Development of Air Pollution Emission Inventory in Hanoi Metropolitan Region for Health Effect Assessment

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INTRODUCTION

Hanoi faces serious air pollution problem with annual $PM_{2.5}$ in 2018 reaching 40.08 μg/m³ (World Air Quality Report) that is alarming figures because of its strong association with health effects.

Major anthropogenic sources come from transportation, gasoline station, residential cooking, industries and biomass open burning.

Statement: lack of Emission Inventory (EI) data prevents from in depth assessment of effects of air pollution under base case and emission reduction scenarios.

Objectives of this study are to update an existing EI for Hanoi Metropolitan Region (HMR) with emission from large point source and predict health benefits from $PM_{2.5}$ emission reduction under selected scenario using modeling.

PREVIOUS STUDIES

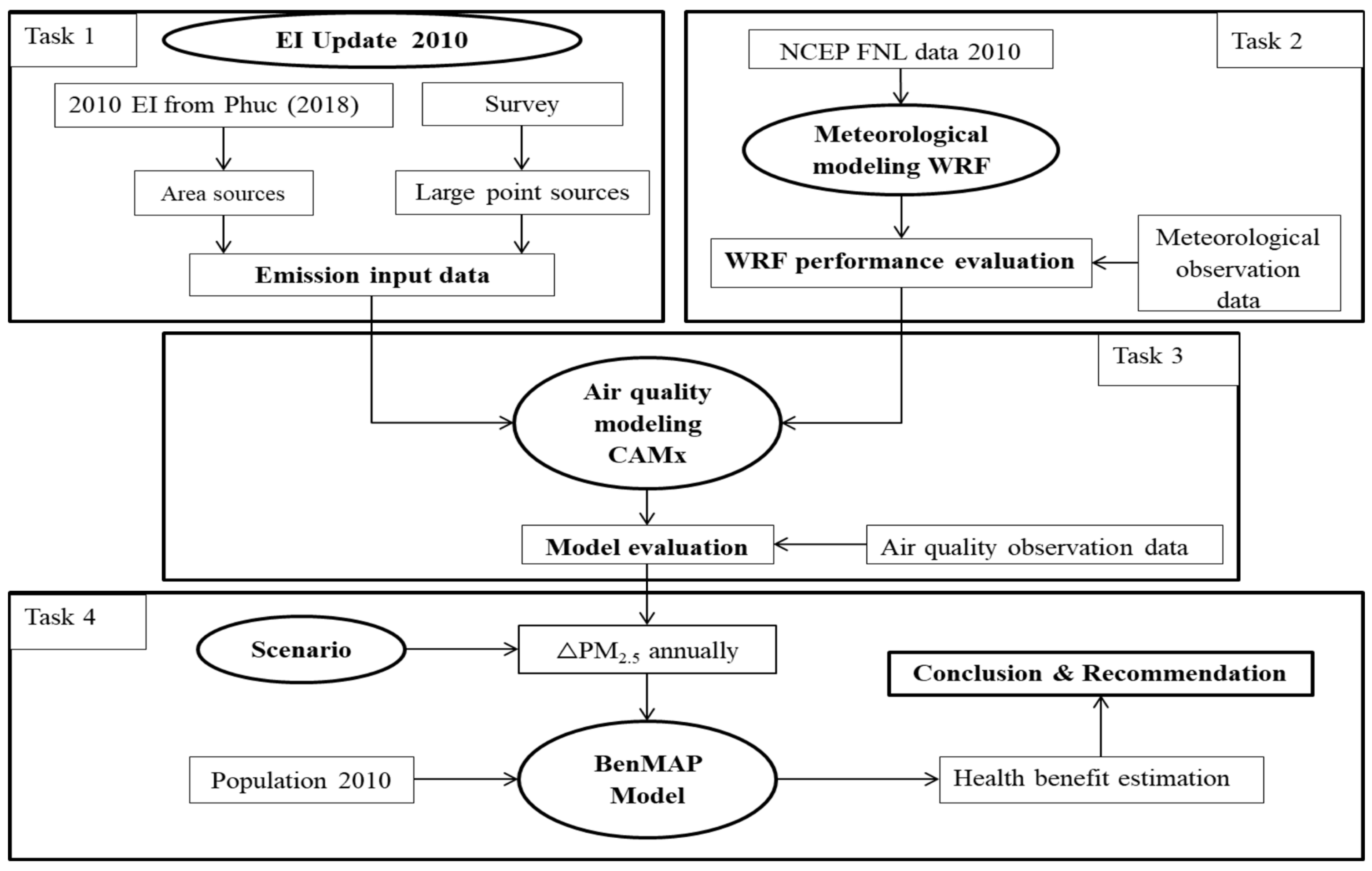
Emission Inventory (EI) = Activity Data (AD) x Emission Factors (EF)

Source	EI calculation	Explanation	Reference
On-road mobile source	$Em_{i,j} = Nv_j \times VKT_j \times EF_{i,j,f}$	i: Pollutant i; j: Vehicle class j; f: fuel type f Em: Emission (g/year) Nv: Number of vehicle in circulation (vehicle/year)[a] VKT: Vehicle kilometer travelled (km/vehicle/year)[b] EF: Emission factor (g/km)[b]	[a]: Vehicle register report [b]: Shrestha et al. (2013), Van (2014), Trang (2011)
Gasoline station	$VOC_i = FC_i \times EF$ $FC_i = \frac{\sum FC}{\sum_1^N Station}$	VOCi: VOC emission from station (i), gVOC/day FC_i: Gasoline sold in station (i) (m³/day)[c] EF: Emission factor (gVOC/m³)[d] FCi: Gasoline sold out in station i (m³/day.station) N: Number of stations[e]	[c]: Compile from internet source in selected cities [d]: Shrestha et al. (2013) [e]: Identified by Google Earth
Residential cooking	$Em_i = \sum_{i=1}^{n} FC_i \times P \times EF_i$	i: type of fuel, Em: Emission of fuel i burning (g/year) FC: Fuel consumption per capita[f] (kg/person/year)[f] P: Total population (urban and rural)[g] EF: Emission factor (g/kg)[h]	[f]: Nhung (2013), JICA (2010) [g]: Provincial statistical yearbook [h]: Shrestha et al. (2013)
Industrial source	• Combustion sector $Em_i = FC_j \times EF_{i,j} \times \left(\frac{100 - EC}{100}\right)$ • Non-combustion sector $Em_i = Productivity \times EF_i$	i: pollutant i; j: fuel type j; EC: Emission control[i] Em_i: Emission of pollutant i (g/year) FC_j: Fuel consumption type j (kg/year)[j] $EF_{i,j}$: Emission factor of pollutant i for fuel type j (g/kg)[k] EF_i: Emission factor for pollutant i (g/ton)[k] Productivity (ton/year)[l]	[i]: Shrestha et al. (2013) [j]: Compile from internet source [k]: Shrestha et al. (2013) [l]: MOIT, compile from internet sources
Biomass burning	$Em_{i,j} = \sum M_i \times EF_{i,j}$	i, j = Pollutant i and crop type j $Em_{i,j}$ = Emission of pollutant i from crop type j M_j =Amount of burned biomass from crop type j(kg/yr)[m] $EF_{i,j}$ = Emission factor of pollutant i from crop type j (g/kg of dry matter)[n]	[m]: Dong (2013) [n]: Shrestha et al. (2013)

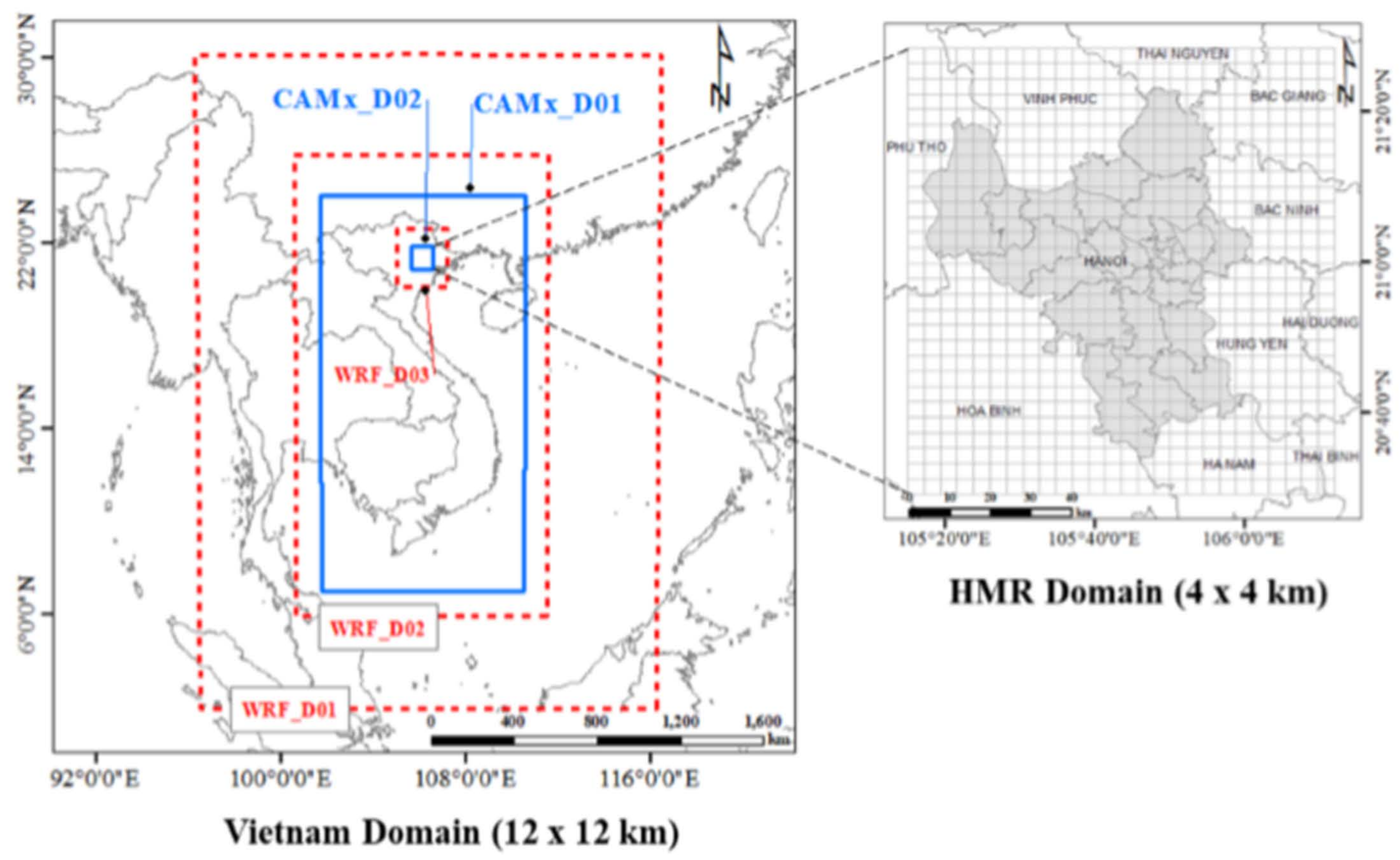
Paramter	Motorcycle[a]	Public buses[b]	Urban taxi[b]	Personal car[b]
Travel distance (km/day/vehicle)	20.3	212	157.0	42.0
CO	158.2	60.2	429.2	228.6
VOCs	51.5	15.1	73.8	40.4
NOx	9.5	147.8	17	18.6
PM_{10}	2.4	18.2	0.2	0.3
SO_2	0.2	1.0	1.5	1.9
1,3 Butadiene	0.3	0.02	0.2	0.04
Acetaldehydes	1.2	0.1	0.5	0.04
Formadehydes	4.9	0.34	1.2	0.1
Benzene	2.1	0.16	6.3	3.75

Annual Emission (Kt/Year) of Various Vehicles Under Base Case in 2010 in Hanoi, Phuc (2018).

METHODOLOGY



Framework of methodology



Nesting configuration of meteorology domains (WRF) and air quality domain (CAMx)

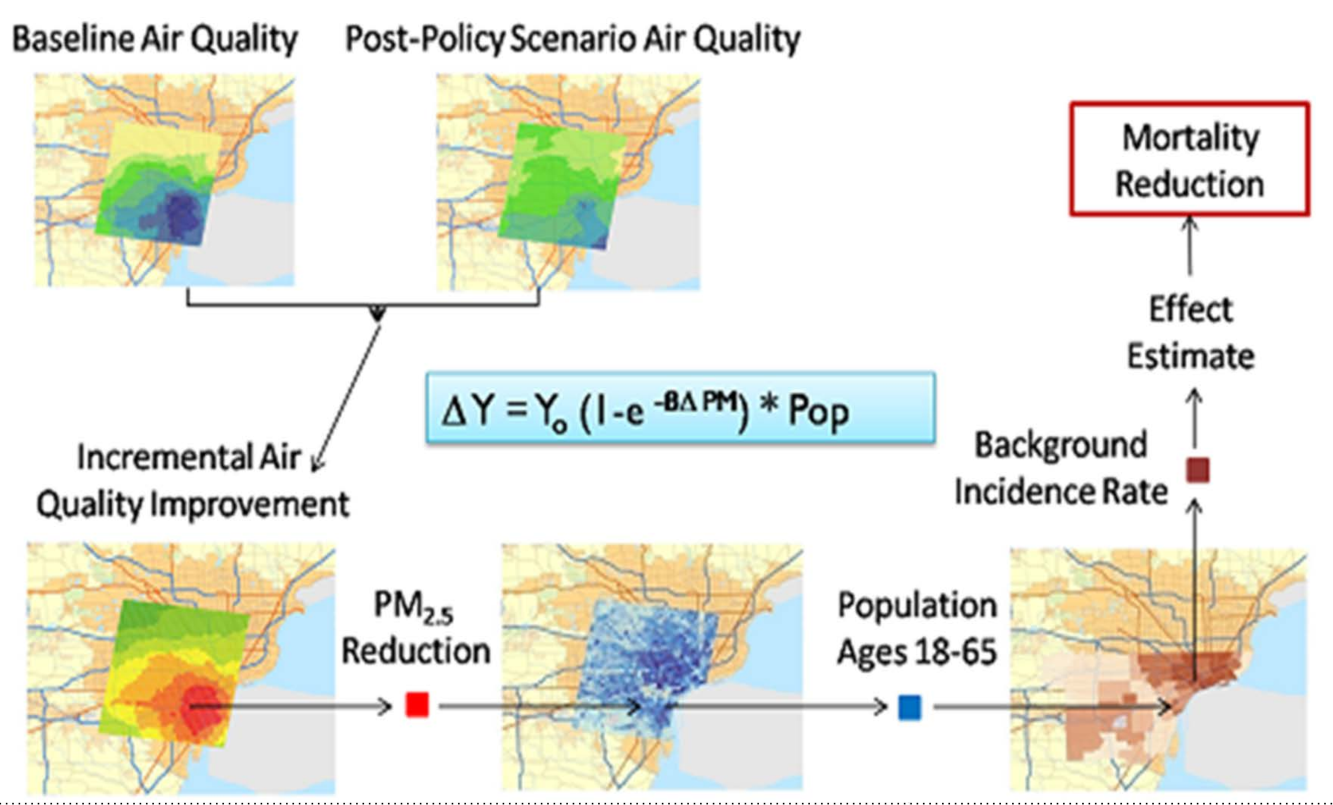
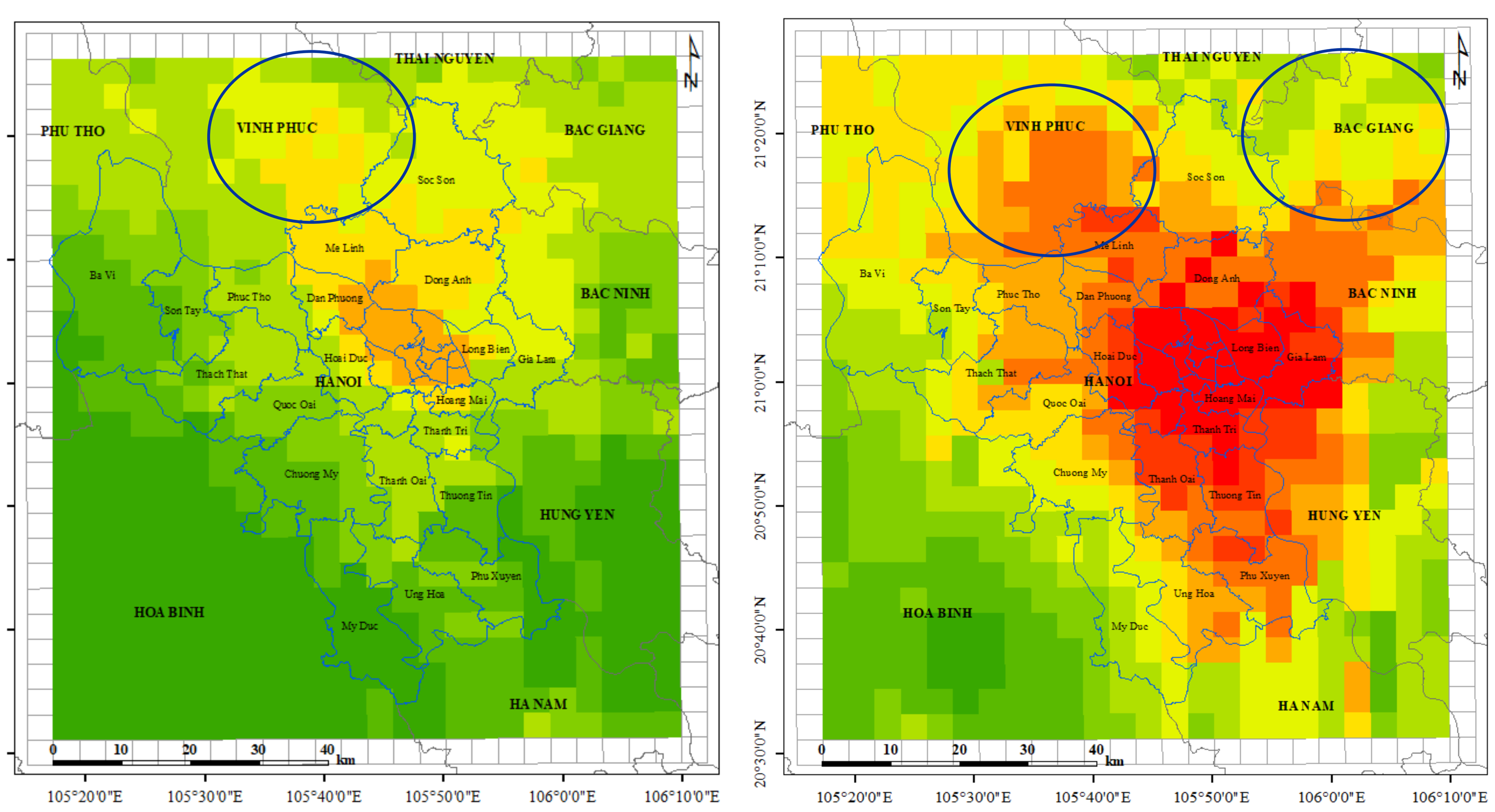
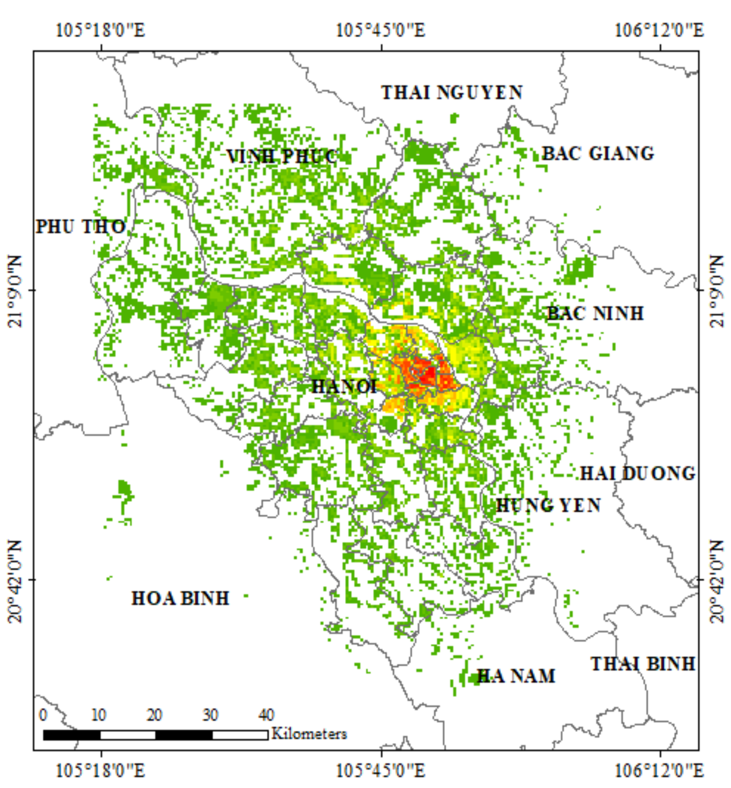


Diagram of BenMAP-CE algorithm, ABaCAS (2013)



Distribution of $PM_{2.5}$ in August (rainy season) and in December (dry season)



Spatially distributed long-term avoided mortality by all-causes resulted from elimination of 50% MC fleet in Hanoi in 2010 per refined grid cell 0.5x0.5 km

EXPECTED REFINED RESULTS

This study will develop comprehensive EI in HMR, especially complete EI data set of large point sources emission in vicinity of Hanoi.

Previous study treat large point sources as area sources, modeled $PM_{2.5}$ overestimated in some industrial zones

This study will refine dispersion modeling results and treat large point sources separately,

The health effect results will be also elaborated based on the refined $PM_{2.5}$