



## THE MILAGRO CAMPAIGN

Megacity Initiative:  
Local and Global Research Observations

### MILAGRO CAMPAIGN: GEOGRAPHIC COVERAGE



**INTEX-B**  
NASA DC-8  
J-31, Satellites

**MIRAGE-Mex**  
NSF C-130,  
King Air, Supersite

**MAX-Mex**  
DOE G-1,  
King Air, Supersite

**MCMA-2006**  
Supersites,  
Mobile Laboratories

The MILAGRO Campaign is integrated by four field campaigns that will occur simultaneously during the month of March 2006 and will involve coordinated aircraft and ground-based measurements supported by extensive modeling and satellite observations.

#### MCMA-2006 (Mexico City Metropolitan Area - 2006)

The Mexico City Metropolitan Area – 2006 (MCMA-2006) campaign is led by Dr. Luisa T. Molina of the Molina Center for Energy and the Environment (MCE2) and Massachusetts Institute of Technology. The funding for the MCMA-2006 Study was provided by several Mexican agencies, which include the Secretariat of Environment and Natural Resources through the National Institute of Ecology (Semarnat-INE), the National Council of Science and Technology (CONACYT), the Metropolitan Environmental Commission (CAM), Mexican Petroleum (PEMEX), as well as the National Science Foundation (NSF) and the Department of Energy (DOE) of the United States and several European research agencies.

The overall purpose of MCMA-2006 is to provide a scientific base for devising emissions evaluation and control policies that are intended for the improvement of air quality in the MCMA by developing scientific information that helps to better understand the generation processes of pollutants in the MCMA, their dispersal, transport and transformation in the atmosphere, the exposure patterns of the general population to these pollutants, and the effects on human health.

The required data on aerosols, VOCs and other gases, meteorology, and solar radiation will be mostly gathered at the T0 supersite (Mexican Petroleum Institute, IMP) and at other sites located in Tula, Hidalgo and Paso de Cortés, in the state of Mexico. A flux tower will be installed at the city center to conduct additional measurements in combination with a highly capable mobile laboratory (from Aerodyne Research Inc.) and 8 fixed units (from Mexican institutions), deployed throughout the MCMA at representative urban and boundary sites.

Similar to previous campaigns, the findings relevant to the design of policies will be identified and presented to the representatives of the Mexican government.

#### MAX-Mex (Megacity Aerosol Experiment in Mexico City)

The Megacity Aerosol Experiment (MAX-Mex) is led by Dr. Jeffrey Gaffney from Argonne National Laboratory, operated by the U.S. Department of Energy (DOE), and is funded by the DOE Atmospheric Science Program (ASP).

The planned field study will focus on chemical, physical, and optical characterization of the aerosols, on aerosol transformations including aging of the black carbon during outflow into the region, and on the effects of the megacity aerosol plume on the regional radiative balance in and near this megacity source. The MAX-Mex program will use two aircraft:

- The DOE Gulfstream aircraft (G-1), a well-instrumented airplane to measure aerosol properties and precursor gas contributions.
- The King Air aircraft will deploy a Lidar in order to provide two-dimensional (height-distance) information on aerosol distribution and plume extents.

In addition, different types of equipment will be installed at the three ground-based supersites, again focusing on aerosol emission and formation, properties, chemical and physical transformations, and effects on climate.

#### MIRAGE-Mex (Megacity Impacts on Regional and Global Environments)

The Megacity Impacts on Regional and Global Environments (MIRAGE) program is a multidisciplinary activity led by Dr. Sasha Madronich of the National Center for Atmospheric Research (NCAR). The project is primarily funded by the U.S. National Science Foundation (NSF).

The overall goal of MIRAGE is to increase the understanding of how the world's megacities affect regional and global air chemistry, and how this in turn can influence weather and climate.

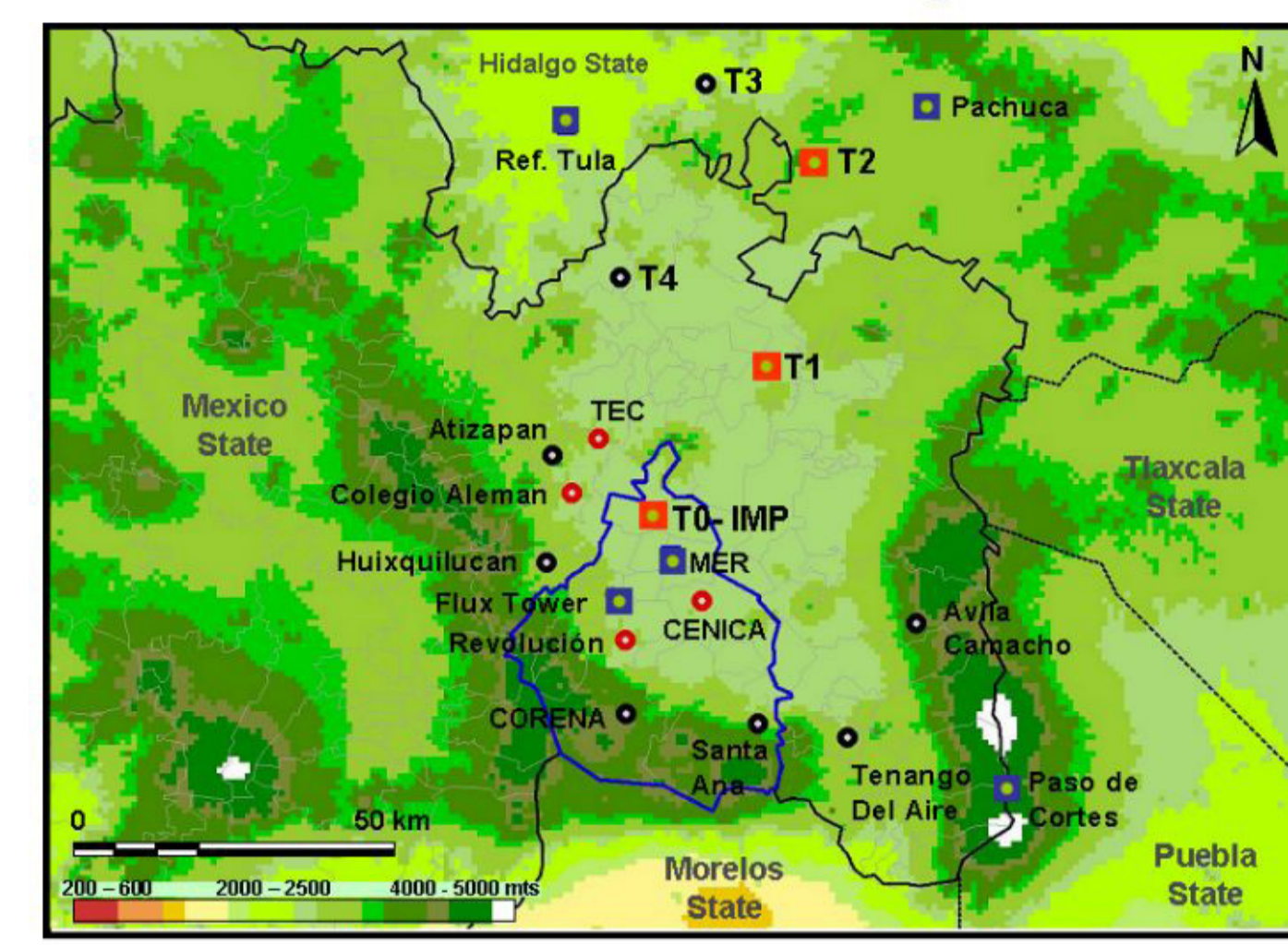
To achieve these goals, an extensive series of observations of the chemical and physical state of the atmosphere in the region surrounding Mexico City will be made during MILAGRO. Flying from its base in Veracruz, the NSF C-130 aircraft will sample air at different distances from Mexico City to measure how gases and particles "age" during transport, specifically tracking those chemical, physical, and optical properties that have the potential to affect air quality, weather, and climate on large geographic scales. An additional aircraft (Twin Otter, also based in Veracruz) will conduct studies of fires and their effects on the local and regional composition of the atmosphere. Other MIRAGE-Mex researchers will be located at the T1 site at Tecámac on the northern boundary of Mexico City, to examine the physical and chemical properties of the air exiting the city.

#### INTEX-B (Intercontinental Chemical Transport Experiment - Phase B)

The Intercontinental Chemical Transport Experiment - Phase B (INTEX-B) is led by Dr. Hanwant Singh of the U.S. National Aeronautics and Space Administration (NASA). The project is funded by NASA with additional support and contributions from NSF and international partner countries. The INTEX-B campaign will emphasize the regional-to-global aspect of MILAGRO with observations from two aircraft, a DC-8 and a J-31.

The larger DC-8 aircraft will provide comprehensive observations of chemistry and aerosols using both direct air sampling and laser remote sensing. Operating from its base in Houston, Texas, the DC-8 will interact with other MILAGRO aircraft to locate and sample pollution associated with the Mexico City Metropolitan Area and will then extend observations well downstream over the Gulf of Mexico. The smaller J-31 will focus exclusively on aerosols and their radiative impacts. Based in Veracruz, the J-31 will seek to examine the impact of aerosols closer to Mexico City pollution sources. The DC-8 and J-31 will fly in coordination with NASA satellites (Aura, Aqua, and Terra) to provide ground truth as well as to provide a bridge between the wealth of detail offered by the MILAGRO observations and the broad regional-to-global perspective provided by satellites.

### MILAGRO: Monitoring Sites



### Ground Based Sites

The measurements will be conducted with a wide range of instruments at ground sites, on aircraft, and satellites. The three main ground locations are: Mexican Petroleum Institute ("T0") in the MCMA, Technological University of Tecámac in the State of Mexico ("T1") and La Bisnaga Ranch, north of Tizayuca in the State of Hidalgo ("T2").

The designations "T0", "T1", and "T2" refer to the transport of urban plume to different points in space and time. Ground sites are ideal for continuous detailed measurements of a large number of species and properties. At each of the sites, standard monitoring and specialized equipment will be installed. At some sites sondes and balloons with instruments to measure meteorological parameters, ozone, and hydrocarbons, will be used.

Additional platforms in or near Mexico City include mobile vans containing scientific laboratories, as well as mobile and stationary upward-looking lasers (lidars). The measurements will be made over a period of 30 days, 24 hours a day

### MILAGRO CAMPAIGN: SUPERSITES



### Educational Activities

The MILAGRO Campaign recognizes the need to contribute to the education and training of young investigators, to raise social awareness toward atmospheric pollution problems, and to disseminate the results of the measurement campaign to the scientific community as well as policy makers and the general public.

With this in mind, a series of education and outreach activities have been set up to be carried out in parallel to the scientific activities conducted by MILAGRO researchers working at the field sites. These activities include poster exhibits, presentations and talks with students, professors and the general public, guided tours of the measurement sites, web-based information and outreach, scientific workshops on the function and use of the equipment being deployed in MILAGRO, and a poster and essay contest for junior and senior high students on atmospheric pollution.

### EXPECTED BENEFITS

The results derived from the MILAGRO Campaign will have considerable scientific and technological significance. Moreover, this environmental effort will prove very useful for the identification of policy-relevant research findings that will help devise emissions control policies in megacities, particularly in the MCMA. A few of the expected benefits are:

- The MILAGRO 2006 Campaign is the first assessment of regional air quality of the MCMA that will consider pollutants both entering and exiting the city.
- It will provide a better understanding of the relative importance of different emissions sources (urban, biomass burning, natural).
- It will contribute to the improvement of meteorological and air quality models.
- It will help validate local emissions inventories.
- It will help acquire a better understanding of processes that transform and remove pollution in the MCMA.
- It will provide educational opportunities for students participating in the campaign to expand and consolidate their knowledge by having access to scientific data and state-of-the-art technology.
- It will promote further collaboration opportunities for researchers, government officials and technical personnel from participating state governments.

### Introduction

The MILAGRO Campaign is an international scientific collaborative effort focused on the study of the local, regional and global impact of air pollution in a megacity, using as a case study the Mexico City Metropolitan Area (MCMA) and its surrounding areas.

### Why select Mexico City Metropolitan Area as the case study?

The Mexico City Metropolitan Area was selected as a case study for the MILAGRO Campaign for the following reasons:

- Tropical latitude similar to other megacities –MCMA receives a large amount of incoming solar radiation all year long making its atmosphere extremely active photochemically, which helps to determine the transformation of atmospheric pollutants.
- The existence of reliable urban and air quality measurement records.
- Previous experiences on several projects with excellent scientific collaboration between Mexican and international scientists.
- The existence of optimal logistical infrastructure.
- Information from previous research campaigns, among them the most recent in 2003 (MCMA-2003 Campaign).

### Goals of the MILAGRO Campaign

The overall goals of the MILAGRO Campaign are:

- To study the transformation and transport of air pollutants generated by megacities, using as case study the Mexico City Metropolitan Area, and
- To analyze the local, regional and global impacts of these pollutants through ground-based measurements and the use of aircraft and satellites, other gases, aerosols, meteorology, solar radiation, and meteorological and air quality models.

This will result in the compilation of a large amount of information, some until now unknown, regarding the physical and chemical processes of the atmosphere in a megacity and its impacts at local, regional and global levels.

The MILAGRO science teams have spent the past two years designing the four mission components so that they come together into a comprehensive measurement plan. This plan takes into account the types of instruments, sample-frequency and geographical coverage of the project, helping to leverage the contributions of the participant agencies and institutions in an optimal and non-overlapping manner.

The aircraft measurement teams have developed concerted flight plans for the six participating aircraft in order to characterize the spatial extent of the plume, quantify gas-aerosol-radiation processes in the evolving plume, and ensure high data quality by intercomparison flights. Similarly, the ground-based measurement teams have selected three supersites (T0, T1 and T2) to characterize the chemical/physical transformations and the ultimate fate of pollutants exported from urban areas.

### MILAGRO CAMPAIGN: AIRCRAFT

Six airplanes:

- Based in Houston  
– DC-8



- Based in Veracruz  
– G-1  
– C-130  
– J-31  
– King Air  
– Twin Otter

