

Highway Noise Levels in a Suburban Environment Under Inversion Conditions

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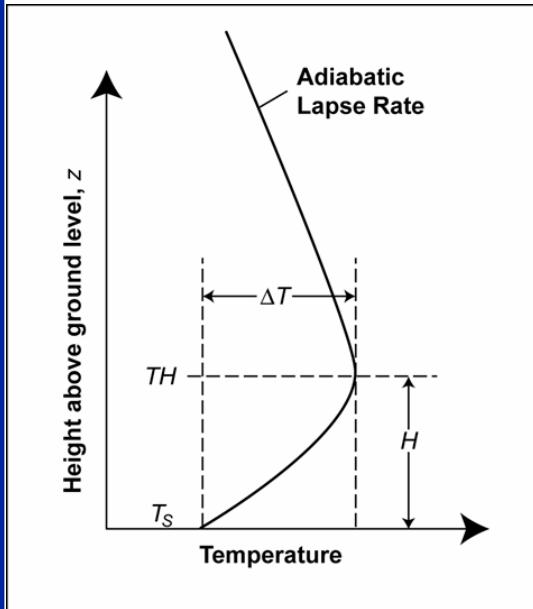
Parabolic Equation Model (PE)

- Full wave solution of wave equation
- Multiple varieties available
 - Split step solution (propagate in uniform atmosphere then correct for atmospheric effects)
 - Requires small steps, constant freq.
 - Can handle arbitrary atmosphere and ground impedance
 - Needs temperature and wind profile to ~10-20% prop range
- Topography changes (barriers, terrain, etc.) open research area

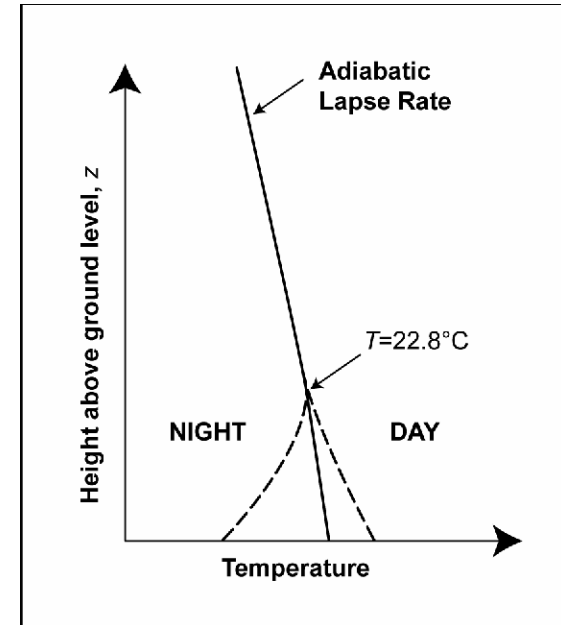


MET MODELING (temperature)

50' tower site 2



Stull's Scaling
Law



$$T(z) = T_s + [1 - (1 - z/H)^\alpha] \Delta T$$

$$dT/dz = \Delta T \alpha / H @ z = 0$$

Assumptions:

$$\alpha = 2.5$$

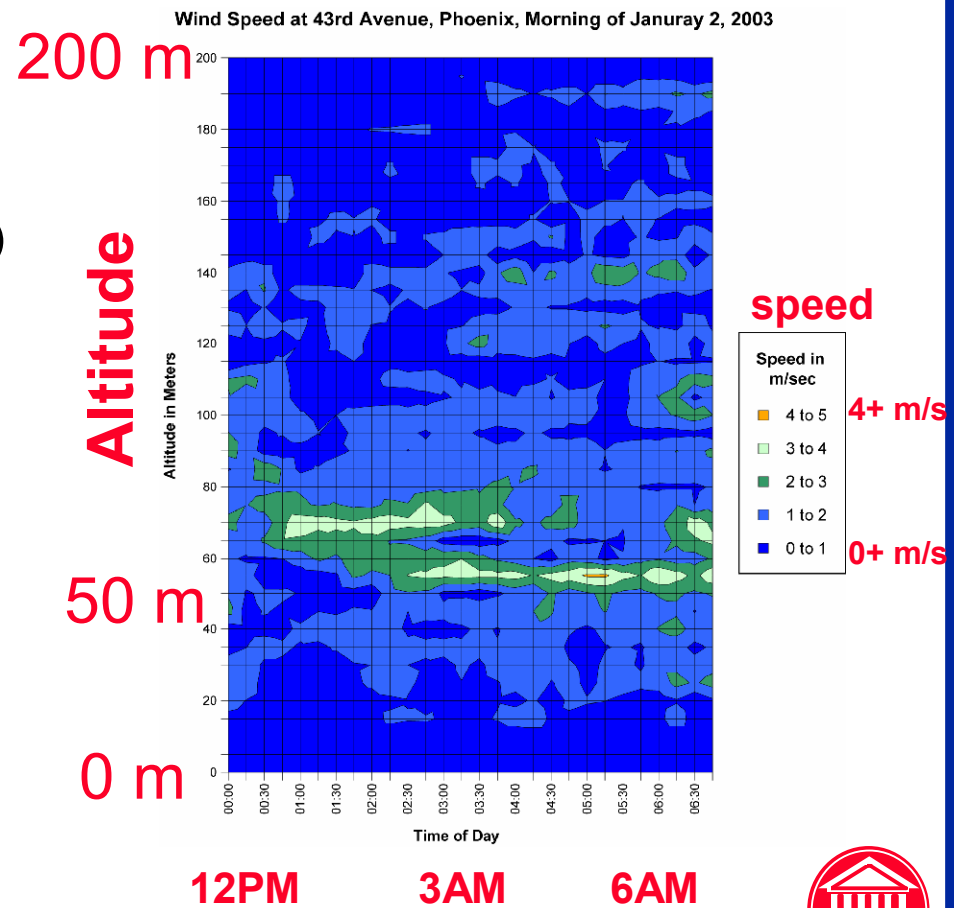
$$\Delta T = 22.8^{\circ} \pm T_s$$

$$dT/dz = \text{measured}$$



MET MODELING (wind)

- No significant winds measured up to 13 m (50')
- Previous Arizona Department of Environmental Quality (ADEQ) suggested low level "jet" of 2-4 m/s at ~50m at site several miles away
- Representative wind profile used to see representative effects

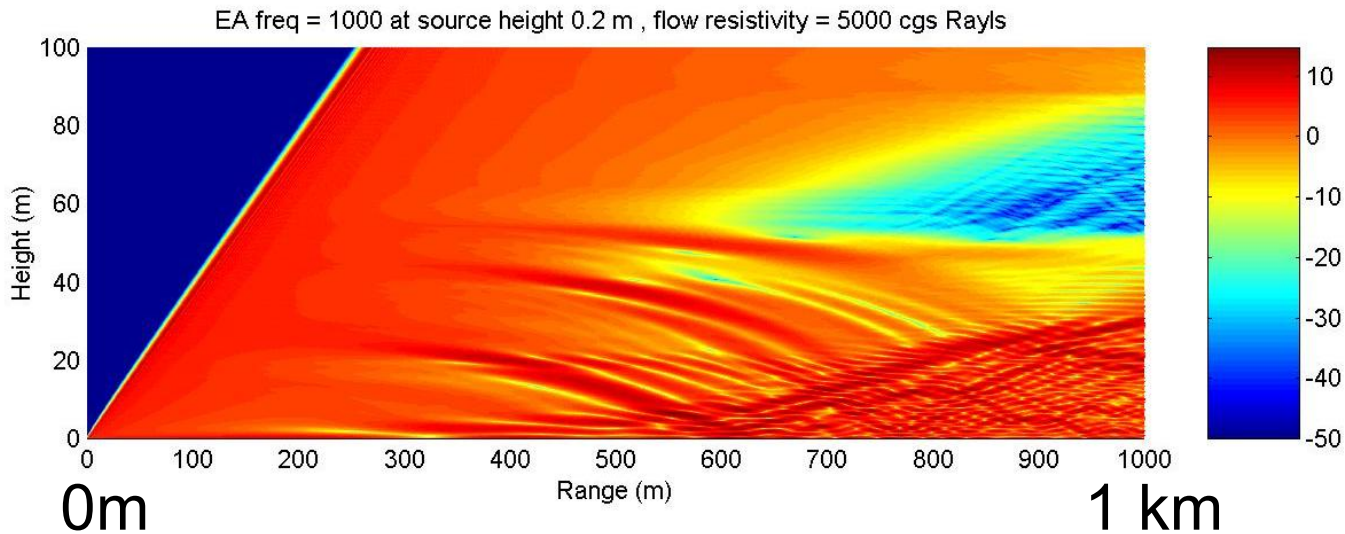
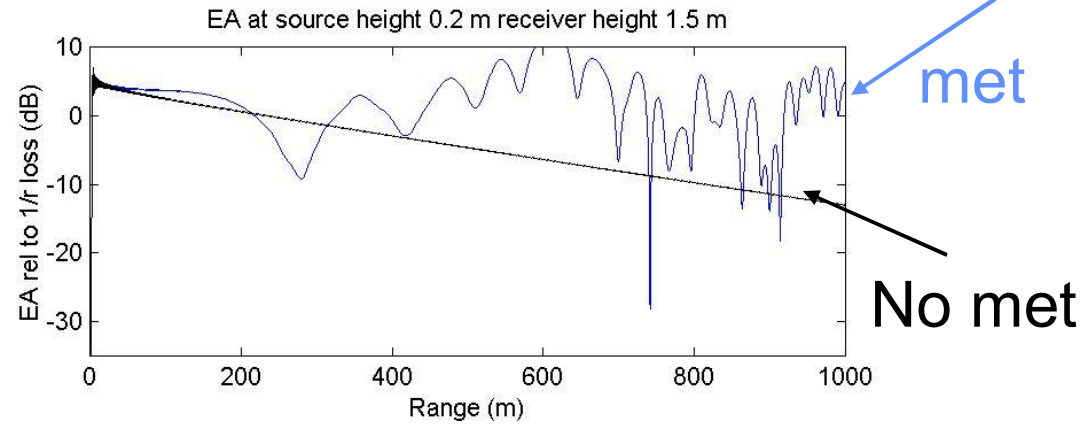
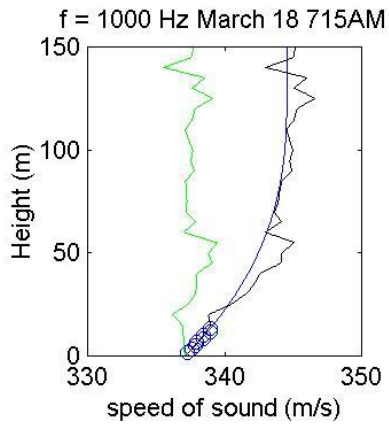


PE RESULTS CONTINUED

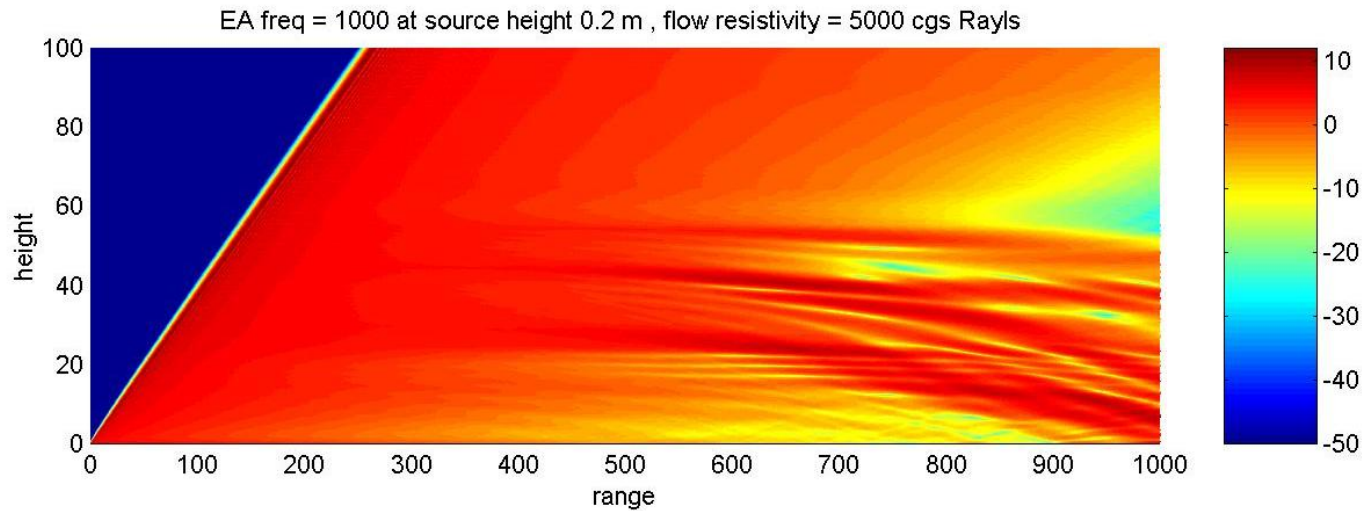
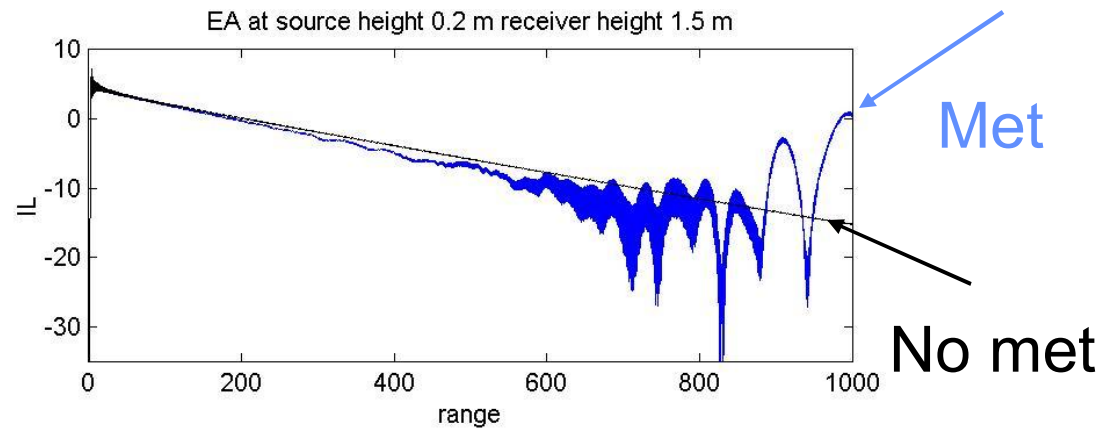
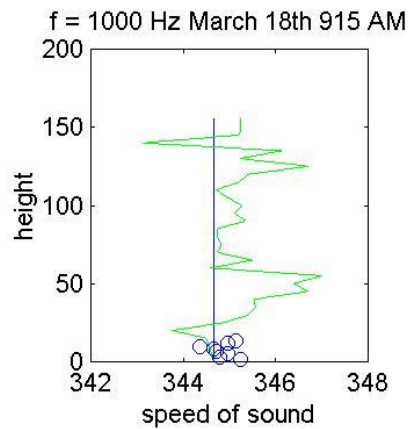
- PE run for octave bands 63Hz to 1 kHz
- PE run for no met (air absorption and ground absorption) as reference
 - rh from met data, $\sigma = 5000$ cgs rayls (assumed)
- PE run for temperature only as well as temperature combined with upwind and downwind
- Site 1 level used as source and range corrected (along with PE output) to predict levels in neighborhood (sites 3-4).



PE RESULTS (freq = 1kHz, temp + wind)

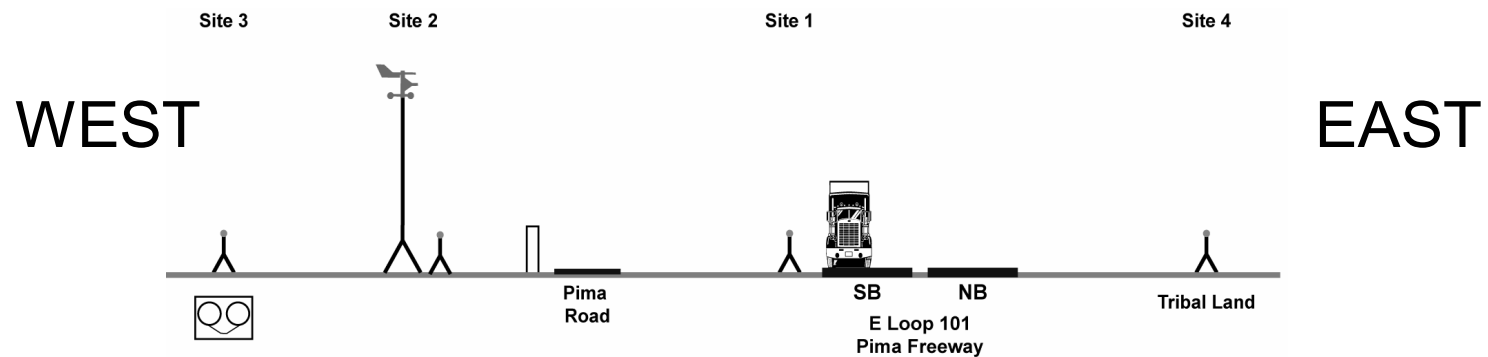


PE RESULTS (freq = 1kHz, wind only)




FIELD MEASUREMENTS


Site 3 Site 2 Site 1 Site 4




1/3 octave band recordings

13m (50') met tower

 **Noise Monitors:** Larson Davis 824s. Data loggers used at Sites 2 and 3 for continuous collection of 1/3 octave band data at one second intervals.

 **Met Station:** 13.7 m (45 ft) tower, wind speed and direction at 13.7 m (45 ft) and ground level, temperature at 1.7 m (5.5 ft) intervals, humidity at ground level.

 **Digital Audio Recorder:** Continuous audio recording saving 15 minute WAV files on a hard drive.



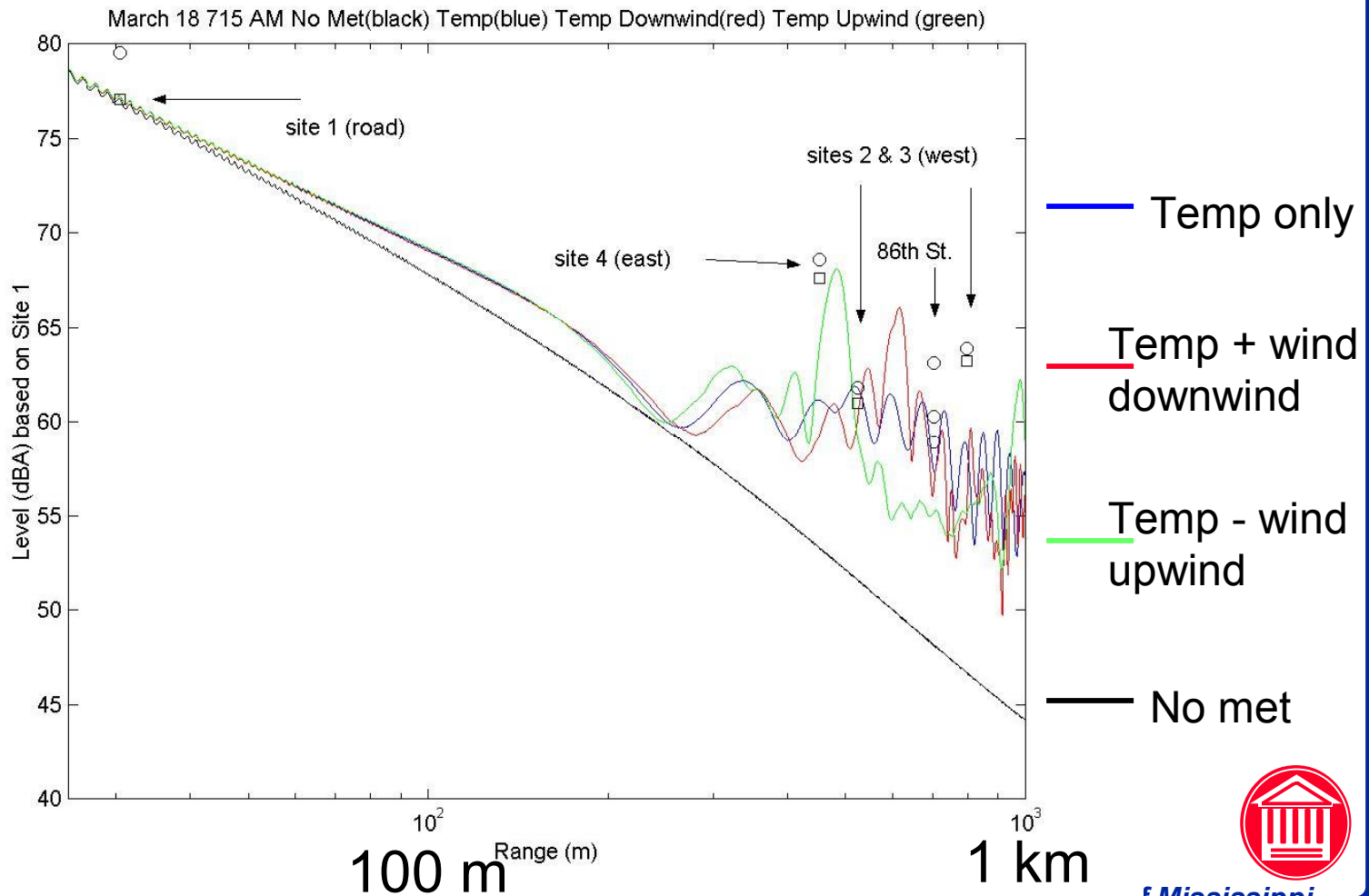
Predicting Levels

- PE code provides Excess Attenuation (relative to spreading loss), need to correct “source” level
- Site 1 used as quasi-source and then range corrected for sites 2-4
- Usually assumes point source ($1/r$ or $20 \log_{10}(\text{range})$)
- Long highway (or infinite line) source $1/\sqrt{r}$ or $10 \log_{10}(\text{range})$
- Our data seems to split the difference $15 \log_{10}(\text{range})$

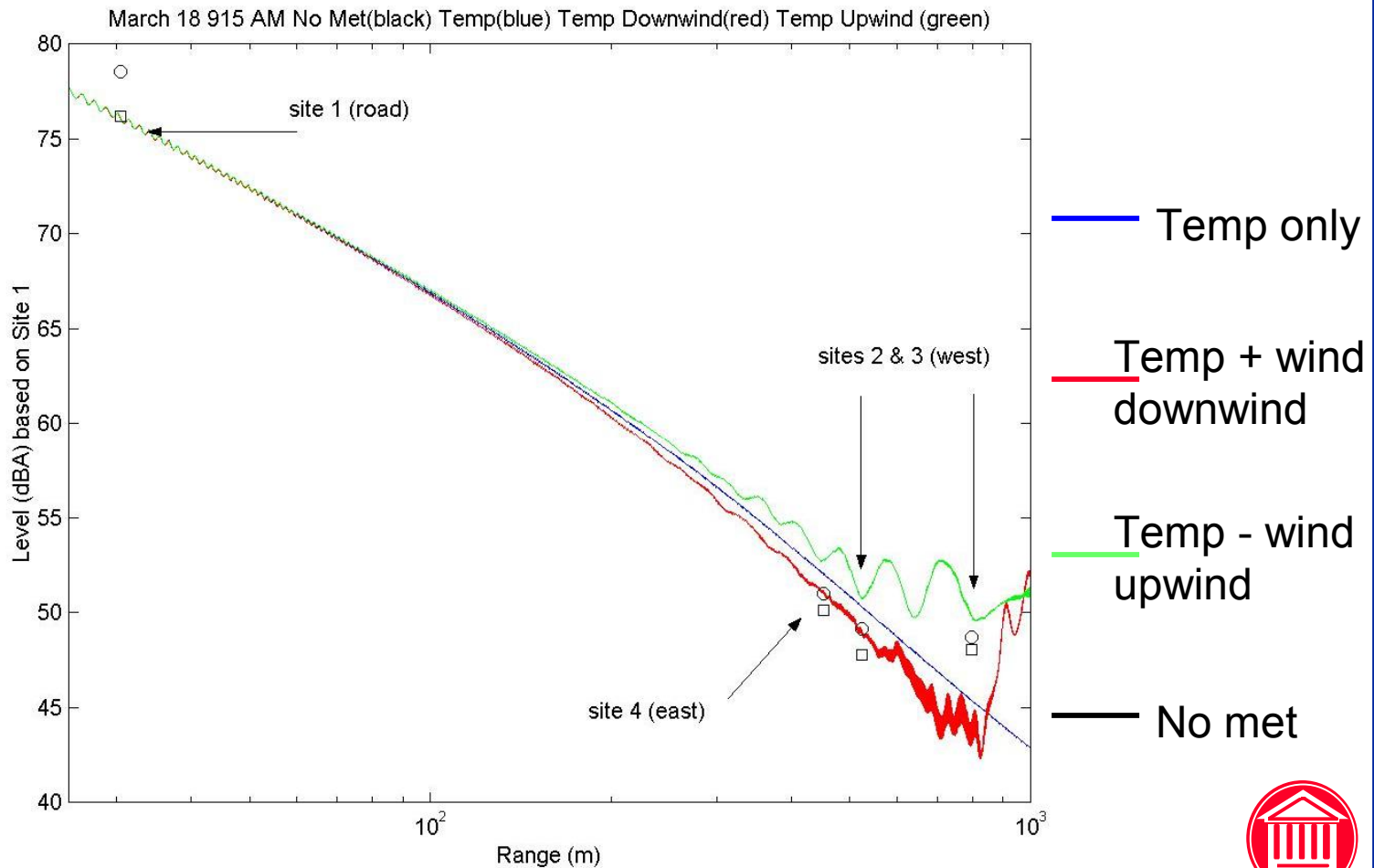
	Spherical $20 * \log_{10}(\text{range})$	Typical data No gradient	$15 * \log_{10}(\text{range})$	Cylindrical $10 * \log_{10}(\text{range})$
Mic2-Mic1	-24.7 dB	-21.2 dB	-18.5 dB	-12.3 dB
Mic3-Mic1	-28.4 dB	-23.5 dB	-21 dB	-14.2 dB



PREDICTED LEVELS (7:15 AM strong gradient)

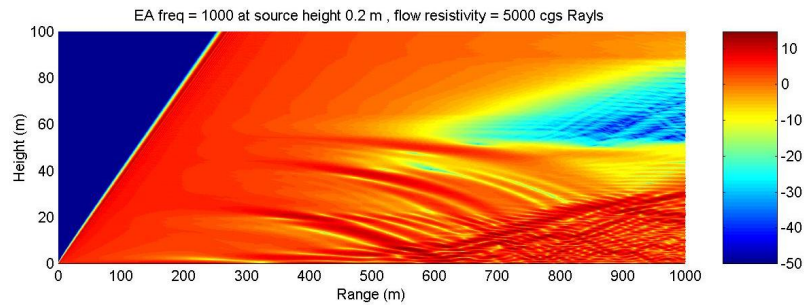
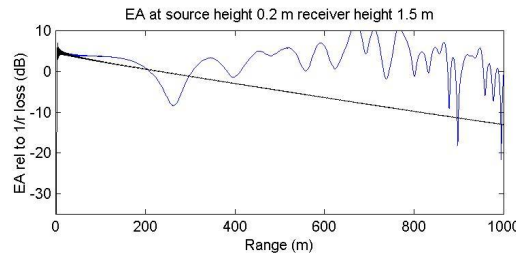
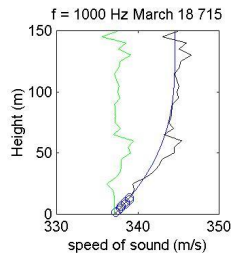
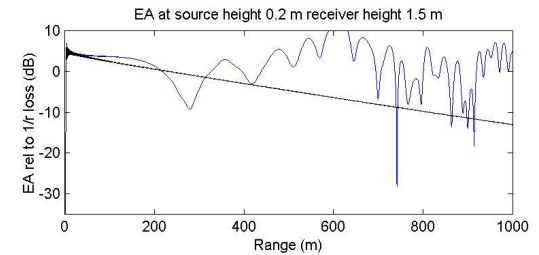
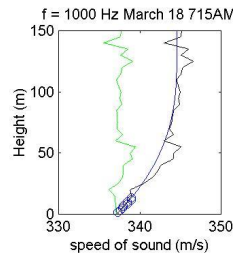


PREDICTED LEVELS (9:15 AM no gradient)

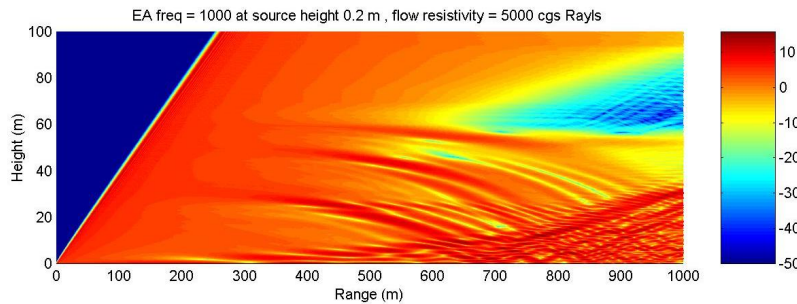


RAISED JET 5 m (PE)

Slight change in structure
Energy pushed to
700 m range



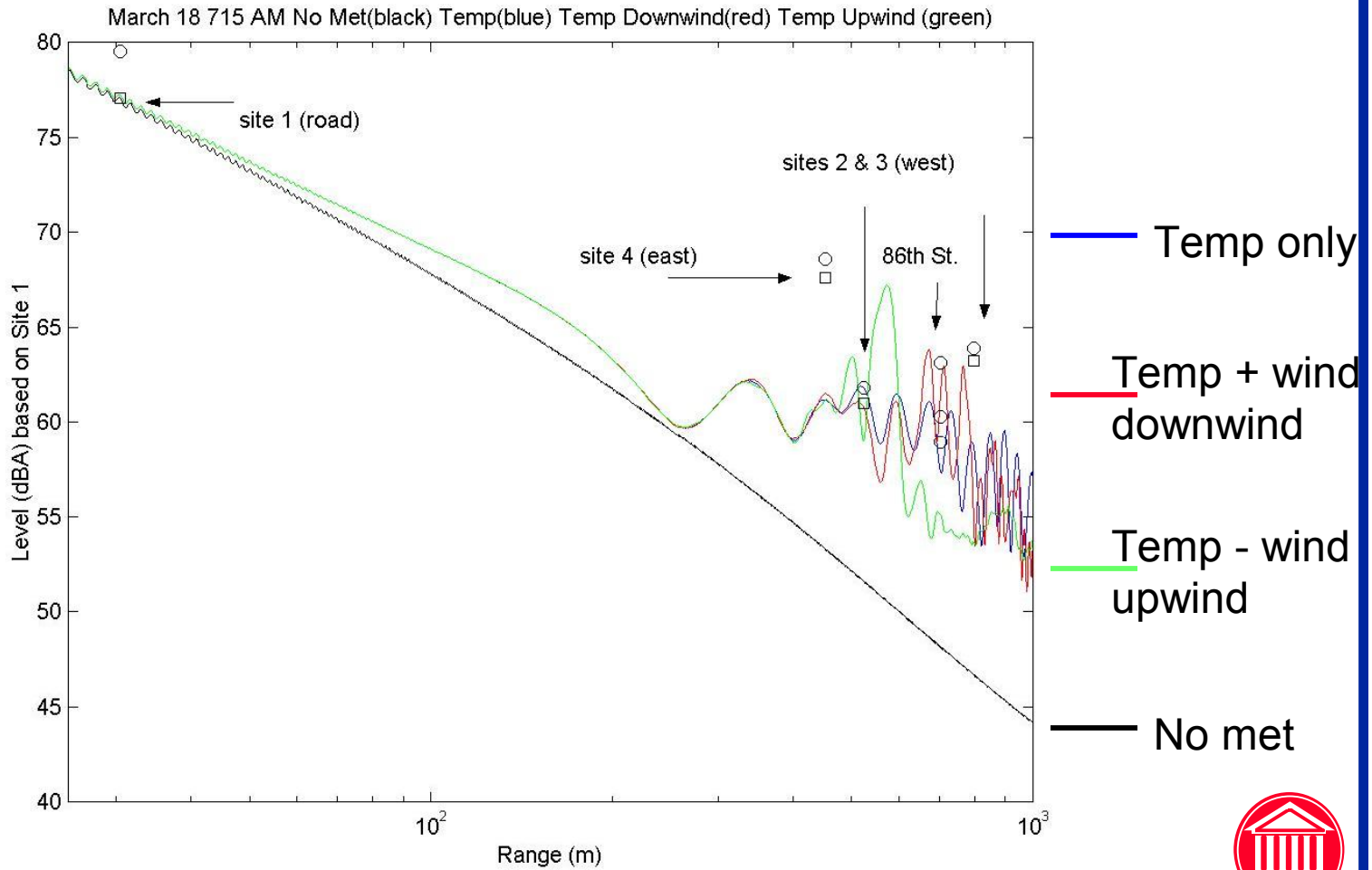
Original



Elevated Jet

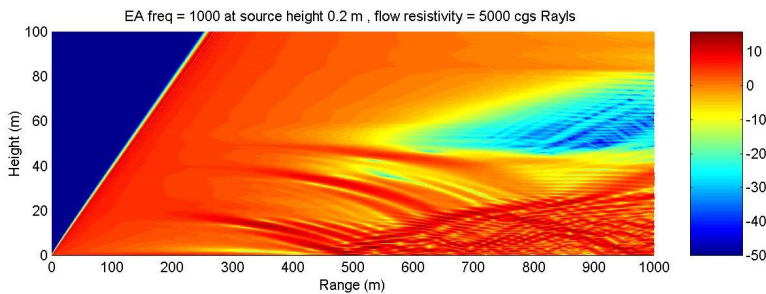
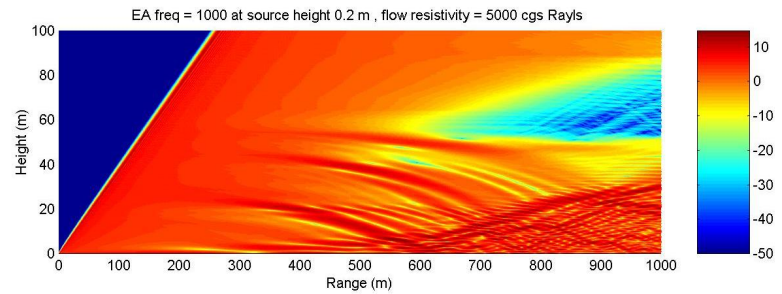
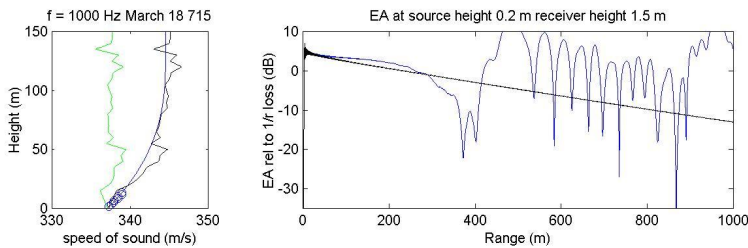
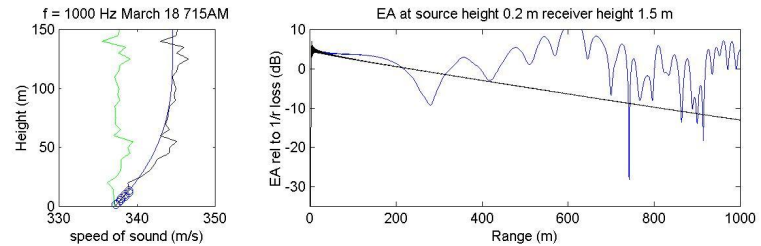


RAISED JET 5 m (Predicted levels)



LOWERED JET 5 m AND DOUBLED SPEED

Slight change in structure
Energy brought in to
500 m range

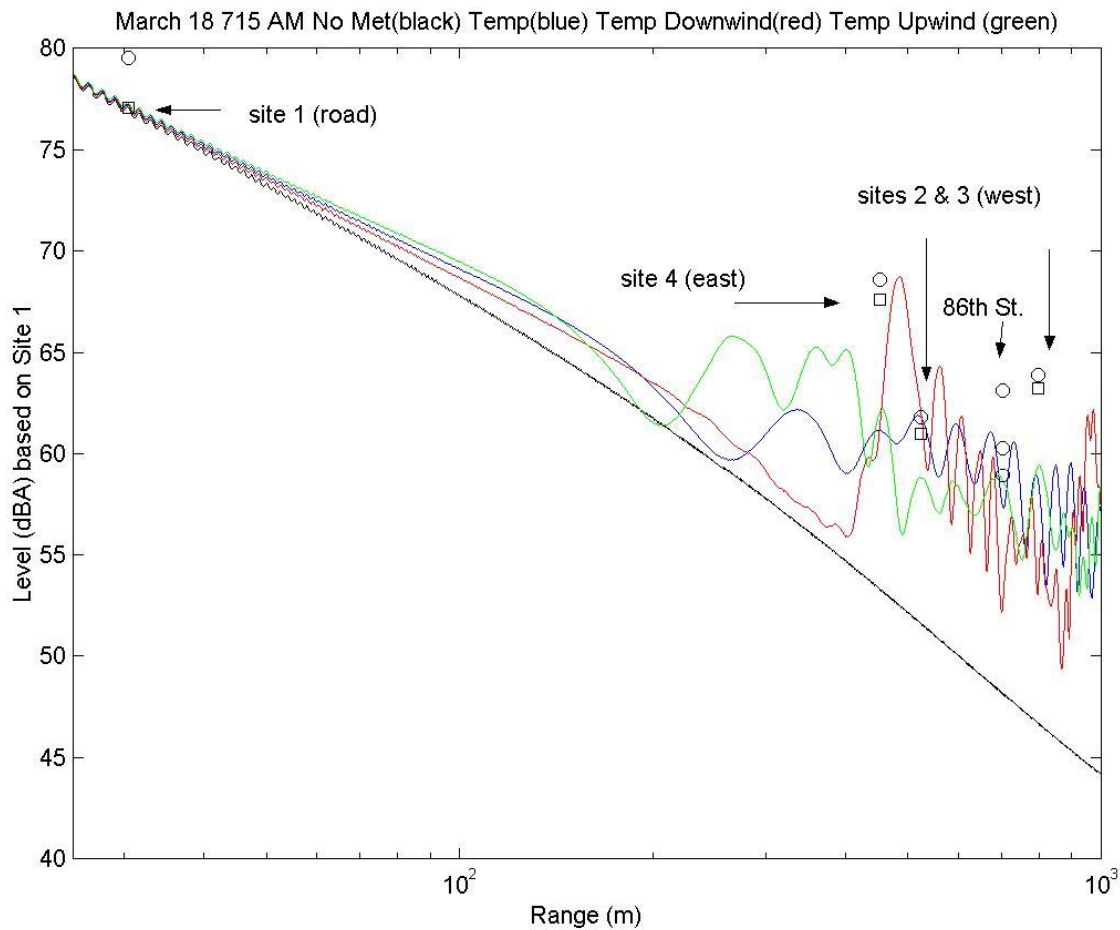


Original

Lower elevation
higher speed Jet



LOWERED JET 5 m AND DOUBLED SPEED



— Temp only

— Temp + wind downwind

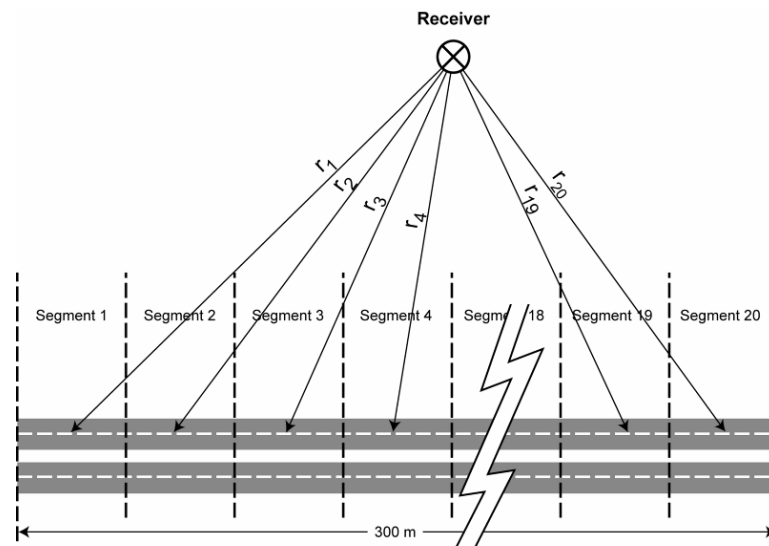
— Temp - wind upwind

— No met

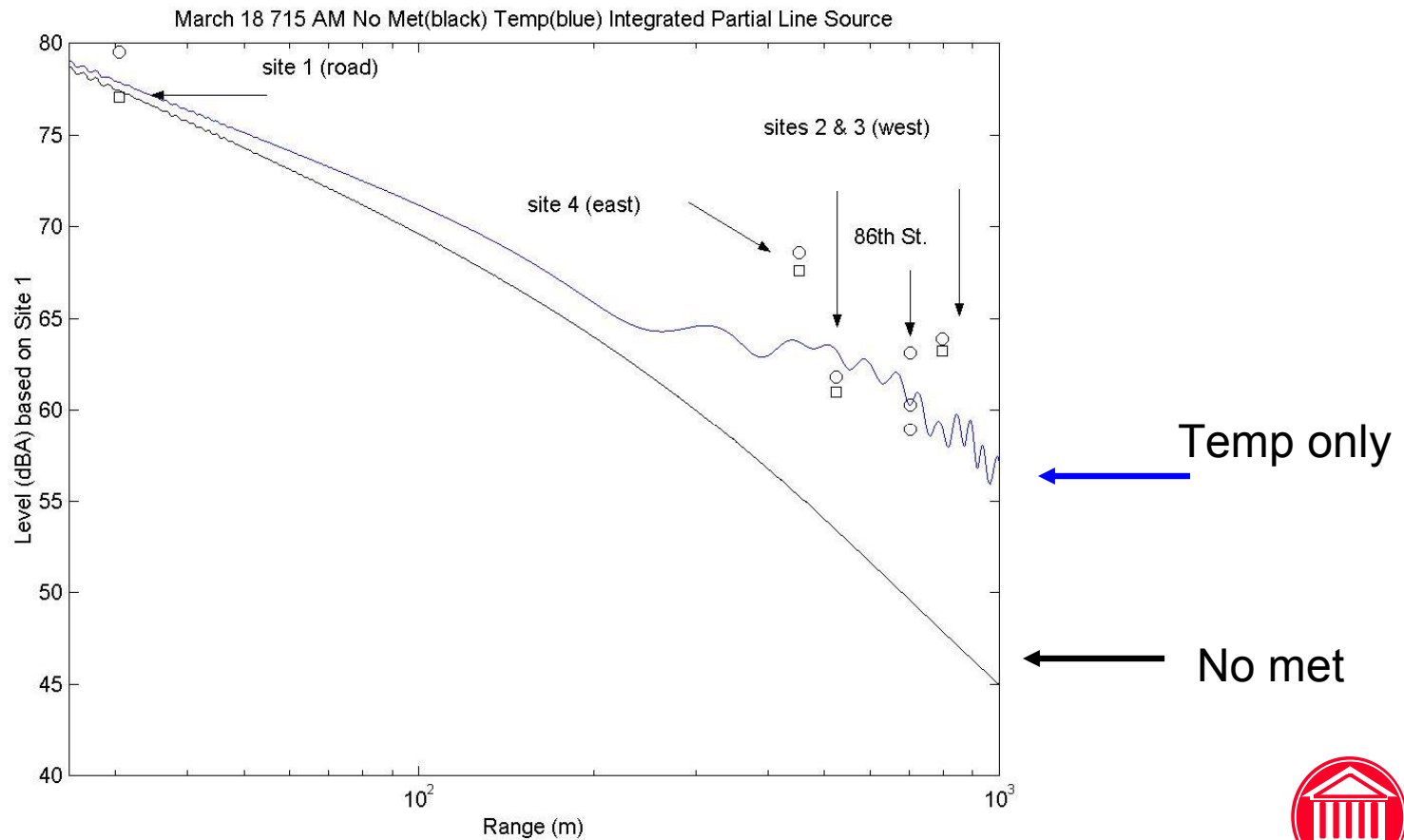


Finite Length Highway

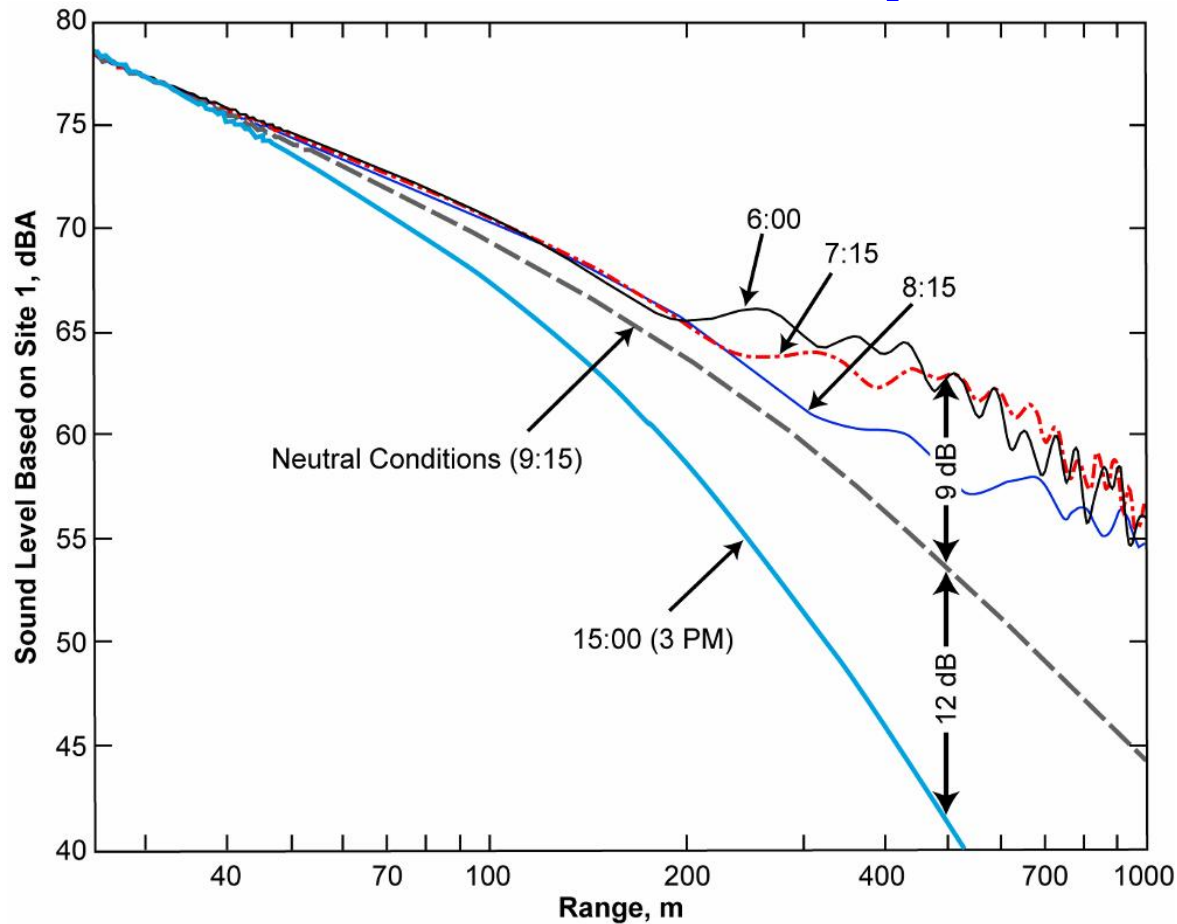
- Each Section of Highway treated as separate source and run through PE model (ala TNM) and combined incoherently
- Twenty 15m sections used
- Functionally provides the $15\log_{10}(\text{range})$ effect observed previously



PREDICTED LEVELS (7:15 AM strong gradient)



SOME OBSERVATIONS (temp only) model output



CONCLUSIONS

- Inversion cause of increased levels in community
- PE model capable of showing increase or decrease in levels due to meteorology
- Effects of temperature inversion sufficient to explain majority of increased levels (and community complaints)
- Implied effects of light winds (assumed profile) explains perturbations about this elevated level (focusing)
- Region of High absorption near highway (plowed field) possible cause of finite length line source effects

