Integrated Program on Urban, Regional, and Global Air Pollution

GURME Expert Workshop on Air Quality Forecasting
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Cuernavaca, Morelos, Mexico

Overview of the Mexico City Air Quality Program

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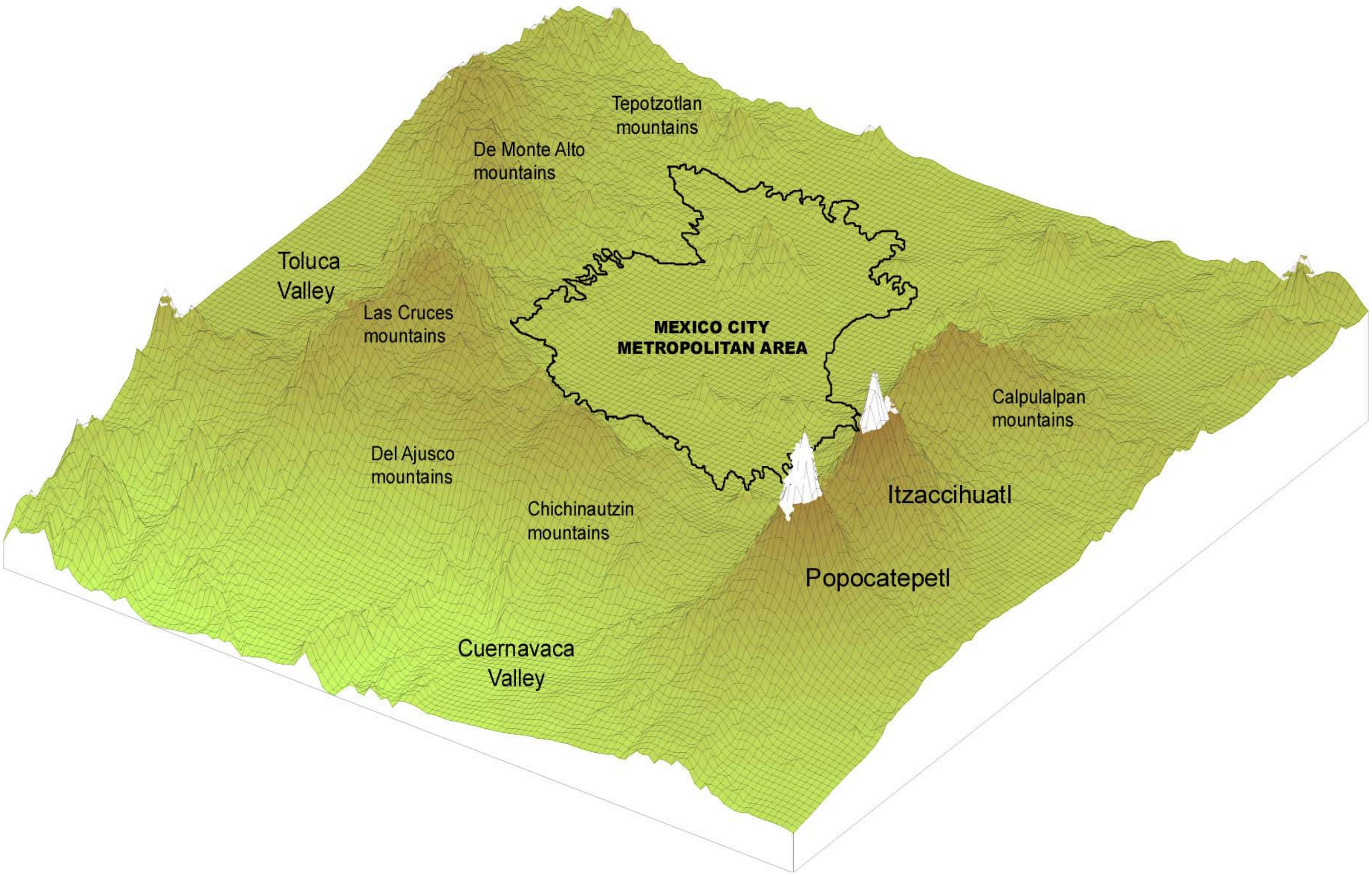
Topographical Map of the MCMA



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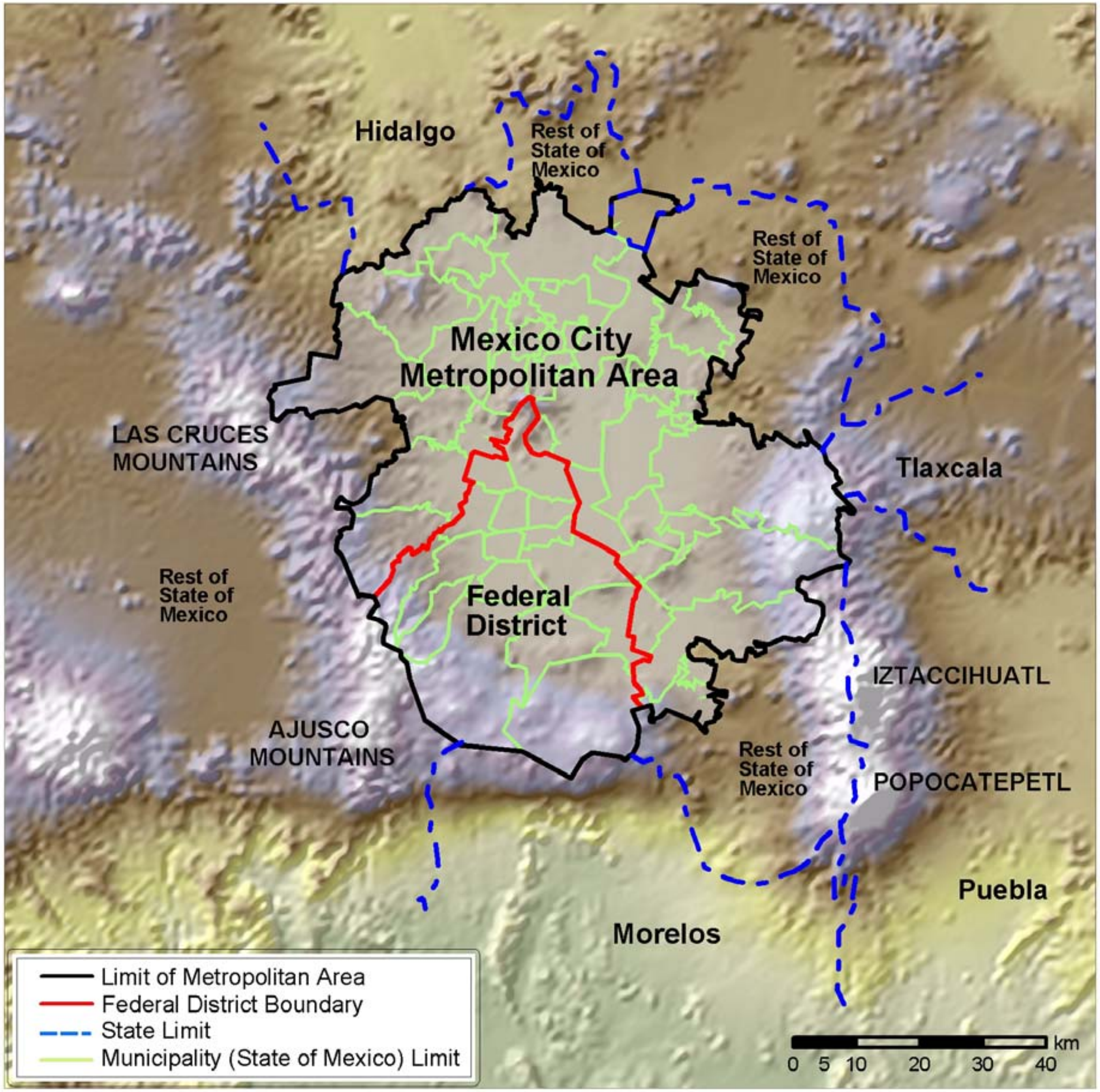
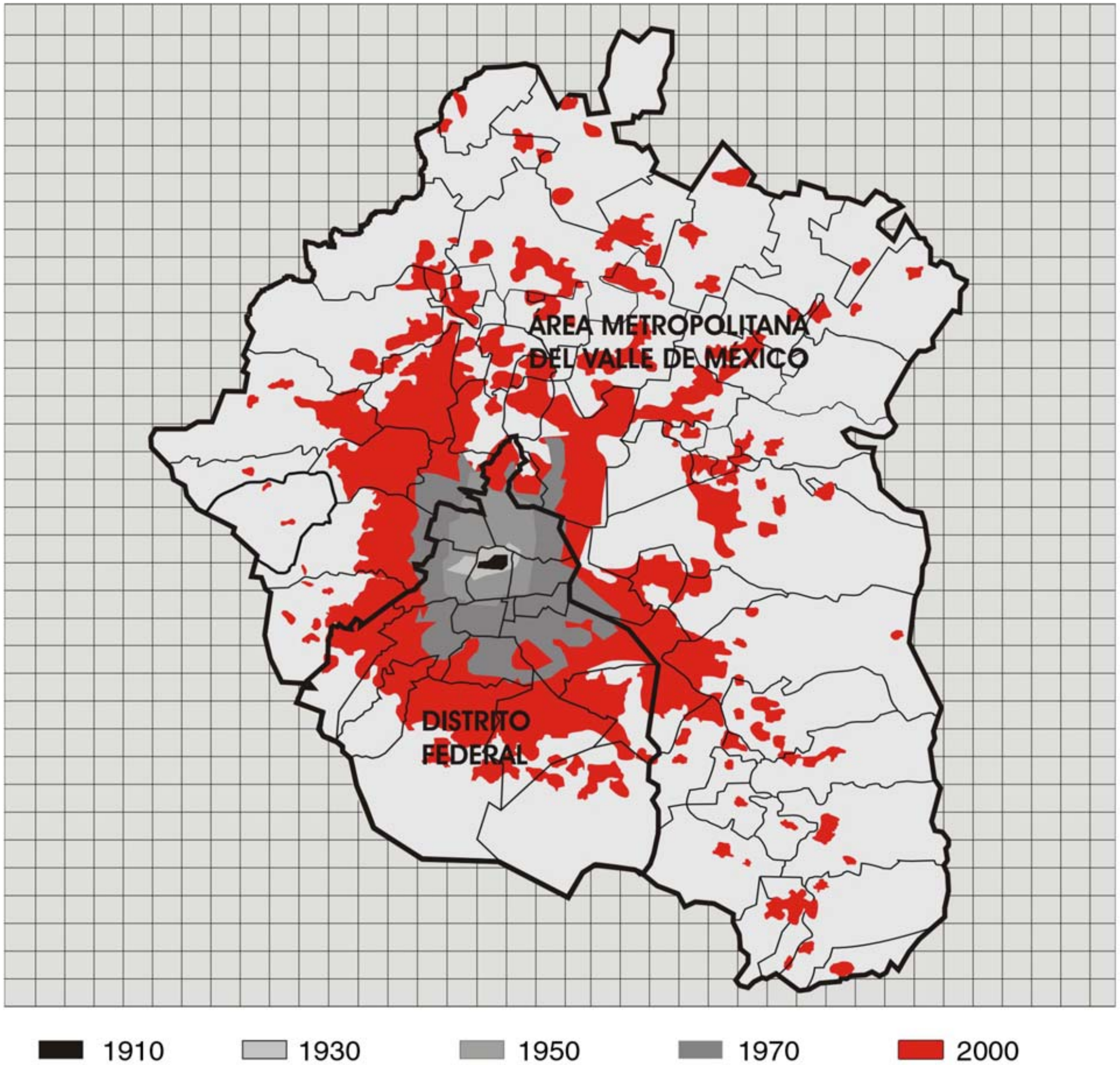
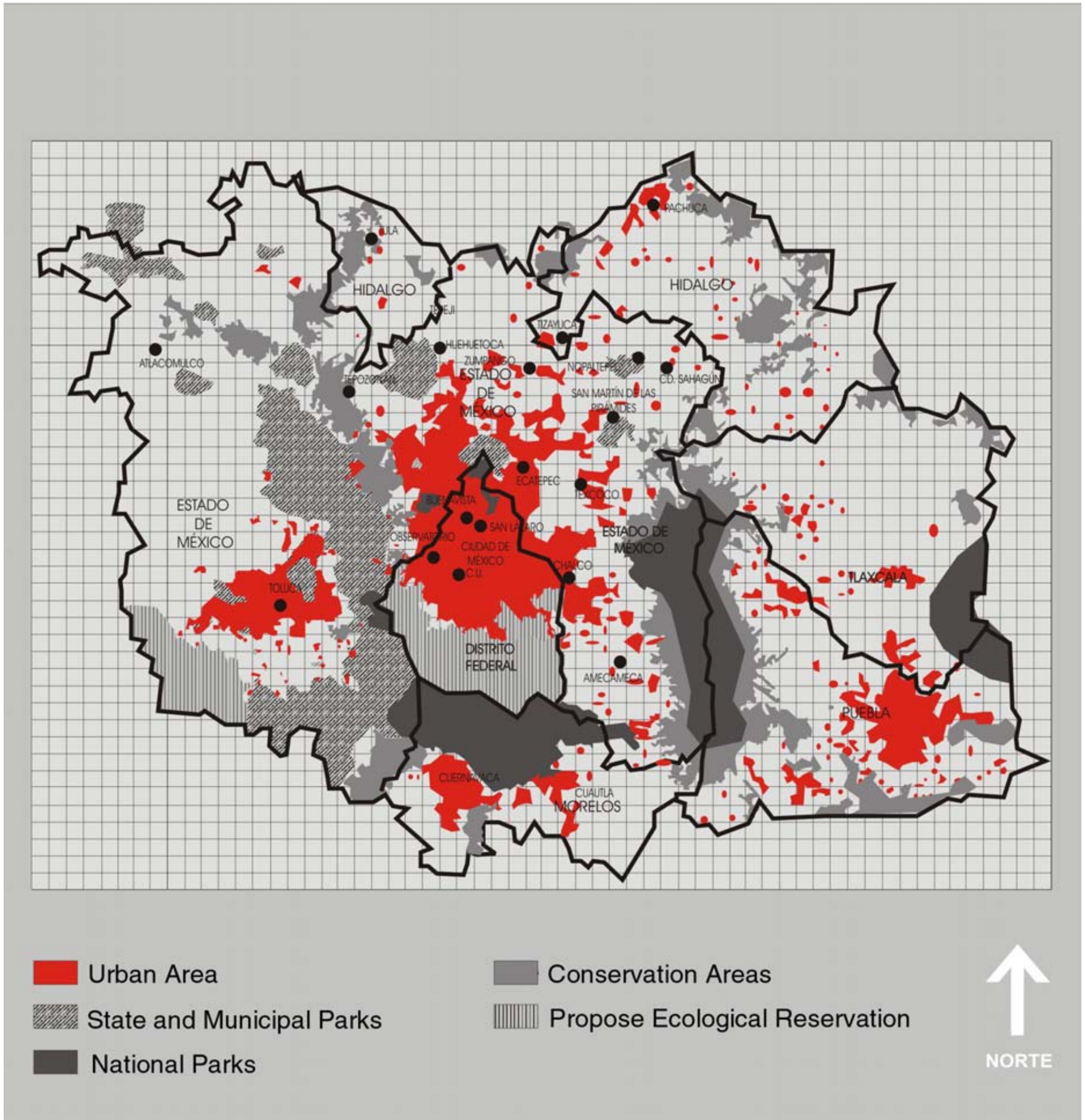


Expansion of the MCMA



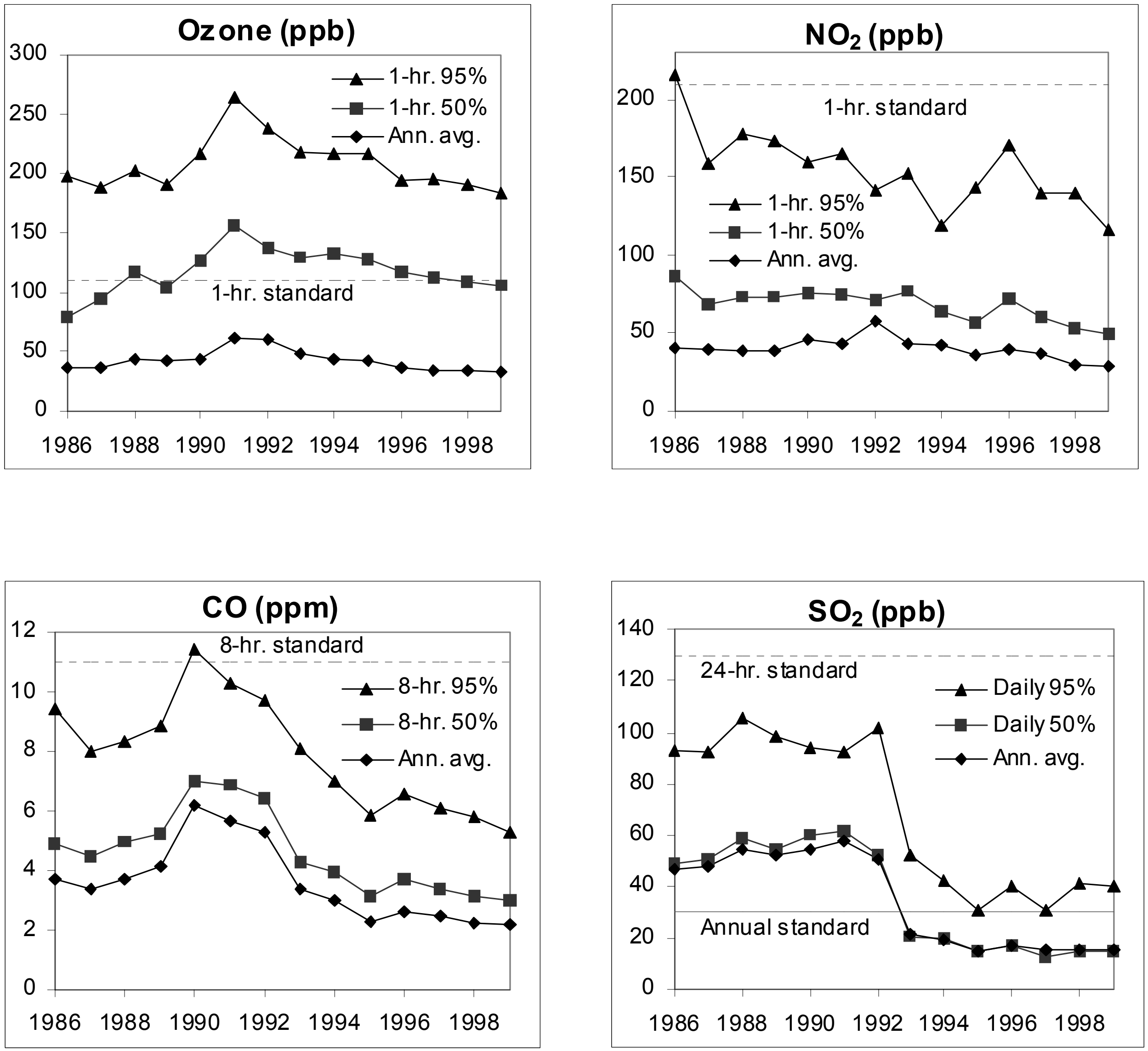
Megalopolis in the year 2000



Comparison of selected statistics between the MCMA and the South Coast Air Basin

	South Coast Air Basin[a]	MCMA[b]
Population (2000)	15 million	18 million
Total area (km^2)	27,800	5,300
Urbanized area (km^2)	17,500	1,500
Population density (inhabitants/km^2)	840	12,000 (central area) 2,700 (periphery)
GDP per capita (2000) in US dollars	32,700	7,750
Energy consumption (petajoules)	4,100	720
Fuel consumption (gasoline) liters/day (1999)	76 million	18 million
Fuel consumption (diesel) liters/day (1999)	10 million	Total =5.3 million Automotive = 4.4 M
Vehicle fleet (1999)	9.3 million	3.2 million
Average Vehicle age (years)	~10	~10
Vehicle emission control technology (1998)		
Pre-control	1 %	50%
Early control	8%	22%
Tier 0	66%	28%
Tier 1	25%	~0
VKT (kilometers per day)	512 million	153 million
Peak ozone conc. (ppbV) in 1999	176	321
Peak PM_{10} conc. ($\mu g/m^3$) in 1999	139	202
NO_X emissions (tonnes/yr)	400,000 (2000) (80% vehicles)	206,000 (1998) (80% vehicles)
VOC emissions (tonnes/yr)	362,000 (2000) (40% vehicles)	475,000 (1998) (40% vehicles)

Trends in criteria pollutant concentrations for the MCMA showing the averages of data at five RAMA sites (TLA, XAL, MER, PED, and CES)



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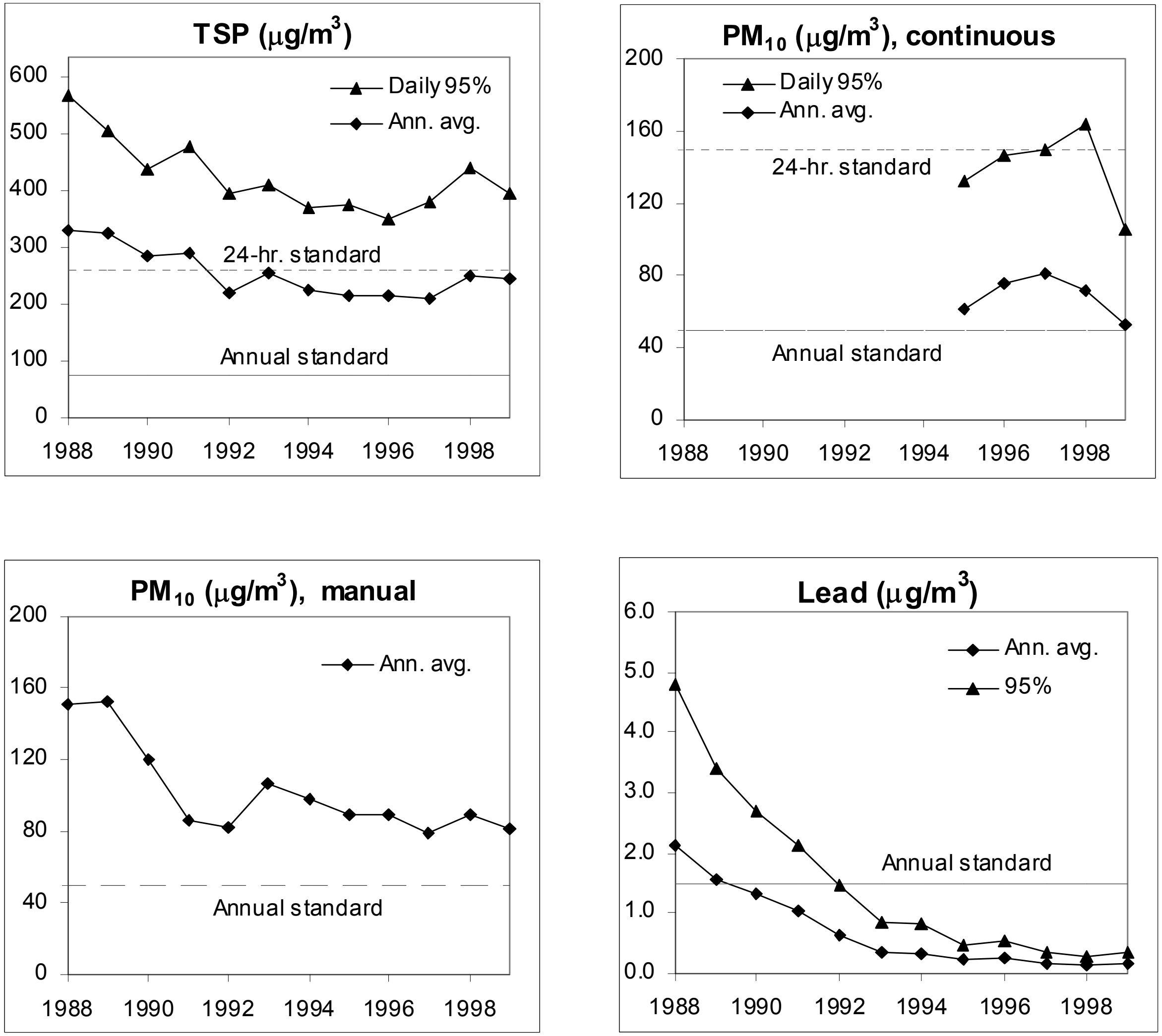
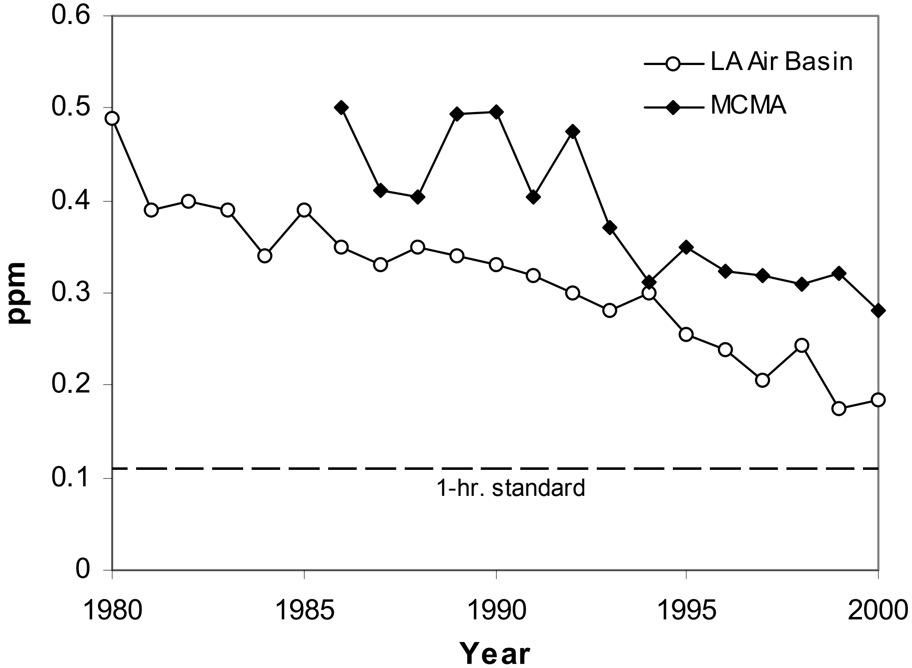
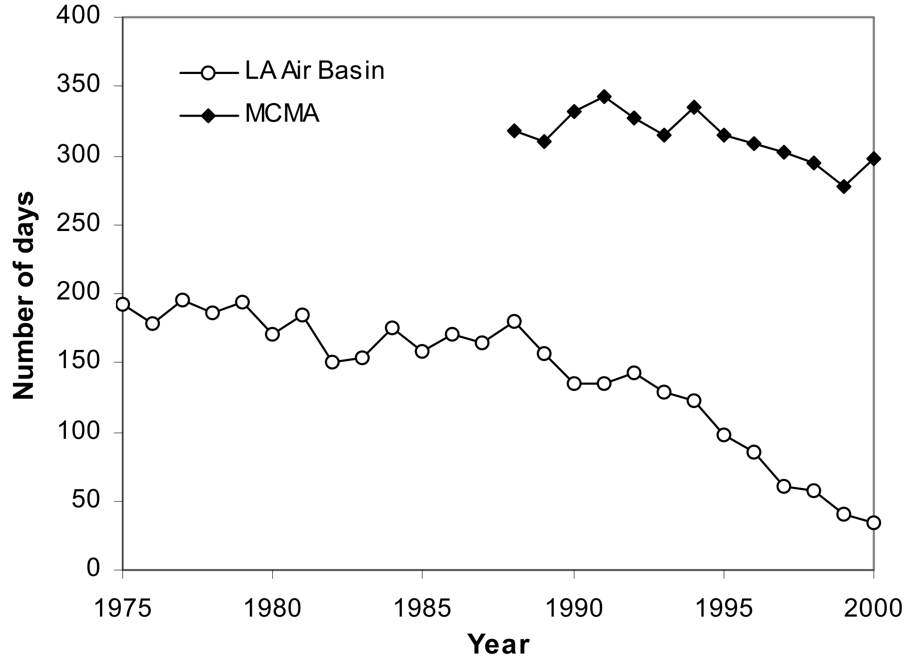


Comparison of the air quality in the MCMA and the LA Air Basin



Ozone trend (peak 1-hr concentrations) in the LA Air Basin and the MCMA



Number of days with ozone exceedences in the LA Air Basin and the MCMA

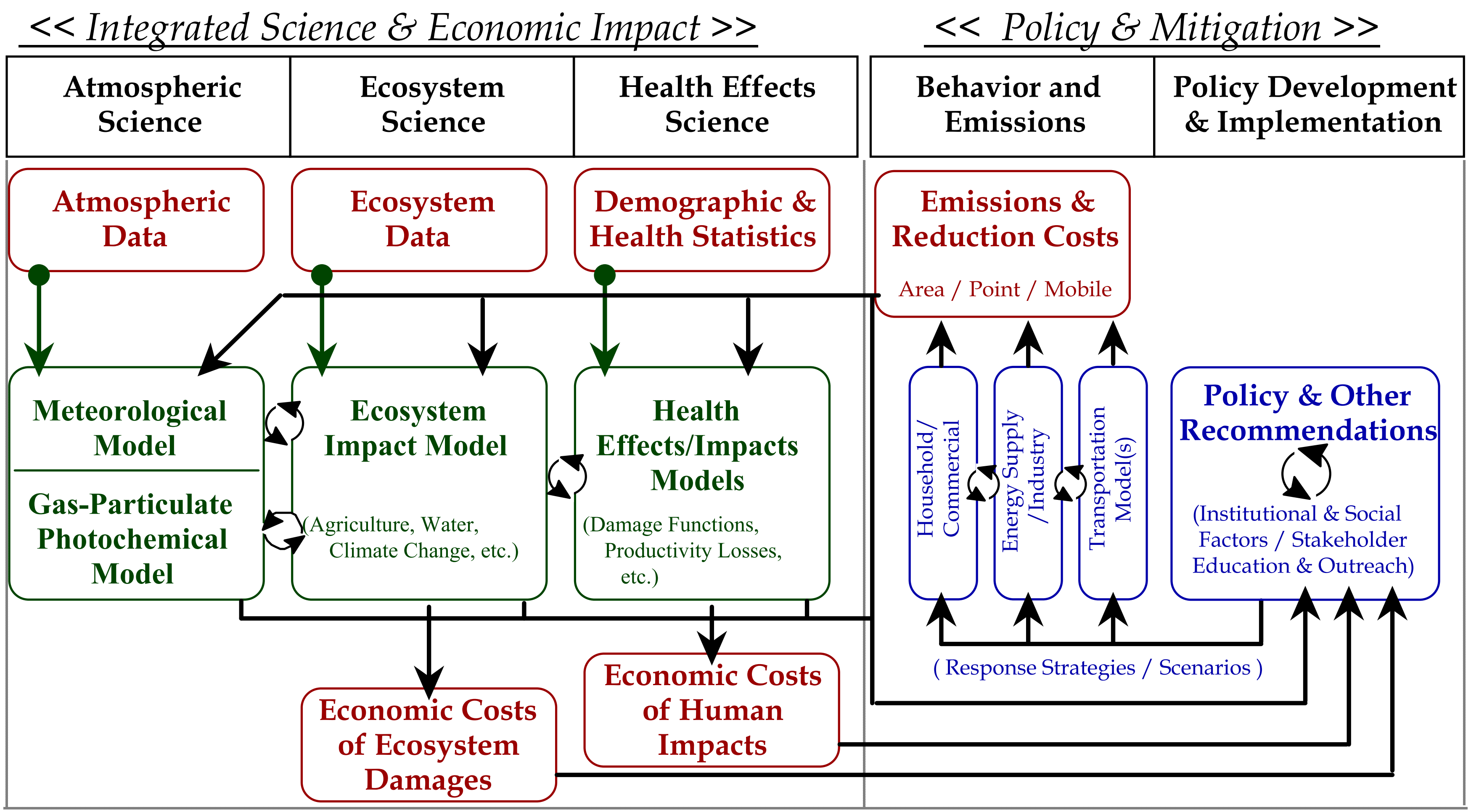
Integrated Program on Urban, Regional and Global Air Pollution: Mexico City Case Study (Mexico City Air Quality Program)

Objective:

Provide objective, balanced assessments of the causes and alternative cost-effective solutions to urban, regional and global air pollution problems through quality scientific, technological, social and economic analysis in the face of incomplete data and uncertainty

- Use Mexico City as the initial case study
- Develop an approach that applies globally
- Build on strong base of ongoing basic research

A Framework for Integrated Assessment

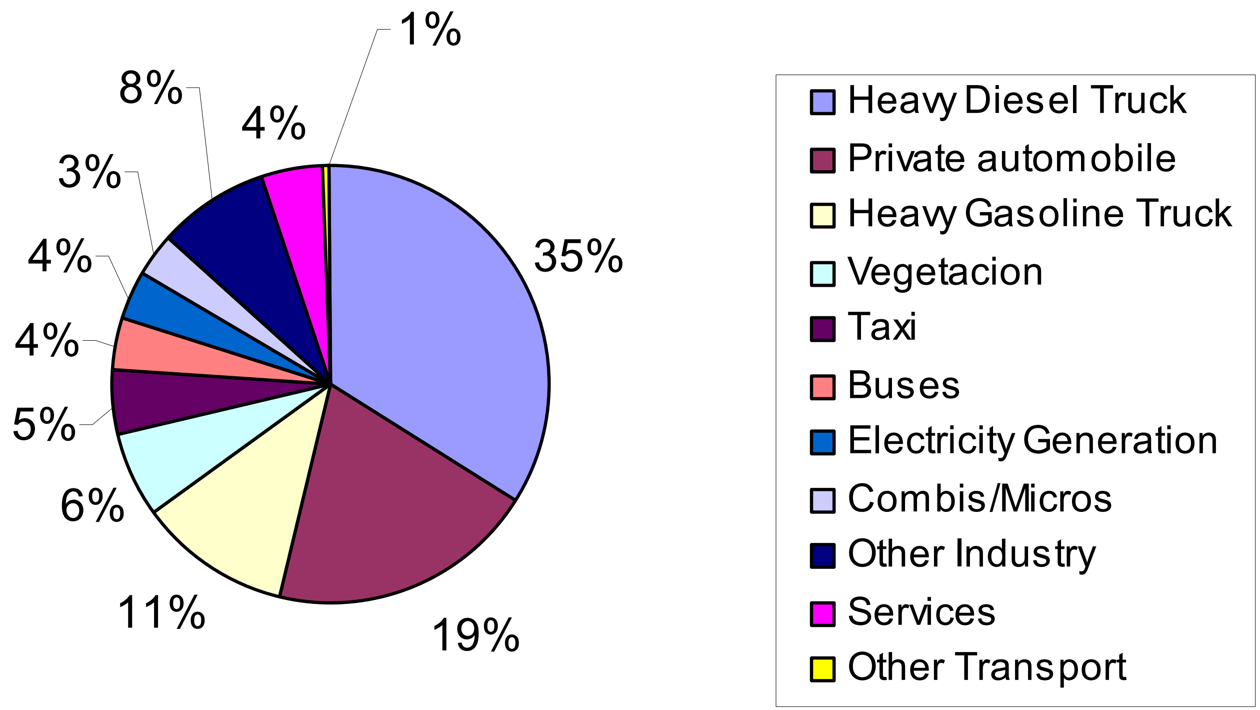


Focus of the Second Phase of the Mexico City Air Quality Program

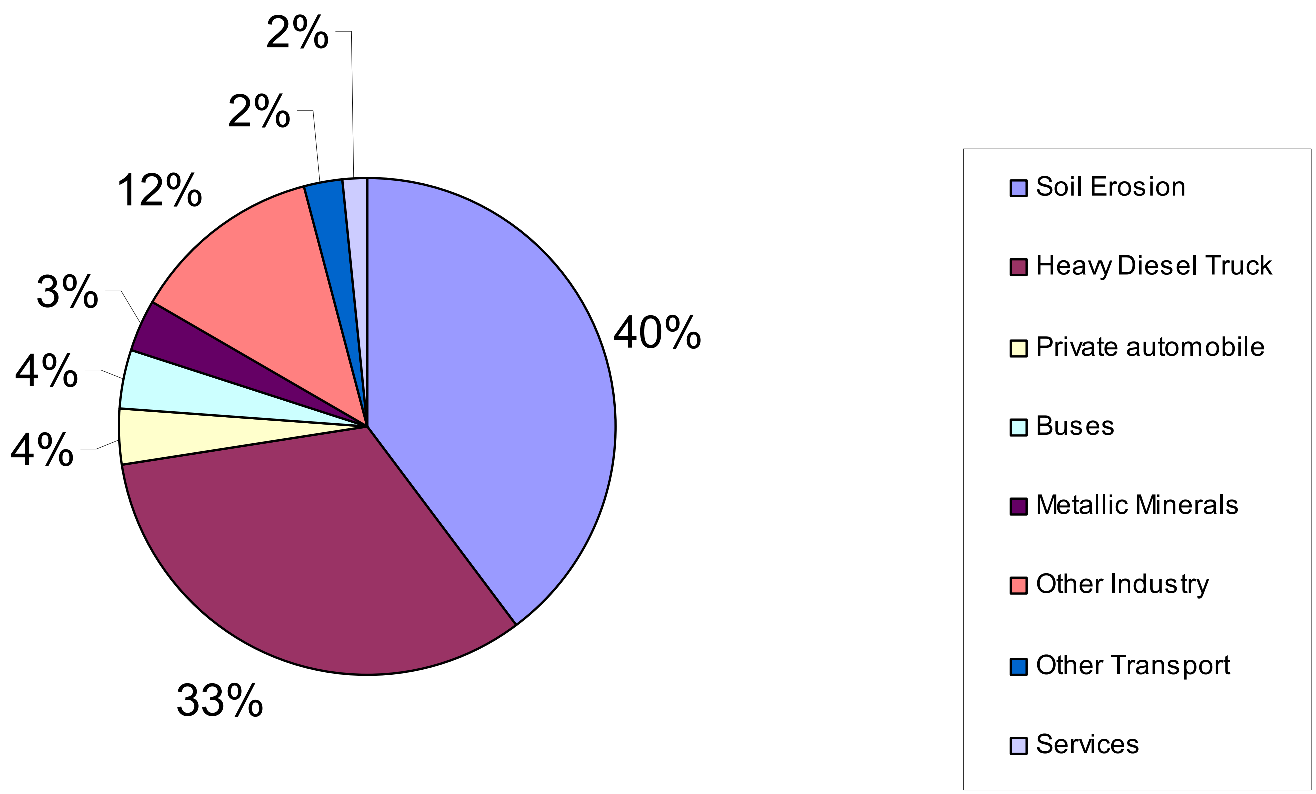
Systematic development of scientific information, evaluation methodologies and simulation tools in the following areas:

- activities that lead to the generation of pollutants in the MCMA (transportation, production of goods and services, degradation of the natural environment, etc.);
- dispersion and transformation of atmospheric pollutants (focus on ozone and particles);
- evaluation of risks and the effects of pollutants on the population;
- cost-benefit analysis of control strategies;
- integrated assessment of policy options and priorities for control strategies;
- strategies for capacity building.

NOx Emissions (1998)



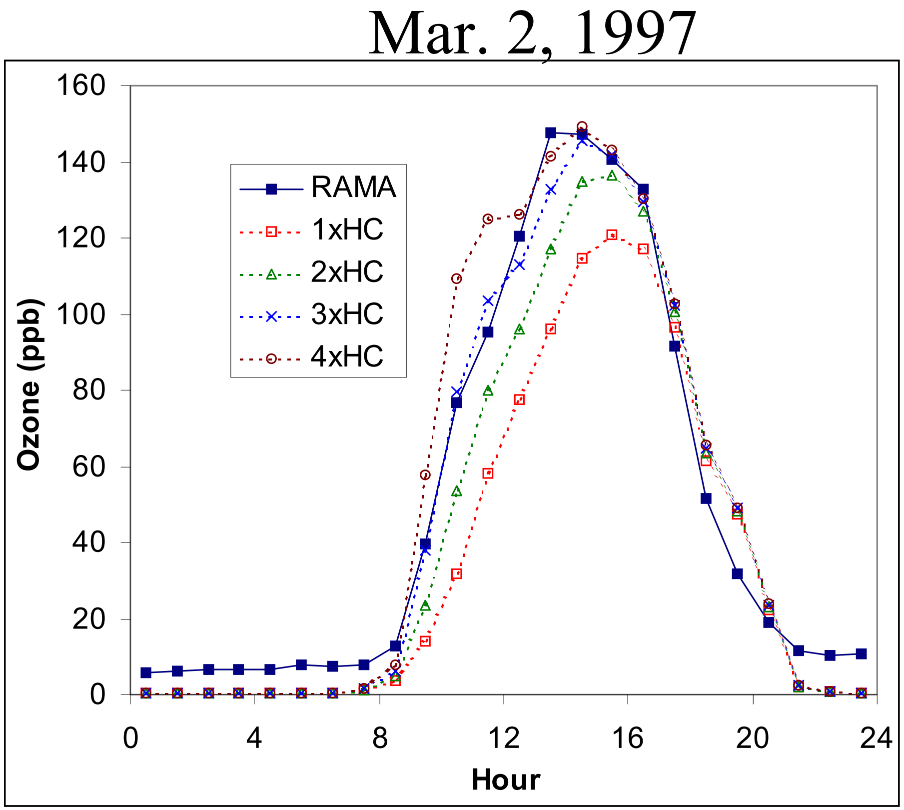
PM10 Emissions (1998)

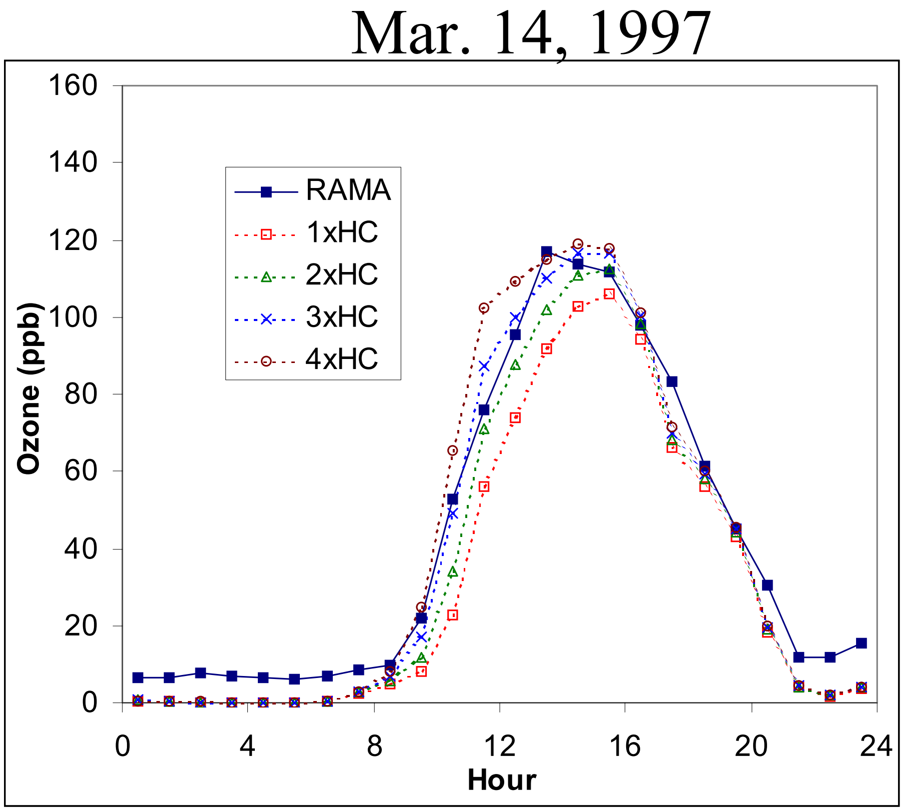


Air Quality Modeling at MIT

- Three-dimensional model of ozone and particulates using the CIT model and measurements from IMADA (March 1997).
  - Using the SAPRC99 chemical mechanism (and LCC).
  - An inorganic PM equilibrium model integrated into CIT.
- Ozone box model (OZIPR).
- Inorganic PM equilibrium model (ISORROPIA).
- Meteorological modeling with MM5.
- Analysis of RAMA measurements.
- Analysis of IMADA PM & gas phase measurements.

Ozone with 1-4 x HC emissions

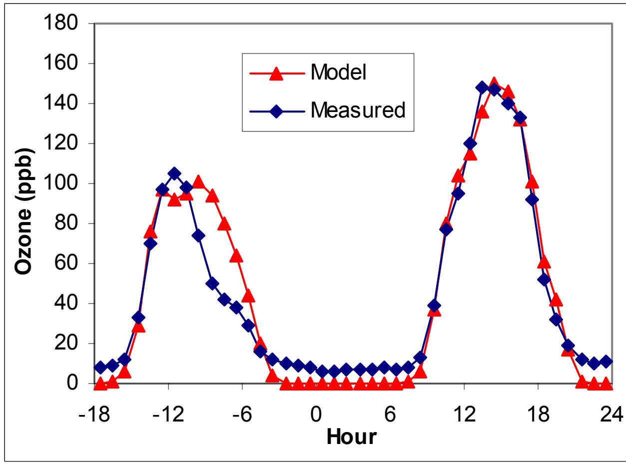




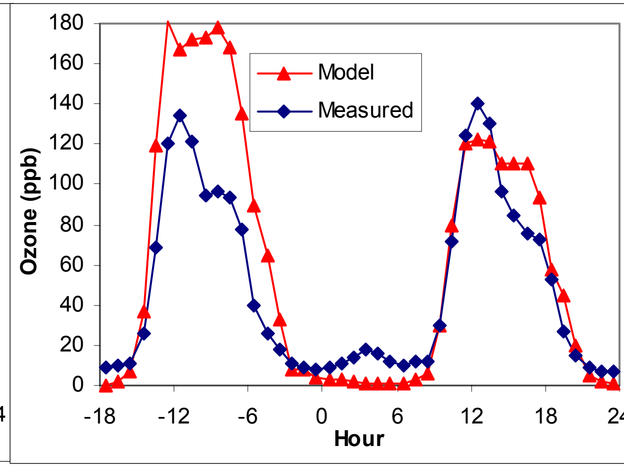
Ozone concentrations are average of all measurement sites.

Ozone Comparison – Average of all Stations

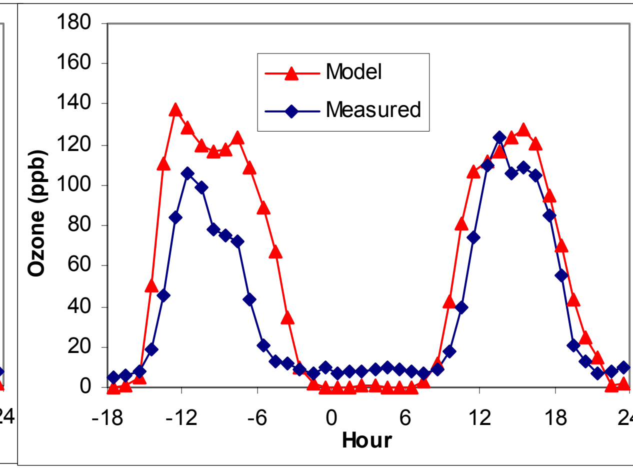
Mar. 1-2



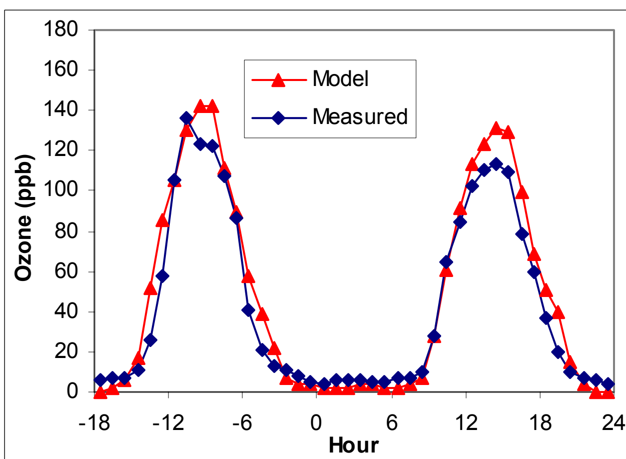
Mar. 3-4



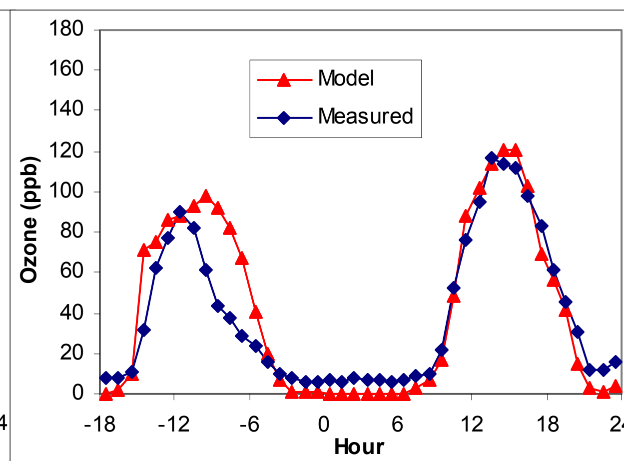
Mar. 8-9



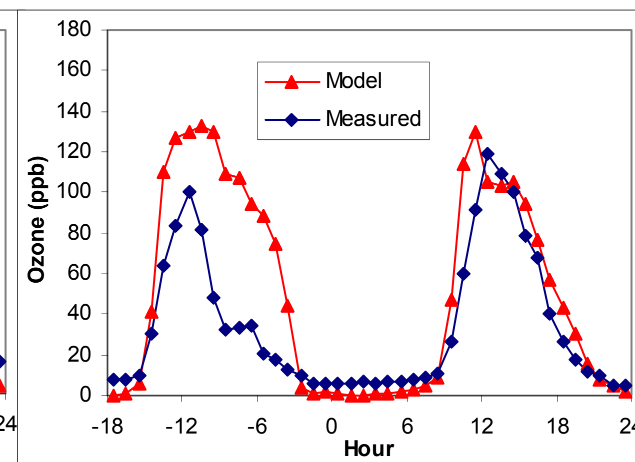
Mar. 10-11



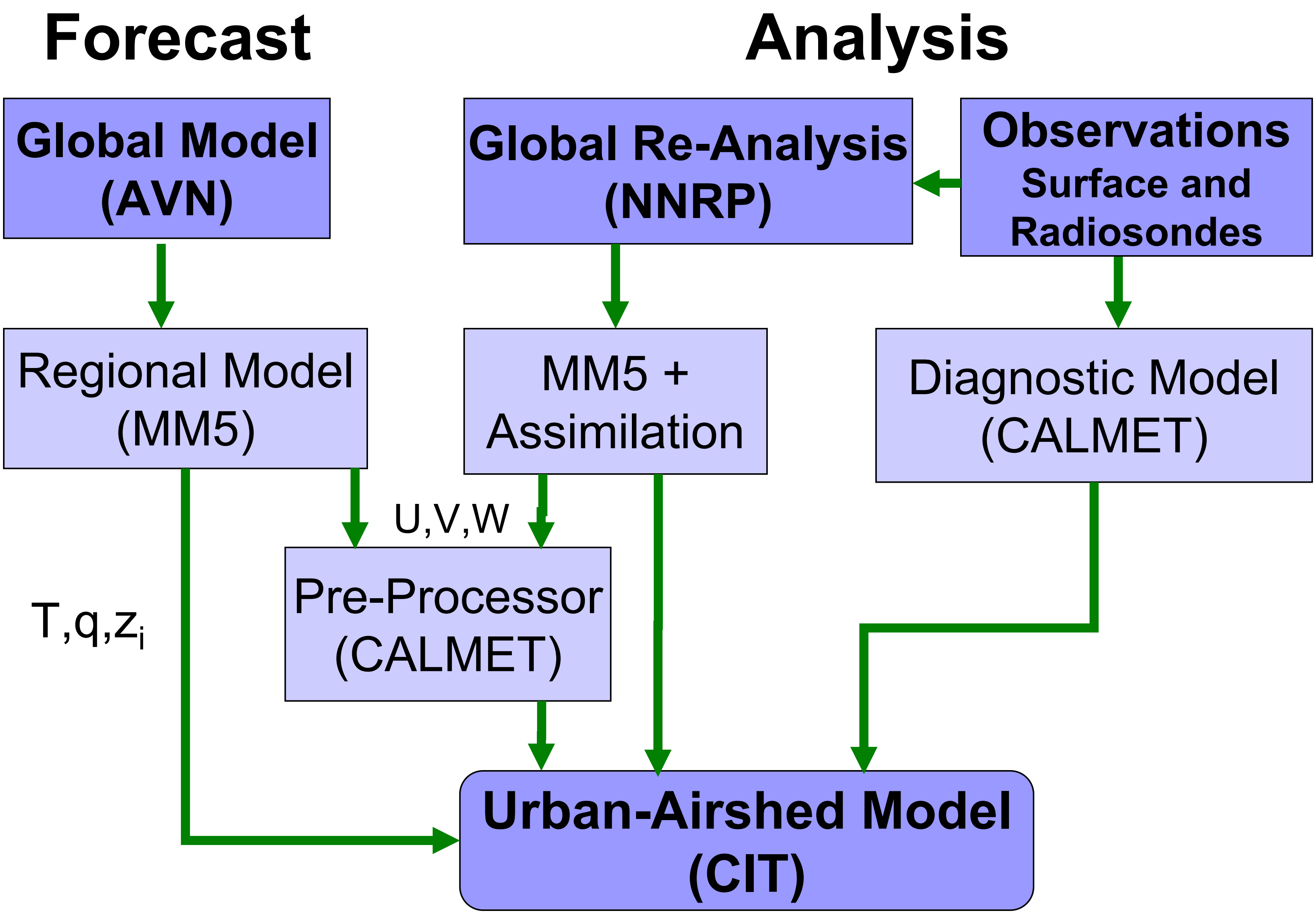
Mar. 13-14



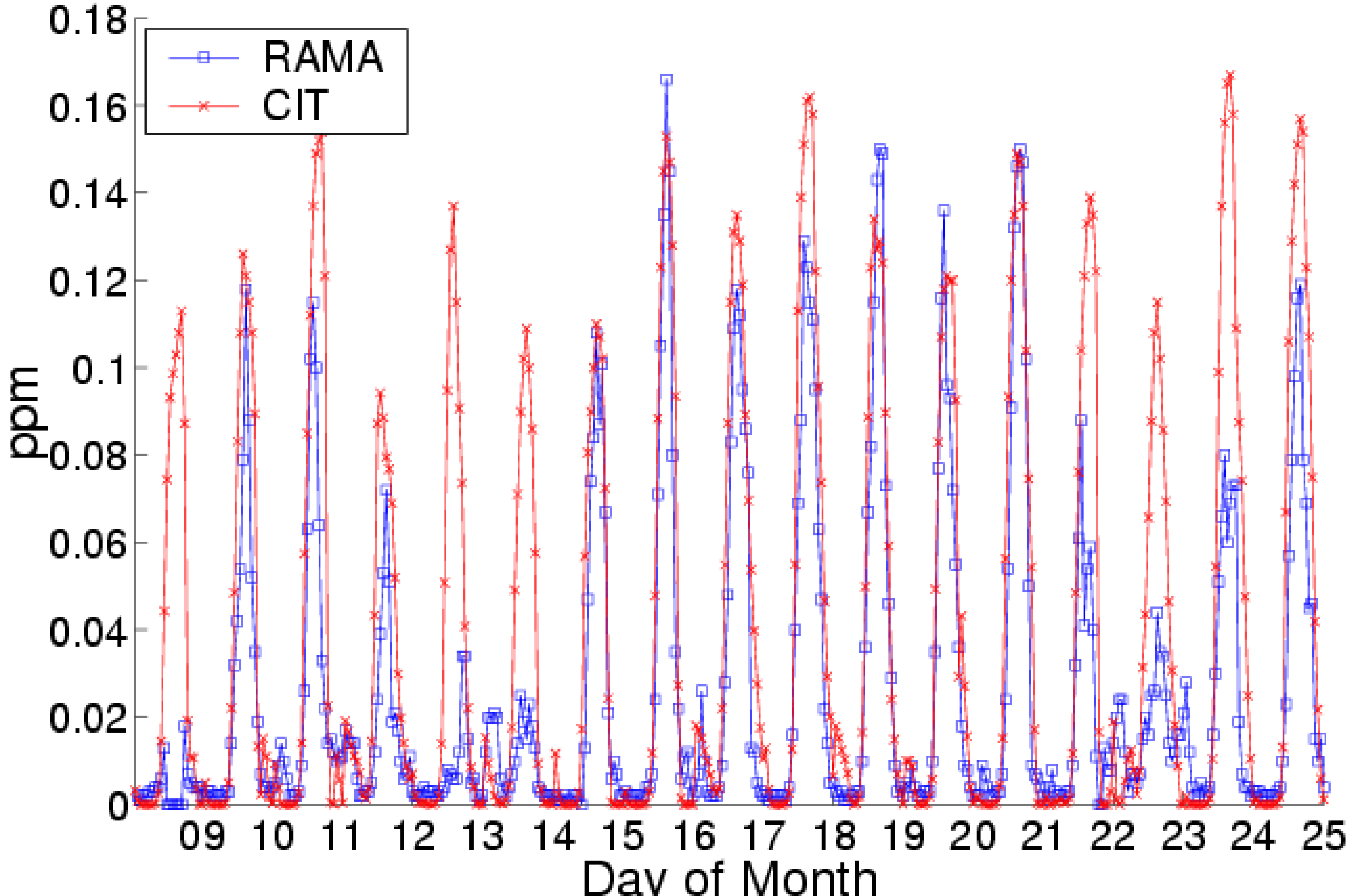
Mar. 17-18



Air Quality Modeling: Forecast and Analysis

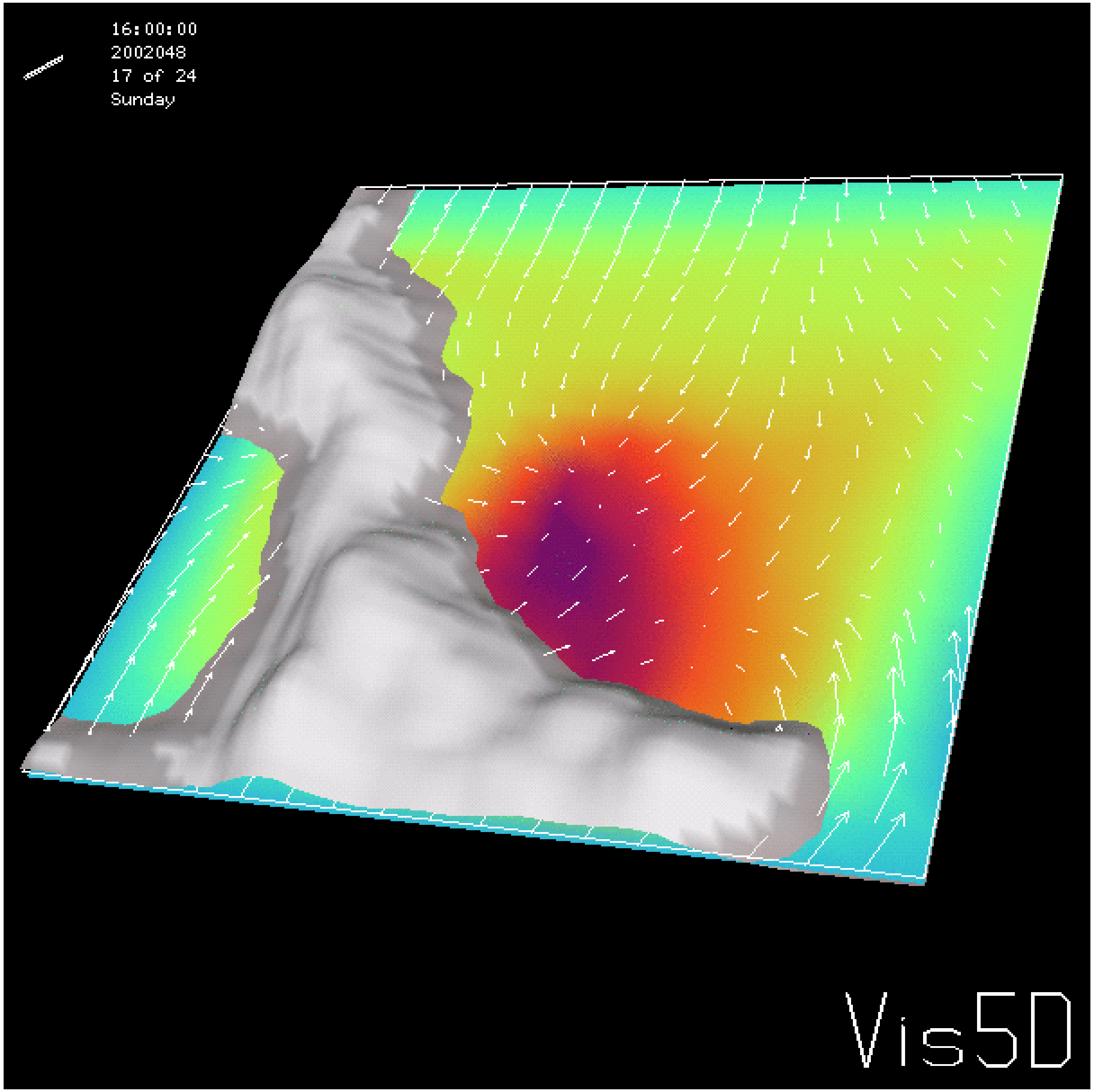


Ozone Forecasts at La Merced
RAMA measurements vs. CIT model
CAM-MIT Field Campaign: 8-24th February 2002

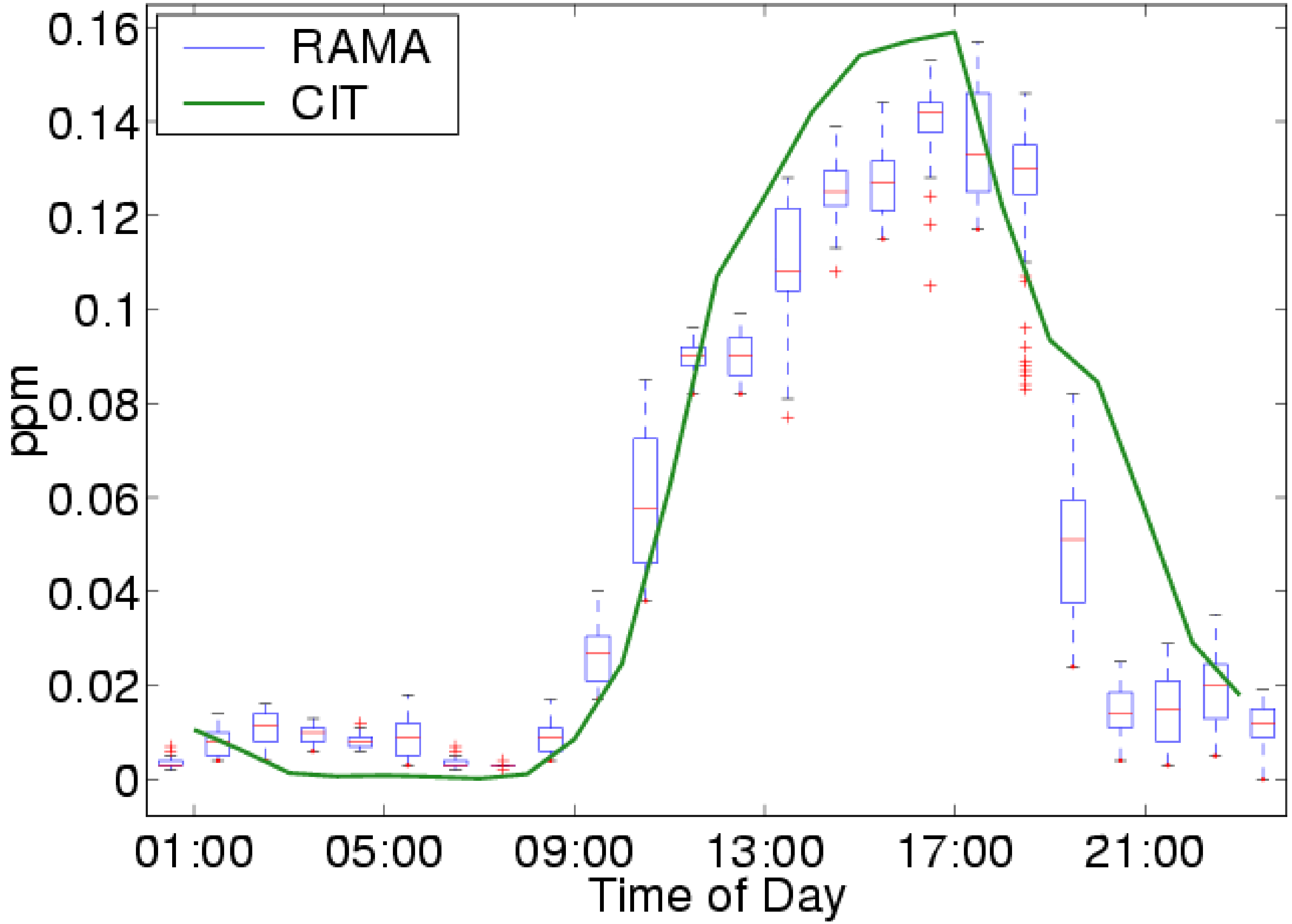


(Model runs did not account for rain/clouds, hence the large discrepancies on Feb 8,12,13,22,23)

Surface Winds + CIT Surface Ozone, 16:00, 17th Feb 2002

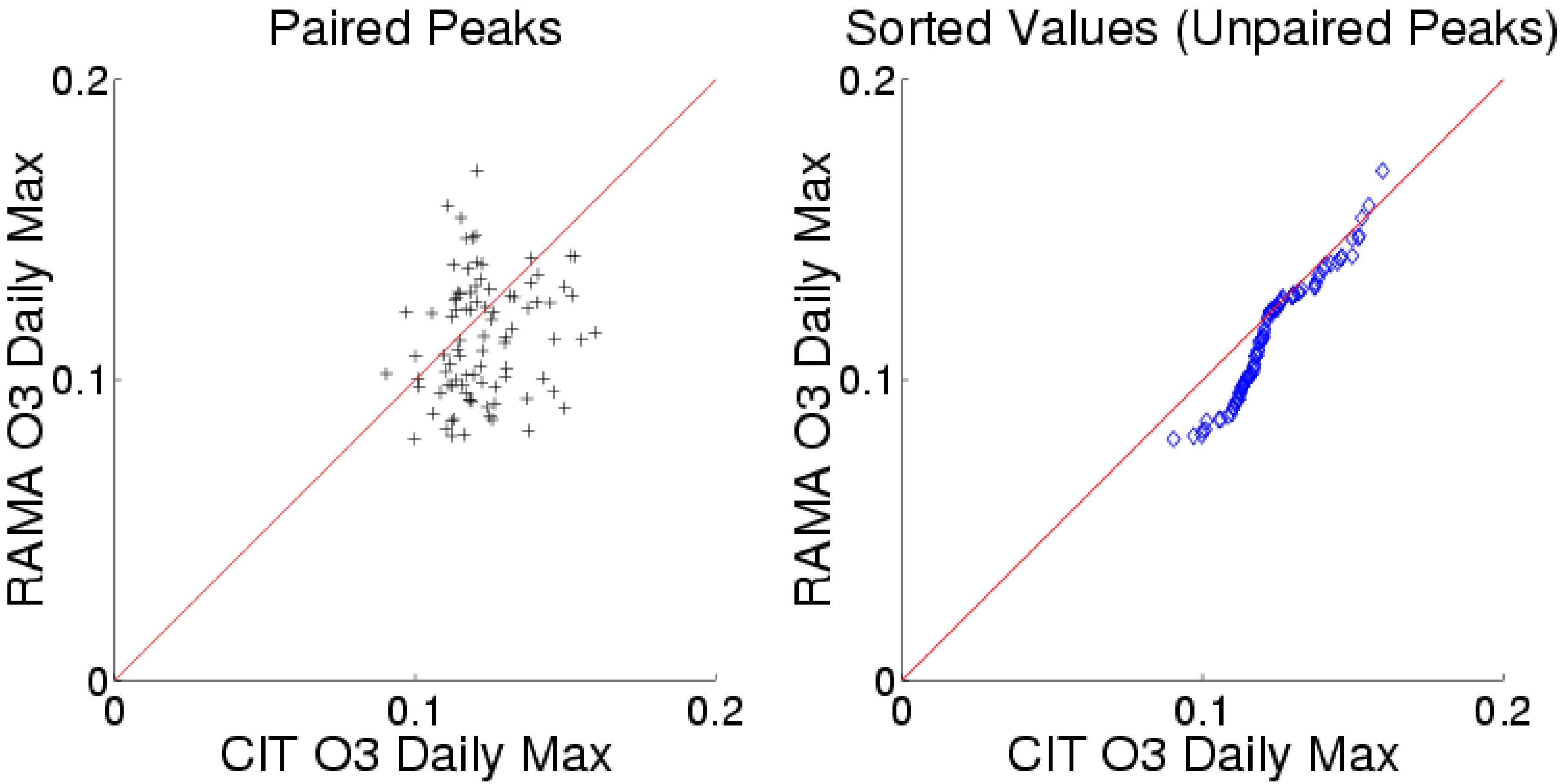


O3 (ppm) Boxplot (RAMA) vs. Timeseries (CIT) at PED for 20020217
ramamn_20020217_o3, cit_20020217_a3_o3



Benjamin de Foy, 16–Oct–2002

Scatter Plots of Maximum Daily CIT and RAMA O3 (ppm)
Daily Runs from 09–Feb–2002 to 31–May–2002
Rama Max >= 0.08 ppm



Benjamin de Foy, 16–Oct–2002

Science Questions

Emission inventories

- Are the existing emission inventories sufficiently accurate for modeling and regulatory purposes?
- Are hydrocarbon emissions underestimated by a large factor, as indicated by some of the modeling studies?
- Are there significant biogenic emissions, e.g., terpenes?

Meteorology

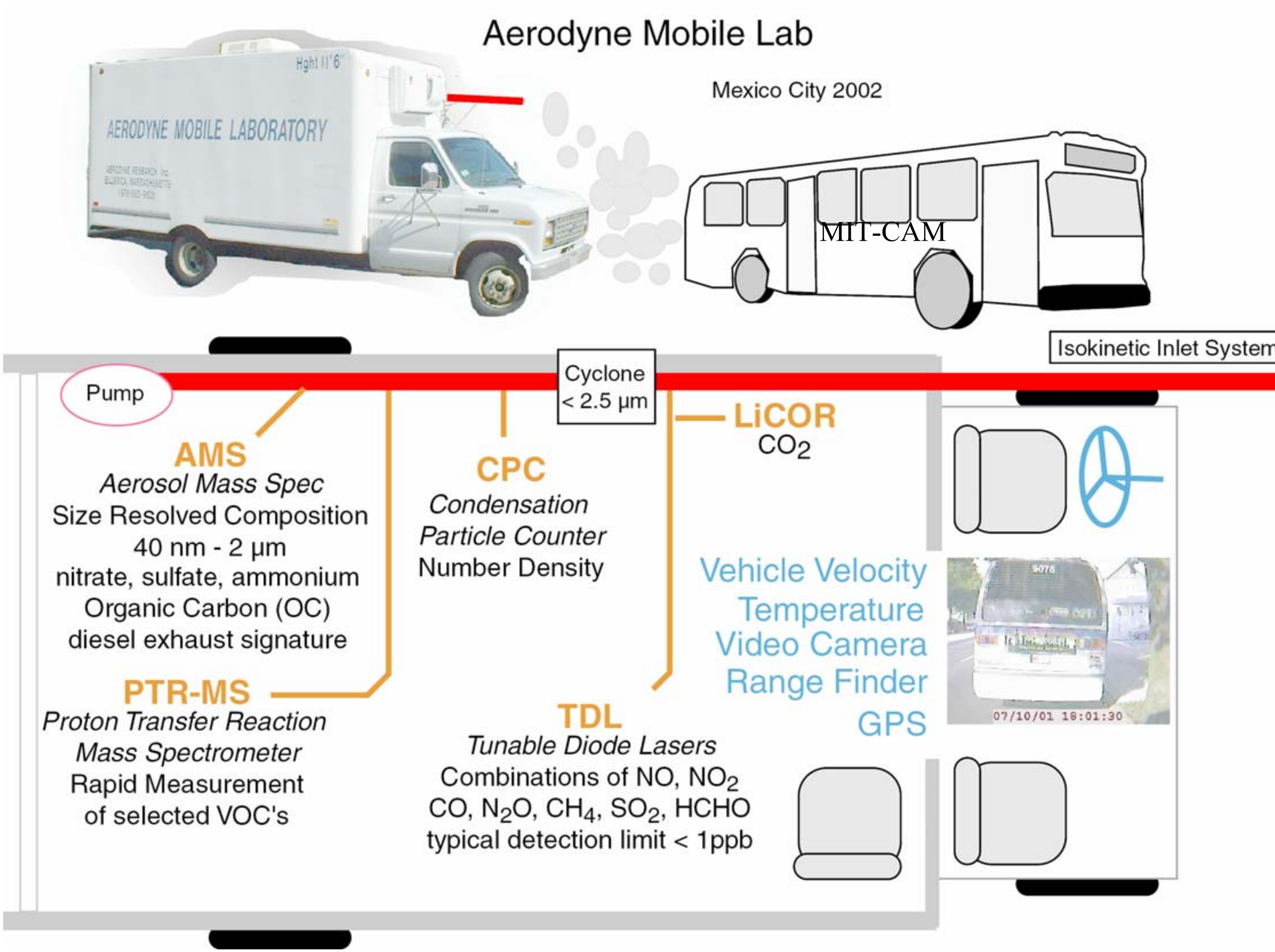
- What is the height of the mixing layer?
- How does this height evolve with time?
- How significant is the “carry over” of pollutants from one day to the next?
- How accurate are the models to predict wind speeds and directions?
- Is there a reasonable set of “typical” meteorological conditions that can be used to model the effects of various emission reduction strategies?

Science Questions

Chemical transformation of emissions in the atmosphere

- ❑ How is the reduction in NOx and/or HC related to reductions in O_3 and organic particulate matter?
- ❑ What are the spatial and temporal distributions of these reductions?
- ❑ Would reductions in NOx lead to a reduction in nitrate particulates?
- ❑ What is the impact of reducing ammonia on the formation of particulate matter, considering that it is probably in excess?
- ❑ How much formaldehyde (HCHO) is emitted directly (primary) vs. produced photochemically (secondary)?
- ❑ What is the partitioning of NOy among NOx, HNO_3, and organic nitrates?
- ❑ What is the chemical composition of the fine particulate matter? Can this information be used to identify the source so that it can be reduced?

MIT-CAM Field Measurement Campaign
February 2002



MIT-CAM Exploratory Field Measurement Campaign
February 2002

STATIONARY SAMPLING

- ❑ High time resolution point sampling
- ❑ Quality assurance for conventional air monitors

MOBILE SAMPLING/MAPPING

- ❑ Motor vehicle pollution emission ratios
- ❑ Large source plume identification
- ❑ Ambient background pollution distributions

CHASE

- ❑ Detailed mobile source emissions characterization
- ❑ Plume tracer flux measurements

MIT-CAM Exploratory Field Measurement Campaign (Cont)
February 2002

SAMPLING AT BOUNDARY SITES

- ❑ Meteorological Parameters (sodar, radiosondes, pilot balloons)
- ❑ Mobile Labs (O_3, NOx, SO_2, CO)

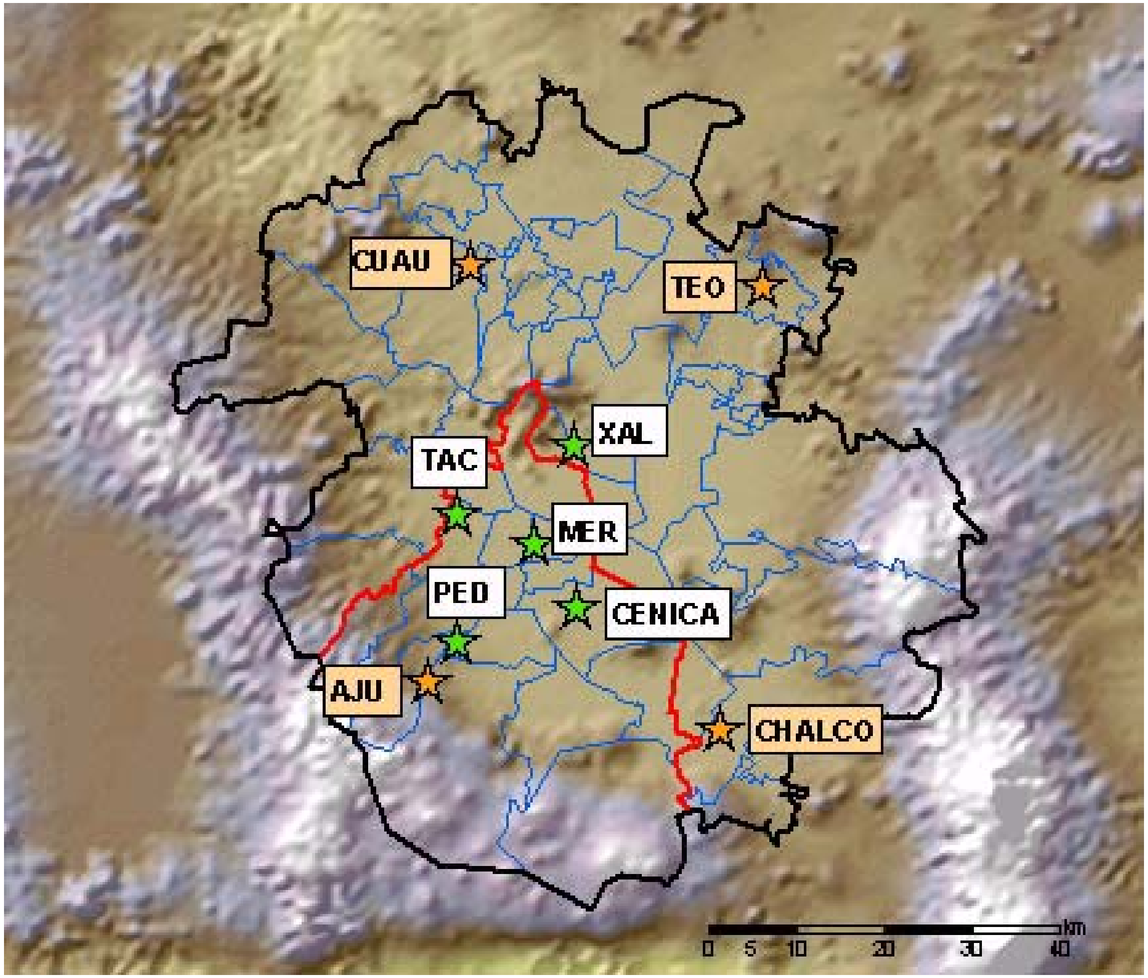
TETHERED BALLOON MEASUREMENTS

- ❑ Ozone
- ❑ Meteorological Parameters
- ❑ VOCs

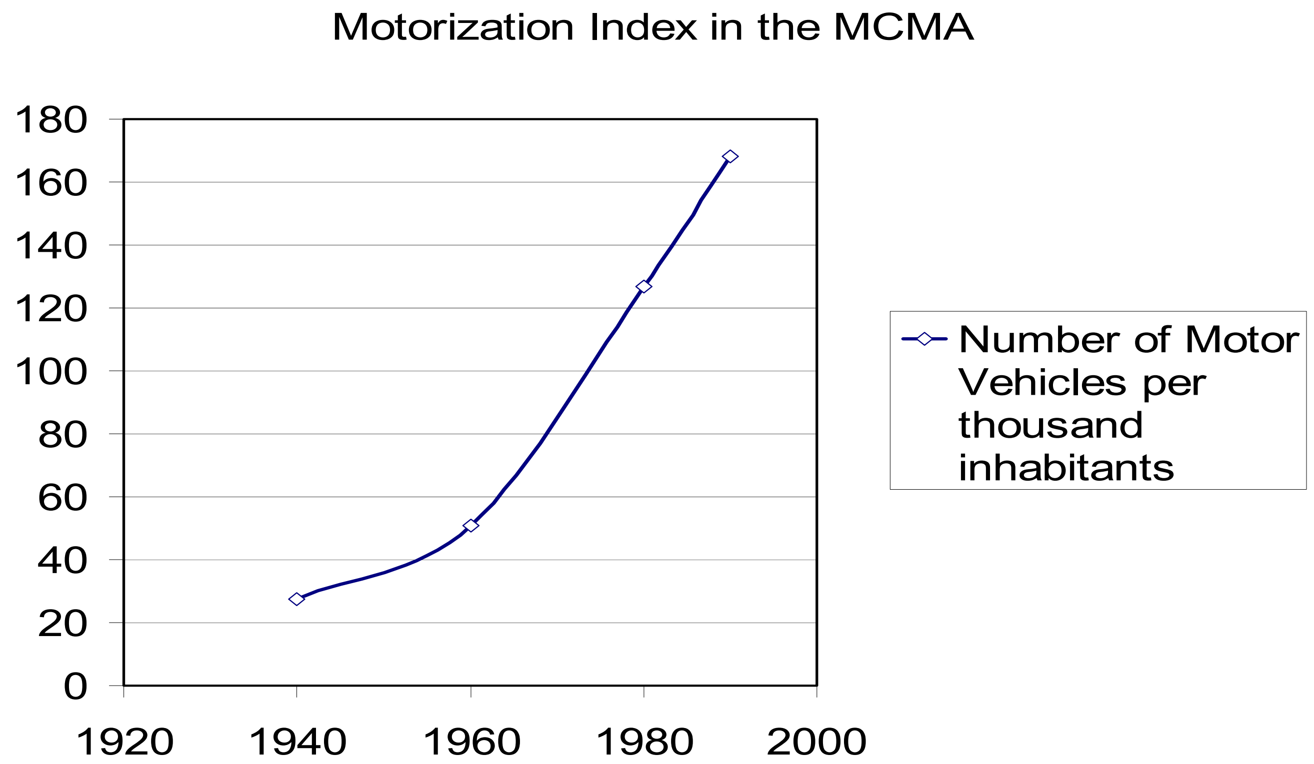
VOC MEASUREMENTS

- ❑ Canisters
- ❑ Proton Transfer Reaction Mass Spectrometer

Mexico City Metropolitan Area
February 2002 Measurement Sites

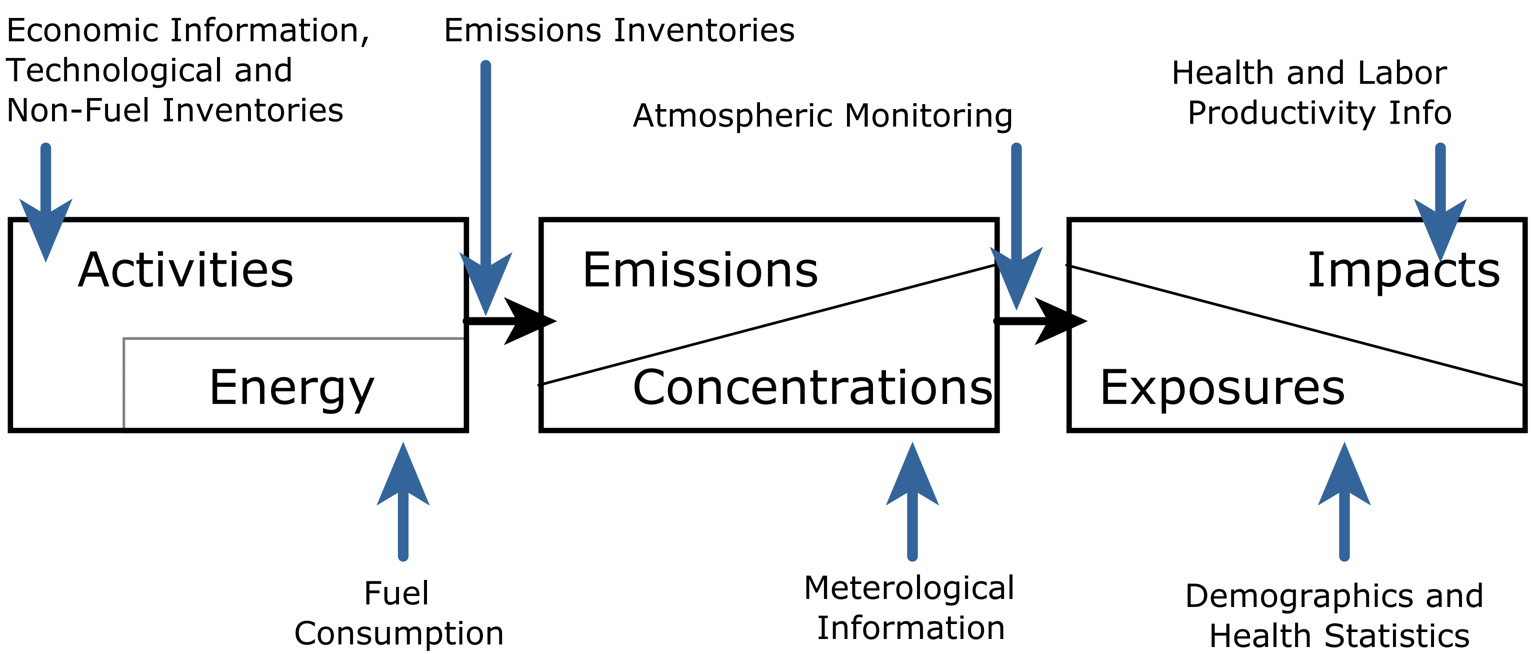


Increase in Automobiles per Capita in Mexico City



Integrated Scenarios

- <u>Data + Models + Research = Results</u>



- Autos
- Buses/Trucks
- Industry/Commercial
- Power Plants
- Cooking/Heating

- NOx
- VOCs
- CO
- PM10/PM2.5
- CO2, Methane
- Air Toxics

- Ozone
- Acid Gases
- Particulates
- GHGs
- Air Toxics

- Household
- Neighborhood
- Workplace
- Transit

- Mortality
- Morbidity
- Acute
- Chronic

Many “Elements”

- Multiple Emission Sources,
  Many Options to Consider
- Transportation Team *(Sussman, Villegas)*
  - » Urban Form and Demand for Transport (Dodder)
  - » Private Cars (Aoki)
  - » Road Based Public Transport (Amano)
  - » Metro & Intermodal Coordination (Gilat)
  - » Freight (Bracamontes)
  - » Fleet Modernization (Mostashari)
- Non-Transportation Team *(Connors)*
  - » Industry and Power (Vijay)
  - » Commercial and Informal Sectors (Flores)
  - » Residential (Roth)

Numerous "Goals"

- What Are the "Scenarios" Looking For?
  - Improved Air Quality
  - Better Mobility
  - Improved Public Health
  - More Vibrant Economy
  - Robust, Cost-Effective, Implementable Solutions
- A New Synthesis
  - Detailed, Long-Term *Bottom-Up* Integrated Scenarios Looking at Short and Long-Term Multi-Option Strategies
  - Evaluation of Strategy Performance Across Fundamentally Different *Top-Down* Scenario Formulations (Future Stories)

Future Stories & Goals

- Future Stories
  - Alternate economic (local & global), population and social paths
    [Not forecasts of the future!]
  - Paths impact wealth/purchasing power, settlement patterns, and the performance and feasibility of parts of a long-term Air Quality program
  - Long-term Air Quality Program design/evaluation under uncertainty

Environmental Education and Outreach

- Visiting Mexican scholars at MIT
- Workshops/symposia on air quality
- Professional development courses on air quality for mid-career personnel in the government, industry and academic sectors as well as non-governmental organizations and the media
- Masters Program in Environment and Health Management at MIT and Harvard School of Public Health (INE-MIT-Harvard joint program)
- Exchange program between MIT and Mexican institutions
- Establish the Research and Development Network on Air Quality in Large Cities in Mexico (communication forum for Mexican researchers)
- Senior High School (Preparatoria)