Development and validation of fine-scale gridded emission inventory of anthropogenic GHGs and air pollutants for Thailand

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Developing countries in Southeast Asia including Thailand are accomplishing rapid economic growth. This is resulting in significant increase of energy consumption, GHG emissions, and air pollution. Effective strategies are required to solve these energy related environmental issues, and hence to achieve sustainable development goals. Emission inventories of GHGs and air pollutants are essential to identify key sectors. In this regard, the main challenge is validating emissions estimated by bottom-up approaches-based inventories. Various top-down techniques based on satellite observations and inverse modeling have been developed to estimate emissions. Recent studies showed that it is quite effective to compare emissions derived from top-down and bottom-up approaches to get more accurate estimates. The purpose of this study is to develop fine-scale gridded emission inventory of GHGs and air pollutants emitted from various anthropogenic sources in Thailand based on a bottom-up approach. GAINS-Asia model was utilized to estimate emissions of greenhouse gases including CO_2, CH_4, and N_2O, and precursors including CO, NH_3, NOx, SO_2, VOC, and PM (including BC, OC, $PM_{2.5}$, PM_{10}, and TSP) in Bangkok Metropolitan Region (BMR) and other four regions in Thailand in 2015. Activity data required to estimate emissions were collected from various national databases, and shares of control technologies were obtained from specific surveys and country-specific literature, whereas emission factors were the default values contained in GAINS-Asia model.
Total amounts of estimated CO_2, CH_4, N_2O, CO, NH_3, NOx, SO_2, VOC and $PM_{2.5}$ emissions for the whole Thailand in 2015 were 350, 3.7, 0.13, 1.8, 0.52, 0.83, 0.31, 0.65, and 0.34 Tg/year, respectively. Key emission sectors were power plants for CO_2, agriculture for CH_4, N_2O and NH_3, industrial processes for CO and VOC, road transport for NOx, and industrial combustion for SO_2 and $PM_{2.5}$. Differences of key sectors for each species imply difficulties to develop overall effective strategies.
The estimated emissions of the five regions were horizontally allocated into fine grids. Their resolution is 12 x 12 km for the whole Thailand and 1 x 1 km in BMR. Information of actual locations of power plants and industrial factories were used to allocate their emissions, whereas various surrogate information, e.g. population, traffic volumes, number of housings, etc., were utilized to allocate emissions of remaining sectors.
Air quality simulations using the regional meteorological model WRF and regional chemical transport model CAMx were conducted to validate the emission estimate in this study. The simulated concentrations of ambient air pollutants were compared to surface observations, and it was found that the observed seasonal variations were well reproduced by the simulations. However, absolute values of the observed concentrations were underestimated for CO, NO_2, and PM_{10}, and were overestimated for O_3. Further improvements of the emission inventory are therefore necessary. In addition, the simulated concentrations were significantly affected by biomass burning emissions, which extensively occurs in northern Thailand and Cambodia, especially during December to early April. Accurate estimates of their emissions are also critical to pinpoint dominant sources and to develop effective strategies.
The results from this study showed that air quality simulations could be one of effective ways to validate air pollutant emission inventory. Nevertheless, additional techniques should be explored, in order to completely validate the emission inventory including GHGs and improve the performance of air quality simulation.

Keywords: Emission inventory, GHG, air pollutant, Thailand

