United States Environmental Protection Agency

NAMTEC Improving Traffic Data Collection, Analysis, and Use
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Traffic Data and Its Uses in Air Quality Analysis

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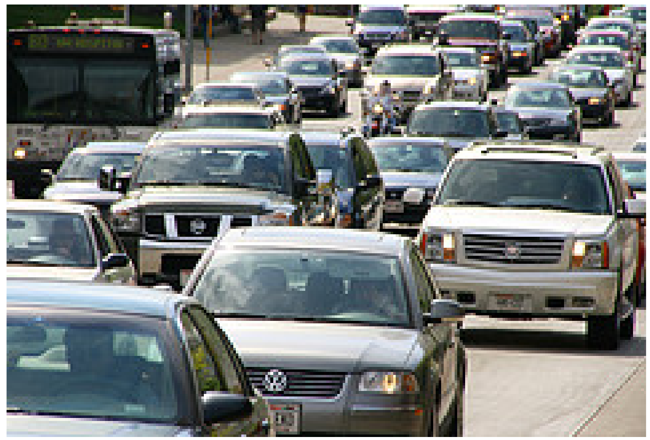


Presentation Outline

- Describe near-roadway ambient air quality study conducted in Las Vegas, NV, from mid-December 2008 thru mid-December 2009
- Discuss uncertainties associated with characterizing ambient air quality impacts due to mobile source emissions
- Summarize observed concentration distributions based on ambient monitoring
- Summarize preliminary results of model-to-monitor comparisons based on application of the AERMOD dispersion model

Las Vegas Study Overview

- Ambient air quality study – Las Vegas, NV – Mid-December, 2008 thru Mid-December, 2009

- Study collected ambient air quality measurements for a number of species including:
  - carbon monoxide (CO),
  - nitrogen oxide (NO), (key pollutants focused in this analysis)
  - nitrogen dioxide (NO_2),
  - oxides of nitrogen (NO_X),
  - black carbon (BC),
  - particulate matter with aerodynamic diameter ≤ 10 microns (PM_{10}), particulate matter with aerodynamic diameter < 2.5 microns ($PM_{2.5}$), PM Coarse (PM_{10}-$PM_{2.5}$), and
  - mobile source air toxics (MSATs) – 1-3, butadiene, benzene, acrolein, formaldehyde, acetaldehyde.

Las Vegas Study Overview

- EPA Key Science Questions ---
  - ✓ **What is the spatial and temporal variability of traffic-related pollutants near roadways?**
  - ✓ **How do traffic (volumes, speeds, fleet mix, etc.) and environmental (meteorology, topography, etc.) conditions affect vehicle emissions and near road air quality?**
  - ✓ What marker(s)/metric(s) can be used to identify exposures to traffic-related emissions?
  - ✓ What tools are available, or can be produced, to identify the relationship of traffic emissions to population exposures and diverse health effects for use in regulatory decision making and transportation planning?
  - ✓ **What are the concentration gradients at a fine(er) scale resolutions?**
  - ✓ How does urban topography and barriers impact these gradients?
  - ✓ Are there mitigation techniques that can reduce exposures to susceptible populations?

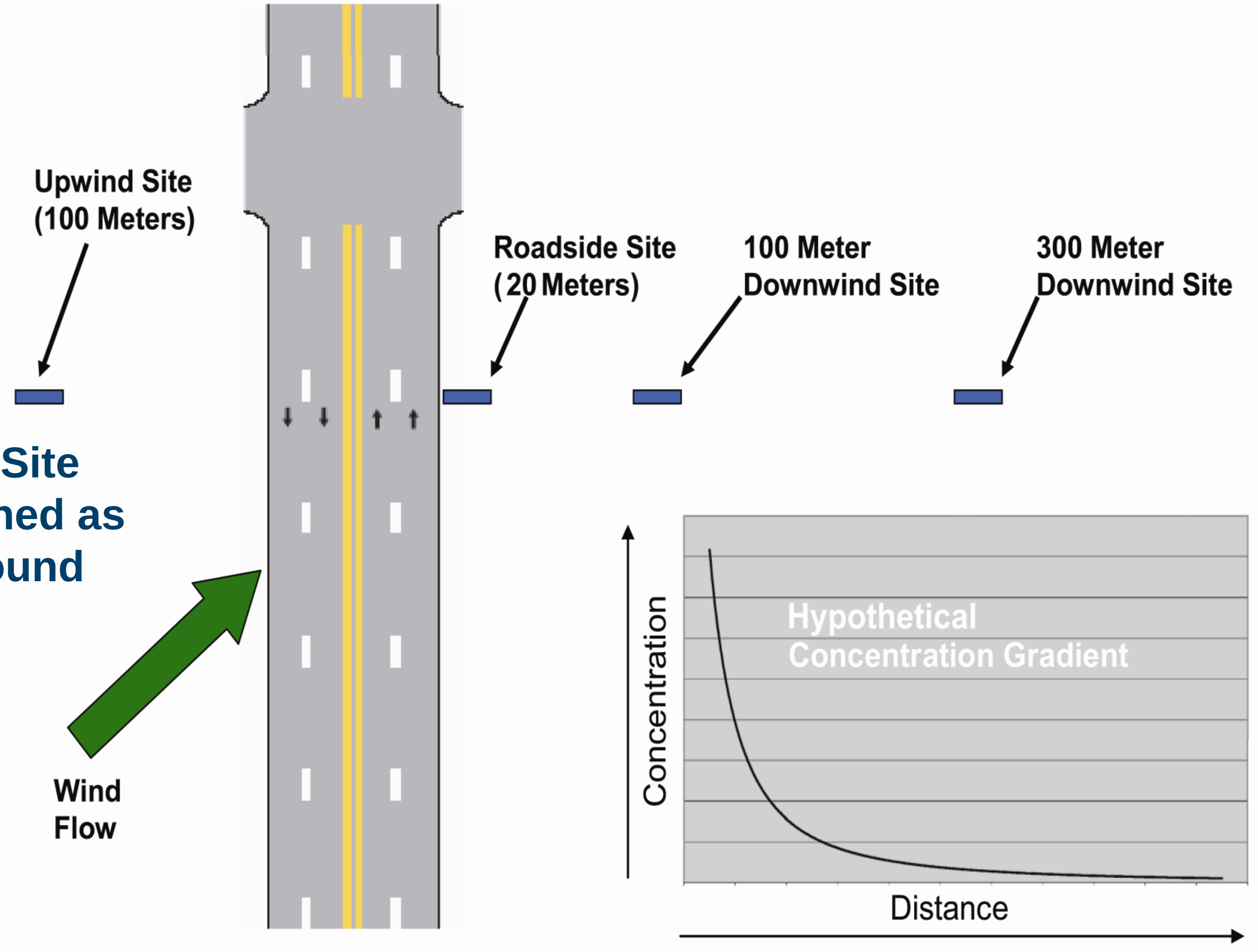
Evaluating Models for Transportation Applications

- Model evaluations based on model-to-monitor comparisons from field studies present many challenges for interpreting results
- Comparisons reflect results from the full modeling system:

  CONC = *f* (E,S,M,D,T,R)

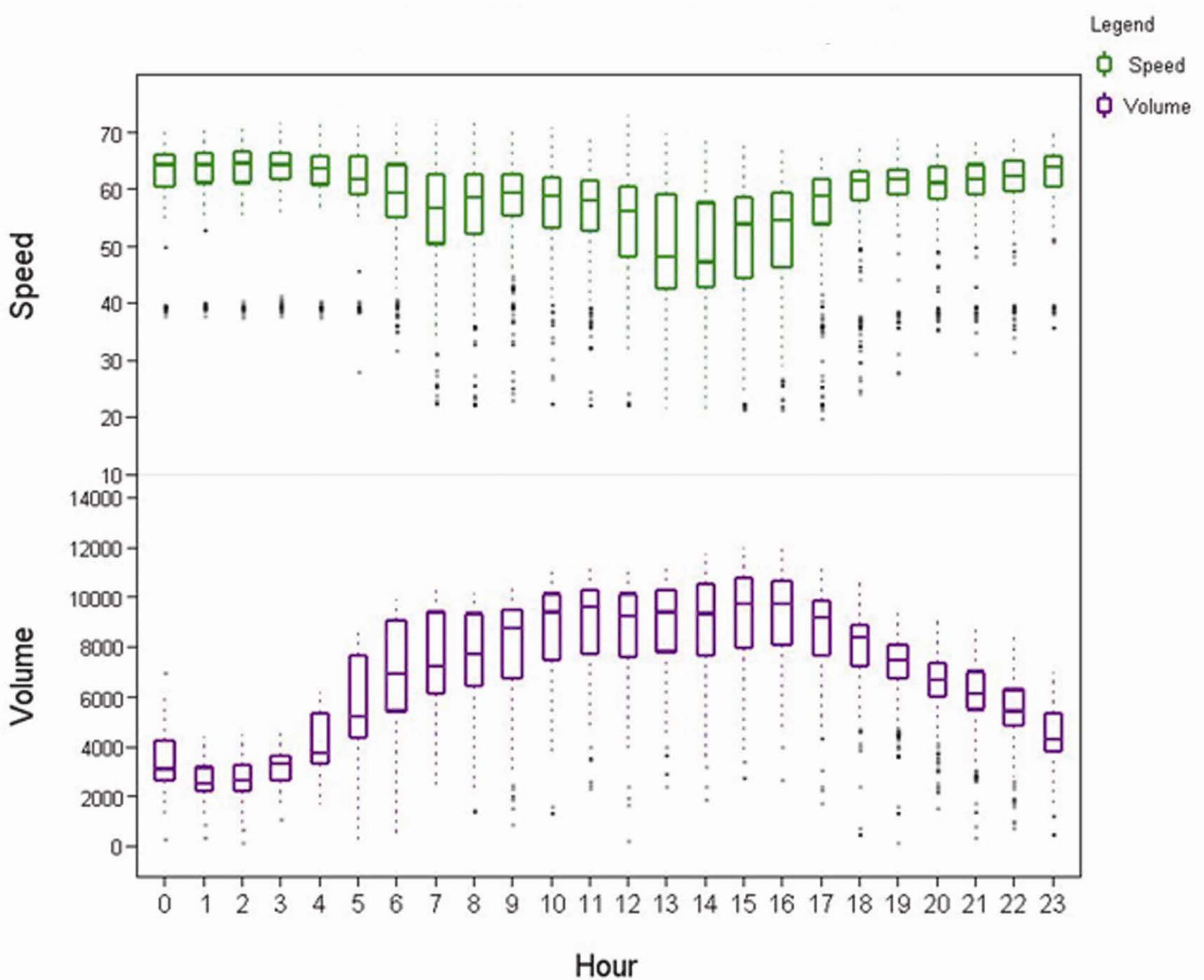
  where: E = emissions
  S = source characterization
  M = meteorology
  D = dispersion model
  T = chemical transformation (e.g., NO to NO_2)
  R = removal processes
- Each of these components incorporates uncertainties related to modeling assumptions and input data, with emissions and source characterization presenting special challenges for mobile sources
- Uncertainty regarding contributions from "background" sources not included in modeling also complicates interpretation of results

Schematic of Monitoring Site Locations



Upwind Site Functioned as Background Site

Average Hourly traffic volume and speed I-15 site from December, 2008 through December, 2009.



Traffic Count Totals (Monitors vs Video) Northbound Traffic I-15

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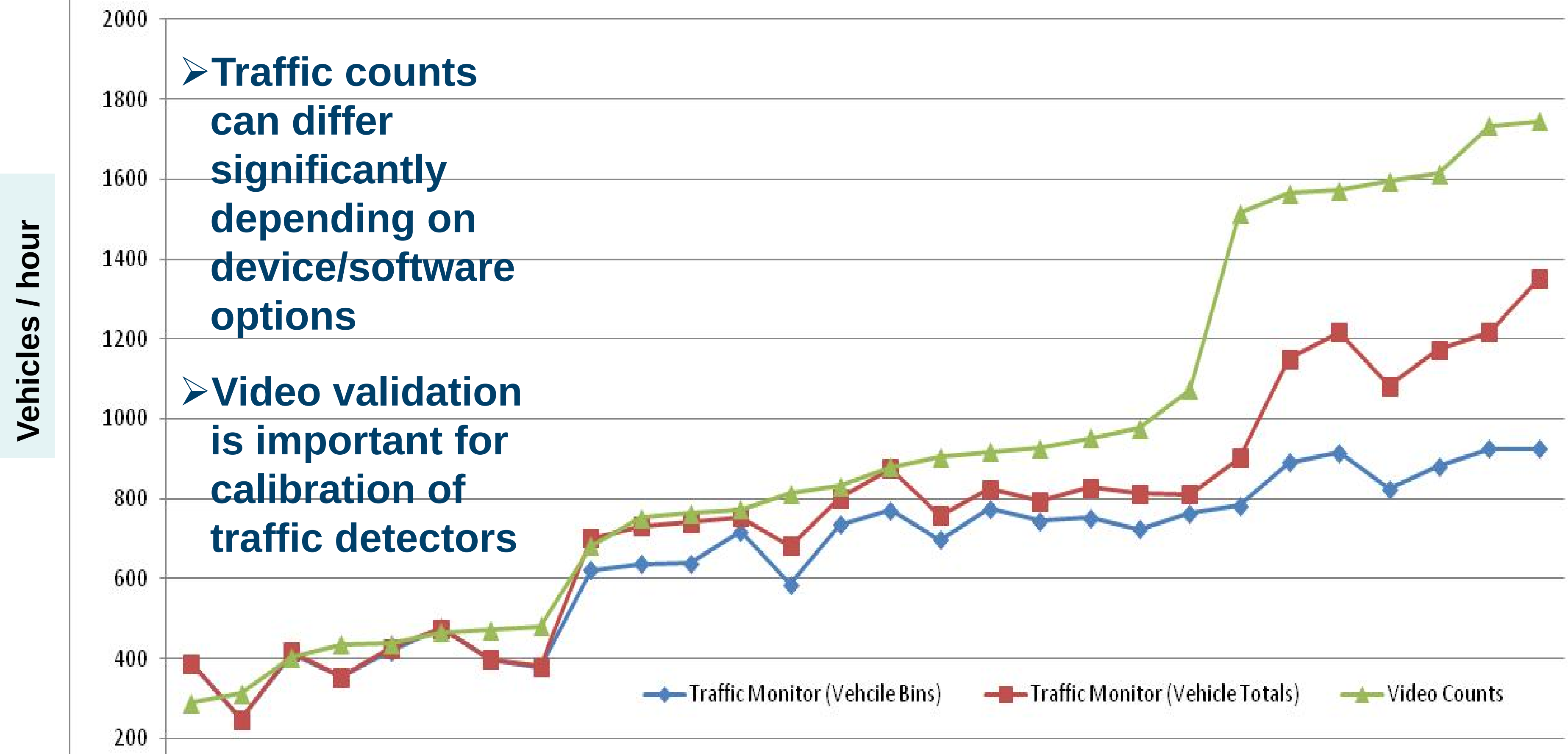


- **Traffic counts can differ significantly depending on device/software options**
- **Video validation is important for calibration of traffic detectors**

Average % Difference Comparing Truck Counts (Totals vs Video) = 30%

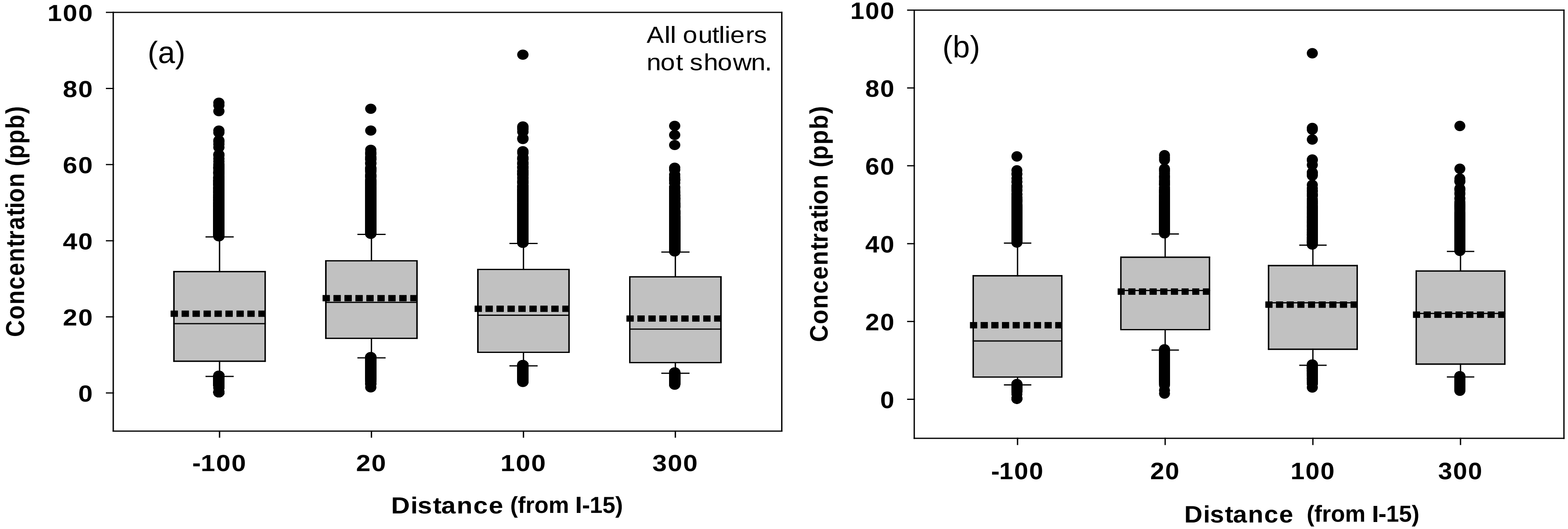
Average % Difference Comparing Car Counts (Totals vs Video) = 26%

Wind Sectors Used for Model-to-Monitor Comparison Relative to I-15 Monitoring Site

Avg Peak Traffic Flow = 6700 vehicles/hour

Max Hourly Target Score = 36

Hourly Average NO_2 Concentration Box Plots, All Sites, (a) All Wind Conditions All Sites, (b) Downwind Conditions (mean is the dotted line in each box).



2009 Hourly Average NO_2 Concentrations

20m site = 24 ppb 100m site = 22 ppb

300m site = 19 ppb - 100m site = 21 ppb

hourly measurements = 8,760

2009 Hourly Average NO_2 Concentrations

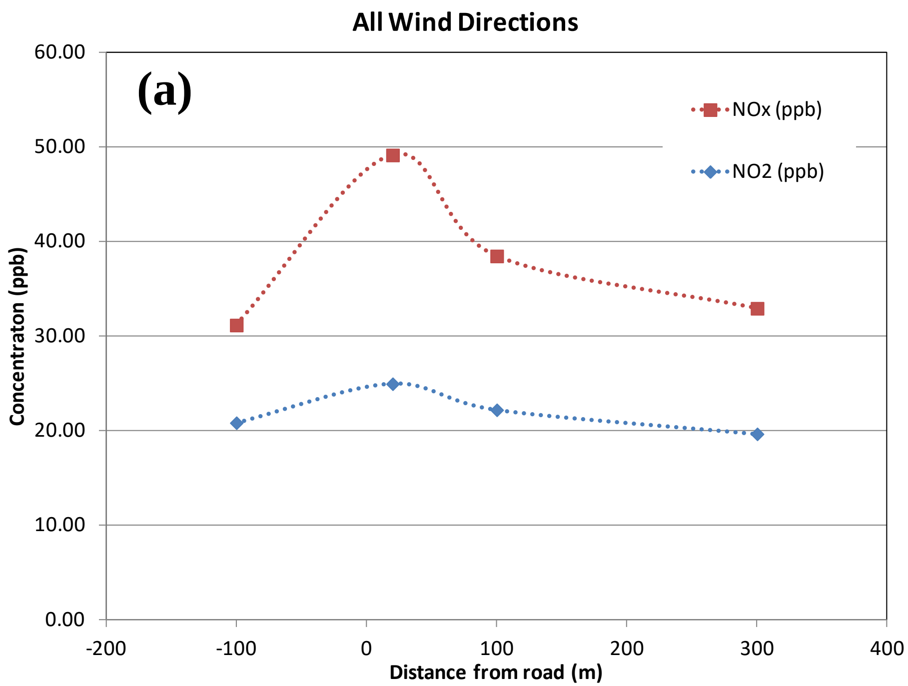
20m site = 30 ppb 100m site = 26 ppb

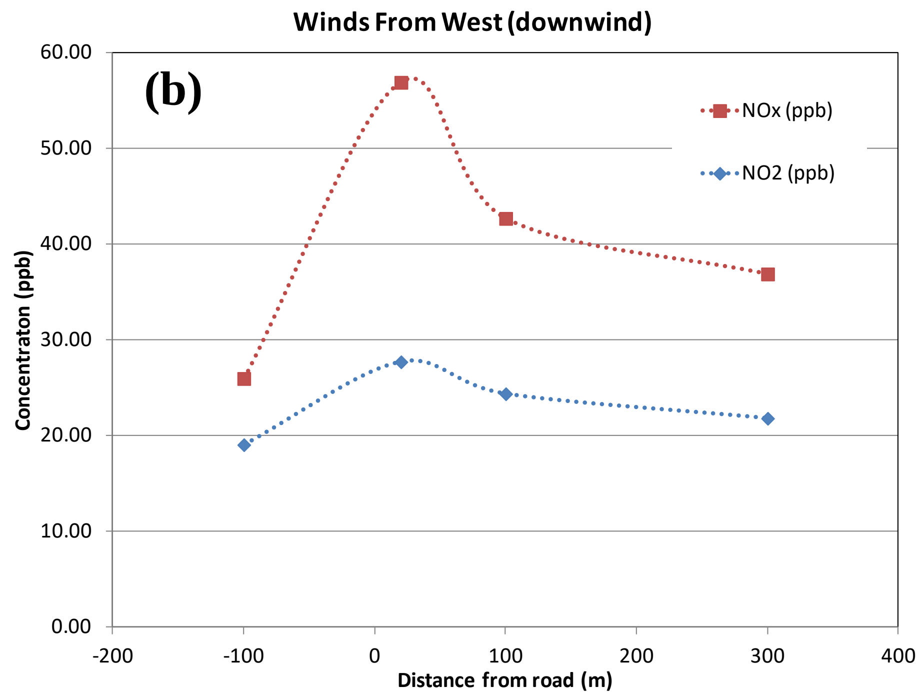
300m site = 23 ppb -100m site = 21 ppb

Downwind: 210 to 330 degrees

hourly measurements = 3,895

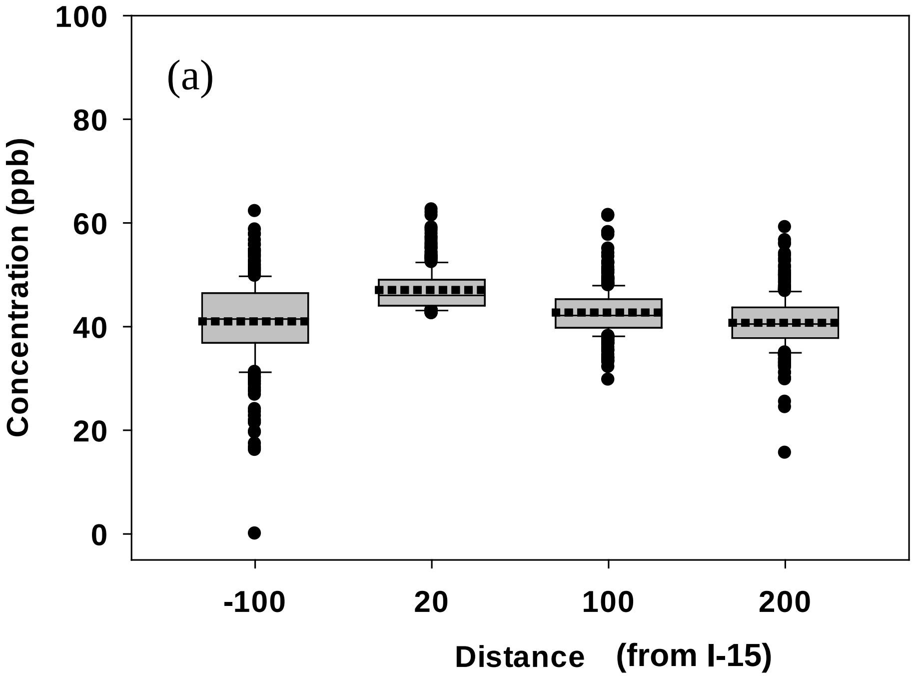
Mean NO_2 and Mean NO_X Concentration Gradients, (a) All Sites and All Wind Conditions and (b) Downwind Conditions (mean is the dotted line in each box).

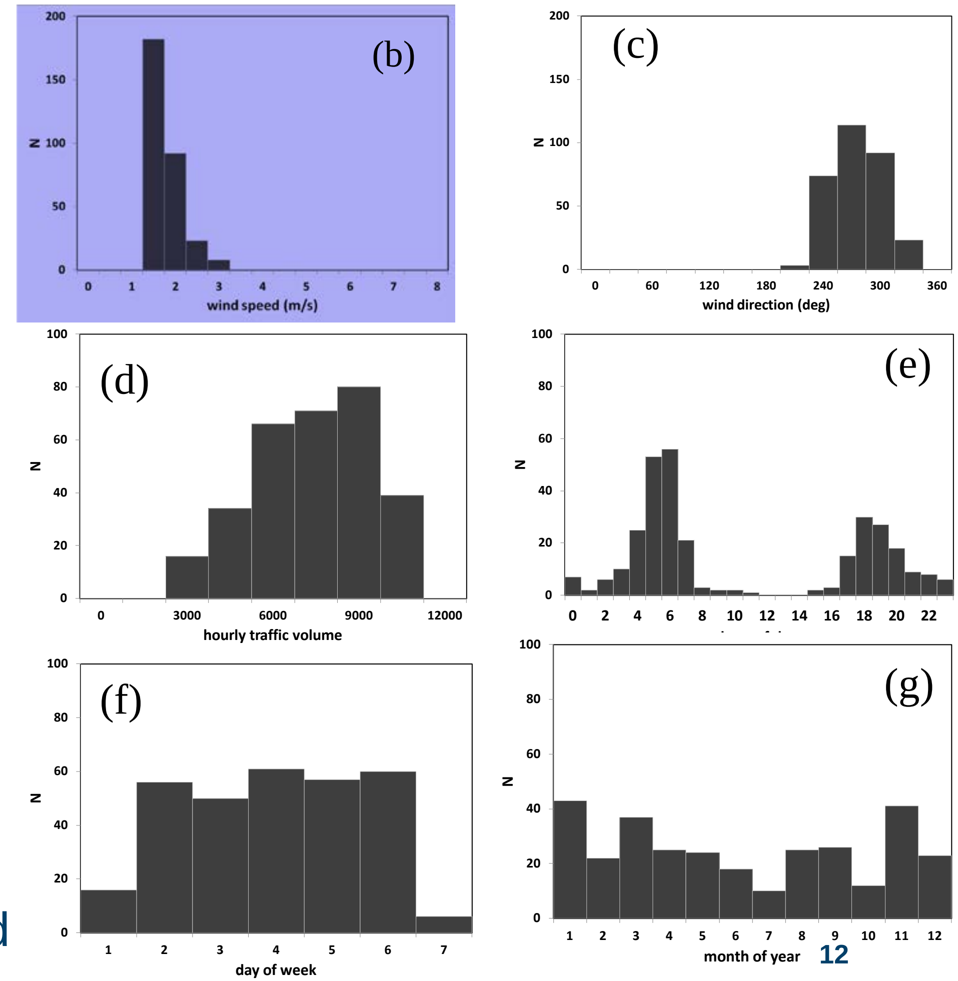




- Mean NO_2 and NO_X concentrations are elevated when winds are from west (downwind conditions)

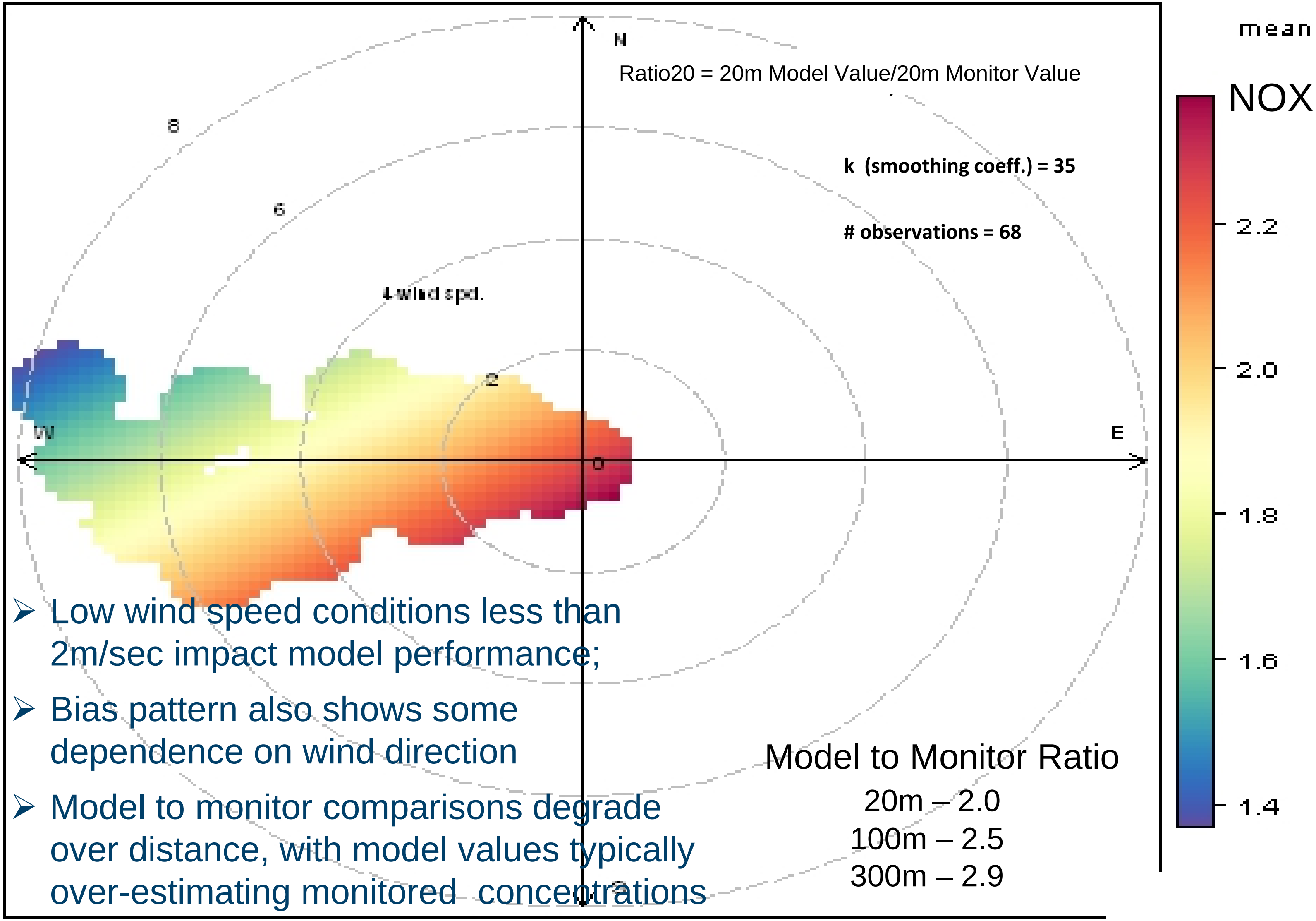
NO_2 Concentration Box Plots Highest 10% of Site 1 for Downwind Conditions (mean is the dotted line in each box) (a) and Histograms of Wind Speed (b), Wind Direction (c), Traffic Volume (d), Hour of Day (e), Day of Week (f), and Month of Year (g) for the Same Time Periods





- Meteorological conditions impact pollutant concentrations
- Pollutant concentrations are elevated under downwind conditions

Nitrogen Oxide Model (AERMOD) to Monitor Analysis



- Low wind speed conditions less than 2m/sec impact model performance;
- Bias pattern also shows some dependence on wind direction
- Model to monitor comparisons degrade over distance, with model values typically over-estimating monitored concentrations

Model to Monitor Ratio
20m – 2.0
100m – 2.5
300m – 2.9

AERMOD is EPA's Recommended Dispersion Model
http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod

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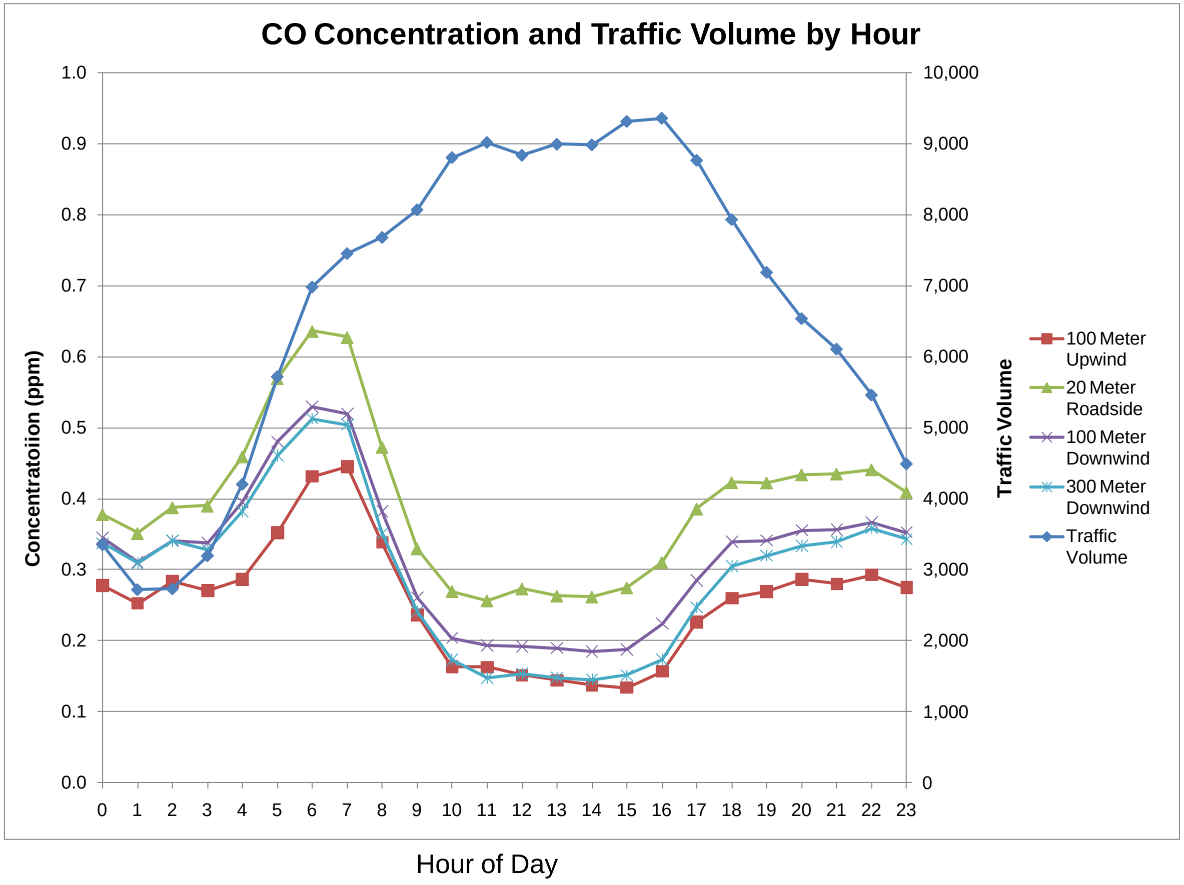
Air Pollutant Concentration Trends and Influence of Meteorological Conditions

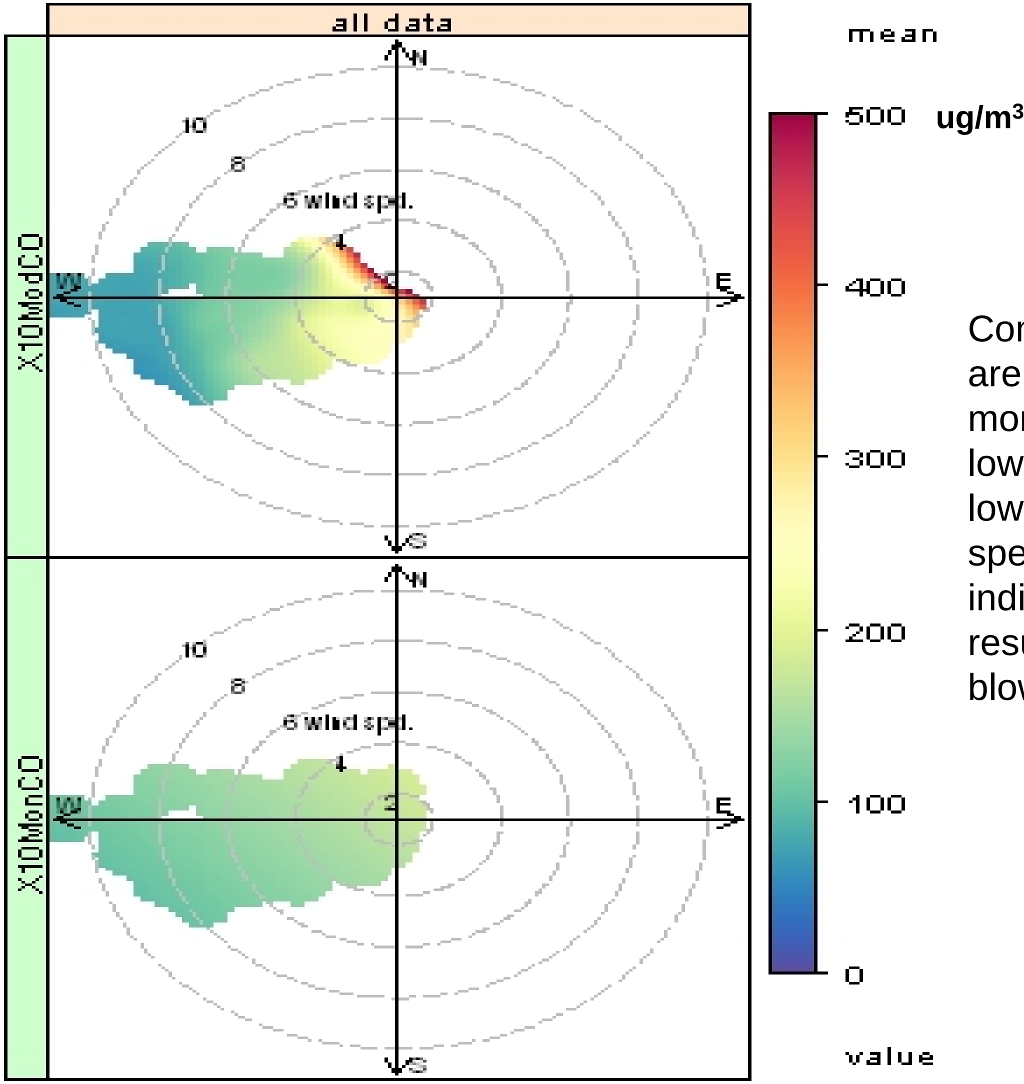
- **CO concentration trends with increase in traffic volume (5-7 A.M.)**
- **CO concentration appears to decrease through morning and early afternoon hours**
- **CO concentrations begin to increase again beginning around 3 P.M.**
- **Influence of Meteorological Conditions**
  - **Solar Heating/Atmospheric Mixing**
  - **Increased Wind Speeds**



Carbon Monoxide Monitor and Model (AERMOD) Results (20 meter Site)

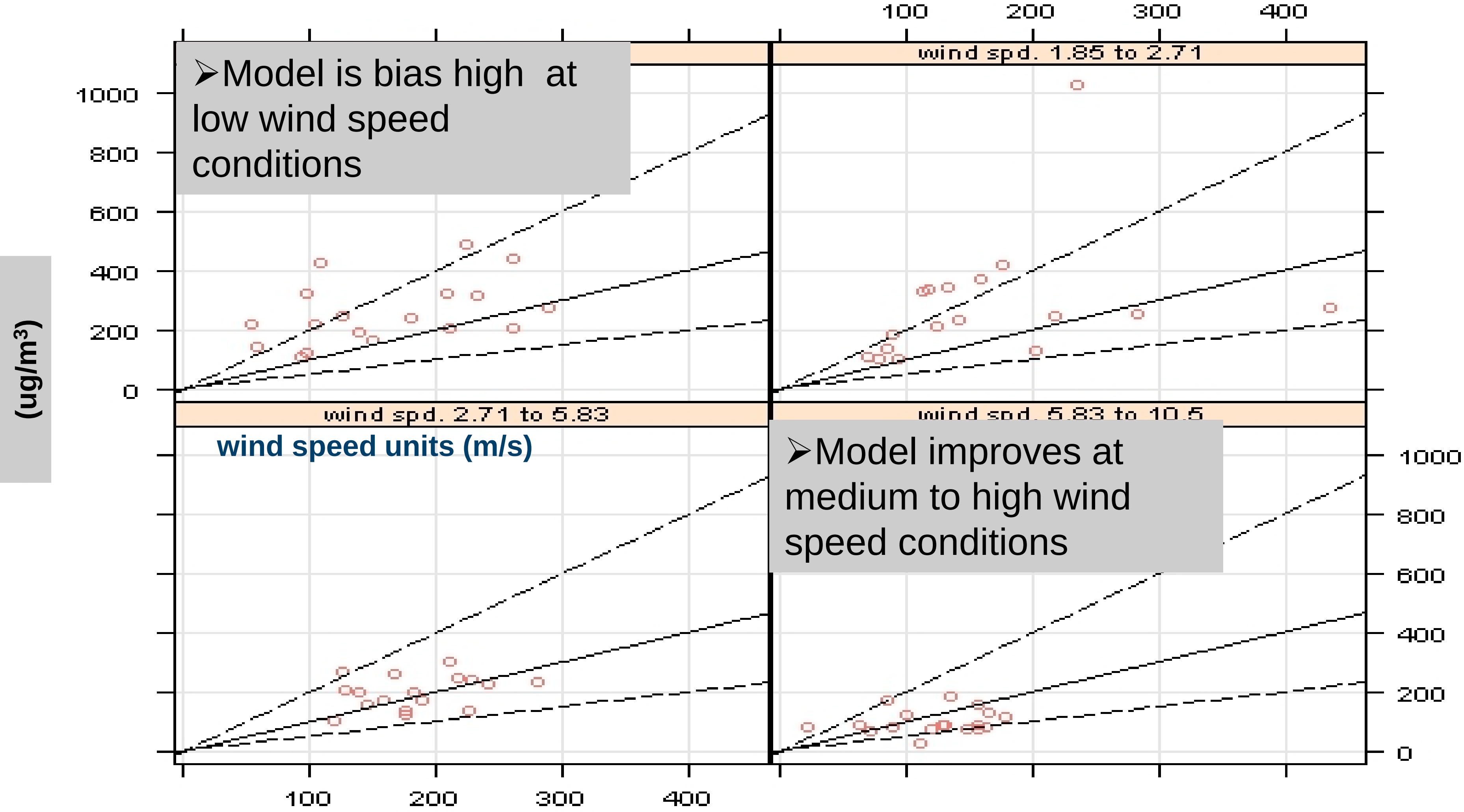
observations = 71

k (smoothing coeff.) = 50



Comments: Model results are typically higher than monitored values during low wind speeds and lower during high wind speeds. The plot also indicates higher modeled results when the winds are blowing from the NW.

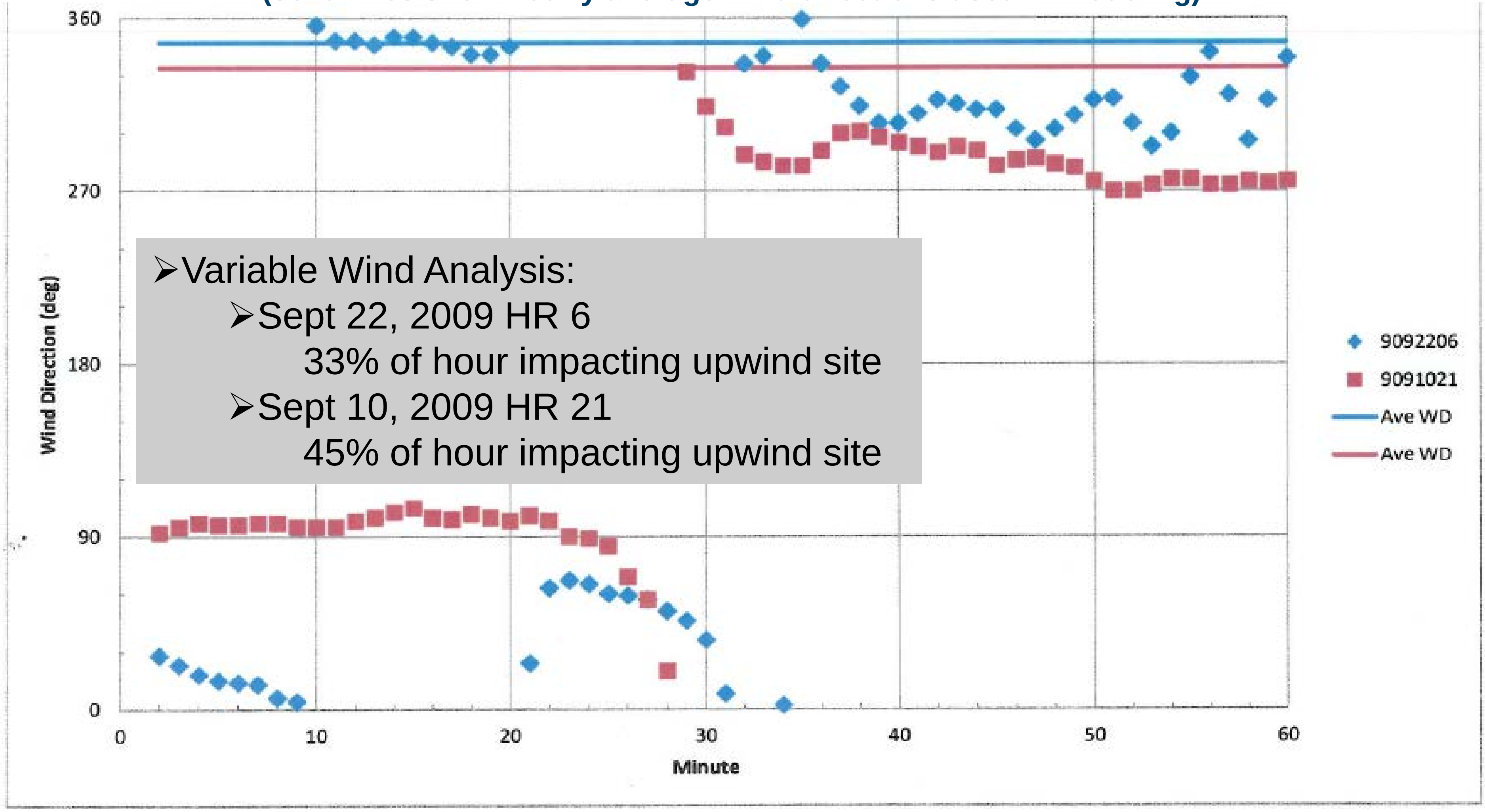
Carbon Monoxide Model (AERMOD) to Monitor Analysis (without outliers at 20 meter site)



CO concentration (ug/m³)

Two highest modeled CO values show significant wind shift during the hour; therefore I-15 emissions were significantly impacting "upwind" monitor

Plot shows 2-minute rolling average wind directions at Las Vegas airport (solid lines show hourly average wind directions used in modeling)



- Variable Wind Analysis:
  - Sept 22, 2009 HR 6
    33% of hour impacting upwind site
  - Sept 10, 2009 HR 21
    45% of hour impacting upwind site

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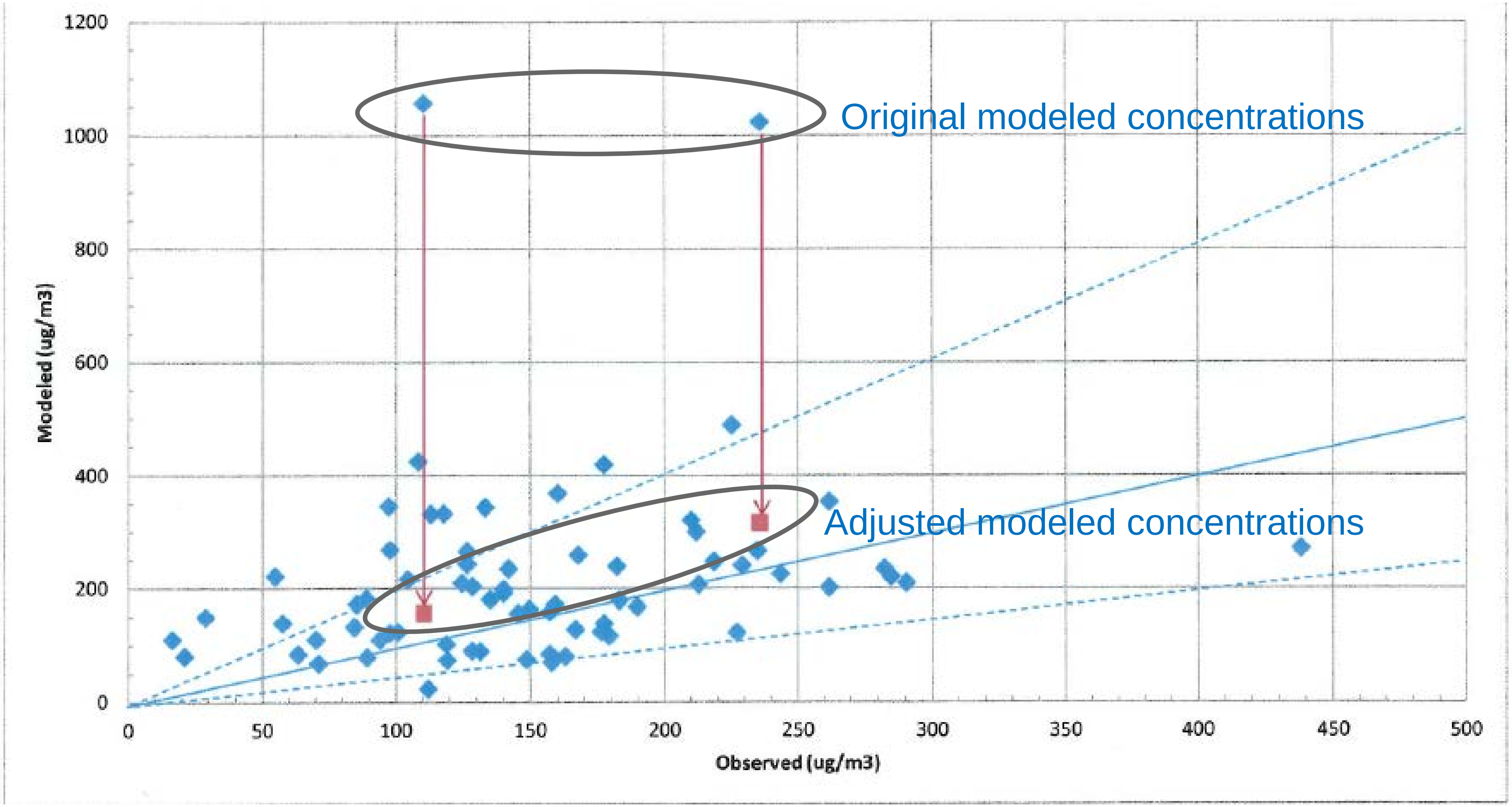
Adjusted Las Vegas 1-Hour Paired CO Model-to-Monitor Comparisons

(using volume sources and six 10-minute average wind directions for top 2 CO values)



Conclusions for CO and NOx Model/Monitor Analysis

- Model to monitor analysis show good agreement within a factor of 2 for the 20 meter site.
- Model to monitor comparisons show increased bias with the model over-reporting during low wind speeds ie. $\leq$ 2 m/s
- Model to monitor comparisons for the 100 and 300 meters sites are slightly higher due to potential background interferences at the monitor and additional mobile sources that were not included in the model emissions inventory
- Additional uncertainties that may improve comparisons
  - Motor Vehicle Emissions Simulator (MOVES): Improved hourly fleet mix and drive cycle data
  - AERMOD: Improved hourly sigma (z) values, and improvements in AERMOD during low wind speed events, and utilization of refined site topography data to account for site conditions (depressed roadway, railroad trestle)