The Potential Impacts of Climate Change on Air Quality in the Upper Northern Thailand

Chakrit Chotamonsak[1], Eric P. Salathé Jr.[2,3], Jiemjai Kreasuwun[4]
Email: chakrit.c@cmu.ac.th
[1]Department of Geography, Faculty of Social Sciences, Chiang Mai University, Chiang Mai , Thailand.
[2]School of Science, Technology, Engineering and Mathematics University of Washington – Bothell , Bothell, Washington, United State.
[3]Joint Institute for the Study of the Atmosphere and Ocean (JISAO), University of Washington, Seattle, Washington, United State.
[4]Department of Physics and Material Science, Faculty of Science, Chiang Mai University, Chiang Mai , Thailand.

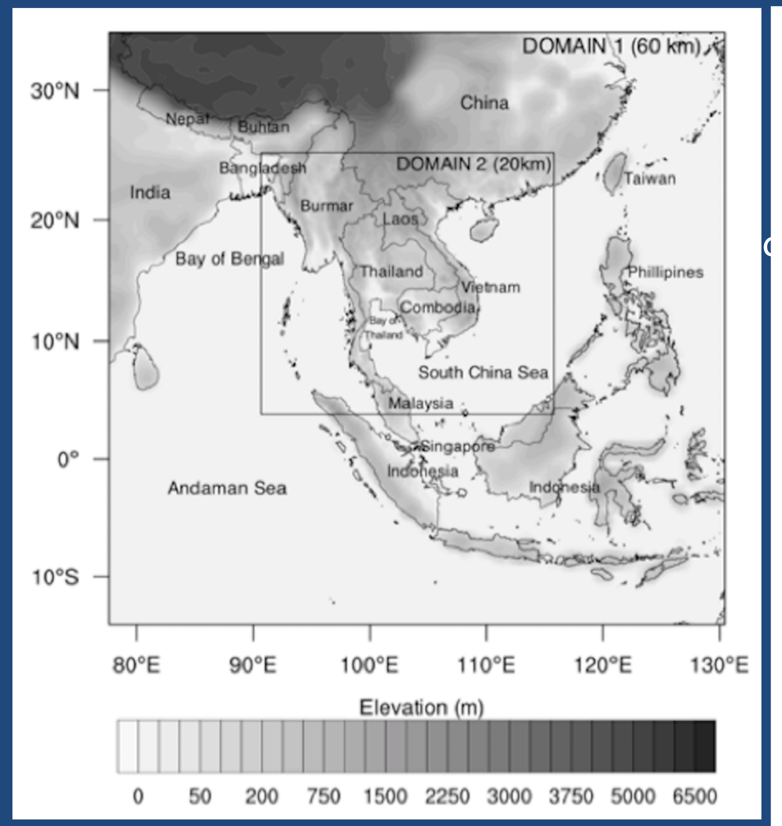
1. INTRODUCTION

The topography of Upper Northern Thailand is terrains complex and surrounded by mountain ranges, and about 5 basins (FIG 1). The basin regions are under the effect of a cool air layer caused by Northeast monsoon in cool-dry season (Jan-March). Upper Northern Thailand has been long recognized for its severe dry season particulate matter (PM) problems from intensive biomass burning. The concentrations of airborne particles with aerodynamic diameter smaller than 2.5 mm (PM2.5) and 10 mm (PM10) consistently exceed the national air quality standards, and is ranked as one of the regions with the highest PMs concentrations nationwide. PMs have serious adverse health effects (Pope et al., 2002). Some previous studies highlighted correlations between mortality and fine-particle air pollutants. High PM concentration can also reduce visibility and influence global climate change (Dickerson et al. 1997). It is essential to explore the potential future changes of these air pollution problems in Upper Northern Thailand so that adequate control strategies can be established in advance. In this study, the Weather Research and Forecasting (WRF) model (Skamarock et al., 2007) were used as regional climate mode (Chotamonsak et al., 2011; 2012) to dynamically downscale the ECHAM5 Global Climate Model projection (SRES A1B) for the regional climate change impact on air quality-related meteorological conditions in the upper northern Thailand.

2. EXPERIMENTAL DESIGN

Table 1. WF regional climate model setup

Physics process and options	Selected options
Microphysics	WSM6
Planetary Boundary Layer (PBL)	Yonsei University
Short-wave radiation	Dudhia
Long-wave radiation	RRTM
Land Surface Model (LSM)	Noah LSM
Cumulus parameterization	BMJ
Grid analysis nudging	With outer most domain nudging
SST update	6 hourly update
Run period	Base line 30 years (1980-2009) Future Projection 30 years (2035-2064)
Model outputs	Hourly



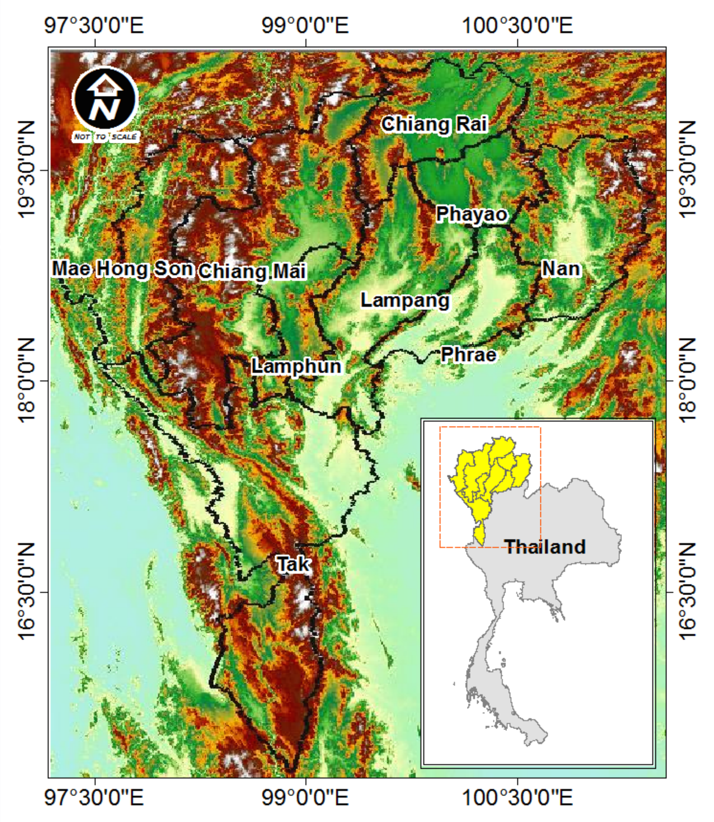


FIG 1. WRF domains (60-km grid space over SE Asia and 20-km grid space over Thailand) and (right) and the Upper Northern Thailand topography.

3. RESULTS

The climate-induced changes to meteorological variables that affect air quality were explored by comparing the future (2045-2064) and present (1990-2009) 20-yr averages during the dry season (January-April). The 20-yr averages for this season were calculated for each grid point using the hourly averaged values in the analysis domain (i.e., 20-km resolution domain). The spatial distributions of the differences between the future and present averages emphasize how climate change could affect Upper Northern Thailand differently. Analyses showed that the sea level pressure (not shown.) will be stronger in the future, suggesting more stable atmosphere. Increases in temperature were obvious observed throughout the region.

The predicted future T2MAX changes (future-present) from WRF-ECHAM5 were positive (0.8-1.5 °C) for the whole domain during dry season (FiIG 2.), and the largest temperature increase of 1.5 °C. The highest increase is seen in January while the lowest is predicted in February. For T2MIN (FIG 2.), the increasing is expected much higher than that increase for T2MAX. The highest increase is seen in January while the lowest is also appealed in February. The increase of nighttime temperature (T2MIN) greater increase than daytime temperature (T2MAX) lead to the increasing of diurnal temperature (DTR) (Not Shown). This increasing in DTR could effect to air quality problem in many way. For instance, It cause to reduce the potential of vertical dispersion of pollutants.

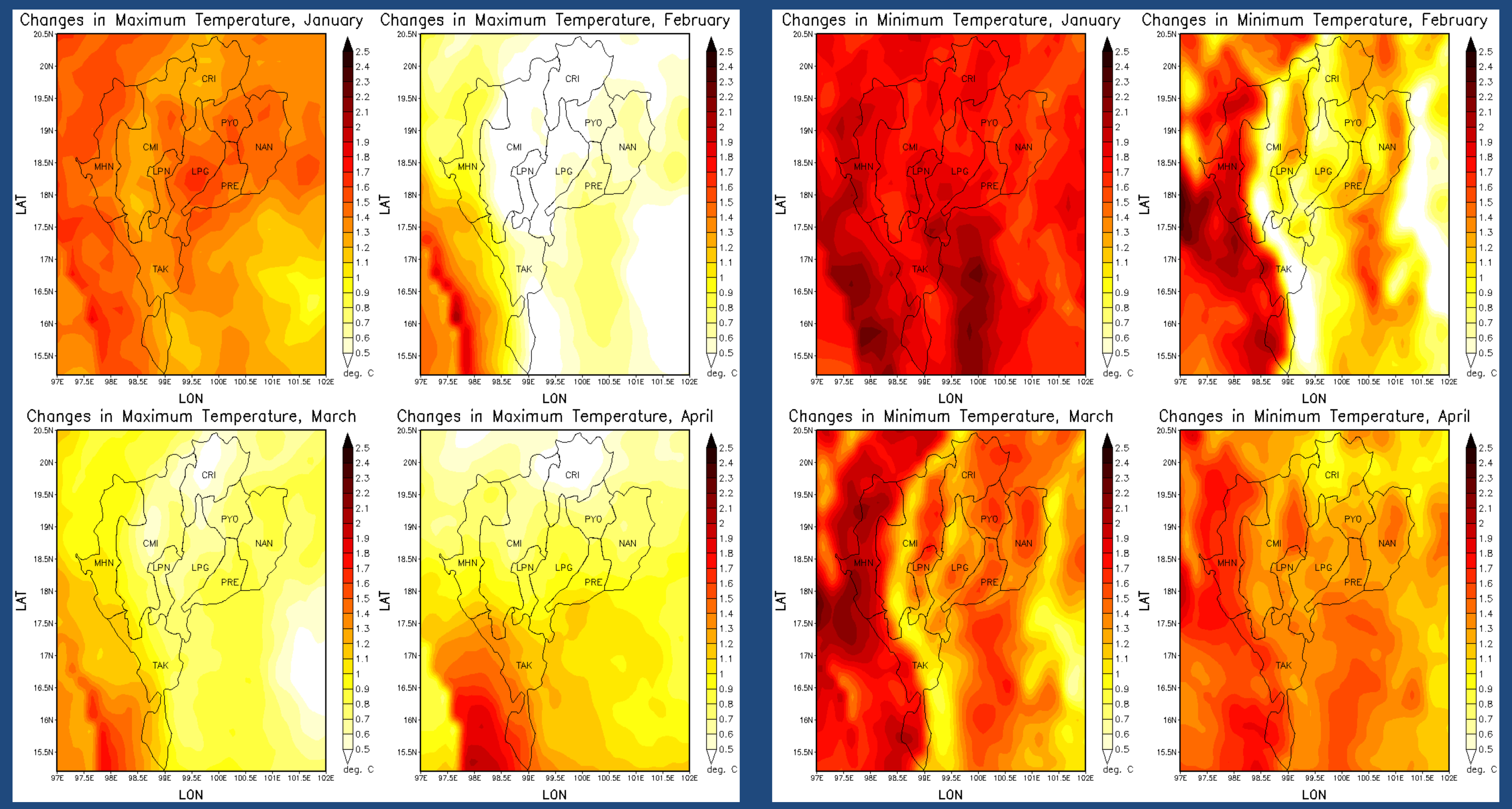


FIG 2. Monthly changes in daily maximum temperature (a) and minimum temperature (b)

Decreases in the surface wind and PBLH were predicted during air pollution season, indicating weaker ventilation rate in this region (FIG 3). The Ventilation Index is a term used in air pollution meteorology. The index is a numerical value related to the potential of the atmosphere to disperse airborne pollutants, such as smoke from a prescribed fire. It is based on both the current wind speed in the mixed layer and the PBLH (mixing height). The mixed layer is the surface layer of air that is turbulent and well mixed. The mixing height is the thickness (sometimes zero) of this mixed layer. In this study, the surface wind and mixing height were predicted to decease, lead to reduce the Ventilation Index especially in February and March (the sever air pollution months). Thus the future atmospheric conditions would be more conducive to the accumulation of dry season pollutants. Wsp10, PBLH and Venting Index are the main meteorological factors that determine wintertime PM concentrations.

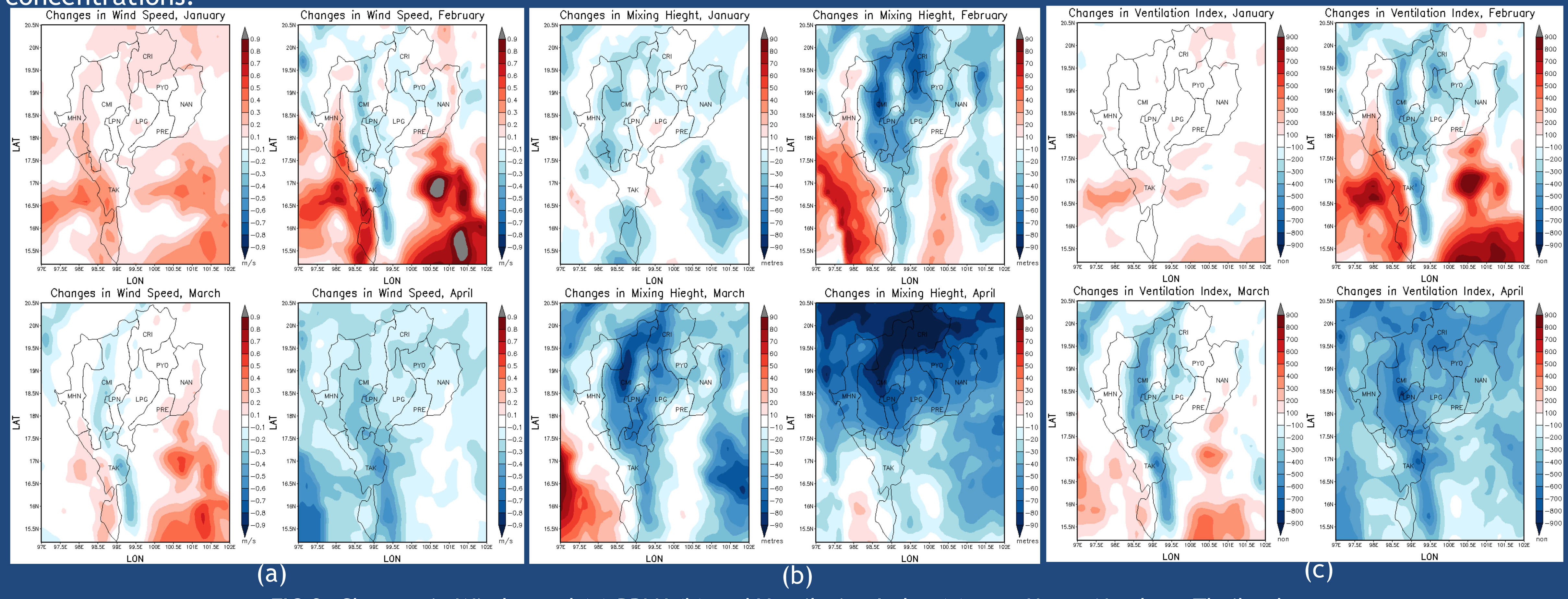


FIG 3. Changes in Wind speed (a) PBLH (b) and Ventilation Index (c) over Upper Northern Thailand

4. CONCLUSIONS

Air pollution episodes in the Upper Northern Thailand usually occur during stagnation events characterized by weak surface wind and low PBLH lead to reduce Ventilation Index. The pollutants are trapped within the boundary layer with concentrations increasing over time until the episode dissipates. The Upper Northern Thailand which reflects the accumulated days of all the stagnation events. In the study area, both the wsp10 and PBLH were predicted to decease, while T2MAX and T2MIN were predicted to remain obviously increased during study time period. These factors would provide less ventilation for the dry season pollutants in this region, favorable meteorological condition for pollutant accumulation during dry season. Results from regional climate projection suggested that the climate change signal was more significant during cool-dry season (Chotamonsak et al., 2011) than wet season in Northern Thailand. Therefore, the Northern Upper Thailand is expected to face with the higher air pollution under climate change. Consequently, air quality-related meteorological variables were predicted to change in almost part of the upper northern Thailand, yielding a favorable meteorological condition for pollutant accumulation in the future.

6. ACKNOWLEGEMENTS

This research has been financially supported by CMU grant for New Researchers. Provision of ECHAM5 data by CERA, WRF model from NCAR are highly appreciated. We also highly thank Assoc. Prof. Dr. Eric Salathé and the Joint Institute for the Study of the Atmosphere an Ocean (JISAO), University of Washington as the constructive host and computer resource.

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European Geosciences Union
General Assembly 2016
Vienna | Austria | 17–22 April 2016