Megacity Aerosol Experiments - Mexico City 2006 (MAX-Mex 2006)

Jeff Gaffney and Nancy Marley

Atmospheric Research Section

Environmental Research Division

Argonne National Laboratory

Argonne, IL 60439

gaffney@anl.gov/marley@anl.gov

MEGACITIES AND MINI-MEGACITIES MAJOR SOURCES OF AEROSOLS AND GREENHOUSE GASES

THESE SOURCES WILL BE CHANGING OVER TIME AS THE CITIES DEVELOP AND THE TECHNOLOGIES EVOLVE

CARBONACEOUS AEROSOLS (ORGANIC & BLACK CARBON)

SULFATE, NITRATE – *FOSSIL FUEL COMBUSTION*

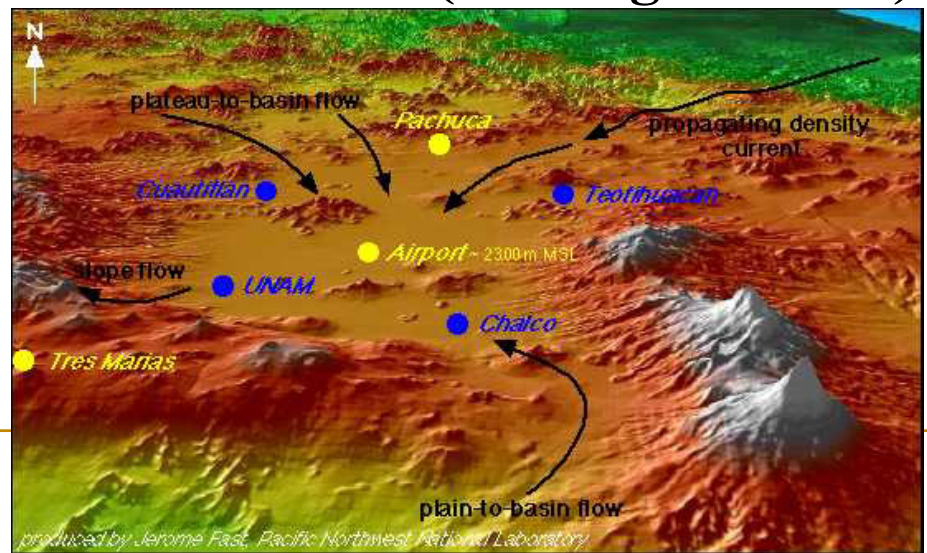
BLACK CARBON – *DIESEL AND TWO-CYCLE ENGINES, ETC.*

SECONDARY ORGANIC AEROSOLS – *FOSSIL AND BIOGENIC*

NEED TO BETTER CHARACTERIZE THE EMISSIONS AND THEIR PROPERTIES (SIZE, ETC.)

TARGET OF OPPORTUNITY - MEXICO CITY

- 2ND LARGEST MEGACITY (May be Numero Uno?)
- LARGEST MEGACITY IN NORTH AMERICA
- BASIN METEOROLOGY - COMPLEX TERRAIN
- INFRASTRUCTURE CONNECTIONS!
- SIZE REASONABLE FOR AIRCRAFT AND GROUND STUDY
- PRELIMINARY GROUND FIELD STUDIES – **1997 & 2003**
- **MEXICO CITY IS IN TRANSISTION (Getting Cleaner)**



Mexico City 1997

LOTS OF AEROSOLS – ON A DAILY BASIS!

> 50 $\mu g/m^3$ PM-2.5

50% Organic and Black Carbon (Soot)

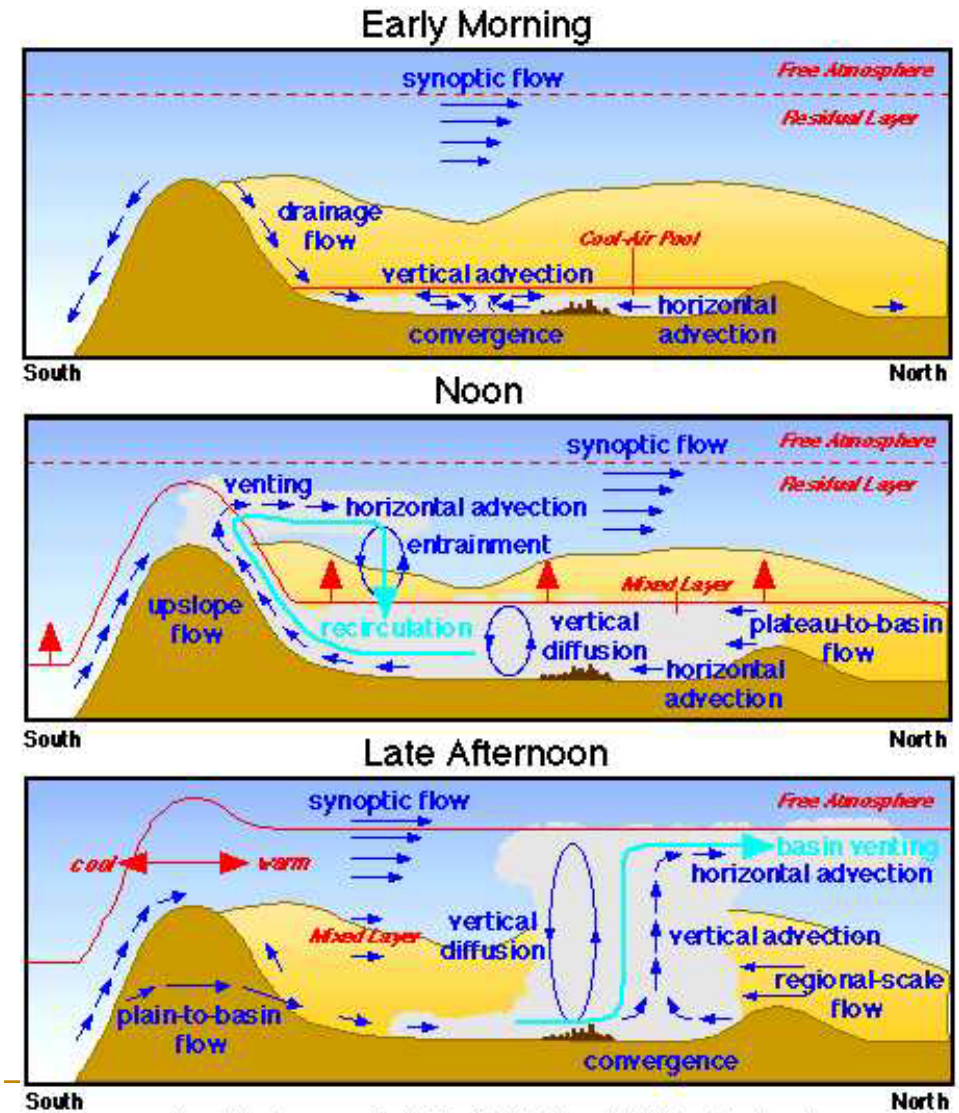
Fast NO to NO_2 Conversion & NH_4NO_3 Production

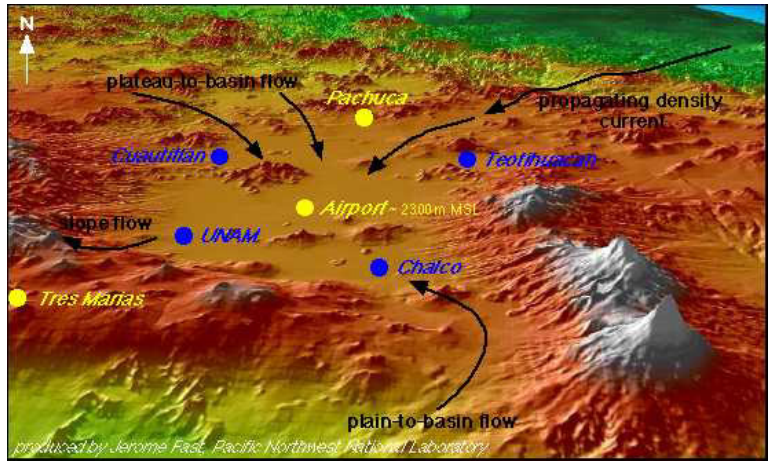
NH_3 Important!

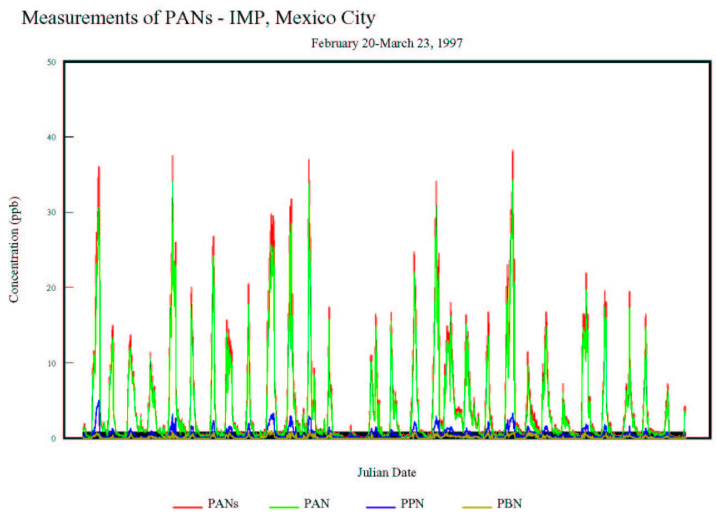
NH_3 Sources?

Mexico City 7:50 am 2/21/97

ASP METEOROLOGY – SHOWED STRONG DIURNAL TRANSPORT IN MEXICO CITY BASIN! TYPICAL?





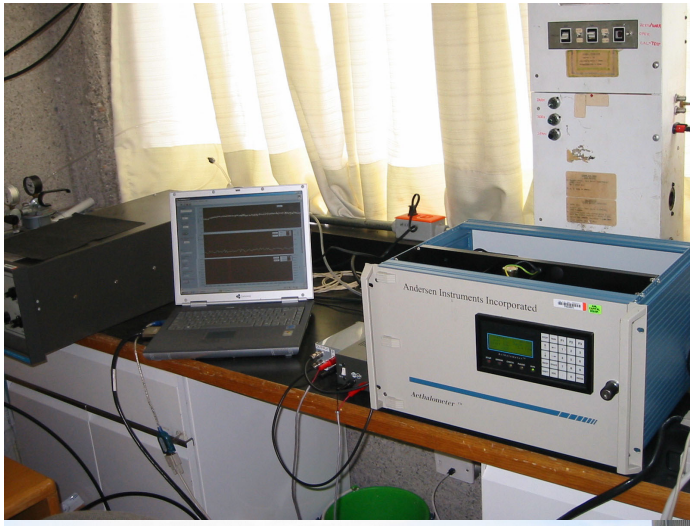


MEXICO CITY MEGACITY 2003 – APRIL

Collaborative Effort with MIT – Luisa and Mario Molina

Mexico City Metropolitan Area 2003 (MCMA 2003) Study

NARSTO Effort



Preliminary Findings of Note:

High Levels of Black Carbon – *Not Washed Out in Rain Event!*

Important – Regional Climate Implications

Obtained Radiation Data as well as Comprehensive Aerosol and Gas Phase Data Sets

- Aerosol Mass Spectrometers (Aerodyne)
- DOAS, LIDAR, TDLAS, MFRSR instrumentation

High Levels of Ammonia – Anti-correlated with NH_4NO_3

New Cars – NH_3 Sources!

April 2003 Intensive Field Measurement Campaign

- Fixed Site Aerosol Mass Spectrometer (Aerodyne)
- Tall flux tower (Washington State University)
- UV-VIS DOAS (University of Heidelberg/MIT)
- LIDAR (University of Berlin/MIT)
- Tethered balloon (CENICA)
- Vertical atmospheric radiosondes (IMP/MIT)
- Fast GC with Luminol detection method - PAN, NOx
- Aethalometer - Black Carbon
- Tunable-diode laser system for NH_3
- VOC Canister sampling
- Fast GC with OLEFIN Detector- isobutene
- Nitroarenes (Arey, Atkinson, UCRiverside)
- Organic Carbon/Elemental Carbon (LBNL)
- MFRSR & Aerosol Characterization (PNNL)
- PTRMS/Aerosol Mass Spectrometer– VOCs (PNNL)

CENICA SUPER SITE

POOLING RESOURCES THROUGH COLLABORATIVE FIELD WORK!

MCMA 2003 – MIT/AERODYNE MOBILE LAB

SPATIAL INFORMATION

- NH_3/HNO_3 /HONO/HCHO QC-TILDAS (Aerodyne)
- AEROSOL MS
- Chemiluminescent NOy instrument (MIT)
- PTR-MS (MSU)
- Real-time Canister/Cartridge Autosampler (WSU)
- PAN/NO_2
- AETHALOMETER (LBNL)

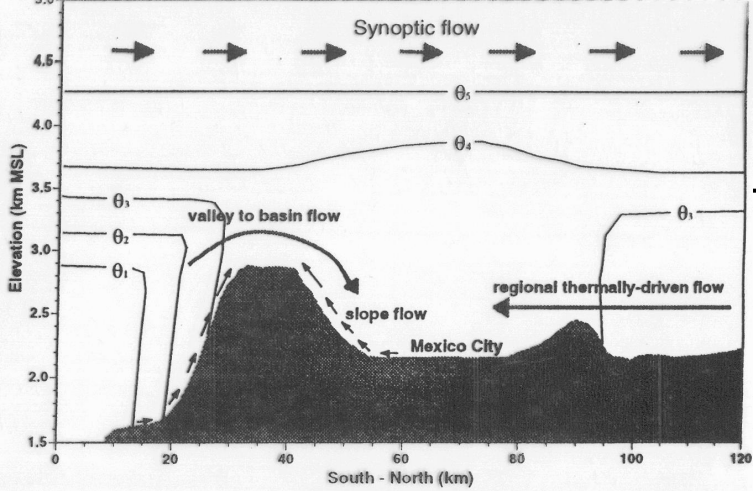


Figure 2. Schematic diagram of possible contributions to local flow patterns in the Mexico City area.

ASP Meteorologists

Showed Regional

"Flushing" of Basin

In Mexico City 1997 Study .

LIDAR AND AEROSOL DATA – BC, SULFATE, NITRATE, NH_3

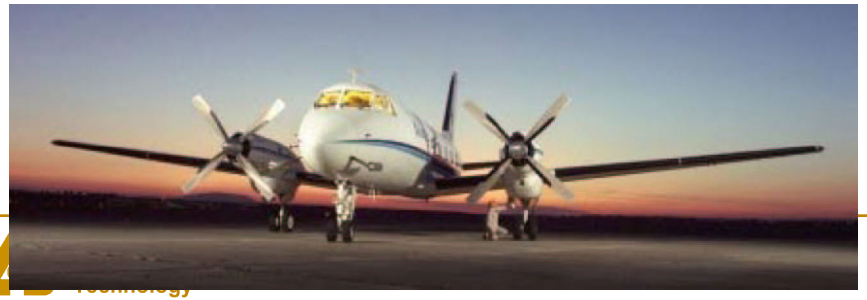
Single Particle Mass Spectrometers, DOAS, etc.

→Daily Flux Estimates of the Mexico City Plume!

→Comparison to Modeled Emissions

Megacity Aerosol eXperiment – Mexico City 2006
MAX-Mex 2006

PLANNING INITIATED FOR JOINT AIRCRAFT
& GROUND BASED STUDY
COLLABORATION WITH
MCMA 2006 – MIT/UCSD
MIRAGE 2006 – NSF
INTEX B – NASA
Mexican Scientist Studies



SOME FOCUS AREAS

DETAILED CHARACTERIZATION OF A MEGACITY PLUME

INTEGRATED AEROSOL SOURCE STRENGTHS FROM A MEGACITY – FOR MODEL COMPARISON

DOE G-1, NSF C-130, and NASA DC-8 Aircraft

NASA Airborne LIDAR – Lear Jet

ASP INFRASTRUCTURE (RASS, SODARS, LIDARS, MFRSRs)

Ground Based Measurements (Two or Three Sites)

SECONDARY AEROSOL FORMATION & AGING – DOWNWIND PLUME MEASUREMENTS – BLACK CARBON, ETC.

NIGHTTIME RADIATIVE FORCING – "SMUDGE POT" EFFECTS (Jacobsen 2002) – GROUND BASED MEASUREMENTS.

MAX-Mex 2006/MCMA 2006/MIRAGE-Mex

Molinas/Aerodyne/ANL
PNNL/BNL
NSF – MIRAGE COLLABORATION
NASA – DC-8 and Satellite Focus
Mexican Scientific Projects and Researchers

AIRCRAFT OPERATIONS VISIT IN MID MARCH

VERACRUZ SELECTED FOR FLIGHT OPERATIONS!

ONWARD TO FINDING SUITABLE GROUND SITES!

Proposed Mexico City Campaign Winter-Spring 2006 PNNL/BNL and others

Chris Doran, Larry Kleinman, Jim Barnard

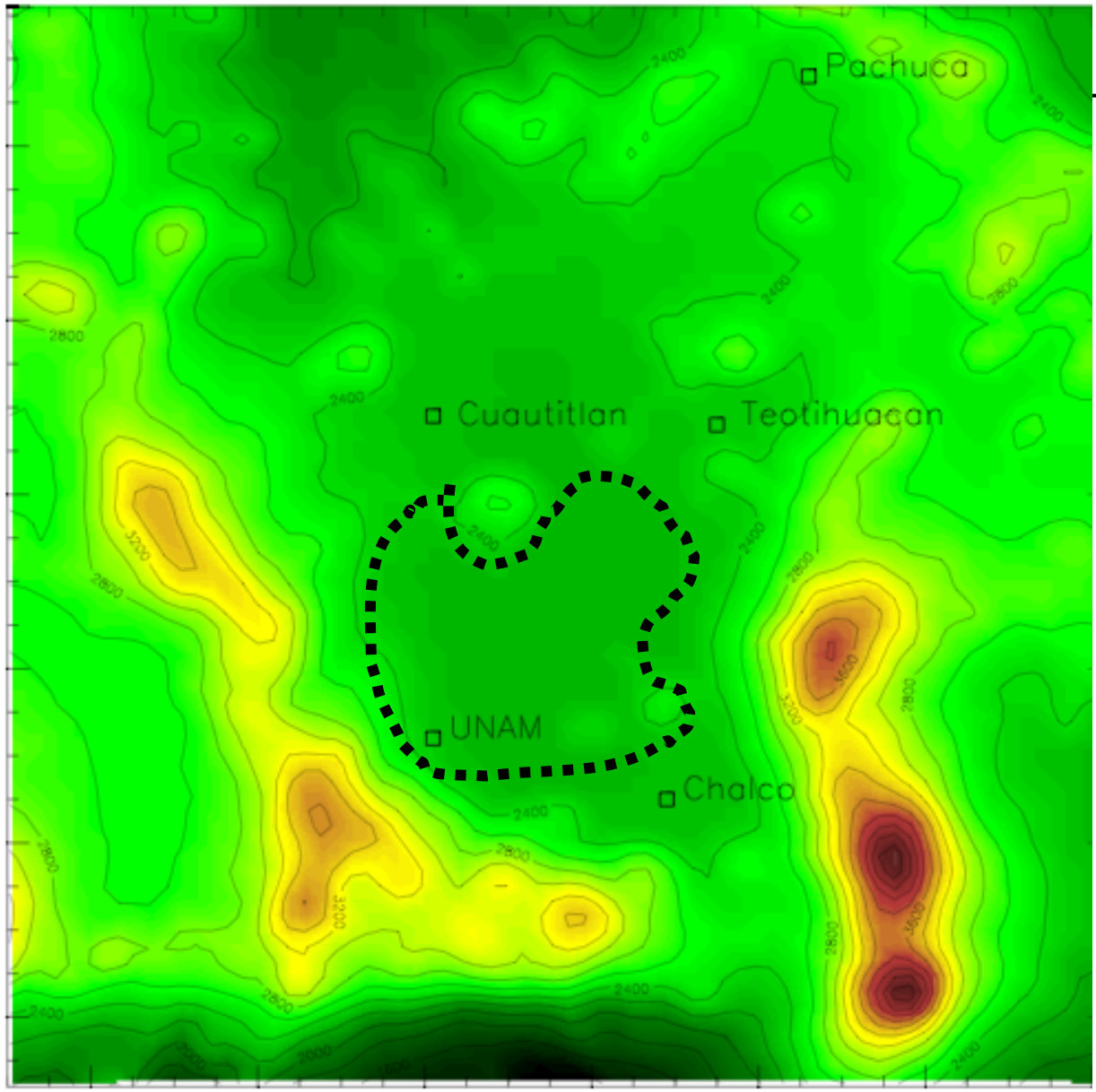
Objective:

To study the evolution of the specific absorption of black carbon and the chemical and meteorological processes that affect it.

Field Approach:

Measure optical and chemical properties of aerosols at two sites downwind from Mexico City, with travel times t_1 and t_2, at the surface and aloft.

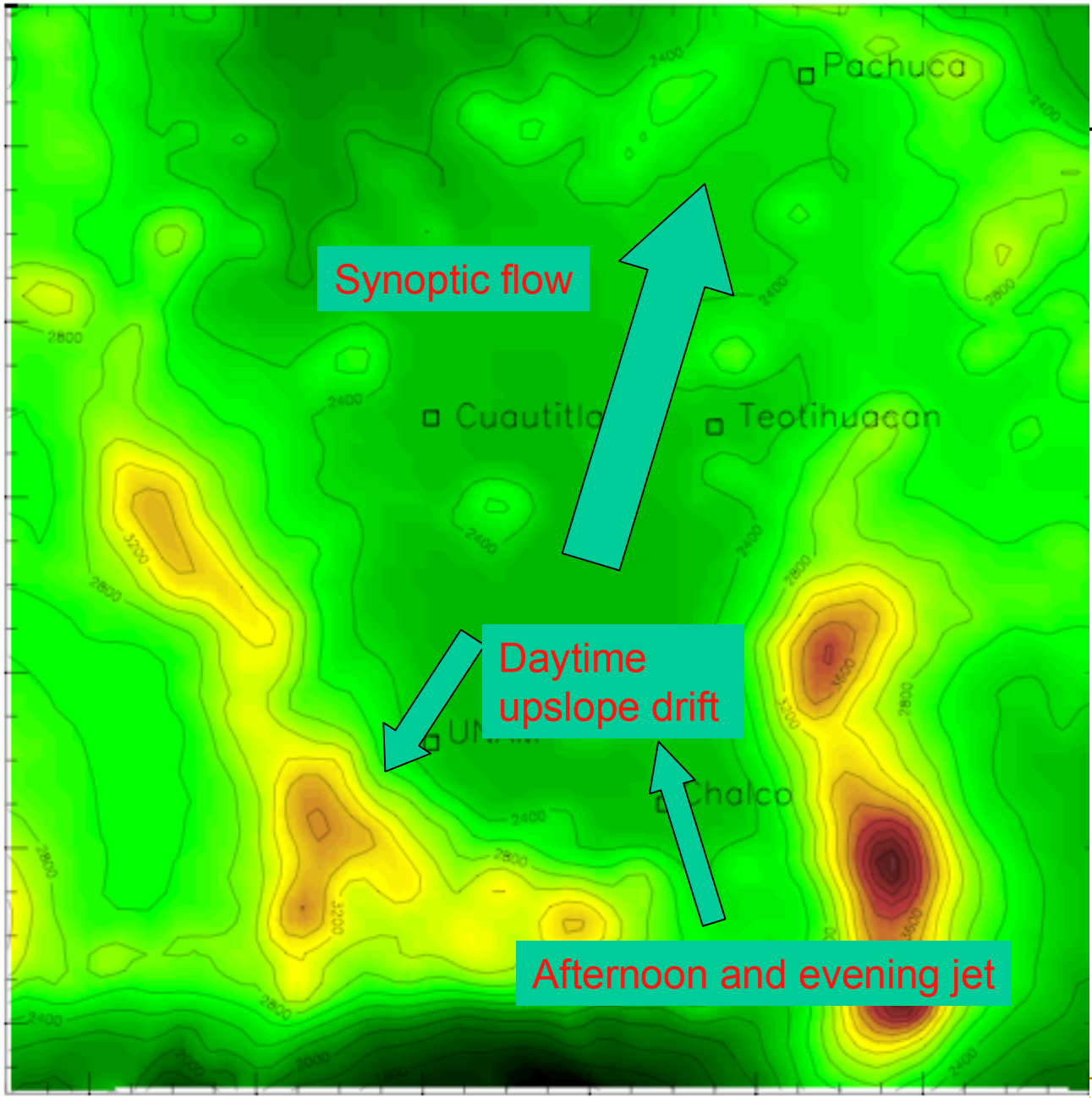
20



19

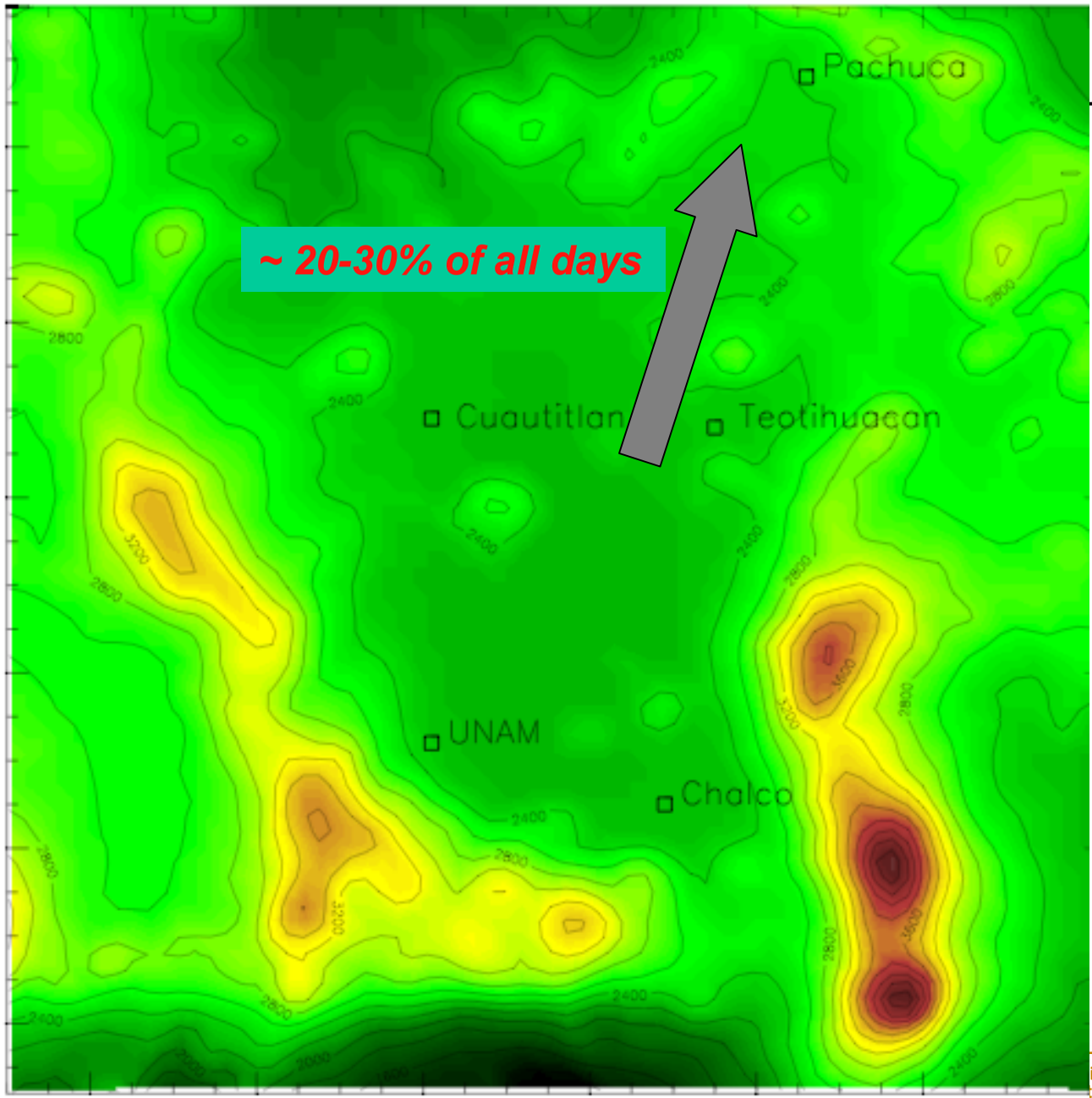
-99.6

-98.6



Pioneering
Science and
Technology
U.S. Department
of Energy

20

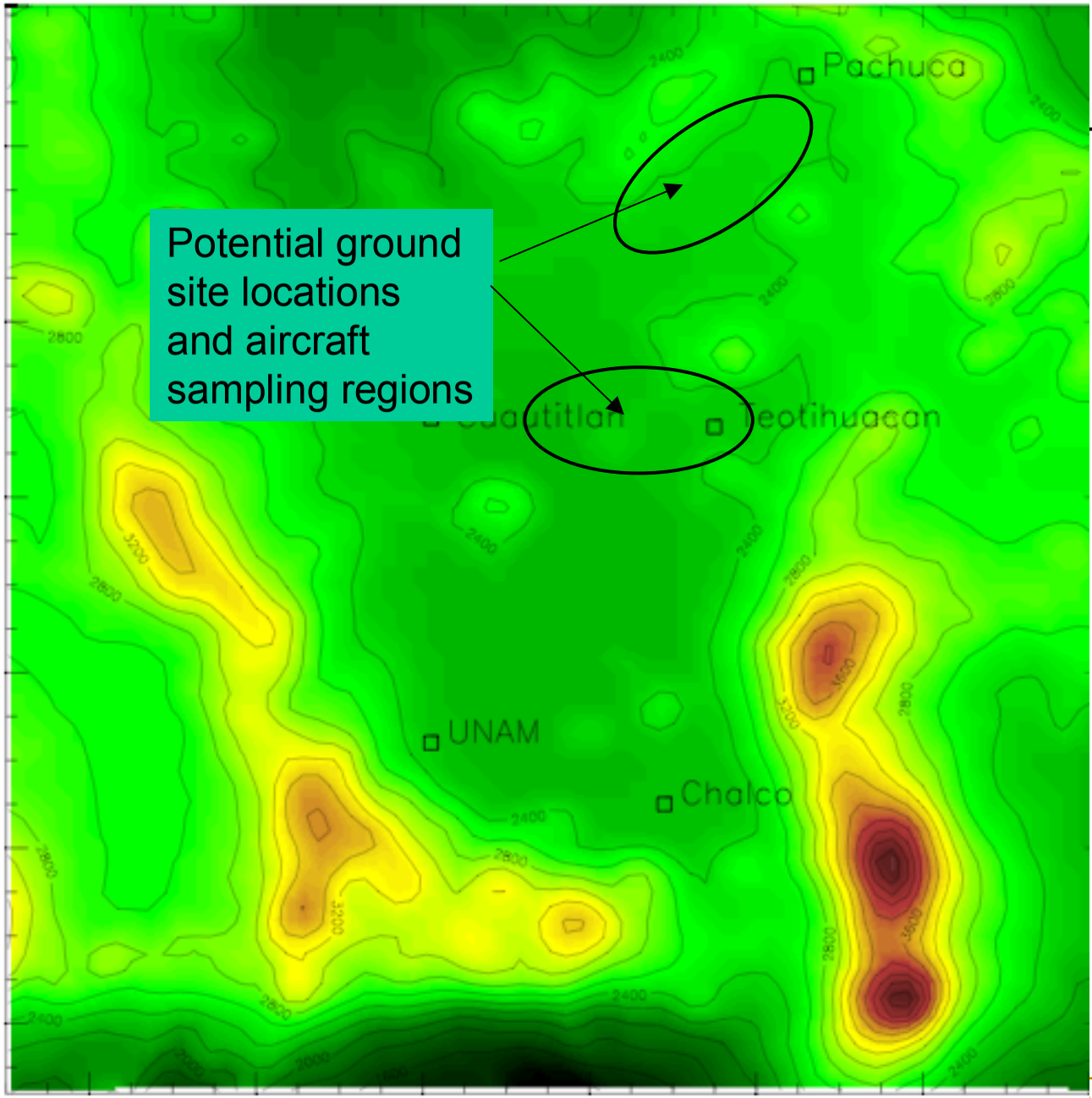

~ 20-30% of all days
Pachuca
Cuautitlan
Teotihuacan
UNAM
Chalco
2400
2800
3200
3600

19

-99.6

-98.6

20


Potential ground site locations and aircraft sampling regions
Pachuca
Teotihuacan
UNAM
Chalco

19

-99.6

-98.6

Invitation:

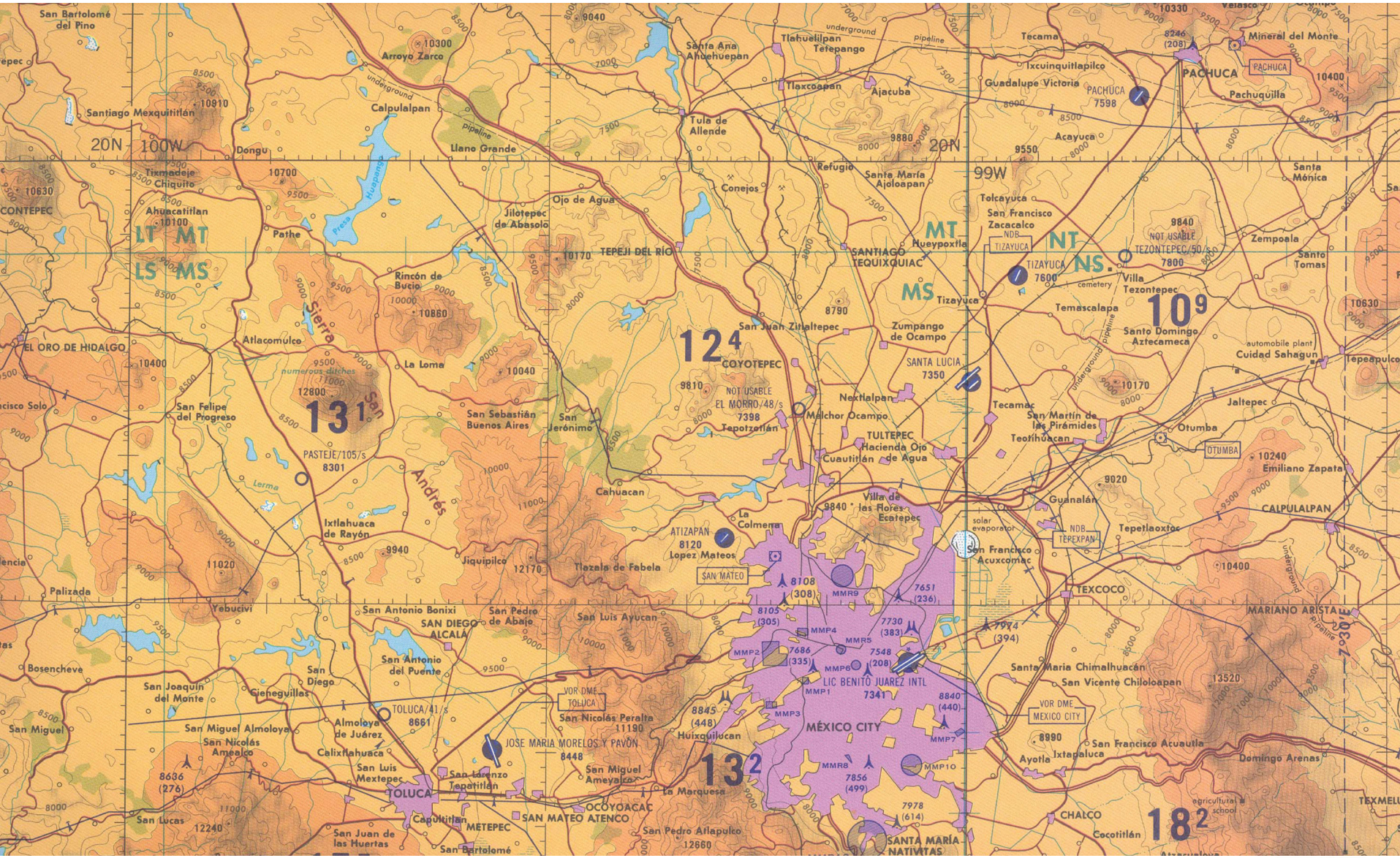
Investigators wishing to deploy instruments at one or both ground sites, whether to look at aerosol aging or for other purposes, are welcome. We will try to accommodate as many interested groups as possible.

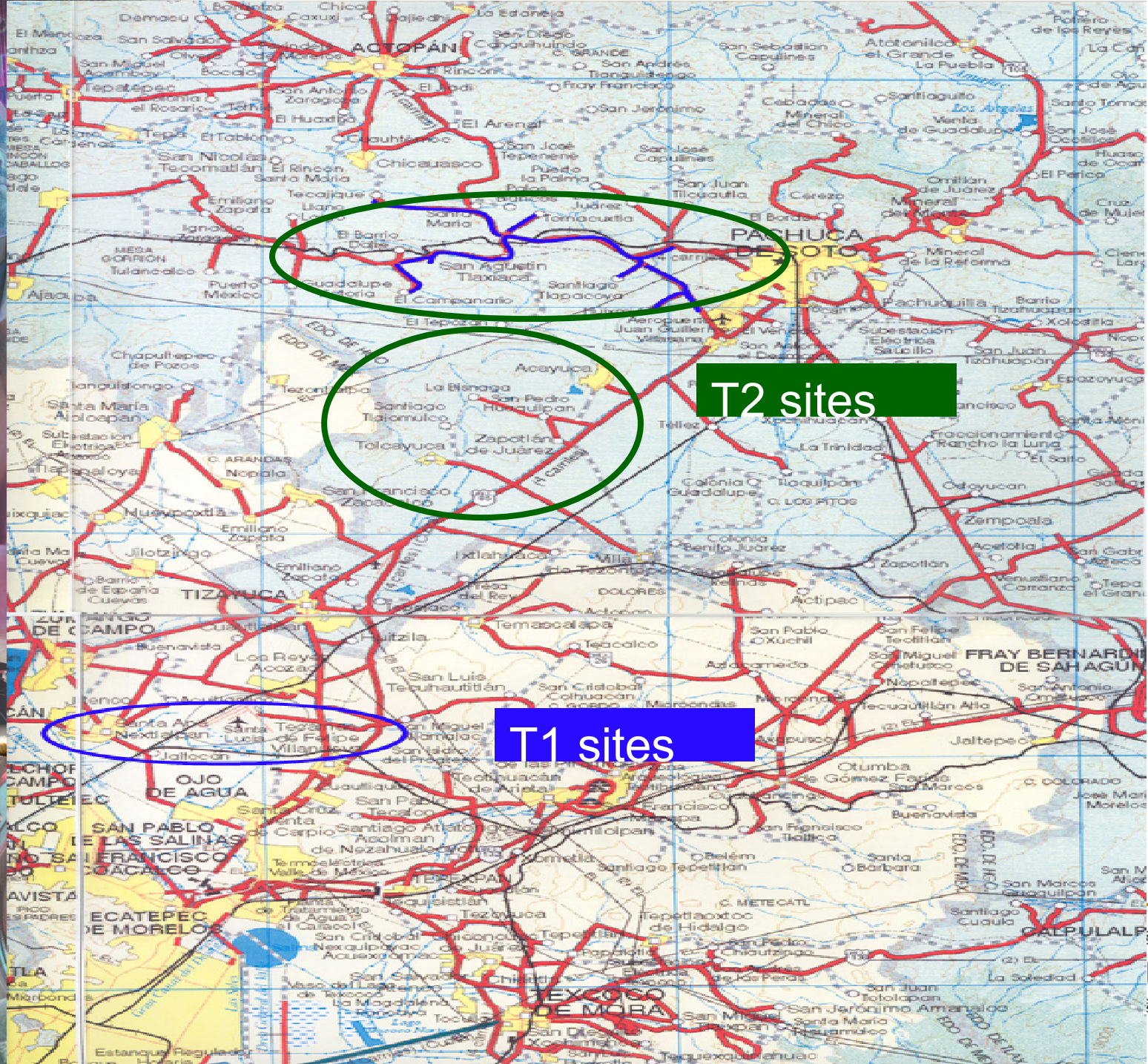
LOTS TO BE DONE

IDENTIFY SCIENCE TO BE DONE
    EQUIPMENT NEEDS
GROUND BASED SITE SELECTION -
AIRCRAFT OPERATION- FLIGHT PLANS/AIRPORTS (VERACRUZ)

PERMITS FOR RESEARCH IN MEXICO
    EQUIPMENT LISTS FOR IMPORT INTO MEXICO

COORDINATION WITH NSF AND NASA , MEXICAN PROJECTS
OTHERS (ADJUNCT SCIENCE TEAM MEMBERS)


San Bartolomé del Pino
Santiago Mexquititlán
Arroyo Zarco
Calpulalpan
Dongu
Llano Grande
Tixmadeje
Chiquito
Ahuacatitlán
CONTEPEC
Pathe
Jilotepec de Abasolo
Ojo de Agua
TEPEJI DEL RIO
Rincón de Bucio
Atlacomulco
EL ORO DE HIDALGO
La Loma
San Felipe del Progreso
San Sebastián Buenos Aires
San Jerónimo
PASTEJE/105/s
8301
Ixtlahuaca de Rayón
Jiquipilco
Tlazala de Fabela
Cahuacan
Palizada
Yebucivi
San Antonio Bonixi
SAN DIEGO ALCALÁ
San Pedro de Abajo
San Luis Ayucan
San Antonio del Puente
Bosencheve
San Joaquín del Monte
Cienegvillas
San Diego
San Miguel Almoloya
San Nicolás Amealco
Almoloya de Juárez
TOLUCA/41/s
8661
Calixtlahuaca
San Luis Mextepec
TOLUCA
San Lorenzo Tepatitlán
JOSE MARIA MORELOS Y PAVÓN
8448
San Miguel Ameyalco
San Nicolás Peralta
11190
VOR DME TOLUCA
OCOYOACAC
SAN MATEO ATENCO
METEPEC
Cápultitlán
San Juan de las Huertas
San Bartolomé
San Lucas
La Marquesa
San Pedro Atlapulco
12660
Huixquilucan
8845 (448)
MÉXICO CITY
LIC BENITO JUAREZ INTL
7341
MMP1
MMP2
MMP3
MMP4
MMP5
MMP6
MMP7
MMP8
MMP9
MMP10
8108 (308)
8105 (305)
7686 (335)
7730 (383)
7548 (208)
7651 (236)
7974 (394)
8840 (440)
7856 (499)
7978 (614)
SANTA MARÍA NATIVITAS
CHALCO
Cocotitlán
Ayotla
Ixtapaluca
San Francisco Acuautla
Domingo Arenas
Santa María Chimalhuacán
San Vicente Chiloloapan
VOR DME MEXICO CITY
MARIANO ARISTA
TEXCOCO
San Francisco Acuxcomac
solar evaporator
Villa de las Flores Ecatepec
9840
ATIZAPAN
8120
Lopez Mateos
SAN MATEO
La Colmena
Cuautitlán
Hacienda Ojo de Agua
TULTEPEC
Melchor Ocampo
Nextlalpan
NOT USABLE
EL MORRO/48/s
7398
Tepotzotlán
San Juan Zitlaltepec
COYOTEPEC
9810
SANTA LUCIA
7350
Zumpango de Ocampo
SANTIAGO TEQUIXQUIAC
Tizayuca
Hueypoxtla
Refugio
Santa María Ajoloapan
Conejos
Tula de Allende
Tlaxcoapan
Ajacuba
Santa Ana Ahuehuepan
Tlahuelilpan
Tetepango
Tecama
Ixcuinquitlapilco
Guadalupe Victoria
PACHUCA
PACHUCA 7598
Pachuquilla
Acayuca
Mineral del Monte
Santa Mónica
Tolcayuca
San Francisco Zacacalco
NDB TIZAYUCA
TIZAYUCA 7600
cemetery
NOT USABLE
TEZONTEPEC/50/s
7800
Villa Tezontepec
Zempoala
Santo Tomas
Temascalapa
Santo Domingo Aztecameca
automobile plant
Cuidad Sahagun
Tepeapulco
Jaltepec
Otumba
OTUMBA
Emiliano Zapata
Tecamac
San Martín de las Pirámides
Teotihuacan
Guanalán
CALPULALPAN
Tepetlaoxtoc
NDB TEPEXPAN
LT
MT
LS
MS
NT
NS
MT
MS
12 4
13 1
13 2
10 9
18 2
20N
100W
99W
Sierra San Andrés
Lerma
Press
Huapango
numerous ditches
underground pipeline


T2 sites
T1 sites
ACTOPAN
PACHUCA DE SOTO
TIZAYUCA
OJO DE AGUA
SAN PABLO DE LAS SALINAS
TEXCOCO DE MORA
FRAY BERNARDINO DE SAHAGUN

WHAT WE HOPE TO ACCOMPLISH…

Mexico City Sites – CENICA (MCMA 2006)
- IMP?
- UNAM ?
- Others

T-1 Sites
T-2 Sites
ASP INFRASTRUCTURE…
Radar Wind Profiler, SODAR, Radiosonde System
Nephelometer, Aethalometer (PSAP/MAP-BC), OC/EC
Multifilter Rotating Shadow Band Radiometers (MFRSR)
Optical Counter, Micropulse LIDAR (PNL/ANL)

DOE ASP MAX-Mex

- Aerosol Mass Spectrometers – ground and aircraft
- Proton Transfer Mass Spectrometers – ground and aircraft
- Black Carbon
- Ground Measurements – Natural Radionuclides/14C – 6 to 12 hr.
- Ammonia – CENICA, T-1 (ANL, LBNL?)
- Three wavelength nephelometer
- MFRSR's
- Radiation Measurements (U of Chicago)
- Aerosol sampling for further analysis – PNNL/LBNL
- Aerosol Precursors
- Photothermal Aerosol Absorption Spectroscopy (BNL)
- New Particle formation
- Others…..

Possible T-1 sites

Site 1- High School

Site 2 near motel

Site 3 – Primary School

Site 4 – Union Sports Complex

Site 5 – School near Santa Lucia Airbase Runway

Site 6 – Tizayuca airport Abandoned?

SITE 7 – Technical University at Tecamac – Likely First Choice for T-1

Possible T-2 Sites

Site 1 – Acayuca Farm

Site 2 – Rancho Near Hwy

Site 3 – Near Pachuca BBQ Farm area

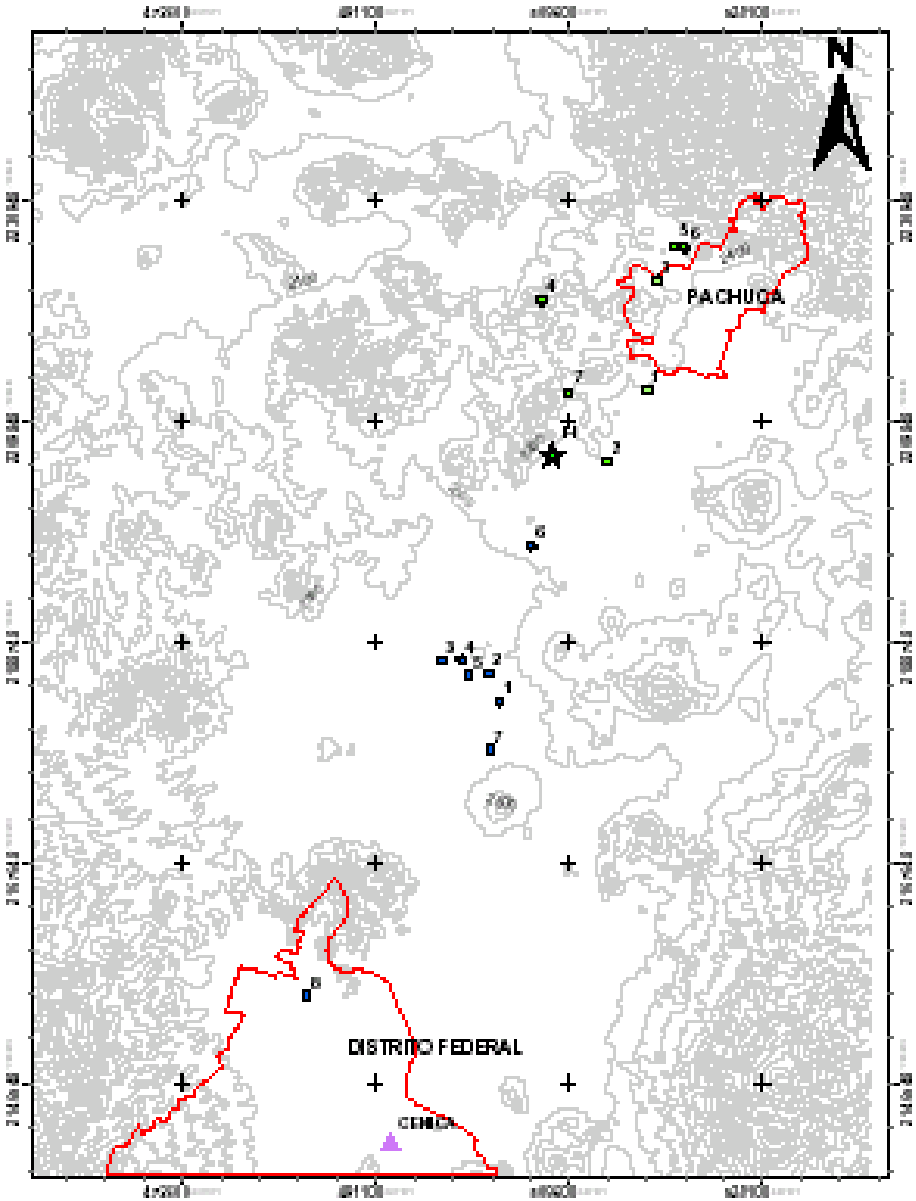
Site 4- Companario

Site 5 – Health/Sports Univ.

Site 6 – Univ. Near 5

Site 7 – Rancho Bisnaga

SITES – T-1 and T-2

Technical University – Tecamac – T-1

Rancho Bisnaga – T-2