The Study on Dispersion of Pollutants from Wildfire in The Northern Thailand Using WRF-Chem Model

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Abstract

- The objective of this research is to estimate the dispersion of air pollutants from wildfire in Northern of Thailand. The WRF-Chem model was used as a tool for this study. The simulation domain was configured as 3 nested domains. The anthropogenic emissions from global inventory was used for domain 1 while locally developed emissions at 1x1 sq.km. resolution was used for domain 2 and 3. The daily wildland fire emission from Fire INventory from NCAR (FINN) and locally developed were used for comparison. The ozone results show that using Thailand local emission as an input for domain 3 yielded a better performance than global emission. The spatial distribution revealed that high ozone concentrations were observed around the center of Domain 3 which are a part of Chiang Mai, Lampang and Lamphun. The highest concentrations is occurred around noon. The further study on aerosols scheme revealed that SORGAM performed better than GOCART on PM_{10} simulation

- **Keywords:** Wildfire, WRF-Chem, Emission inventory from wildfire

Introduction

Wildfires in Thailand are usually occurred during the dry season started from December to May. The monitoring data from Forest fire control division of Thailand in 2013 revealed that the most frequent burn area is Northern Thailand which the peak period is around February-April. The major type of forest that was burnt are deciduous forest. Smoke from wildfire consists of several air pollutants such as CO, NOx, O_3, PM_{10}, $PM_{2.5}$ and other secondary air pollutants. These hazardous air pollutants have significantly impacted on health of residents and reduce visibility. In addition, the atmospheric inversion that usually occurred during dry season in northern part of Thailand which are mountainous and valley area is also made air quality even worse during haze episode.

The WRF-Chem model was used as a tool to study the dispersion of air pollutants from wildfire in Thailand. The WRF-Chem model is 4th generation or the online model. The advantage of the online model is an ability to calculated both of meteoritical data and chemical mechanism at the same time and have two-way feedback form both calculation. The study period is March – April 2013 and study covers nine provinces in northern part of Thailand including; Chiang Mai, Lamphun, Lampang ,Uttaradit ,Phrae ,Nan , Phayao, Chiang Rai, and Mae Hong Son. The interested air pollutants are CO, NOx, O3 , PM10 and PM2.5.

Model Configuration

The version of WRF-Chem model is 3.6. The study area are divided in 3 Domains. The Mother domain (Domain 1) is cover South East Asia and Sothern part of China. The Two nested domain are cover Thailand (Domain 2) and the Northern part of Thailand (Domain 3), respectively. The resolution of each domain and the important parameter are shown in Table 1.

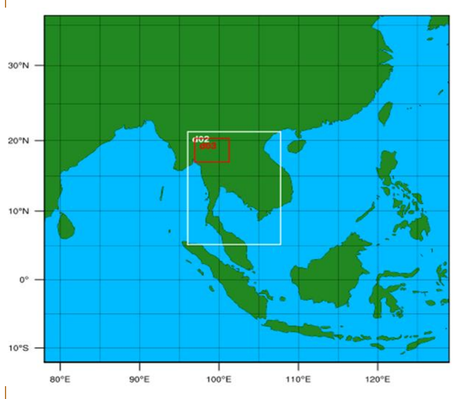

Figure 1. Study domains

The purpose of this study is to investigate the effect of different emission inventories and aerosols scheme on performance of WRF-Chem. Three case studies were carried out.

CASE 1: Use global emission inventory for 3 domains and GOCART aerosols scheme. The detail of global dataset are shown below.
Anthropogenic Emission: EDGAR & RETRO
Wildfire Emission: FINN
Biogenic Emission: MEGAN
CASE 2 Use the same global emission inventory as CASE 1 for domain 1, Thailand local emission inventory for domain 2 & 3 and GOCART aerosols scheme.
Anthropogenic Emission: Thailand Emission Model 2010 (THEM-2010)
Wildfire Emission: Jiranuch Chianong. (2015).
CASE 3 same as CASE 2 but change the aerosol scheme from GOCART to SORGAM

Table 1.Domain resolution and configuration.

Parameter	Description
Domain 1	Resolution : 27 x 27 km^2 No. of grid : 210 x 210 x 30
Domain 2	Resolution : 9 x 9 km^2 No. of grid : 145 x 205 x 30
Domain 3	Resolution : 3 x 3 km^2 No. of grid : 160 x 130 x 30
Meteorogical Data	Global Forecast System (GFS)
Chemical Mechanism	Regional Atmospheric Chemistry Mechanism (RACM)
I.C. and B.C Condition	NCAR-NCEP's Final Analysis (FNL)
Photolysis Schemes	Fast-J Photolysis

Results

The result are divided in 3 parts. (1) Comparison between the Monitoring Data from Thailand Pollution Control Department (PCD) station and from WRF-Chem model. (2) spatial distribution of Ground level ozone (3) Model sensitivity of the different case

- ❑The comparison between the result from WRF-Chem model and monitoring data.

The monitoring data was retrieved from station at Mae Moh, Lampang (Station 40T) where locate in center of domain 3. The location of Lampang station is shown in Figure 2

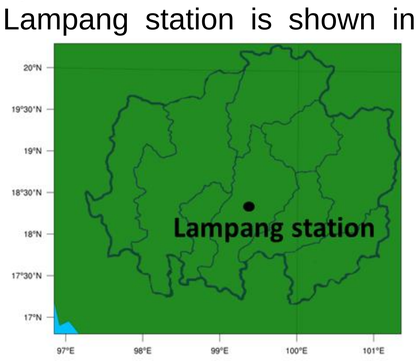

Figure 2 location of Lampang station

The time series plot of O_3 from March 1-23, 2013 for case 1 and 2 were shown in Figure 3. The results of case 2 (figure 4b) revealed that the simulation that used Thailand local emission inventory yielded the better result than the global emission(case 1, figure 4a). can capture the trend of monitoring data better than the Case 1.

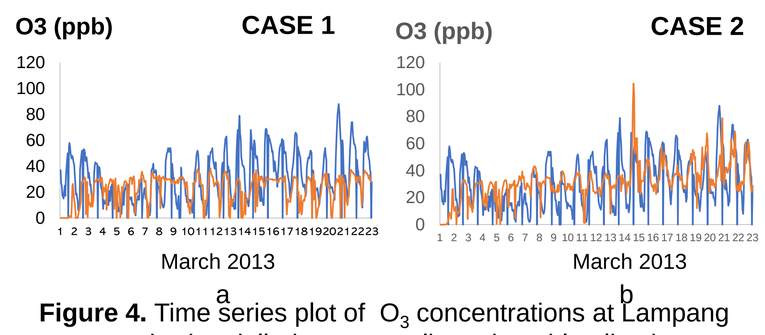

Figure 4. Time series plot of O_3 concentrations at Lampang station(modelled – orange line, obs – blue line)

The time series plot of PM_{10} from March 1-16, 2013 for case 2 and 3 were shown in Figure 5. The results revealed that simulation results using SORGAM aerosols scheme(case 3) have better performance than GOCART (case 2).

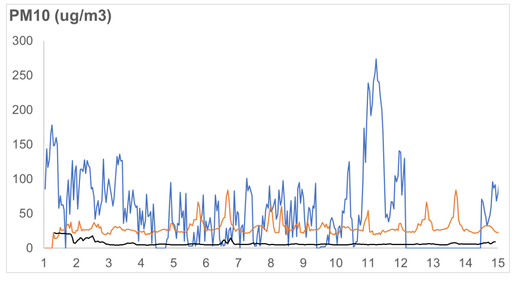

Figure 5. Time series plot of PM_{10} concentrations at Lampang station(CASE 2 – black line, CASE 3 – orange line obs– blue line)

❑ Spatial distribution of O_3
The spatial distributions of ground level ozone over Northern Thailand simulated by WRF-Chem model in Case 2 shown in Figure 6. The high ground level ozone concentration were observed around center of study area Lampang, Lamphun and Chaing Mai

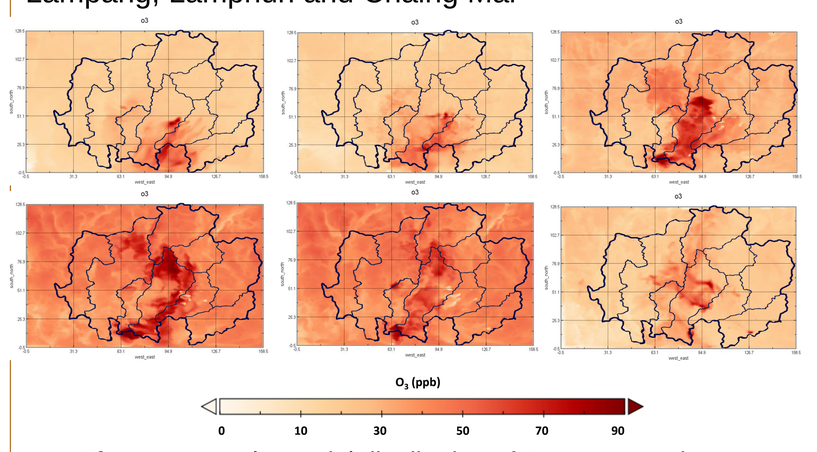

Figure 6. Hourly spatial distribution of O_3 concentration over Northern Thailand on 17 March 2013 (CASE 2)

❑ Model sensitivity of the different case
The hourly scattered plot of O_3 concentrations from WRF-Chem of CASE 1 and 2 were compared with monitoring data of 4 monitoring stations are shown in Figure 7. This result is also confirmed that using Thailand local emission yielded the better result.

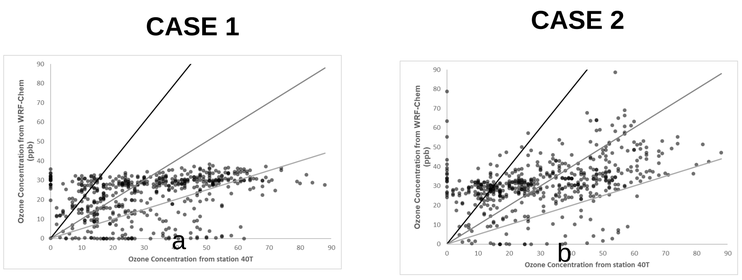

Figure 7. Scatter plot of O_3 concentrations between the WRF-Chem results CASE 1 (a) , CASE 2 (b).

The hourly scattered plot of PM_{10} concentrations from WRF-Chem of CASE 2 and 3 are shown in Figure 8. The scattered plot is shown that result of PM_{10} from SORGAM (case 3) scheme are better than that of GOCART (case 2).

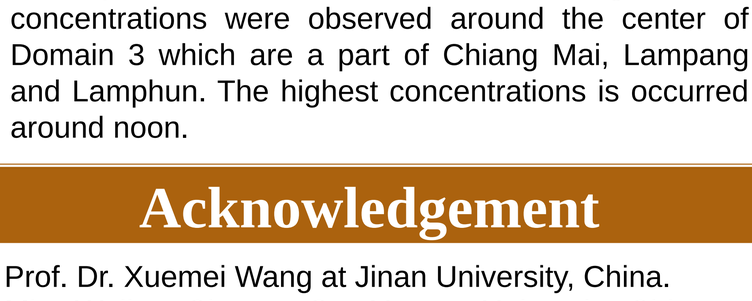

Figure 8. Scatter plot of PM_{10} concentrations from 1-16 March 2013, between the WRF-Chem results CASE 2 (a) , CASE 3 (b).

Conclusions

The results from 3 case studies of WRF-chem on Wildfires simulation over northern Thailand could be summarized below

- The ozone results show that using Thailand local emission as an input for domain 3 yielded a better performance than global emission.
- The aerosol scheme has a significant effect on the result of PM_{10}
- The spatial distribution revealed that high ozone concentrations were observed around the center of Domain 3 which are a part of Chiang Mai, Lampang and Lamphun. The highest concentrations is occurred around noon.

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