Impact of air pollutants from ships on coastal population

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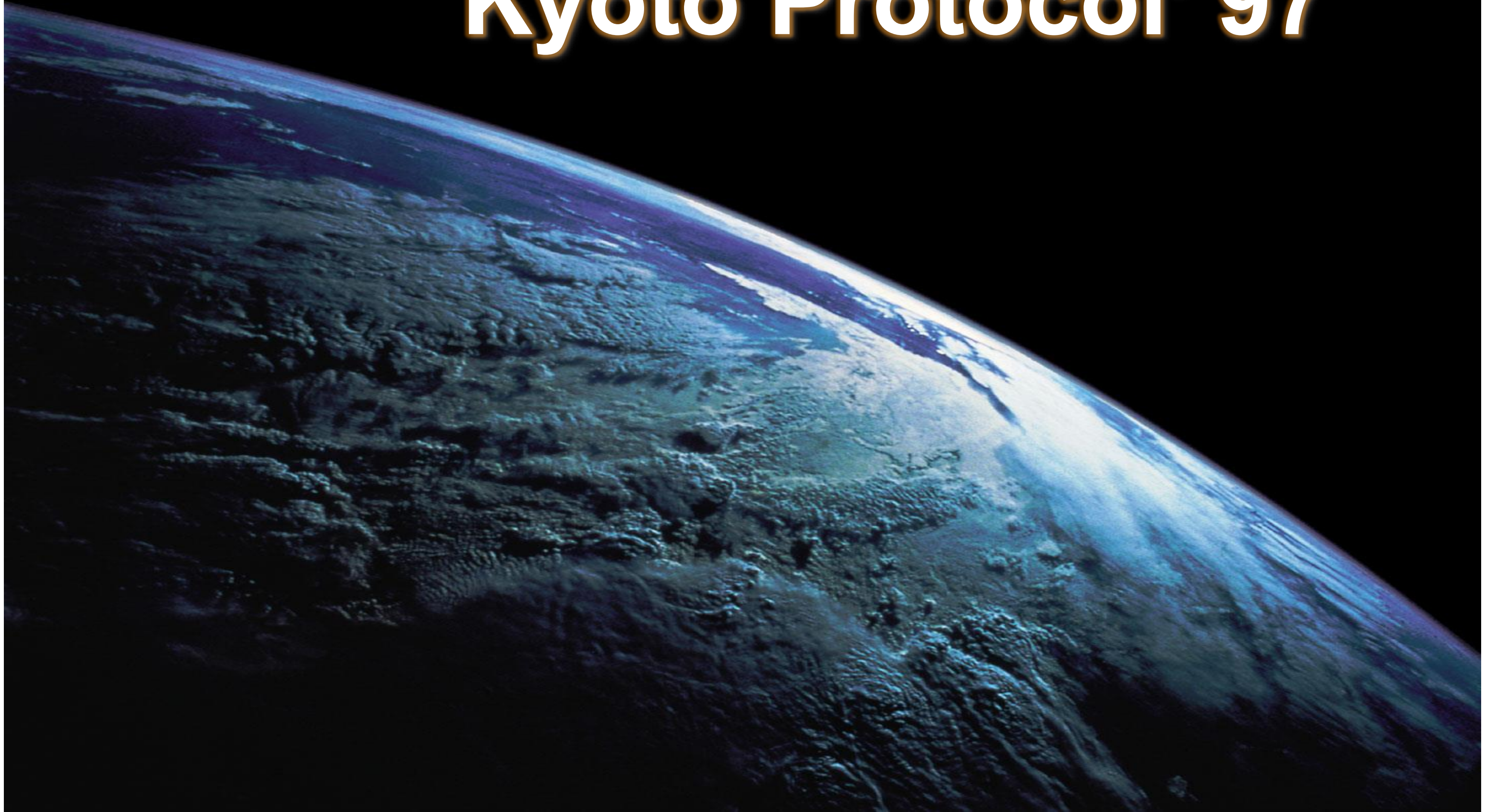
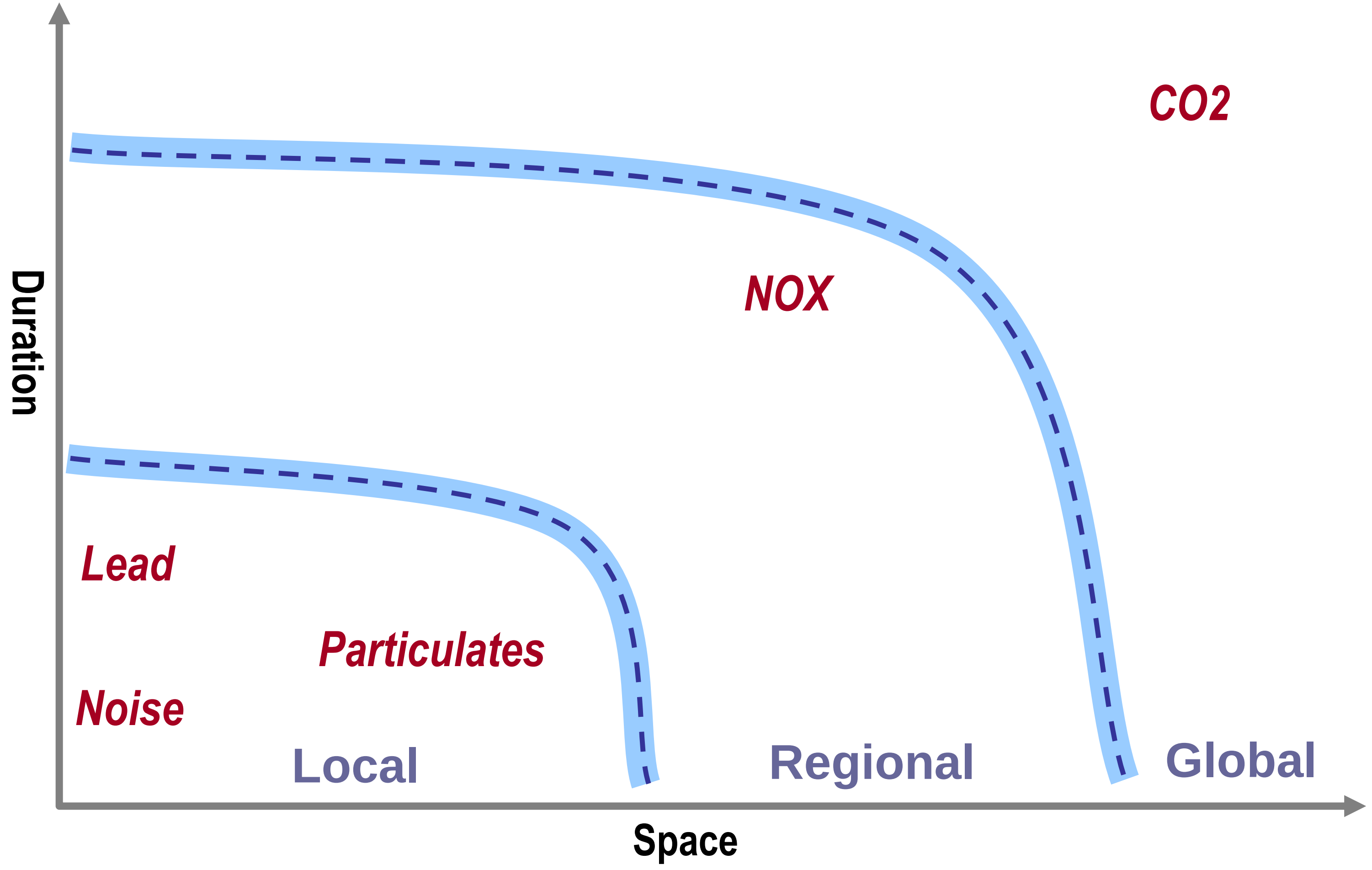
CONTENTS

UNFCCC' 92

Kyoto Protocol' 97



Spatial and Durational Environmental Effects



Source: Dr. Jean-Paul Rodrigue, Dept. of Economics & Geography, Hofstra University.

Carbon Footprinting

- Mapping
- Monitoring & Reduction

International Shipping

IMO

- Technical Measure
- Operational Measure
- Market Based Measure
  - Carbon Tax
  - Emission Trading Scheme

Emission Control Area(ECA)?

- MARPOL Annex VI entered into force on 19 May 2005 and Regulations 14 and 18 define the method of controlling Sulphur Oxide (SO_x) emissions on a global basis and in defined protected areas called Sulphur Emission Control Areas (SECAs).

- The aim of the legislation is to reduce SO_x emissions from ships to reduce the acidification of the atmosphere and the resulting acid rain

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Health Problems

Respiratory disease

Cardiovascular disease

Asthma

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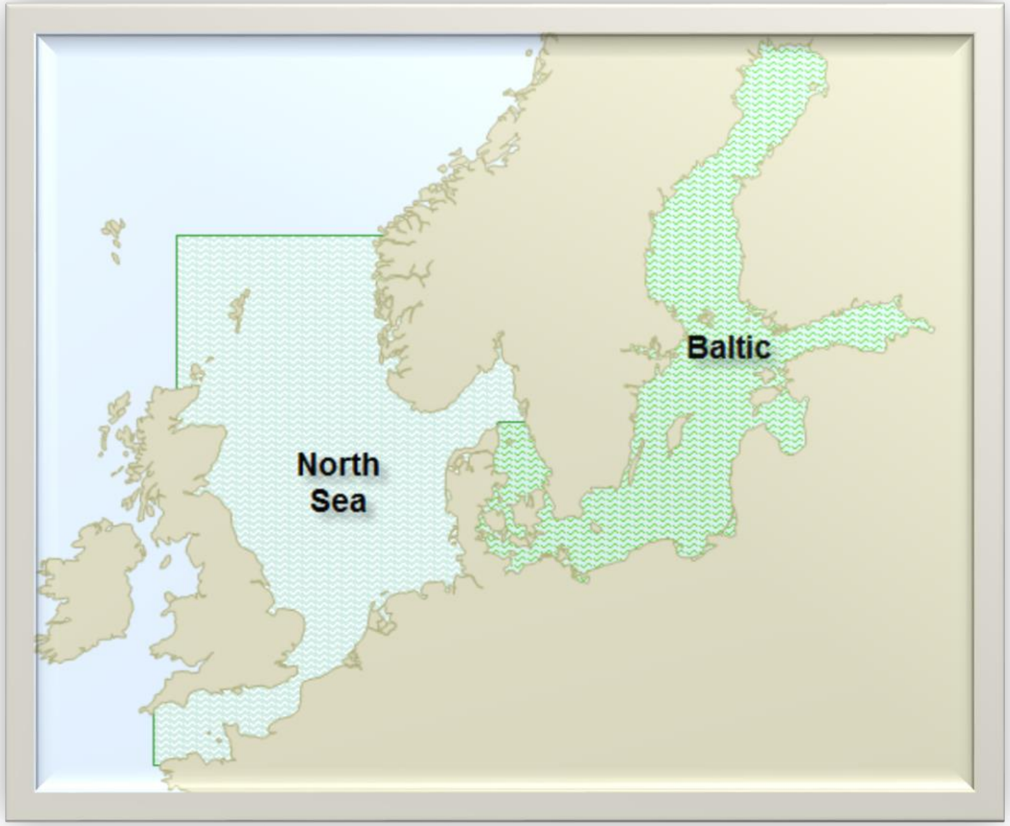
ECA Areas in force to date



1. Baltic Sea
 - came into force on 19 May 2005

2. North Sea and English Channel
 - came into force on 11 August 2007

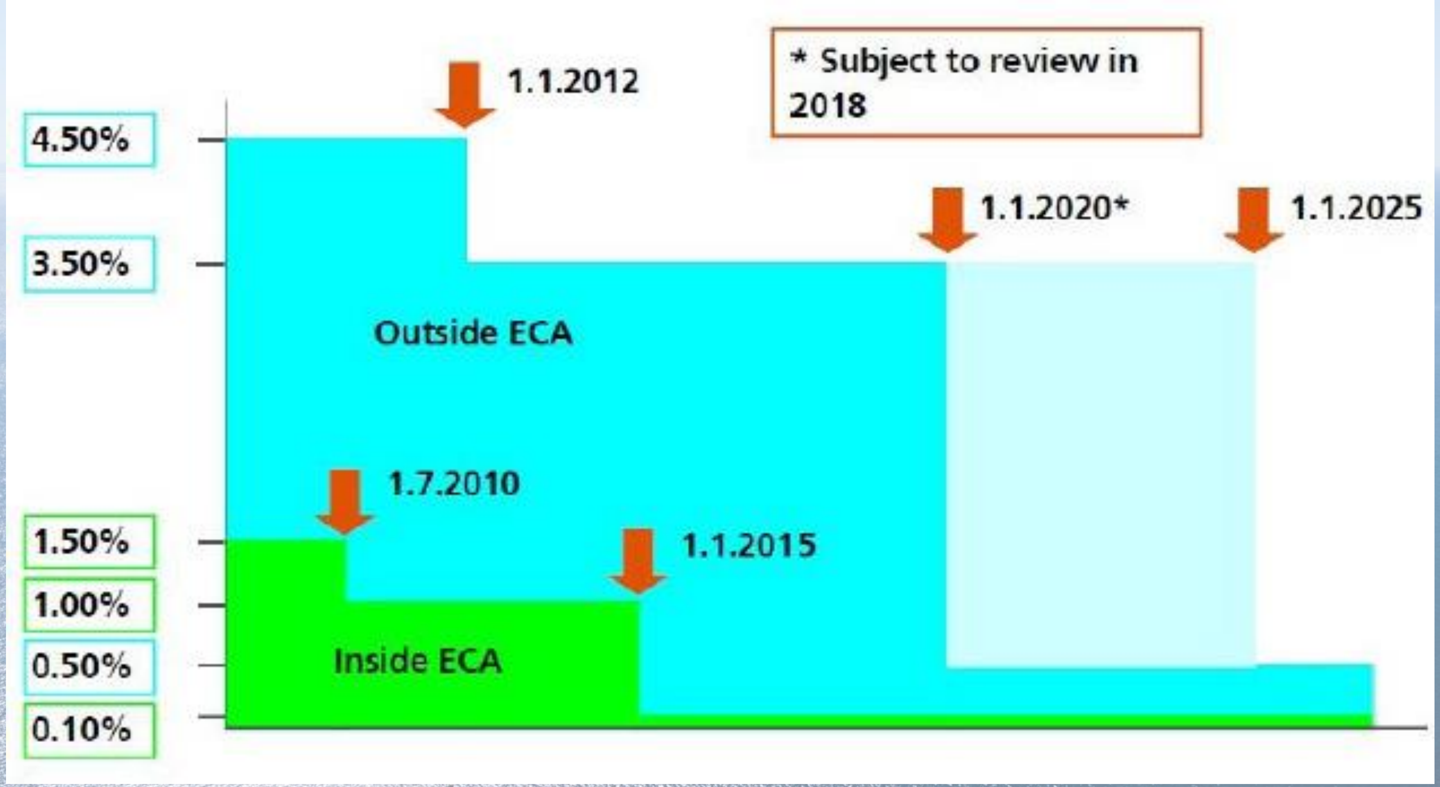
ECA Areas in force to date

1.US East Coast
 - came into force on 1st August 2012

2.US East Coast
 - came into force on 1st August 2012

3.Hawaiian Islands
 - came into force on 1st August 2012

INTERNATIONAL SHIP ENGINE & FUEL STANDARDS
: MARPOL ANNEX VI



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Assessing greenhouse gas emissions from port vessel operations at the Port of Incheon

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ARTICLE INFO

Keywords:
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Sea ports
Vessel operations
Bottom-up approach

ABSTRACT

This paper measures greenhouse gas emissions from port vessel operations by considering the case of Korea's Port of Incheon. It provides estimates of greenhouse gas emissions based on the type and the movement of a vessel from the moment of its arrival, to its docking, cargo handling, and departure. Taking a bottom-up approach based on individual vessels' characteristics and using data on vessels processed by the port in 2012 estimate emissions. The results indicate that the level of emissions is five times higher than that estimated through the top-down approach. Among various types of vessels, international car ferries are the heaviest emitters, followed by full container vessels and car carriers. A vessel's passage through lock gates and maneuver to approach the dock accounts for 96% of its emissions. Docking for cargo handling shows the lowest level of GHG emissions.

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Port of Incheon (POI)

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Data

- Port of Incheon (POI)
  - Incheon Port Authority(IPA)
  - 13,784 vessels
  - From Jan to Oct 2012
  - European Environmental Agency(EEA) 2009
  - *Significant Ships* 1996-2001
  - etc

Methodology

$$F_{ijk} = [MF_k \bullet (\frac{s_{1k}}{s_{0k}})^3 + AF_k] \bullet \frac{d_{ij}}{24 s_{1k}}$$

where F_{ijk}: amount of consumed fuel by vessel *k* moving from *i* point to *j* point

MF_k: daily fuel consumption of a vessel's main engine

AF_k: daily fuel consumption of a vessel's auxiliary engine

s_{1k}: vessel's operating speed (nm/hour)

s_{0k}: vessel's design speed (nm/hour)

d_{ij}: distance from *i* point to *j* point

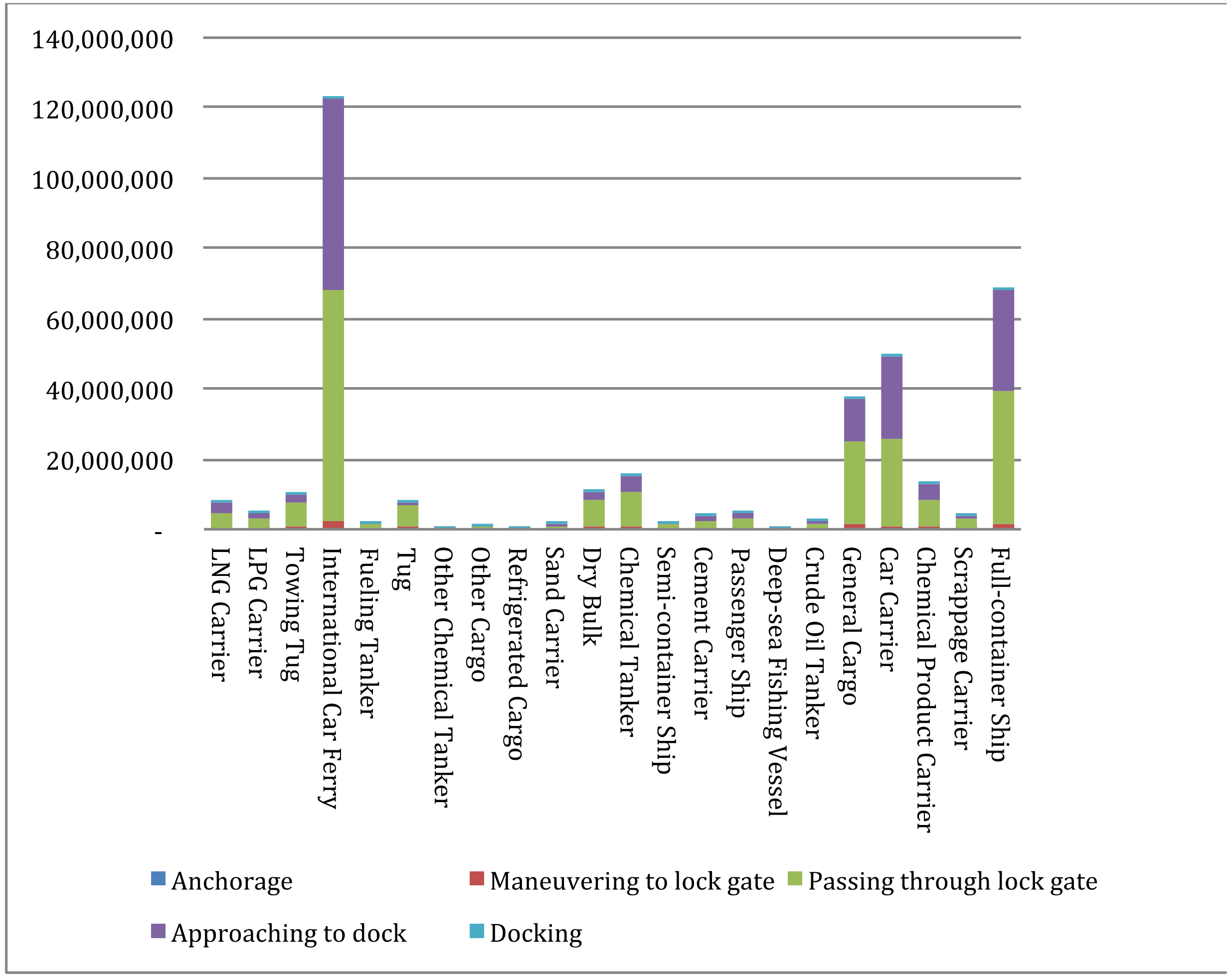

Figure 2. Estimation of CO_2 emissions by ship type and movement

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Assessing noxious gases of vessel operations in a potential Emission Control Area

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Main Source
– Internal combustion

- Soot

    Carbon Monoxide(CO)
    Volatile Organic Compounds(VOC)
    Nitrogen Oxides(NO_x)
    Particulate Matter(PM)

- Sulfur-rich fuels

    Carbon Dioxide(CO_2)
    Sulfur Dioxide(SO_2)

Methodology

$$E_{trip,k,p,g,f} = \sum_{m} (F_{g,f,m} \times EF_{p,g,f,m})$$

where, E_{trip}: emission over a complete trip (ton) of vessel k

$F_{g,f,m}$: amount of fuel consumed by vessel *k*

EF: emission factor

p: pollutant (NO_X, SO_2, PM)

f: fuel type (bunker fuel oil, marine diesel oil/marine gas oil, gasoline)

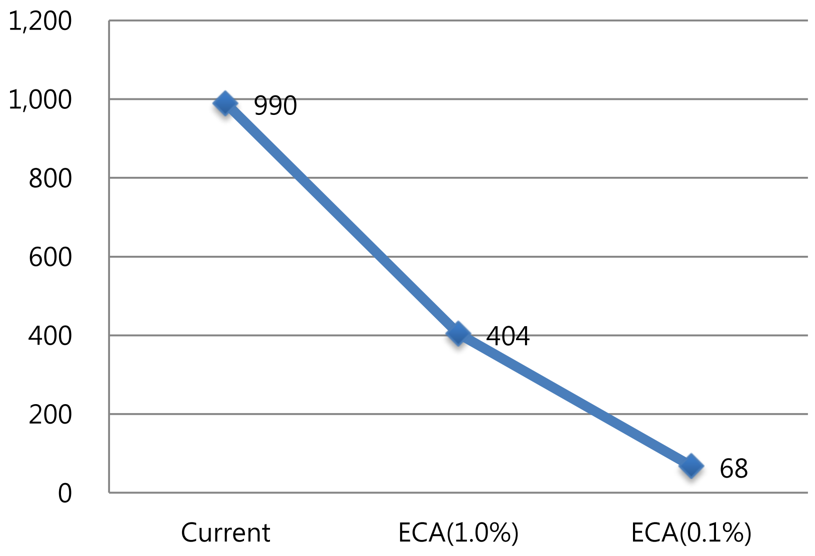
g: engine type (slow-, medium-, and high-speed diesel, gas turbine and steam turbine)

m: different phase of the trip (cruise, hotelling, maneuvering)

Results

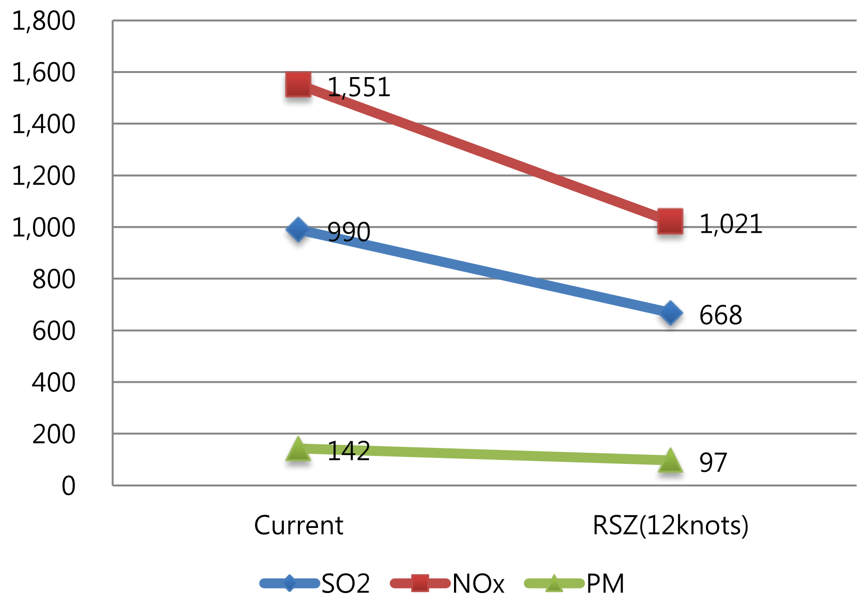
<Reduction by ECA>

1.0% or 0.1%(Sulphur content)



<Reduction by RSZ>

12kn speed limit
within 25 mile zone



Conclusion

- Emission of SOX, NOX & PM from ships is critical on health of human population
- No ECA has been designated yet in Asia
- Designating ECA can reduce the impact remarkably as shown in this study
- It is high time that Asian countries should consider ECA in their regions.

Estimating externality of population health exposure to near-road vehicular emissions

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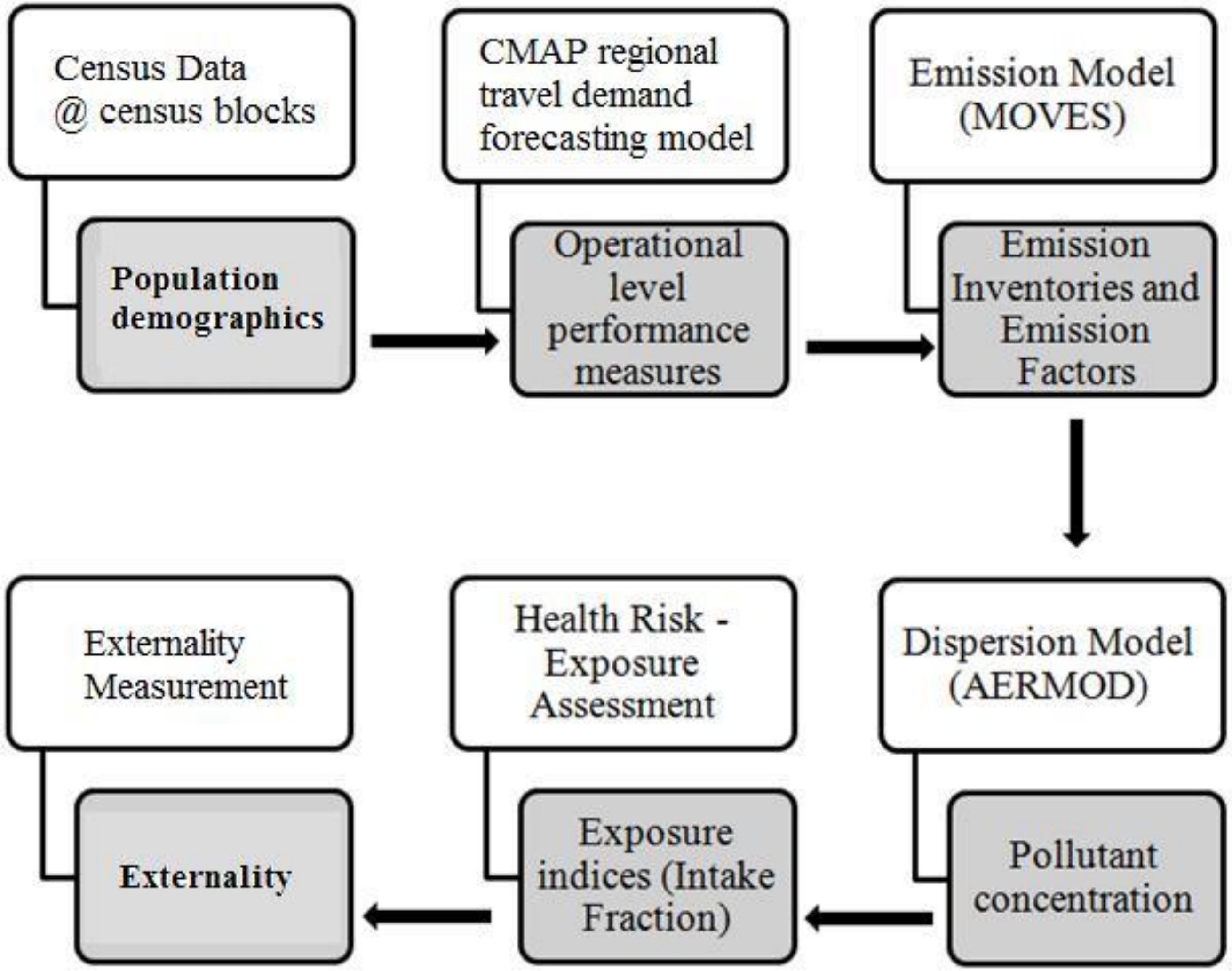
Modeling Process



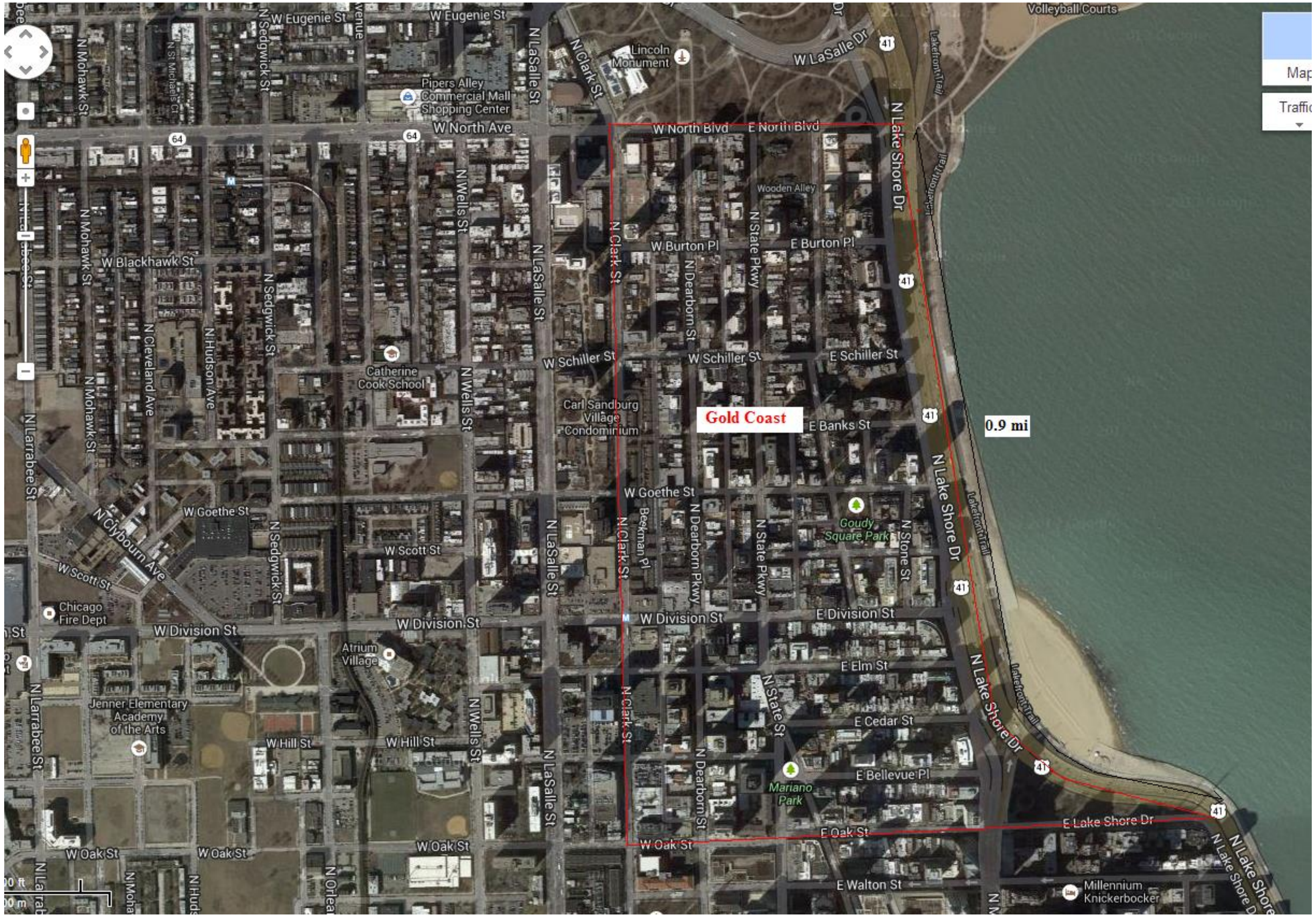
Case Study

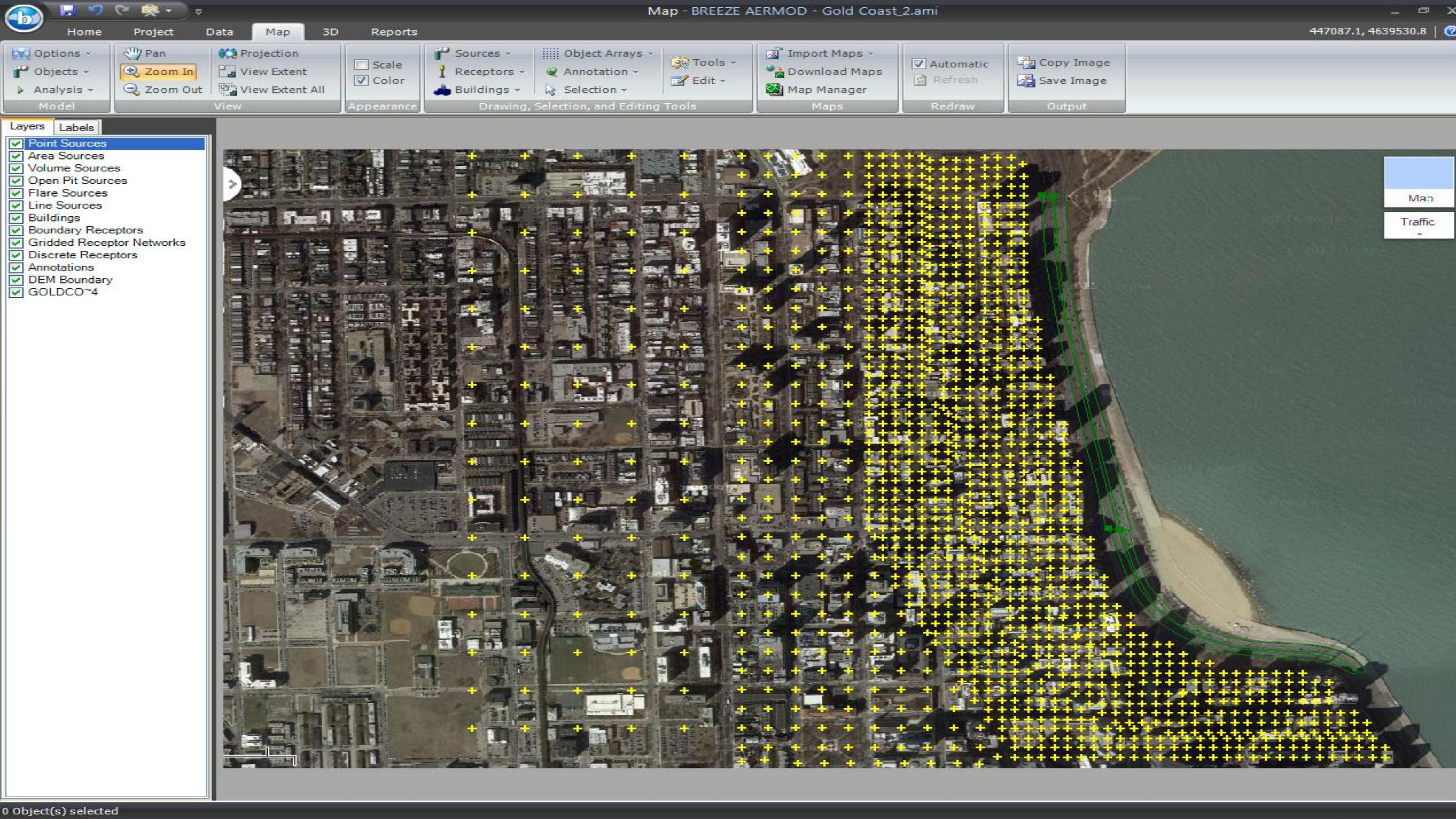
- Gold Coast, Chicago
- Lakeshore Drive between North Ave and Oak Street
- Analysis year – 2010
- For a typical day in January
- Extent of 1000m from Lakeshore Drive
- Particulate matter of size 2.5um
- 24 hour averaging period

Case Study – Gold Coast Region, Chicago

- One of most densely population regions in Chicago
- Bounded on the south by Oak St and East Lake Shore Drive, on the north by North Ave, from Lake Michigan west to Clark St

Case Study Extent




Map - BREEZE AERMOD - Gold Coast_2.ami
Home
Project
Data
Map
3D
Reports
447087.1, 4639530.8
Options
Objects
Analysis
Model
Pan
Zoom In
Zoom Out
Projection
View Extent
View Extent All
View
Scale
Color
Appearance
Sources
Receptors
Buildings
Object Arrays
Annotation
Selection
Tools
Edit
Drawing, Selection, and Editing Tools
Import Maps
Download Maps
Map Manager
Maps
Automatic
Refresh
Redraw
Copy Image
Save Image
Output
Layers
Labels
Point Sources
Area Sources
Volume Sources
Open Pit Sources
Flare Sources
Line Sources
Buildings
Boundary Receptors
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Annotations
DEM Boundary
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Map
Traffic
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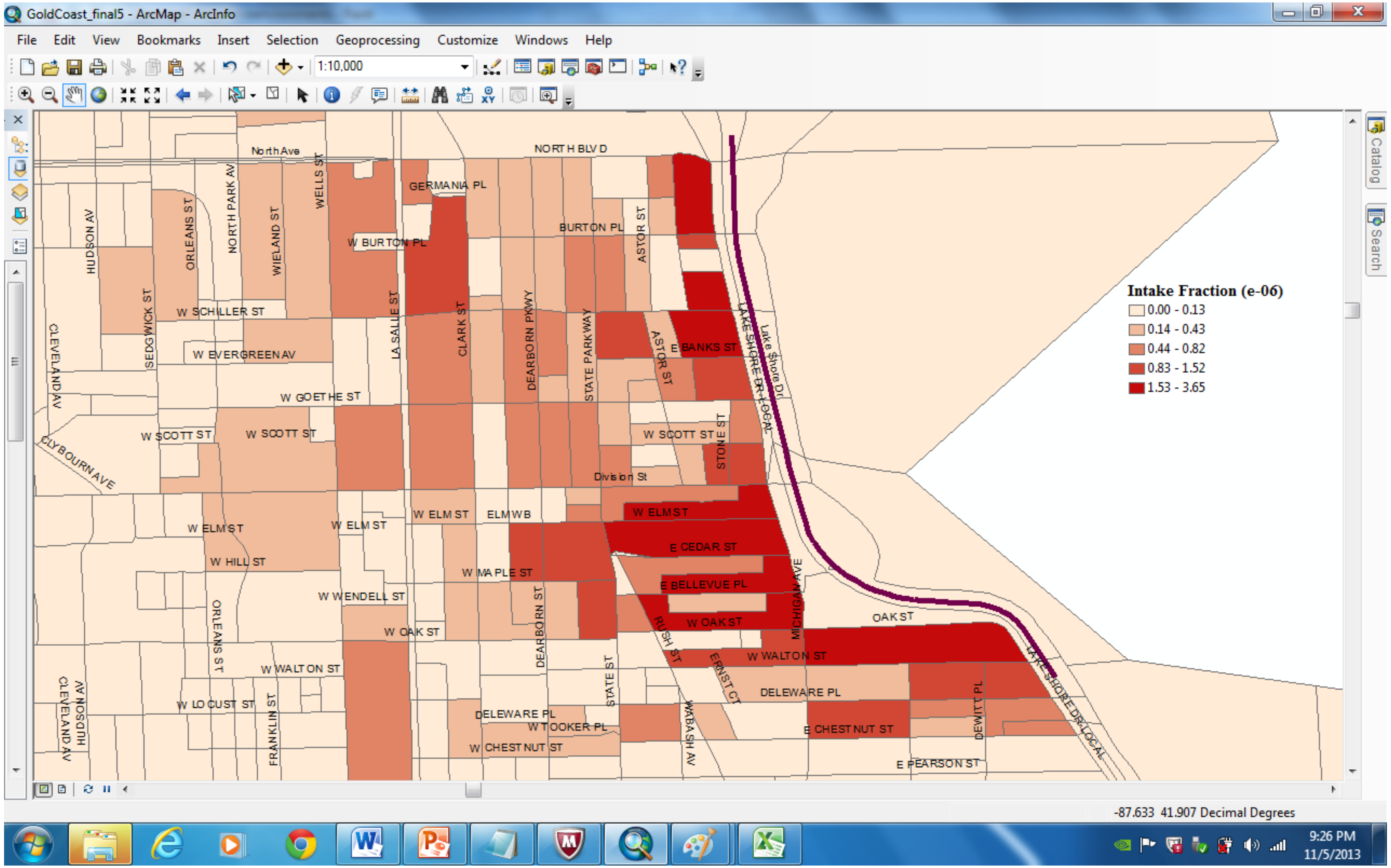
Intake Fraction – Subgroups and Microenvironments



estimates of externalities: physical impacts and monetary value

	Cardiopulmonary deaths (persons, %)	Circulatory sickness cases	Respiratory sickness cases
Short-distance block (within 300 m)	30.9 (50%)	237.4	139.3
Medium-distance block (within 800 m)	26.9 (43%)	206.4	121.2
Long-distance block	4.6 (7%)	35.4	20.8
Total impacts	60.4 (100%)	479.2	281.2
Monetary value (million $)	461.875	1.591	0.884
% in total monetary value	99.5	0.3	0.2

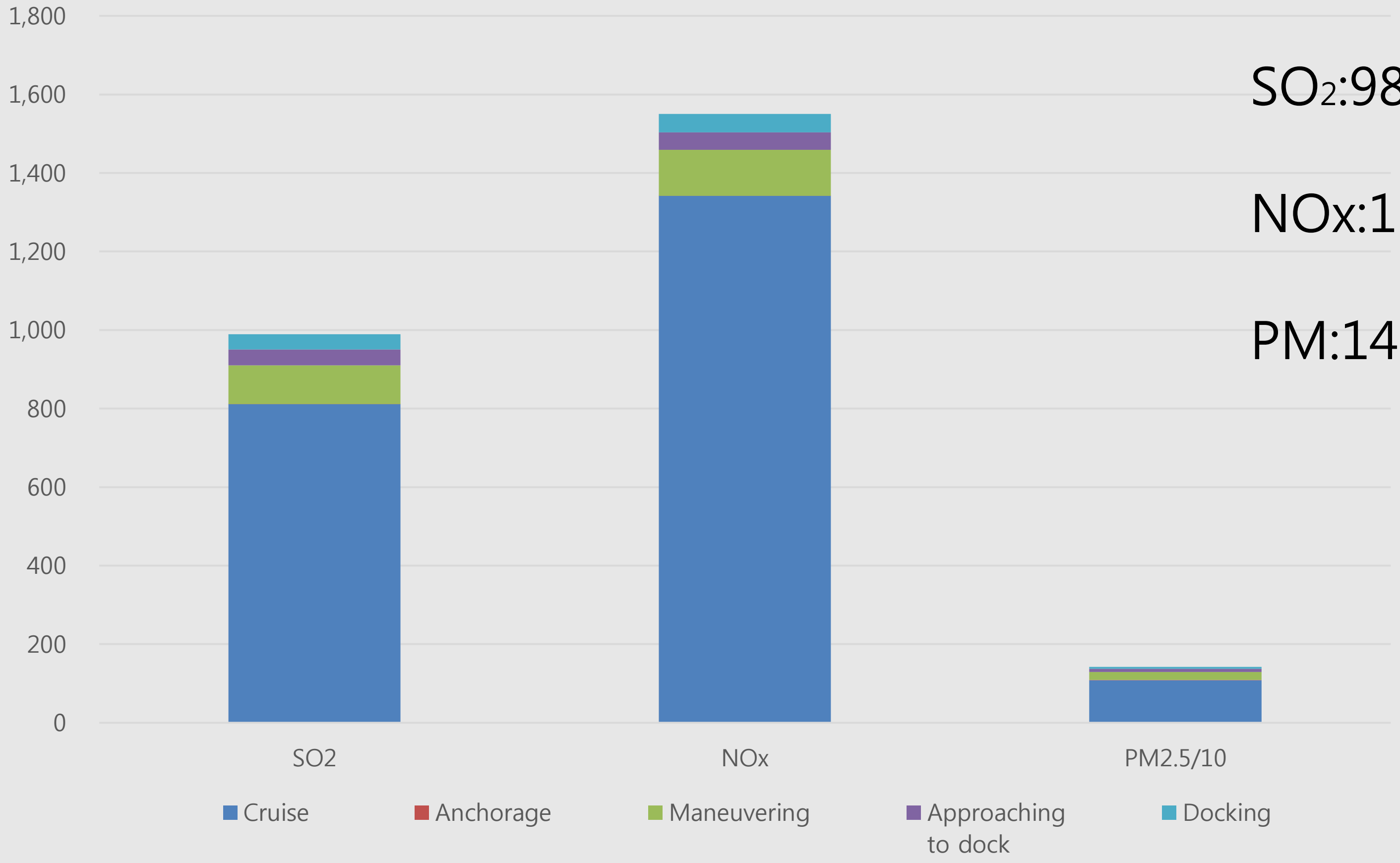
Major findings

- The long-term impact, cardiopulmonary deaths are about **60 people**, comprising 0.08 % of the total population of 82,841 people in the case study area.

- People living within 300 meters are contributing 50% of the total physical impacts attributable to the emissions of PM from the roadway although the portions of this short-distance area are 24% in the total population and 18% in the total number of blocks, respectively.

- Next medium-distant people between 300 m and 800 m are contributing 43% to the total impacts and the long-distant people are affected by a minor portion (7%).

Total emission



SO_2:989ton/year

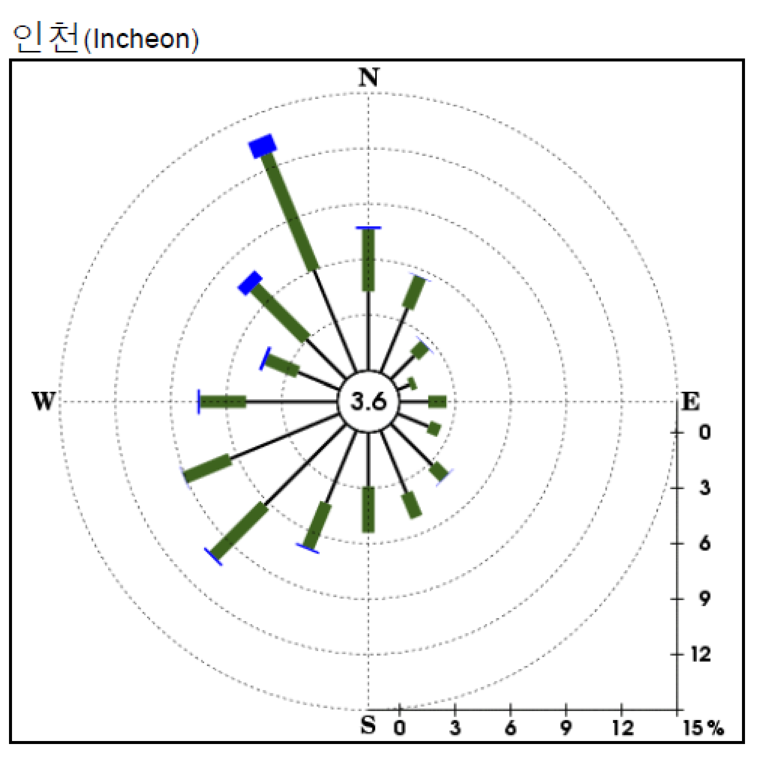
NOx:1550ton/year

PM:142ton/year

2

Dispersion model

WINDROSE INCHEON 2014

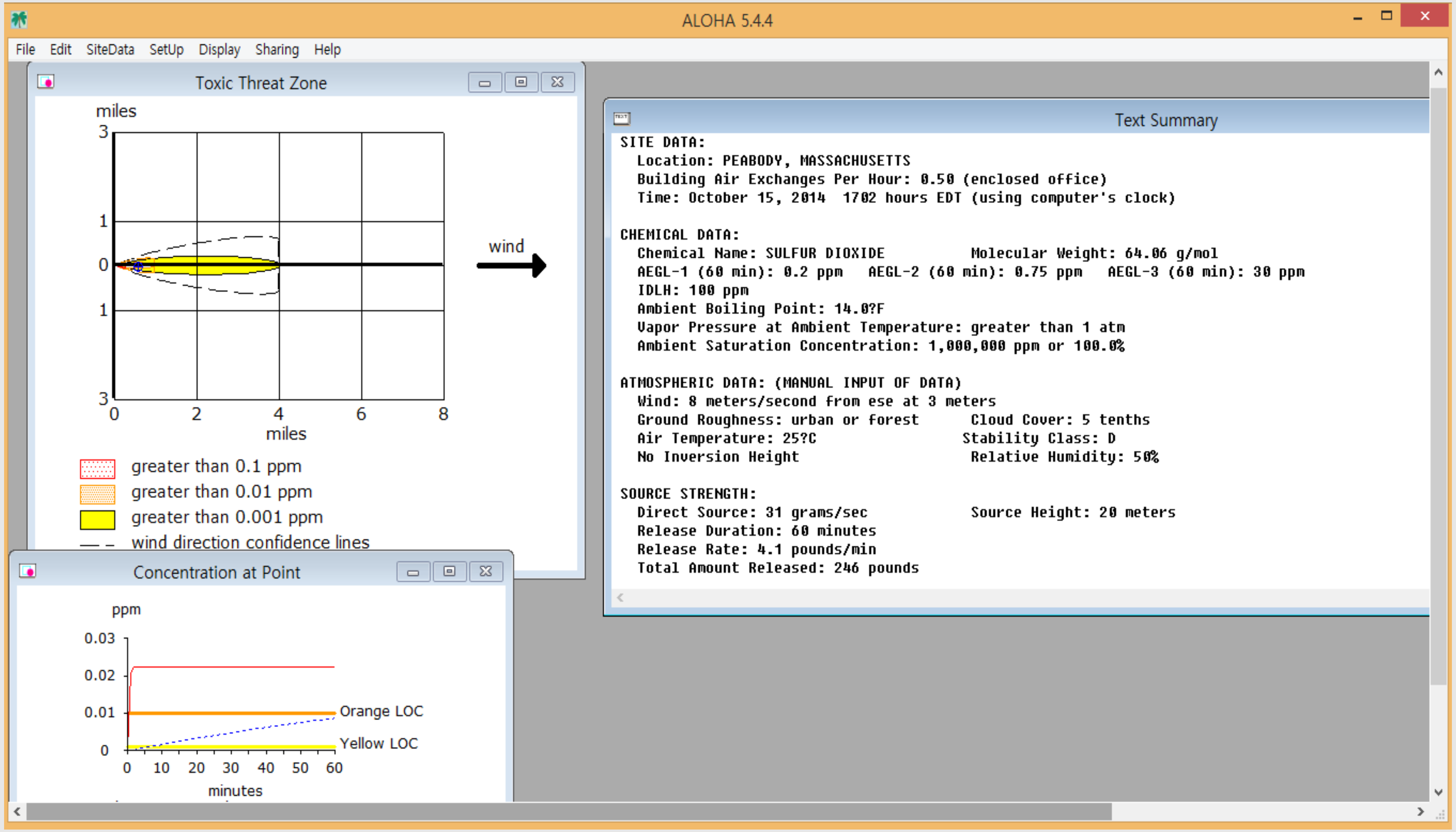


Dominant Wind is

-8m/s

-direction : NNW

Aloha program simulation



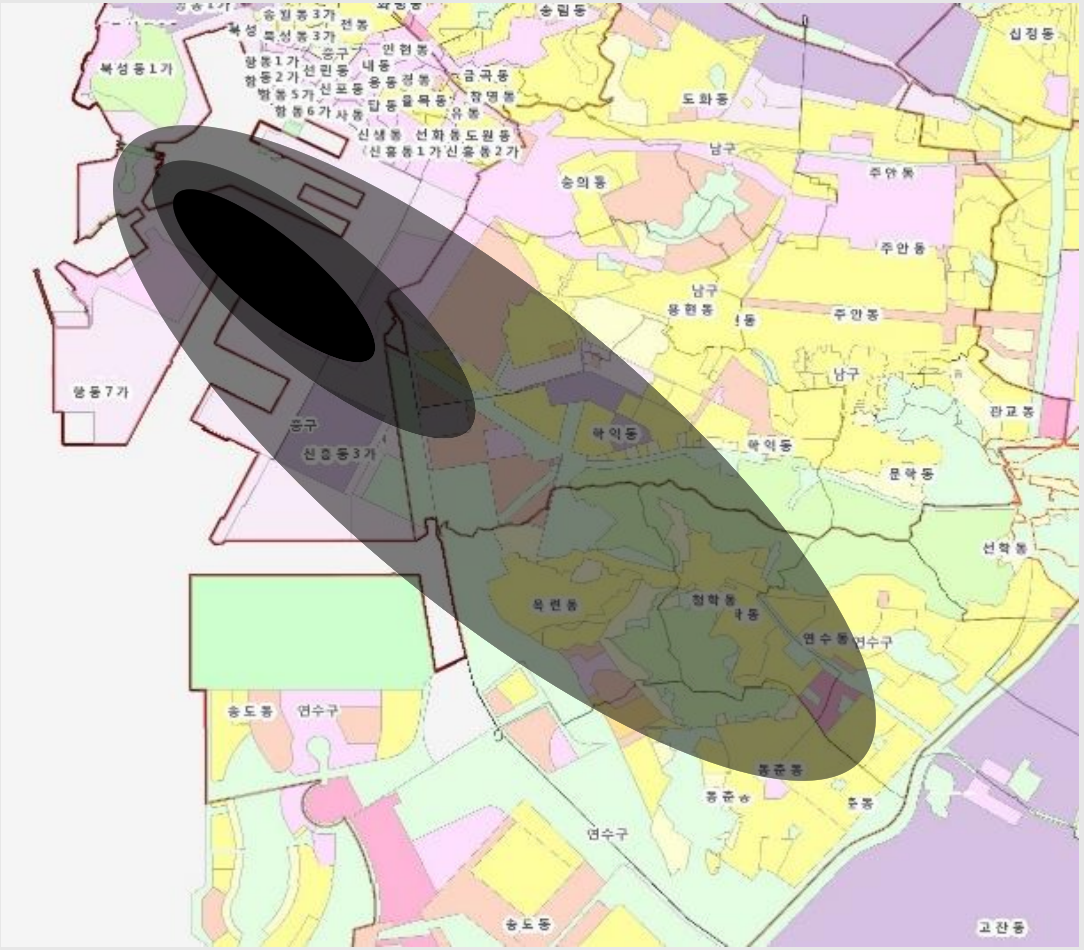
Simulated emission table

SULFUR DIOXIDE			
THREAT ZONE: (GAUSSIAN SELECTED)			
Model Run: Gaussian	SO2	ppm	g/s
Red : 484 yards --- (0.1 ppm)	0.5km	0.1	120
Orange: 1724 yards --- (0.01 ppm)	2km	0.01	90
Yellow: 4.0 miles --- (0.001 ppm)	4km	0.002	50
	10km	0.001	20

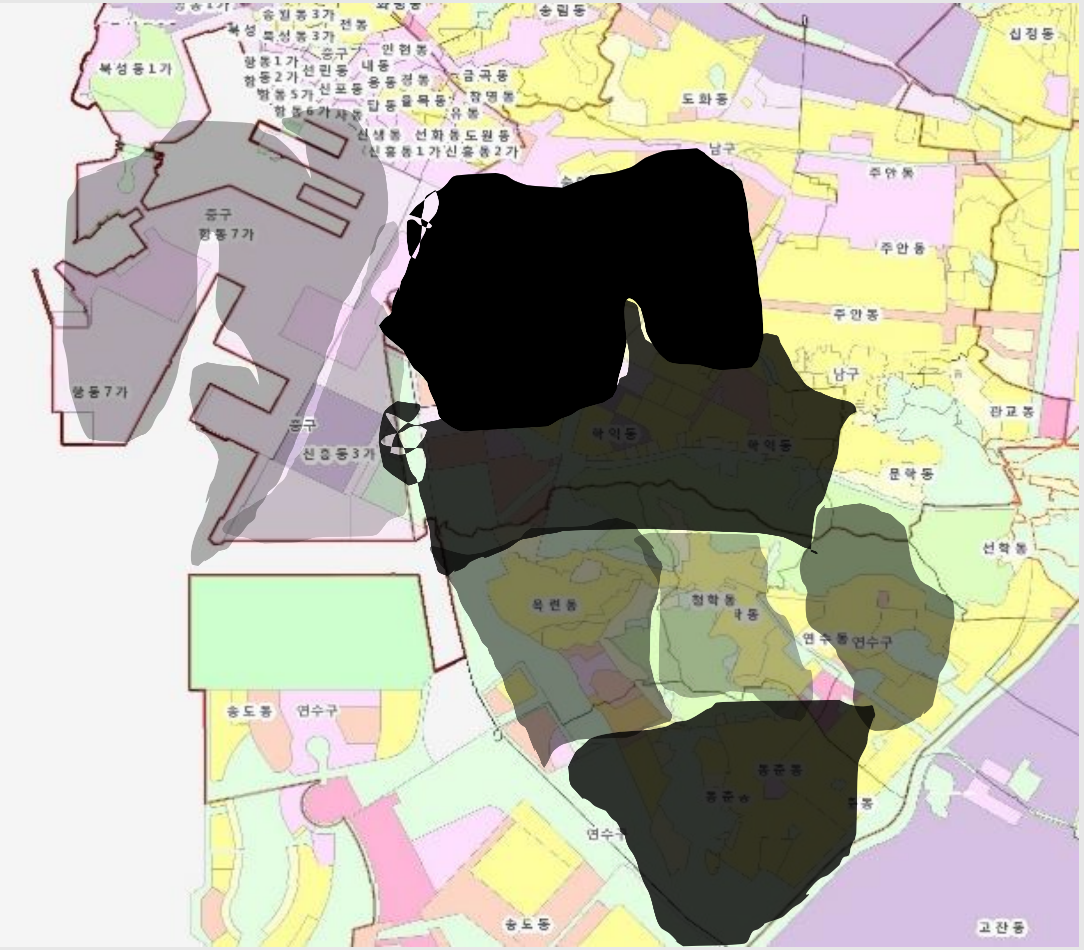
NITRIC ACID	NOX	ppm	g/s
THREAT ZONE: (GAUSSIAN SELECTED)	0.5km	0.1	180
Model Run: Gaussian	2km	0.01	150
Red : 472 yards --- (0.1 ppm)	4km	0.002	90
Orange: 1.1 miles --- (0.01 ppm)	10km	0.001	30
Yellow: 4.9 miles --- (0.001 ppm)			

Particulate matter	PM	ppm	g/s
THREAT ZONE: (GAUSSIAN SELECTED)	0.5km	0.01	12
Model Run: Gaussian	2km	0.001	10
Red : LOC is not exceeded --- (0.1 ppm)	4km	0.001	7
Note: Threat zone was not drawn because	10km	0.0005	2
the ground level concentrations never exceed the LOC.			
Orange: 361 yards --- (0.01 ppm)			
Yellow: 1708 yards --- (0.001 ppm)			

Dispersion Map

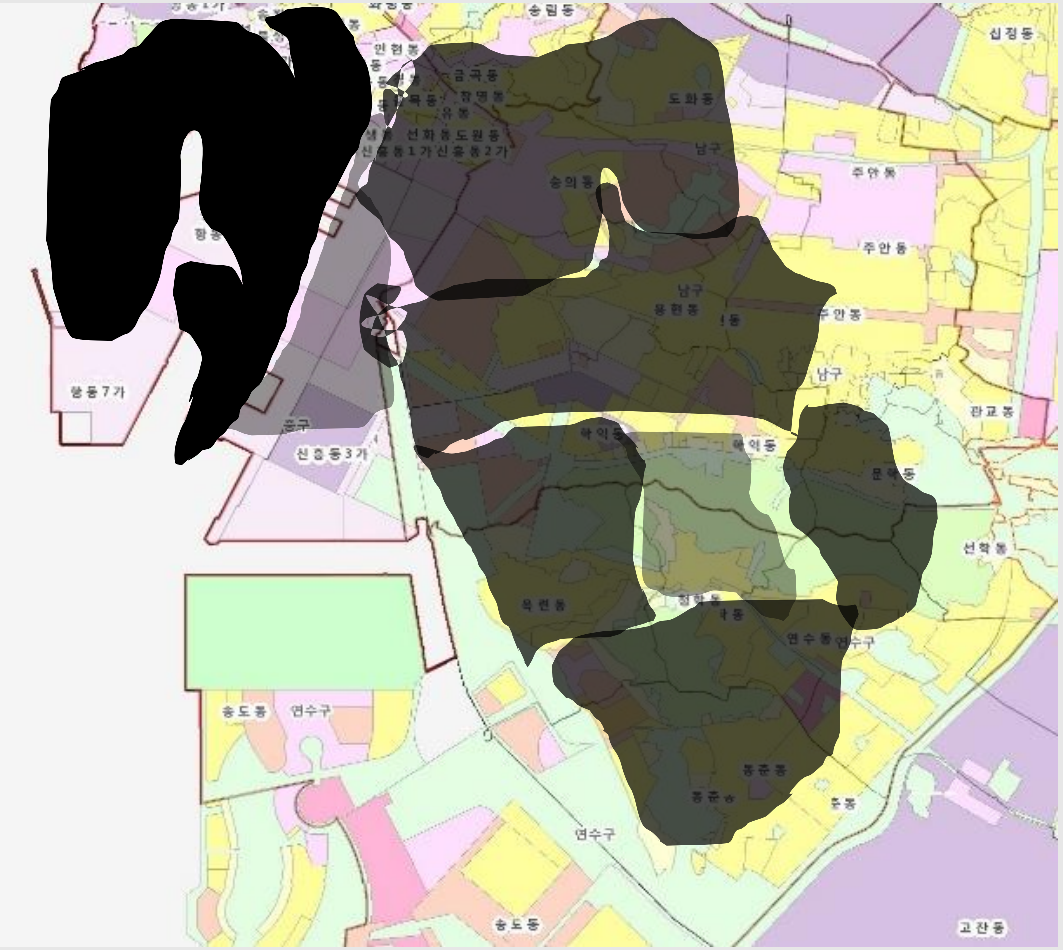


Population density Map



	Total population	Male	Female
Yong hyeon	79645	40929	38716
Dong chun	60038	29687	30351
Hak ik	57803	28832	28971
Yeon su	52757	27142	25615
Ok ryeon	47786	23,772	24,014
Chung hak	31320	16032	15288
Sin hung	15372	7823	7549
Yeon an	7839	4173	3666

SO_2 IF density map

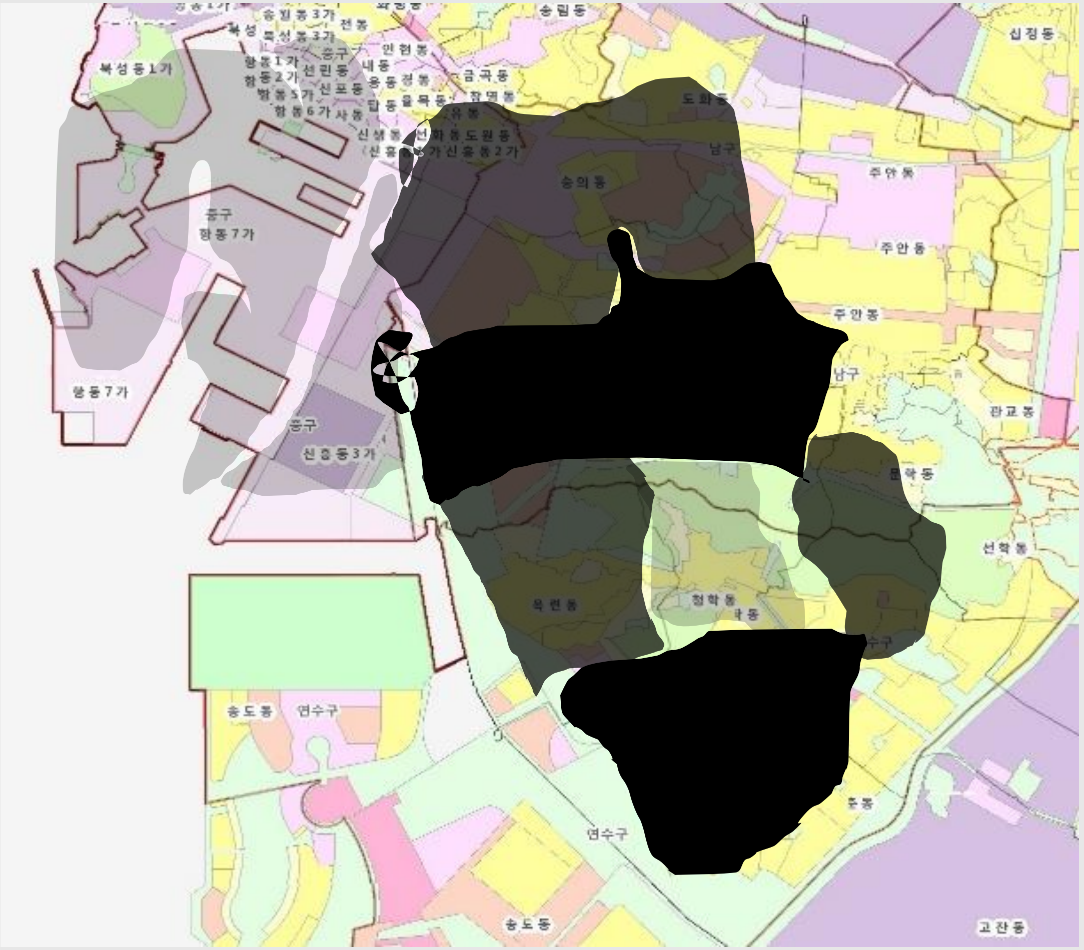


SO2			
	Male	Female	Total
Yeon an	1669	1173	2842
Sin hung	417	322	739
Yong hyeon	786	595	1381
Dong chun	712	583	1295
Hak ik	692	556	1248
Yeon su	651	492	1143
Ok ryeon	571	461	1032
Chung hak	385	294	678

NOx IF density map

NOX			
	Male	Female	Total
Yeon an	1113	782	1895
Sin hung	250	193	444
Yong hyeon	437	330	767
Dong chun	475	388	863
Hak ik	461	371	832
Yeon su	434	328	762
Ok ryeon	380	307	688
Chung hak	257	196	452

PM IF density map



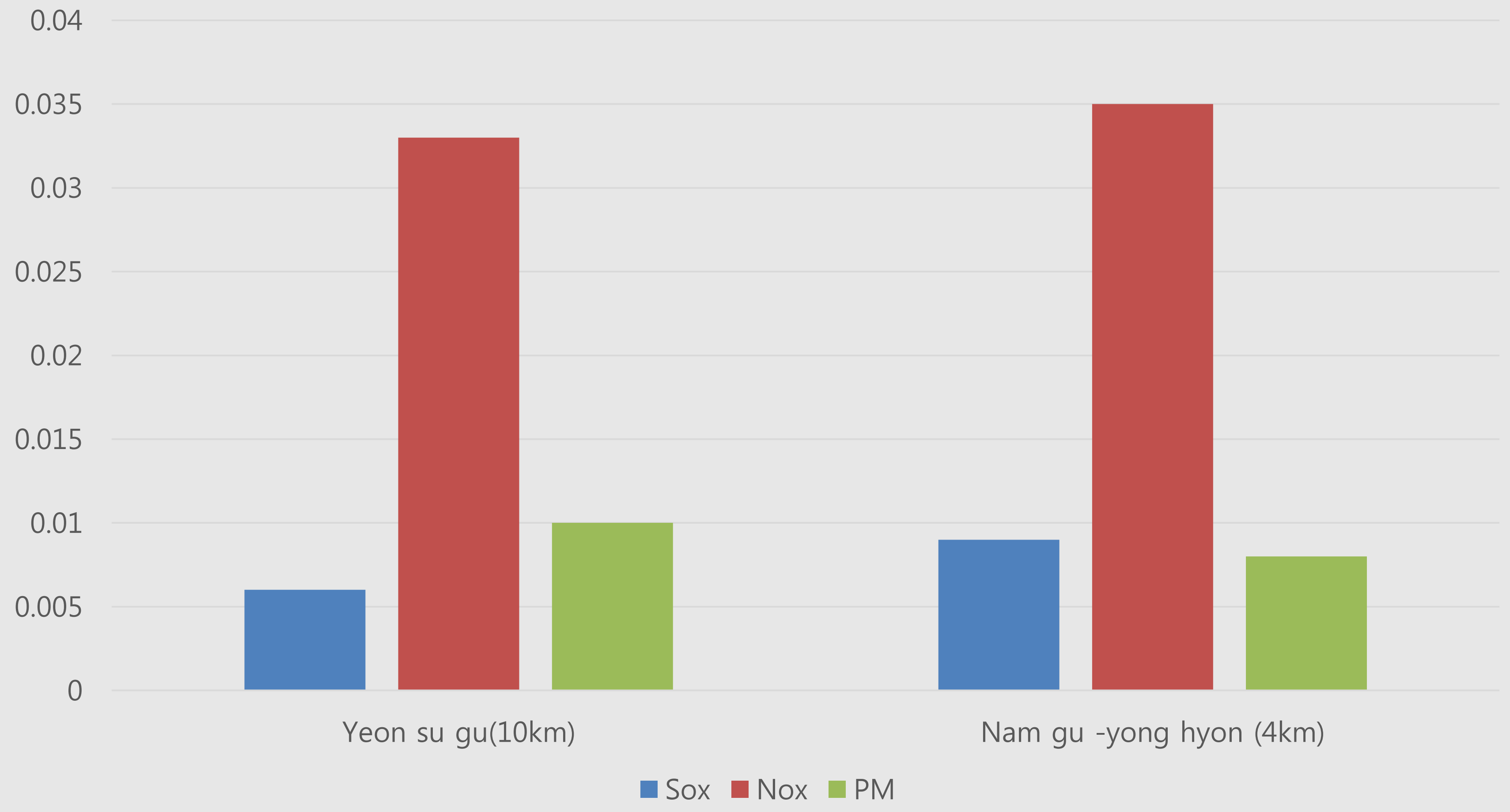
PM			
	Male	Female	Total
Yeon an	1669	1173	2842
Sin hung	376	290	665
Yong hyeon	2807	2124	4930
Dong chun	3562	2914	6476
Hak ik	3460	2781	6241
Yeon su	3257	2459	5716
Ok ryeon	2853	2305	5158
Chung hak	1924	1468	3391

Impact of PM

Pope and Dockery

Table 3. Comparison of estimated excess risk of mortality estimates for different time scales of exposure.

Study	Primary Sources	Time Scale of Exposure	% Change in Risk of Mortality Associated with an Increment of 10 $\mu g/m^3$ $PM_{2.5}$ or 20 $\mu g/m^3$ PM_{10} or BS: All Cause	Cardiovascular/ cardiopulmonary	Respiratory	Lung Cancer
Daily time series	Table 1	1–3 days	0.4–1.4	0.6–1.1	0.6–1.4	–
10 U.S. cities, time series, extended distributed lag	Schwartz 2000[213]	1 day	1.3	–	–	–
		2 days	2.1	–	–	–
		5 days	2.6	–	–	–
10 European cities, time series, extended distributed lag	Zanobetti et al. 2002[215]	2 days	1.4	–	–	–
		40 days	3.3	–	–	–
10 European cities, time series, extended distributed lag	Zanobetti et al. 2003[216]	2 days	–	1.4	1.5	–
		20 days	–	2.7	3.4	–
		30 days	–	3.5	5.3	–
		40 days	–	4.0	8.6	–
Dublin daily time series, extended distributed lag	Goodman et al. 2004[217]	1 day	0.8	0.8	1.8	–
		40 days	2.2	2.2	7.2	–
Dublin intervention	Clancy et al. 2002[203]	months to year	3.2	5.7	8.7	–
Utah Valley, time series and intervention	Pope et al. 1992[20]	5 days	3.1	3.6	7.5	–
		13 months	4.3	–	–	–
Harvard Six Cities, extended analysis	Laden et al. 2006[184]	1–8 yr	14	–	–	–
Prospective cohort studies	Dockery et al. 1993[26] Pope et al. 2002[179]	10+ yr	6–17	9–28	–	14–44


0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Yeon su gu(10km)
Nam gu -yong hyon (4km)
Sox
Nox
PM