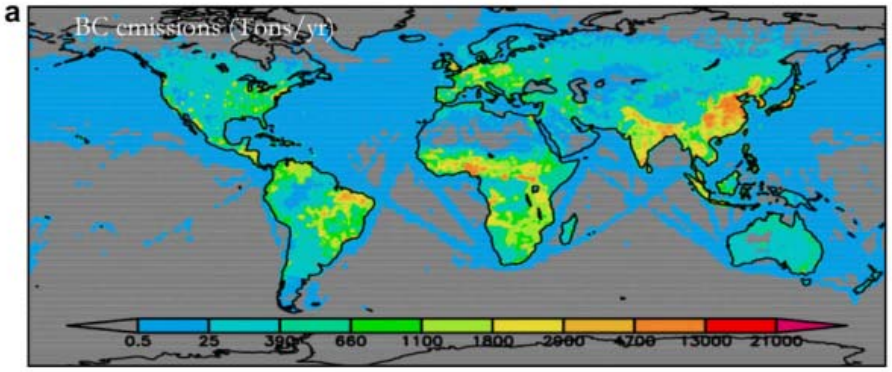
Deaths attributed to 19 leading risk factors, by country income level, 2004.



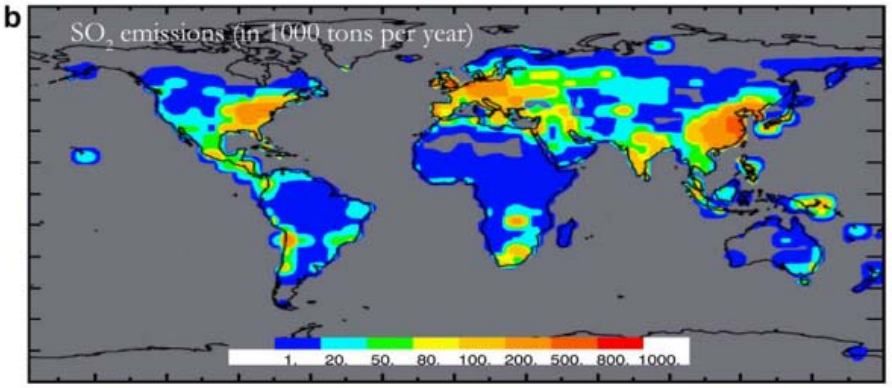

- At the Least Developed Countries, Air Pollution is still major threat to human health.

# Background (2)

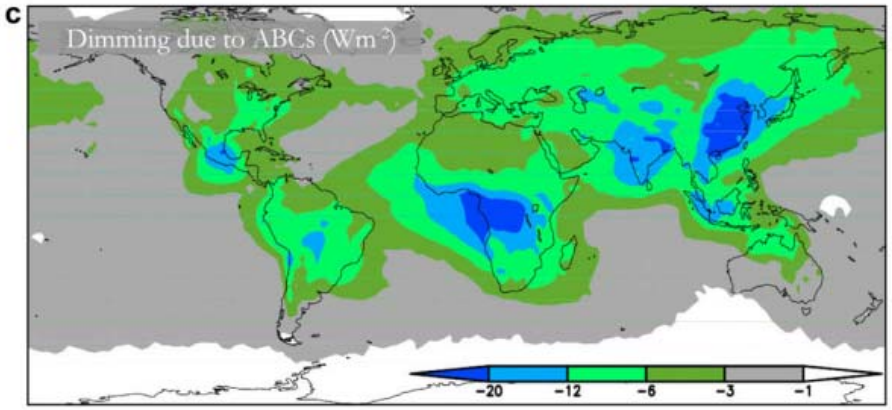
## Air Pollution issue in Least Developed Countries




Emission of Black Carbon




Emission of Sulfur

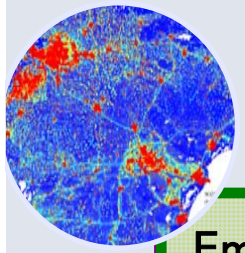


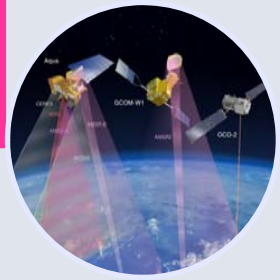

Simulated Global dimming at the surface due to ABCs

*V. Ramanathan, Y. Feng / Atmospheric Environment 43 (2009) 37–50*

# Outline of the study

To quantify the **co-benefit** of LCS countermeasure to reduction of health impact of air pollution





LCS policies

Emission inventory (Mesh data)

Downscaling

Time variation (Annual, Daily)

ArcGIS

Emission Inventory (Regional)

Death Disease

Health Impact

Exposure

Indoor

Co-benefit Analysis

Micro Environment

Outdoor

Calculated Concentration

Impact Assessment

Emission Mesh data

Boundary Condition

CMAQ

Chemical Transport Model

GCM Output

Landuse Terrain

WRF

Meteo. Field

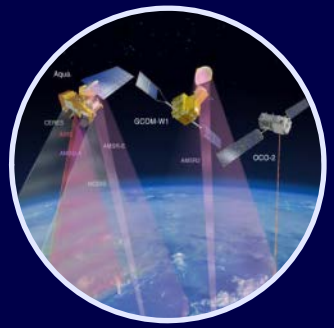
Meteorological Model

# progress of the study

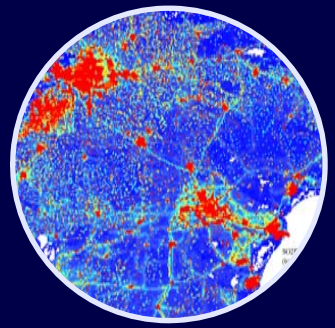
To quantify the **co-benefit** of LCS countermeasure to reduction of health impact of air pollution

Roadside monitoring of $PM_{2.5}$ and Gaseous species

in Iskandar Malaysia



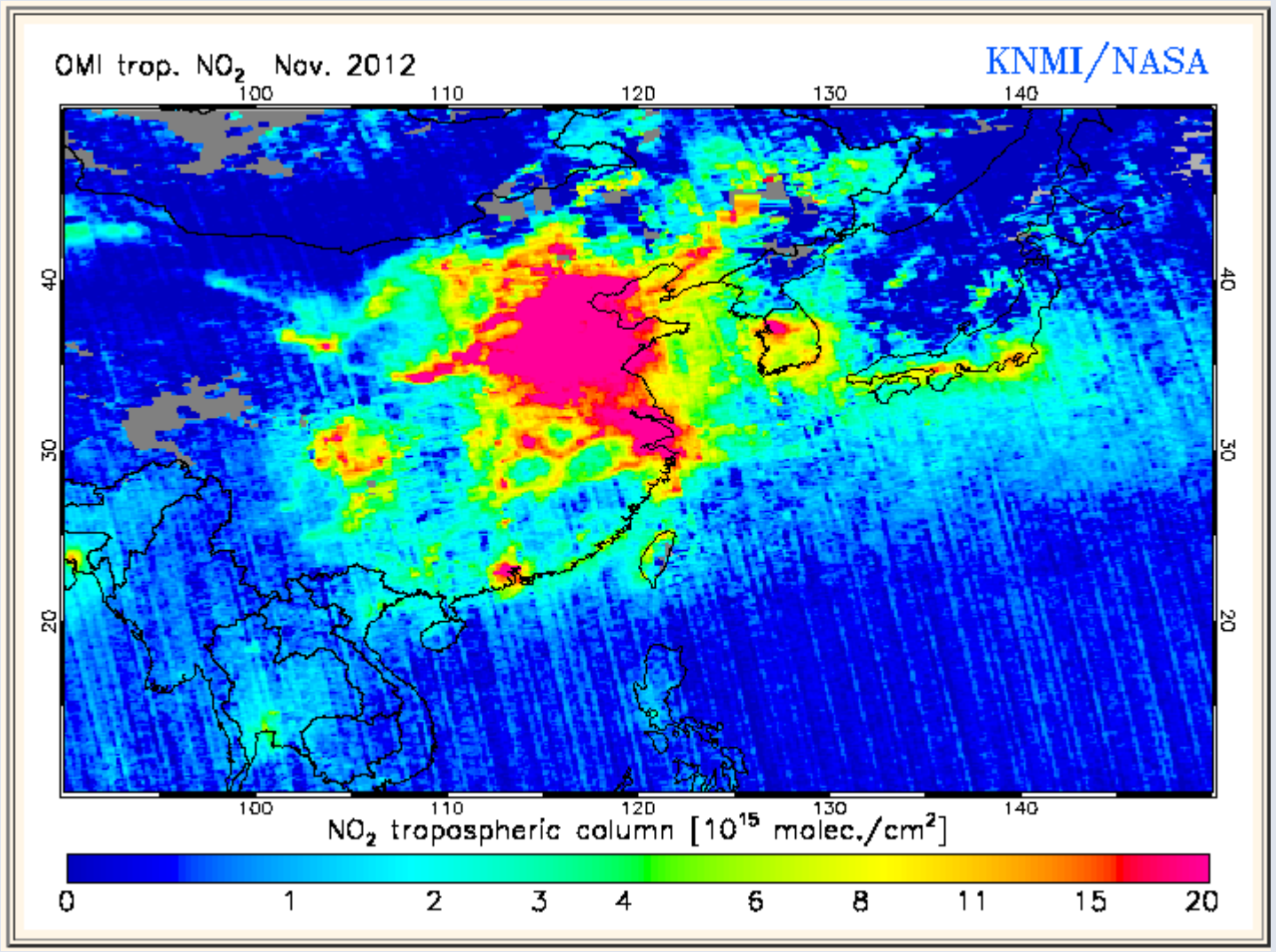
Using the Satellite retrieval of trace species to improve an emission information



Developing the Asian extension of SMOKE emission Inventory system of Air Pollutants

Developing the Indoor Air Quality and Exposure model

# SATELLITE OBSERVATIONS




$NO_2$

$CH_2O$

CO

Ozone

Aerosol

$SO_2$

.....

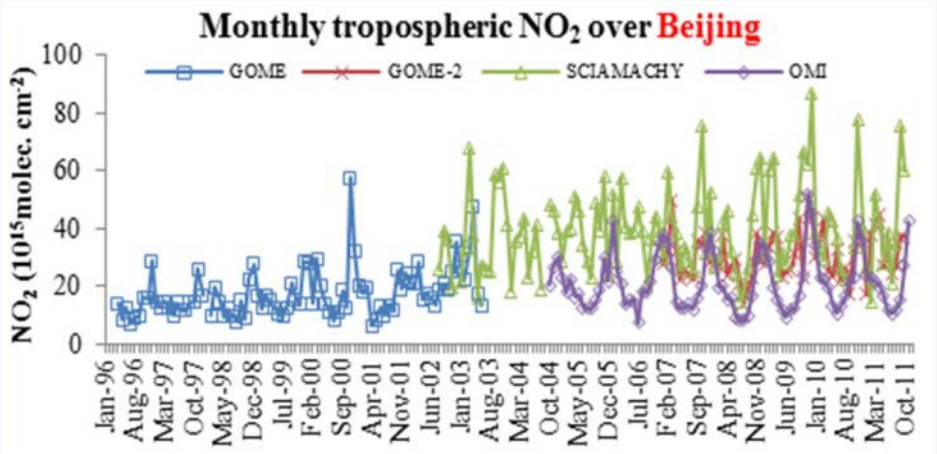
.....

Monthly average of $NO_2$ Vertical Column concentration (November, 2012) by OMI

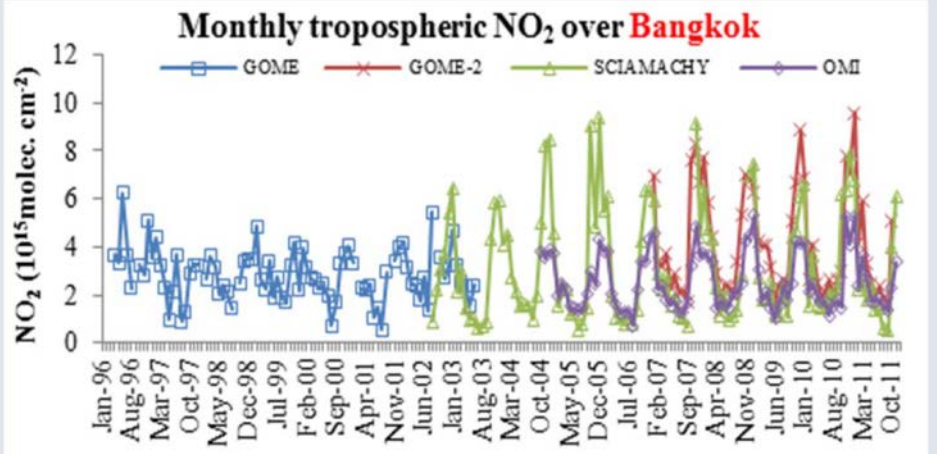
# SATELLITE OBSERVATIONS:

## Temporal & seasonal variability of $NO_2$ columns

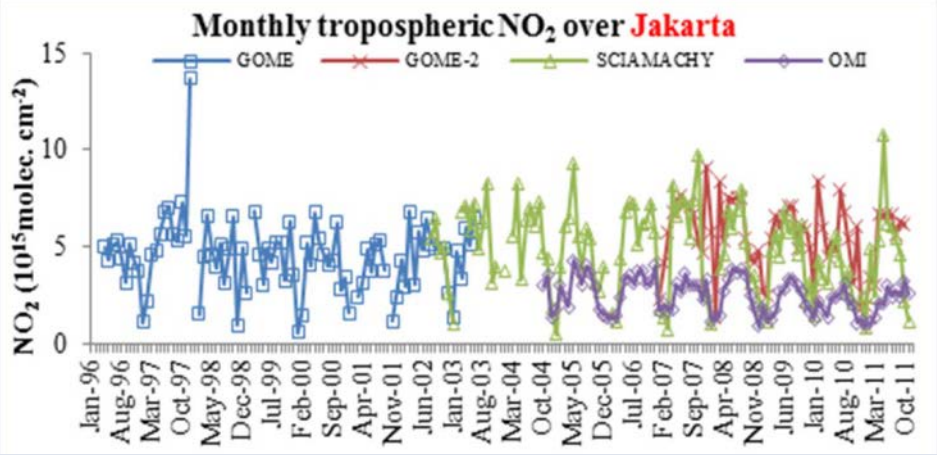
**Mid-latitude zone**




**Low-latitude zone**




**Equator zone**




**Mid/Low – latitude zone:**

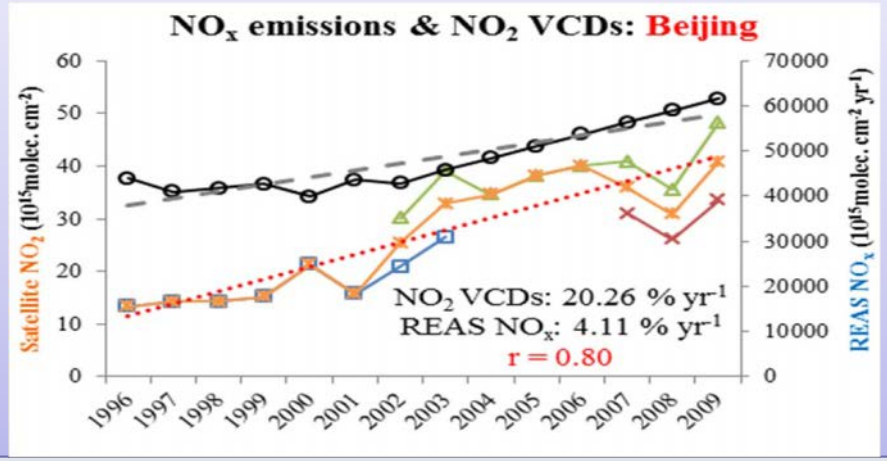
- ✓ Maximum: wintertime (Nov-Feb)
- ✓ Minimum: summertime (Jun-Aug)

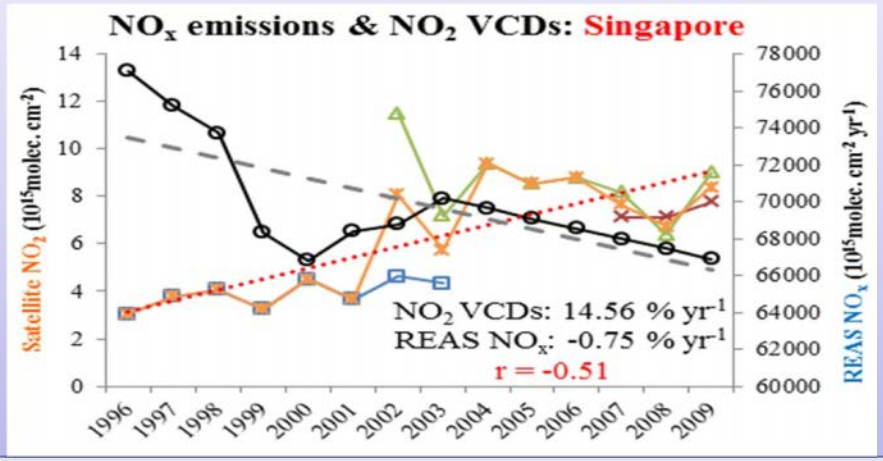
**Equator zone:**

- ✓ Maximum: dry season (Jun-Aug)
- ✓ Minimum: rainy season (Dec-Feb)

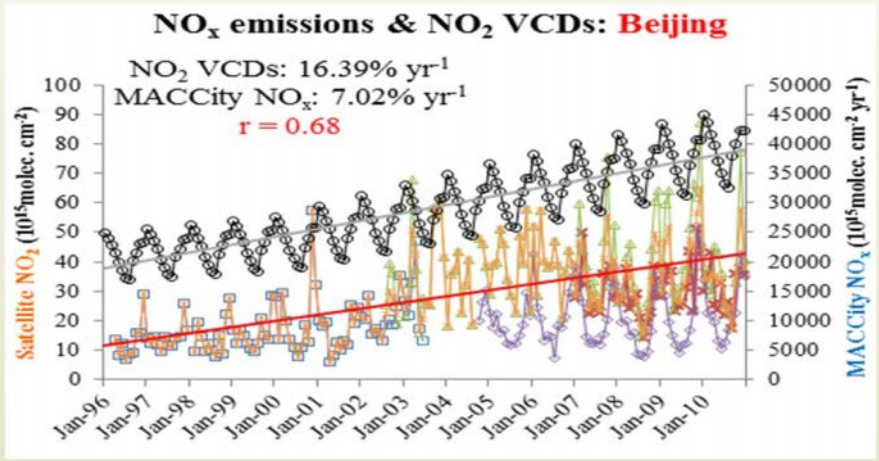
# Comparison of $NO_x$ emission and satellite data

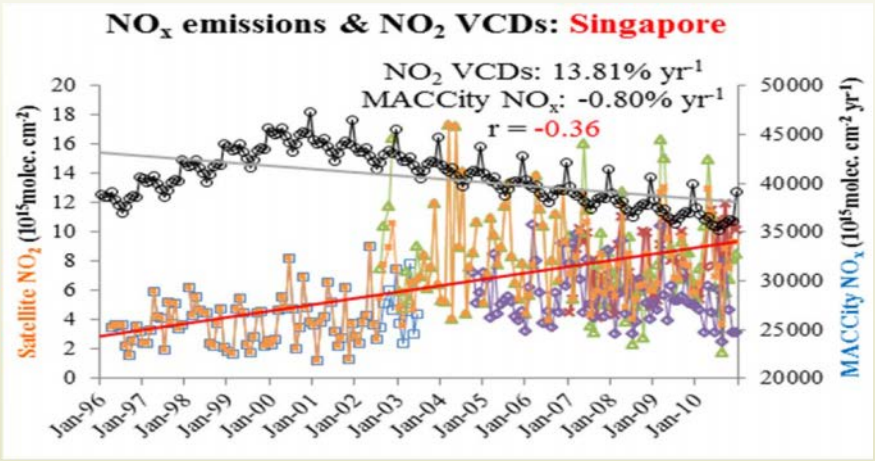
## REAS $NO_x$ emission vs. satellite $NO_2$ columns




## MACCity $NO_x$ emission vs. satellite $NO_2$ columns



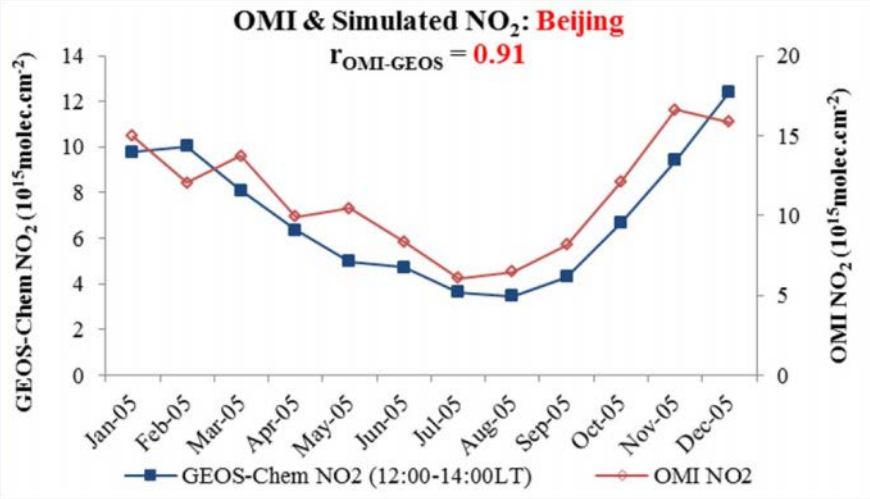


- ✓ Most of the cities located in **mainland** → give relatively good relationship (r > 0.7)
- ✓ The cities located near **coastal area** → r is quite low → the **inaccuracy of the emission** & **effects of met**

# Model simulation vs. Satellite data

## OMI vs. GEOS-Chem simulated $NO_2$ columns

### Mid-latitude zone




**GEOS-Chem**
- Year 2005
- 12:00-14:00LT
- Monthly data

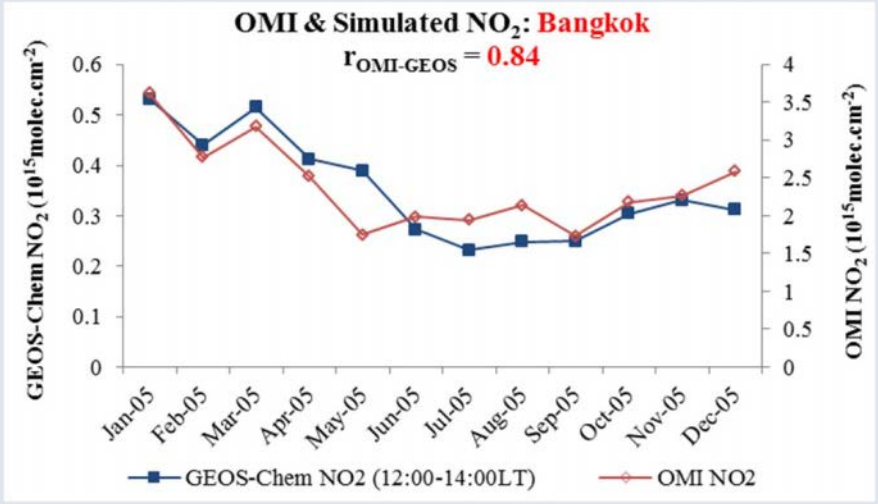
**OMI**
- Year 2005
- 13:40LT
- Monthly data

*Model results underestimate satellite data by the factor around 3-5*

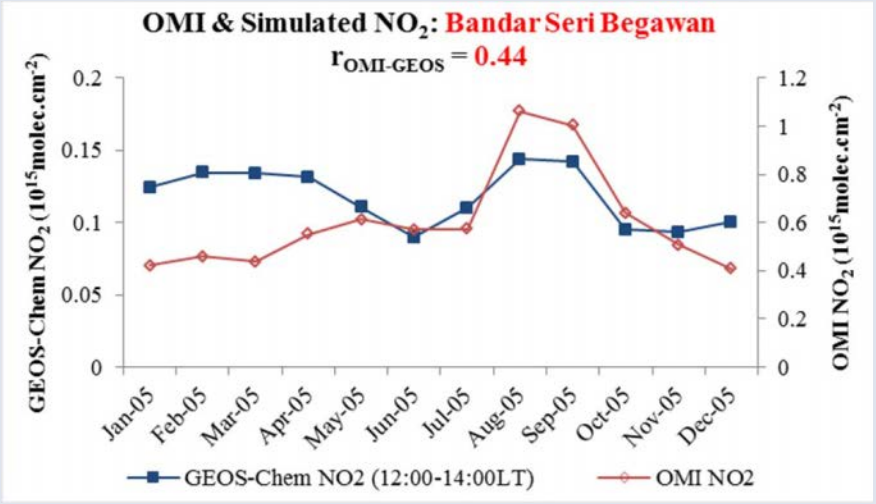
**Mid/Low – latitude zone:**
- ✓ Maximum: wintertime (Nov-Jan)
- ✓ Minimum: summertime (Jun-Aug)

**Equator zone:**
- ✓ Maximum: dry season
- ✓ Minimum: rainy season

### Low-latitude zone




### Equator zone



# Development of Thailand Emission inventory

## Thailand Emission Inventory for year 2005

✓ **Developed by:**


- **Chatchawan Vongmahadlek, Pham Thi Bich Thao, Narisara Thongboonchoo**
  *Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok, Thailand*
- **Boonsong Satayopas**
  *Department of Civil Engineering, Chiang Mai University, Chiang Mai, Thailand*


✓ **Spatial Allocation Profiles:** a 1- by 1-km resolution

## Emission Sources

✓ **Anthropogenic Sources**

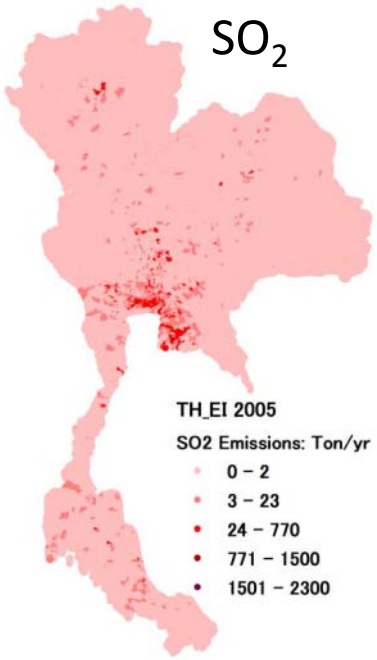
- **Industrial stationary source:** power plants, industrial facilities and industrial processes
- **Mobile source:** on-road & nonroad sources
- **Nonindustrial stationary source:** residential households, biomass burning, NH3 sources, incinerators, gas stations, and smoking tobacco

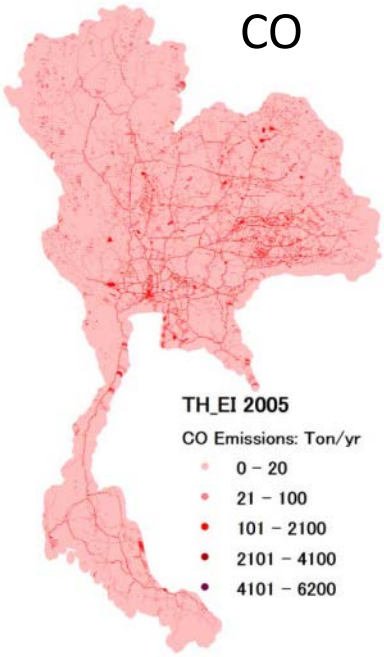
✓ **Natural Sources**

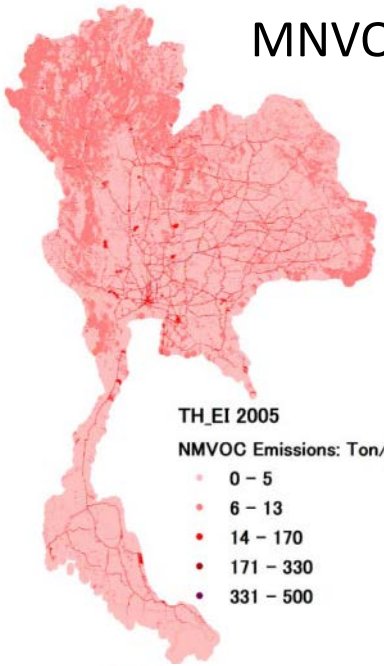
- **NMVOC emissions from vegetation**
- **$NO_x$ emissions from:** the soil of forestry, the soil of agricultural farms and lightening strikes

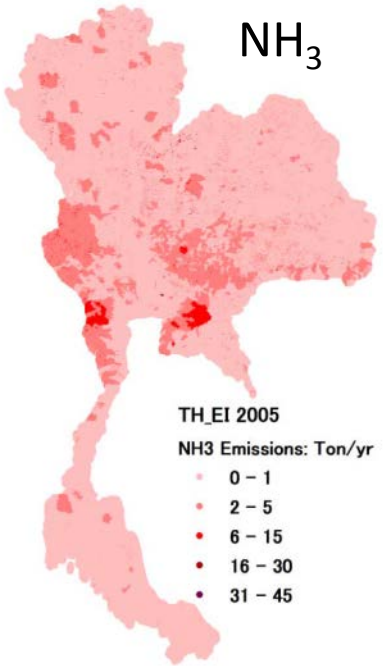
✓ Most emissions species are dominant in anthropogenic sources (92–99%)
✓ Except NMVOC emissions → highly contributed by natural sources (53.5%).

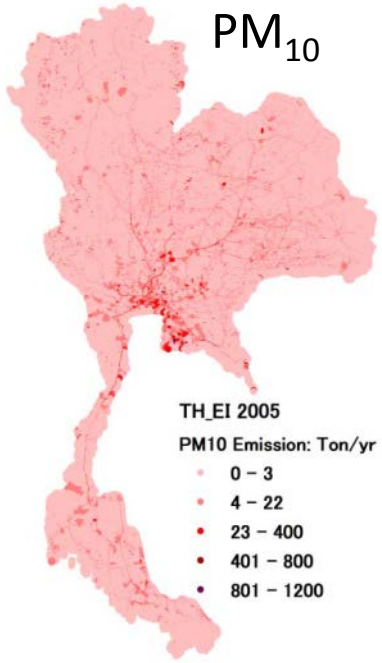
# Thailand emission inventory 2005

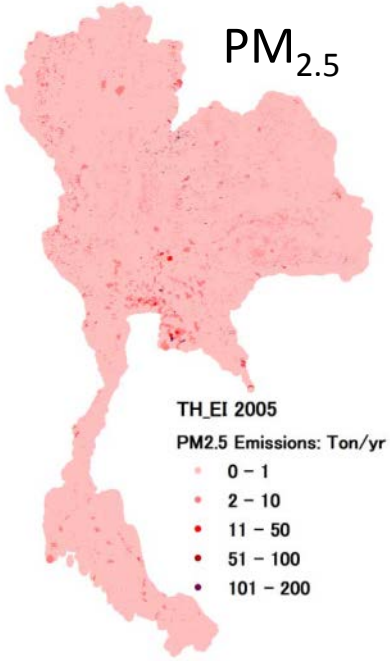


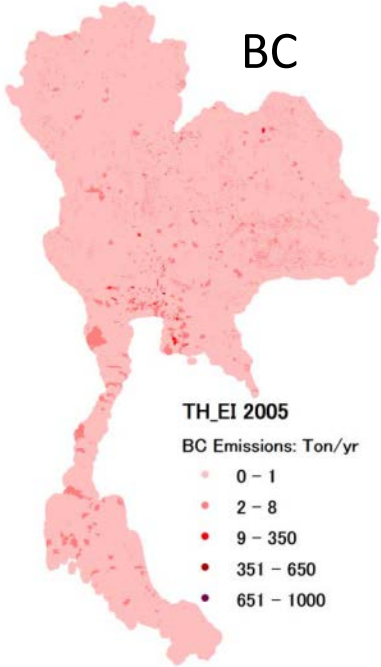



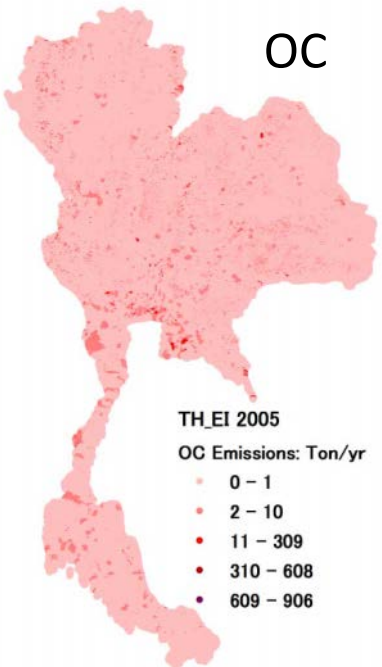



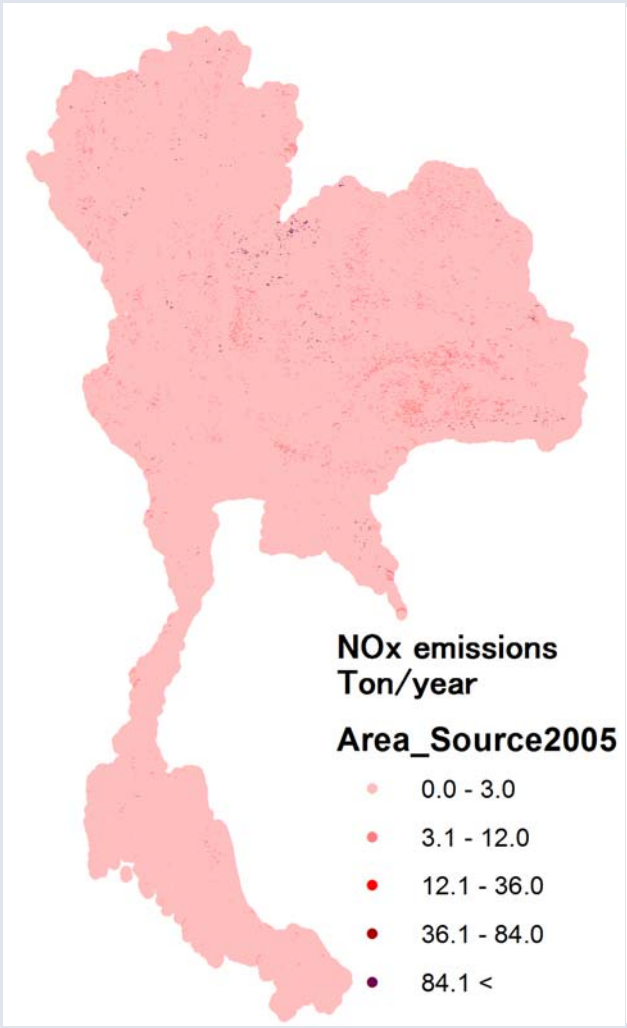



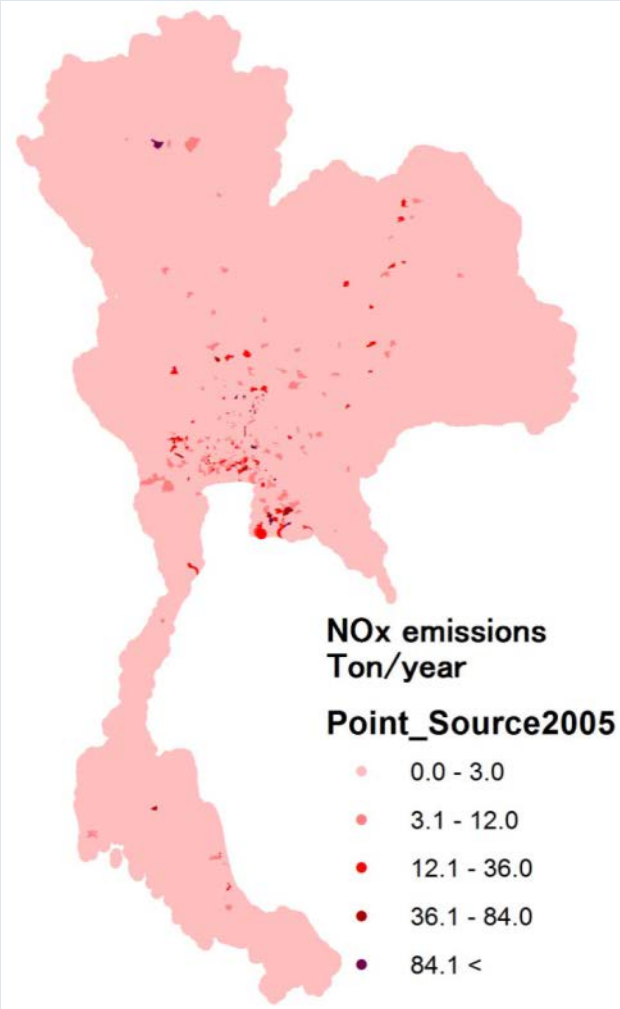



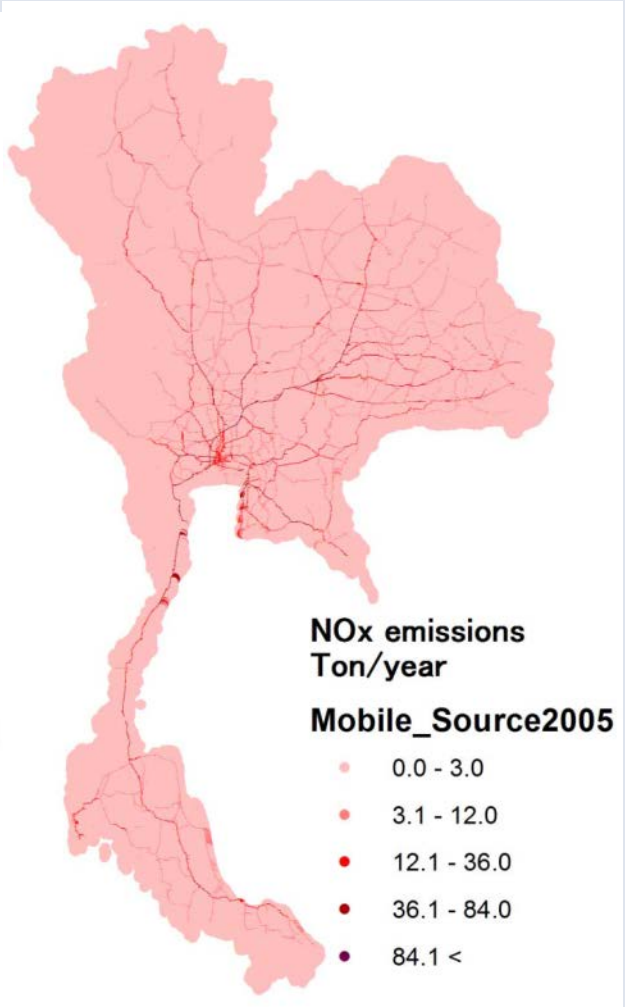



# Thailand $NO_x$ emissions 2005



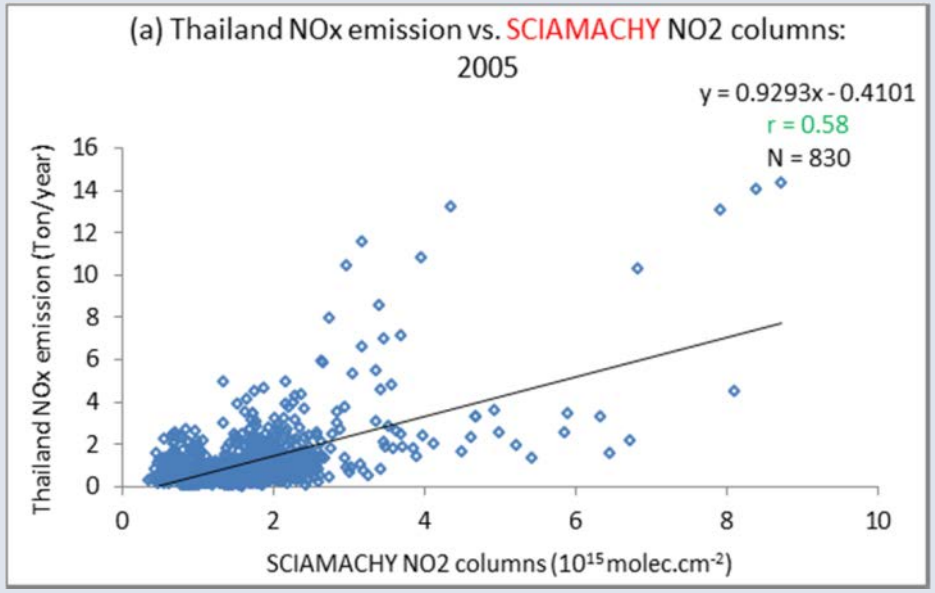



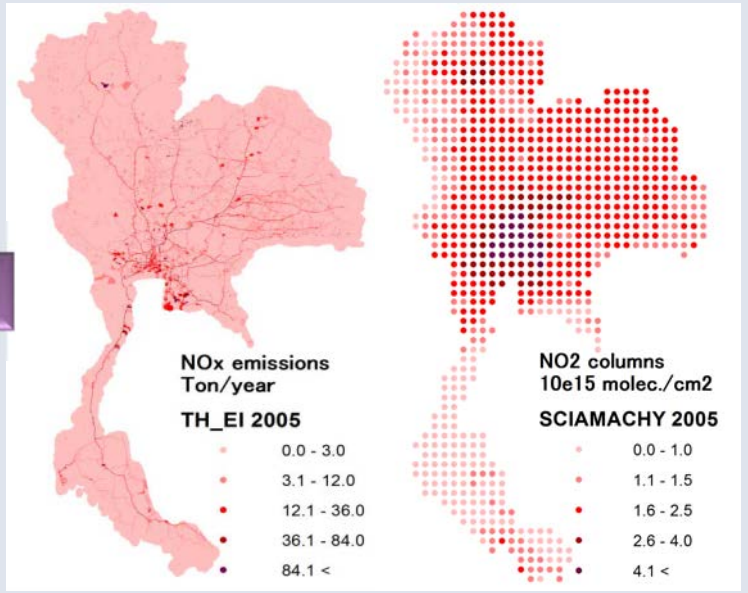

**Area Source**
**Resolution: 1x1 km$^2$**

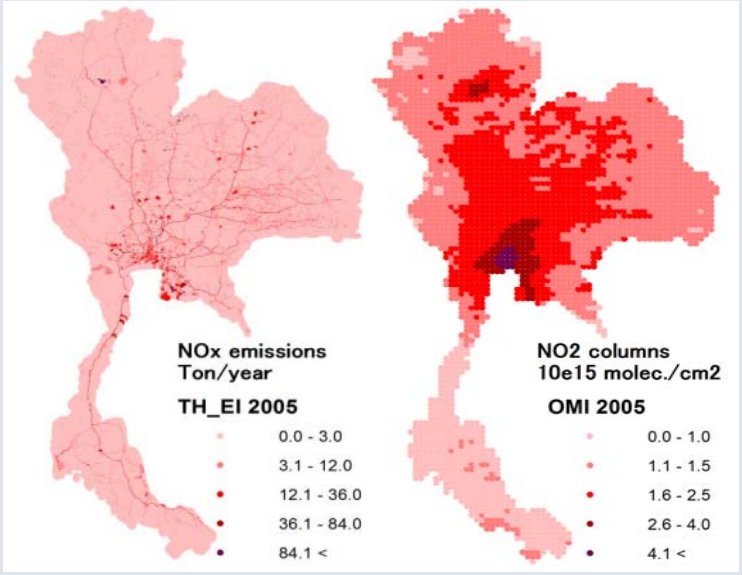
**Point Source**
**Resolution: 1x1 km$^2$**

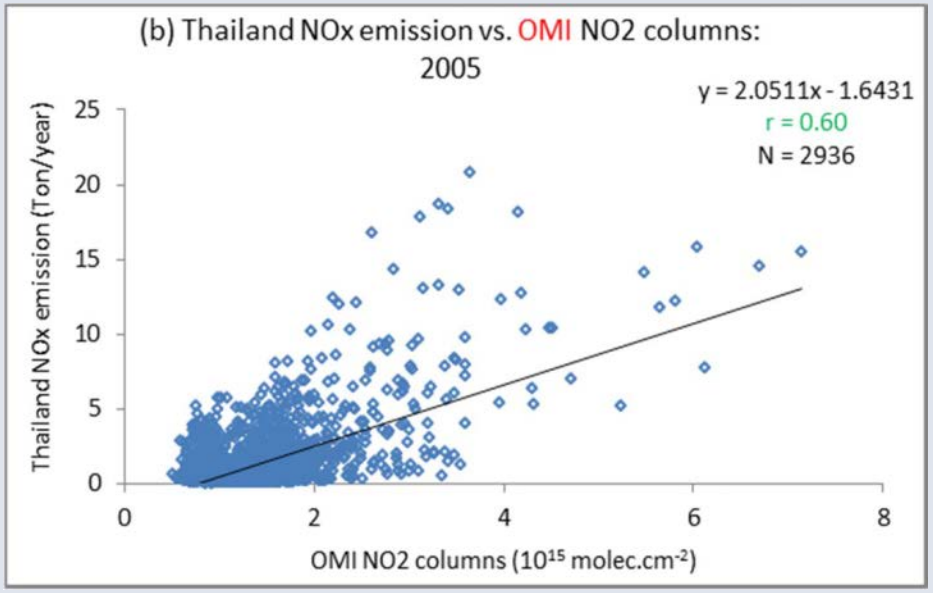
**Mobile Source**
**Resolution: 1x1 km$^2$**

# Thailand $NO_x$ emissions vs. Satellite $NO_2$ columns

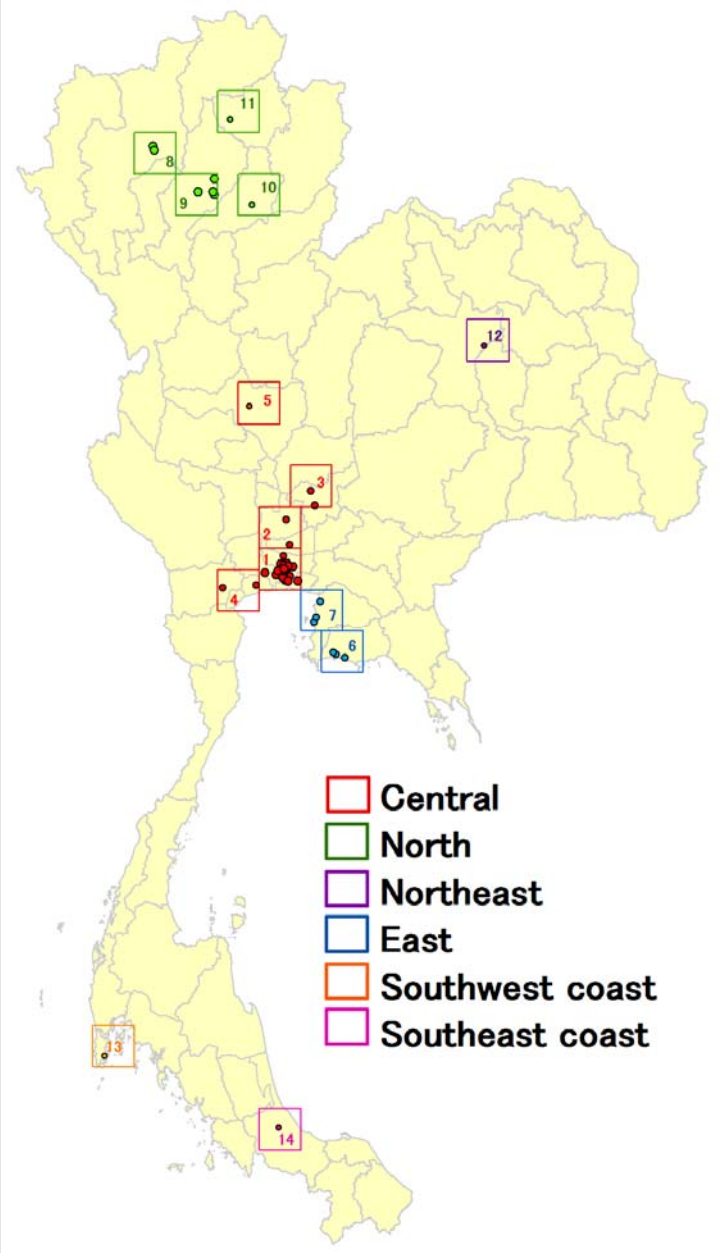


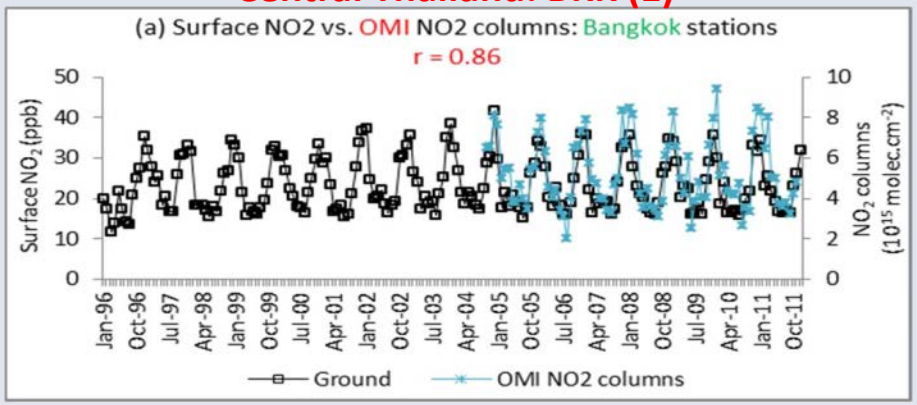



# Ground monitoring $NO_2$ vs. Satellite $NO_2$ columns

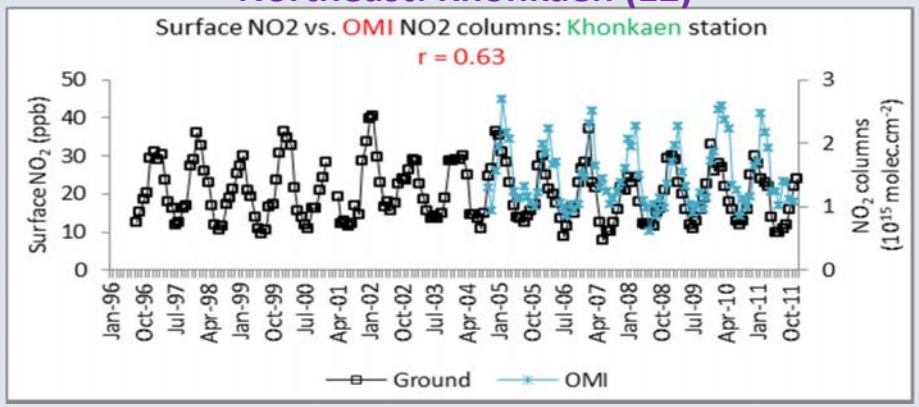



# Ground monitoring $NO_2$ vs. Satellite $NO_2$ columns

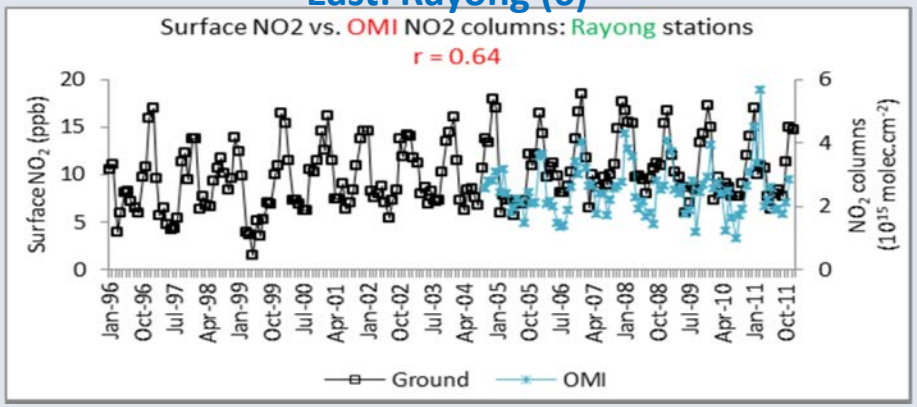
## Central Thailand: BKK (1)



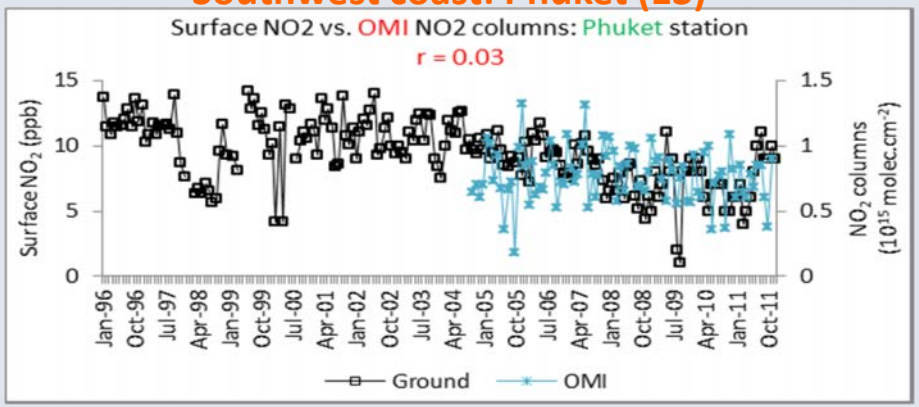

## Northeast: Khonkaen (12)



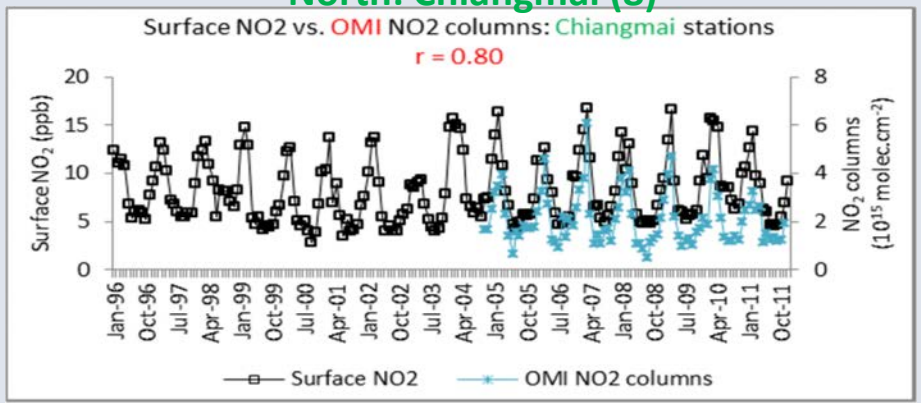

## East: Rayong (6)



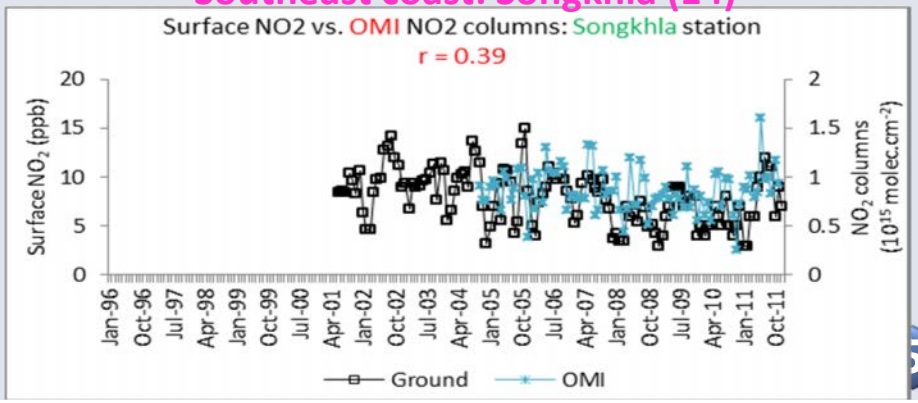

## Southwest coast: Phuket (13)




## North: Chiangmai (8)



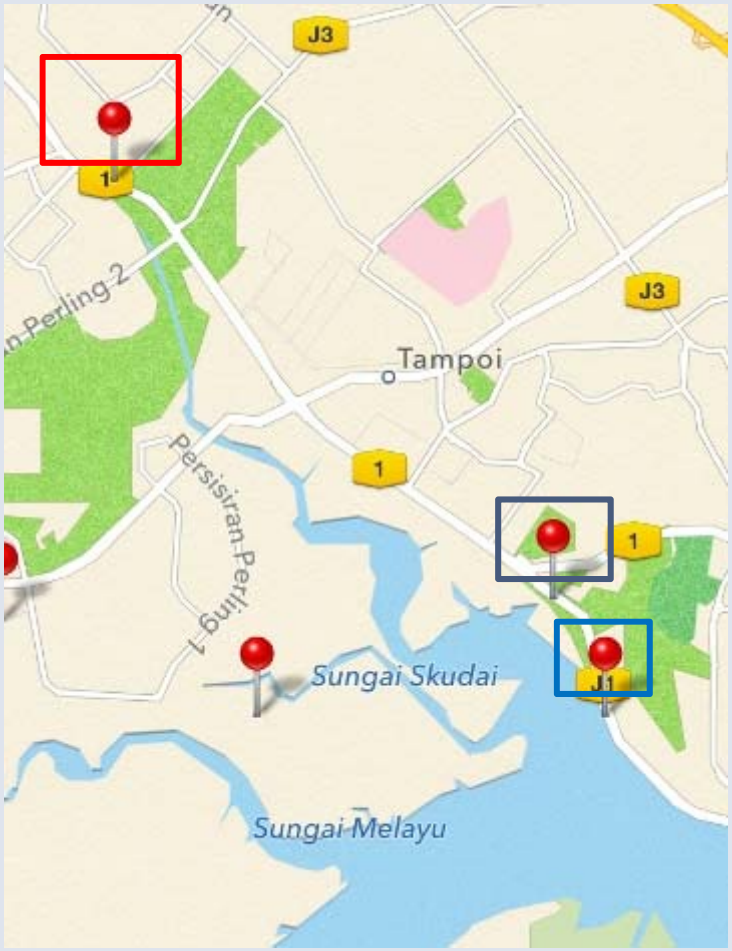

## Southeast coast: Songkhla (14)



# Roadside monitoring of Particulate Matters in Iskandar Malaysia

# Counting of Road transportation

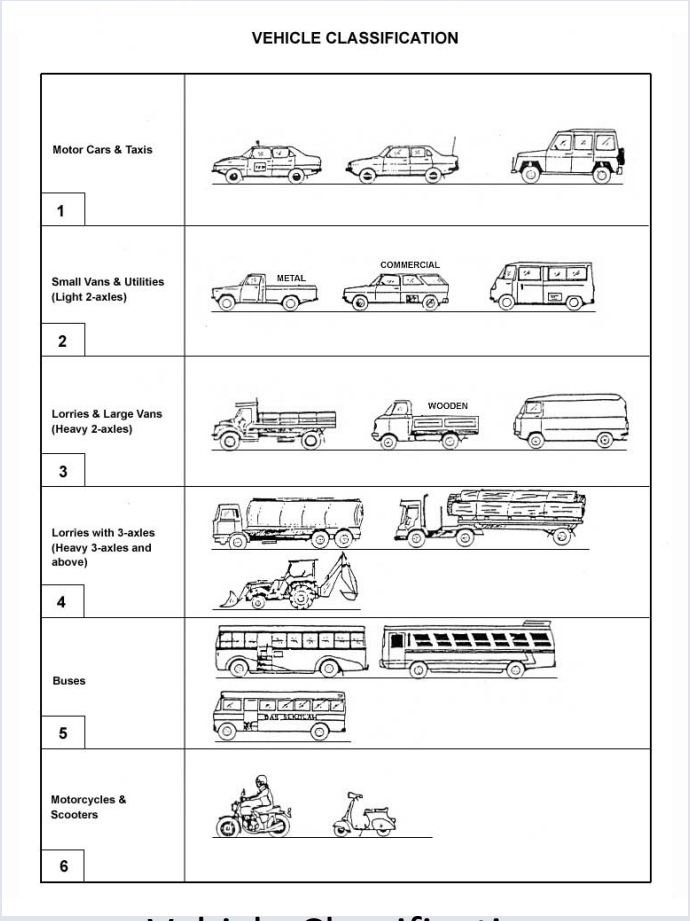
Counted the number of transportation at 3 locations along the major highway in Johor Bahru, Malaysia




Loction1

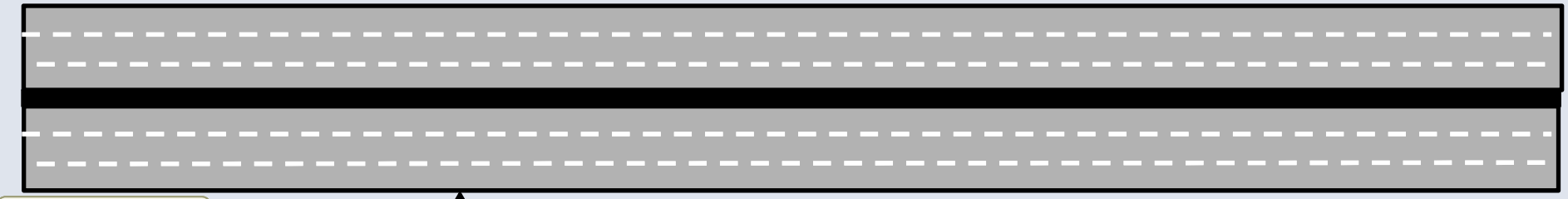
Loction2

Loction3




Vehicle Classification

# Roadside monitoring



**Equipments**

**DUSTTRAK Ⅱ 8532**

PM:1.0~10μm


**HAZ6000**

$CO_2$ : 0-5,000 ppm
CO : 0-100 ppm
NO2 : 0- 5,000 ppb
SO2 : 0-5,000 ppb
Ozone : 0-1000 ppb
VOC : 0-100ppm

**GRIMM EDM164**

PM : 0.25μm-34um , 31 channels
Meteorology: wind, temperature, precipitation, RH

20m

30m

50m

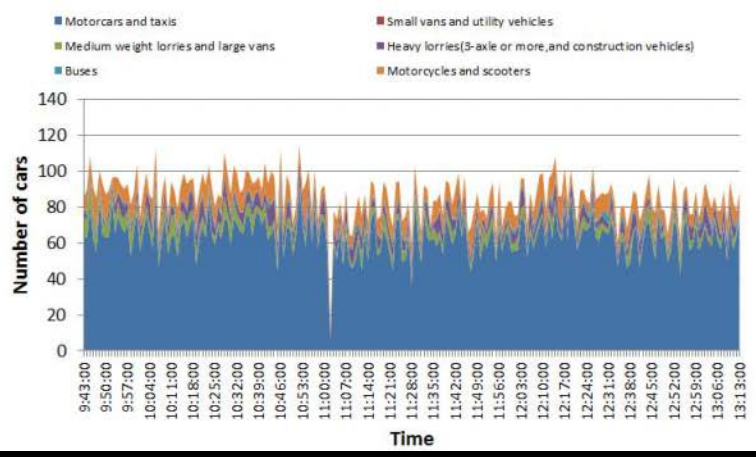
DUSTTRAK Ⅱ 8532 | HAZ 6000 | Grimm EDM164 | Camera

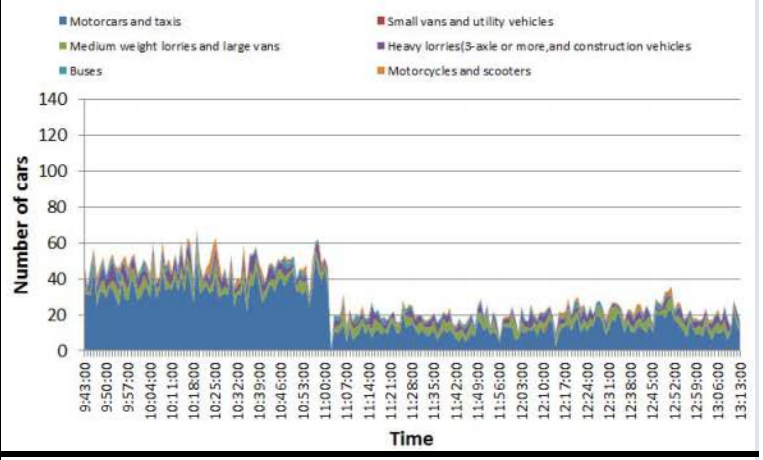
Move DUSTTRAK Ⅱ 8532 per 1 hour(total 3 hours)

## Johor to Skudai

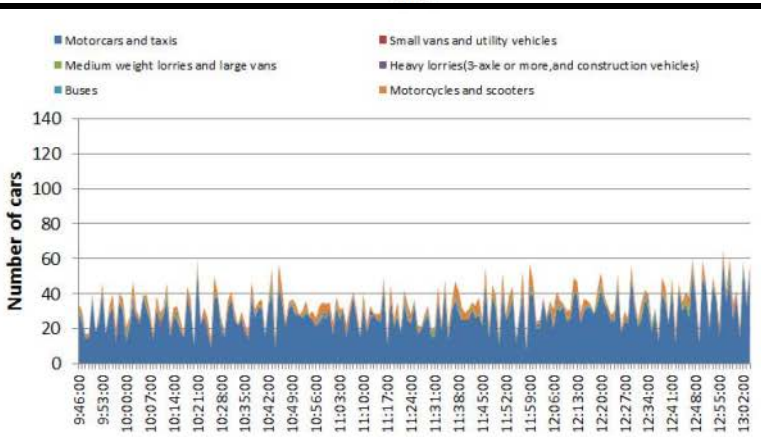
## Skudai to Johor

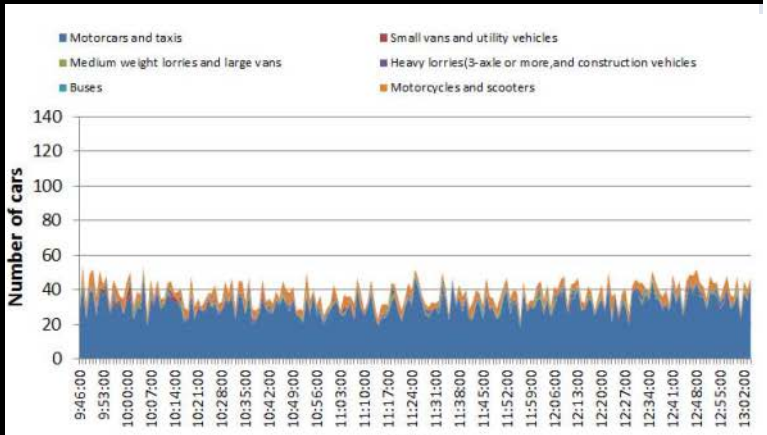
### Loction1



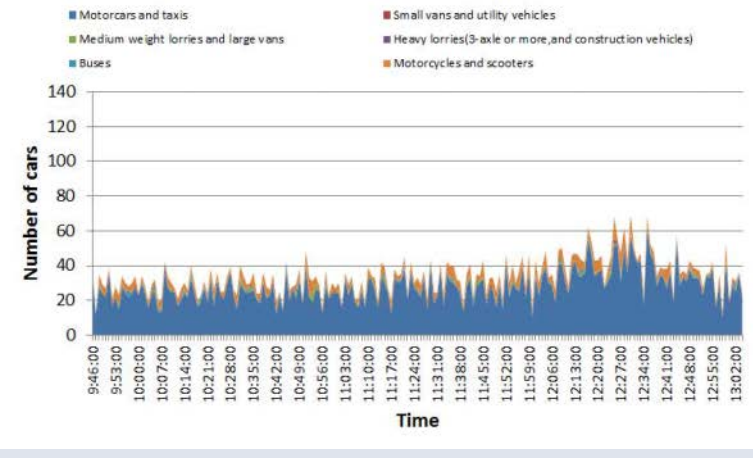



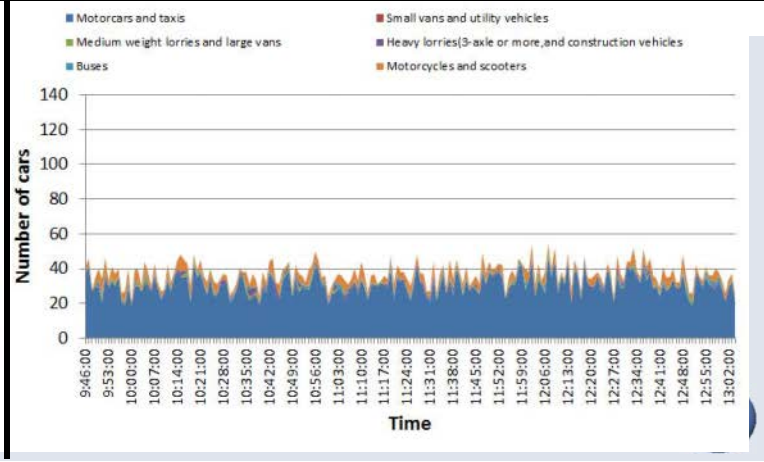

### Loction2




### Loction3



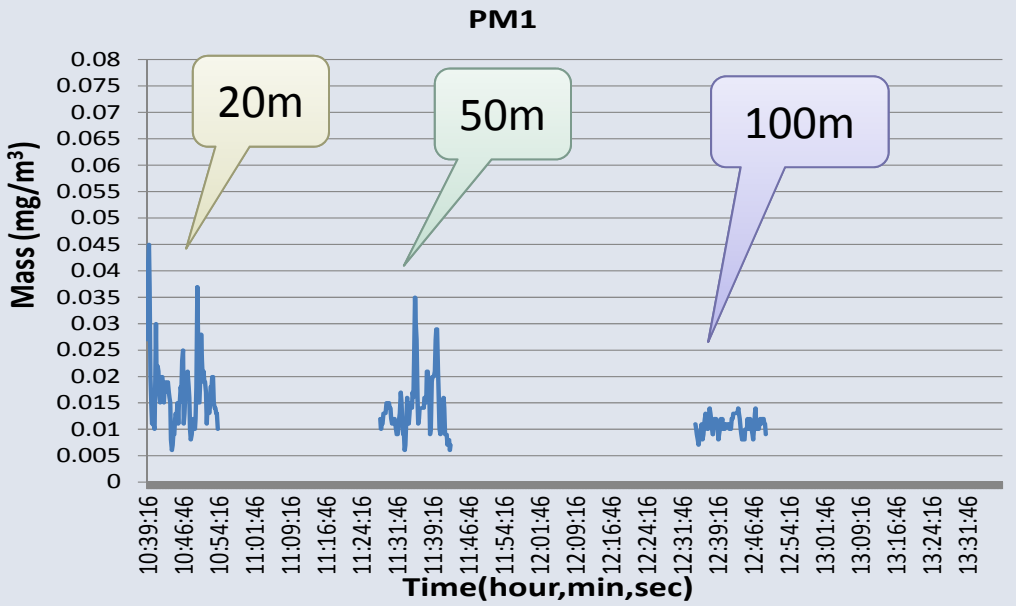
# Sample of Observed data

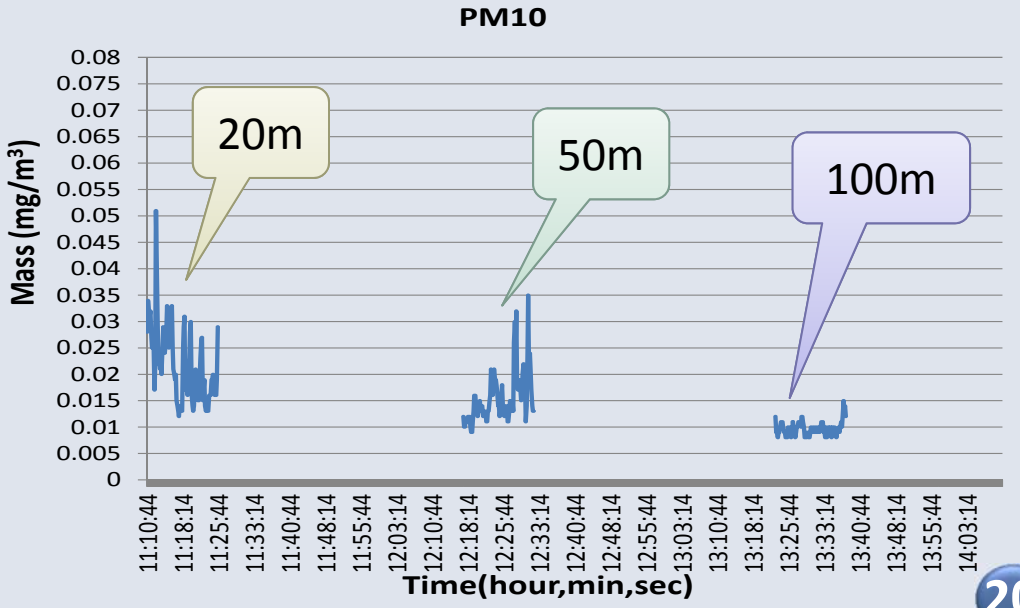
PM concentration
from DUSTTRAK Ⅱ
(20m,50m and 100m point)

Next step

We will use the Gaussian Plume model from line source to reproduce the concentration variation and compare with the observation.

evaluate the emission factor of PM2.5 from the road transportation.



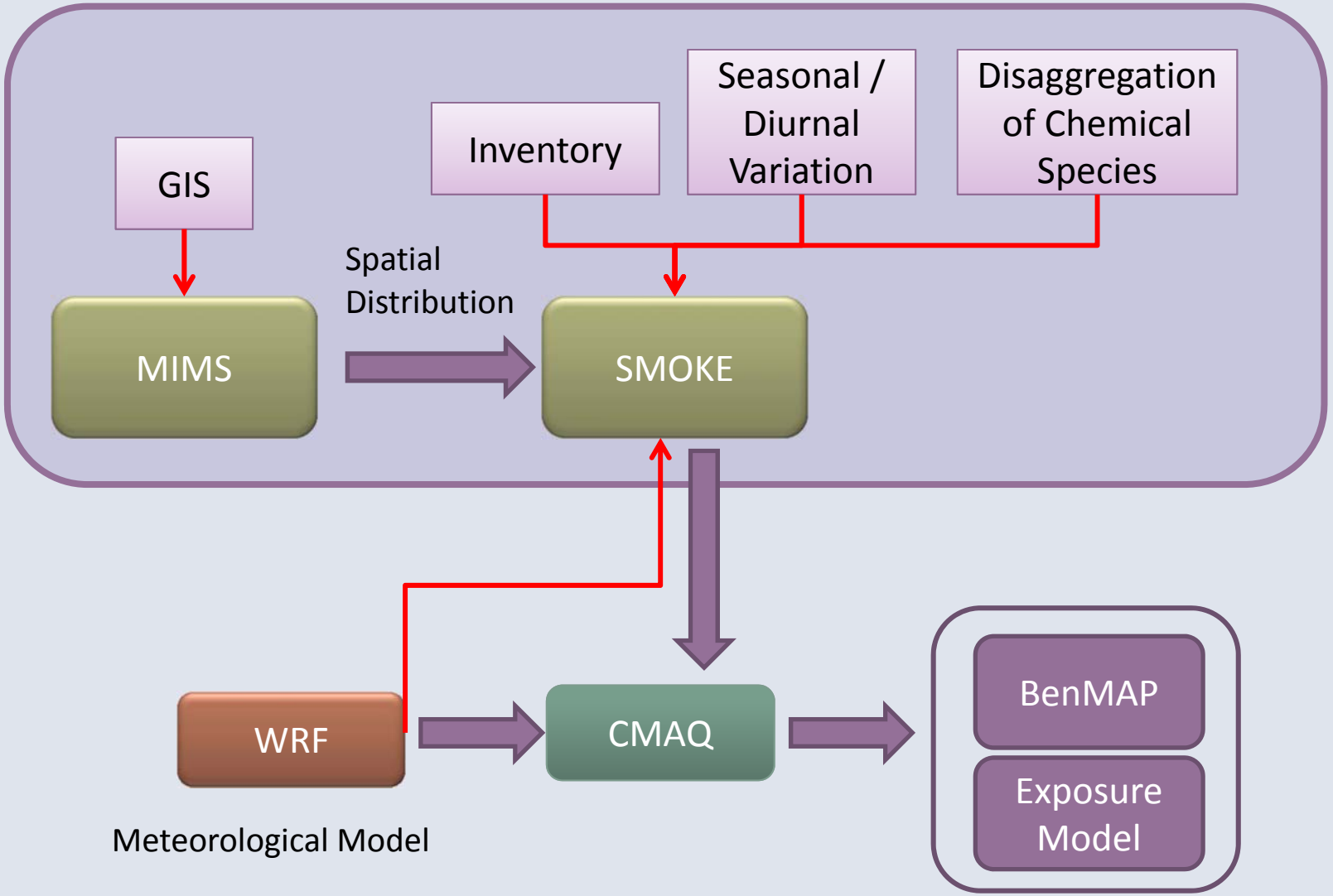



# Improvement of the emission data for the input to Chemical Transport Model.

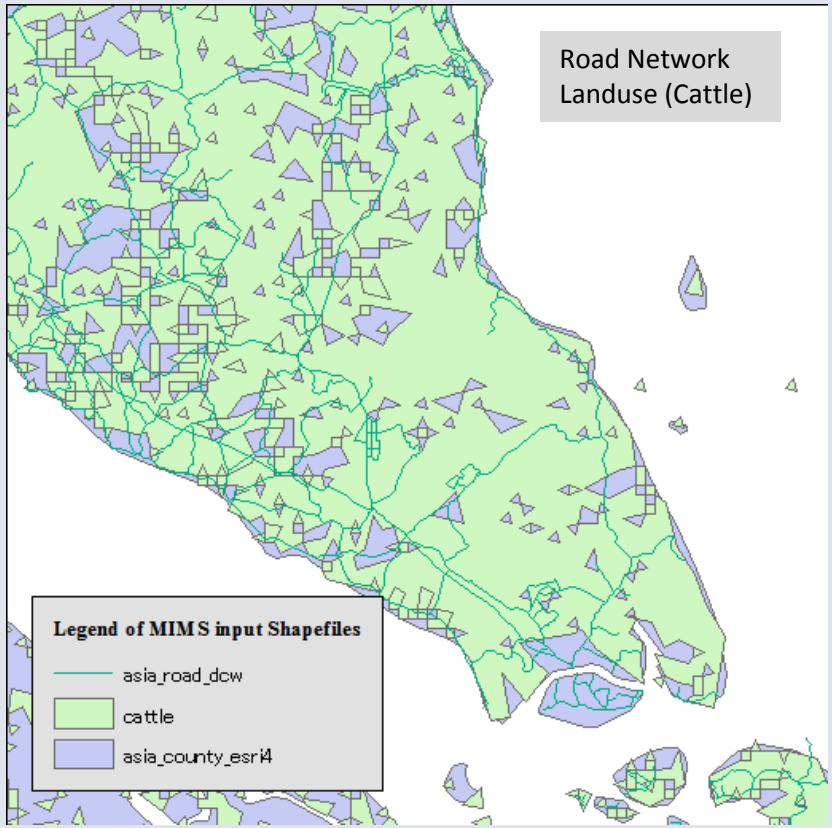
- We have developed the  emission inventory for atmospheric pollutants for Asian countries.
- To use these data for the input of Chemical Transport Model (Air Quality Model), following information is not enough.
  - Spatial distribution ( Spatial Downscalling)
  - Seasonal and Diurnal variation of emission
  - disaggregation of NMVOC to model chemical species.

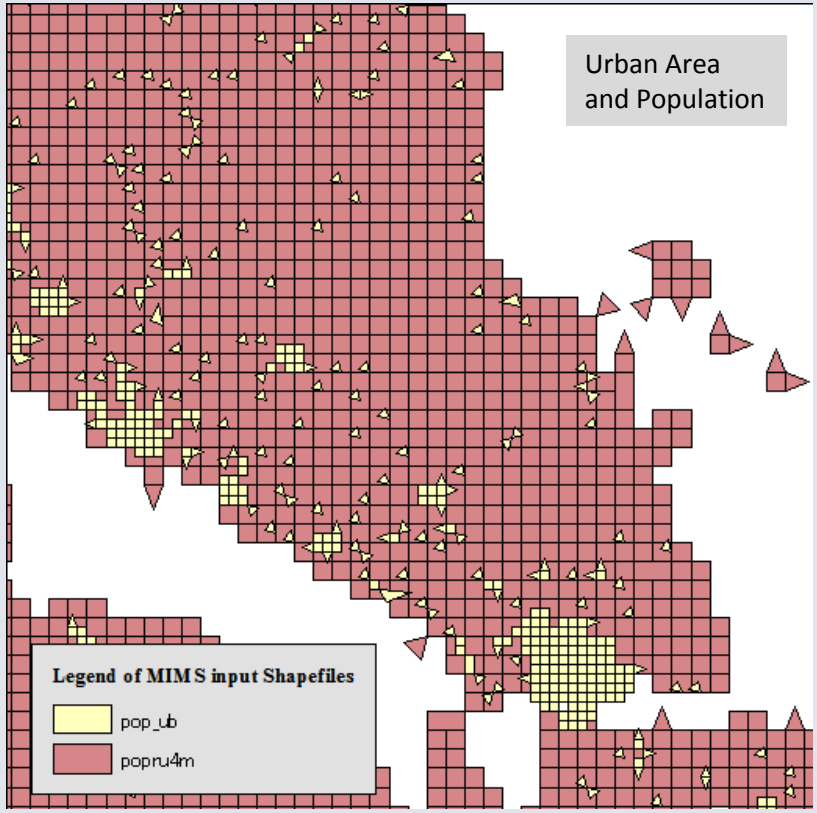
Asian extension of SMOKE system

# Program Flow of SMOKE emission processor



# MIMS input Shapefiles focused on south Malay Peninsula




- Current GIS input is not enough ...
  - Road Network is only covers major highway.
  - Population mesh is coarse and not so accurate

➔ replace the GIS data for input to MIMS processor.



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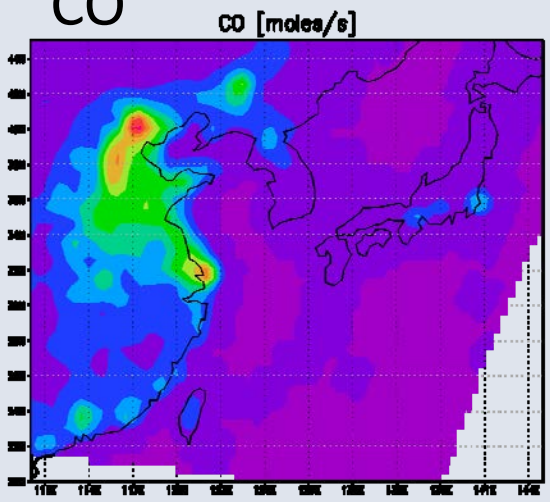
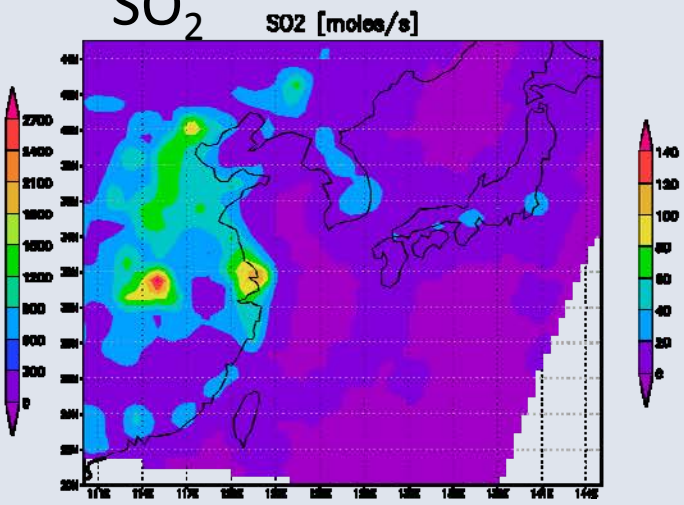
# SMOKE output example

| Emission Processing System | SMOKE-Asia v1.1 (Konkuk Univ) |
|---|---|
| Spatial Domain | East Asia |
| SMOKE Processing Period | 5/26/2008 ~ 6/01/2008 |
| Emission Inventory Data | 2008 |
| Chemical Mechanism | Carbon Bond Mechanism IV (CB04) |
| Meteorological Data | WRF-MCIP |
| Processing Target Materials | CO, NOX, $SO_2$, VOC, $PM_{10}$ |

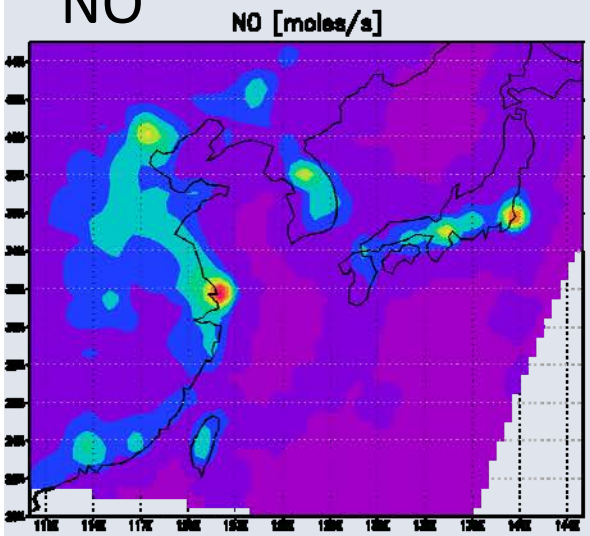
CO



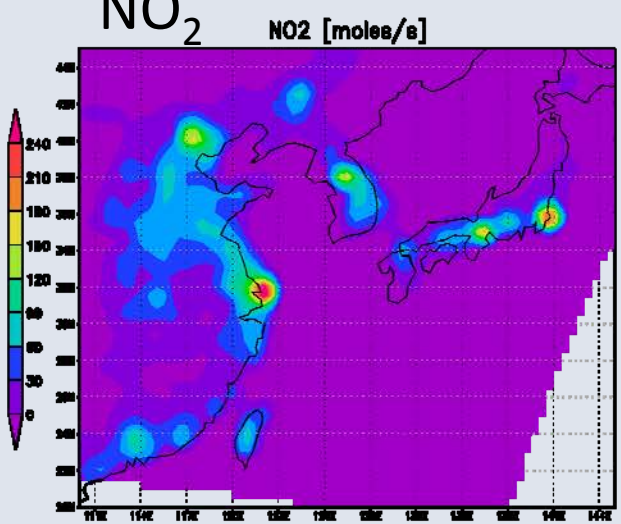

$SO_2$



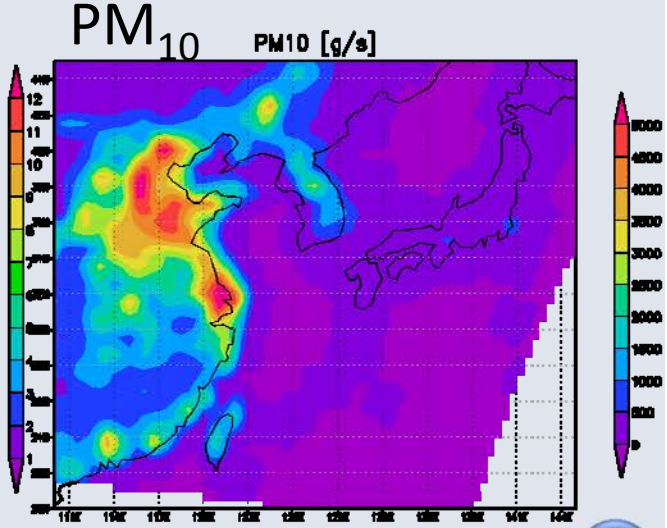

NO




$NO_2$




$PM_{10}$



# Next step of the study

To complete current project in next several months.