Meteorology, Transport, and Modeling

(1) General Meteorology, Transport (observations)

There have been a number studies on the meteorology of the Mexico City basin and the related transport.

Questions:

(i) Did we see anything that was new, unexpected, unexplained, etc, at any scale in the meteorology (synoptic, mesoscale, small-scale)?
(ii) How well do we understand the basin-scale flow and the diurnal topographical heating effects?
(iii) PBL evolution – Is there anything obviously new or unexpected?
(iv) Meso- and small-scale transport – did we see anything new in transport in and out of the basin?
(v) Do the ground and aircraft measurements confirm our general understanding of transport in the large-scale flow regimes?

Preliminary Answers:

Confirmatory Results:

Large-scale flow regimes: Transport to the N-NE (over the Gulf) during southwesterly flow regimes was similar to observed transport in other field campaigns. Similarly for transport to the south and southwest over the Pacific in northerly flow regimes.

PBL: Daytime PBL growth similar to to other field campaigns (2003 1997). Days with/without convection - no difference in morning growth (clear in morning). Mixing starts ~1 h after sunrise. Several hundred m lower at T2 (early morning is terrain-following, but flat in the afternoon).

Preliminary Answers:

New results:

In weak flow regimes, the basin flows appear to be very complex with pollutants often exiting and then re-entering the basin.

Measurements: Missing aerosols around sunset at T1, returning to normal after 1-1.5 h. Winds show little change. Maybe cleansing by rainfall? Appears to be meteorological effect - what is it?

PBL depth estimates, ambiguous depth in late afternoon (lidar, sondes give different pictures). This behavior is not that of a classical boundary layer. At times may be modulated by convection.

Quite variable night-time BL depths. Not well mixed (as expected) but some suggestion of mechanical mixing at times (not expected?). Urban boundary layer (even night-time BL) is complex.

(2) Modeling: Met/Transport, Chem/Aerosols

Operational models run during Milagro

MM5/FlexPart: (local/reg; met/disp; 3, 12, 36 km), Molina Center…
MM5/MCCM: (local/reg; met/chem; 8, 24 km), UNAM
WRF-Chem: (regional; chem/particulates; 6 km), NCAR

WRF: (local/reg/syn; met/disp; 3, 9 km), NCAR
STEM: (reg/syn; chem/particulates; 12, 60 km), Univ. Iowa

MOZART: (synoptic, chem; ~2 degrees), NCAR
FLEXPART/ECMWF: (syn; dispersion; ~ 1 degree), NILU
RAQMS: (syn; chem; ~2 degrees), NASA
GEOS-Chem: (syn; chem; 50 km), Harvard

A variety of models were run in real time, and many more runs are being made in the post-analysis phase.

Questions:

How good are the forecast models – meteorology and pollution-plume predictions?

(a) synoptic and regional scales?
- meteorology (winds)
- plume location, constituents, age.

(b) urban (basin) scale.
- PBL evolution
- heating-terrain induced flows (convergence zones, etc).
- basin-scale plume transport
- chemical predictions

Preliminary answers (and some needs):

Models:

Models generally better on stronger transport days (strong flow regimes) i.e. models are good at downscaling.

Large-scale models quite good for long-range plume transport.

PBL problematic
- fundamental problem in Met models (turbulence problem).
- need feedback with chemistry and aerosols? Need dust?

Recirculations predicted in weak-flow regimes - are they correct?

Emissions are likely the biggest problem for chemistry studies. Need to eliminate the variability in emissions between modeling groups.

Metrics - very useful for model evaluation and comparison. Whole month metrics. Both meteorological and chemical.

Preliminary answers (continued)

Models:

Model intercomparison - default comparisons with observations (met and chem) separately requires clear documentation of inputs (initial state, boundary conditions, emissions, etc).

View intercomparison more in terms of an ensemble?

Consensus - further comparison of model results needed with the observations that are now becoming available.

Some other discussion points:

Data synthesis - doing some of this (MOPITT/MOZART) - more?

Clocks - calibrate time (age) using various approaches - models: trajectories, timed tracer releases. Observations: chemical ratios and other age effects.

Look at Mexico City foot print at various scales.

Methodology of footprint of a megacity.

What we would like to see:

Central clearing house for model and obs results and analyses - list of web sites with descriptions of what is contained on them.

A few topics for collaborative research:

Convergence within the basin
Characterizing gap flow

Sensitivity of model predictions on PBL parameterization, surface layer and land surface models.

Small-scale – large-scale (synoptic/global) forecasts: resolution effects.

Papers:

Fast: Synoptic meteorology overview (measurements and analysis)
Fast: Evolution of particulates and aerosol radiative effects downwind of Mexico City (modeling)
Fast and de Foy: Use of Lidar data from the B-200 to understand pollutant transport and aerosol optical properties of pollutants.
Shaw: Evolution of PBL heights and at T1 and T2 from radiosonde, radar wind profilers and lidars (measurements and analysis)
Hodizc: The relative role of anthropogenic and biomass burning on aerosol optical properties downwind of Mexico City (modeling)
Coulter: PBL evolution?
Eichinger - Mechanically generated turbulence at night from lidar (measurements and analysis)
Garcia: Transport of pollutants through the gap and age of air parcels (modeling)
Garcia: Impact of city on surrounding crop/forest areas including wind erosion (modeling)
Voss: Reconstruction of trajectories/atmospheric stability/wind shear along downwind transport using balloons, aircraft. and profilers.
McMillen: Footprint of the Mexico City pollutant plume using AIRS (measurements and analysis).
McKenna: Back trajectories to support C-130 measurements and how they relate to Lagrangian time scales and "chemical clocks" (modeling).
Skamarock: Evaluation of model forecast plume transport on regional and synoptic scales.
Skamarock: Evaluation of basin-scale model forecasts – terrain and heating effects.
de Foy: Overview of the basin-scale meteorology and its affect on local transport
Mena: Improving ozone modeling during MILAGRO by recovering emissions scaling factors through data assimilation
Mena: Evaluating the impact of Mexico City emission on ozone production regimes
Mena: Estimation of ozone formation, sensitivity to anthropogenic sources of NOx and VOC for Mexico City; policy implications
Tang: Model study on the influence of aerosol and clouds on urban photochemistry