United States Environmental Protection Agency

RLINE Updates/ Mobile Source Modeling

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RLINE – Development to Date

- Significant amount of model development for mobile sources over the last ~8 years
  - R-LINE released by ORD as stand-alone model
    - New dispersion curves to better fit results from Prairie Grass and Idaho Falls datasets
    - Numerical integration to compute concentrations from a line source
    - Single barrier algorithm
    - Depressed roadway algorithm
  - AERMOD 19191 added RLINE beta and RLINEXT **alpha** option as part of joint effort with FHWA
    - RLINEXT source is available as an option, includes barriers and depressed roadway algorithms
  - AERMOD 21112 improved single-barrier and addition of two-barrier algorithm
  - Two field campaigns underway to collect tracer data for roadways
    - Caltrans collecting tracer data for 1 & 2 barriers + no-barrier case
    - NCHRP project collecting tracer data for no-barrier scenario

RLINE – Work Needed

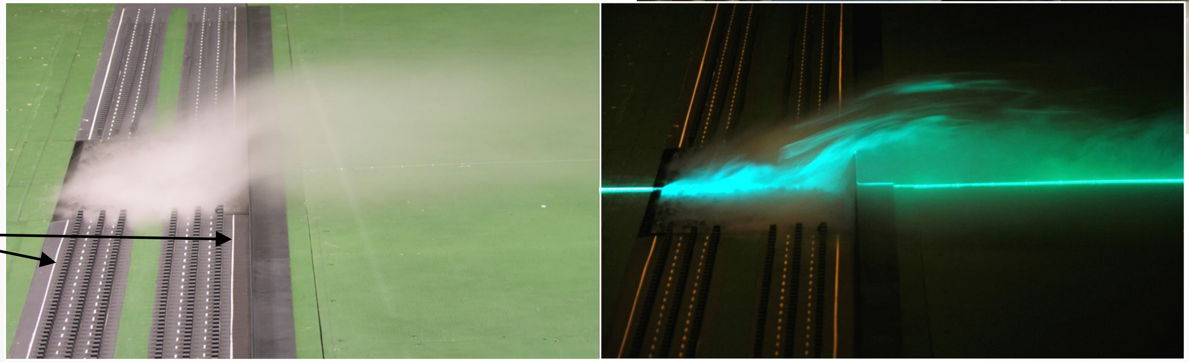
- Many areas of development still needed
  - The URBAN option when paired with RLINE or RLINEXT is **alpha**
  - RLINE does not currently have any terrain treatment
  - Treatment for edge effects - major missing piece of barriers formulation
  - Implementation issues related to pairing sources with barriers (i.e., each source tied to 1 or 2 barriers only)
- Joint effort with FHWA to address many of these gaps in RLINE options
  - Urban effects & evaluation of barriers algorithms
- EPA efforts to address other areas
  - Terrain treatment
  - Continued development on barriers, particular emphasis on edge effects

Meteorological wind tunnel studies

Study of roadway configurations included 14 cases with

- noise barriers
- road cuts
- elevated roadways

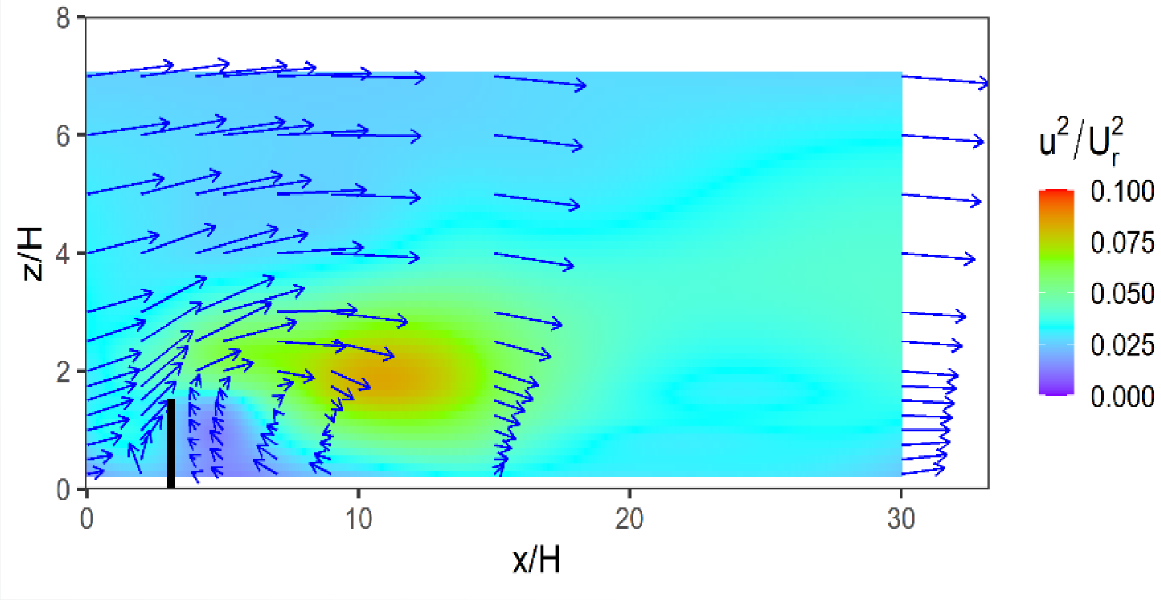
Noise barriers

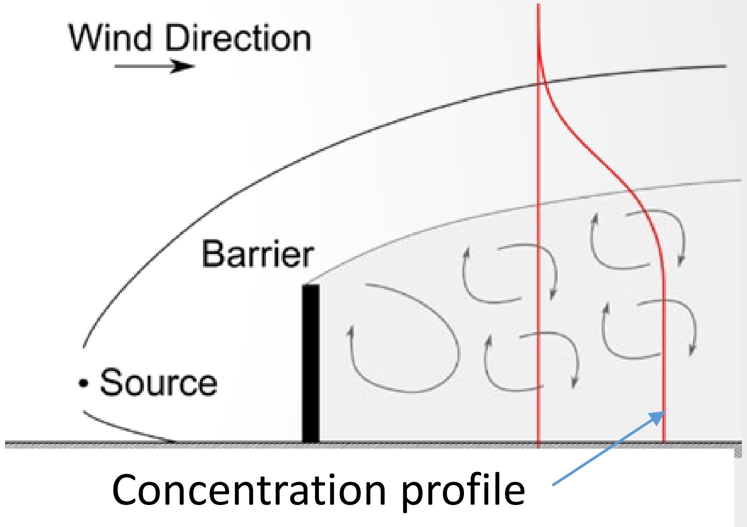


A wind tunnel study of the effect of roadway configurations on the dispersion of traffic-related pollution. D. K. Heist, S. G. Perry, L. A. Brixey (2009) *Atmos. Env.* **43**, 5101-5111.

Observations from wind tunnel studies

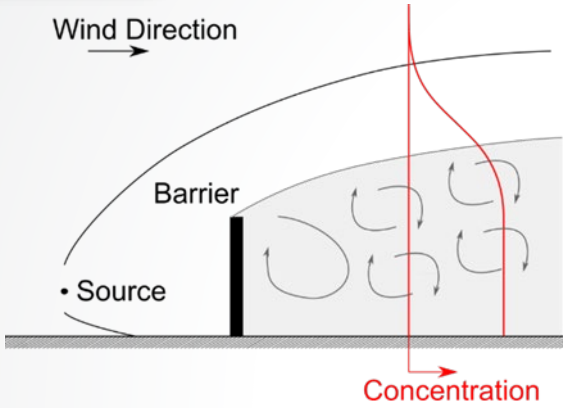
Measured velocity & turbulence patterns

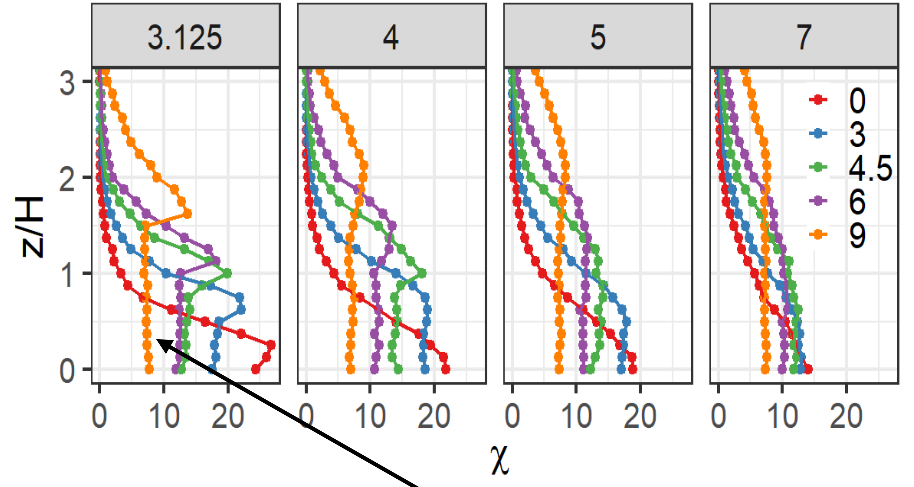




- Barrier pushes flow up and over the top of the barrier
- Increased turbulence level promotes mixing
- Recirculation region downwind of barrier also enhances mixing

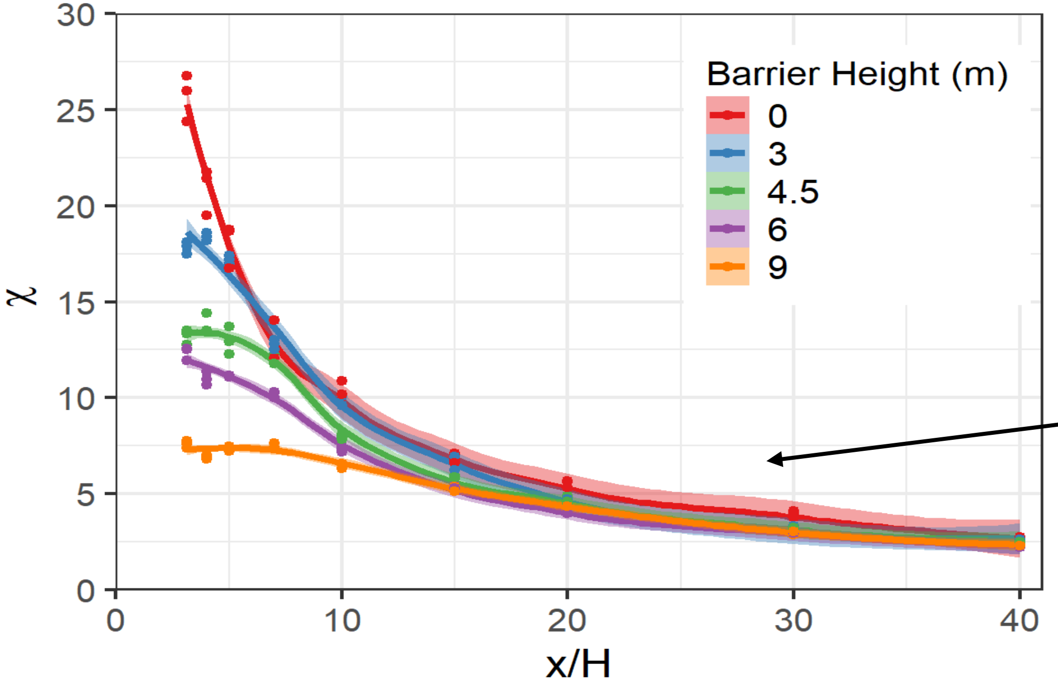
Observations from wind tunnel studies





Vertical concentration profiles downwind of barrier

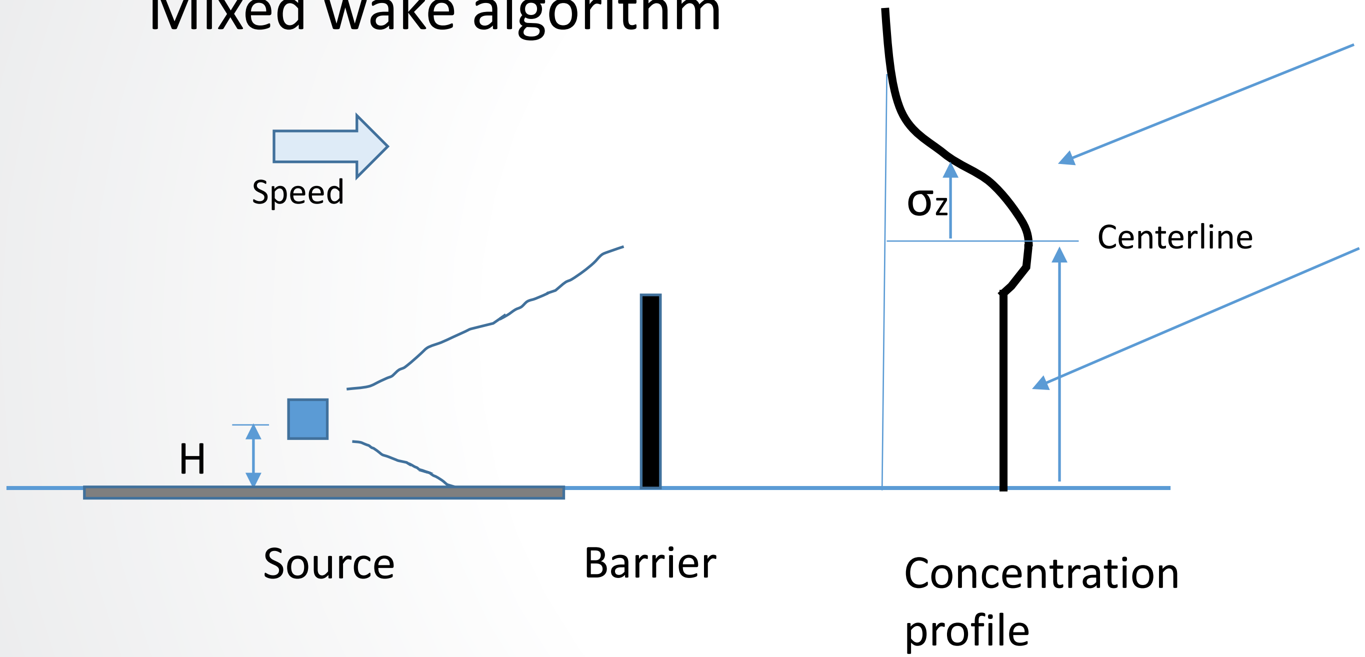
Concentration at breathing height downwind of barrier



- Concentrations are well-mixed below z = H
- With taller barriers, the well-mixed region extends higher, while reducing ground level concentrations.

Algorithms for solid barrier – downwind case

Mixed wake algorithm



Mixed wake concept:

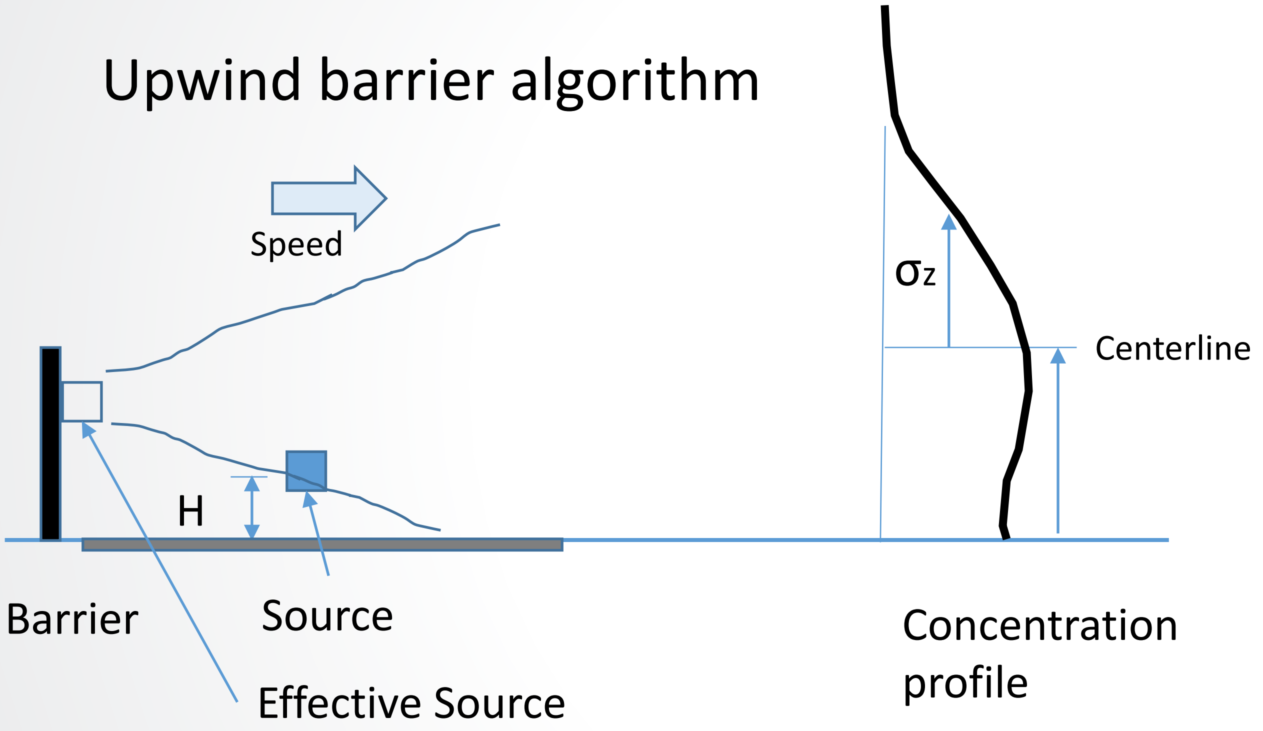
- Above barrier, the concentration profile retains its Gaussian shape
- Below barrier, the concentration profile is flat
- The emissions are balanced between these two parts to maintain pollutant flux equal to the emission rate
- Enhanced turbulence levels downwind of barrier affect growth rate of plume

Publications:

- Effects of solid barriers on dispersion of roadway emissions. N. Schulte, M. Snyder, V. Isakov, D. Heist, A. Venkatram. (2014) *Atmos. Env.* 97, 286-295.
- Reduction of air pollution levels downwind of a road with an upwind noise barrier. F. Ahangar, D. Heist, S. Perry, A. Venkatram. (2017) *Atmos. Env.* 155, 1-10.

Algorithms for solid barrier – upwind case

Upwind barrier algorithm



Upwind barrier concept:

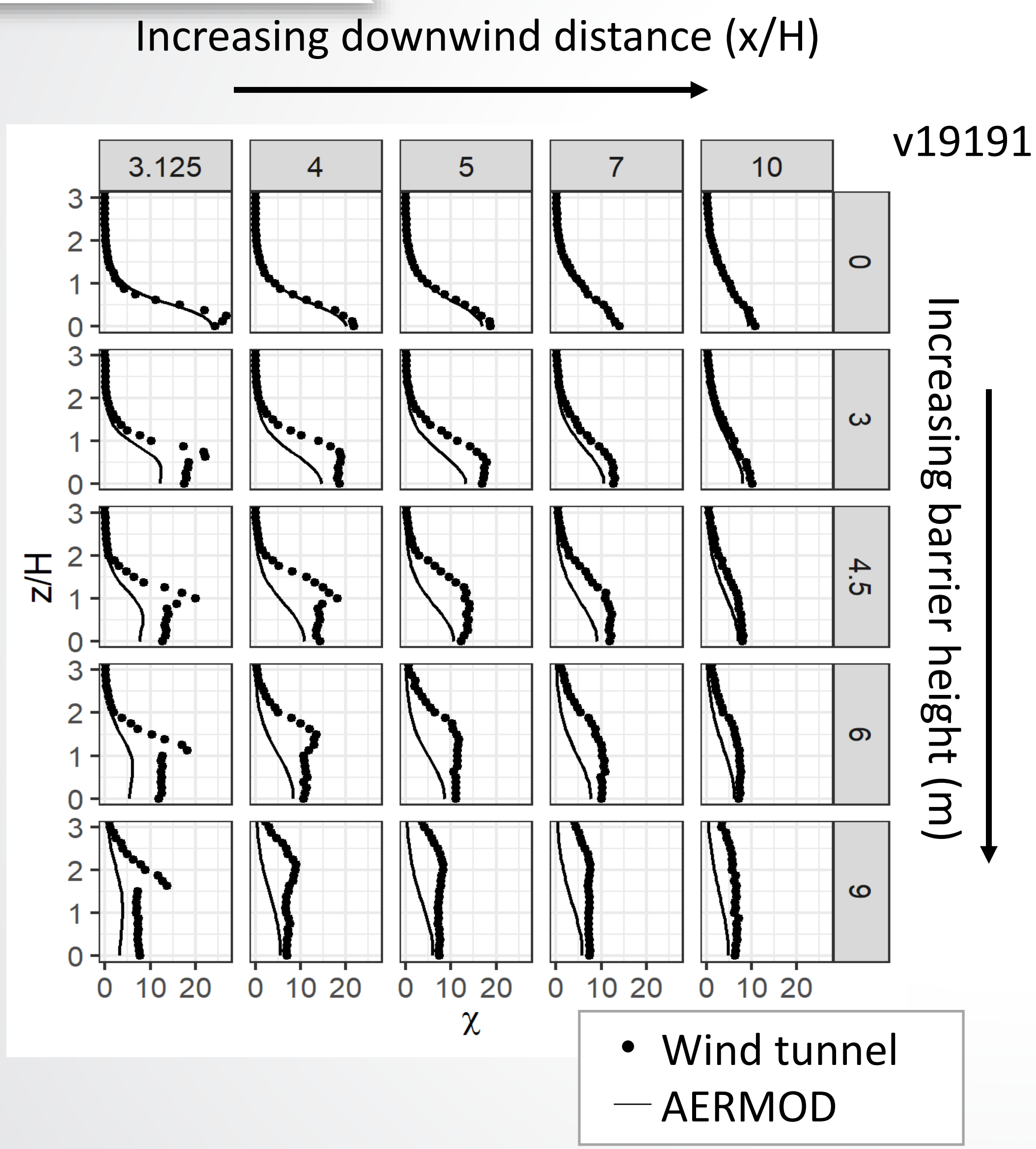
- Source is moved upwind so emission originates at the upwind barrier
- Source is elevated to ¾ height of barrier
- Enhanced turbulence levels downwind of barrier affect growth rate of plume
- Can be used in combination with a downwind barrier

Publications:

- Reduction of air pollution levels downwind of a road with an upwind noise barrier. F. Ahangar, D. Heist, S. Perry, A. Venkatram. (2017) Atmos. Env. 155, 1-10.

Performance of downwind barrier algorithm Sensitivity to barrier height

***H* = 6 m**

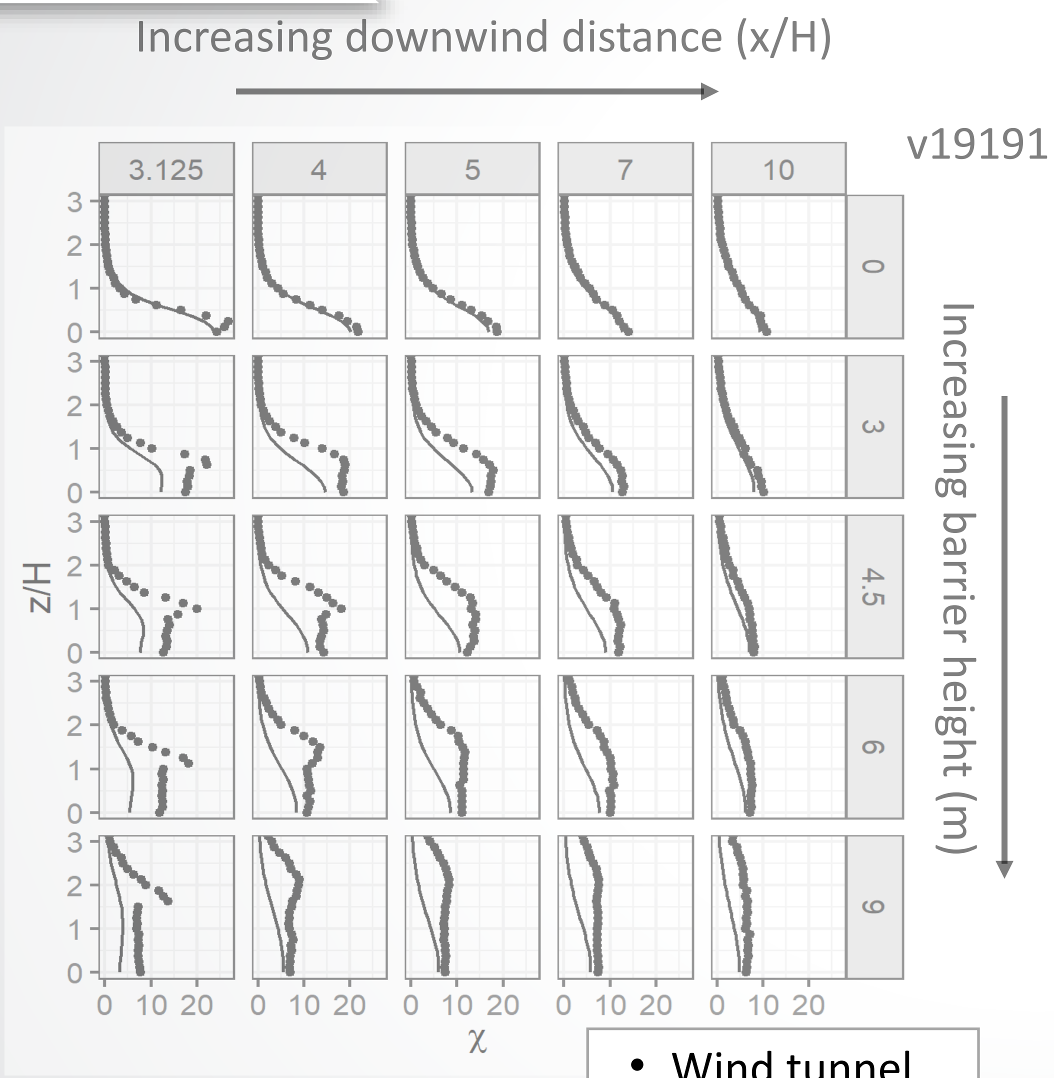


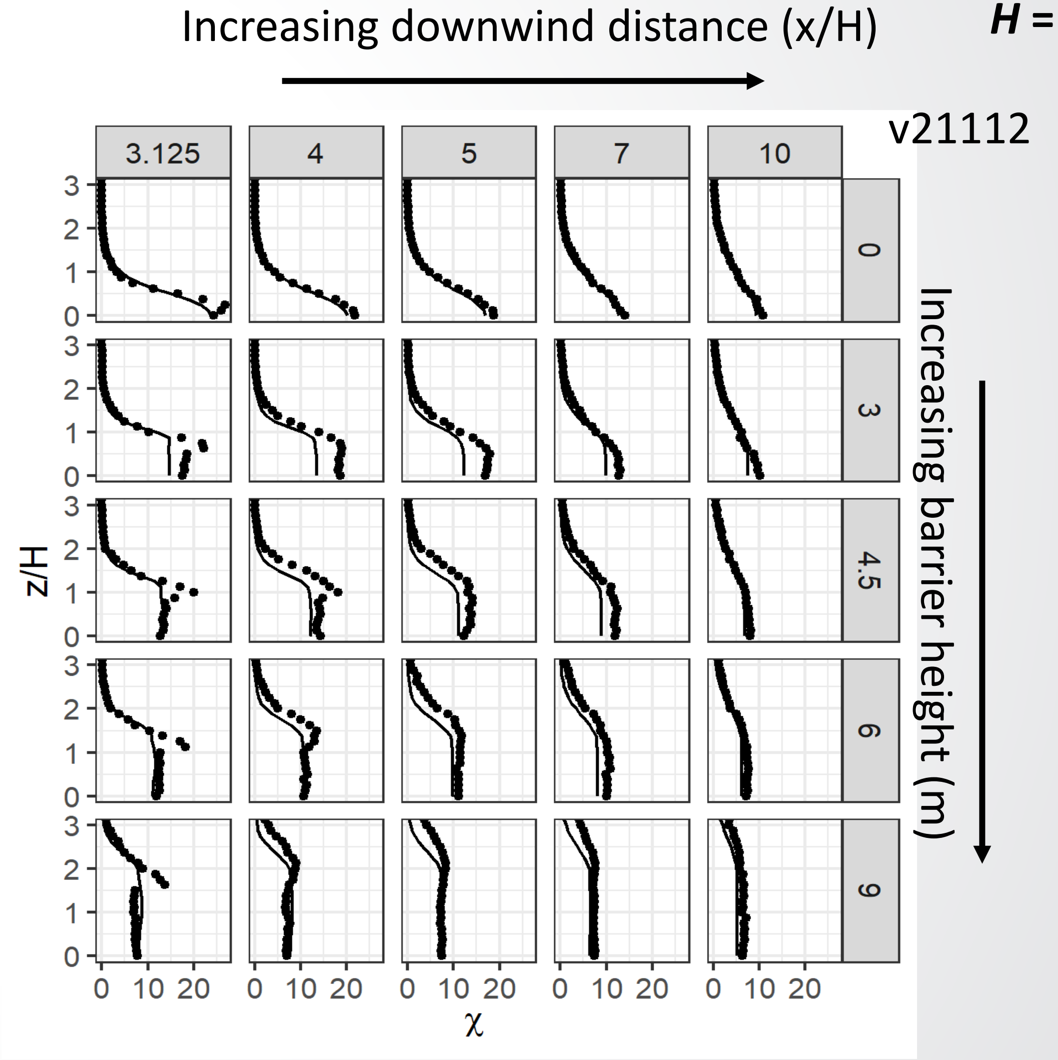
Vertical concentration profiles using barrier algorithm in AERMOD v19191

- Based on descending plume concept
- Plume is lofted over the barrier and gradually descends with downwind distance
- Reduces ground-level concentration with increasing barrier height
- Profile shape does not match 'mixed-wake' shape seen in more recent wind tunnel results

Performance of downwind barrier algorithm
Sensitivity to barrier height

H = 6 m



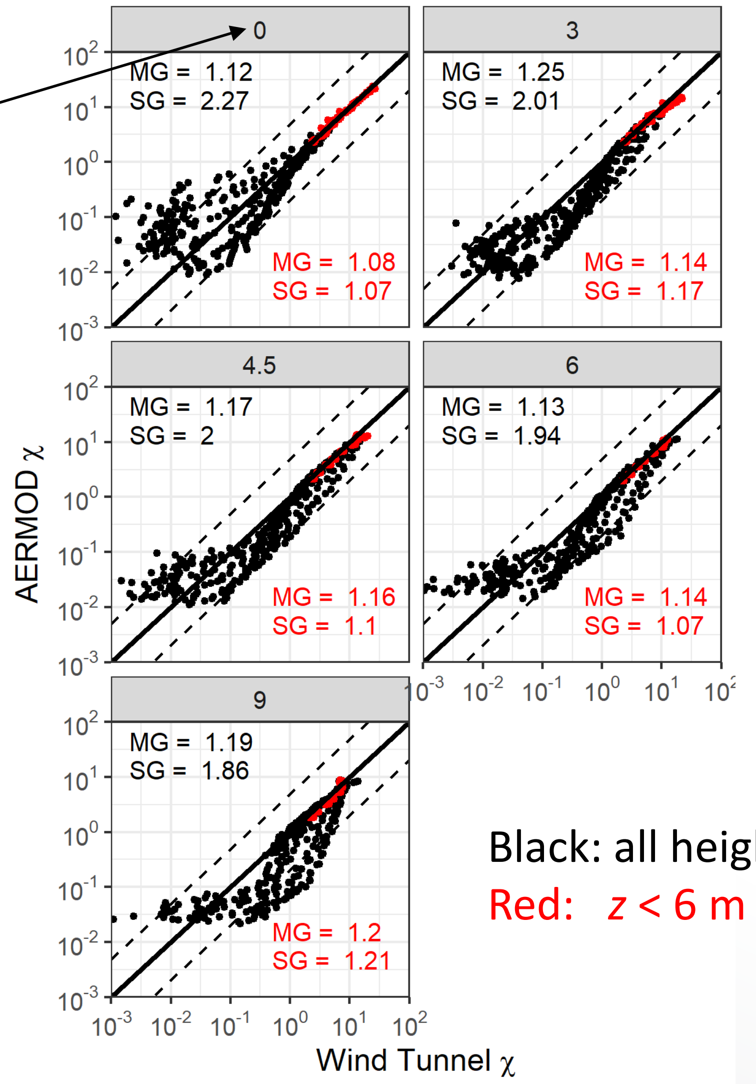


• Wind tunnel
— AERMOD

Performance of downwind barrier algorithm
Sensitivity to barrier height

Scatter plots are paired in space

Barrier Height (m)

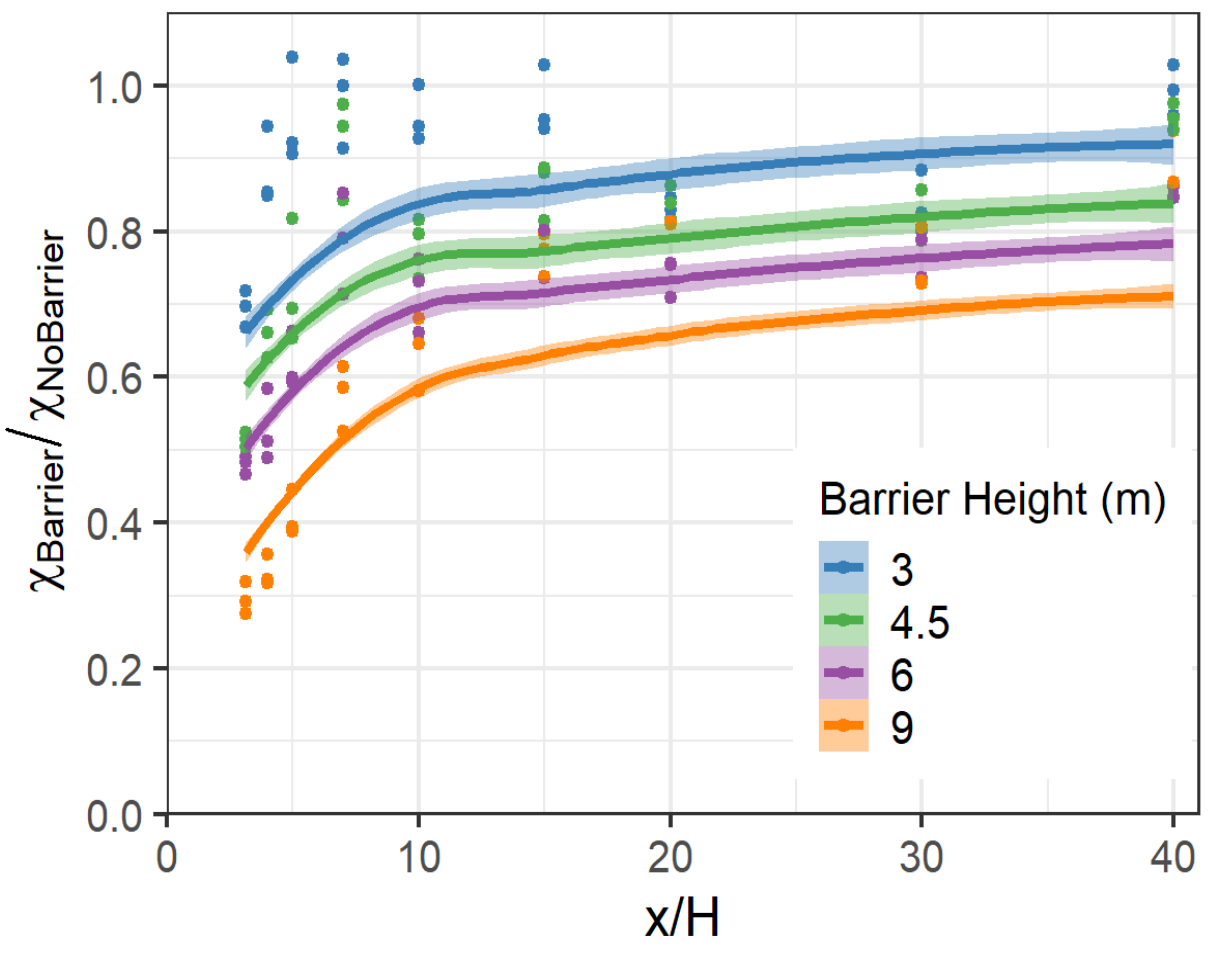


Black: all heights

Red: $z < 6$ m

Breathing-level concentration ratios (with barrier/without barrier)

***H* = 6 m**



Summary and Looking Forward

- New roadside barrier algorithms were implemented in v21112
  - New algorithm for an upwind barrier, based on relocating source
  - Mixed-wake algorithm for downwind barrier
  - Both algorithms can be used at once if two barriers are present
- Comparisons are underway with wind tunnel data sets as well as field data sets currently under development
- Journal article (Francisco et al.) is being drafted to describe algorithms in detail
- Next steps include:
  - Explore harmonizing aspects of the RLINE source with other sources within AERMOD. For example:
    - meteorological profiles and dispersion curves
  - Urban, terrain, and edge effects

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