Managing Air Quality to Benefit Health & Climate in India

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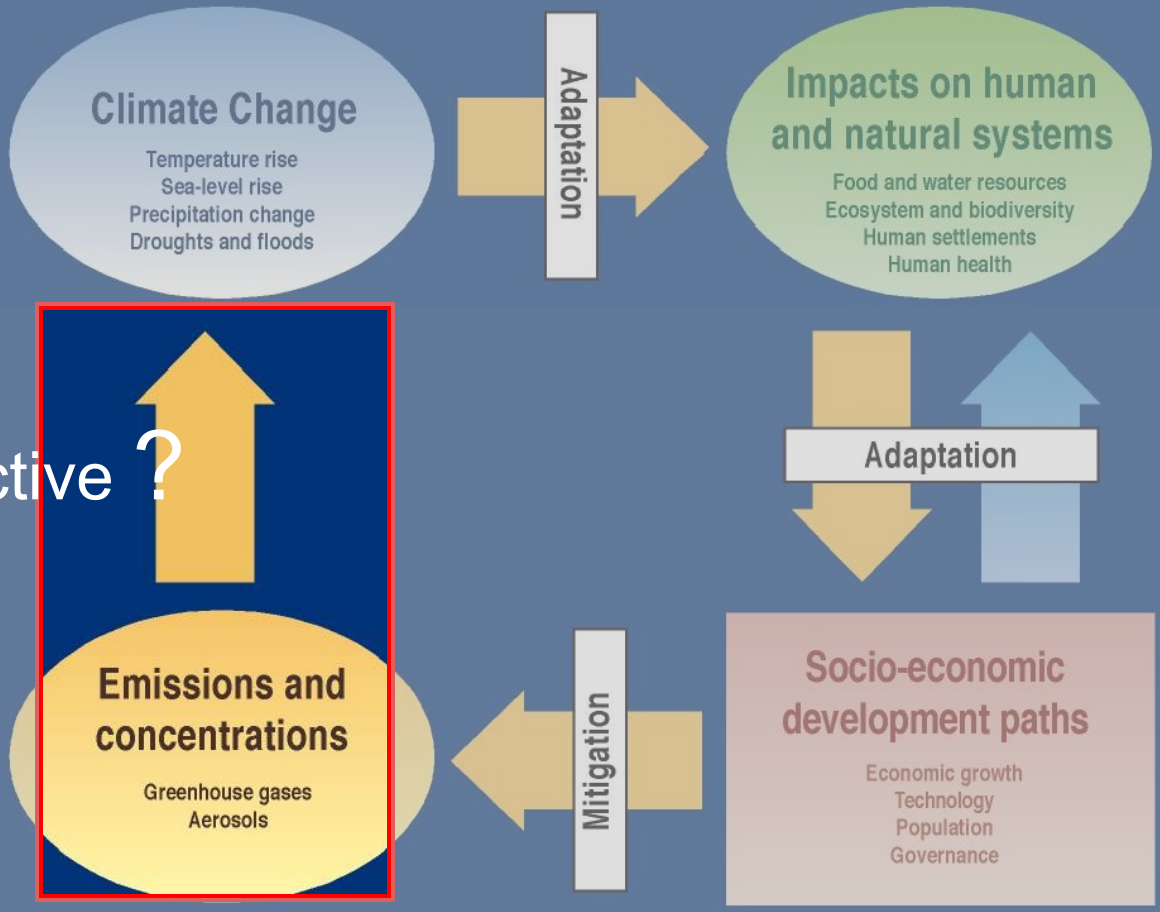
Clean Air task Force, Asia Society, & SAIS (Washington DC)
March 30th, 2011

Today's Outline

- Air quality basics
- Why focus on AQM?
- Informed AQM for climate co-benefits
- What do we know?
- What's next?

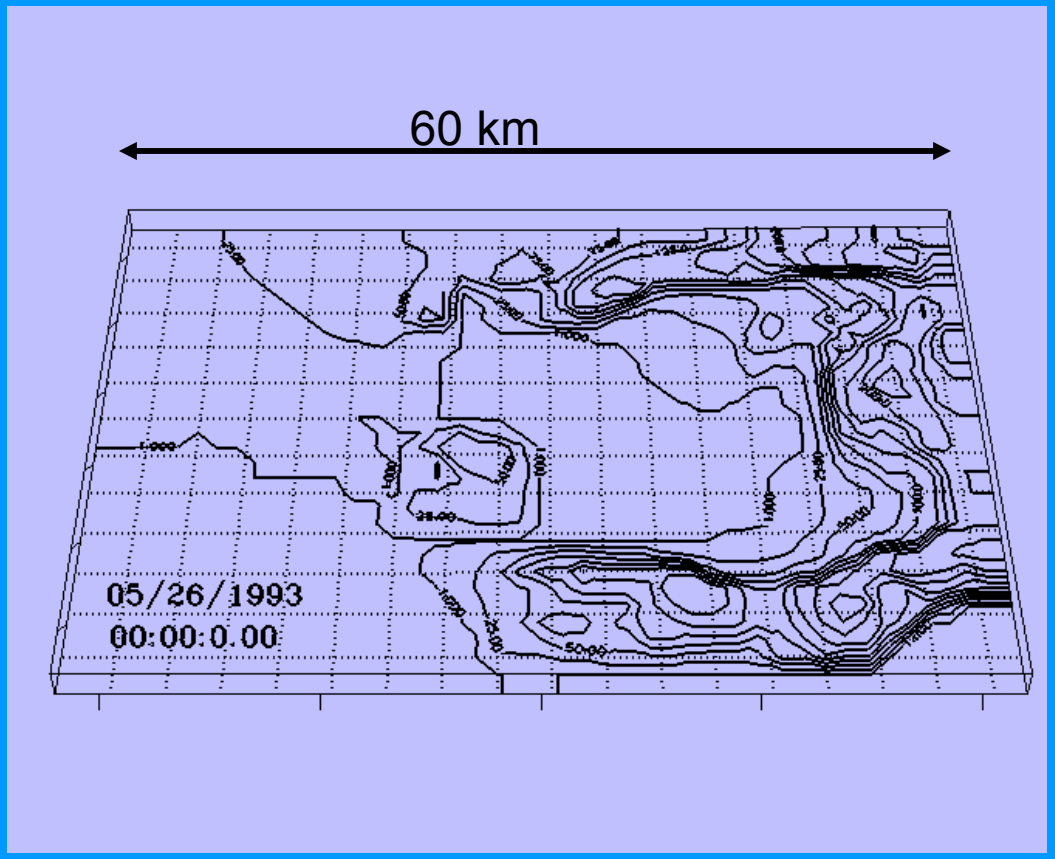
Climate Change - an integrated framework



Local perspective ?

SYR FIGURE 1-1

% Emissions ≠ % Ambient Pollution



A simulation of sulfur dioxide emissions from power plant stacks

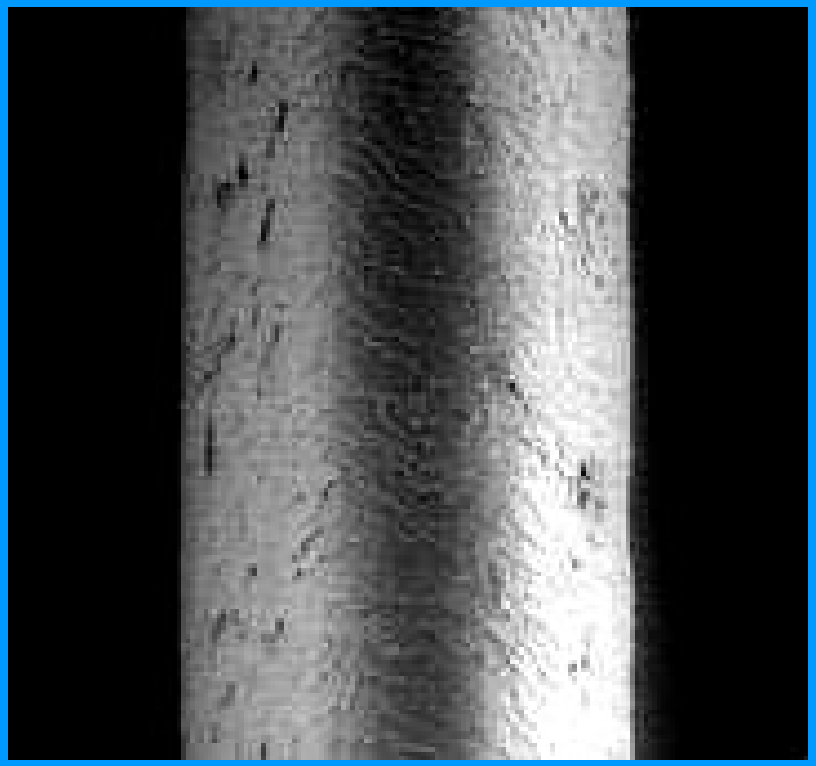
Air Pollution & Impacts

- Particulate matter
- Sulfur dioxide
- Nitrogen oxides
- Hydrocarbons
- Ozone

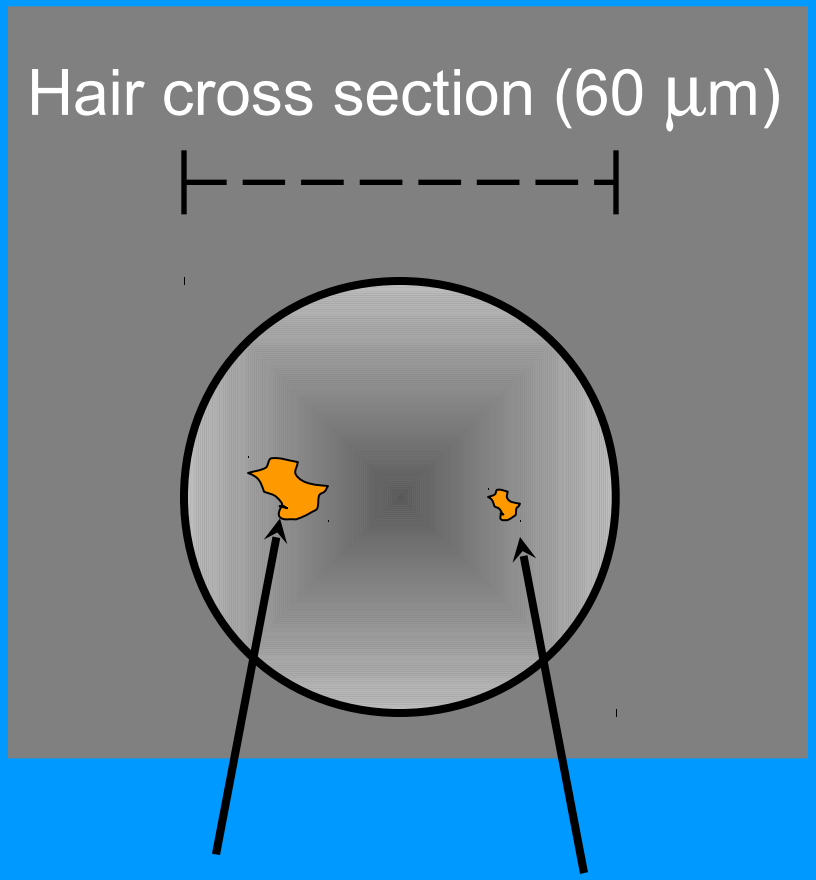
- **Carbon Dioxide**
- **Other GHGs**

- Respiratory infections
- Asthma
- Emphysema
- Heart attacks
- **Premature death**
- **Visibility**
- **Corrosion**
- **Acid rain**

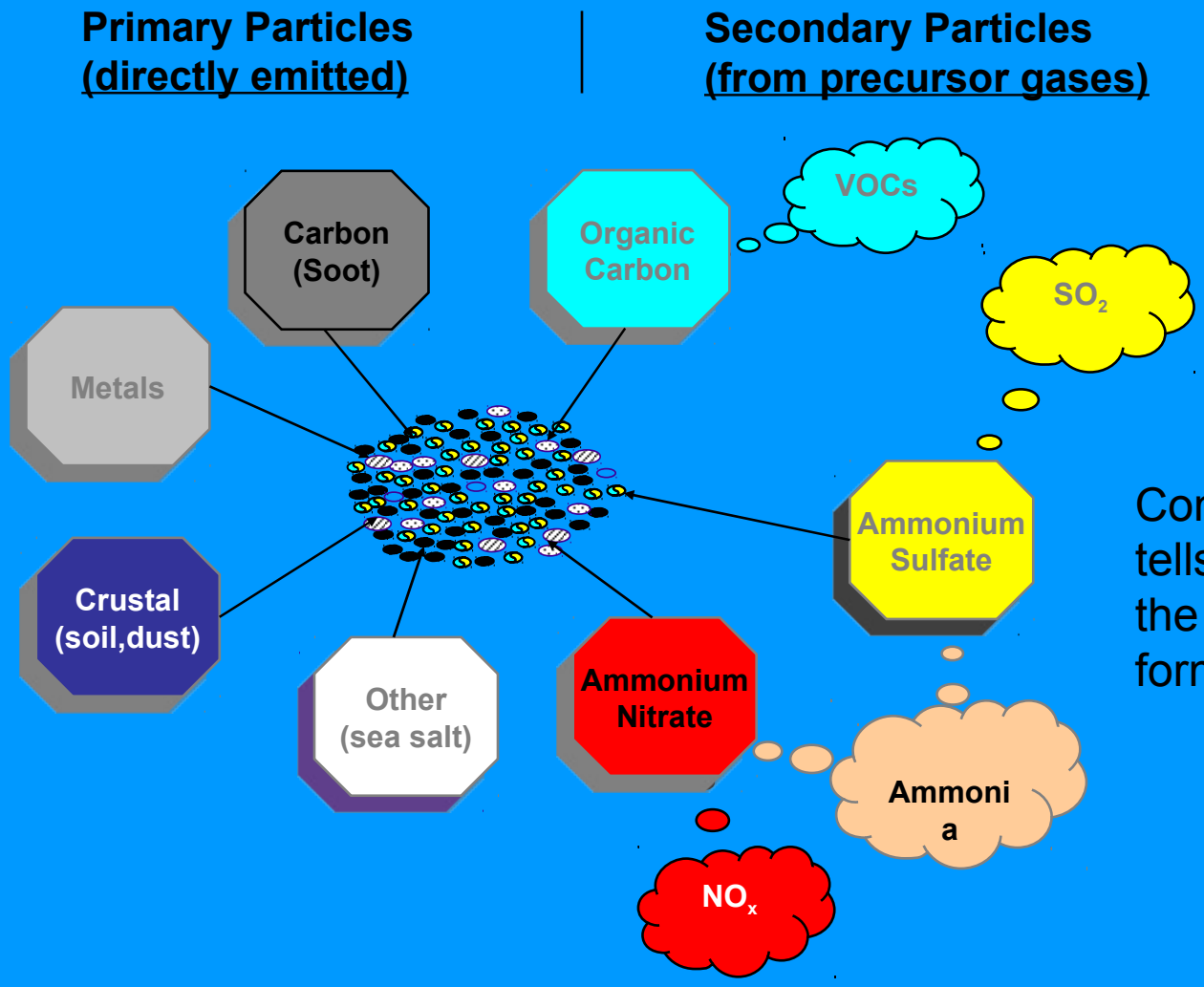
Particulate Matter



Human Hair



PM Chemical Composition



Composition of PM tells us about the sources and formation processes

Dr. Judy Chow, DRI

Most polluted cities

1. Delhi, India
1. Beijing, China
3. Santiago, Chile
4. Mexico City, Mexico
5. Ulaanbaatar, Mongolia
6. Cairo, Egypt
7. Chongqing, China
8. Guanzhou, China
9. Hong Kong, Hong Kong
10. Kabul, Afghanistan

Daily Finance, November, 2010

Capital has more toxic particles in its air than other major Indian metros

DELHI IS INDIA'S ASTHMA CAPITAL

DELHI has the highest levels of Respirable Suspended Particulate Matter (RSPM) among the four metros, exposing its residents to a greater risk of asthma than people elsewhere in the country.

Acceptable levels of RSPM should not be more than 60 microgram (mg) per cubic meter (cu m) annually. In 2008, Delhi's RSPM was recorded at a shocking 149 mg/cu m, according to a report published by the Central Pollution Control Board (CPCB) with the help of data collected between January and August 2008.

By **Meenal Dubey** in New Delhi

This is well above Mumbai's RSPM mark of 118 mg/cu m, Kolkata's 104 mg / cu m and Chennai's 54 mg/cu m.

It is no secret that India's capital is highly

Turn to Page 6

March, 2009

Smoke alarm in Delhi

Continued from page 1

polluted; what's startling is the dangerous levels to which its air has been polluted leaving children vulnerable to respiratory disorders. Experts say this danger is showing no sign of abating.

That, in short, makes Delhi India's asthma capital. The reasons for this dubious distinction are not far to see. The city, with 5.5 million vehicles, handles far more traffic than all the other metros put together. More vehicles are added each day. This is a major contributing factor to the abnormally high concentration of pollutants in the air.

RSPM is made of air-borne particles bigger than 4 to 5 microns, which get attached to the nasal membrane and are prevented from entering the lungs. However, if these particles are smaller, they do not get blocked by the nasal tract, thus entering the lungs and causing various diseases. Combustion, burning of fossil fuels, vehicular pollution and emissions from power plants are the main sources of RSPM.

Anhumita Roy Chaudhury, associate director at the Centre for Science and Environment (CSE), said, "The almost mindless addition of vehicles on the city's roads and the lack of a proper policy to counter this are adding to pollution."

'Vehicles are the main culprits for the high RSPM levels'

Construction activity also adds pollutants, but Delhi did not see significant construction activity last year to contribute to pollution. "Vehicles are the main culprit for the high RSPM levels," Roy Chaudhury said. It does not help that 18,000 trucks from other states enter Delhi everyday and add to the pollution levels.

She added, "Mumbai and Kolkata have a better public transport system. People there invest in car pools, while the bus, local train and tram systems are sound. Though the Metro has made some difference to Delhi, the city still has miles to go as far as pollution control is concerned."

The rise in the number of diesel vehicles has also dented Delhi's efforts to curb its RSPM levels.

CPCB member secretary J.S. Kamyotra said Delhi's pollution levels are monitored through two methods; manually and by continuous methods at monitoring stations located across the city. "For instance, at high-density traffic areas such as ITO, RSPM levels are measured on all 365 days using both methods. At other locations we measure these levels at least twice a week."

The question though is that for a city that pioneered CNG usage, why are RSPM levels high? A senior CPCB official said: "Delhi has only one lakh CNG vehicles. The other 5.4 million vehicles are non-CNG. Is it any surprise that the city is polluted?"

Kolkata has the highest levels of nitrogen oxide (NO)levels at 63 mg/cu metre, while in Delhi it is 43 mg/cu metre in 2008. This is a significant increase from 2007, when it was 36 mg/cu metre. Acceptable value of NO is 60 mg/cu metre. NO pollution affects the respiratory system causing bronchitis and damage to lung tissue.

The only good news in the CPCB report is that all four metros have done well to control sulphur dioxide (SO2) pollution. While the acceptable level is 60 mg/cu metre, Mumbai has 8 mg/cu metre, followed by Chennai and Kolkata at 7 mg/cu metre, while Delhi has the lowest at 4 mg/cu metre.

SO2 reacts with other chemicals in the air to form tiny sulfate particles. Coal burning, smelting, manufacture of sulphuric acid, conversion of wood pulp etc. contribute to SO2 pollution. When these particles are inhaled, they gather in the lungs and are associated with respiratory tract diseases, difficulty in breathing, and in extreme cases, premature death.

Govt says things will improve in 3 years

A senior government official said the government has given the nod to cleaner and better fuels, usage of Euro IV compliant in vehicles and also a revamp of the public transport system. "The Delhi Metro is a step in that direction," the official said. "Things will begin to improve in the next three years and the changes will be there for everyone to see."

meenal.dubey@mailtoday.in

See what you breathe

A LOOK AT THE AMOUNT OF POLLUTANTS IN THE CAPITAL'S AIR

Respirable Suspended Particulate Matter (RSPM)

City	2006	2007	2008 (Jan-Aug)
Delhi	136	159	149
Kolkata	100	99	104
Mumbai	86	92	118
Chennai	57	37	54

Sulphur Dioxide (SO_2)

City	2006	2007	2008 (Jan-Aug)
Delhi	9	4	4
Kolkata	7	8	7
Mumbai	9	11	8
Chennai	7	9	7

Nitrogen Oxide (NO)

City	2006	2007	2008 (Jan-Aug)
Delhi	43	36	43
Kolkata	53	58	63
Mumbai	29	40	34
Chennai	10	9	10

The figures are annual and should not exceed 60 microgram per cubic metre of air

MAIN CULPRITS

80,000 vehicles which enter Delhi from the National Capital Region daily. These include diesel-guzzling SUVs that emit thick smoke

18,000 trucks which enter city every day

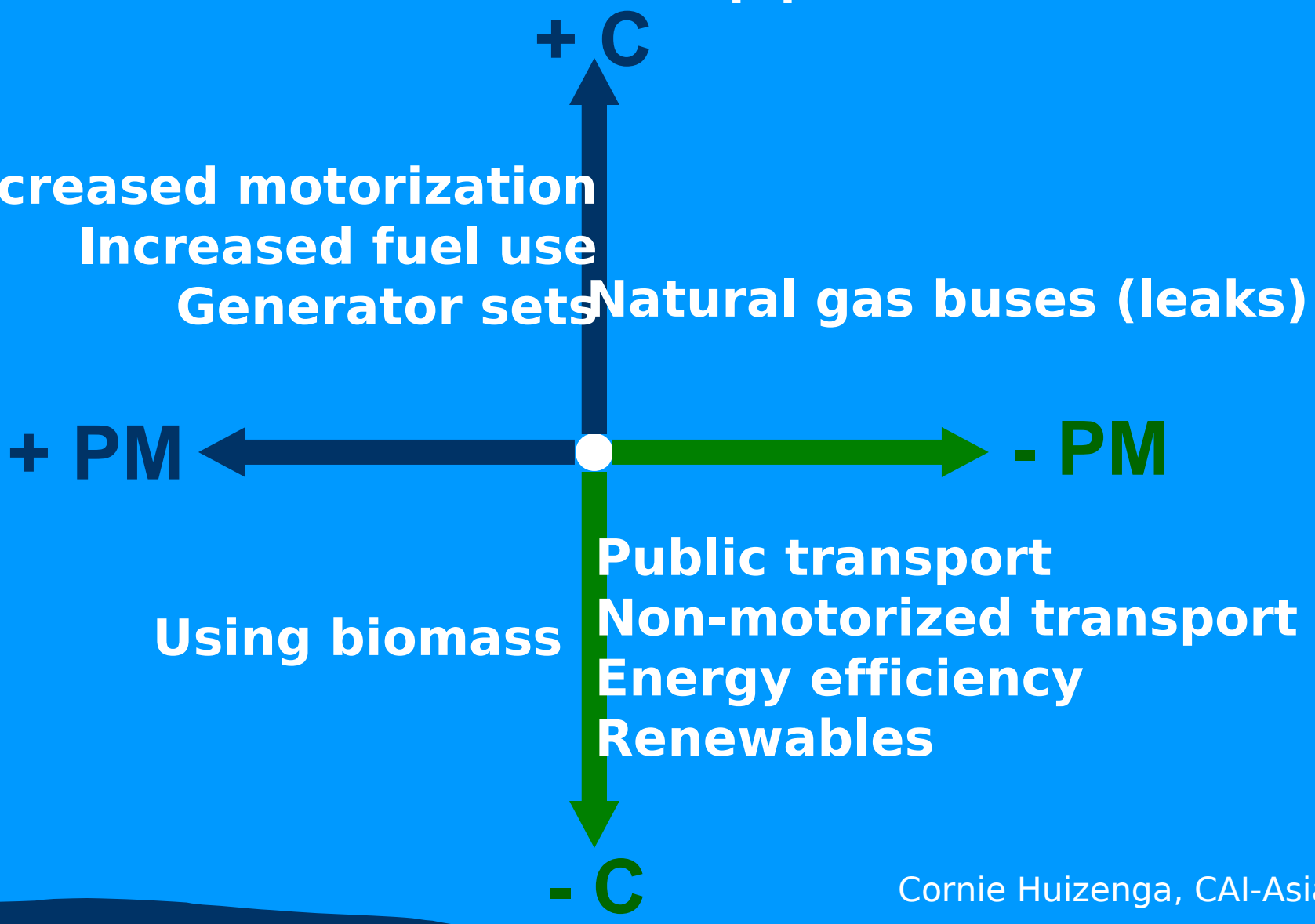
Children suffer

The Capital's polluted air is harming its children the most, with asthma cases rising among them

- The number of children with asthma has doubled over the past decade in the Capital
- Doctors blame the high levels of RSPM in the air for the attacks
- Dust and construction work squirt RSPM into the air. But those spewed by vehicles are the most harmful because of their small size
- RSPMs larger than 10 micrometres can't go past the nose or throat because of their size, but those less than one micrometre easily enter lungs
- Children are more susceptible to RSPMs than adults as they spend more time outdoors
- With their heart beating faster, children playing outdoor games tend to inhale more RSPMs

Others – WHO, HEI, PCB's

Co-benefits approach

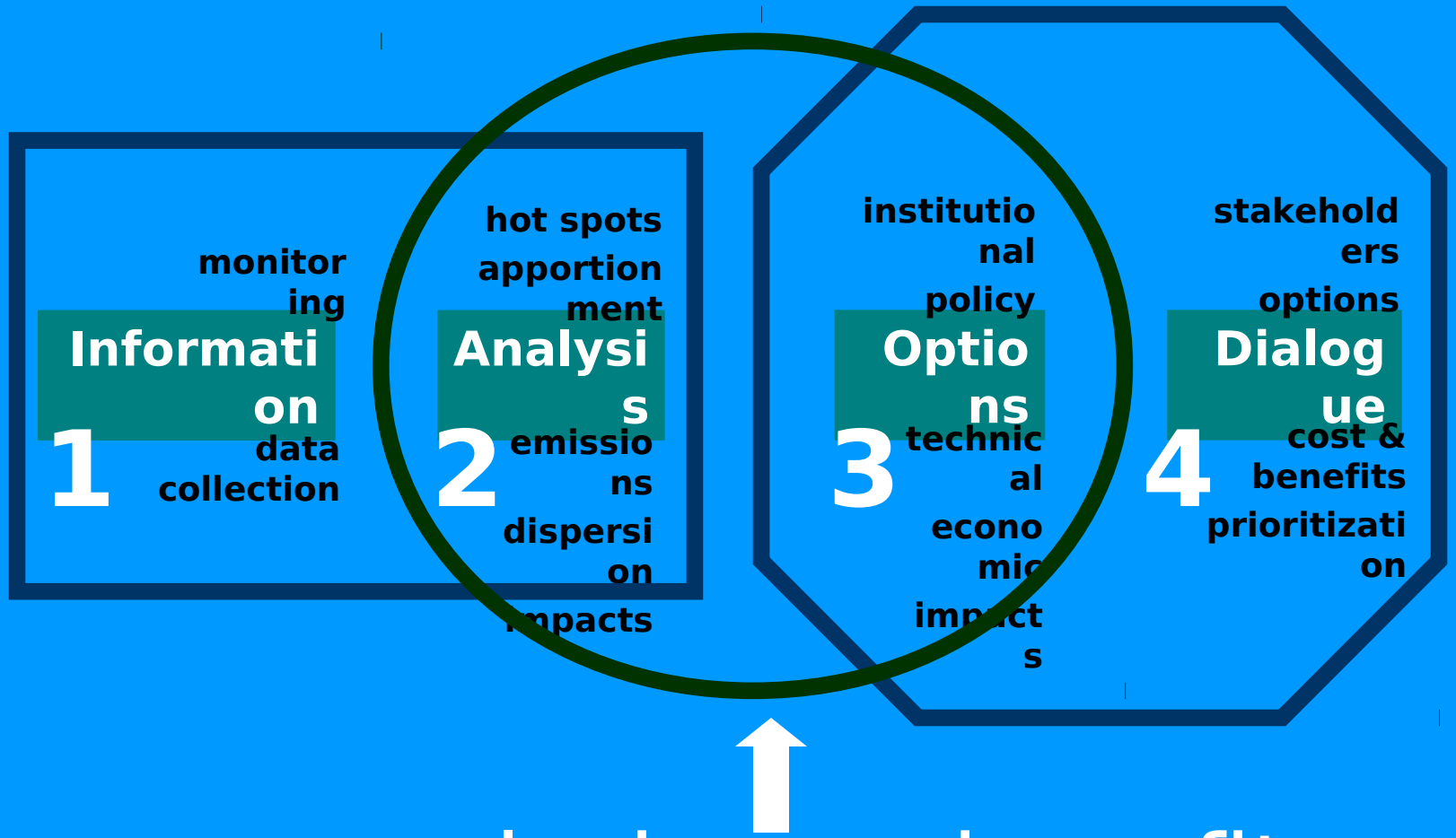


Cornie Huizenga, CAI-Asia

we know where the benefits are

question to ask:
how much are these benefits?

How are we addressing these gaps?



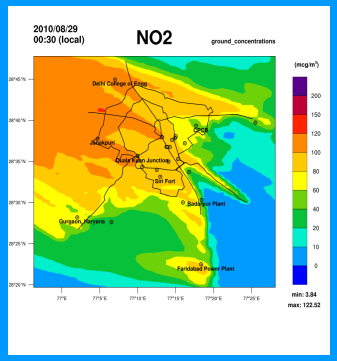
analyzing co-benefits

air quality forecasting system

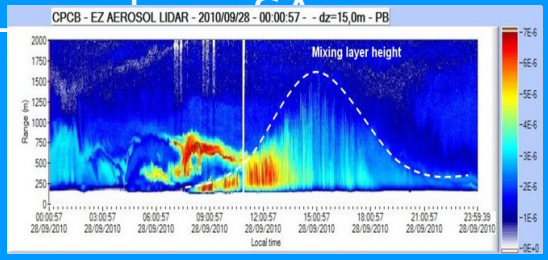
Collaborative effort during the CWG

Forecast system by Aria Technologies SA

UrbanEmissions.Info

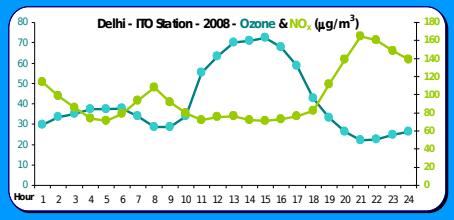


Mobile and stationary lidar measurements by



DELHI 2010
XIX COMMONWEALTH GAMES
COME OUT AND PLAY

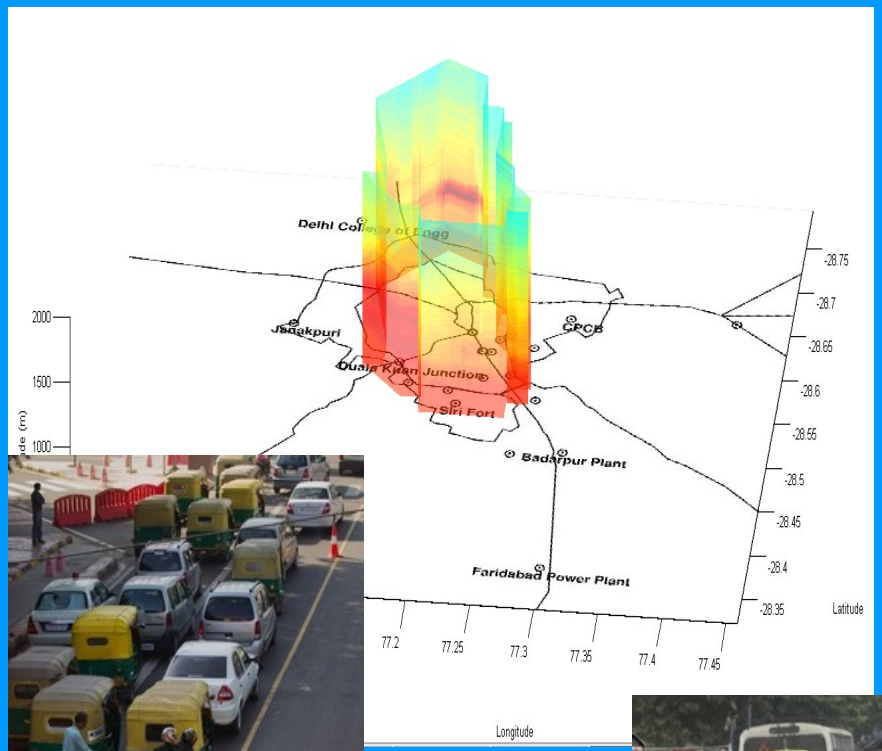
Continuous and manual measurements by CPCB



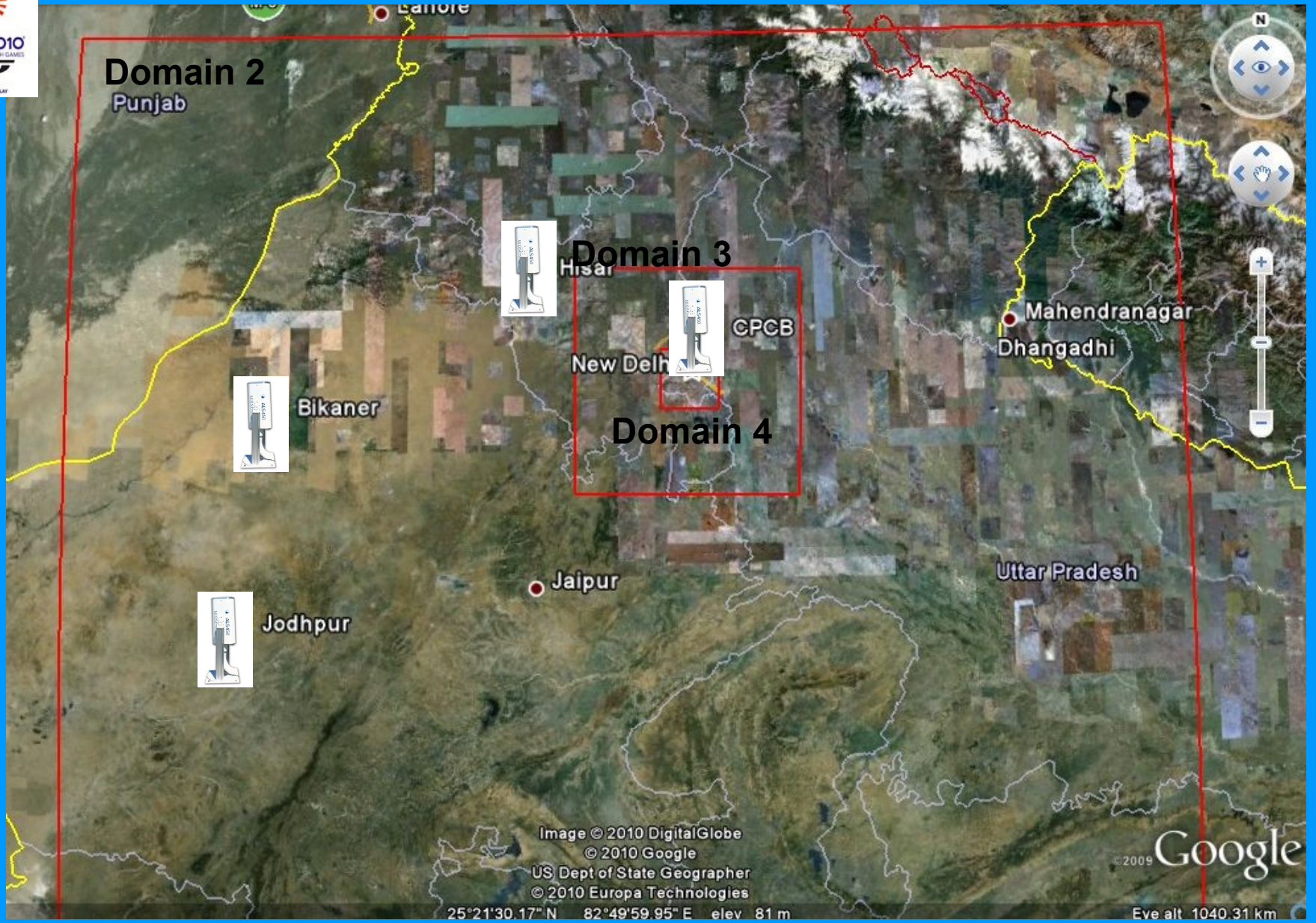
What we did during the CWG….

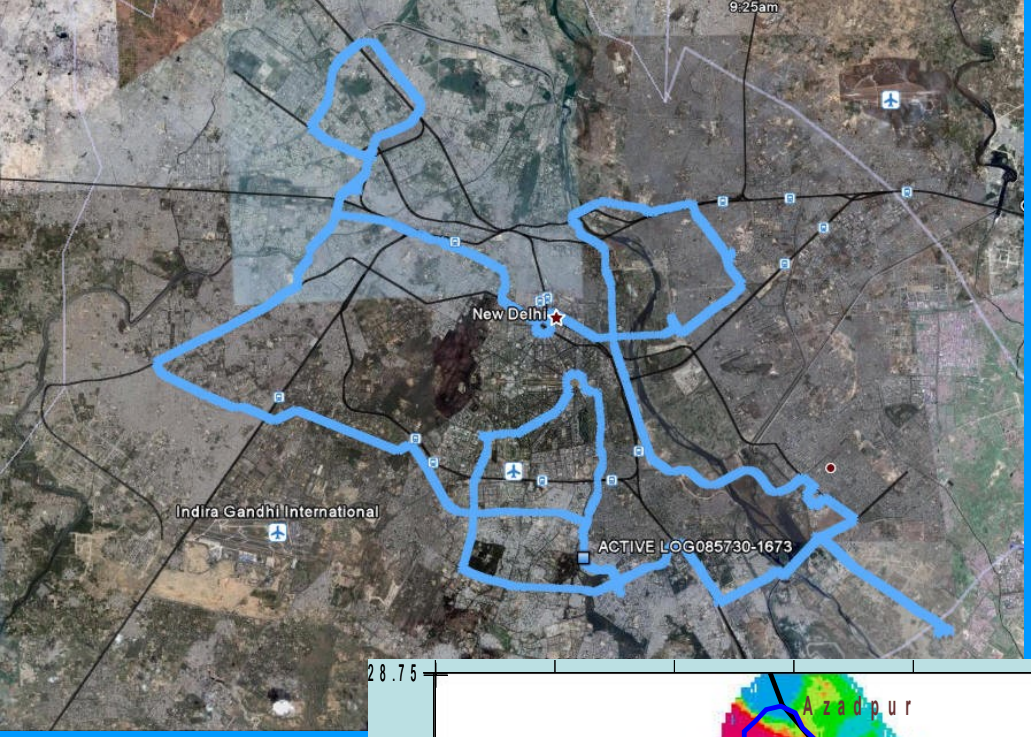
Mobile lidar monitoring provided spatial and temporal evolution of pollution

October 10th, 2010;
Circling the CWG venues



Pollution due to high congestion is reflected in the results

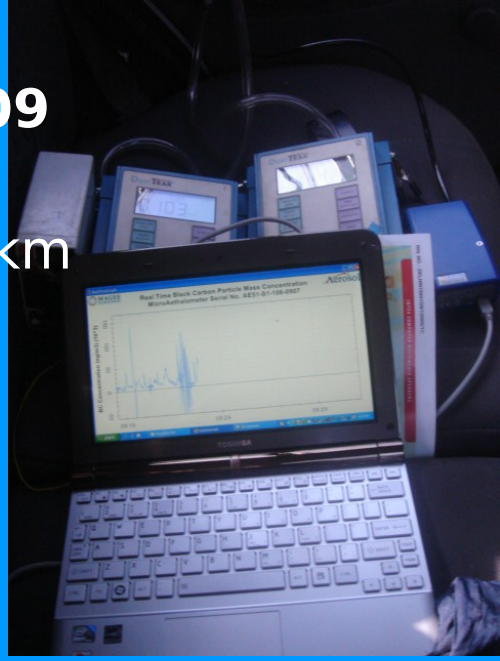

Domain 2
Punjab
Lahore
Domain 3
Hisar
CPCB
New Delhi
Domain 4
Bikaner
Jaipur
Jodhpur
Mahendranagar
Dhangadhi
Uttar Pradesh
Image © 2010 DigitalGlobe
© 2010 Google
US Dept of State Geographer
© 2010 Europa Technologies
25°21'30.17" N 82°49'59.95" E elev 81 m
Eye alt 1040.31 km
©2009 Google

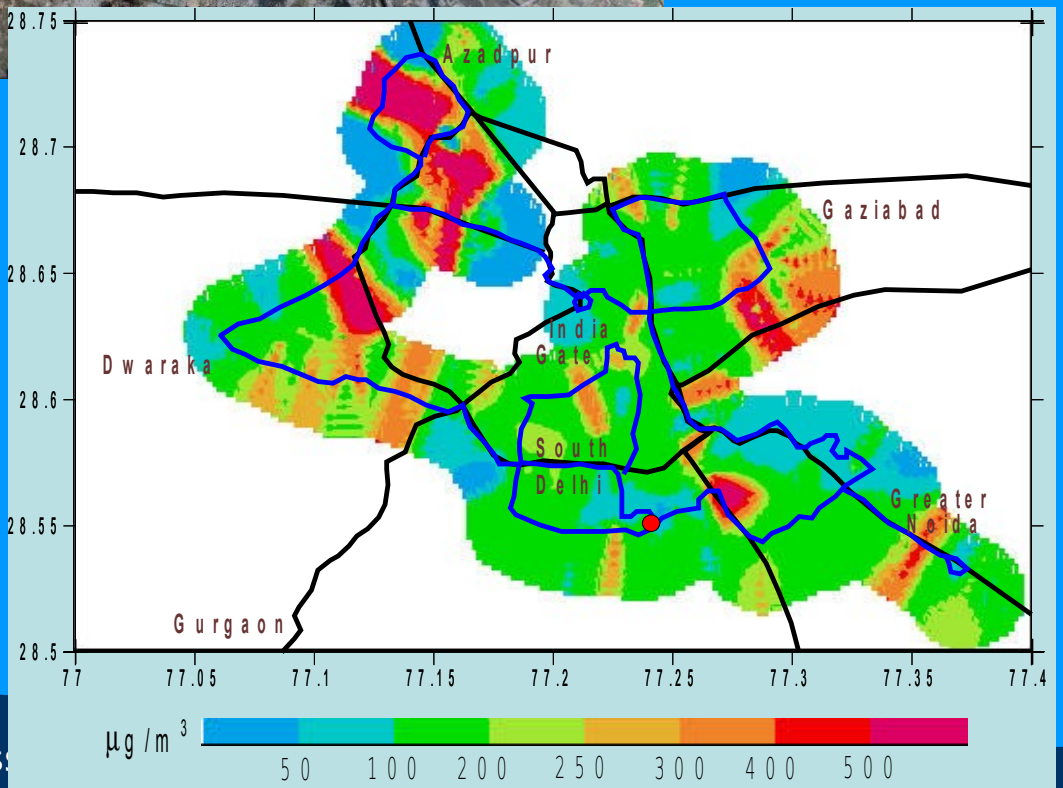


October, 2009

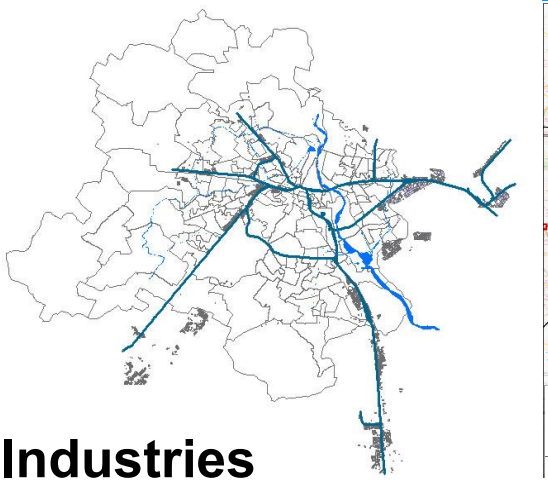
~10 hours
covering 160 km

PM_{10} $PM_{2.5}$ BC

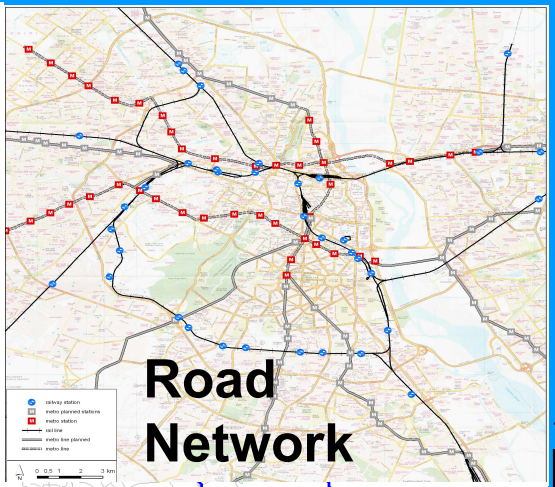


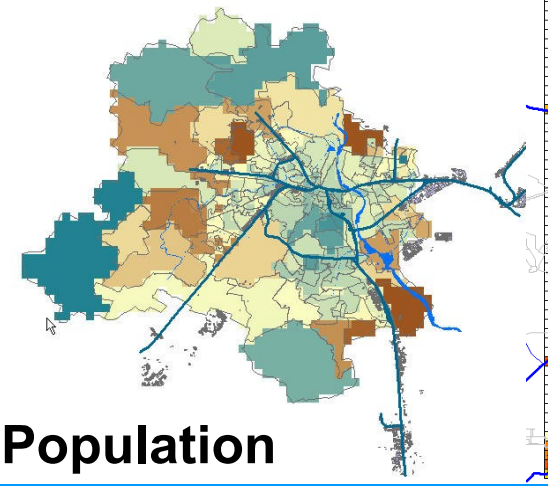


Emissions in Delhi, 2010

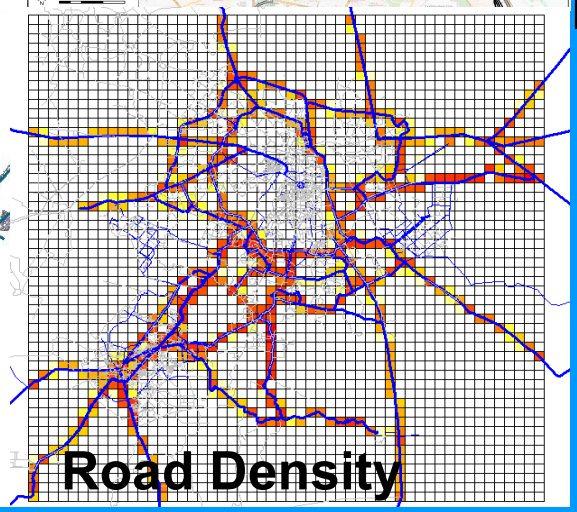


Industries

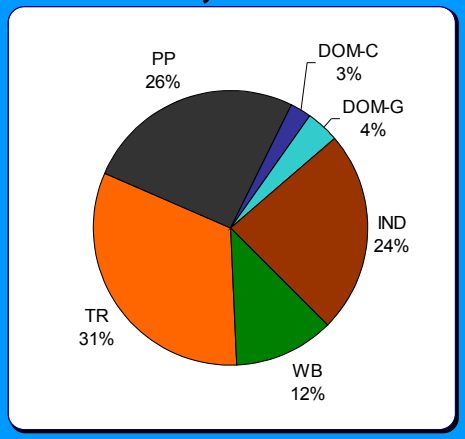




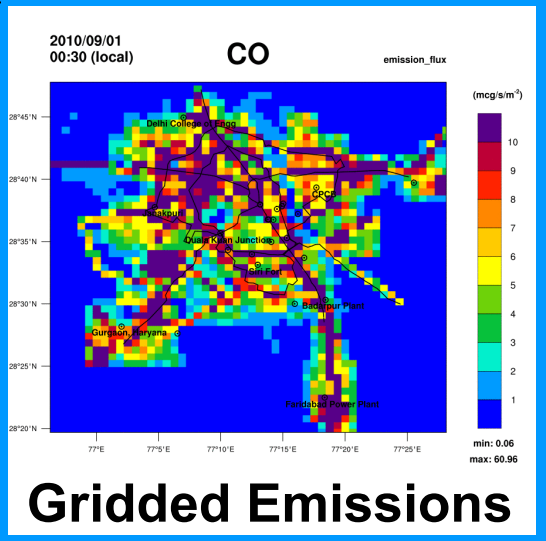
Population



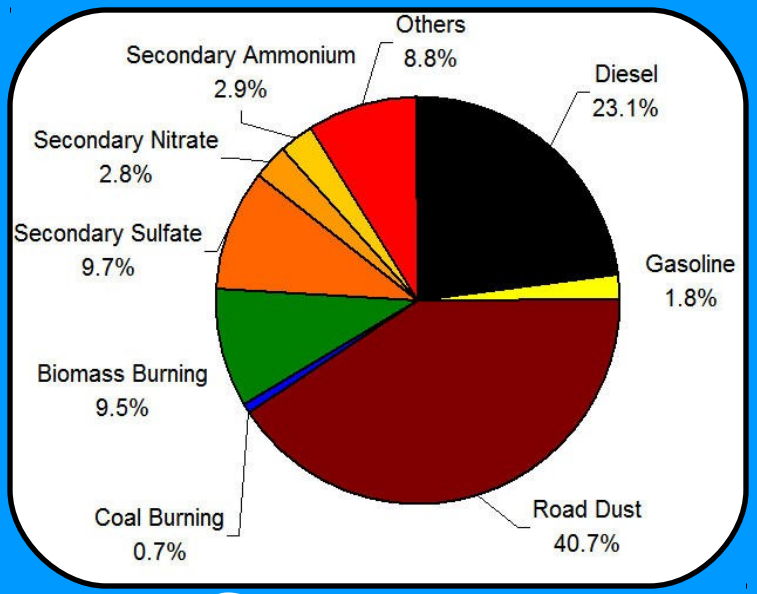
NCR, Delhi

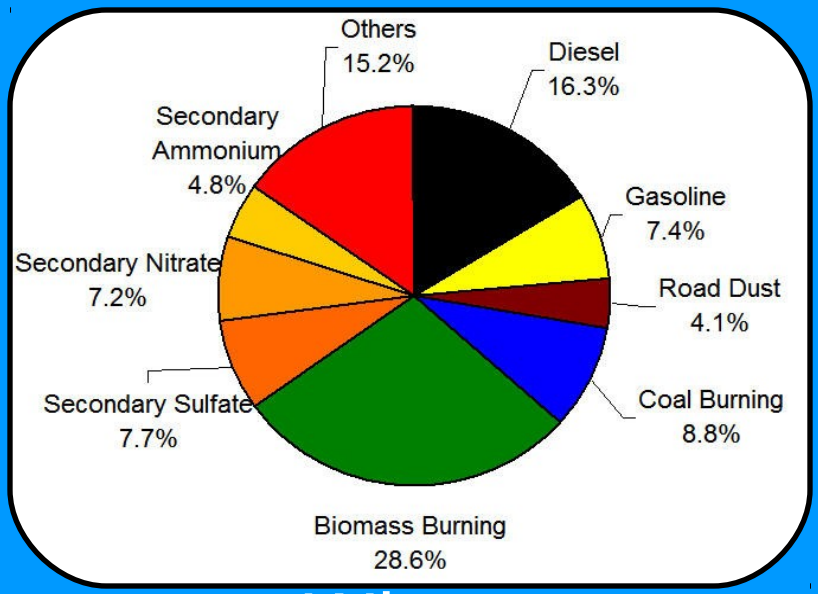


PM_{10} = 60,000 tons/yr



Receptor Modeling Results:
Average Sectoral Contributions





Summer Delhi, India Winter

Study results from PM$_{2.5}$ Molecular analysis of measured samples from 2002.

Summer concentrations 40-80 μg/m^3 daily average

Winter concentrations 90-320 μg/m^3 daily average

Details @ www.urbanemissions.info/pmsa

Dispersion Modeling

time dependent geo-referenced

emissions inventory

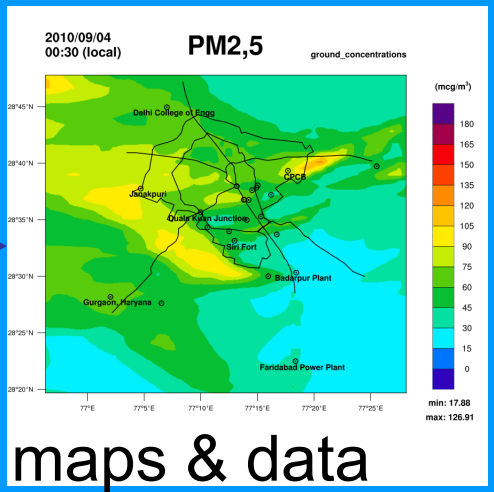
3D meteorology landuse data satellite data

Initial and boundary conditions

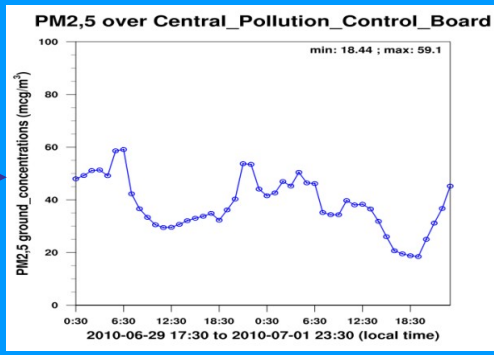
modeling

3D Chemical Transport Modeling

post processing



maps & data



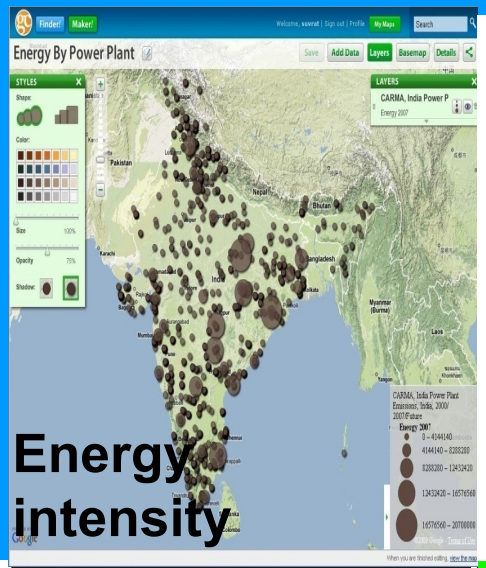
48 hr time series

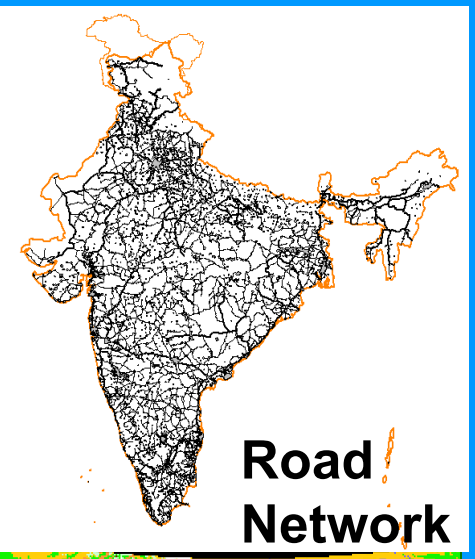
AQI Scale

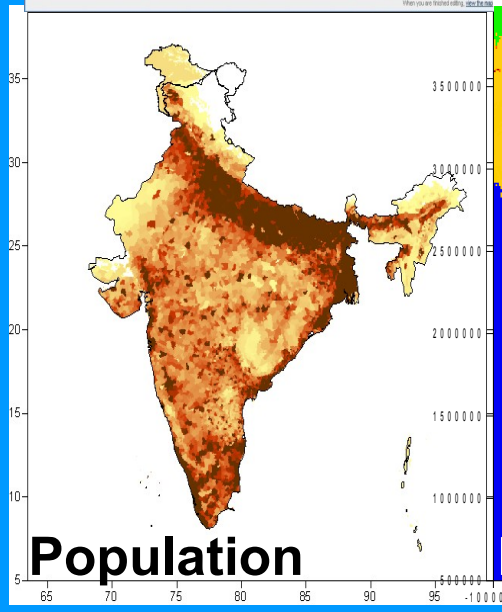
0-50	51-100	101-150	151-200	201-300	>300
Healthy	Moderate	Unhealthy (sensitive groups)	Unhealthy	Harmful	Hazardous

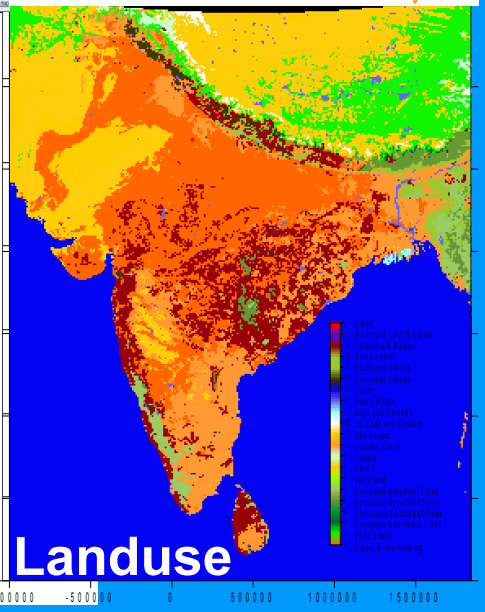
Individual, averages, worst cases, weighted averages

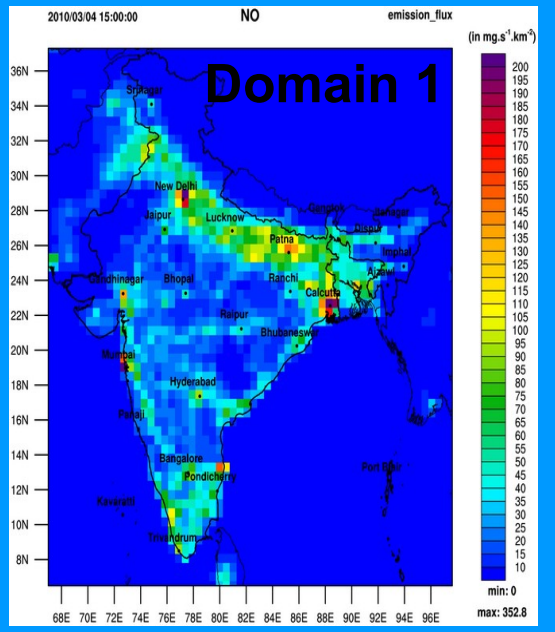
(2011) www.indiaairquality.info

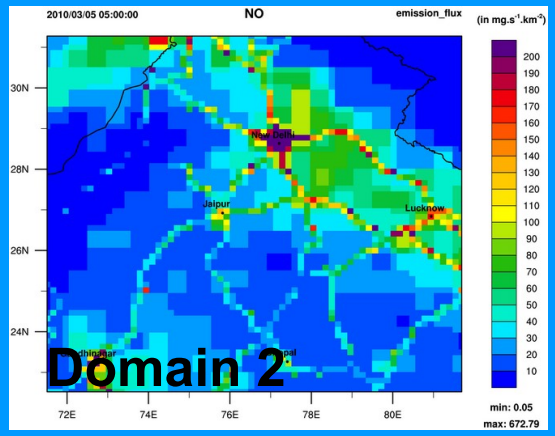






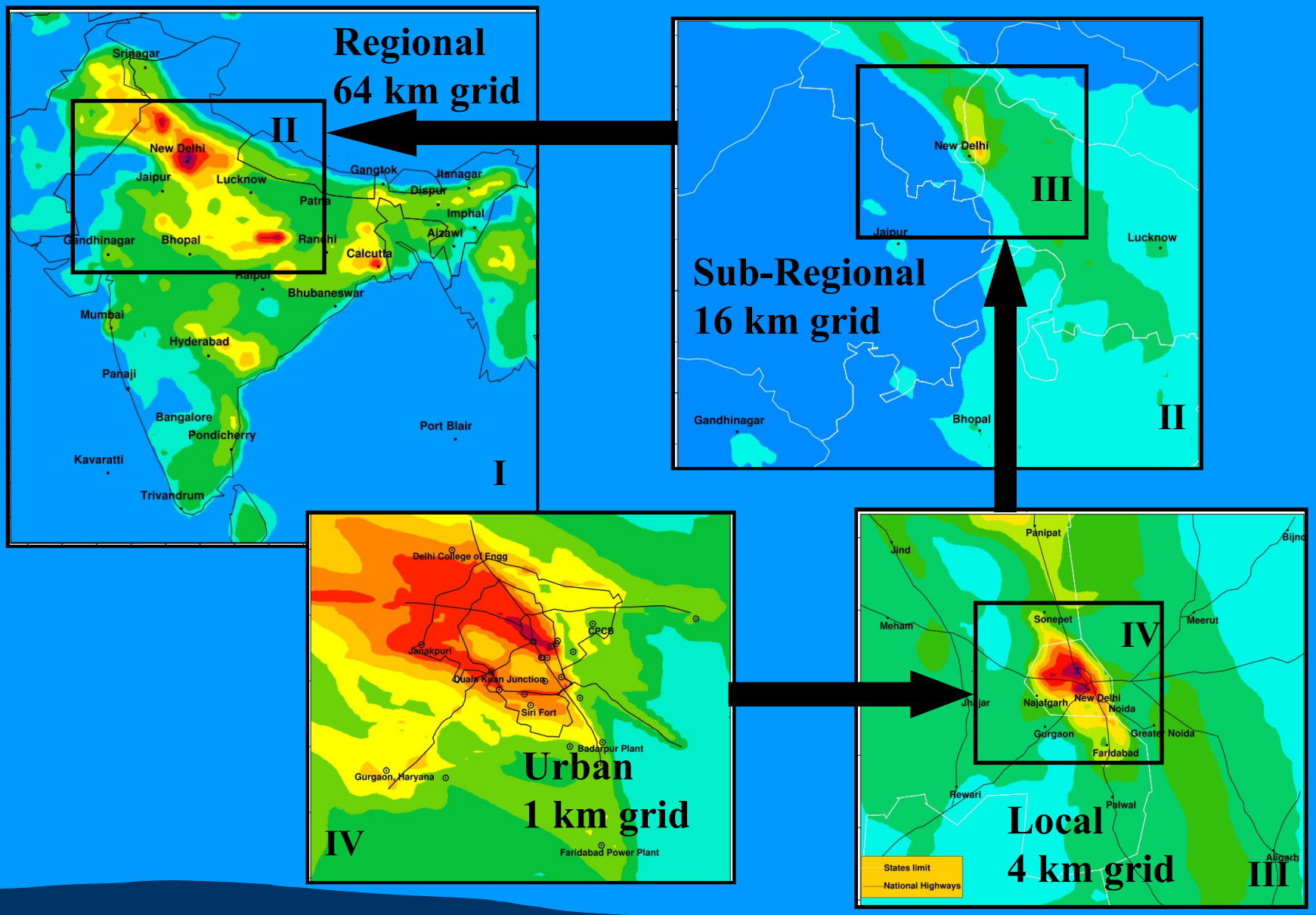






Gridded Inventory

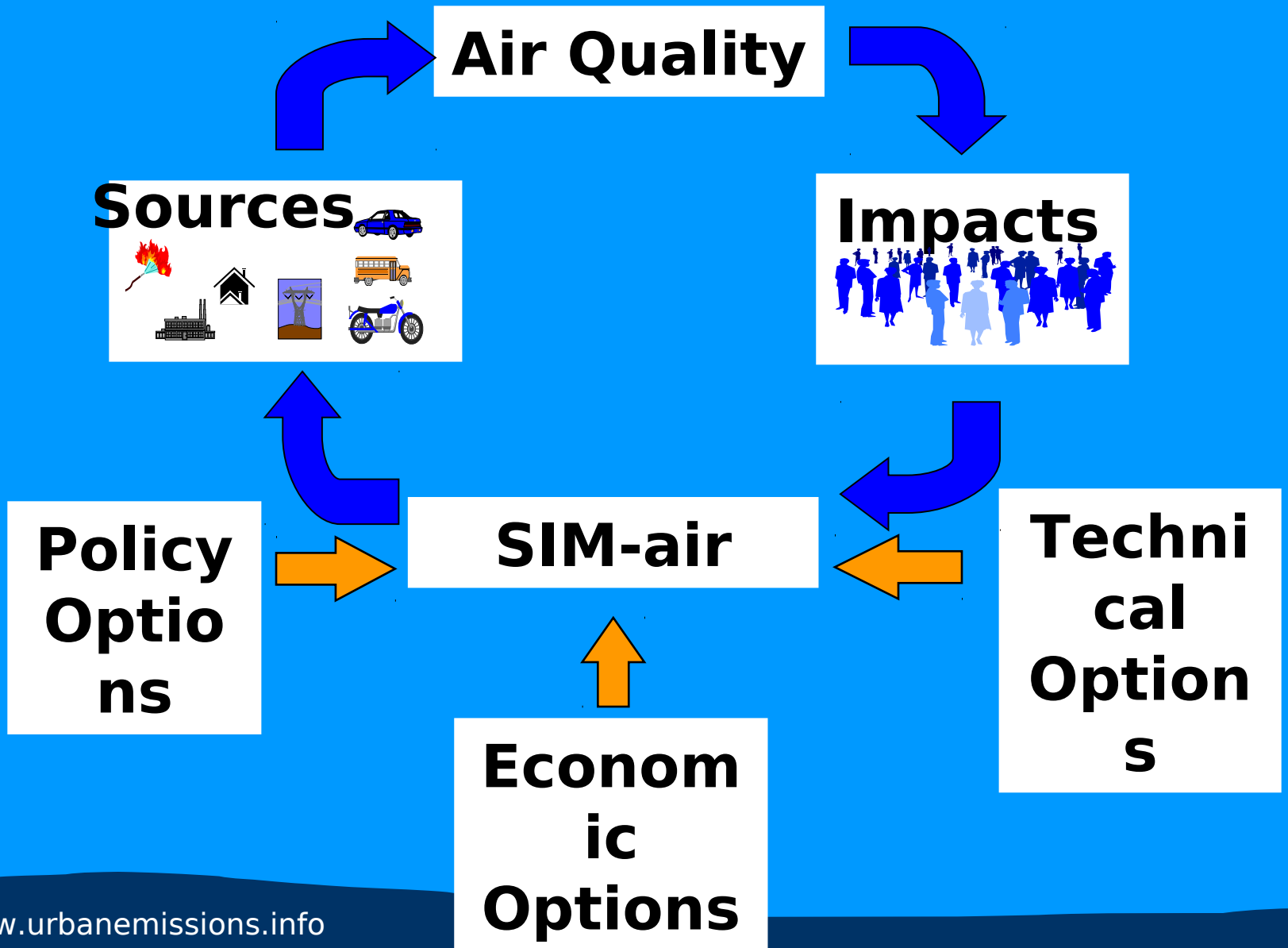
(2011) www.indiaairquality.info



city level programs

SIM-air family of tools

Simple **I**nteractive **M**odels for better **AIR** quality



SIM-air family of tools

- Free for use
- Excel based interface
- Simple, yet complex

- No cookie cutter solutions

So far..


Traffic
More...
Map
Satellite
Terrain
Ulaanbaatar
Kathmandu
Delhi
Dhaka
Pune
Shanghai
Hanoi
Ouagadougou
Hyderabad
Bangkok
Chennai
Cotonou
Lagos
Jakarta
Antananarivo
Santiago
Durban
Perth
2000 mi
2000 km
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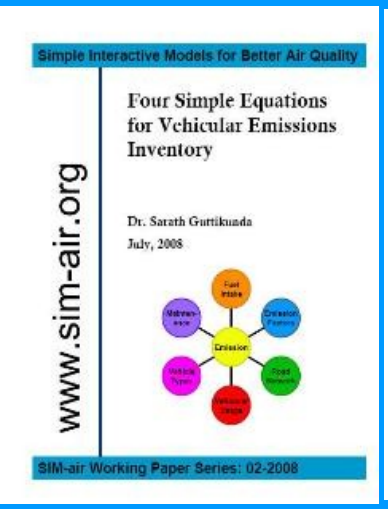
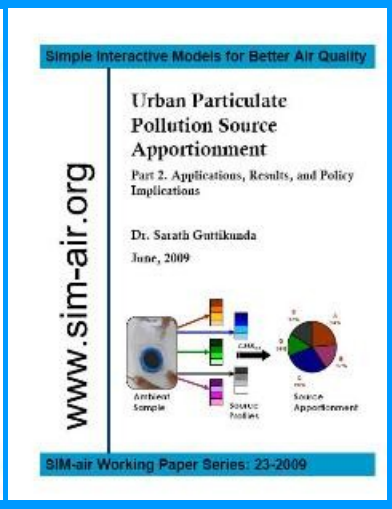
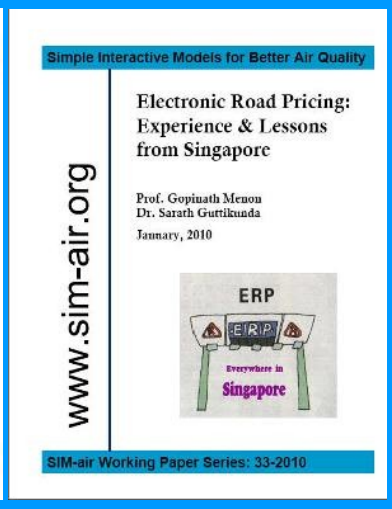
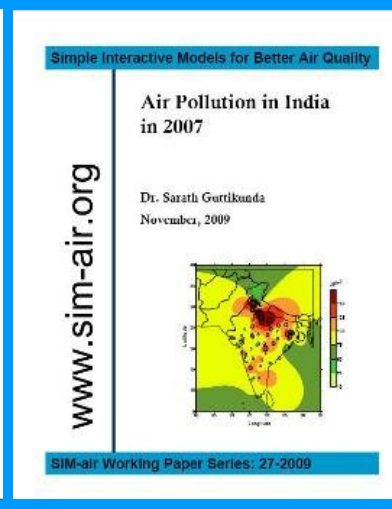
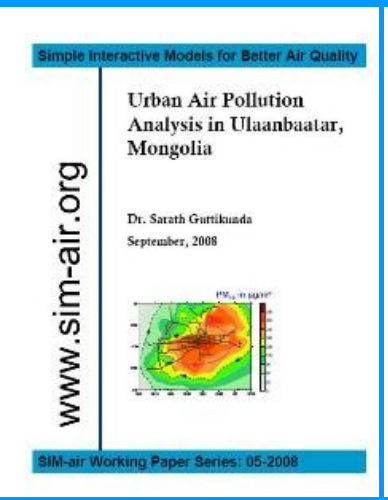
SIM-air Working Paper Series

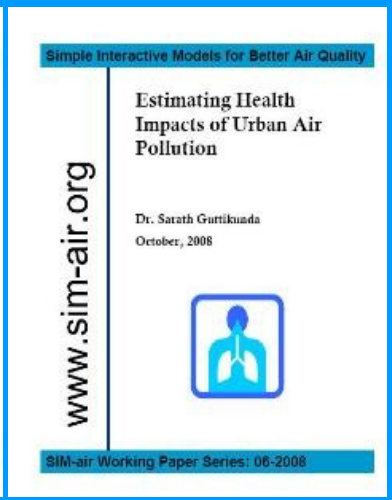


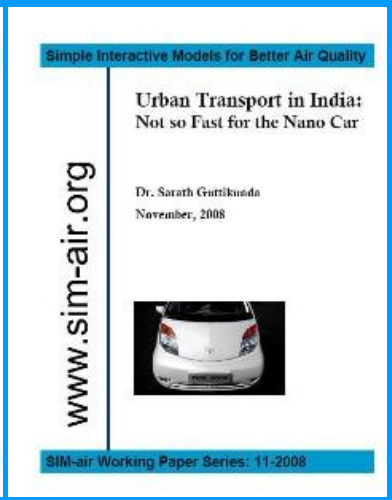


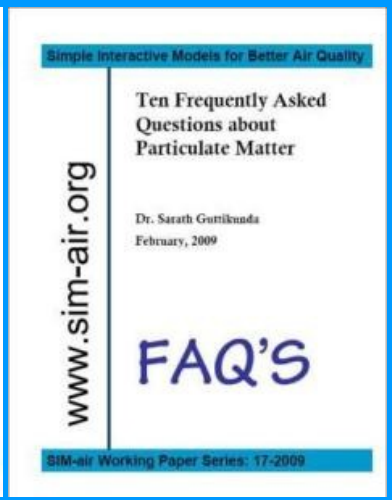


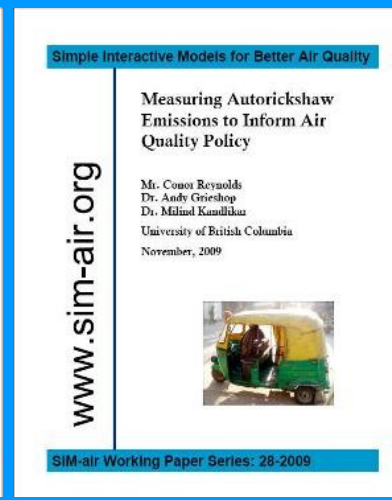








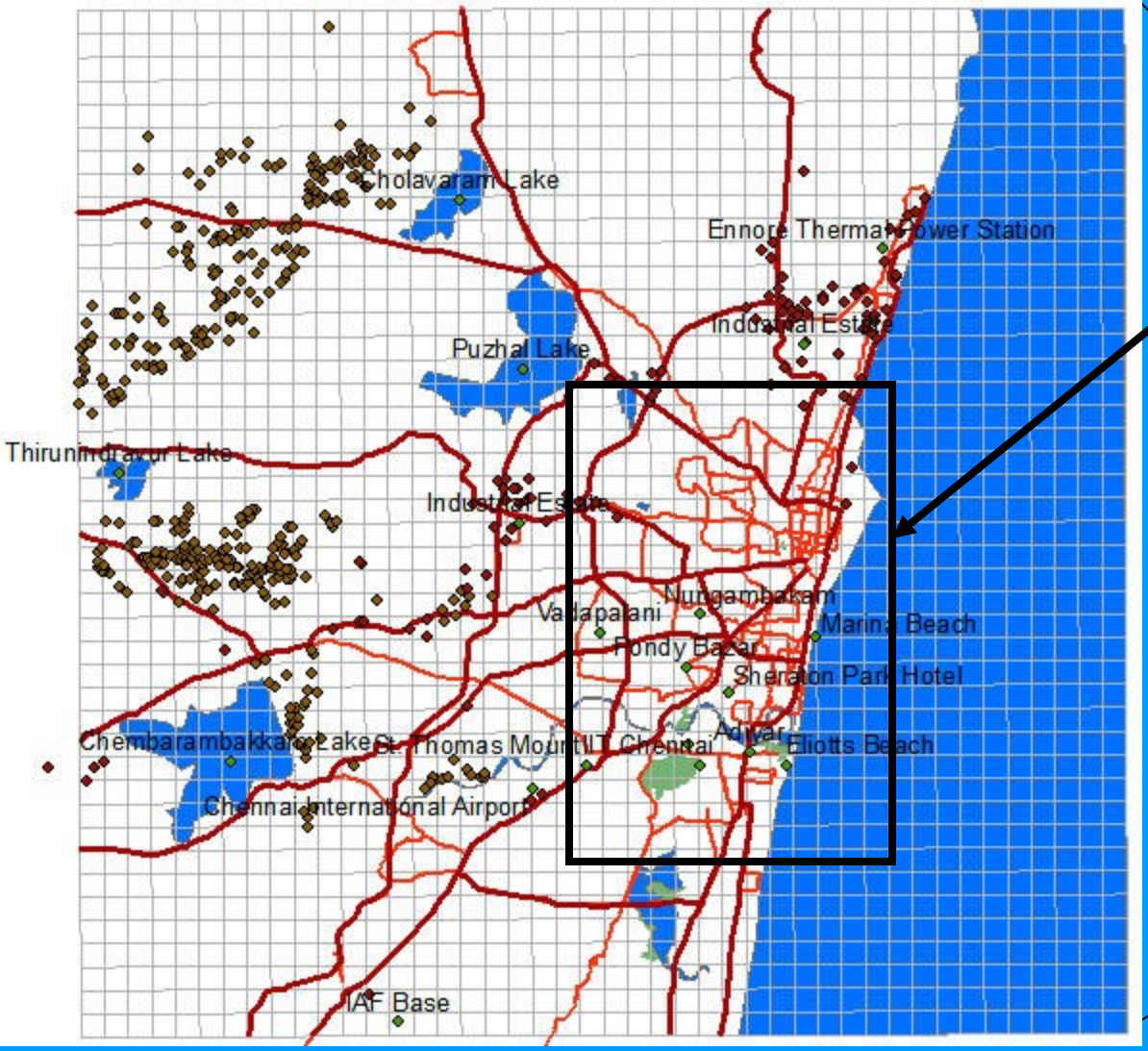




Last released No.36

Six Cities in India

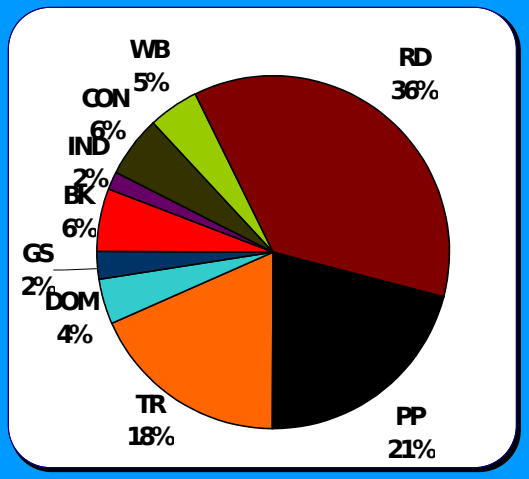
March 2011

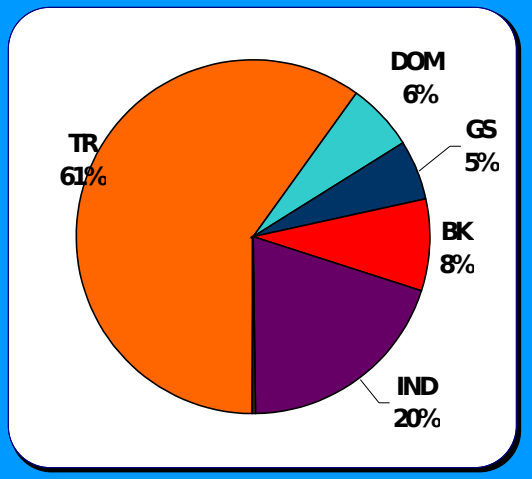


~ Chennai district border

eater Chennai Area
km x 44km @ 1km grid
ts include industries and brick kilns

Brick Kilns

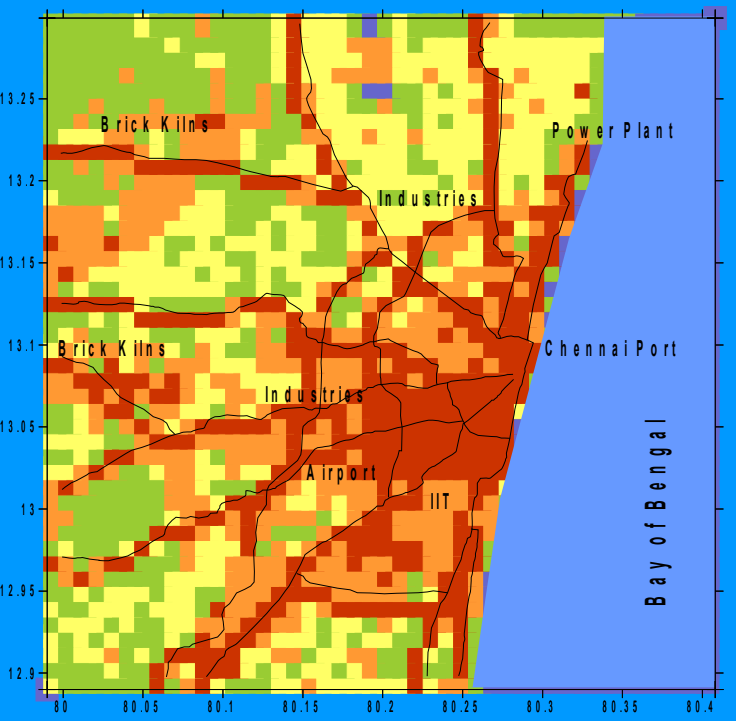


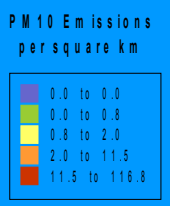


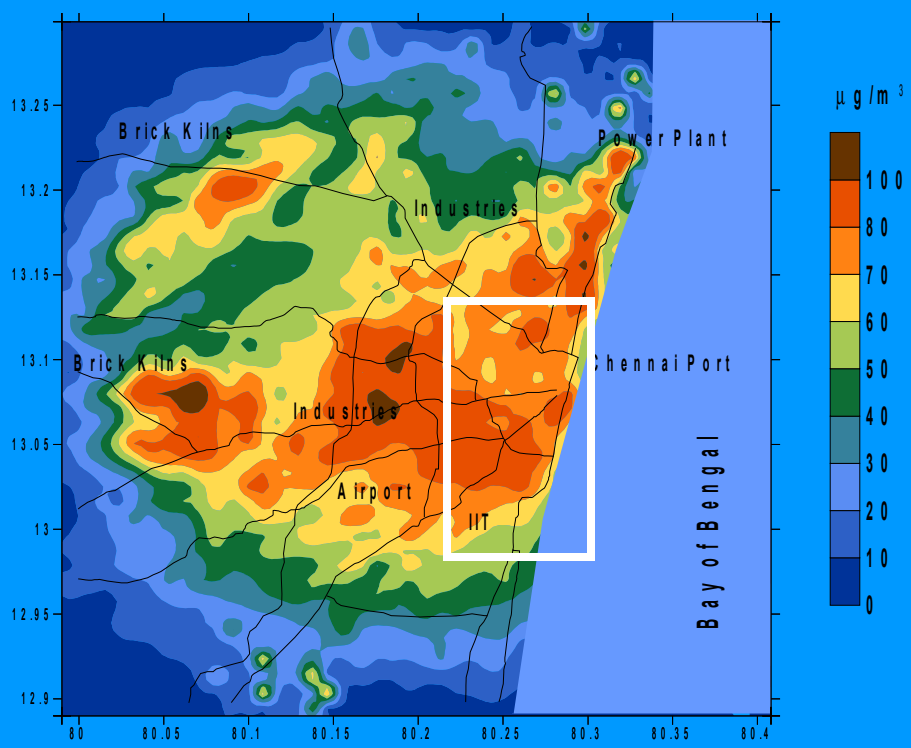
2010 - PM10
~56,000
tons/yr

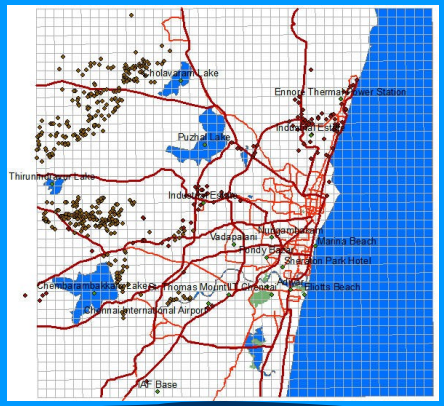
2010 - CO2
~25 mil
tons/yr

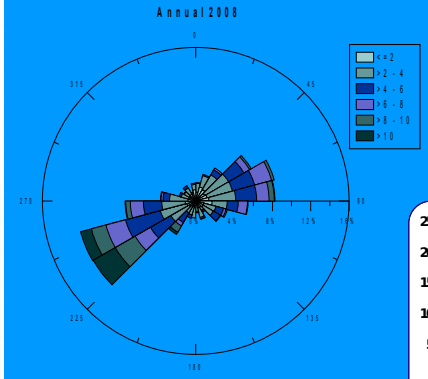
Chennai Pollution Modeling

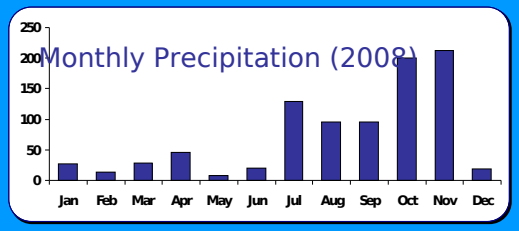


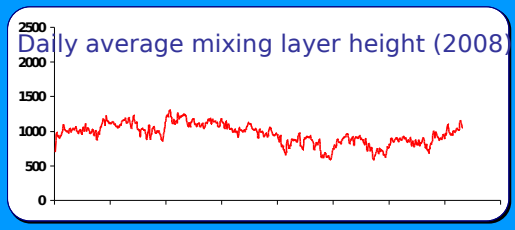






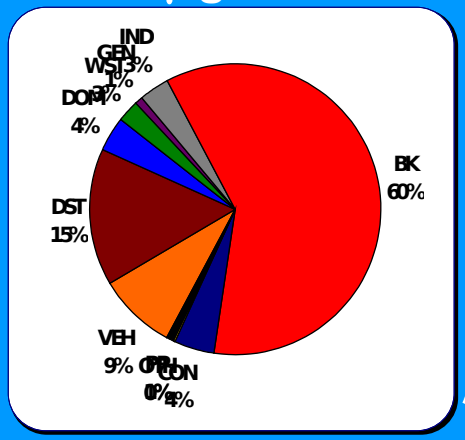




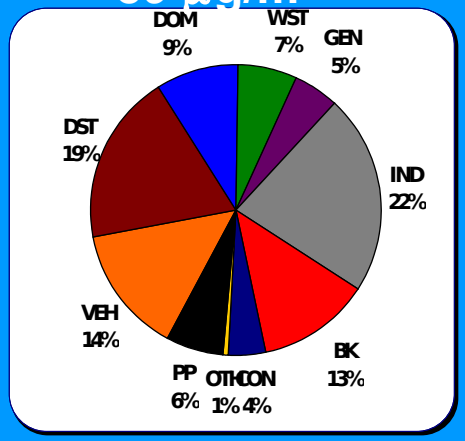


Annual Average PM10 for year 2010

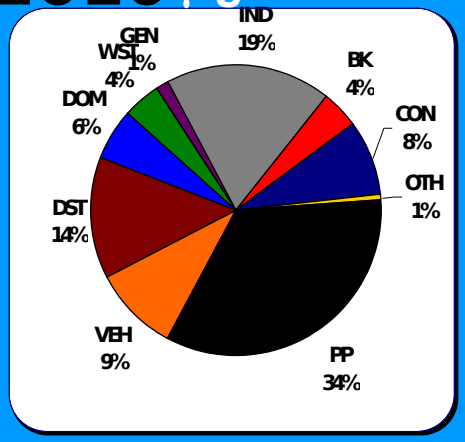
56 µg/m³

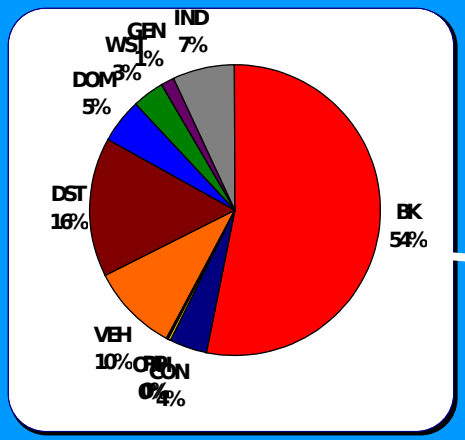


89 µg/m³

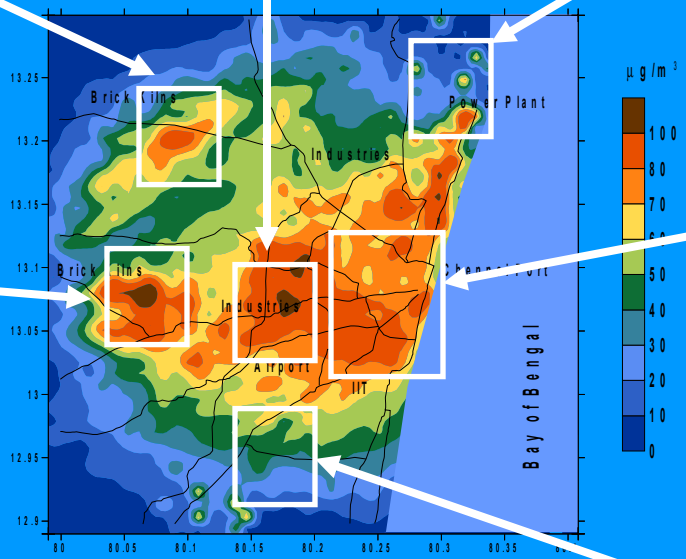


37 µg/m³

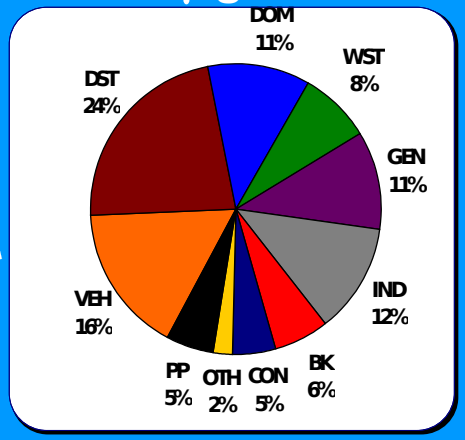




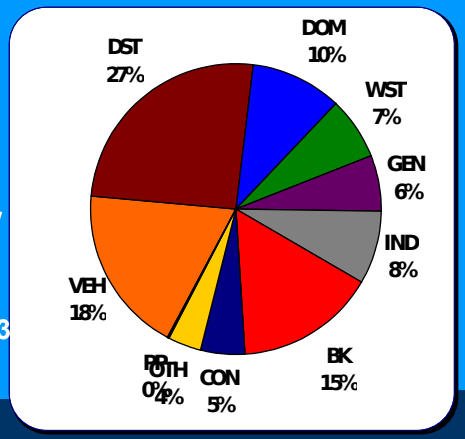
73 µg/m³



76 µg/m³



40 µg/m³



Health Impacts in 6 Cities

Table 5.2: Estimated Mortality and Morbidity due to air pollution for 2010 (numbers rounded to nearest zero)

Mortality & Morbidity	Pune	Chennai	Indore	Ahmedabad	Surat	Rajkot
Domain size (km x km)	32 x 32	44 x 44	32 x 32	44 x 44	44 x 44	24 x 24
Study Domain Population (million)	6.5	8.5	3.3	7.8	5.0	1.4
Land-Sea Breeze	NO	YES	NO	NO	YES	NO
2010 PM_{10} emissions (tons/yr)	36,600	56,400	18,100	35,100	19,900	14,000
Premature Deaths	**3,600**	**3,950**	**1,800**	**4,950**	**1,250**	**300**
Mortality per ton of PM10	0.1	0.07	0.1	0.14	0.06	0.02
Adult Chronic Bronchitis	10,800	11,800	5,400	14,800	3,750	950
Child Acute Bronchitis	79,250	86,600	39,300	108,300	27,400	6,800
Respiratory Hospital Admission	5,000	5,460	2,500	6,800	1,700	450
Cardiac Hospital Admission	1,350	1,480	670	1,850	470	120
Emergency Room Visit	97,800	106,900	48,500	133,700	33,800	8,400
Asthma Attacks (million)	1.2	1.3	0.6	1.7	0.4	0.1
Restricted Activity Days (million)	10.4	11.3	5.1	14.2	3.6	0.9
Respiratory Symptom Days (million)	49.7	54.1	24.5	67.6	17.1	4.2

Co-benefits from Chennai AQM

Table 6.xx: Estimated Co-benefits in 2020 in Chennai (Tamilnadu)

Scenarios	Mortality savings	Health benefits (USD millions)	CO2 savings (mil tons)
Non-motorized transport	260	28	2.4
Alternative Fuels	60	6	0.6
Road dust management	650	71	-
Brick Kilns efficiency	100	11	0.6
Truck movement	220	24	1.6

Co-Benefits in 6 Cities

Table 6.14: Estimated combined benefits for emissions and health from the six interventions in 2020

Mortality & Morbidity	Pune	Chennai	Indore	Ahmedabad	Surat	Rajkot
Domain size (km x km)	32 x 32	44 x 44	32 x 32	44 x 44	44 x 44	24 x 24
Study Domain Population (million)	7.6	10.5	4.3	10.3	6.2	1.9
Land-Sea Breeze	NO	YES	NO	NO	YES	NO
2020 PM_{10} emissions (tons/yr)	38,000	55,100	21,000	31,800	23,200	18,500
Estimated PM10 emissions reduced (tons/yr)	13,900	17,400	6,200	8,800	8,200	7,900
% compared to 2020	37%	31%	30%	27%	35%	42%
Premature deaths saved	1,700	1,270	630	1,390	590	290
% compared to 2020	39%	21%	25%	18%	29%	42%
Estimated CO2 emissions reduced (million tons/yr)	3.0	5.7	1.8	2.5	2.4	1.4

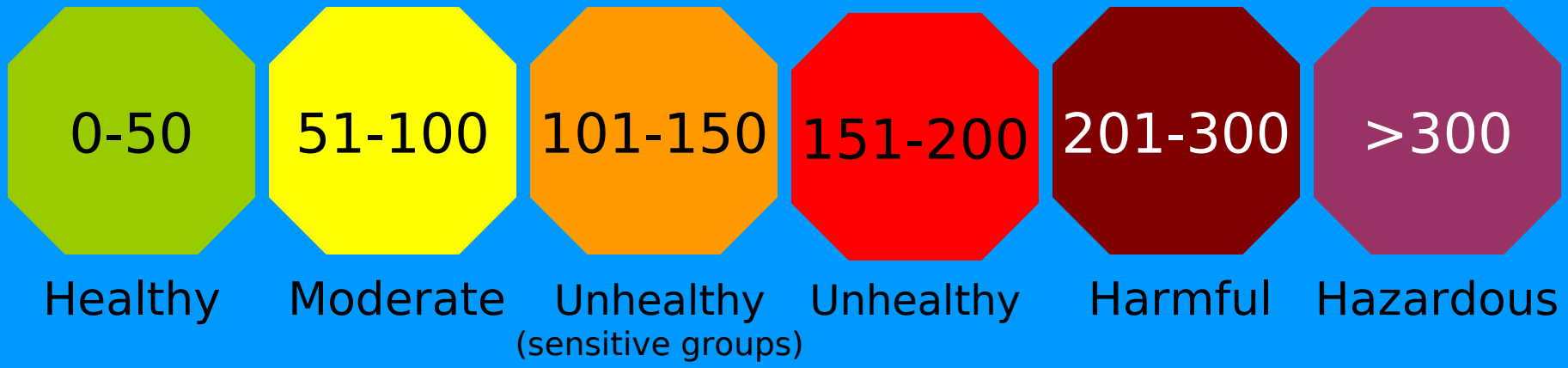
Questions to ask?

- What is the role of black carbon emissions from domestic and construction sectors?
- What is the role of sustainable transport interventions in the transport sector?
- How can we improve the monitoring baseline for PM and BC?

New cities in 2011

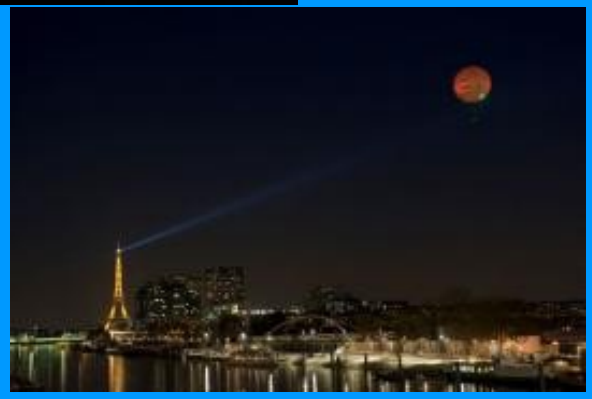
- Kolkata, India
- Mumbai, India
- Bangalore, India
- Cairo, Egypt
- Kabul, Afghanistan
- Manila, Philippines
- Durban, South Africa

Simplest of the information
Air Quality Index

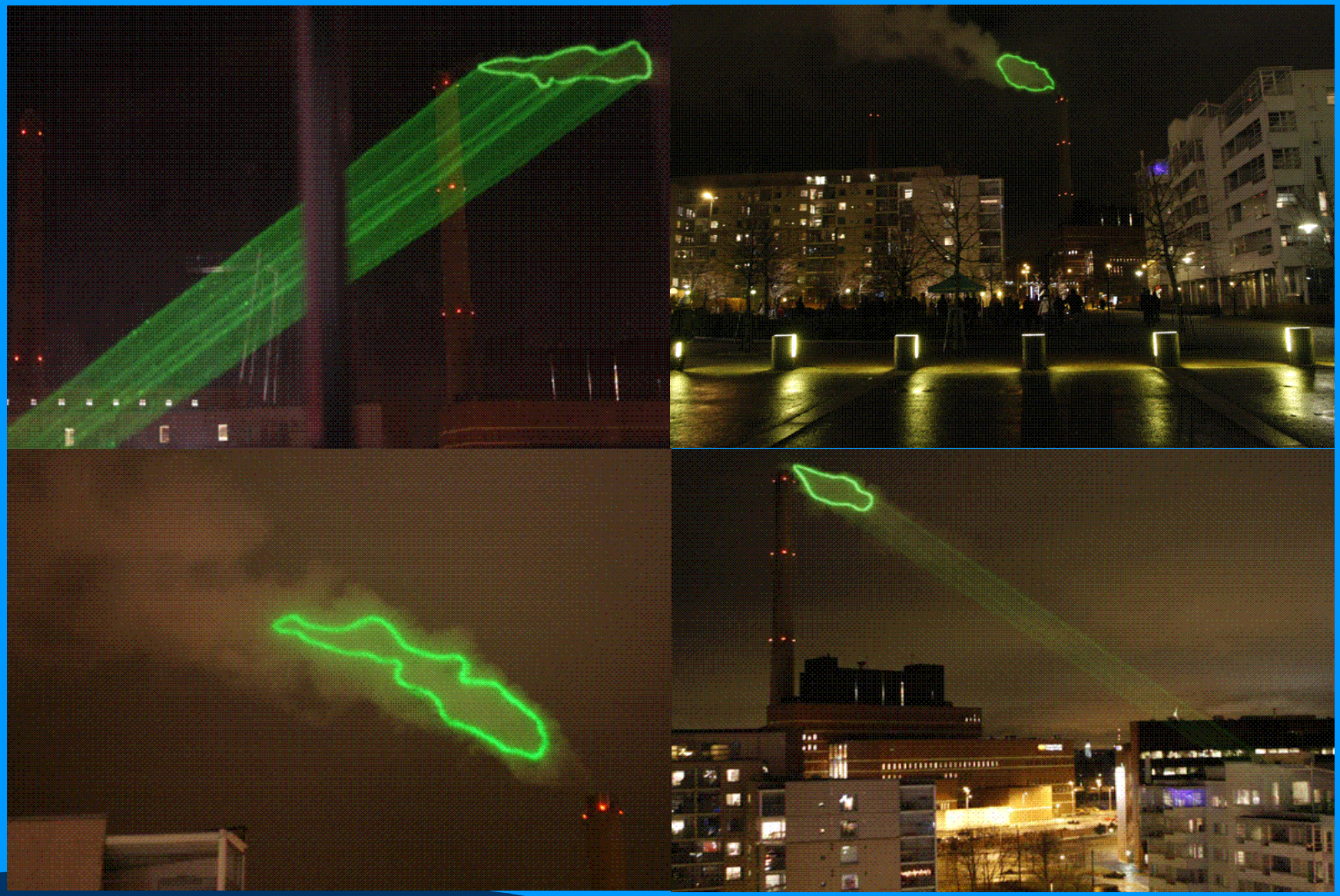


- AirNOW programs in US and EU
- In Asia – Beijing, Shanghai, HK, Seoul, Taiwan, Singapore, and now Delhi
- In LAC – Santiago, Sao Paulo, Rio

Pollution alerts in Paris, France



Pollution alerts in Helsinki, Finland



Seoul, South Korea

Thank you

Questions?

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March, 2011