Japan Clean Air Program (JCAP)

Preliminary Modeling Study of Vehicle Emission Impacts on Air Quality

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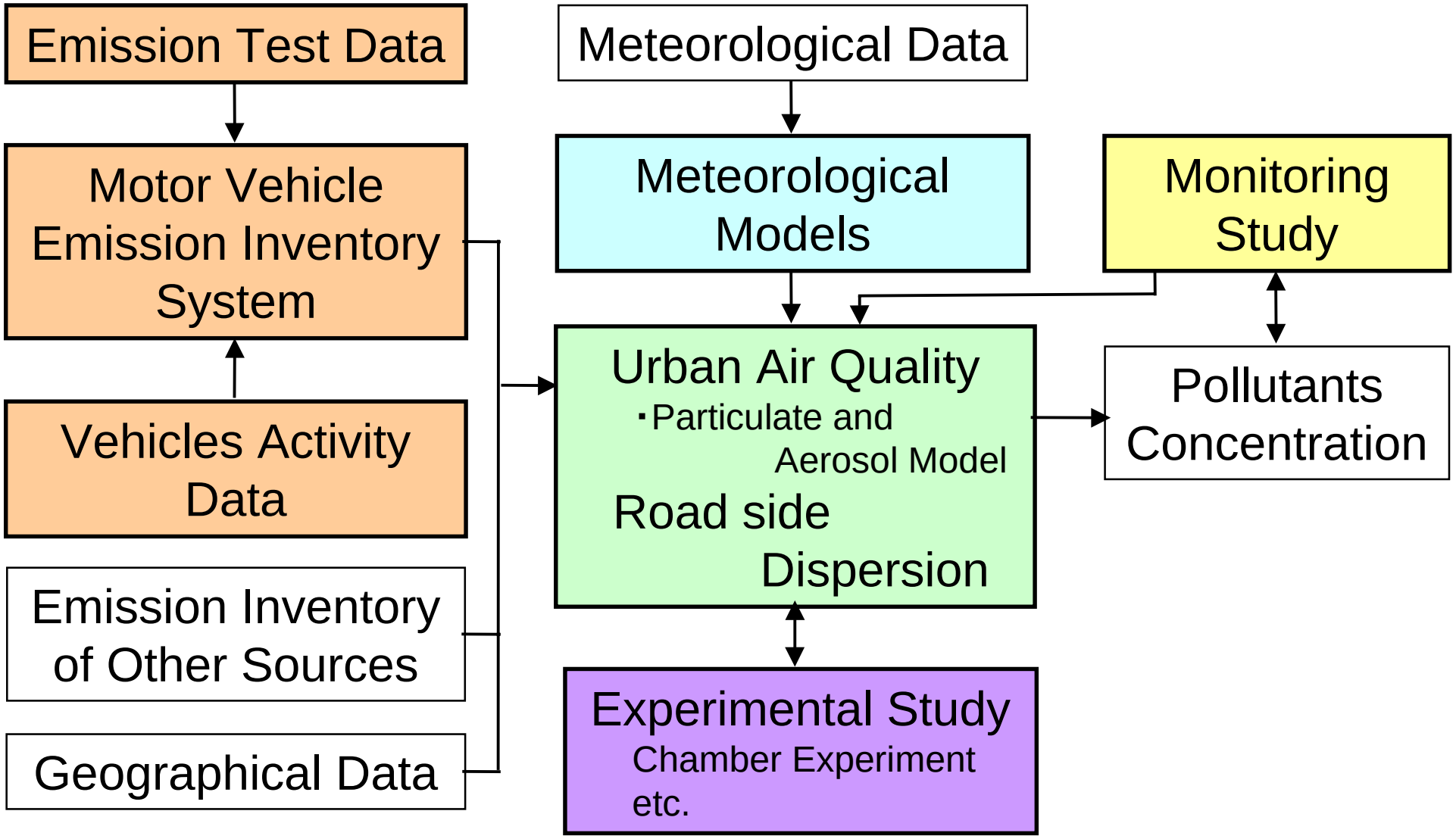
Objective of This Study

- **Objective of this study is to clear the effectiveness of vehicle emission reduction for the air quality improvement in Tokyo urban area.**

- **This report focuses on influence of Diesel vehicle emissions.**

Air Quality Study in JCAP



Estimation of Total Vehicle Emissions

<Total Vehicle Emissions>

$$= \sum_{\text{Vehicle Category}} \sum_{\text{Year}} \sum_{\text{Average Velocity}} \text{(Emission Factor(g/km)} \times \text{Travel Distance(km))}$$

<Emission Factor>

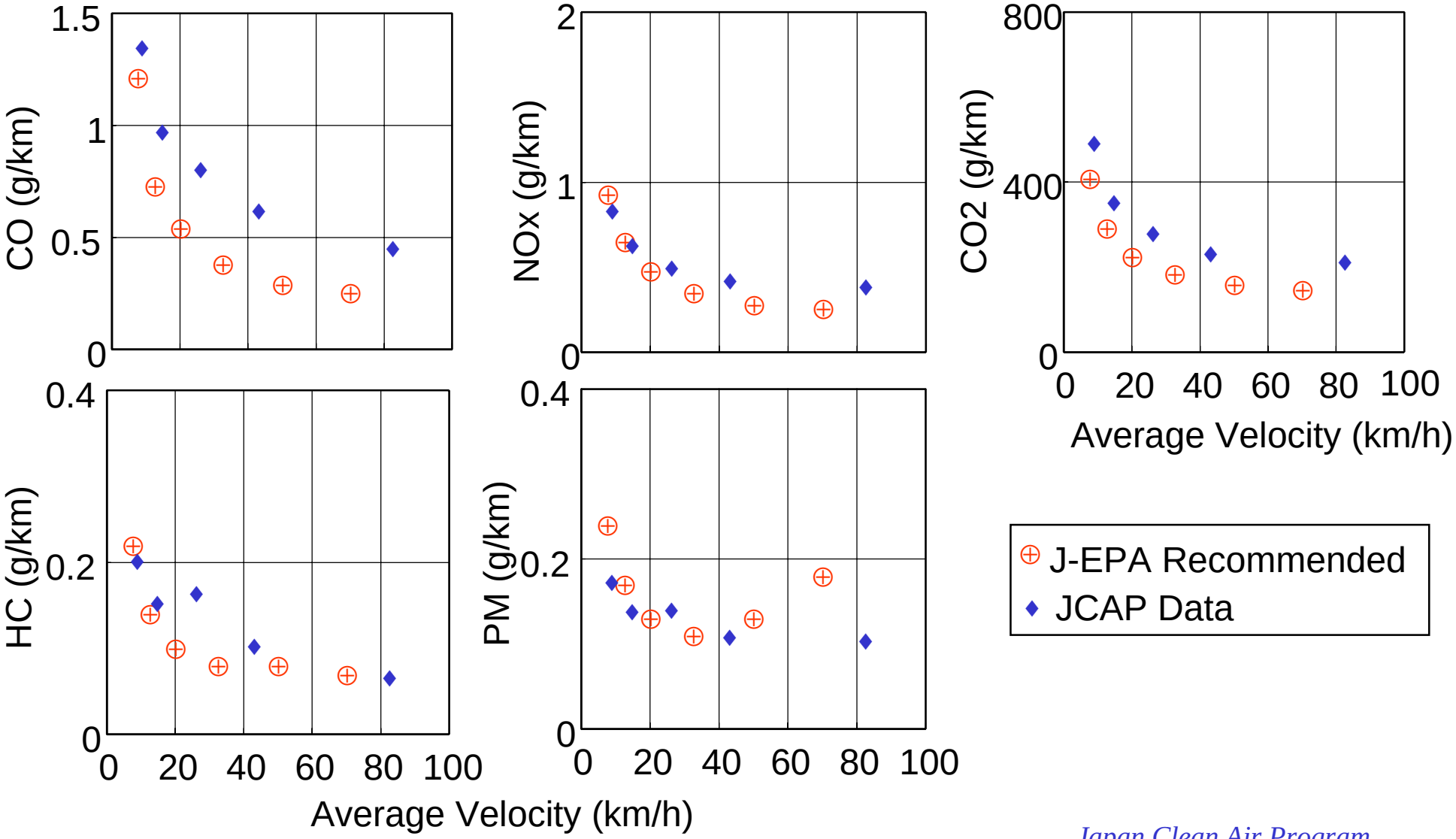
= <Basic Emission Factor> x <Deterioration Factor>

x< Fuel Correction Factor>

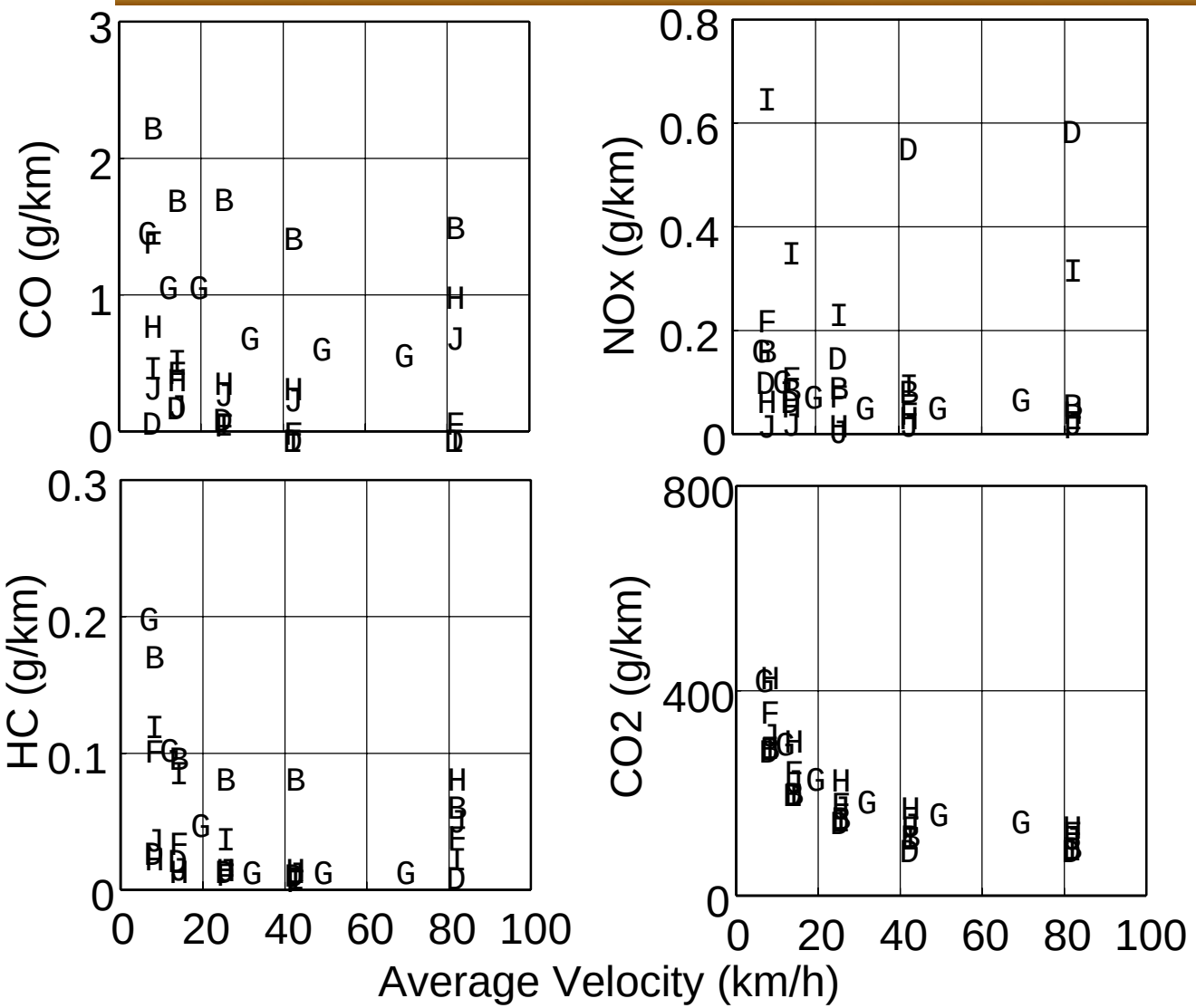
x < Temperature Correction Factor>

x<Other Correction Factors>

Emission Factors Evaluated in JCAP
(Diesel Passenger Car)

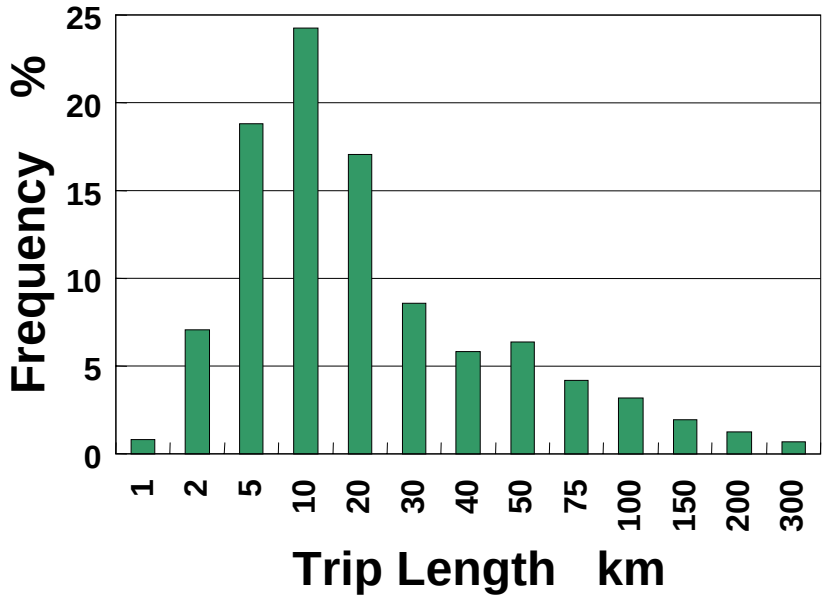


Emission Factors Evaluated in JCAP
(Gasoline Passenger Car)

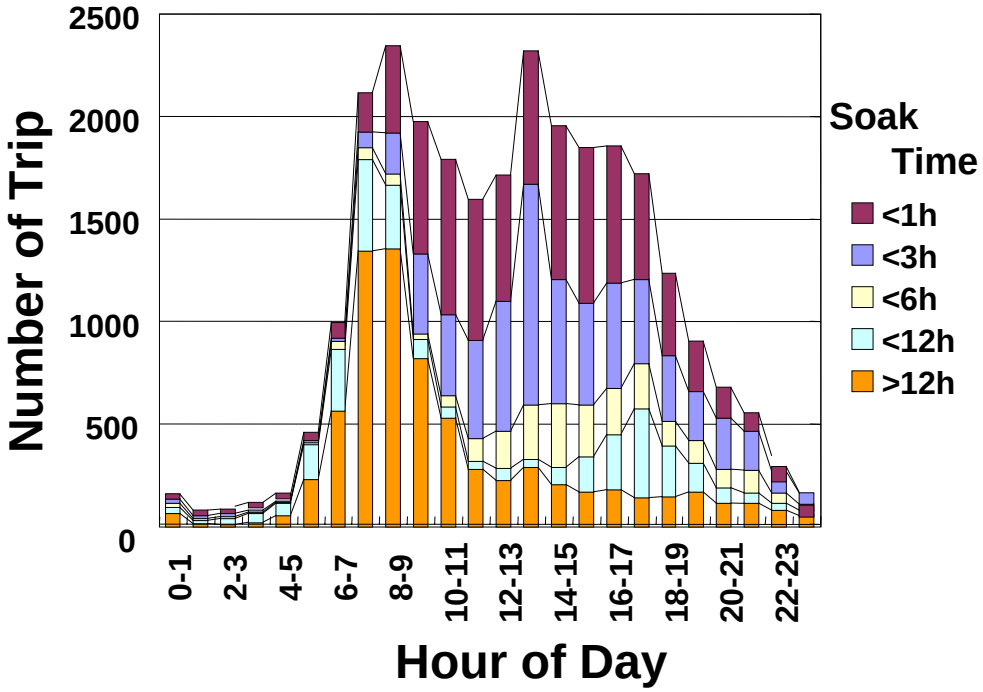


- G J-EPA Recommended
- J GV01
- H GV02
- B GV03
- D GV06(lean burn)
- I GV07(lean burn)
- F GV08

Vehicle Activity in Tokyo Urban Area

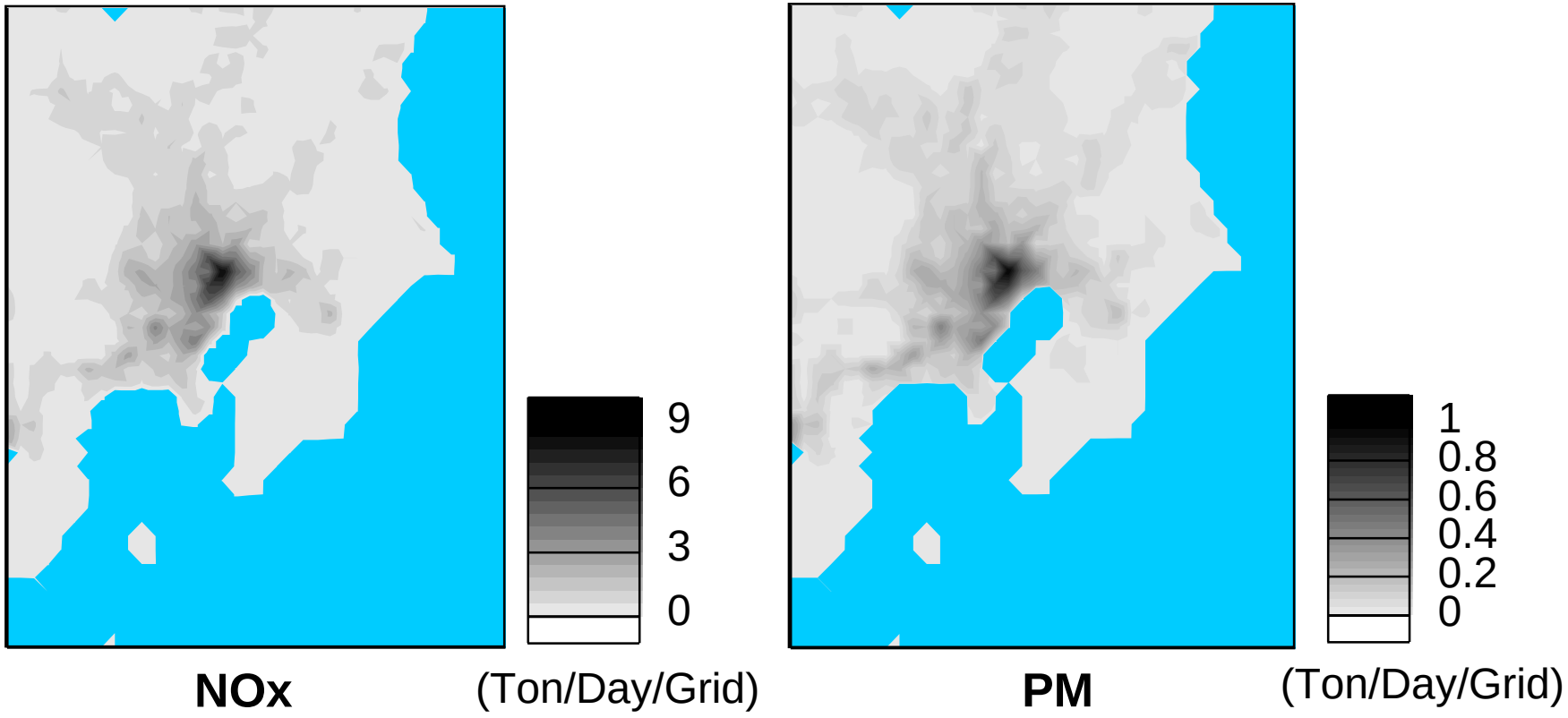


(Distribution of Trip Length)



(Distribution of Soak Time)

Distribution of NOx and PM Emission from Vehicle



Assumptions for Estimating Vehicle Emissions in 2010

Transportation volume:

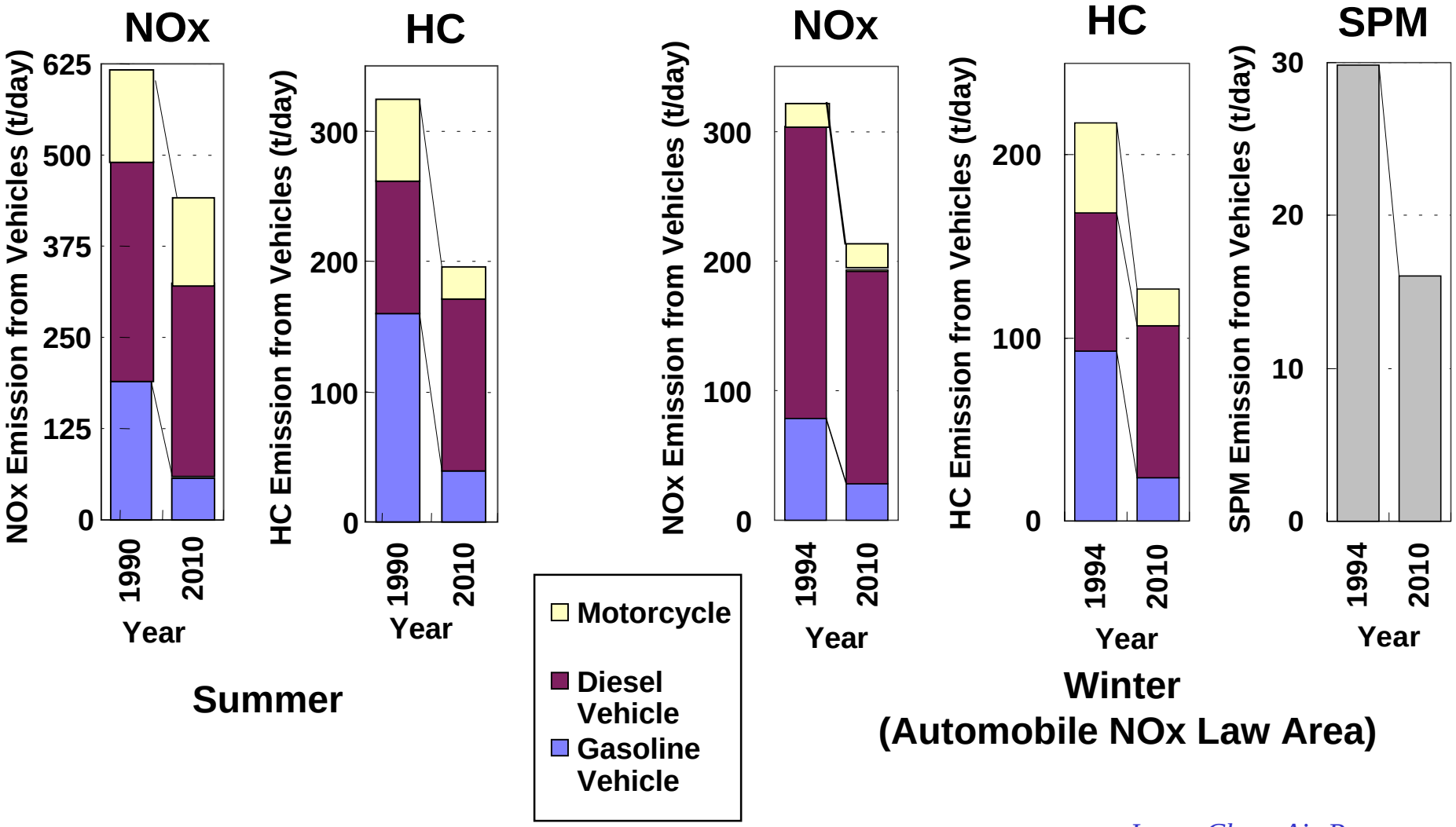
Based on the growth rate recommended by Ministry of Construction and Tokyo Metropolitan Government. (increase +19.2% from year 1994)

Emission factor:

Considered vehicle exhaust emission controls to be taken in future.

Gasoline Vehicle (2000~2002 Regulation)
Diesel Vehicle (1997~1999 Long-term target)
Motor Cycles (1998~1999 Regulation)

Estimation of Vehicle Emissions
(without Evap. Emissions)



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Methodology for Estimating Emissions from Other Sources

Ship: *consider growth of number, no changes of emission factors*

Air Plane:*consider growth of number, with limitation of airport capacity*

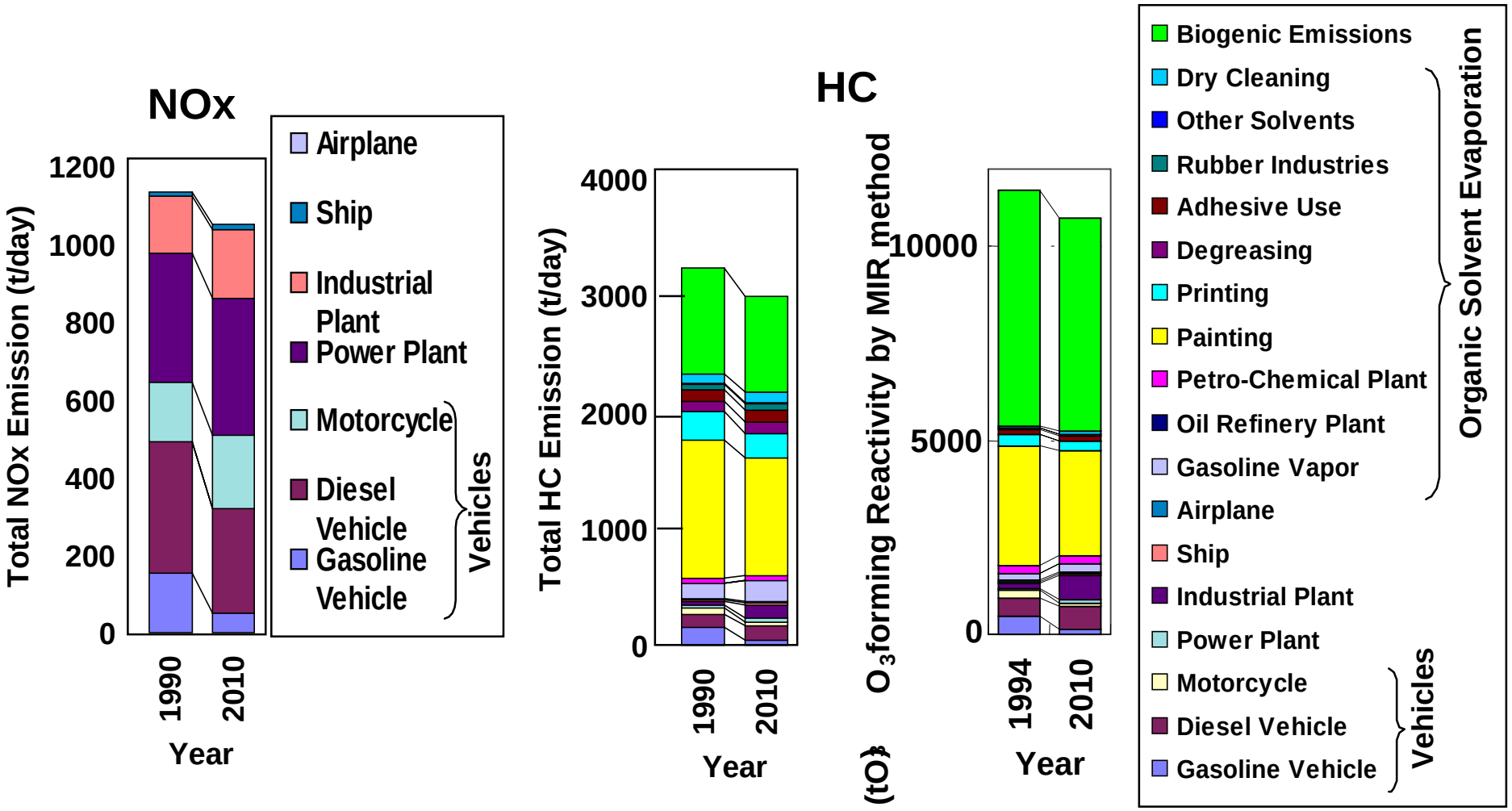
Point Sources

- **Civil**: *consider structural changes of energy consumption*
- **Industry**: *estimation of future trend of energy consumption*
- **Power Plant** : *Consider new power plant projects, effect of low NOx combustion technology included*

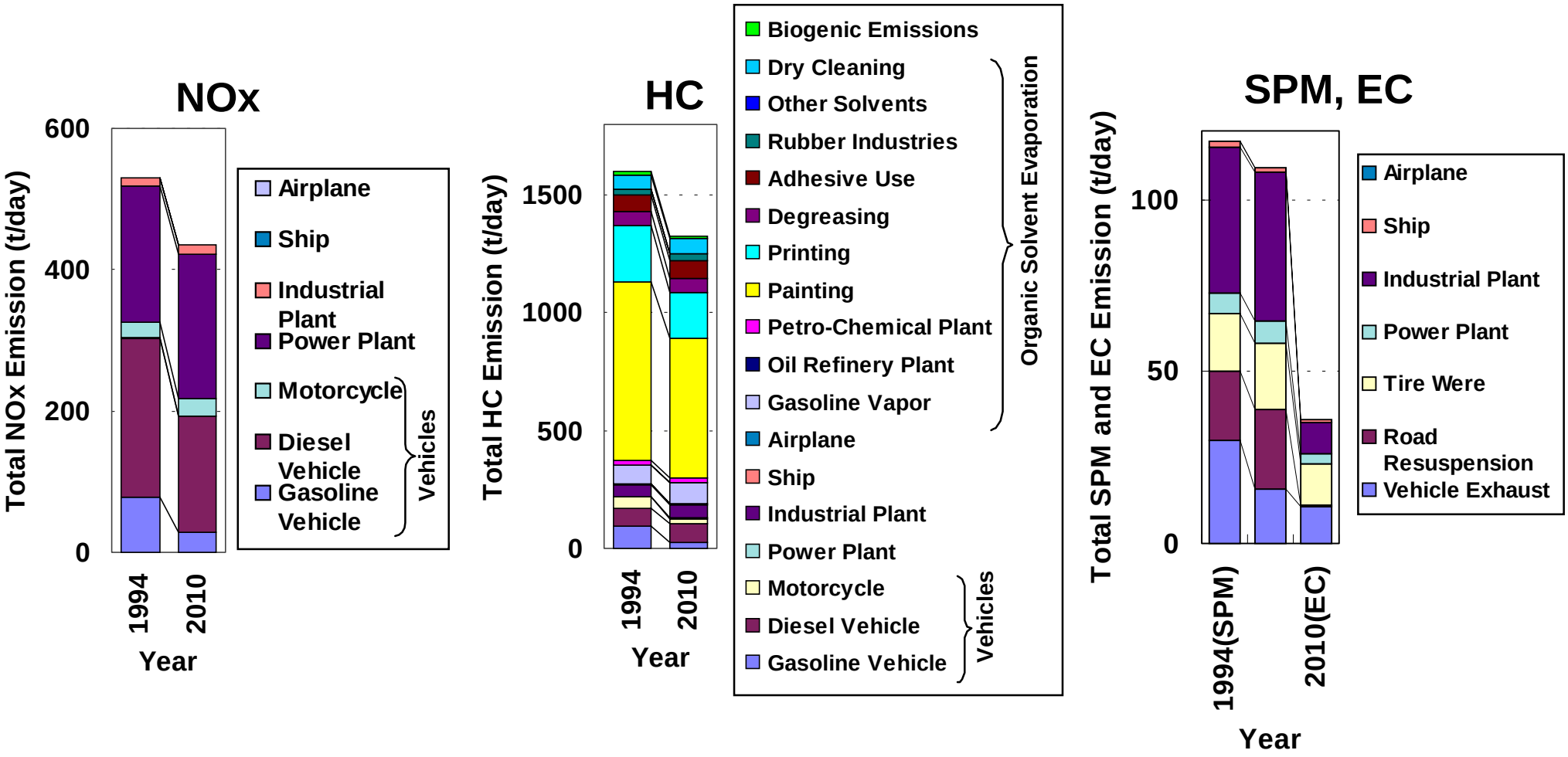
HC evaporation: *based on growth of energy consumption of industry*

NH_3: *consider agriculture and population growth*

Estimation of Total Emissions
(Summer)



Estimation of Total Emissions
(Winter, Automobile NOx Regulation Area)



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Air Quality Simulation

3D Grid Transport/Reaction Program:

Based on

UAM (Urban Airshed Model)

CIT (Caltech Model)

Turbulent Diffusion Coefficient were Modified

Meteorological input data:

NIRE mesoscale model

RAMS Program

Target Pollutants :

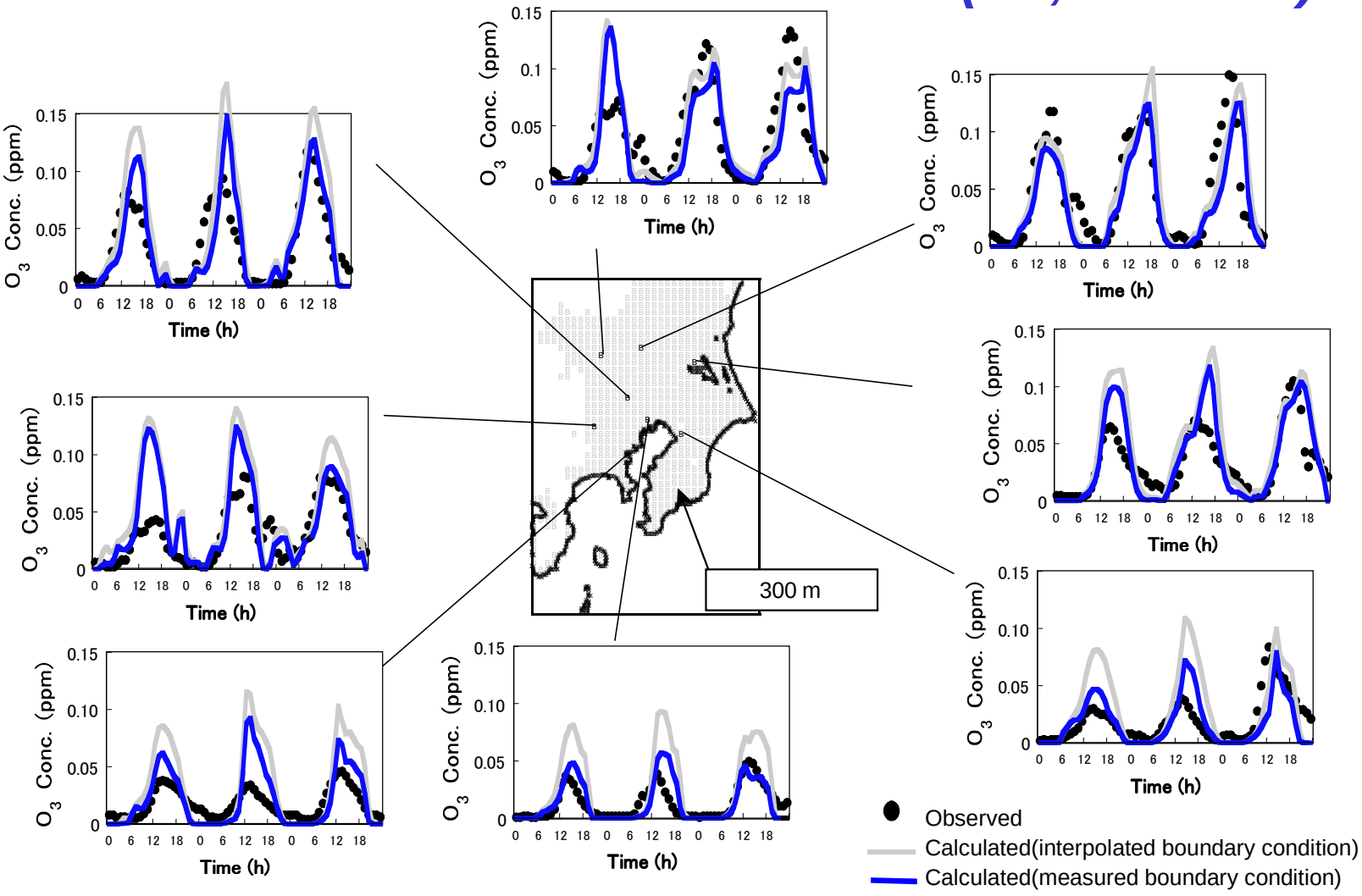
Summer season --- O_3

Winter season --- NO_2, SPM

(as Elemental Carbon)

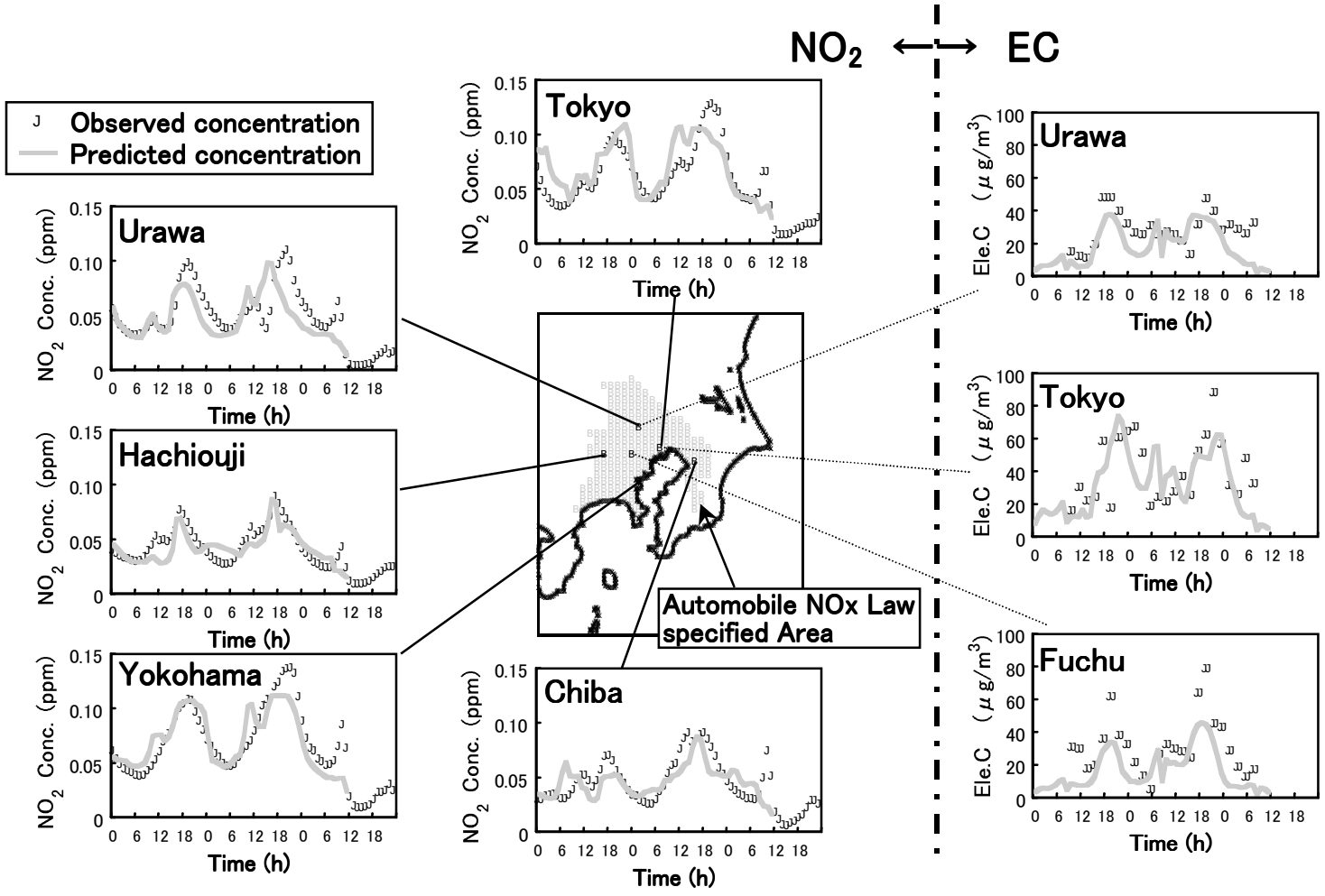
Evaluation of Model Performance

(O3, Summer)



Evaluation of Model Performance

(NOx,EC, Winter)



Quantitative Evaluation of Model Performance

	EPA Recommended Ranges	O_3 (Summer)			NO_2 (Winter)
		UAM	CIT	NIES model	CIT
NGE	＜0.3 ～ 0 35	0.240	0.235	0.261	0.302
NGB	＜±（0 05 ～0. 15	0.067	0.049	0.049	−0.006
HPA	＜±（0 15 ～0.2	0.046	0.119	0.144	0.157

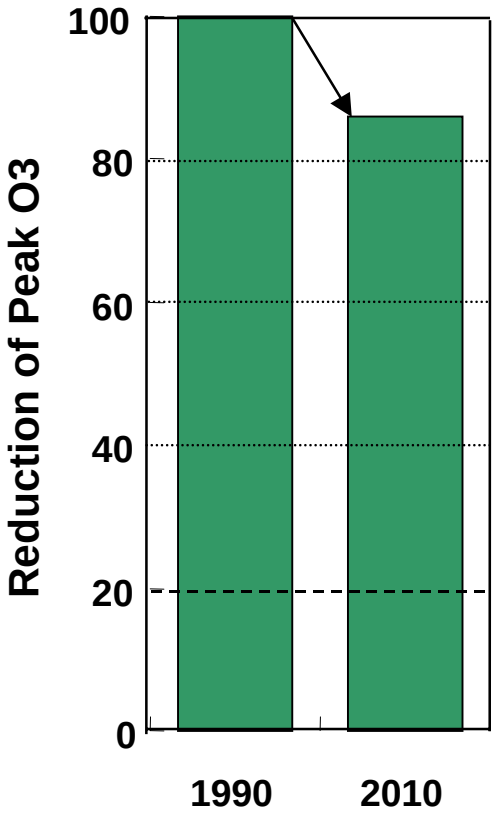
NGE : Normalized Gross Error = $\frac{1}{N_T}\sum_{i=1}^{N}\sum_{j=1}^{H}\frac{\left|C_{obs}(i,j)-C_{cal}(i,j)\right|}{C_{obs}(i,j)} < 0.30\sim0.35$

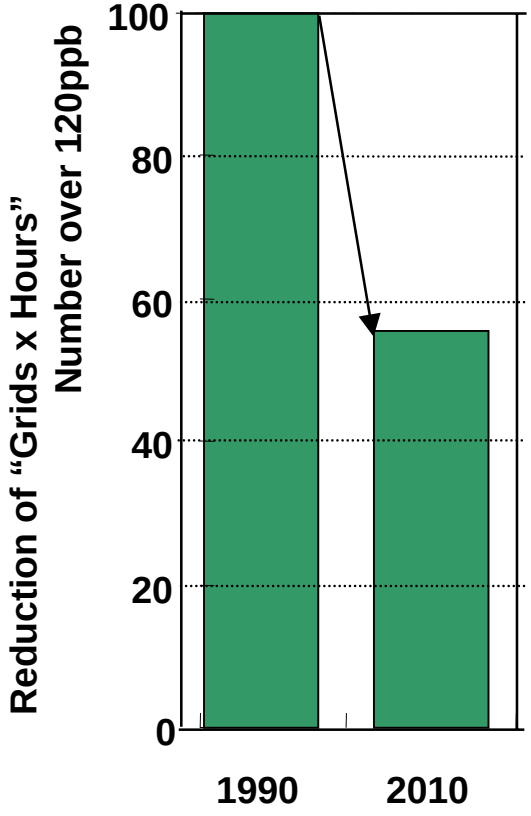
NGB : Normalized Gross Bias = $\frac{1}{N_T}\sum_{i=1}^{N}\sum_{j=1}^{H}\frac{C_{obs}(i,j)-C_{cal}(i,j)}{C_{obs}(i,j)} < \pm(0.05\sim0.15)$

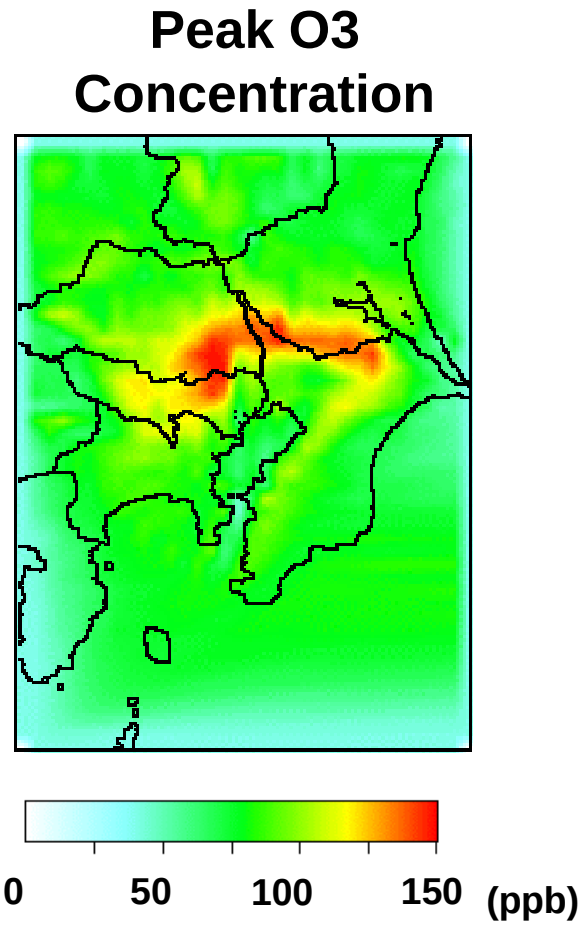
HPA : unpaired Highest-Prediction Accuracy = $\frac{C_{obs,\max}-C_{cal,\max}}{C_{obs,\max}} < \pm(0.15\sim0.20)$

Improvement of Air Quality in 2010

(Summer O3, Under Current Regulation)







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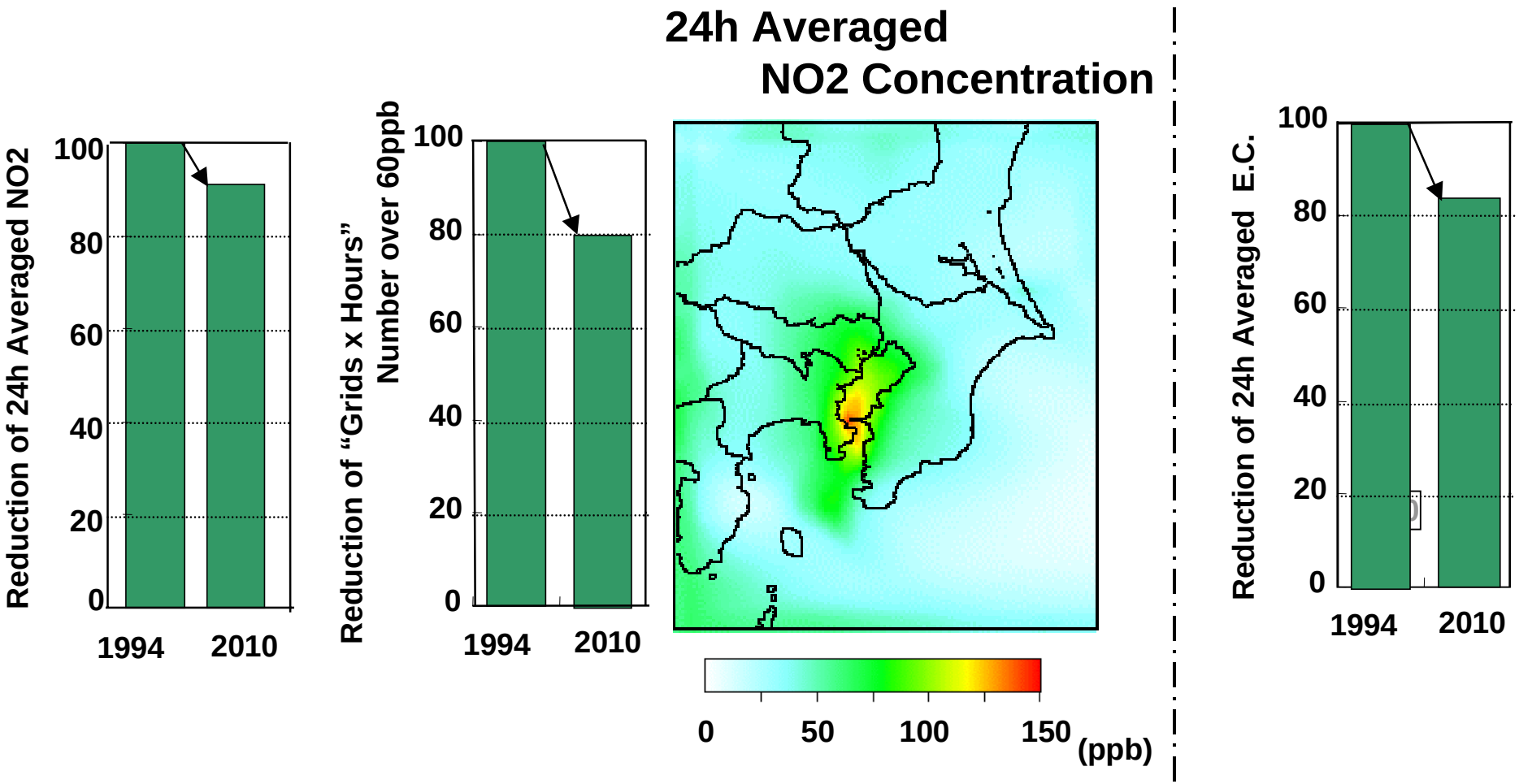
Improvement of Air Quality in 2010

(Winter NO2, EC Under Current Regulation)



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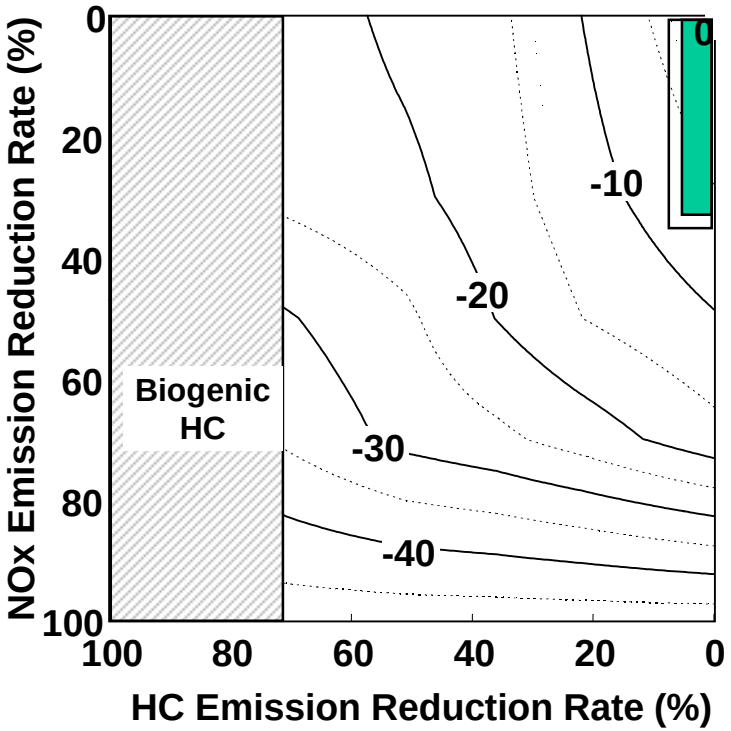
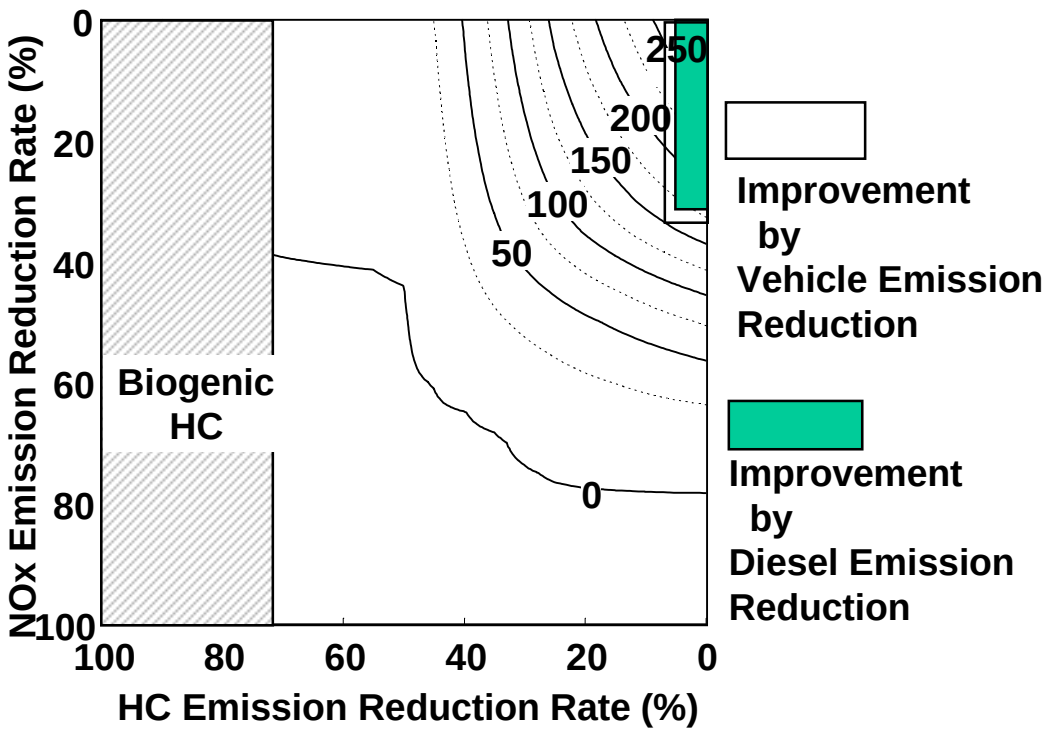
Contour Map for O3 Improvement by Total NOx/HC Emission Reduction

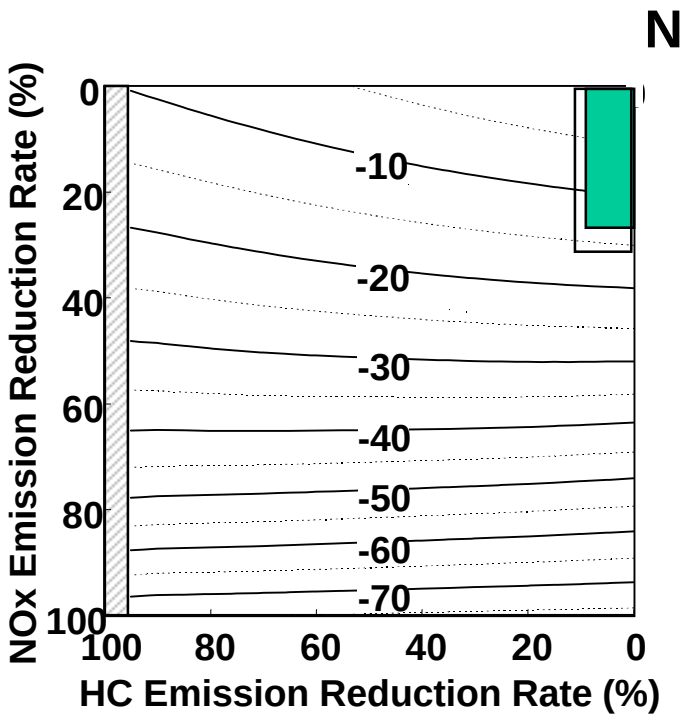


Reduction Rate of Peak O_3 Concentration (%)

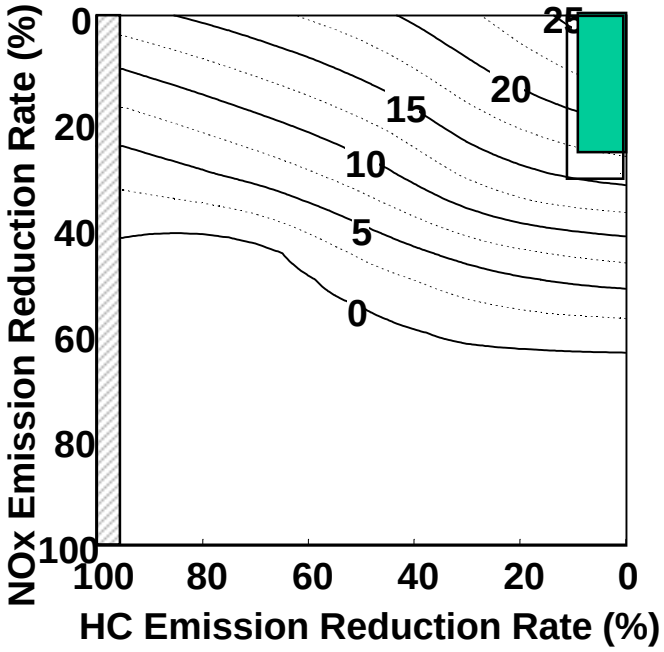


Number of Grids over 120ppb x Hours

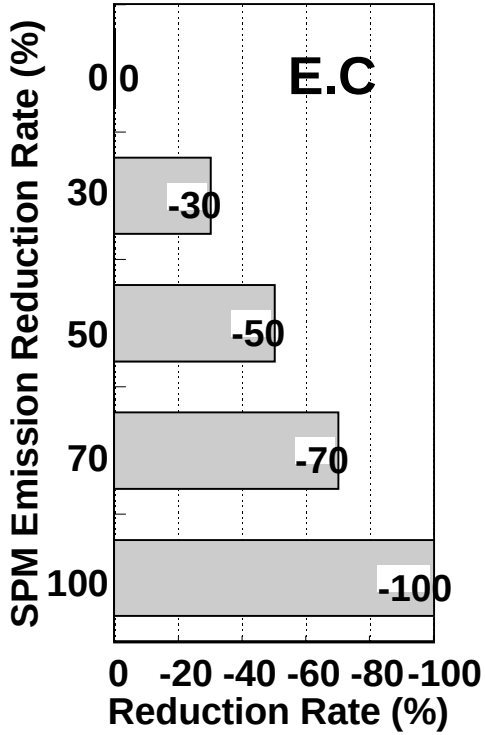
Contour Map for NO2 and EC Improvement by Total NOx/HC Emission Reduction



Reduction Rate of 24-hour Averaged NO_2 Concentration (%)



Ratio of Grids over NO_2 Environmental Quality Standard (%)



Reduction Rate of 24-hour Averaged EC Concentration (%)

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Conclusion -1-

Air quality simulation study was conducted for Tokyo urban area in 2010, and followings were cleared

1. Sources of Total Mass Emissions

1) 50% of NOx and 10% of HC to total mass Emissions are caused by vehicles including motorcycles.

2) 70% of the NOx Emission from vehicles is caused by Diesel.

3) more than 50% to total HC emissions is caused by Painting.

4)For the reduction of NOx emissions, reduction of emissions from Industrial plants is also effective.

Conclusion -2-

2. Effect of Diesel Emissions Reduction on Air Quality

1) Reduction of both HC and NOx from Diesel vehicle is effective to reduce peak O_3 concentrations in summer.

2) Reduction of NOx from Diesel is effective to reduce 24-hour averaged NO_2 concentration in winter, while, reduction of HC shows little effect.

3) SPM concentration in winter shows proportional changes to the reduction of Diesel vehicle emission. (Only elemental carbon was considered in this study. It should be extended to secondary particles in future study.)

Future Studies

1. Study for air quality along urban main roads

Development of new models, Construction of input data

2. Extension to secondary particle matters

Development of secondary particle models,
Construction of input data

3. Study of evaluation methodology of air quality

Evaluation by exposure population, etc.

4. Improvement of reliability of air quality simulation

Atmospheric observation study as validation of simulation models
Improvement of accuracy of emission inventory