

# **MCMA-2006 Field Campaign Overview**

**Luisa T. Molina and Beatriz Cardenas**

# Integrated Program on Urban, Regional and Global Air Pollution: Mexico City Case Study

## Goal:

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

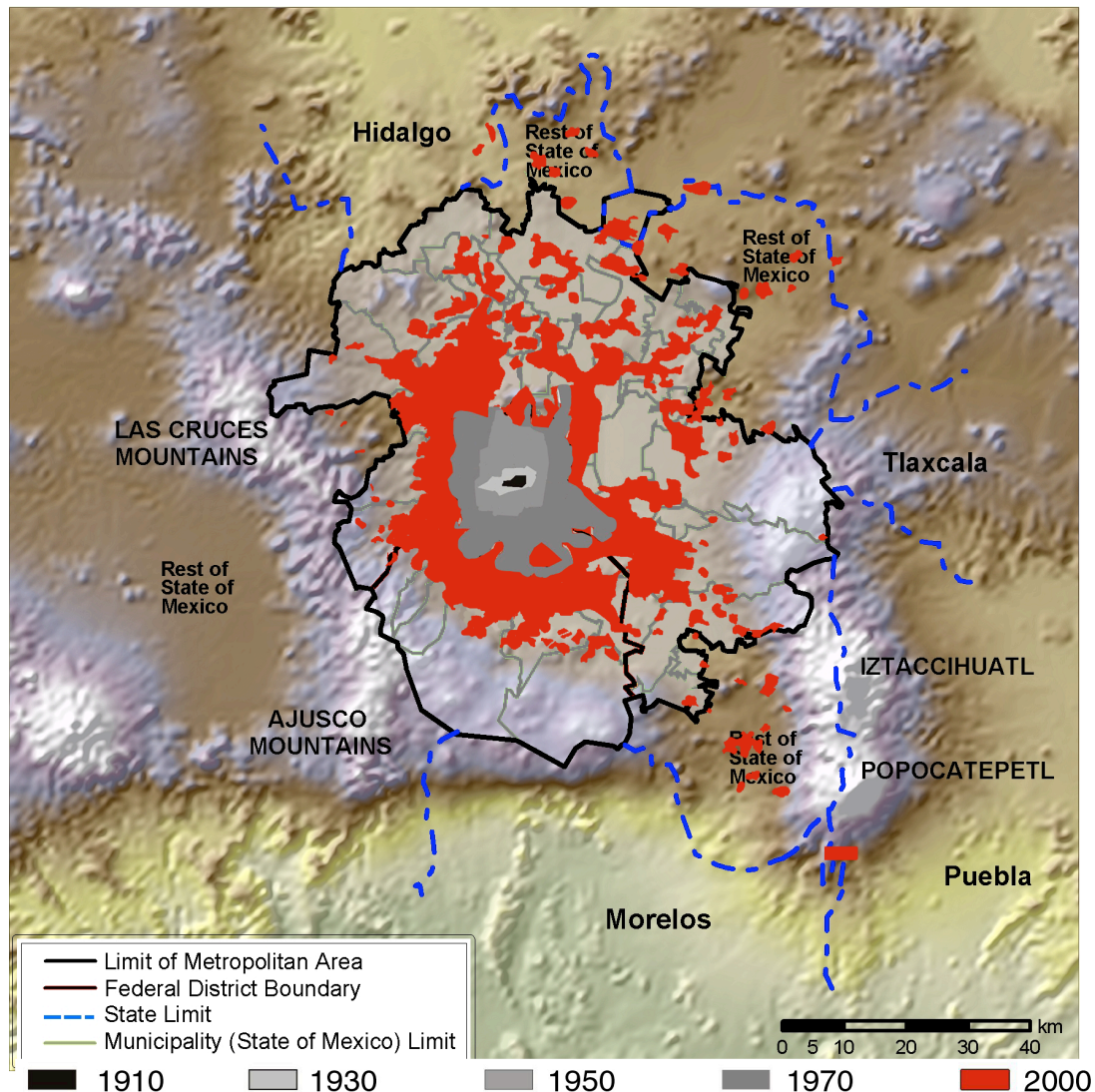
***Collaborative Research and Education Program  
involving Mexican, US and other international institutions***

<http://www.eaps.mit.edu/megacities>

<http://mce2.org>



# Topographical map of Mexico City Metropolitan Area showing the urban expansion



- Population Growth

- >18 million (2000):  
20-fold increase since 1900
  - Growth projection to >25 million (2010)

- Urban Sprawl

- >1500 km<sup>2</sup> (2000):  
10-fold increase since 1960
  - >Expansion to peripheral areas

- Geographic and Topographical Conditions

- >High altitude (2240m): less efficient combustion processes
  - >Mountains are a physical barrier for winds
  - >2nd largest megacity in the world
  - >Temperature inversions in the dry season

- Increases in Emissions Sources

# **Summary of MCMA-2003 Field Measurement Campaign**

- **Exploratory mission (February 2002)**
- **Intensive 5-week field measurement (Spring 2003)**
- **Special Session on “Megacity Impacts on Air Quality” at the Fall 2004 AGU Meeting, San Francisco, CA**
- **Special Issue of the MCMA 2003 Campaign in ACP (Atmospheric Chemistry and Physics)**
- **Participants**  
**30 institutions from Mexico, US and Europe**
- **Sponsors:**  
**Comisión Ambiental Metropolitana (CAM)**  
**Massachusetts Institute of Technology/ Alliance for Global Sustainability**  
**National Science Foundation (NSF, USA)**  
**Department of Energy (DOE, USA)**  
**Petroleos Mexicanos (PEMEX)**  
**Others**



# Aerial View of CENICA Supersite MCMA 2003



# ARI Mobile Laboratory

Base: T<sub>0</sub> (CENICA)

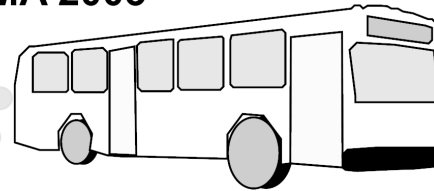




# CAMPAÑA MCMA-2003: ARI MOBILE LAB

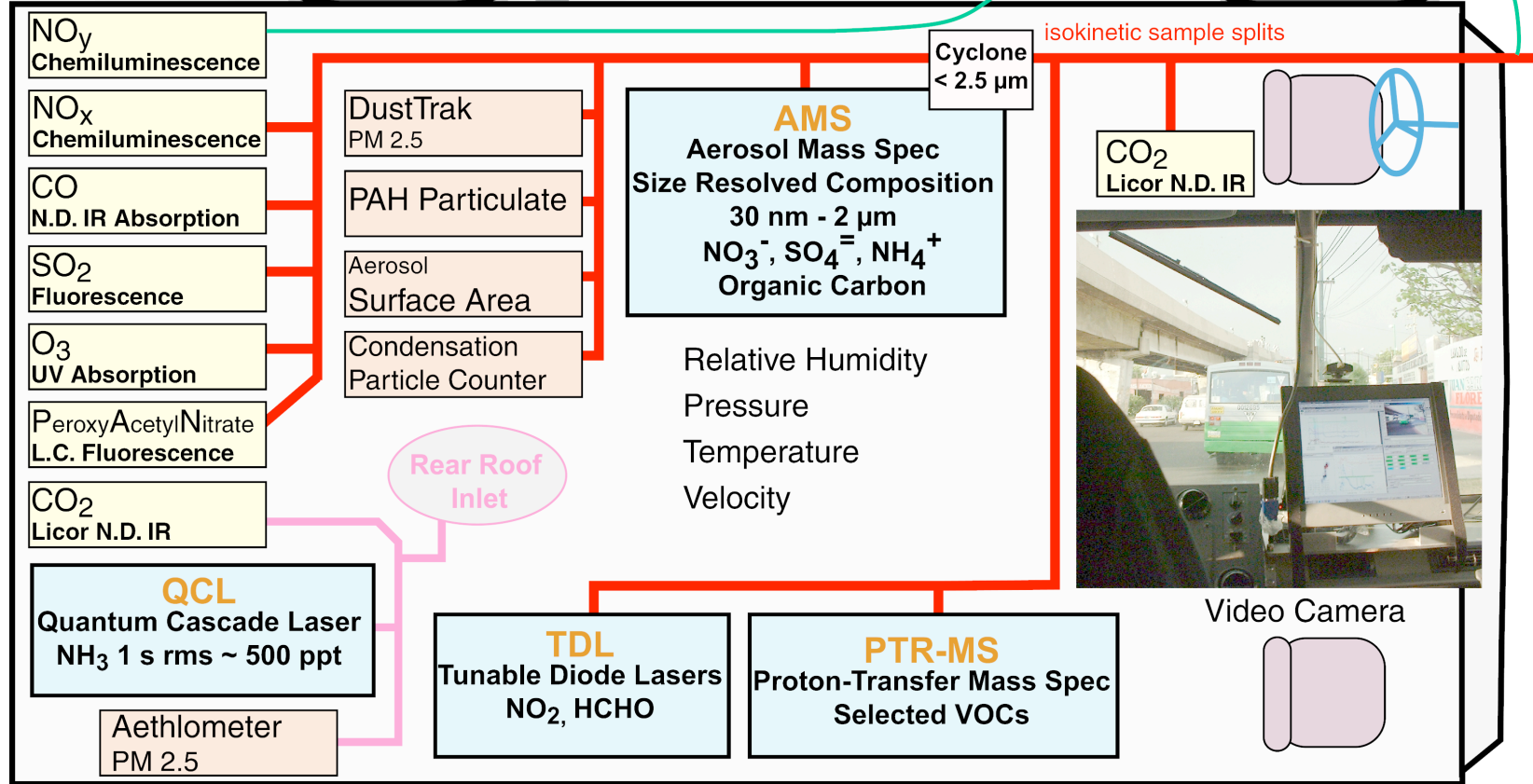


Aerodyne Mobile Lab  
MCMA 2003

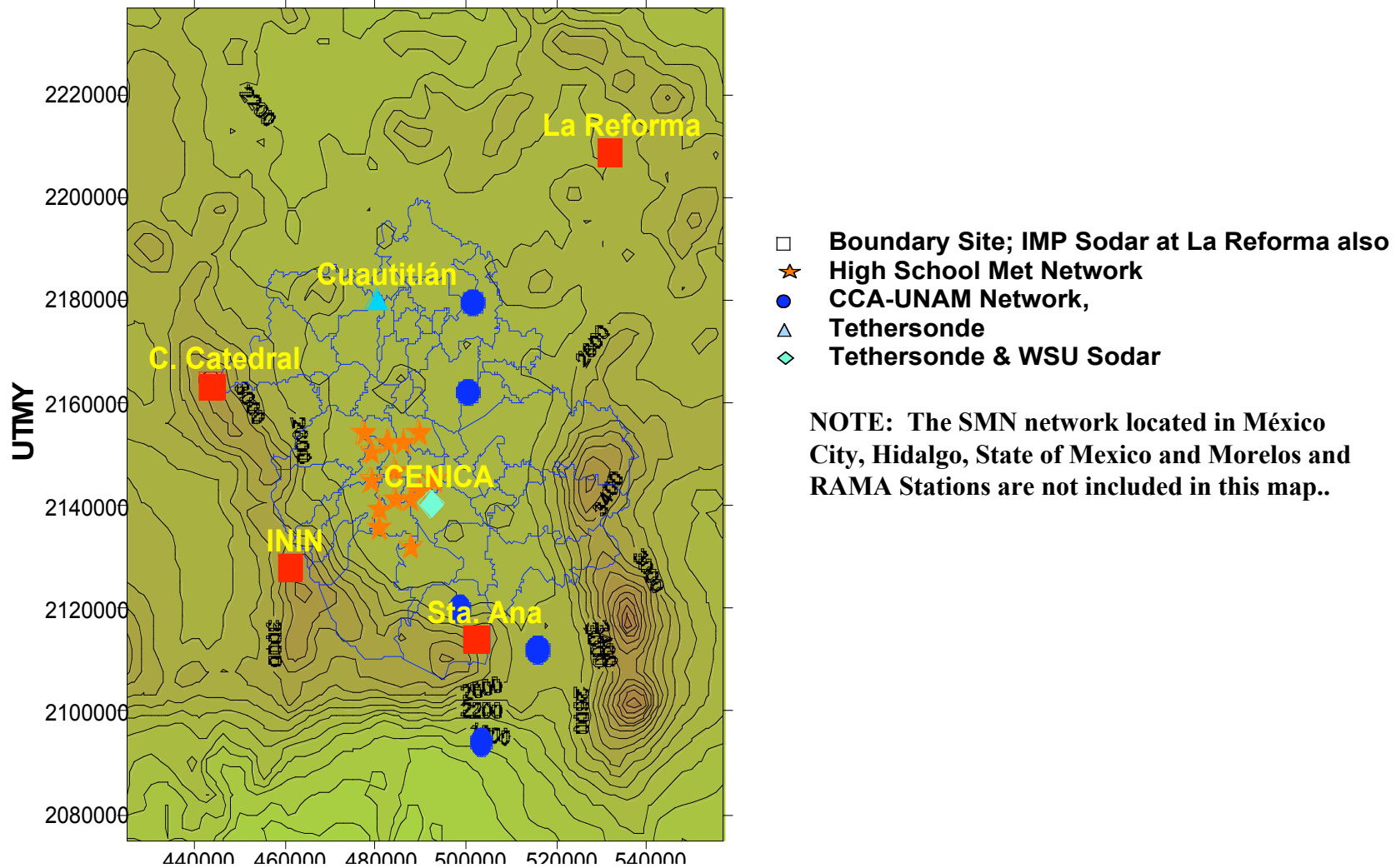


Roof  
Sun Photometer  
Anemometer  
GPS

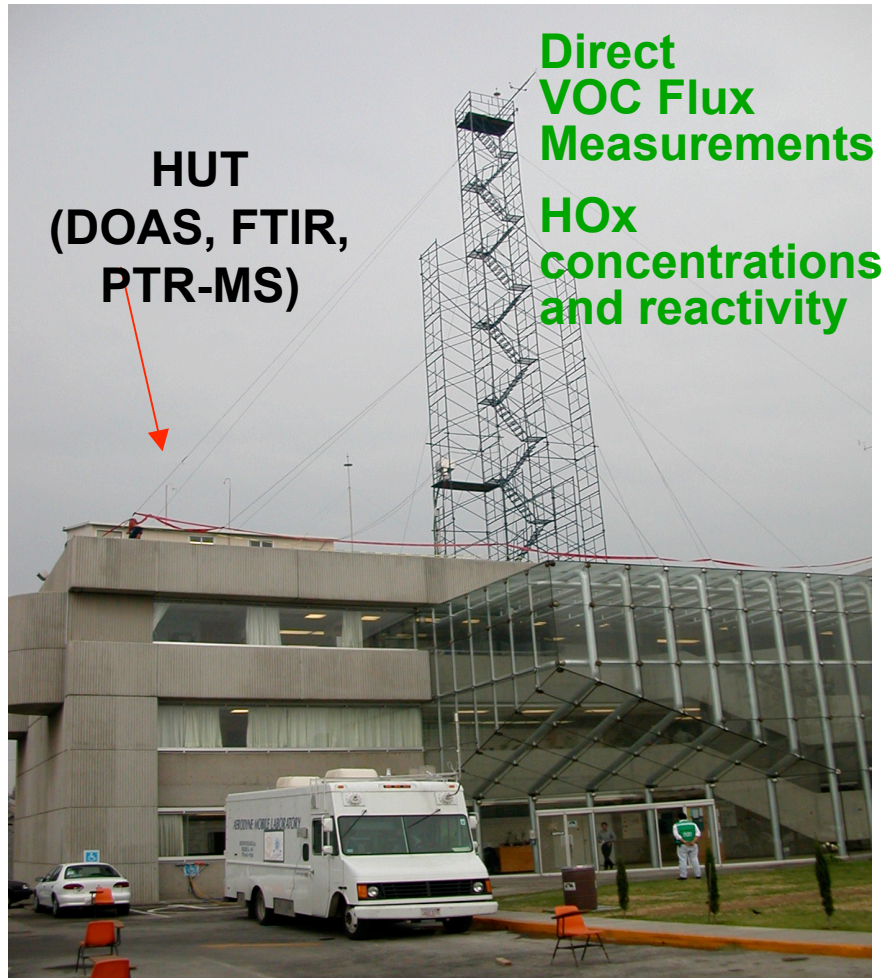
NO<sub>y</sub> converter



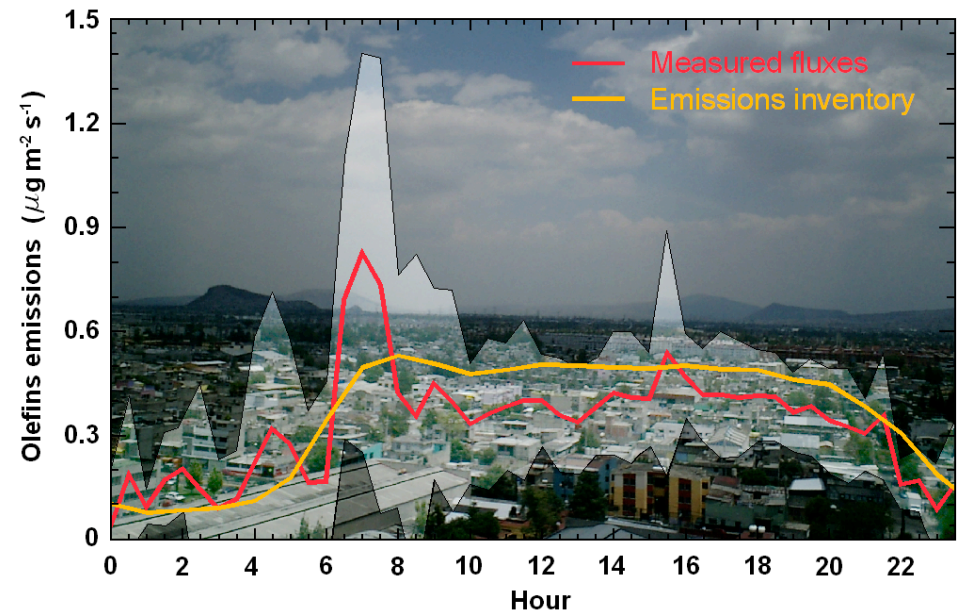
# Boundary Sites and Surface Meteorological Stations for the MCMA-2003 Campaign



# CENICA Supersite VOC Measurements during MCMA-2003



## Emission Inventory Comparison: Measured Olefin Flux vs Gridded Inventory





# DOAS + Spectroradiometry (MCMA-2003)



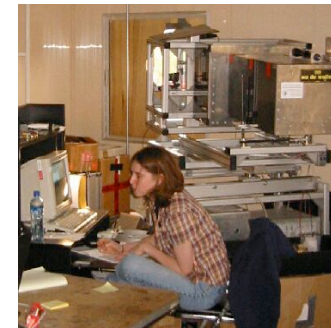
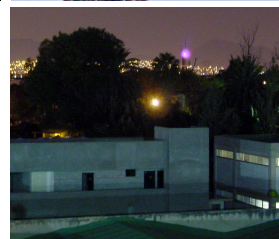
## Radiation:

- **Spectrometry**  
Actinic photon flux  
(incl. straylight)  
-> any J-value
- **Filterradiometry**  
J(NO<sub>2</sub>)



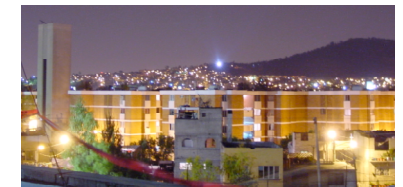
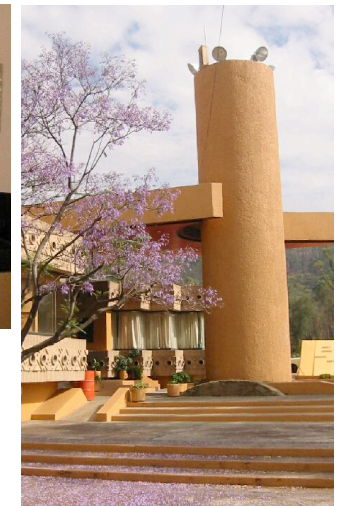
**DOAS-1**  
L= 860m  
H= 16m

- BTX, Styrene
- Benzaldehyde, Phenol
- Naphtalene
- NO<sub>2</sub>, HONO
- HCHO, O<sub>3</sub>, SO<sub>2</sub>



**DOAS-2**  
L= 4420m  
H= 70m

- HONO, HCHO, O<sub>3</sub>
- NO<sub>2</sub>, (NO<sub>3</sub>)
- SO<sub>2</sub>
- Glyoxal



East

South

South-West



# MCMA 2003 Field Measurement Campaign

## Preliminary findings

1. The MCMA atmosphere contains high levels of:
  - ? Highly reactive VOCs;
  - ? Nitrogen oxides ( $\text{NO} + \text{NO}_2 = \text{NO}_x$ );
  - ? Ammonia ( $\text{NH}_3$ );
  - ? Toxic air pollutants (e.g. formaldehyde, acetaldehyde, benzene, toluene, and PAHs).
2. Large concentrations of secondary PM composed primarily of oxidized organic species, ammonium nitrate and sulfate are correlated with atmospheric oxidant production.
3. The MCMA atmosphere can develop unhealthy levels of ozone and related oxidants surprisingly early (before noon), even on cloudy days.
4. Glyoxal was measured directly for the first time. Its rapid formation rate indicates there is missing smog chemistry.
5. MCMA motor vehicles are
  - ? the major source of  $\text{NO}_x$  emissions;
  - ? emit surprisingly high levels of formaldehyde and acetaldehyde;
  - ? newer gasoline-powered light duty vehicles are a source of NH emissions.

# DOAS measurement of Glyoxal as an indicator for fast VOC chemistry in urban air

HIGHLIGHTS OF THE RECENT LITERATURE

## EDITORS' CHOICE

edited by Gilbert Chin

### CLIMATE SCIENCE

#### Urban Air Quality

The oxidation of volatile organic compounds (VOCs) is an important step in the formation of photochemical smog in urban areas, but the rate at which VOCs are oxidized has been difficult to quantify. A reliable way to measure this rate would lead to improved prediction of smoke/fog events.

Volkamer et al. used differential optical absorption spectroscopy (DOAS) to make direct measurements of atmospheric glyoxal concentrations over Mexico City in the spring of 2003. They show that VOC oxidation, of which glyoxal is a product, begins about an hour after sunrise and continues throughout the day. These observations allow a lower limit to be placed on the rate of VOC oxidation and reveal that VOC chemistry is active throughout sunlit hours. On the basis of these results, satellite measurements of glyoxal appear to be feasible, which would support the identification of photochemical hot spots in the atmosphere. — HJS



Smog above Mexico City.

Geophys. Res. Lett. 32, 10.1029/2005GL022616 (2005).

**Volkamer R, Molina LT,  
Molina MJ, Shirley T,  
Brune WH (2005)**

**DOAS measurement of  
Glyoxal as an indicator  
for fast VOC chemistry in  
urban air**

**GRL, 32, doi:  
10.1029/2005GL022616**

**SCIENCE, June 3 2005, VOL 308, 1379**

<http://www.sciencemag.org/>

# Scientific Objectives

## MCMA-2006 Campaign

1. To characterize primary fine PM and secondary PM precursor gases at CENICA and selected downwind sites using high time resolution, state-of-the art instruments on board the Aerodyne Mobile Laboratory as well as deployed at the CENICA supersite.
2. To evaluate medium range transport from MCMA to borders sites, using chemical characterization of PM<sub>2.5</sub>, PM<sub>10</sub> and TSP by simultaneous sampling at the three sites (T0, T1 and T2) with high, medium and low volume samplers.
3. To evaluate the total concentration, gas and particulate phases of Mercury at T0 and T1 sites.

# Scientific Objectives

## MCMA-2006 Campaign

4. To quantify the Tula's refinery apportionment to the total particles and gaseous emissions associated to the GHE, and to assess the local and regional environmental impacts at short and long term, as a collaborative effort within the MILAGRO 2006 Project.
5. To characterize the chemical and physical composition of PM<sub>2.5</sub> in the MCMA and its diurnal variation, and to speciate VOCs from samples taken from industrial stacks located in the MCMA.
6. To measure the Aerosol Optical Thickness (AOT) using sun photometers in 5 to 6 different locations over the urban area than is currently available in the AERONET, in order to provide a more consistent validation of the aerosol optical thickness product retrieved from MODIS satellite.

# Scientific Objectives

## MCMA-2006 Campaign

7. To measure the vertical profiles of ozone, VOCs, and meteorological parameters using tethered balloon and lidar at the CENICA supersite.
8. To provide meteorological support for MILAGRO field campaign. This includes analysis of plume dispersion from the Mexico City basin for: pre-campaign planning, campaign forecasting and post-campaign analysis.
9. To develop methods for source identification based on particle trajectories.

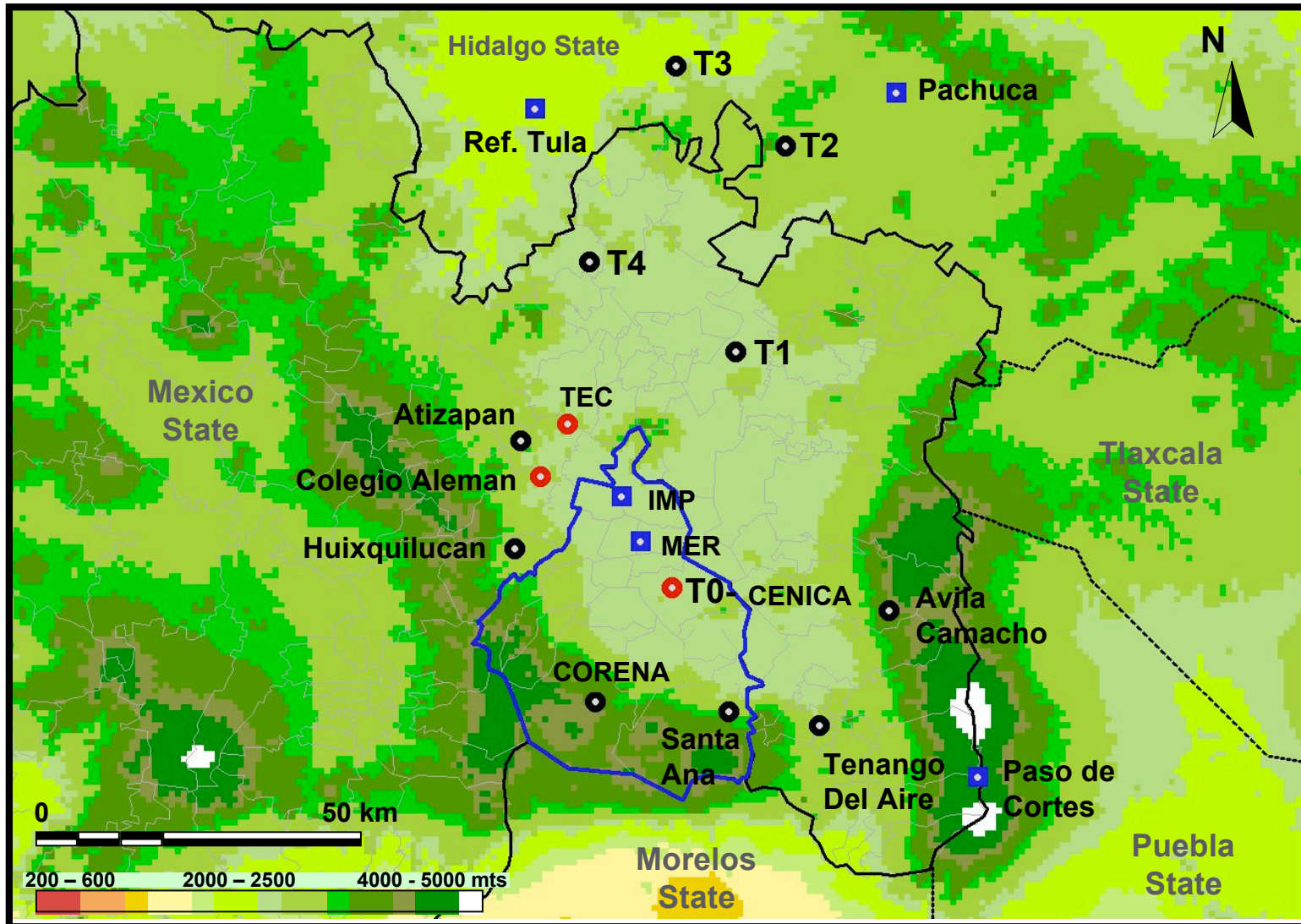
# Scientific Objectives

## MCMA-2006 Campaign

10. To study the health impacts of air pollutants:
  - A: To conduct exposure assessment study of children and young adults in three different areas along the path of transportation of air pollutants from Mexico City to the neighboring states of Mexico and Hidalgo.
  - B. To evaluate the oxidative potential of urban PMs collected in three different zones using Electron Paramagnetic Resonance (EPR) technology and its correlation with the potential of inducing *in vitro* DNA degradation.



# MILAGRO Monitoring Sites

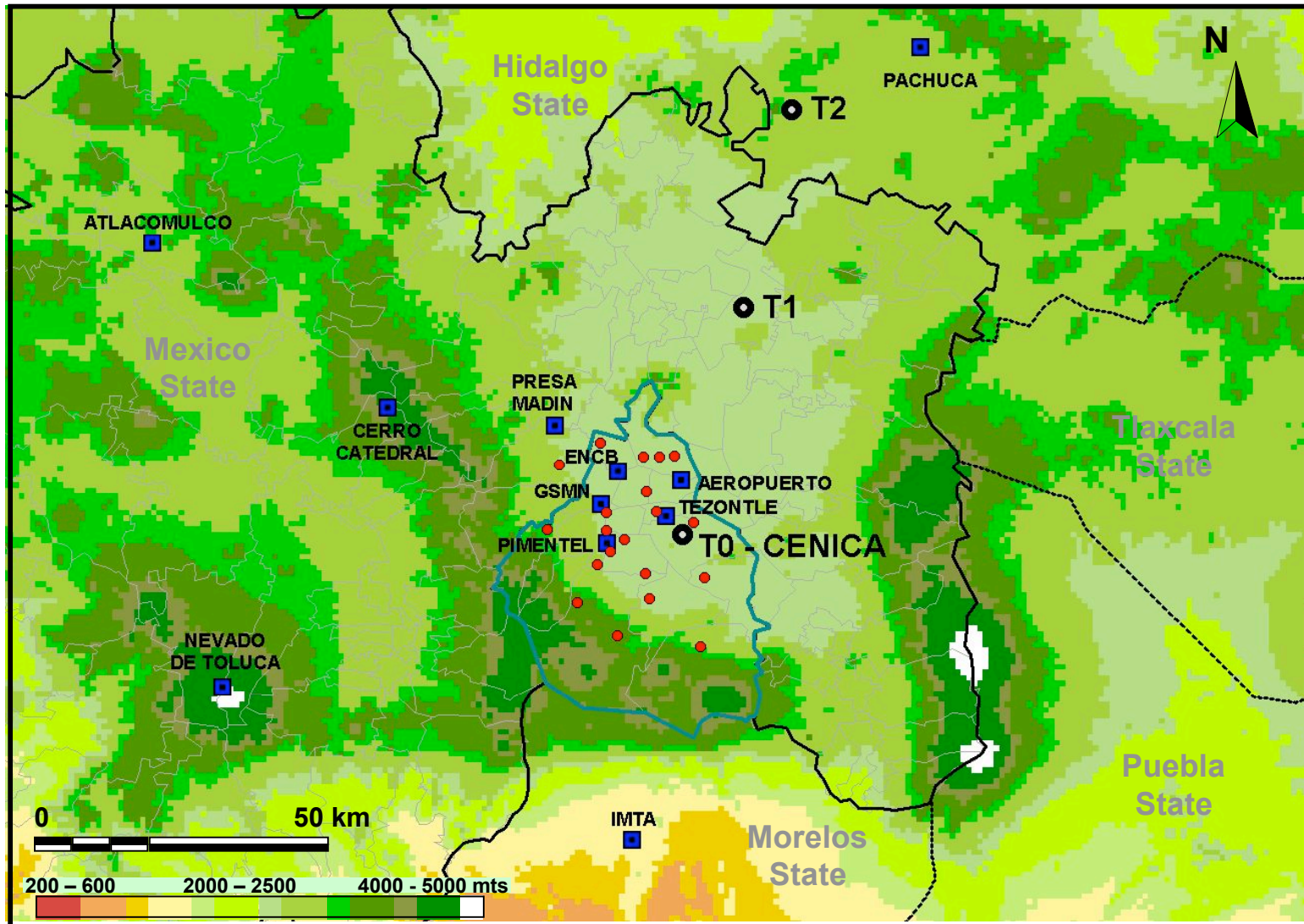


● Fixed site

● Mobile site

■ Other measurements

# Meteorological Monitoring Sites



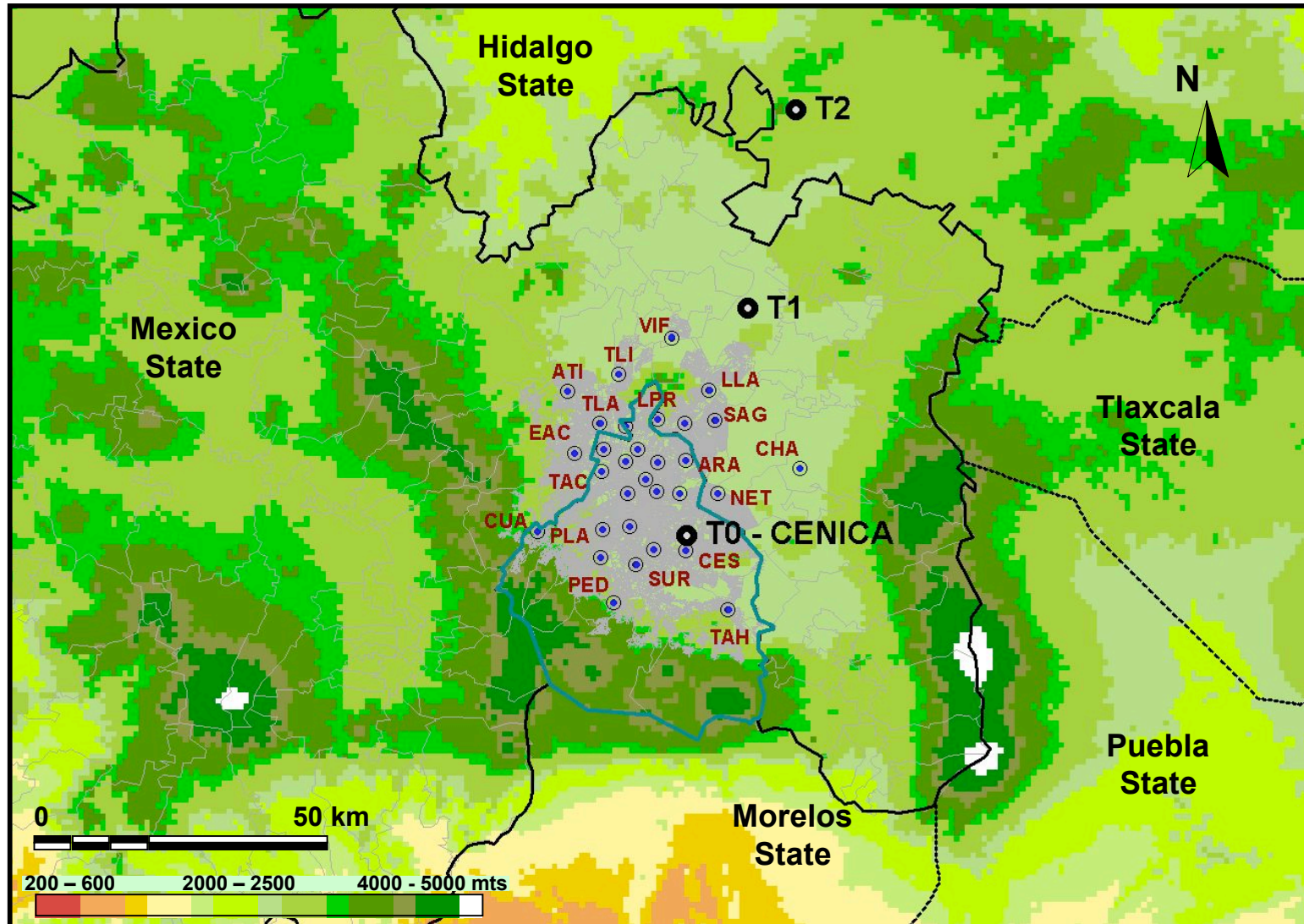
■ EHCA (SMN)

● PEMBU (UNAM)

● Other measurements



# RAMA Automatic Monitoring Stations



● RAMA station

● Other measurements

# EDUCATIONAL PROGRAM

**The objective of these activities is to contribute to the education of students**

- **High-school students**

- Tours to the sites for GLOBE schools
- GLOBE = Global Learning and Observations to Benefit the Environment ([www.globe.gov](http://www.globe.gov))
- "GLOBE is a worldwide hands-on, primary and secondary school-based education and science program". Students follow protocols to monitor environmental variables and post their findings in internet. They also have access to other schools measurements around the world.
- "GLOBE is managed by UCAR/CSU with support from NASA, NSF, the US Dept. of State"
- There are at least 45 schools (mainly highschools) in Mexico City associated to GLOBE.

- **Undergraduate students**

- Atmospheric Chemistry class @ UNAM
- Internships for exchange students

- **Graduate students / technicians**

- Workshops on specific technical issues
- Examples: "Air quality modeling in Mexico City", " Aerosol Lifetimes and Use of Natural Radioactivity", "Instrumentation for atmospheric chemistry measurements", "Mobile Air Quality Measurements"

# COMMUNICATION PROGRAM

**The objective of these activities is to inform the public about the goals, methods and findings of MILAGRO.**

- **Universum (UNAM science museum)**
  - March will be dedicated to MILAGRO (9 lectures, exposition, workshops)
- **¿Cómo ves? (science communication magazine)**
  - Notes in their News section before the campaign and updates after the campaign
  - Special report
- **Radio interviews (University radio stations)**
  - Interviews to participant scientists about their work and findings
- **Videos**
  - Showing the sites, and instruments. They can also include interviews. If the videos are produced by UNAM or UAEM, they might be shown at the University's TV channel.

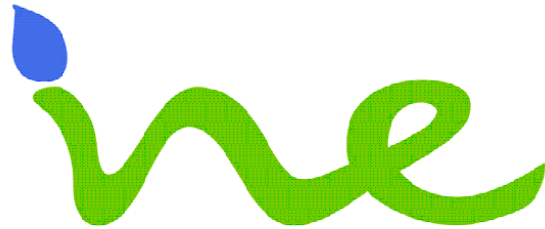
# Measurement Plan

## Excel Tables:

- Urban sites
- Mobile Units
- Mobile Labs
- Laboratory Analysis
- Modeling

# CENICA

## National Center for Environmental Research and Training



**Instituto Nacional de Ecología**

DIRECCIÓN GENERAL DEL CENTRO NACIONAL DE  
INVESTIGACIÓN Y CAPACITACIÓN AMBIENTAL

[www.ine.gob.mx](http://www.ine.gob.mx)

[www.semarnat.gob.mx](http://www.semarnat.gob.mx)



### **CENICA is part of the National Institute of Ecology**

- Created in 1995
- Approx. 40 staff
- The technical and scientific branch of SEMARNAT  
(Federal Ministry of Environment )
- Technical support to the state's air quality monitoring station
- Technical training to states staff





**CENICA is located in one of the buildings of the Iztapalapa Campus of the Autonomous Metropolitan University (a public university) as part of a cooperative agreement**

**UAM Iztapalapa:  
30 years old  
Approximately 12,000 students  
(both undergraduate and graduate)**

**Iztapalapa  
One of the 16  
“Delegaciones” of Mexico  
city most populated  
Delegación of Mexico City  
(1.7 million):**

[www.uam.mx](http://www.uam.mx)

[www.iztapalapa.uam.mx](http://www.iztapalapa.uam.mx)

[www.iztapalapa.df.gob.mx](http://www.iztapalapa.df.gob.mx)



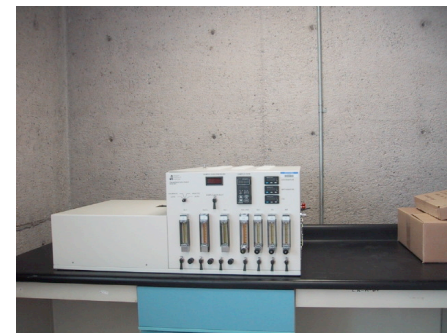
# CENICA

**Scientific research and short studies on air pollution, contaminated soils and hazardous waste**

➤ **Laboratories\* for chemical and physical analysis of soils, hazardous waste and suspended particles:**

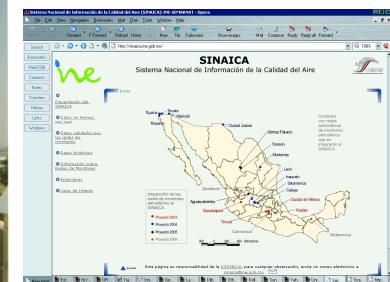
- **Elemental analysis: ICP-optical, Atomic adsorption, XRF**
- **HPLC-ion chromatography**
- **GC-MS for semivolatile organics**
- **Gravimetric determination of suspended particles**
- **OC/EC by optical thermal reflectance**
- **Scanning electron Microscope with EDS**

**\* most of them with accreditation of the Mexican Entity**



# CENICA: Infrastructure

- Personal exposure equipment
- GC-FID for VOCs analysis (canisters and continuous monitoring)
- Tethered balloon (ozone and meteorological sondes)
- Manual sampling of suspended particles (high vol, minivol, Rass)
- One mobile unit and two air monitoring stations (one in UAM-I)
  - Criteria pollutants and meteorological parameters





# Preparation for MILAGRO

- **Coordination with local institutions**
  - T0: UAMI
  - T1: UTTEC
  - T2: Owner of La Bisnaga
  
  - Boundary sites for mobile units: different institutions (public and private)
  
  - Local governments: coordination and support
    - State of Mexico, Mexico City, Hidalgo, Veracruz
  
  - Federal government: coordinations, permits, authorization and support
    - SEMARNAT (meteorology), SCT (communications and aviation), SHCP (customs), SRE (foreign affairs), CNSNS (radioactive materials)

# Preparation for MILAGRO (2)

- **Infrastructure**
  - Power, internet, telephone
  - Food at sites (where to buy)
  - Working and storage space
  - Maintenance and cleaning
- **Transportation**
  - Contracted buses and drivers (distribute the cost)
- **Housing**
  - Recommended sites:
    - T0: Royal Plaza
    - T1 y T2: Zumpango sports club and Crowne Plaza Pachuca
- **Safety and health**
  - Guidelines for safety and health issues proposed by Mexican part (update 2003)
    - No driving
    - Authorized taxis
    - No eating from streets vendors
    - **Medical records**

# Take home message

- **follow the guidelines** and instructions
- **send all your information:** instruments requirements and specifications, in the proposed format... **URGENT**

This information is crucial to define the infrastructure needs, do adequations and preparations.