



# IOWA DEPARTMENT OF NATURAL RESOURCES

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LEADING IOWANS IN CARING FOR OUR NATURAL RESOURCES

# Air Dispersion Modeling Updates

## AERMOD Modeling System Enhancements for More Accurate Predictions

ADJ\_U\*  
POINTCAP/POINTHOR

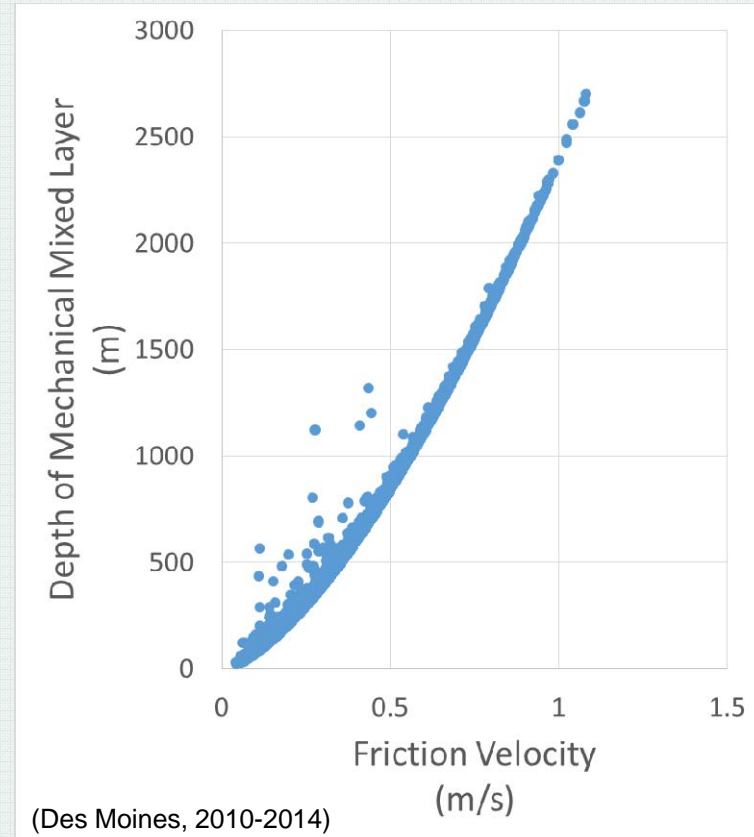
Air & Waste Management Association – Iowa Environmental Conference  
October 27, 2017

# Air Dispersion Modeling Updates

- EPA recently updated the Guideline on Air Quality Models (Appendix W).
- Updated the regulatory model: AERMOD (v16216r).
  - ADJ\_U\*
    - Addresses technical concerns and improves model performance under extremely light winds and stable conditions.
  - POINTCAP/POINTHOR
    - Enhanced treatment of capped and horizontal stacks.

## ADJ\_U\*

- Adjustment to the model estimation of the  $u_*$  parameter (friction velocity).
- *Friction velocity is “a measure of the vertical transport of horizontal momentum.”\**
- Used to estimate turbulence and the depth of the mechanically mixed layer.
- Indicator of the dispersive capacity of the atmosphere during stable conditions.



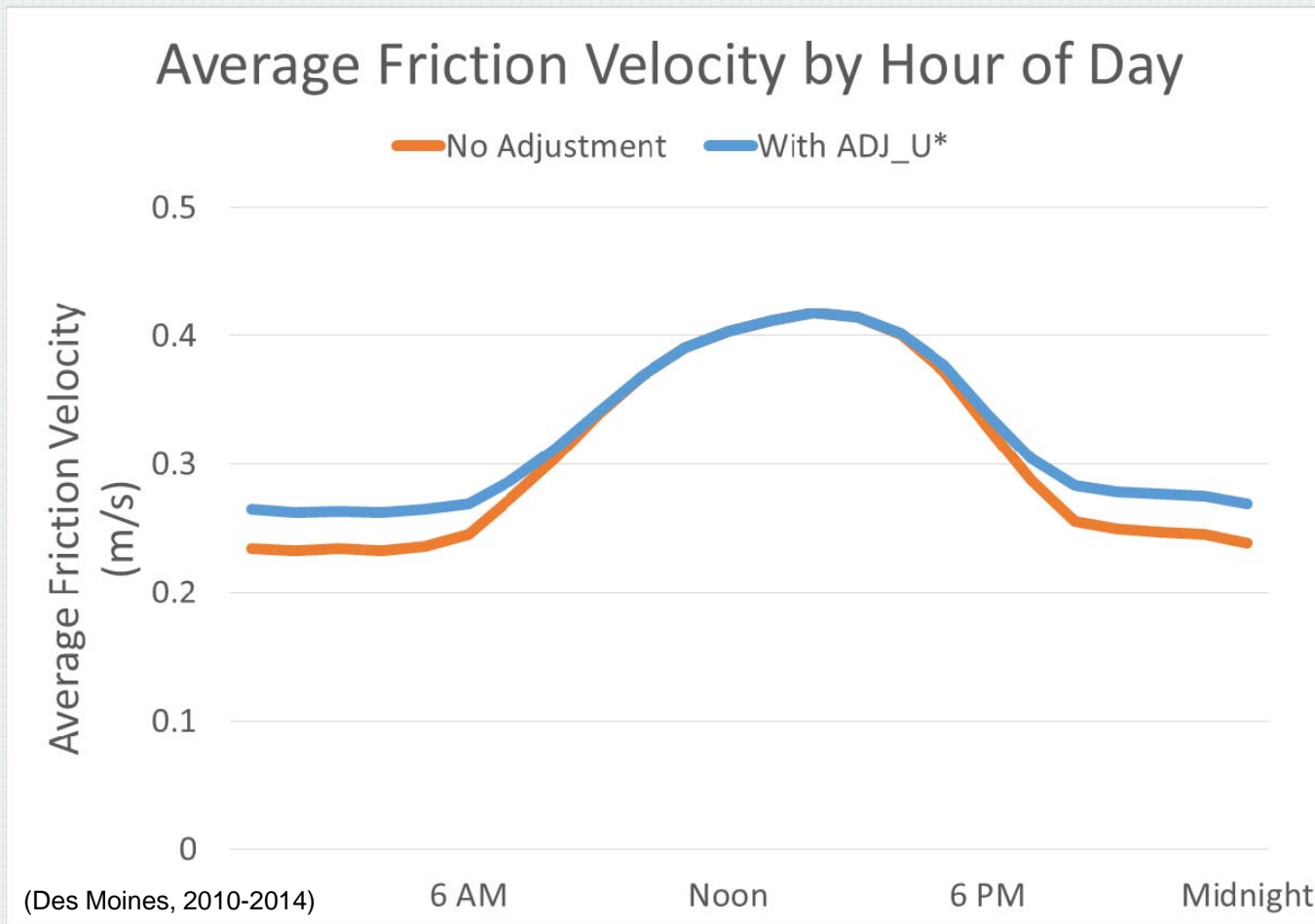
\* U.S. EPA, “User’s Guide for the AERMOD Meteorological Preprocessor (AERMET)”

## ADJ\_U\*

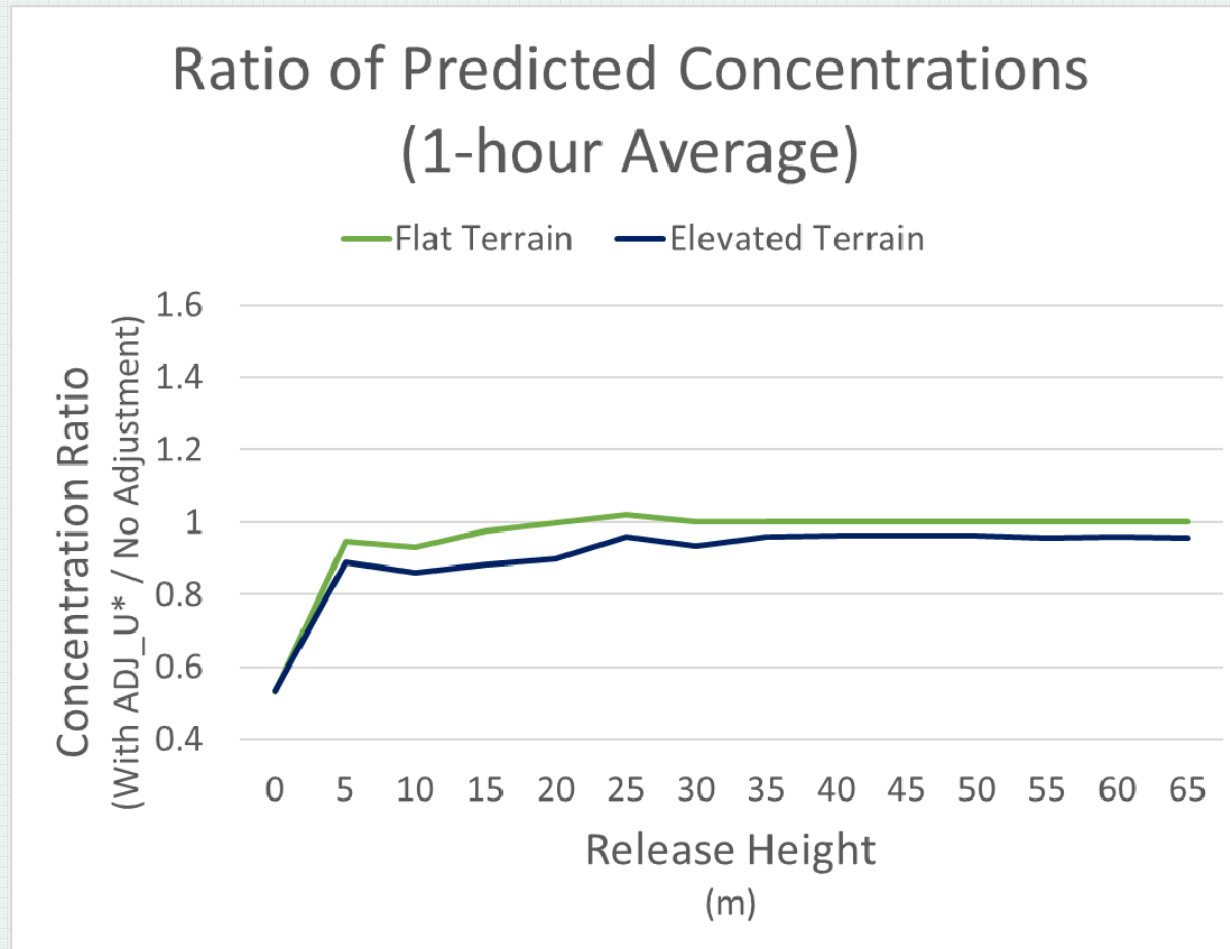
- Earlier versions of AERMET were shown to underestimate  $u_*$  during stable, low wind conditions.
- As  $u_*$  decreases so does mixing (less dispersion).
- Depending on the source this could cause the model to over-predict pollutant concentration.
- A model reformulation\* was proposed to address this issue.
  - Based on field tracer studies and meteorological measurements.
  - Originally a BETA option in AERMOD/AERMET v12345 (December 2012).
- Recent update promotes this to a regulatory default option.

\* Qian, W., and A. Venkatram, 2011: "Performance of Steady-State Dispersion Models Under Low Wind-speed Conditions," *Boundary Layer Meteorology*.

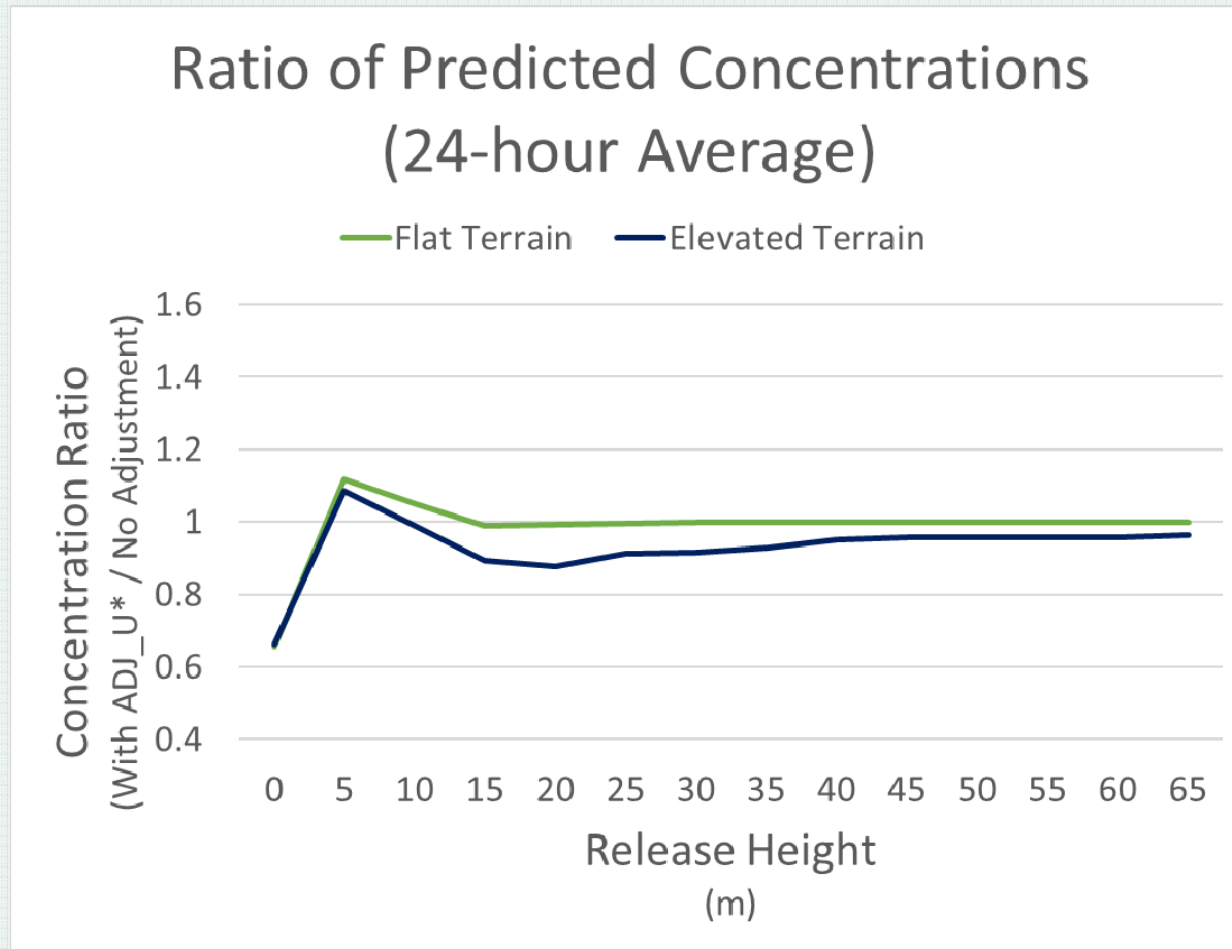
ADJ\_U\*



ADJ\_U\*

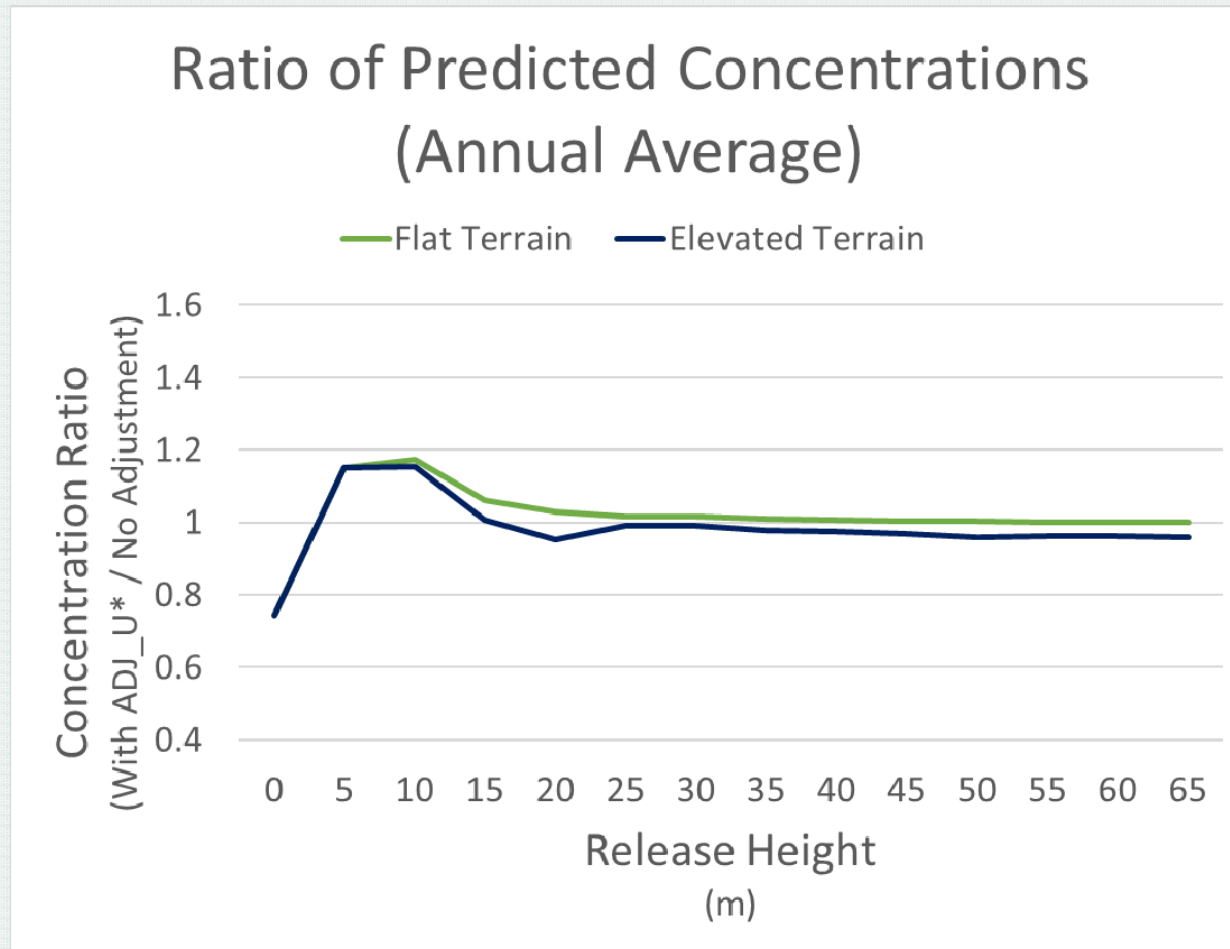


ADJ\_U\*





ADJ\_U\*

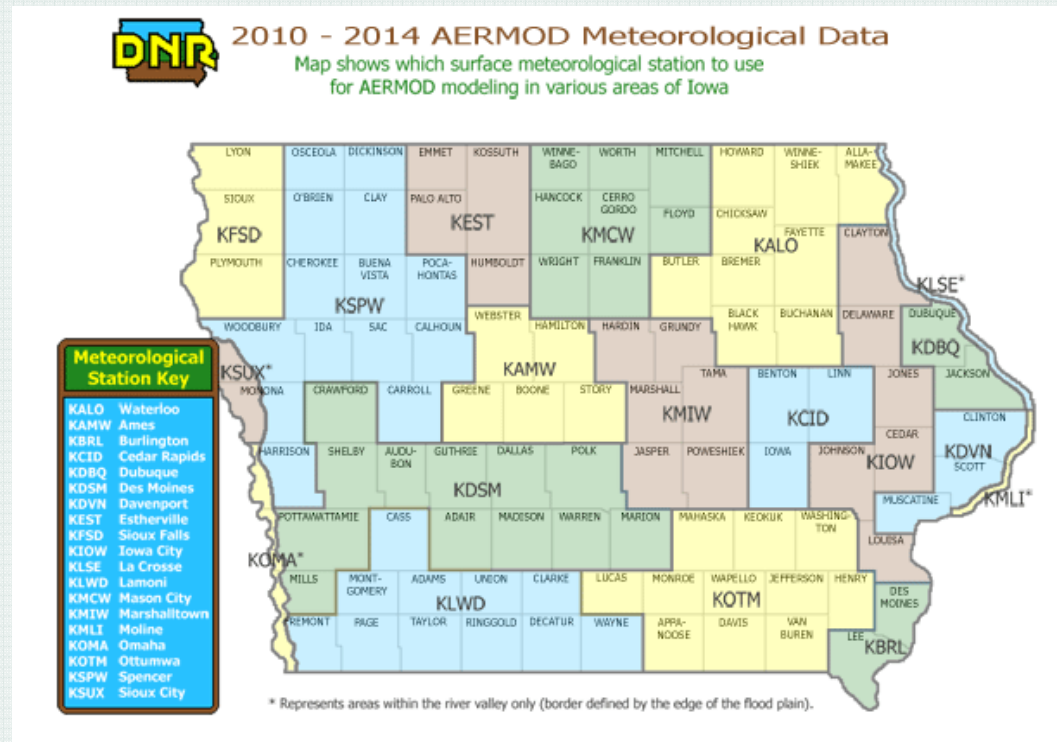


## ADJ\_U\*

- Reductions in concentration will likely be seen for:
  - Ground-level sources
  - Sources in areas with elevated terrain
  - Maximum 1-hour concentrations
- Increase in concentration may be seen for:
  - Emission sources that are slightly above ground-level
  - Multi-hour and long-term average concentrations (indicates that while the maximum 1-hour concentrations are decreasing, many of the non-maximal 1-hour concentrations are increasing)

# ADJ\_U\*

- Iowa DNR has preprocessed meteorological data that incorporates the ADJ\_U\* option.
- This data is available on our website ([www.iowacleanair.gov](http://www.iowacleanair.gov)).



## Capped and Horizontal Stacks

- Dispersion of a plume depends (in part) on plume rise:
  - Momentum
  - Buoyancy
- More of either increases plume rise, and therefore reduces ground-level concentrations.
- Unobstructed vertical stacks result in the most plume rise. →
- For some stacks it may be necessary to protect from the elements...



## Capped and Horizontal Stacks

- Rain caps significantly reduce or eliminate the vertical momentum of a plume by redirecting the flow of the exhaust around the cap.
- Reduces plume rise.



## Capped and Horizontal Stacks

- Horizontal stacks direct the entire momentum of the plume laterally instead of vertically.
- Reduces plume rise.



## Capped and Horizontal Stacks

- Historically, this lack of vertical momentum has been represented in modeling using a nominally low exit velocity of 0.001 m/s.
- Prior to AERMOD this method worked relatively well.
  - At that time an effective stack diameter would also be used to maintain the actual flow rate of the plume, thereby conserving the buoyancy of the plume.
- This method is not directly compatible with AERMOD.
  - Artificially increasing the stack diameter in AERMOD can cause an error.
  - The method of modeling these sources was changed so that only the nominally low exit velocity was used, without the effective diameter
  - This practice reduces the plume's buoyancy, causing overly conservative predictions in many cases.

# Capped and Horizontal Stacks

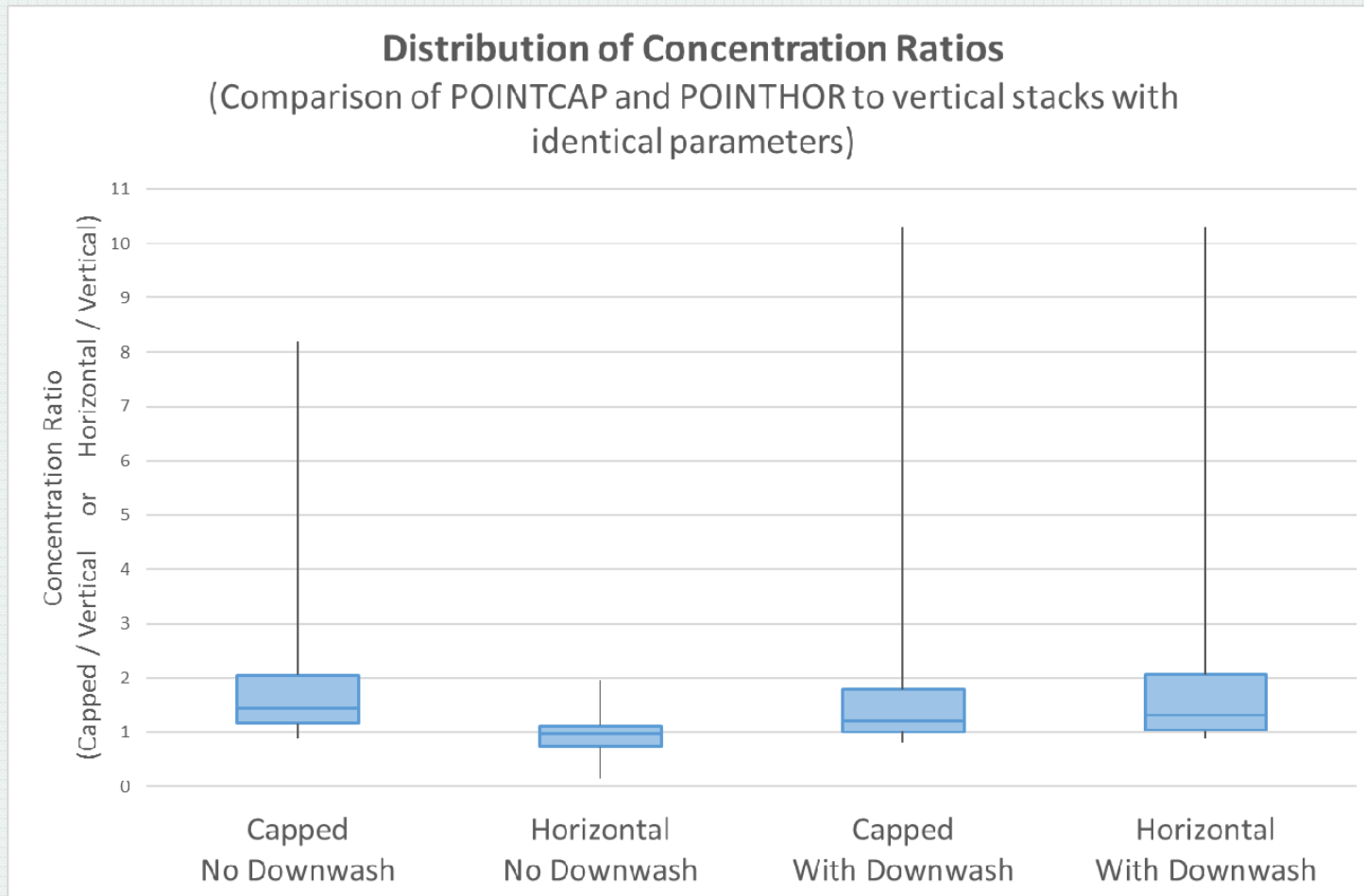
- In 2006 EPA developed Beta options for AERMOD to address horizontal and capped sources.
  - Referred to as POINTCAP and POINTHOR.
  - These options were available to use for testing and as an alternate modeling technique (required approval).
  - Actual source parameters are input by the user and the model internally adjusts the plume to more realistically reflect the vertical and horizontal momentum.



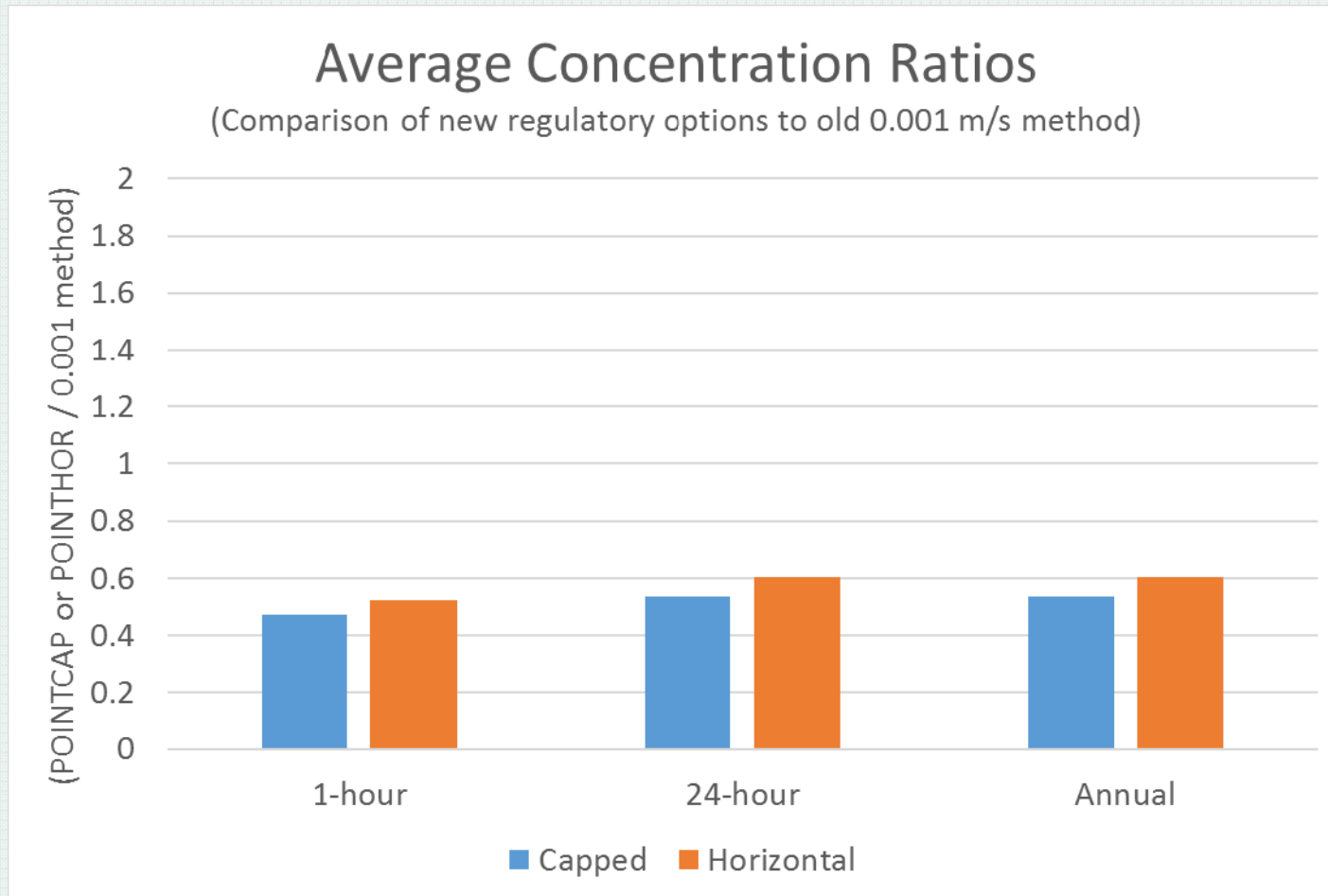
# Capped and Horizontal Stacks

- Earlier this year the revisions to Appendix W were finalized and include both options as regulatory defaults.
- DNR conducted a sensitivity test to determine the impacts of these new source types (shows good results).
- DNR now implementing these options in all regulatory analyses.
  - Require building downwash with use of POINTHOR
    - Potential under prediction bias when modeling horizontal sources without downwash.
    - Generally not a problem since horizontal vents almost always extend from the side of a building.

# Capped and Horizontal Stacks



# Capped and Horizontal Stacks



# Capped and Horizontal Stacks

- Vertical sources still result in lower concentrations on average in all cases.
- The use of the POINTCAP and POINTHOR source types will result in a reduction in concentration of approximately 50% on average as compared to using the 0.001 m/s method.
  - The reduction will be greater for buoyant sources and those with a large amount of momentum.
  - There will be little to no reduction in concentration for ambient temperature sources or those with very little momentum.

# Conclusion

- EPA has incorporated these changes to the model to address specific model over-prediction biases.
- The Iowa DNR is implementing these model enhancements now.
- The ADJ\_U\* option is included in the meteorological data provided on our website and is automatically implemented in AERMOD when this data is used.
- The POINTCAP and POINTHOR options are now regulatory defaults, allowing their use in all analyses.
- Applicants can expect decreased concentrations in many cases.

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