The Transport of Air Pollutants in Asia : A Report on Thailand Air Quality Modelling Effort

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Abstract

This report reviews several activities happening in Thailand as related to modelling the transport of air pollutants in Asia. Firstly, during March 2007 Thailand experienced one of the worst air pollution episodes, which is the extended elevated haze pollution in the Upper Northern Region. Following the episode, Pollution Control Department (PCD) in collaboration with the Joint Graduate School of Energy and Environment (JGSEE), Bangkok, decided to examine and employ a trajectory model HYSPLIT to perform a forward simulation, aiming at identifying potential fire emissions and quantifying their contributions to the haze pollution in the region. On-going work is the development of a base-line haze modelling and forecasting system for applying to the region during the drought fire seasons. Secondly, throughout 2007, PCD has taken a key role in improving and using a lagrangian puff dispersion model CALPUFF, approved by US EPA as a long-range transport regulatory model and a short-range model for complex terrain, in application of finding the maximum ground level concentrations (a criterion used by the board of environmental policy for decisions on the approval of new industrial facilities) of the two gaseous pollutants; sulfur dioxide and nitrogen dioxide. The study is crucial to the development of the Maptaphut industrial complex on the Eastern Seaboard of Thailand where the 291 point emissions sources were considered their impacts to an array of community receptors set within a geographic domain characterized by gently rolling hills and 25 km of coastline. CALPUFF uses meteorological input data from its meteorological preprocessor, CALMET, which incorporates data from surface stations in additions to output from a prognostic meteorological model, MM5. The work raises public interest on how to specify a cap on total emission and a fair goal for emission trading and maintaining acceptable level of ambient air quality. A training course on the model has also been carried out to let primarily, the academic community and, eventually, the general public realise the model capability. Finally, the Linux Cluster set up at PCD is still awaiting the installation of chemical transport models like Models-3/CMAQ and STEM. It has been considered that a model with capability to treat full chemistry should be used for assessing local episodes like ozone and fine particulates problems. This is paving the way towards integrating the use of chemical transport models to predict long-range transport of all key pollutants in Asia; sulfur, nitrogen, black carbon, organic carbon, ground-level ozone, PM10 and PM2.5 and fulfilling the aims of model-intercomparison study in Asia as well as globally as next.

Activities

1) Modelling and Forecasting the Haze Episode in Upper Northern Region of Thailand

The Upper Northern Region borders on Myanmar in the west to north, on Laos in the north to east, and is a few hundred kilometers away from Southern China. Most of the area is hilly and mountainous. There are north-south aligned hill ridges parallel from west to east, forming a number of valleys where there are cities of Chiang Mai, the economic center and the largest city of the Northern Region, and Lampang, with the 1725 MW coal fired power plants remain operating. The haze episode during March 2-22, 2007 was chosen for examination. According to PCD's daily report, on March 13 and 14, the 24-hour average ambient PM10 level at a monitoring station in Chiang Mai went up dramatically to 284 µg/m3 and 304 µg/m3, respectively

As described by Manomaiphiboon (2007), the work carried out at JGSEE was implemented using the standard forward-trajectory mode of the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model together with archived GDAS meteorological dataset [http://www.arl.noaa.gov/ready/hysplit4.html]. The HYPSLIT model has been developed by the Air Resources Laboratory (ARL) of the National Oceanic and Atmospheric Administration (NOAA), US. The March 2007 active fire dataset for Southeast Asia was one of many MODIS (Moderate Resolution Imaging Spectrometer) products that were derived from the scanning of the Terra and Aqua earth observation satellites, obtained from the public server of the Fire Information for Resource Management System (FIRMS) [http://maps.geog.umd.edu/firms] and used to represent fire occurrences. The modeling domain was set to Lat. (13N, 25N) x Lon. (93E, 105E), including parts of Thailand, Myanmar, Laos, China, Vietnam, etc. The receptor domain for the region was set to Lat. (18N, 20.5N) x Lon. (98E, 100.5E) (Figure 1).

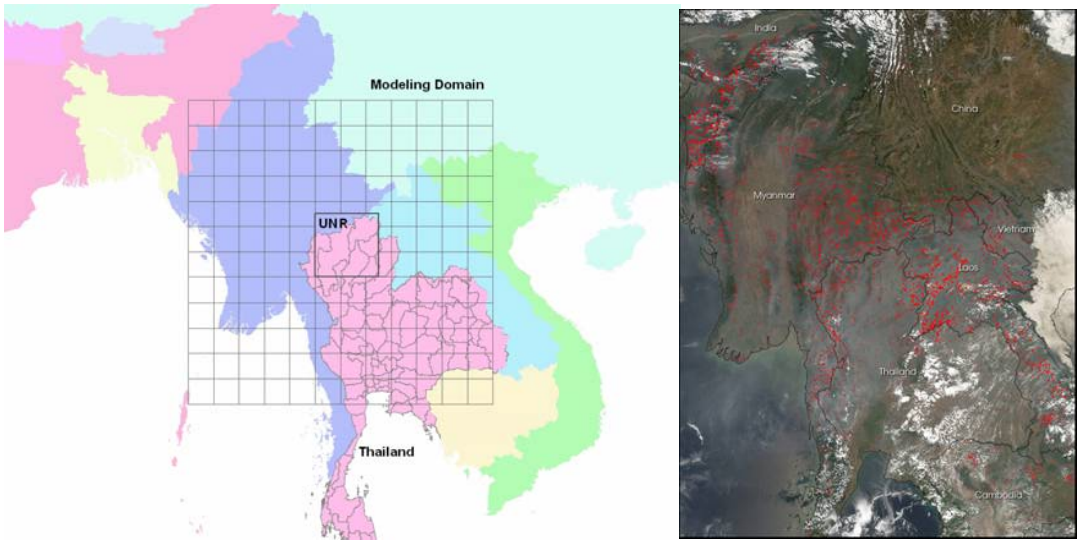

Figure 1 Modelling and Receptor Domains (left), and the MODIS-AQUA hotspots image on March 13, 2007

Although the study is preliminary, it can be concluded that during the 1st week, potential fires were found around the region, with relatively large contributions from the Lower Northern Region, the Upper Central Region of Thailand, and Eastern Myanmar. Medium-range pollutant transport from Central Myanmar is evident but the degree is not substantial. The 2nd week clearly appears to have medium-range pollutant transport from Laos. The contribution pattern in the 3rd week is somewhat similar to the 1st week, with stronger contributions from the areas right above the northern region and down south in the Central Region of Thailand. No significant contribution from Southern China is seen during these weeks. On-going work is the development of a base-line haze modelling and forecasting system for applying to the region during the drought fire seasons.

2) Regulatory Air Model for a Seaside Industrial Complex

The Maptaphut Industrial Estate of Thailand consists of approximately 50 companies representing the petroleum refining, petrochemical and chemical, fertilizer manufacturing, steel refining industries, coal-fired power plants as well as marine bulk loading terminals and numerous wastewater treatment plants. This complex, which was established in 1990, is situated on 2400 acres and is located in an environmentally sensitive zone due to its close proximity to schools, a religious temples and residential communities.

The CALPUFF model was employed due to its capacity to simulate the land-sea breeze circulation, as well as treating the complex terrain to the NW and NE of the source region. The PSU/NCAR Mesoscale Model System (MM5) (Grell et. al., 1995) was used as a complement to 6 meteorological observations because no wind observations located over water, and the upper air

profiler RADAR/RASS, LAPTM-3000 (Radian Corporation) did not provide sufficient measured levels of wind speed/direction and virtual temperatures.

The MM5 model was run in non-hydrostatic mode for the full simulation year, October 2001 – September 2002, over 4 two-way nested domains of increasing spatial resolution, producing hourly three-dimensional meteorological fields at resolutions as fine as 3km (Domain 4), along with larger scale fields at 9km (Domain3), 27km (Domain 2), and 81km (Domain 1). The modelling domains and final CALPUFF results cases of policy-driven 20% emission reduction of NO_x (as well as SO_2 which is not shown) with each new projects are presented in Figure 2.

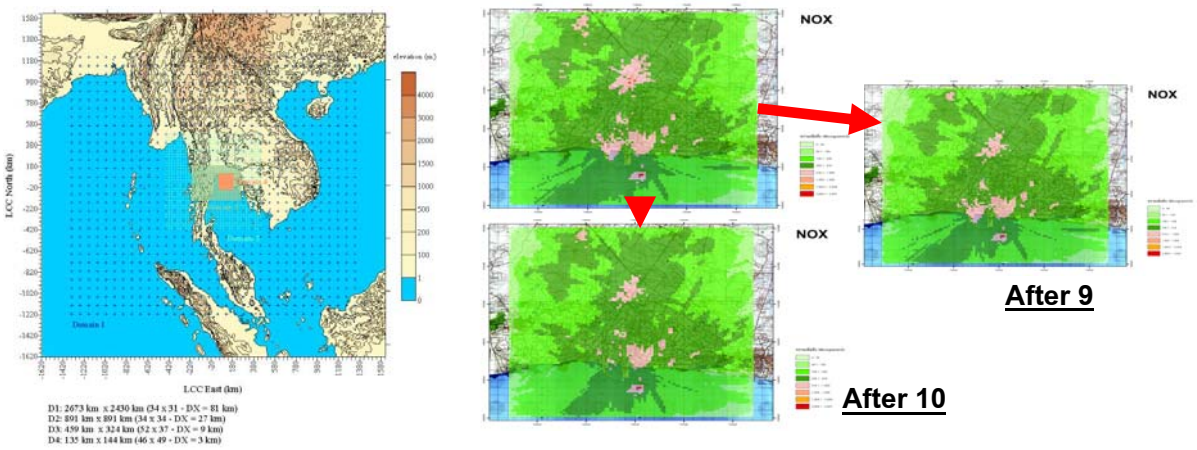

Figure 2 MM5 nested domains for meteorological input to CALMET modelling and final CALPUFF results.

Due to high public interest and decisive roles of the modelling activity to the economy, a three-day training course on the model has been carried out in January 2008 with 40 Thai participants aiming at the academic primarily. Outcome was that the capacity of the model to treat wet and dry deposition attracts further research. Similar content were reviewed during the Third Country Training Workshop on Emission Inventory and Modelling for Acid Deposition Assessment supported by JICA undertaken in Thailand as mentioned in 2007.

Conclusion

The air quality modelling work at PCD, Thailand, is going on various scales. Fire emission datasets for HYSPLIT forecasting has become the first priority in dealing with haze early warning. The capacity to run CALPUFF has been implemented and public understanding on the issue is thought to be important to the progress in enforcing policy on air quality control. Long-range transboundary air pollution could be the next component that requires careful model study. It is hoped that once the Linux Cluster set up at PCD is installed with chemical transport models like Models-3/CMAQ (near future collaboration with Asian Institute of Technology and JGSEE) and/or STEM (potential future collaboration with Dr. Narisara Thongboonchu of King Mongkut Institute of Technology at Ladkrabang), full chemistry should be used for assessing local episodes like ozone and fine particulates problems. Local monitoring data to be used for long-range transport of all the key pollutants in Asia can be discussed in the model-intercomparison study workshop.

References

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Grell, G., Dudhia, J. and Stauffer, D. (1995) A description of the fifth-generation Penn State/NCAR mesoscale model (MM5). NCAR/TN-398+STR.