

# Investigation of Particulate Matter in Thailand using WRF-Chem Model

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# Thailand Geography

**ASEAN Member:** 10 countries:  
Brunei, Cambodia, Indonesia, Laos,  
Malaysia, Burma, Philippines,  
Singapore, **Thailand**, Vietnam

**Area:** about 513,000 km<sup>2</sup>

**Populations:** about 63,000,000

**North:** the mountainous areas

**Northeast:** Plateau

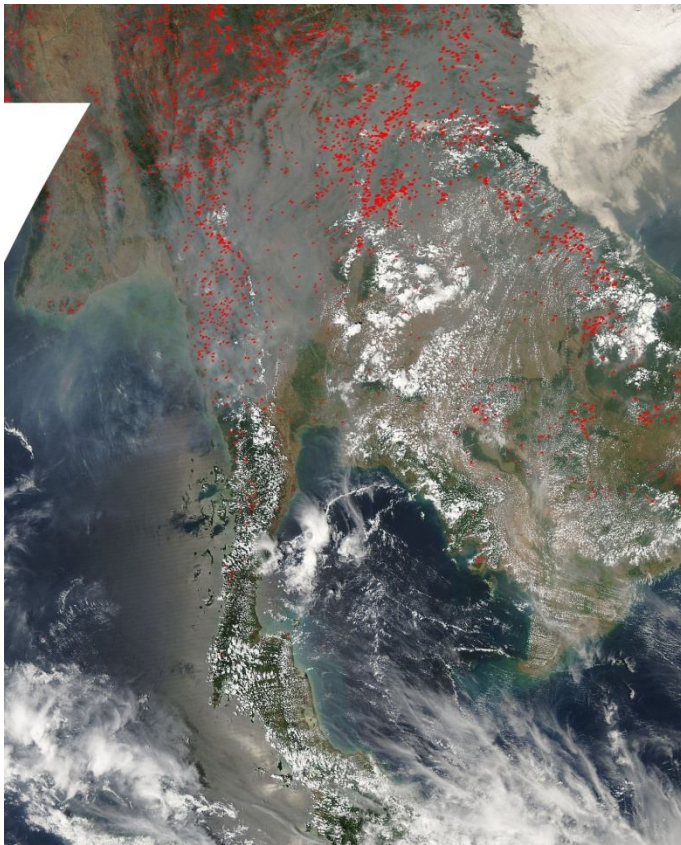
**Central:** low land

**Southern:** mountain chain in middle



# Air Pollution in Thailand

- Particulate Matter (PM) is a main problem in Thailand and Southeast Asia
- Biomass burning and forest fires are the major sources of the PM.



- Fire sources and smoke over Thailand and neighbors was captured on March 13, 2007 by Aqua/MODIS
- High sources are in Thailand, Laos, Myanmar and some part of Cambodia

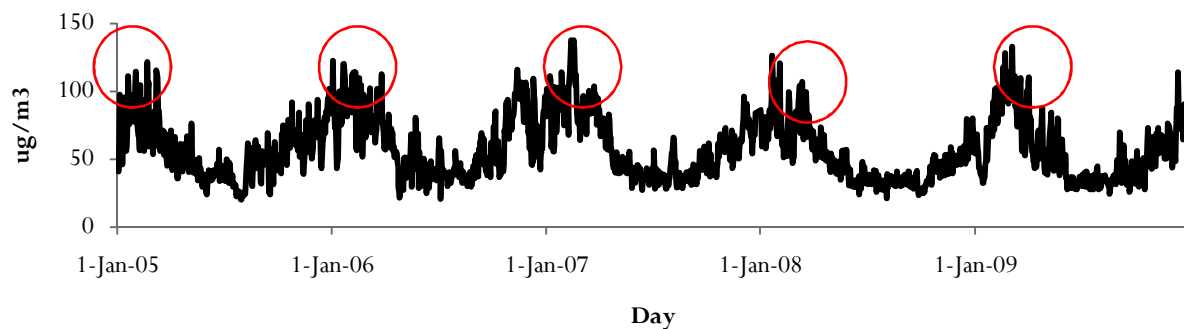
# Air Pollution in Thailand

- Biomass burning and forest fire usually take place during the dry season from December to early April of the following year
- The age-old practice of burning-off undergrowth in forest in the mountainous region.



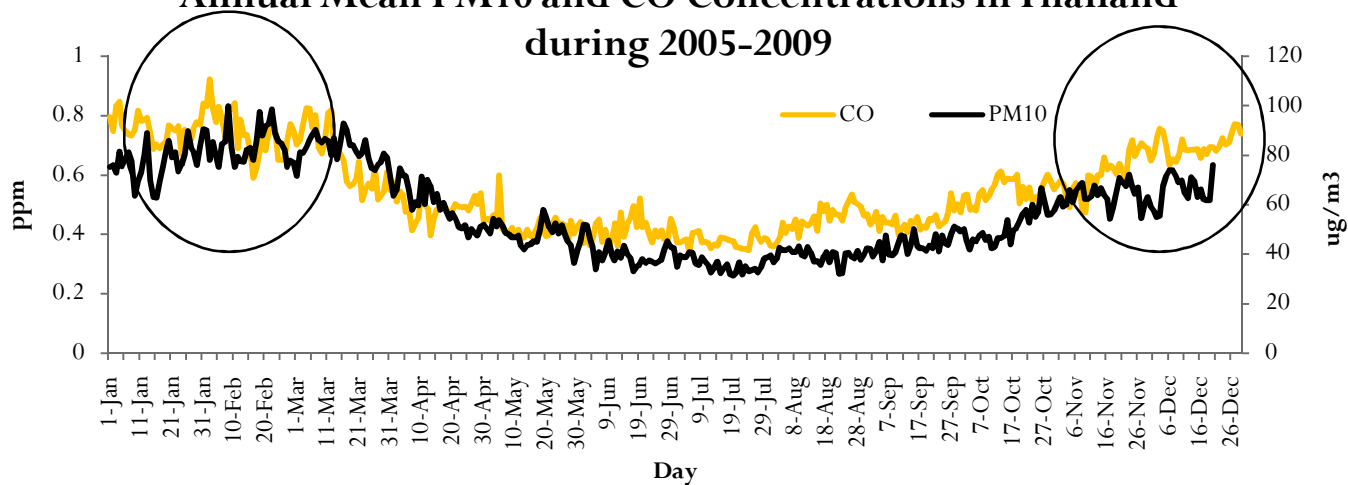
# Air Pollutions in Thailand

## Daily Mean PM10 Concentrations in Thailand



Start in December to early April

## Annual Mean PM10 and CO Concentrations in Thailand during 2005-2009



# Air Pollutions in Thailand



March 5, 2007, Chiang Mai, Thailand  
PM10 Concentrations are  $197.7 \mu\text{g}/\text{m}^3$

**Thailand Standard: Not exceed  $120 \mu\text{g}/\text{m}^3$**

March 10, 2010, Chiang Mai, Thailand  
PM10 Concentrations are  $162.2 \mu\text{g}/\text{m}^3$



Air pollution in Chiang Mai , Northern part of Thailand

# WRF-Chem

- The Weather Research Forecasting Model with Chemistry (WRF-Chem) has been developed by several groups.
  - the National Oceanic and Atmospheric Administration (NOAA)
  - The National Center for Atmospheric Research (NCAR)
  - Pacific Northwest National Laboratory (PNNL)
  - Earth System Research Laboratory (ESRL)

# WRF-Chem

- Completely embedded within WRF Model
- Consistent: all transport done by meteorological model
- Include gas phase chemistry packages
- Available aerosol module
- Photolysis packages-all coupled to aerosol and hydrometeors

(Grell, 2009)



# Air Pollution Modeling in Thailand

- WRF-Chem was used as Regional Chemical Dynamical Model.
- NCEP NCAR Reanalysis Projected (NNRP) data were used as Meteorological initial and boundary data.
- Model for Ozone and Related chemical Tracers (MOZART) data were used as Chemical initial and boundary data.
- Reanalysis of the Tropospheric Chemical Composition (RETRO) data were used as anthropogenic emission data.
- The Fire Inventory from National Center for Atmospheric Research (NCAR) (FINN) data were used as biomass burning data.

# Air Pollutions Modeling in Thailand

- **Model Configurations**

- **Physics**

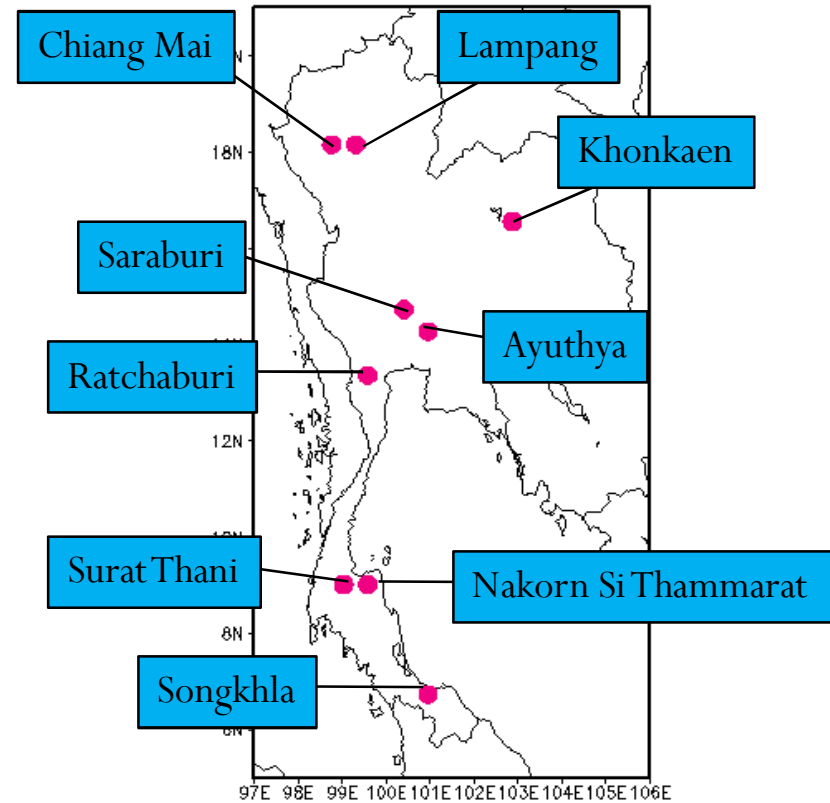
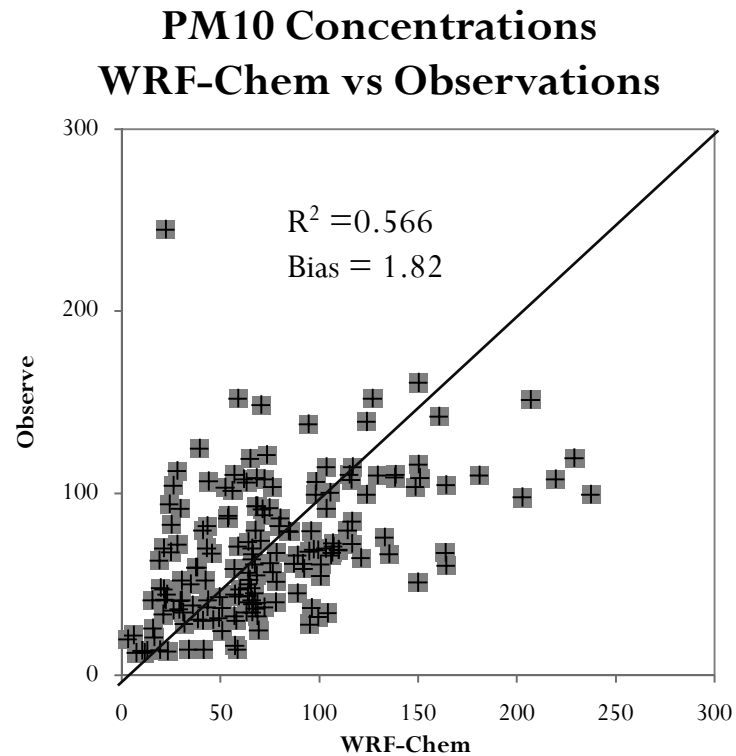
- WSM 6-class graupel scheme
    - RRTM for longwave radiation
    - Dudhia scheme
    - Monin-Obukhov (Janjic Eta) scheme
    - Noah land-surface model
    - Mellor-Yamada-Janjic scheme
    - New Grell scheme

- **Chemistry**

- MOZART Chemistry and GOCART aerosols
    - Madronich F-TUV photolysis
    - Include dry deposition
    - Biomass burning plume rise

WRF-Chem Model was tested with Particulate Matter Simulation over Thailand and Neighbors with 60 km grid resolutions

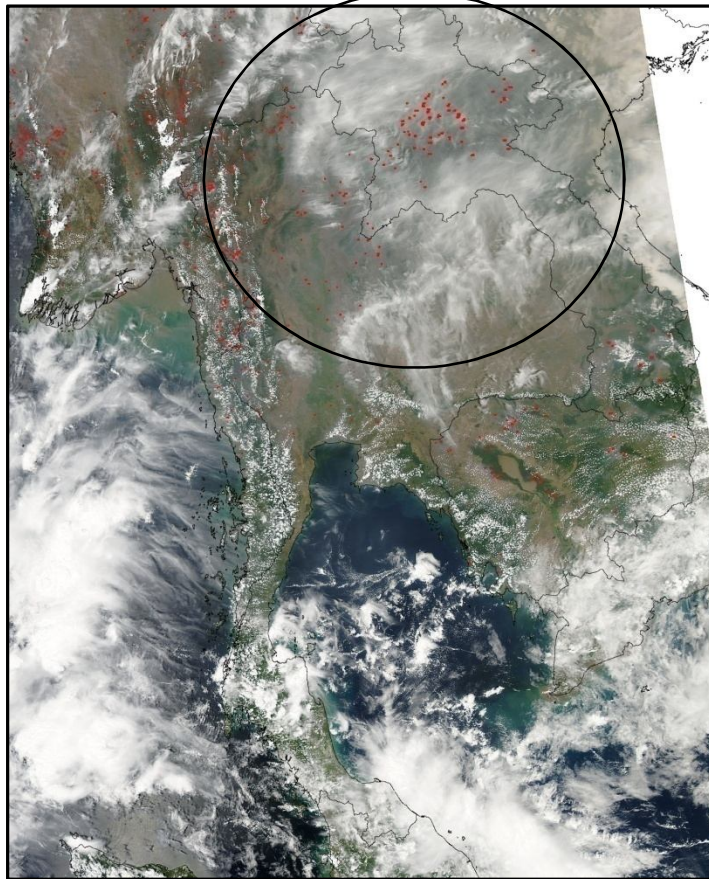
# Model Evaluation



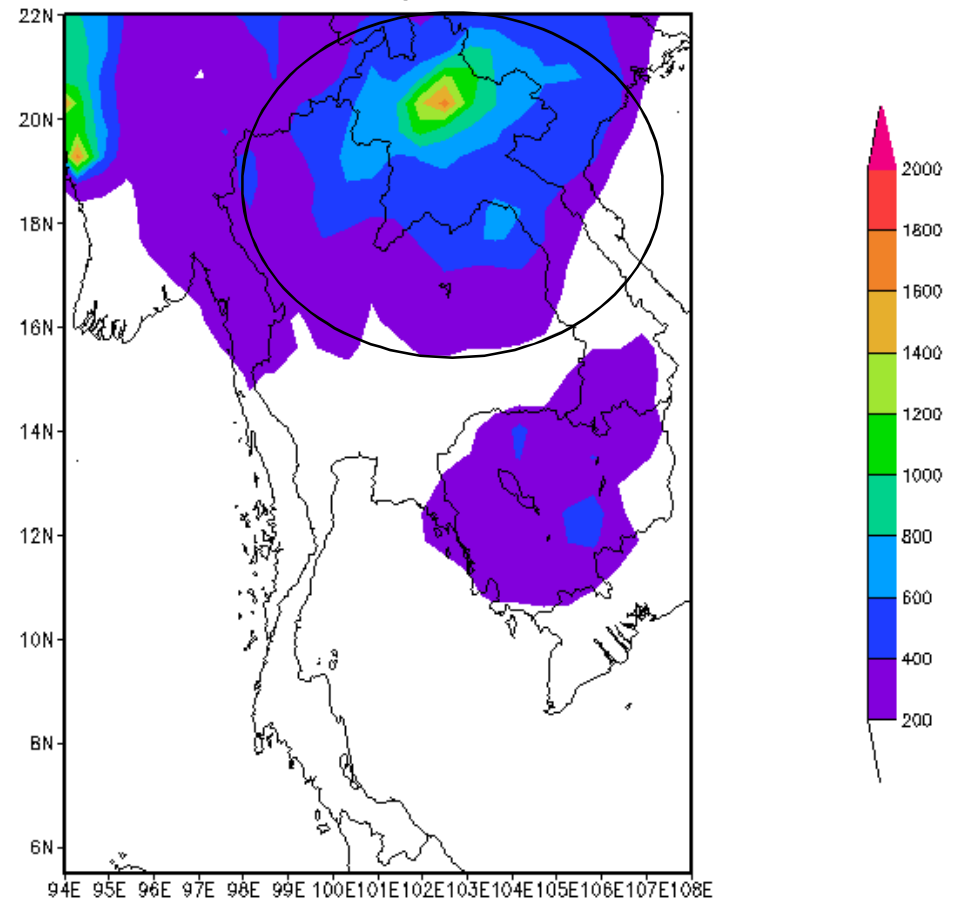
9 Observations in Thailand were used to evaluate with WRF-Chem simulations in March 2005

# Model Evaluation

Aqua/MODIS Real Image  
March 16, 2009

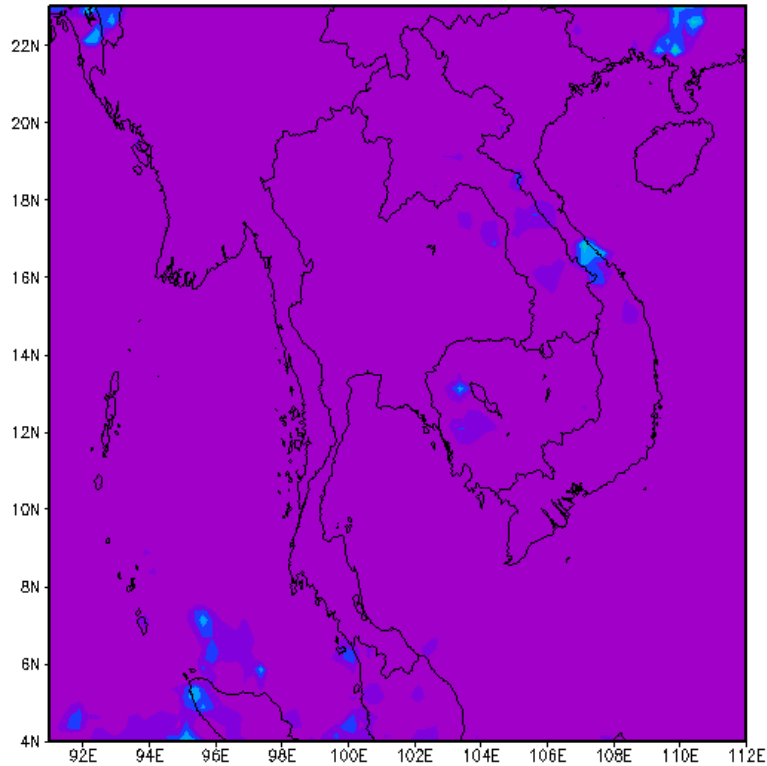


PM10 WRF-Chem Simulation  
March 16, 2009

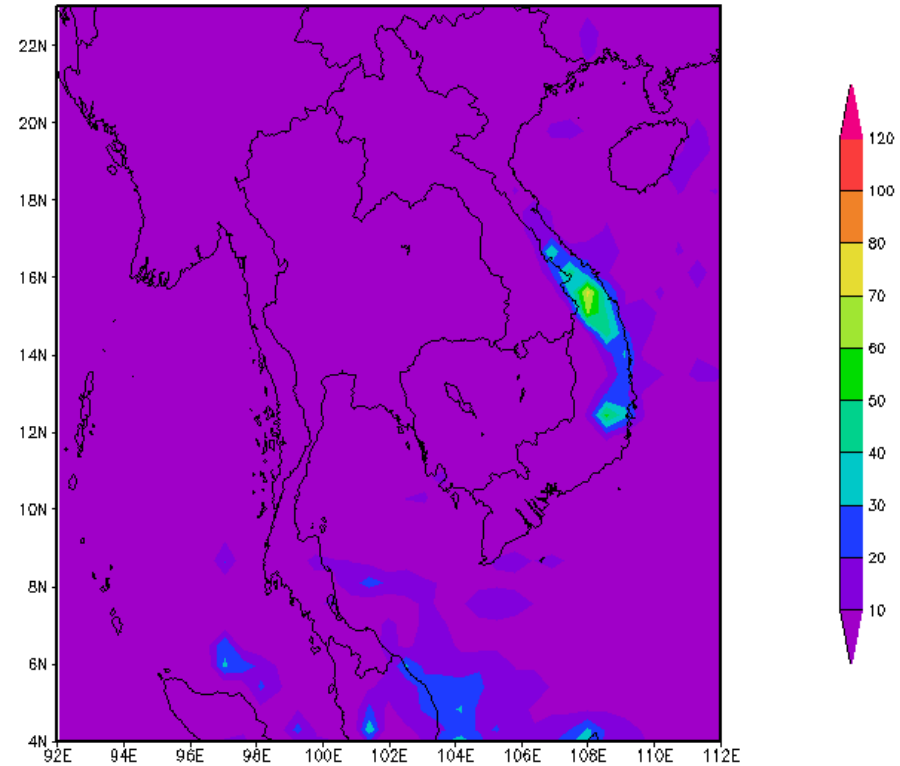


# Model Evaluation

TRMM Precipitation (mm)  
March 22, 2005



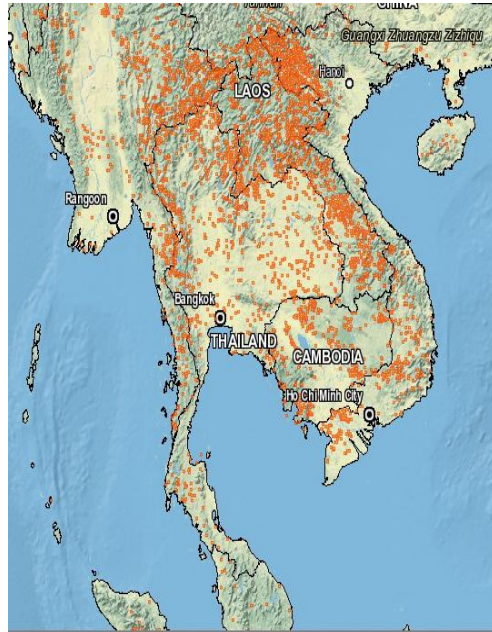
WRF-Chem Precipitations (mm)  
March 22, 2005



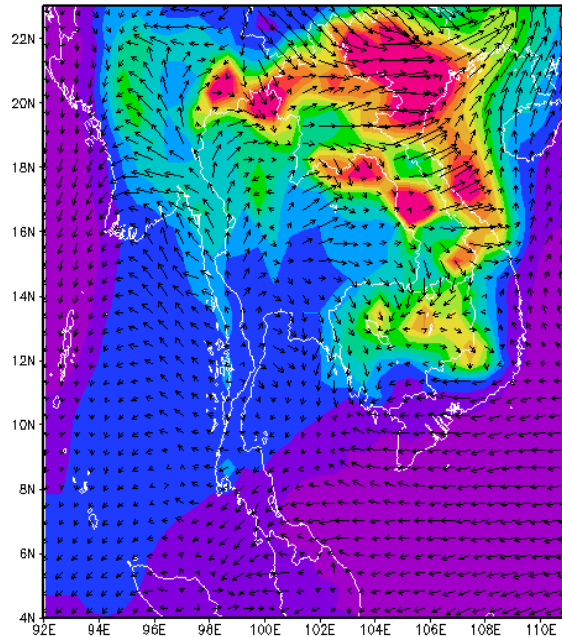
**Comparable with Tropical Rainfall Mission Measurement from NASA**

# PM10 and PM2.5 Dispersion

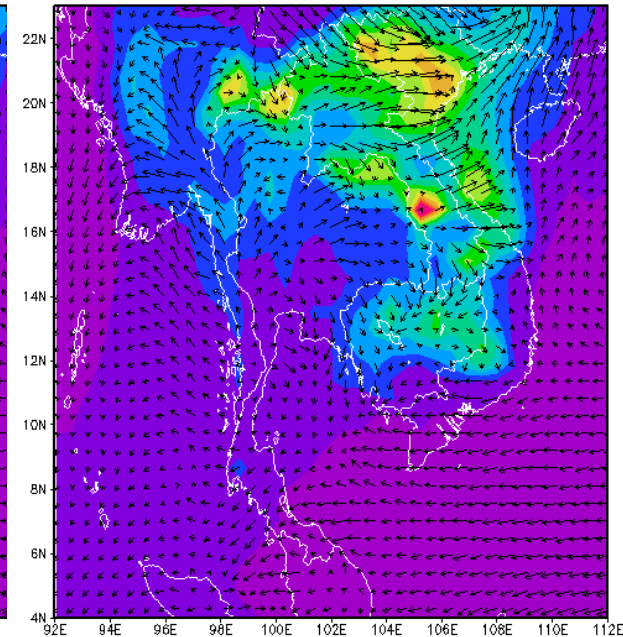
FIRM hot spot  
March 11, 2005



PM10 Concentrations ( $\mu\text{g}/\text{m}^3$ )  
March 11, 2005

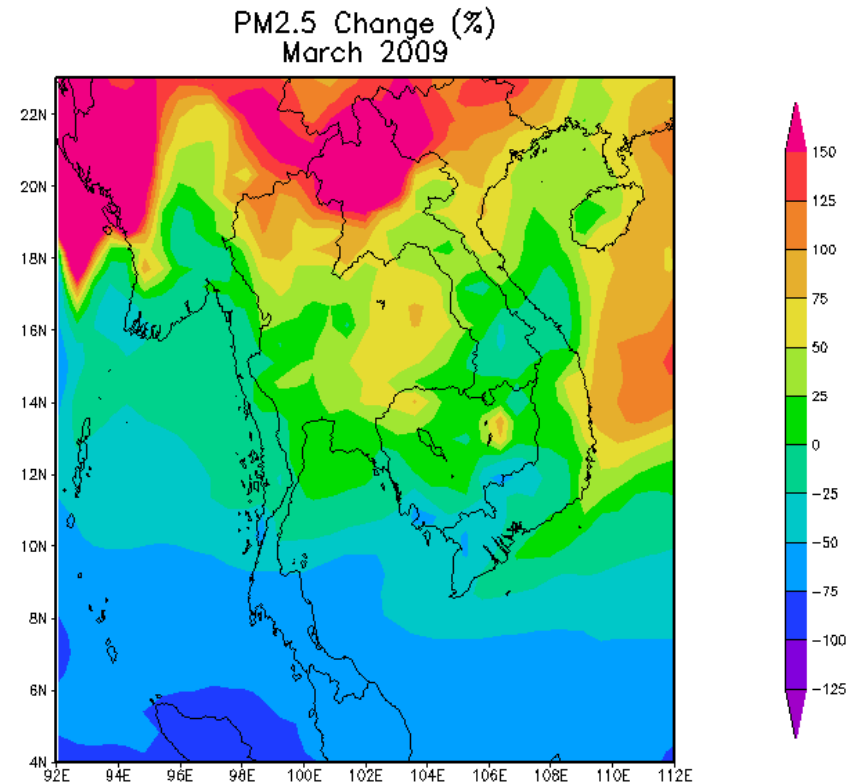
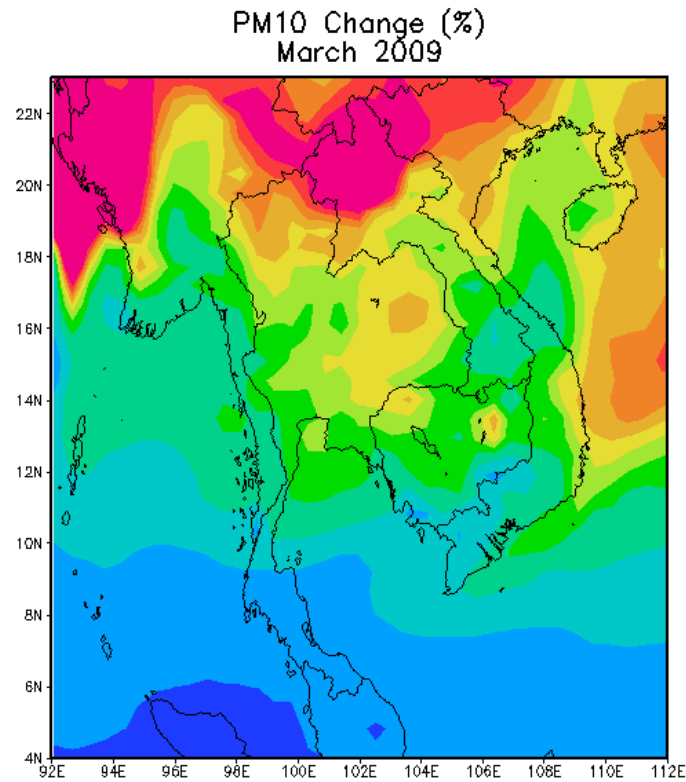


PM2.5 Concentrations ( $\mu\text{g}/\text{m}^3$ )  
March 11, 2005



High concentrations of the PM agree with hotspots in the burning areas nearby sources (Laos, Myanmar and northern Thailand as well as Vietnam) and spread out along wind

# PM and PM2.5 Change in 2009



PM10 and PM2.5 Change in March 2009 compared to March 2005

PM increase in upper domain

# PM10 and PM2.5 Change in 2009

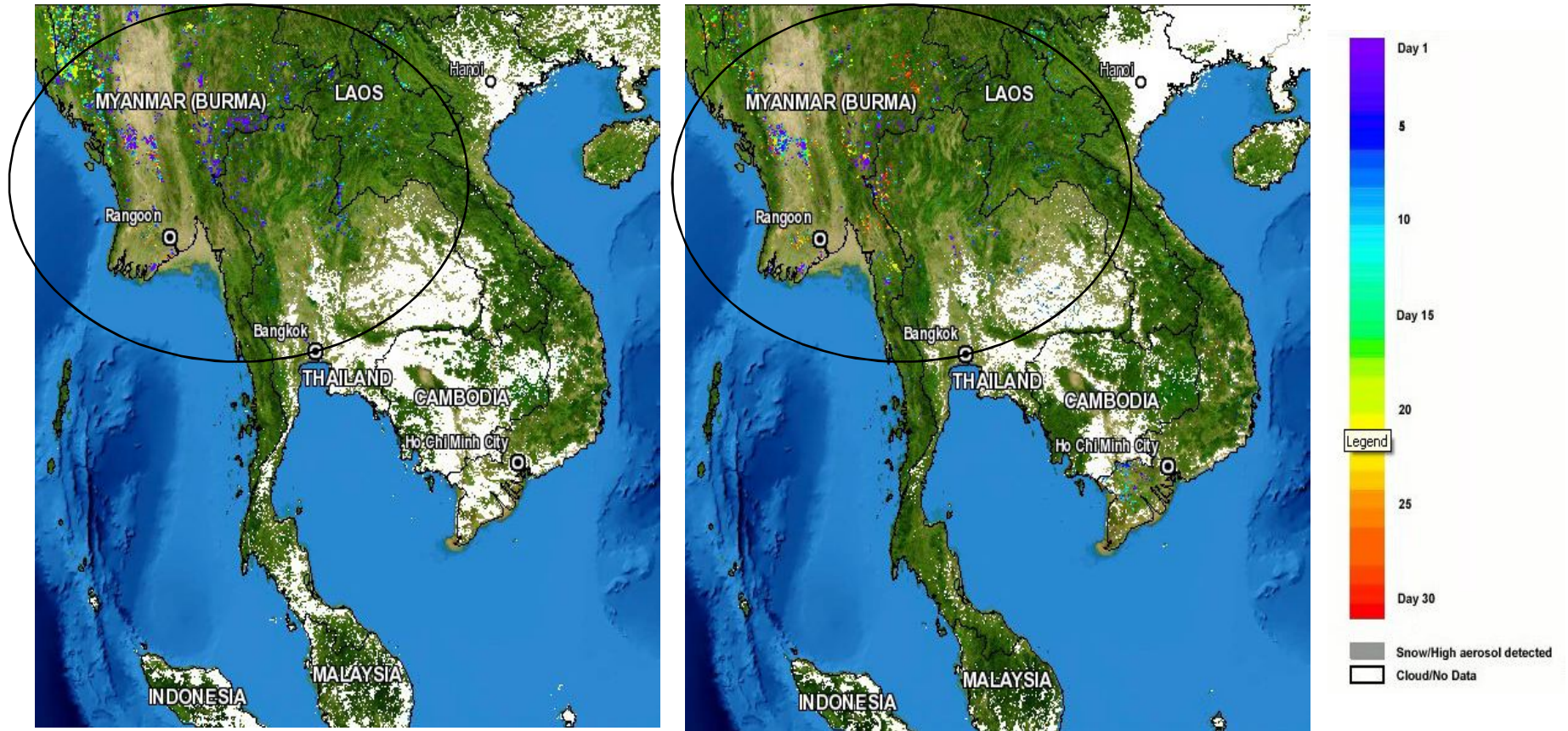
- Why PM10 and PM2.5 increase in upper domain and decrease in lower domain in 2009 ?

Consider :

- Biomass burning sources
- Weather: precipitation will also decrease pollutants concentrations directly.



# Burning Area Sources



MODIS burning area 2009

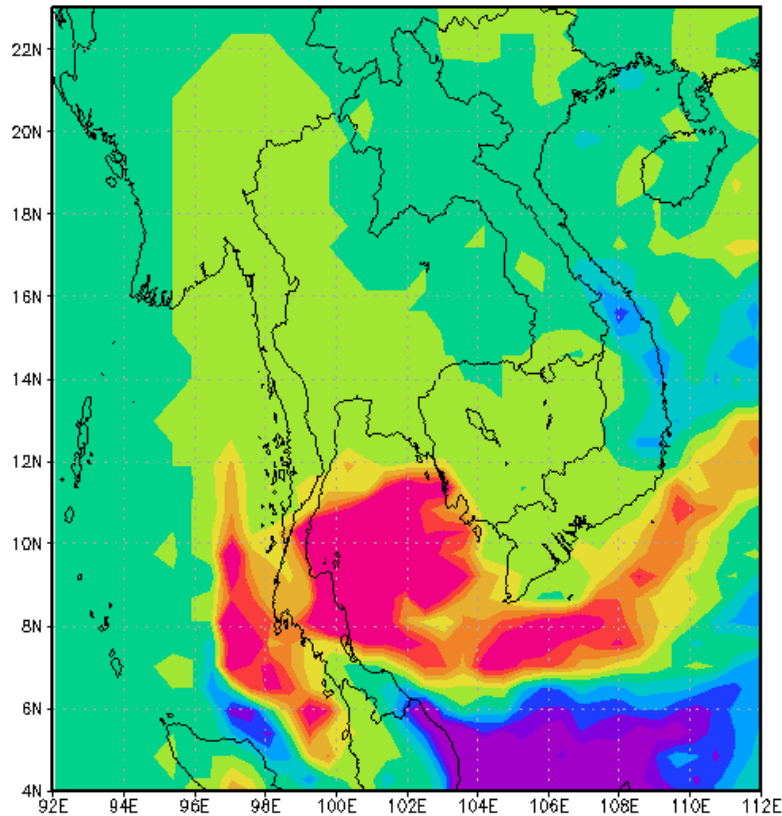
MODIS burning area 2005

High in Upper part of Thailand, Laos, Myanmar, Vietnam and Cambodia

Slightly Difference

# Precipitations Change

Precipitations Change (mm)  
March 2009



- Precipitations change **obviously** increase in lower part of domain (Southern Thailand), whereas decrease in upper part.

# Summary

- Biomass burning and forest fires are main sources of particulate pollution in Thailand and neighbors
- Major biomass burning and fires sources are in Thailand, Laos, Myanmar and Cambodia
- PM10 and PM2.5 increase more than 100% in Upper Thailand, Myanmar and Laos in March 2009 compared to 2005
- Precipitations change affect on Particulate Matter Change

# Future Works

- Study Impact of Projected Climate Change on Air Quality Change based on Particulate Matter and Surface Ozone in Thailand using WRF-Chem Model with finer resolution (36 and 12 km)

# Acknowledgement

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Thank you for your attention

