

# Comparing MOPITT CO retrievals against TCEQ ground-based CO values in the El Paso, Texas region

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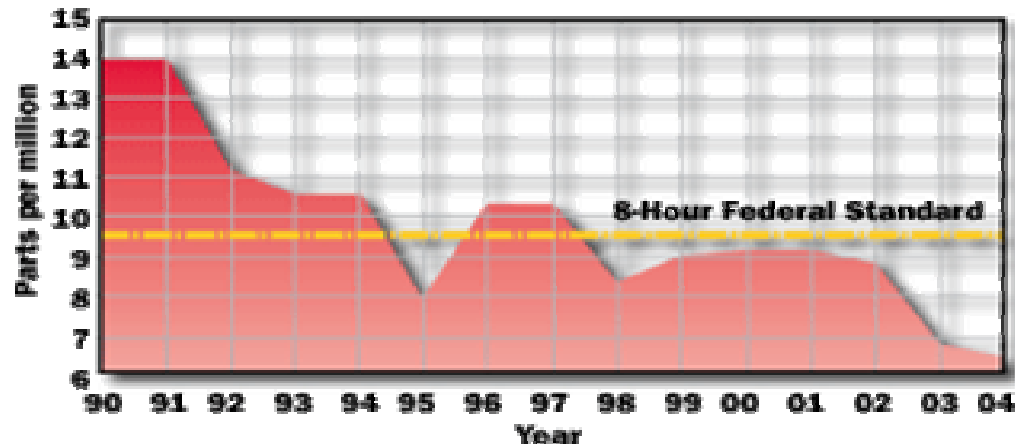
Wednesday, November 30, 2005  
EES 5053

# Region of Interest

- Carbon monoxide is a colorless, odorless, very toxic gas produced by the incomplete combustion of carbon-containing fuels, most notably by gasoline powered engines, power plants, and wood fires.
- In 1990, El Paso County was designated a "serious" nonattainment area for 1-hour ozone, a "moderate" nonattainment area for carbon monoxide, and a nonattainment area for particulate matter (PM10). Control measures developed by the TCEQ, in consultation with EPA and local officials, were instituted soon after.
- Air monitoring data show the area has been in compliance with the federal 8-hour carbon monoxide standard since 1997.

www.tceq.state.tx.us

## Carbon Monoxide Design Values El Paso County, 1990-2004



- Climate Conditions, Automobile Emissions
- Topography
- Fast-growing neighbor just across the Rio Grande.

## Continuous Ambient Monitoring System (CAMS) in the El Paso, Texas Region

CAMS ID	Station Name	Lat	Long	EPA Site #	Elevation
12	El Paso UTEP	31.768056	-106.501111	48-141-0037	1158 m (3799 ft)
37	Ascarate Park SE	31.746667	-106.402778	48-141-0055	1122 m (3681 ft)
40	El Paso Sun Metro	31.758611	-106.501111	48-141-0053	1128 m (3701 ft)
41	Chamizal	31.765833	-106.455	48-141-0044	1122 m (3681 ft)
49	Socorro	31.662222	-106.303056	48-141-0057	1109 m (3639 ft)
72	Skyline Park	31.893889	-106.425833	48-141-0058	1201 m (3940 ft)
413	Tillman	31.7575	-106.482778	48-141-0002	1134 m (3721 ft)
414	Ivanhoe	31.786389	-106.324167	48-141-0029	1207 m (3960 ft)
661	Cd Juarez Advance	31.689722	-106.459722	80-006-0004	1173 m (3849 ft)
662	Cd Juarez Club	31.735556	-106.459722	80-006-0006	1133 m (3717 ft)
663	Cd Juarez Delphi	31.712222	-106.395278	80-006-0007	1123 m (3685 ft)

## Location of Air Monitors in El Paso and Ciudad Juárez

Air quality monitors are operating at 10 sites in El Paso and three in Juárez. At these sites, a variety of equipment takes readings several times a day for ozone, carbon monoxide, and/or particulate matter. The resulting data are posted on the TCEQ Web site.

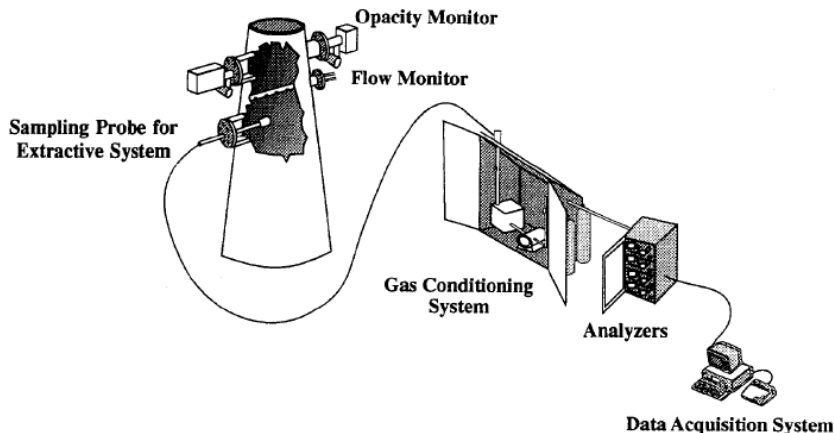


# Ground-Based CO levels

- Carbon Monoxide is measured in parts per million.
- A CAMS is composed of a number of subsystems: a gas monitoring system (which may use either extractive or in-situ sampling techniques and may include either a CO<sub>2</sub> or O<sub>2</sub> diluent correction monitor), a flow monitor, a transmissometer (opacity monitor), and a data acquisition and handling system(DAHS).



CAMS Site 414, 10834 Ivanhoe Dr.  
Real-time monitoring since: Wednesday,  
March 29, 2000  
Current status: Active



[http://www.tceq.state.tx.us/cgi-bin/compliance/monops/site\\_photo?cams=414](http://www.tceq.state.tx.us/cgi-bin/compliance/monops/site_photo?cams=414)

# MOPITT Launch

- MOPITT (Measurements Of Pollution In The Troposphere) was provided to NASA by the Canadian Space Agency. The University of Toronto directed its development.
- Launched December 18, 1999 from Vandenberg Air Force Base in California
- Aboard NASA's Terra satellite, MOPITT observes the earth each day at 10:30 a.m. and 10:30 p.m. from its sun-synchronous orbit at 705 kilometers (437 miles) altitude.
- MOPITT determines CO concentrations at different levels in the lower atmosphere. Its resolution is 22 kilometers horizontally and 4 km vertically, 300 km swath.

# MOPITT LAUNCH



Assembled TERRA  
satellite

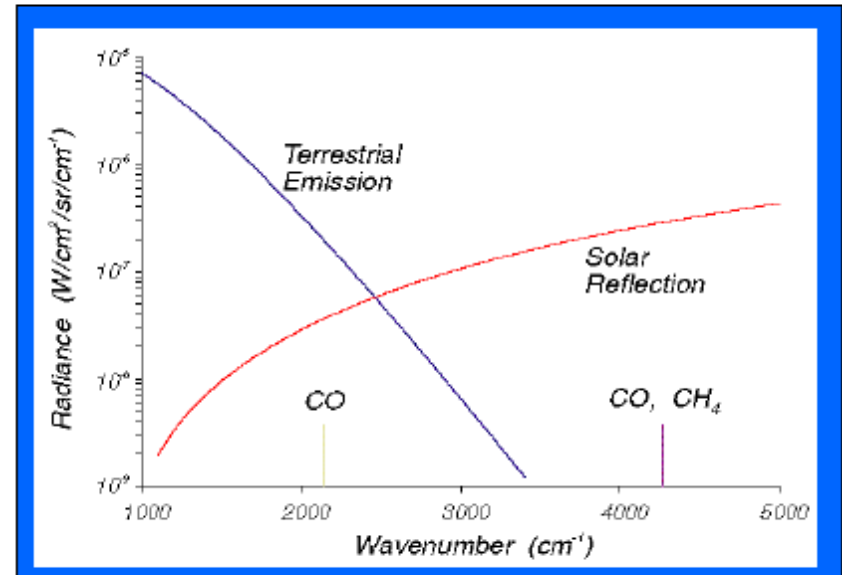
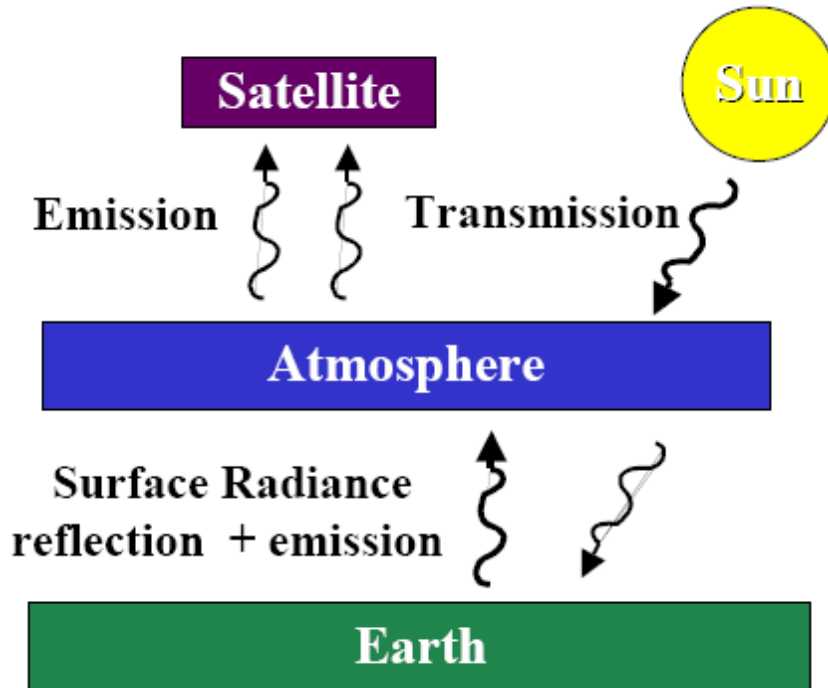


Terra being  
put into rocket



Launched

# MOPITT Spectral Bands

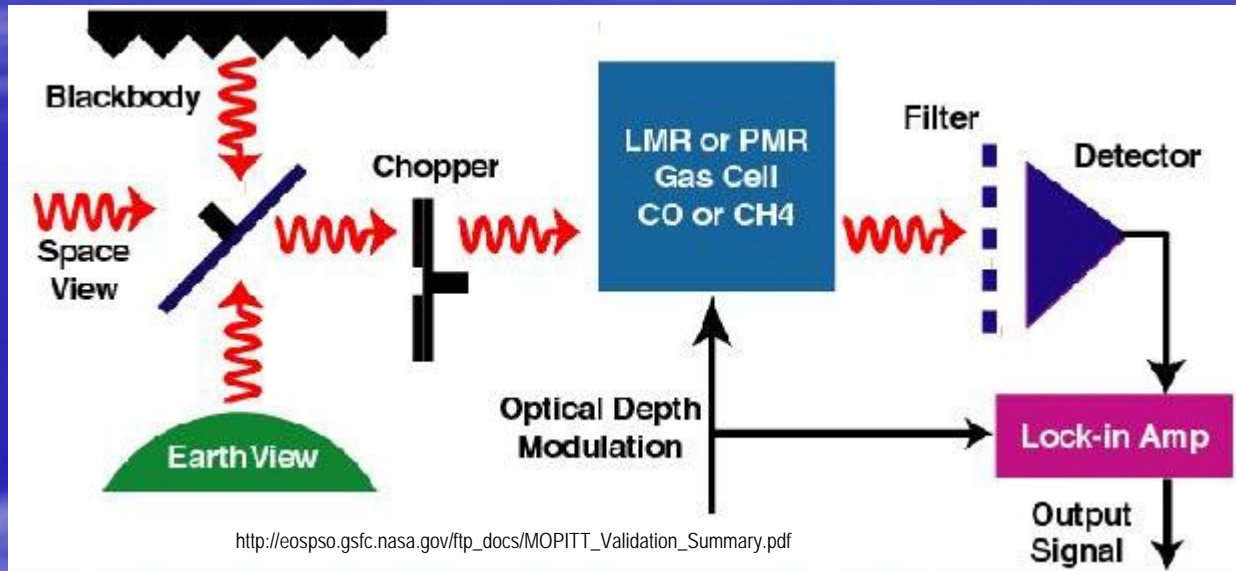


[http://eospsso.gsfc.nasa.gov/ftp\\_docs/MOPITT\\_Validation\\_Summary.pdf](http://eospsso.gsfc.nasa.gov/ftp_docs/MOPITT_Validation_Summary.pdf)

- MOPITT operates by sensing infra-red radiation from either:
  - The thermal emission/absorption at 4.7  $\mu m$  for CO profiles.
  - Reflected sunlight at about 2.2-2.4  $\mu m$  for CO and CH<sub>4</sub> column measurements in daylight. The use of solar channels enhances the instrument sensitivity to the atmosphere boundary layer.
- The radiation is modified by absorption/emission processes in the atmosphere and these changes are detected in the MOPITT instrument using Correlation Radiometry

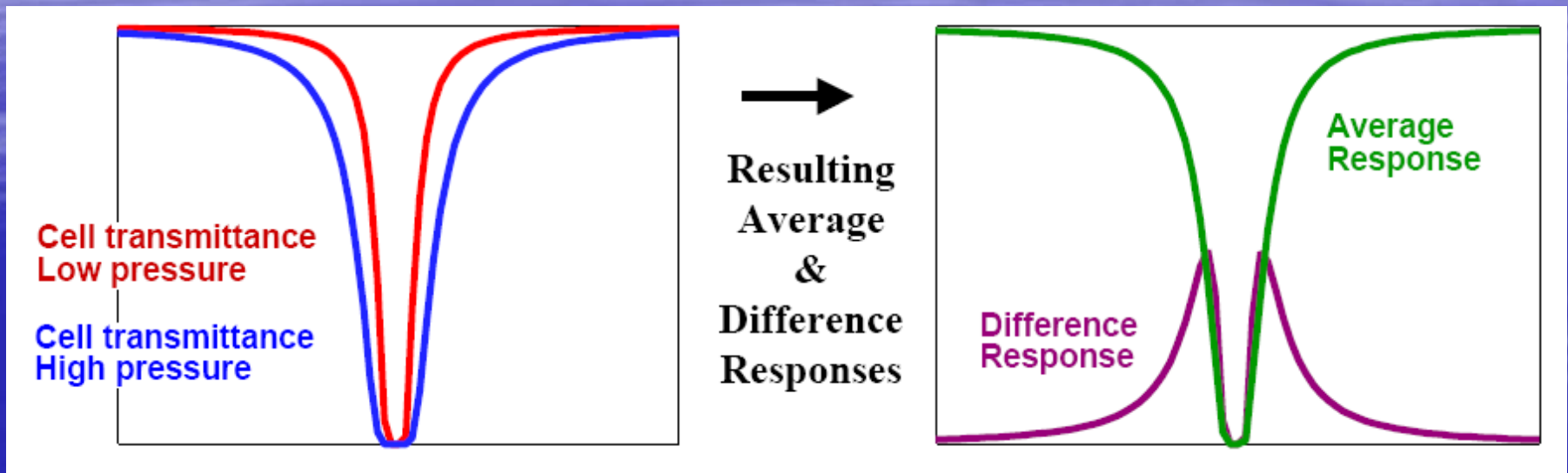
# Carbon Monoxide Detection

MOPITT uses **correlation radiometry** for the detection of CO and CH<sub>4</sub>



Signals pass through a cell containing the target gas, CO or CH<sub>4</sub>. The cell pressure or length is varied, which produces a modulation in cell opacity within the lines of the target gas, while the cell opacity at other frequencies remains constant.

# MOPITT Measurements by Correlation Radiometry: Average and Difference Signals



[http://eosps0.gsfc.nasa.gov/ftp\\_docs/MOPITT\\_Validation\\_Summary.pdf](http://eosps0.gsfc.nasa.gov/ftp_docs/MOPITT_Validation_Summary.pdf)

Two MOPITT signals are possible:

Average Signal: Mean of the low and high opacity signals

Difference Signal: Difference of low and high opacity signals

- Average response is low at target gas line positions

Information about background radiance (surface temperature)

- Difference response is only significant at target gas line positions

Effective high-resolution spectral filter to information about target gas

# MOPITT Data Products

- **Level 0:** Raw output data from the instrument supplemented by time, spacecraft position and attitude information.
- **Level 1 (MOP01 files):** Calibrated radiances (average and difference signals) from the instrument, with location and time information.
- **Level 2 (MOP02 files):** Retrievals.
  - CO mixing ratio profiles with 22 km horizontal resolution, 4 km vertical resolution, 10% precision. The daytime and nighttime CO profiles correspond to the global clear sky measurements between 65° S and 65° N.
  - CO total column with 10% precision.
  - CH<sub>4</sub> total column with 1% precision.
- **Level 3 (MOP03 files):** Gridded global CO and CH<sub>4</sub> distributions: 1 deg x 1 deg, daily and monthly averages (global maps via assimilation).

# Data Retrieval

- MOPITT DATA

- Level 2 and Level 3 data were obtained from Atmospheric Sciences Data Center @

- [http://eosweb.larc.nasa.gov/PRODOCS/mopitt/table\\_mopitt.html](http://eosweb.larc.nasa.gov/PRODOCS/mopitt/table_mopitt.html)

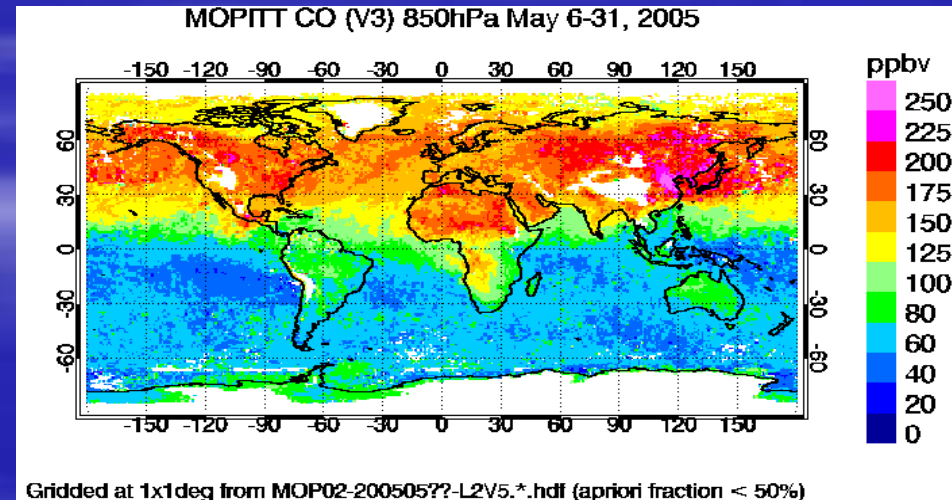
- IN-SITU DATA

- El Paso, Texas continuous air monitoring data was obtained from the TCEQ website @ [www.tceq.state.tx.us](http://www.tceq.state.tx.us)

- Data was collected from both source for May 2005.

# MOPITT DATA

- HDFView software v.4.5.2.0 (obtained from Atmospheric Sciences Data Center website) was utilized to view and export Level 2 and 3 data into Excel.
- Level 2 data files (~75MB, 165K records). Extracted for Lat range: 31° to 32°, Long range: -107° to -106°.
  - Fields of interest:
    - Latitude
    - Longitude
    - Seconds in Day
    - Retrieval Bottom CO Mixing Ratio
    - Retrieval Bottom CO Mixing Ratio Percent A priori
- Level 3 data files (~6MB, 180 records).  
Extracted for Lat: 31.5° Long: -106.5°
  - Field of Interest
    - Latitude
    - Longitude
    - Averaging Kernel Day
    - Averaging Kernel Night

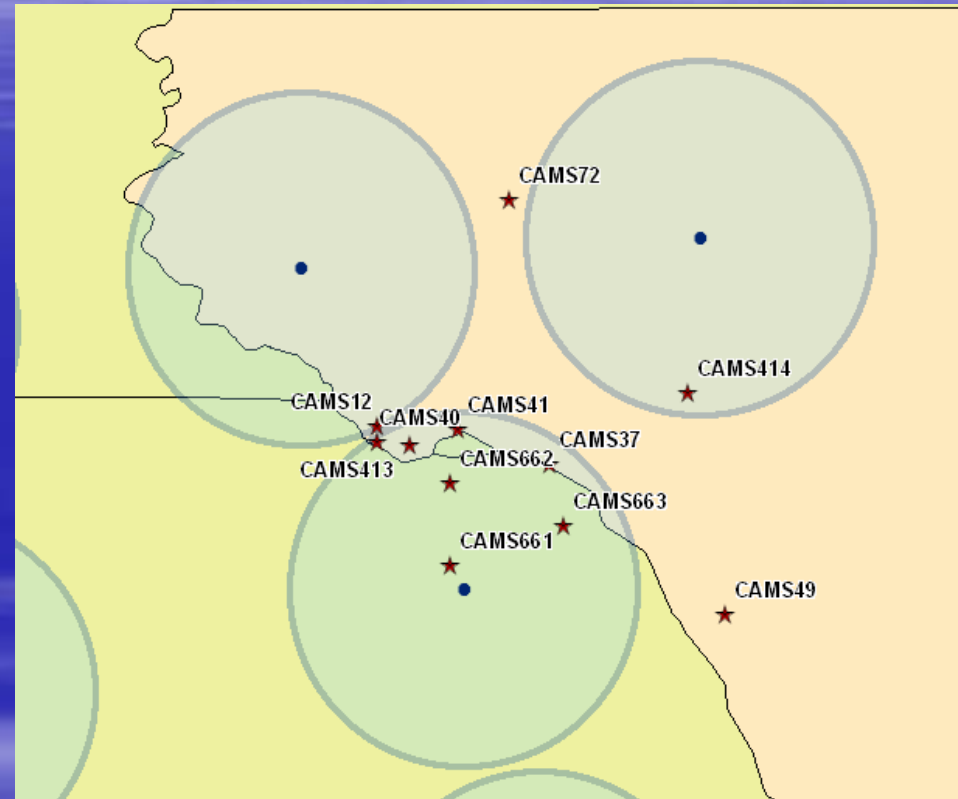


# TCEQ Data

- Continuous Ambient Monitoring Systems (CAMS) CO Monthly reports were obtained for all active sites via TCEQ's website.
- Data was obtained for May 2005 except for the following dates due to limited MOPITT data: May 1-5, May 31.
- TCEQ has CAMS located Texas and Mexico.

# Data Mining

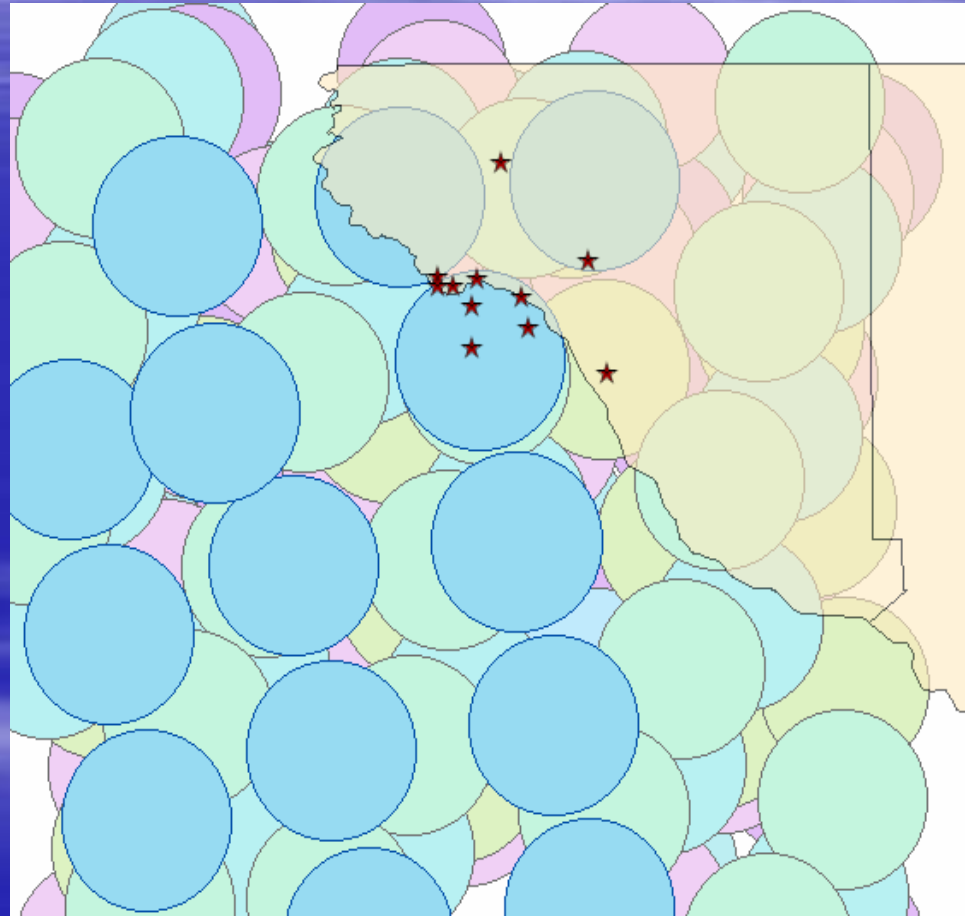
- MOPITT files containing data for area of interest were reduced from 25 daily files to 13 daily files.
- ArcMap was used to generate a map showing MOPITT CO values (buffered to 22 km) and TCEQ CAMS sites in relation to the buffered areas.
- Hourly CO levels for TCEQ CAMS sites within the buffers were obtained.



May 6, 2005

# Data Mining - Continued

- 101 TCEQ CAMS sites were within the MOPITT buffer zones.
- TCEQ CAMS values were averaged whenever more than one CAMS site was within the same MOPITT buffer zone.
- Data was reduced to 30 MOPITT retrievals within the region of interest.



# Data Comparison

The following table shows MOPITT and TCEQ data for May 6 thru 15, 2005.

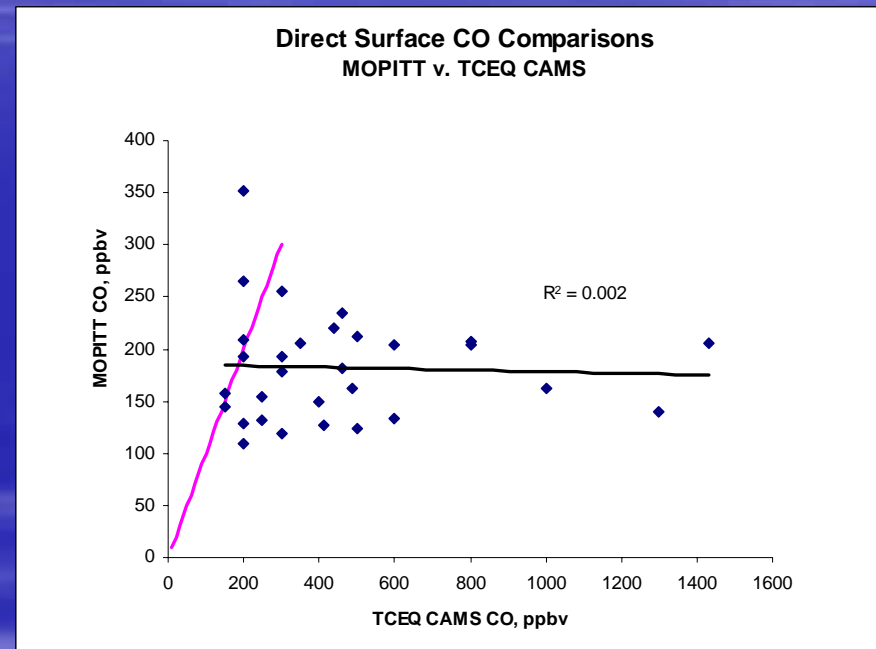
Lat	Long	Date	Hour	MOPITT CO (ppbv)	TCEQ CO (ppmv)
31.676023	-106.4516	6-May-05	5.2	205	1.433
31.87213	-106.317444	6-May-05	5.2	204	0.800
31.855068	-106.54435	6-May-05	5.2	204	0.600
31.777824	-106.49143	9-May-05	17.7	234	0.463
31.993612	-106.45573	9-May-05	17.7	256	0.300
31.689573	-106.31376	11-May-05	5.5	134	0.600
31.810078	-106.388214	11-May-05	5.5	163	0.486
31.945673	-106.430885	13-May-05	5.3	150	0.400
31.660091	-106.445175	14-May-05	18.0	209	0.200
31.864037	-106.399994	14-May-05	18.0	193	0.200
31.63654	-106.46223	15-May-05	5.1	352	0.200
31.77765	-106.54898	15-May-05	5.1	192	0.300

# Comparison Plots

## MOPITT retrievals v. TCEQ CAMS

Satellite measurements do not by themselves contain sufficient information to unambiguously determine the trace gas concentration

The MOPITT retrieval algorithm incorporates statistical properties of the trace gas variability in the form of the a priori vertical profile and covariance matrix.



# Comparison Plots

## MOPITT retrievals v. TCEQ CAMS

Cannot simply make **DIRECT** comparisons between retrievals and other measurements or models!!

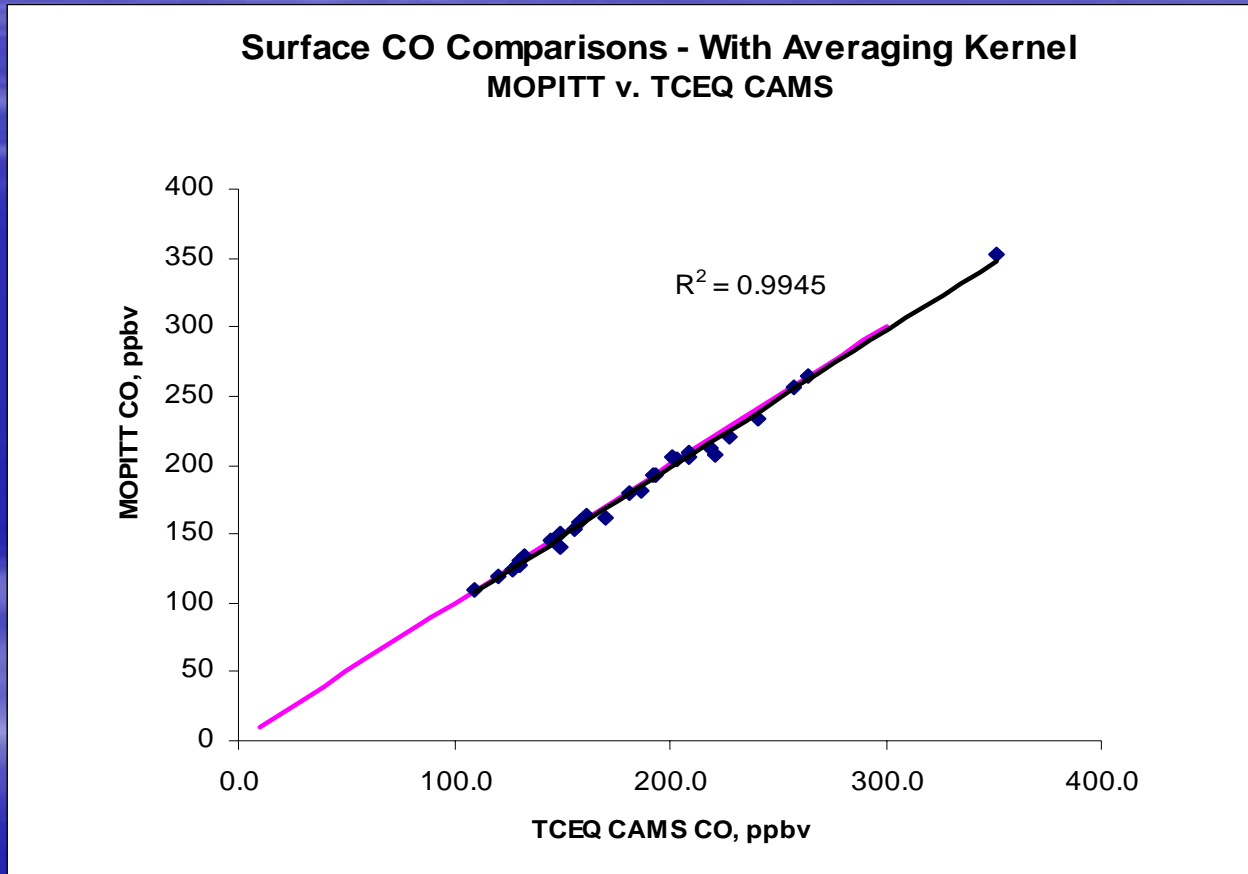
An in situ comparison profile ( $x_{\text{comp}}$ ) must be transformed using the averaging kernel ( $A$ ) (obtained from Level 3 MOPITT files) and a priori profile ( $x_a$ ) (obtained from Level 2 MOPITT files) before being compared to MOPITT retrieved values.

$$x_{\text{comp}}' = x_a + A(x_{\text{comp}} - x_a)$$

- The Averaging Kernel ( $A$ ) represents the measurement sensitivity to the true profile and depends on those factors affecting the radiative transfer of the measured signal through the atmosphere; such as: surface temperature.

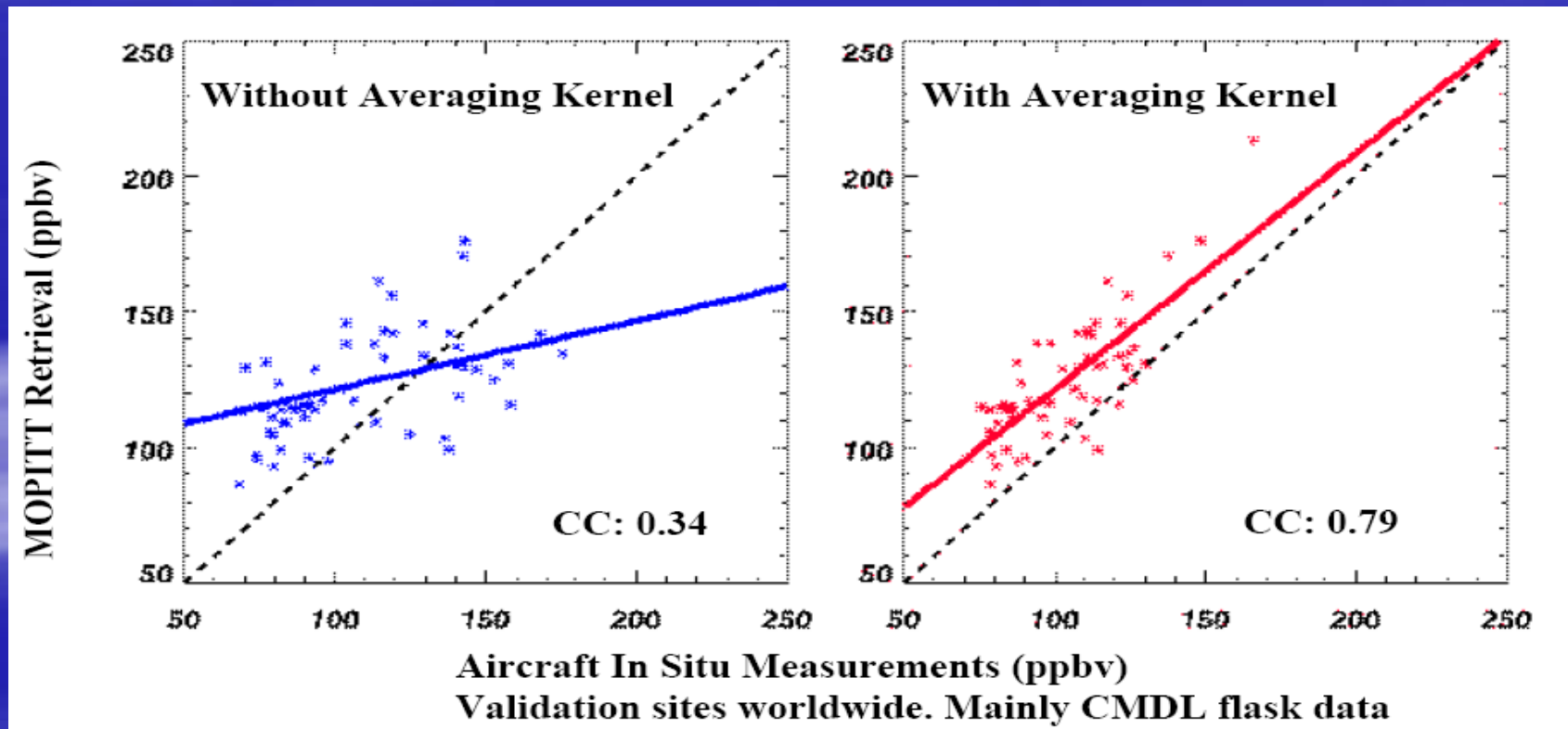
# Comparison Plots

MOPITT retrievals v. TCEQ CAMS  
With Averaging Kernel



# Comparison with Formal Validation

We were unable to find data validation at surface levels: however when comparing against data validations done at 500 mb – comparing correlation coefficients CC:0.79 for 500mb and we got CC: 0.99.



# Conclusion

- **Direct comparison between MOPITT and other measurements and models cannot be made!!**
- **Averaging kernels play a big role when transforming in situ profiles. Averaging kernels also vary from night to day (-0.004 to 0.036).**
- **A very good correlation exists when comparing in situ ground measurements with MOPITT retrievals once the averaging kernel is applied.**

# Conclusion

Probable reasons for obtaining a higher CC value than the formal validated data

- Different altitudes, we compared at ground level while the formal validation study was done at 500 mb using an aircraft.
- Different concentration levels, our ground concentration ranges were from ~ 100 to 400 ppbv (after applying averaging kernel), while the formal validation data had concentrations from ~100 to ~150.
- Multiple TCEQ data for one MOPITT retrieval, these values were averaged and then compared against MOPITT.

