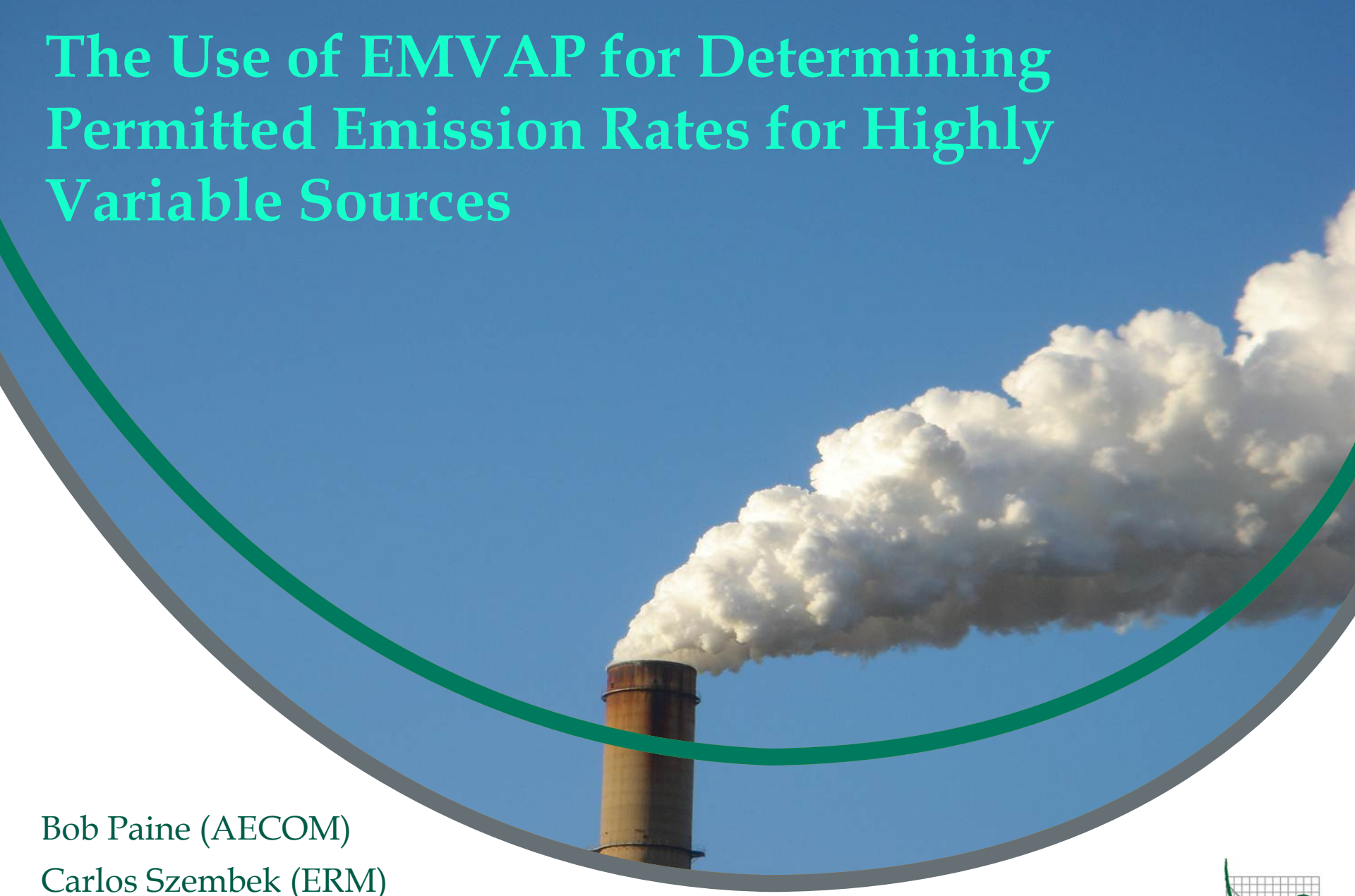
The Use of EMVAP for Determining Permitted Emission Rates for Highly Variable Sources



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Outline of Presentation

- Review of Emissions Variability Processor (EMVAP)
- Use of EMVAP for setting new emission limits

Emission Rate Variability

- Large variation possible over the course of a year
- Intermittent sources (e.g., emergency backup engines or bypass stacks) present modeling challenges
- For these sources, assuming fixed peak 1-hour emissions on a continuous basis <u>will</u> result in unrealistic modeled results
- EPA's SO_2 Modeling TAD provides that for existing sources, actual hourly emissions may be modeled
- EMVAP can be used with a prescribed <u>distribution</u> of variable emission rates to determine a longer term average emission rate that will support compliance with the 1-hour SO_2 NAAQS.

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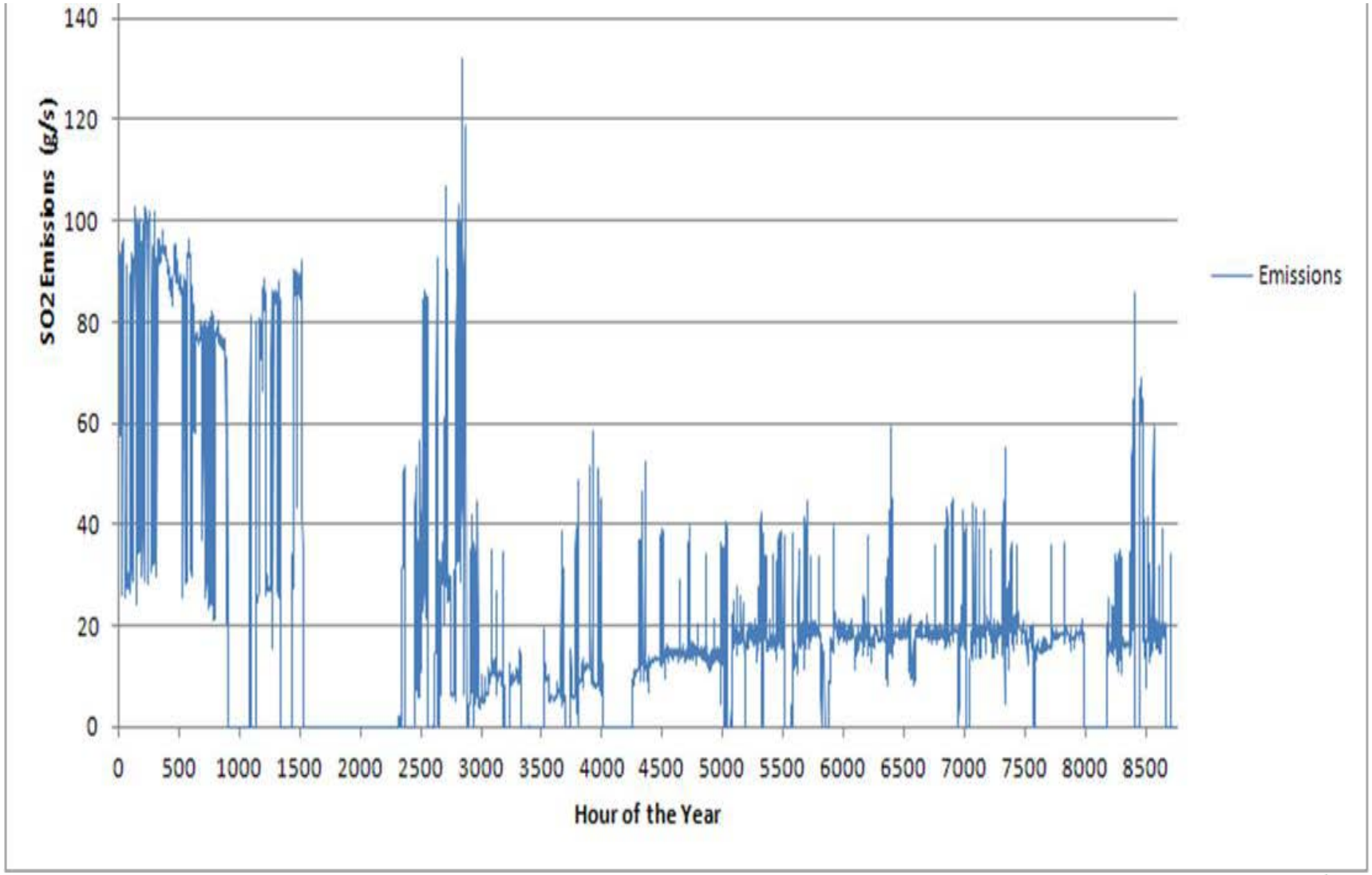
Consider a Time Series of Variable Hourly Emissions



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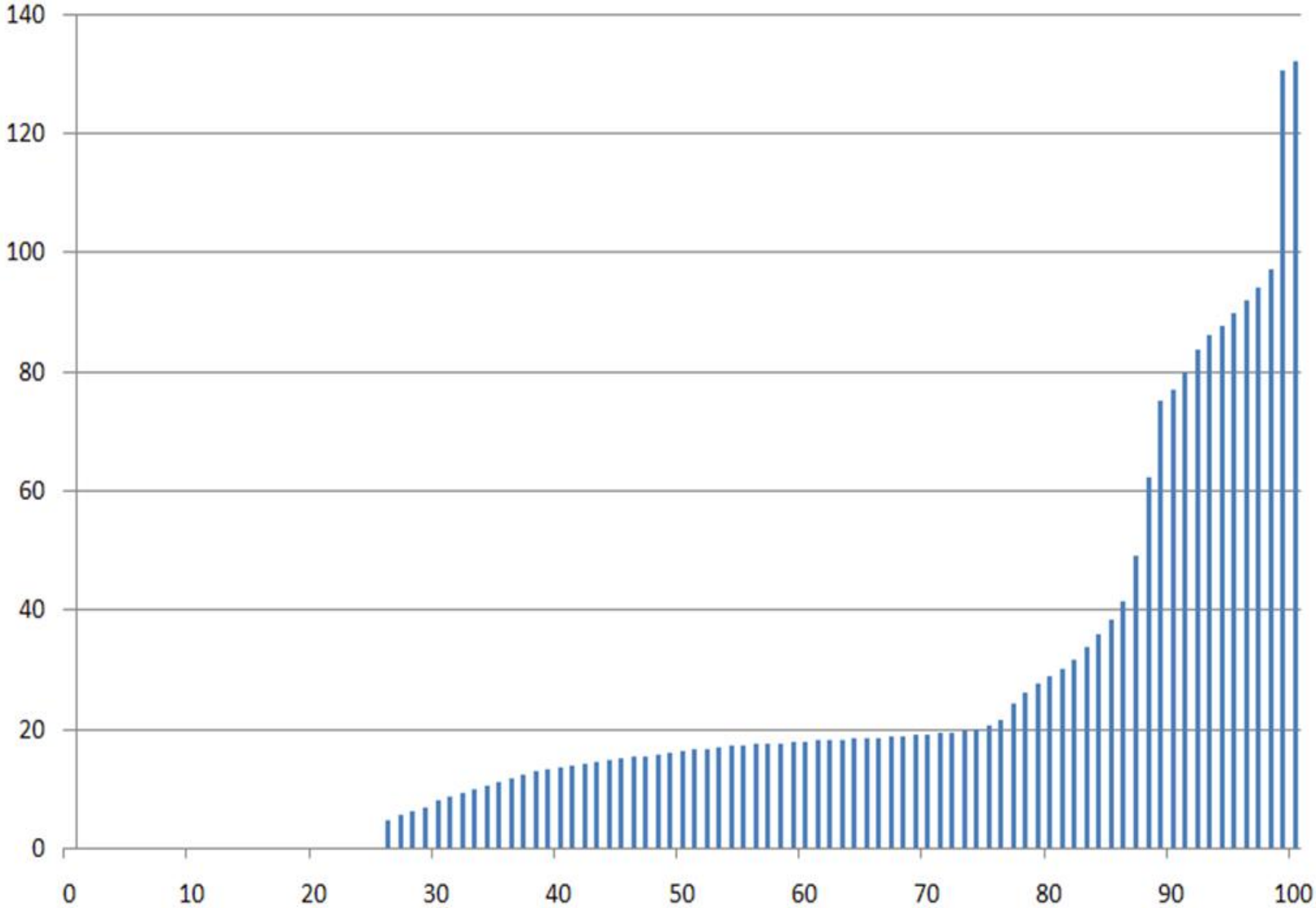
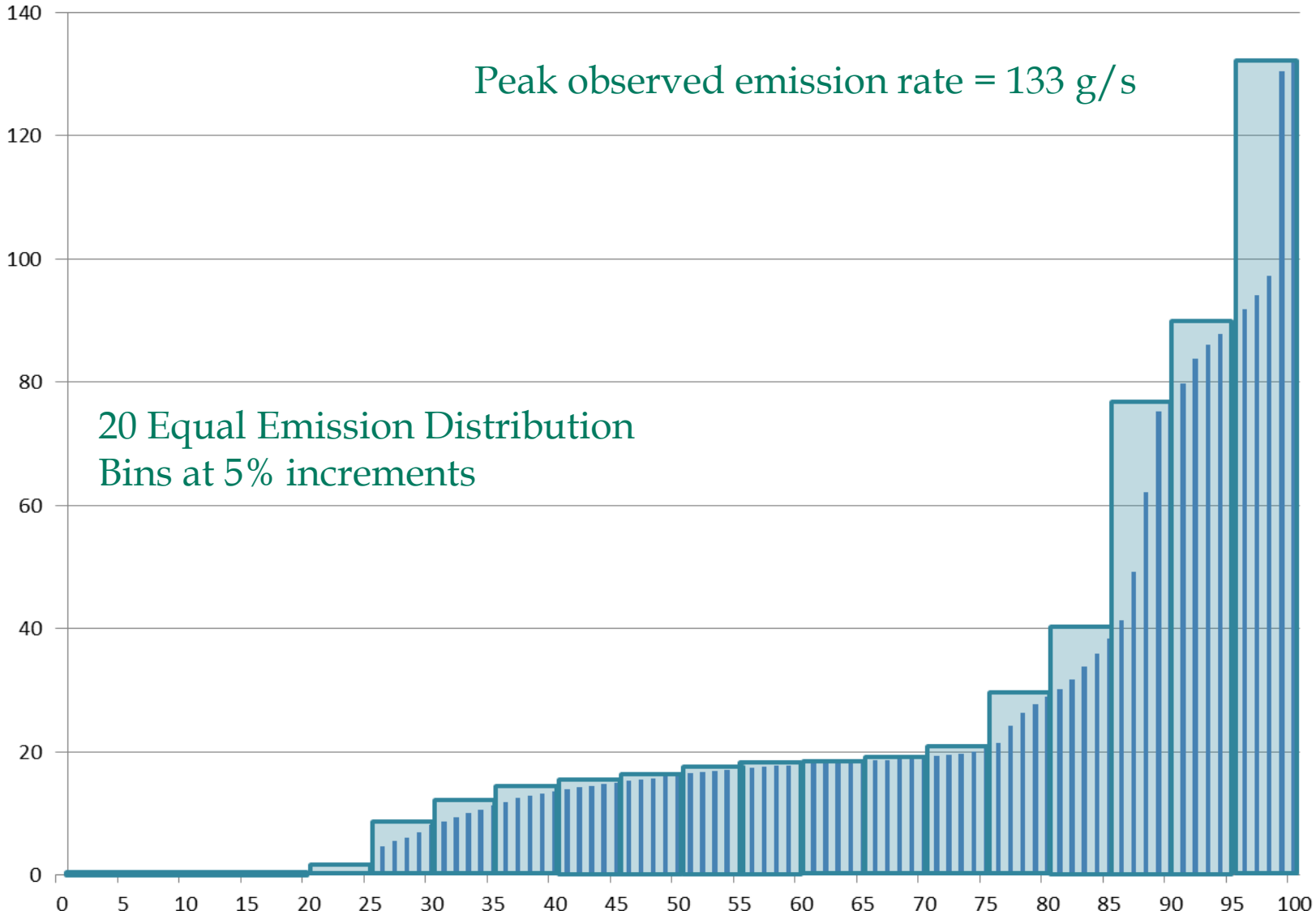
Cumulative Frequency Distribution



For EMVAP, Fit Discrete Emission Cases to Distribution



Apply EMVAP to Determine Design Concentration

EMVAP is a Monte Carlo model randomly assigning an emission rate for each hour according to the discrete emissions distribution for 500+ simulated iterations

EMVAP processes appropriate summary statistics for each receptor for each yearly simulation

- e.g., For SO_2 this is the daily maximum 1-hour concentration

EMVAP also sums concentrations for multiple sources and adds background

- Reports "design" concentrations such as the 99th % maximum daily 1-hour concentration for SO_2
- Estimates design concentrations at user specified probabilities:
  - Probability of 50% represents most expected value
  - Evaluation results indicate that the EMVAP approach overstates the design concentration relative to monitored data
  - The appropriate percentile to be selected can be tested with each application

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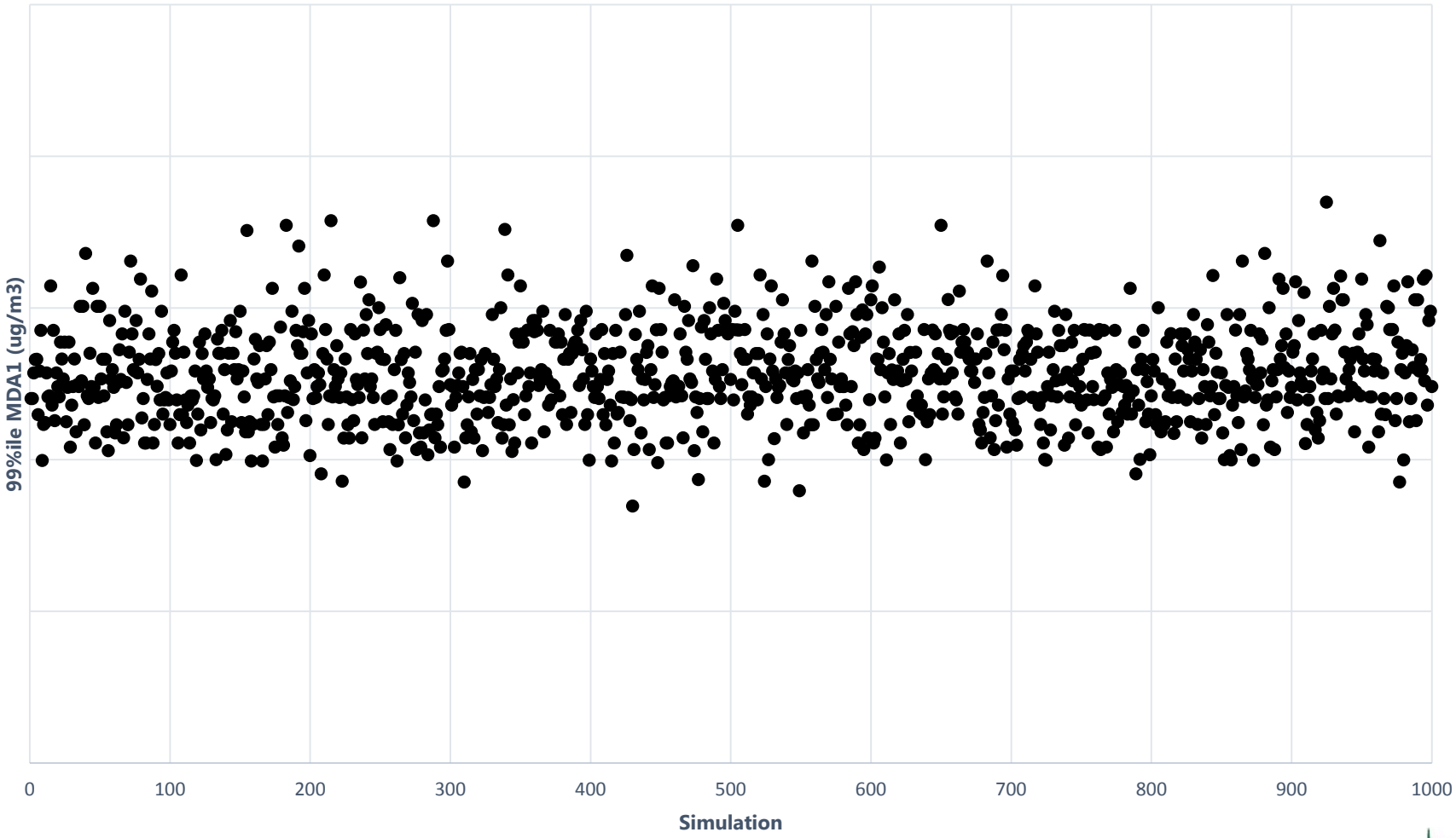
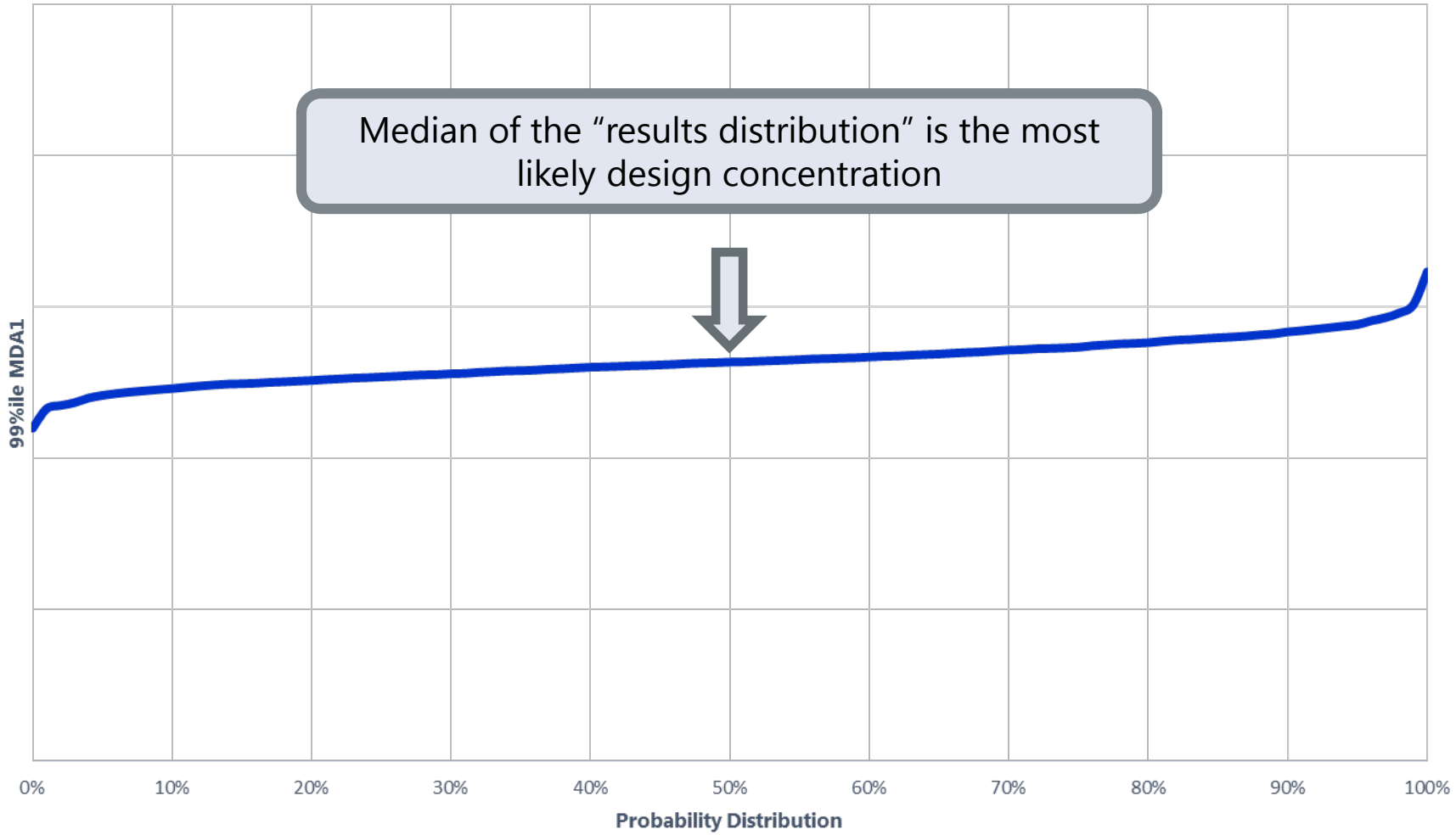
EMVAP Design Concentration Results (over 1000 Simulated Years)



EMVAP Results Are Expressed as a Distribution



Available Information on EMVAP

- Can be freely downloaded from the EPRI web site: http://sourceforge.net/projects/epri-dispersion/
- Presentation at the 2014 Regional/State/Local Modeling Workshop showed much more information about EMVAP and its evaluation
- EMVAP journal articles are available in the December 2014 issues of the Air & Waste Management Association's Journal and Environmental Manager publications

The Critical Value and Compliance Emission Rate

EPA Guidance: "Critical Value"

- Past EPA guidance: averaging times for emission limits should be the same as the averaging time of the applicable NAAQS

- Initial approach: emission limits for attaining the 1-hour SO_2 standard should limit emissions for each hour

- **"Critical value" =** hourly emission rate, not to be exceeded, that would result in the 99th percentile of daily maximum hourly SO_2 concentrations at the 1-hour NAAQS

- Complication: as NAAQS averaging times get shorter, how should emission variability be handled?

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EPA Considerations

- EPA expects that it may be possible in specific cases for states to develop control strategies that account for variability in 1-hour emission rates

- This would be accomplished through emission limits with averaging times that are longer than 1 hour, but still demonstrate attainment of the 1-hour NAAQS

Long-Term Average vs. Critical Value

- EPA expects that any emission limits with an averaging time longer than 1 hour might need to be less than the critical value to compensate for the loss of stringency inherent in applying a longer-term average limit

- In the limit as variability becomes zero (constant emissions), the long-term average equals the critical value

- If the infrequent emissions above the critical value are sufficiently sporadic in nature, they will have little or no effect on the longer term complying emission rate

- The challenge is: how to demonstrate that with hourly emission variability, the longer-term emission rate is still protective of the NAAQS?

EPA Example

- Assumes that the variability pattern of a source will remain similar after control measures
- Calculate critical value (600 lb/hr)
- Obtain 99th percentile of 1-hour emissions (800 lb/hr)
- Obtain 99th percentile of 30-day average emission rates (720 lb/hr)
- Multiply critical value by ratio of 99th percentile 30-day average rates to 99th percentile 1-hour rates (720/800 = 0.9)
  - 600 lb/hr x 0.9 = 540 lb/hr
- The EMVAP approach is an alternative to the EPA approach that provides additional confidence in the protection of the NAAQS because it uses a <u>modeling demonstration</u> that encompasses the <u>emissions variability</u> in its design

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Example Application of EMVAP

Determining Long-Term Compliance Emission Rate Using EMVAP with Critical Value Analysis*

Step 1

Find Critical Value (AERMOD) with constant 1-hour emission rate

Step 2

Determine Emission Distribution and Emission Cases for EMVAP
(Optional use of EMDIST)

Step 3

Run AERMOD Prior to EMVAP

Create Binary Files for all of the Emission Distribution Cases

Step 4

EMVAP

Part 1:
Estimate compliance emission rate.

Part 2:
Re-Run EMVAP with refined background and scaled emissions to verify NAAQS compliance with the final long-term emission rate.

The Critical Value is the constant 1-hour emission rate that results in NAAQS compliance.

As per EPA's guidance, the CV acts as a threshold emission rate, that the long-term average emission rate ***cannot exceed.***

***This method is illustrated for a single emission source for simplicity.**

AERMOD: Critical Value

Step 1:
Determine the Critical Value (CV)

AERMOD

For a single source, run using:

- representative normal operating stack parameters
- 1 g/s emission rate

Calculate the Target Design Value (TDV):

TDV = NAAQS – Ambient Background

Using the Design Concentration (DC) from the AERMOD output to find the Critical Value by simple scaling:

CV = TDV ÷ DC

Example:
A single source run with:

- *Emissions: 1 g/s*
- *Stack Temp: 416 K*
- *Exit Velocity: 23 m/s*
- *Stack Height: 122 m*
- *Stack Diameter: 5.2 m*

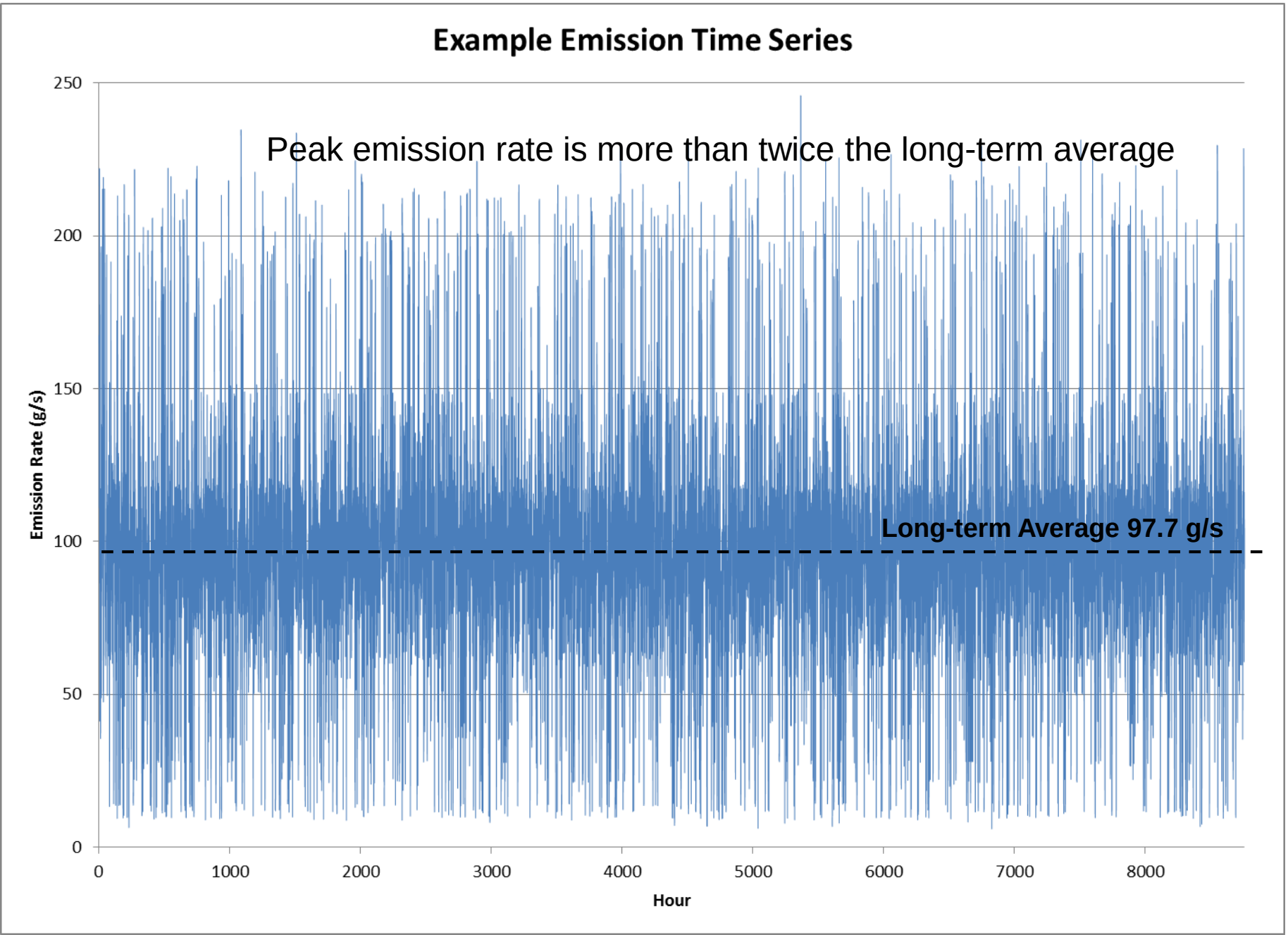
Ambient SO_2 background:
15 ppb (39.3 μg/m^3)
TDV: 196 – 39.3 = 156.7 μg/m^3

AERMOD 1 g/s DC: 1.31 μg/m^3

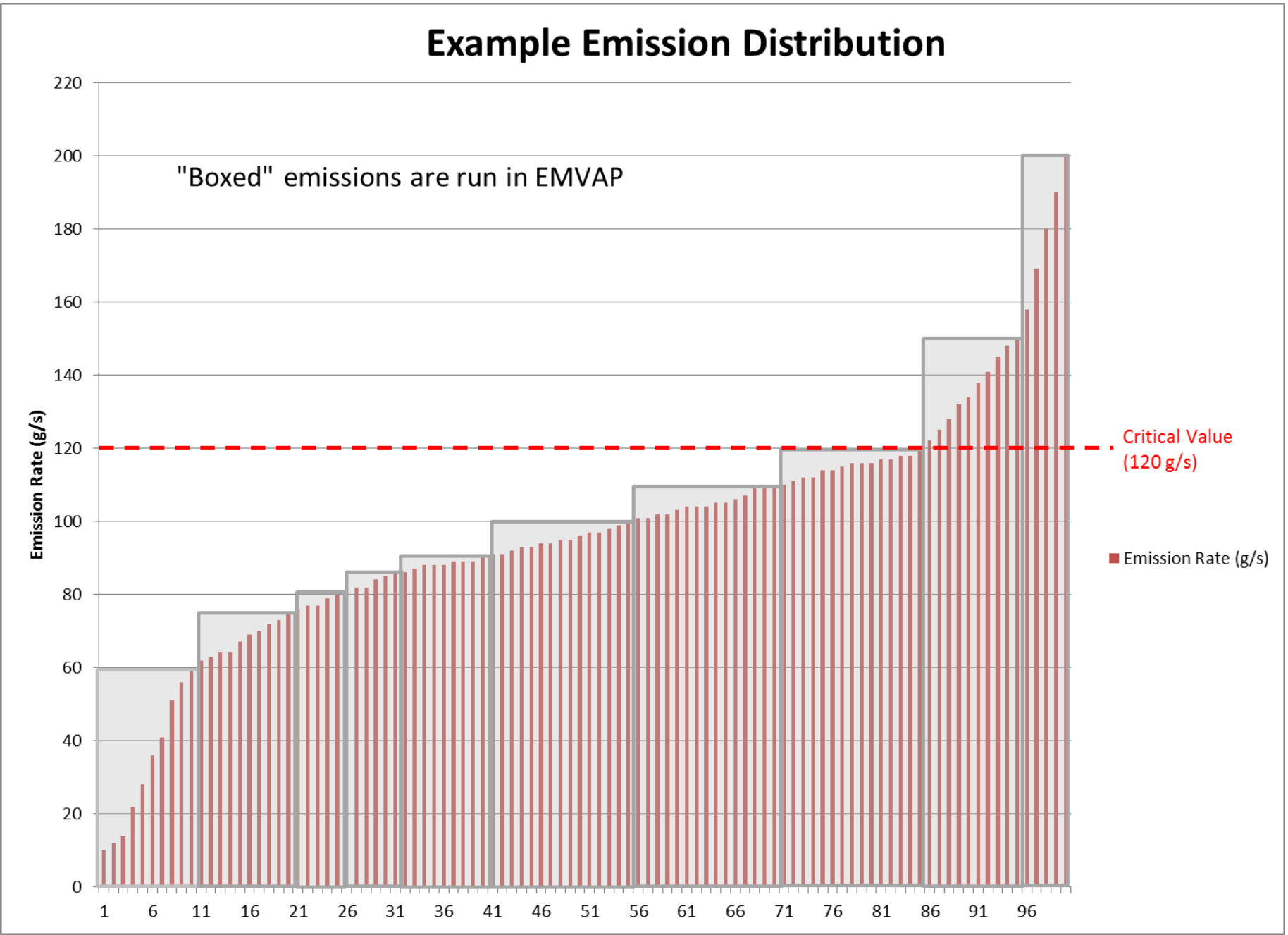
*Hence the **CV**:*

$$\frac{156.7\ \mu g/m^3}{1.31\ \mu g/m^3 (per\ g/s)} = \mathbf{120\ g/s}$$

Example Application of EMVAP: Step 2



Example Critical Value Analysis EMVAP Case



Example Application of EMVAP: Step 3

Generate AERMOD Binary Files for each Emission Distribution case.

AERMOD

If the stack parameters vary between the emission distribution bins, a separate source must be modeled for each emission bin*.

Each source must be run with:

- 1 g/s emission rate
- the corresponding stack parameters from the Emissions Distribution

These binary files will be used in the EMVAP run.

*Refer to EMVAP User's Guide for details.

EMVAP: Verify that Long-Term Emissions Distribution Complies with the NAAQS

Step 4:

Determine NAAQS Compliance using EMVAP

Inputs:

- Ambient Background Value(s)
- CV for 1-hour Emission Rate (Step 1)
- Emissions Distribution (Step 2)
- AERMOD Binary Files (Step 3)

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EMVAP

Run with Emissions Distribution

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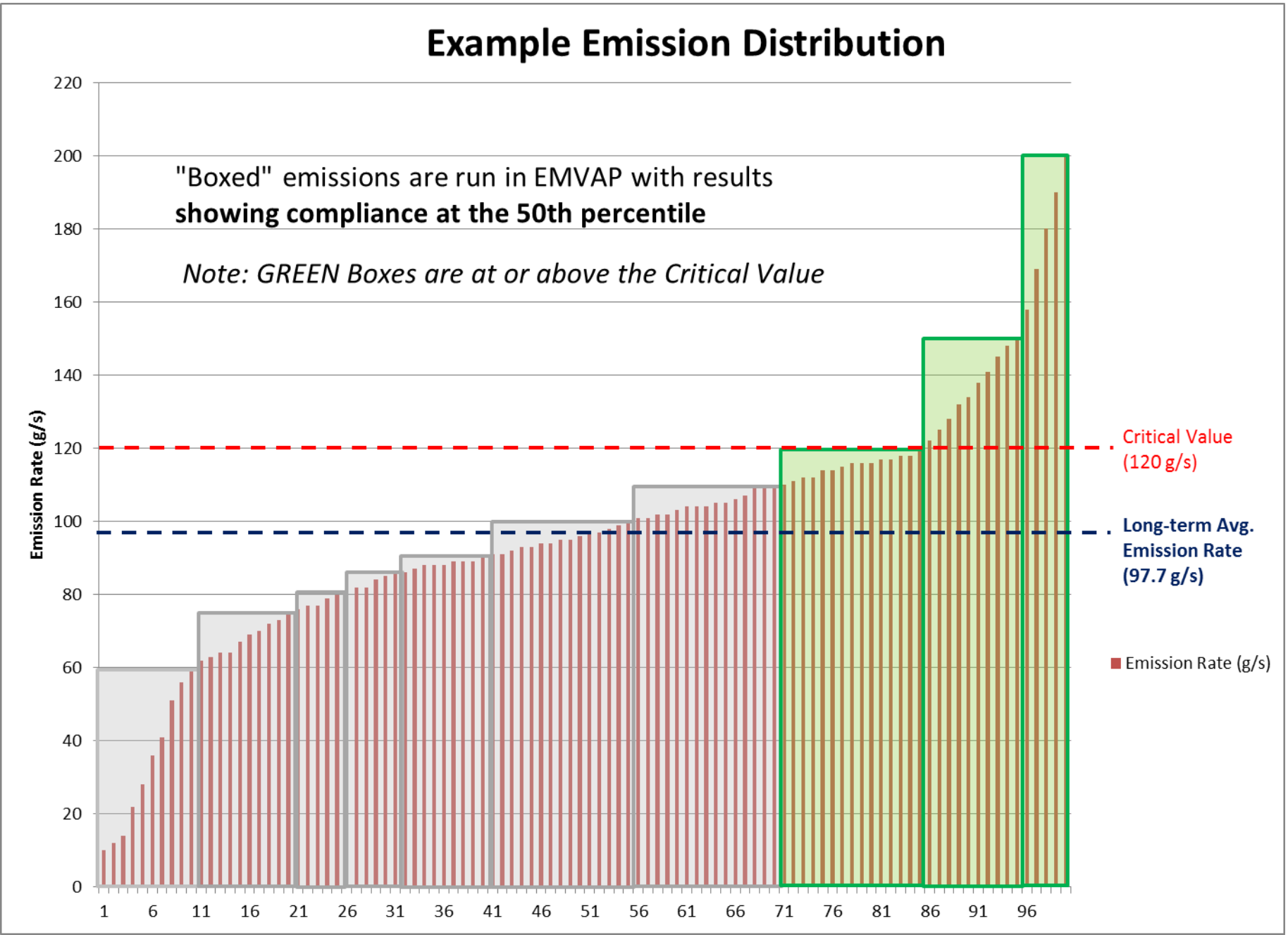
Output:

Confirm that the results at the 50th percentile are at least as high as AERMOD run with actual hourly emissions.

Then adjust emissions downward, if needed, to show NAAQS compliance with subsequent EMVAP runs.

For this example, assume that the emissions run with EMVAP show NAAQS compliance without further adjustment.

Example Critical Value Analysis EMVAP Case



EMVAP Alternative Emission Limit Approach: Coupled Short-term limits

- For a hypothetical source with a critical value emission rate of 120 g/s, suppose that the emission bins at or above 120 g/s are:
  - Top bin is 200 g/s, 5% bin width
  - Next bin is 150 g/s, 10% bin width
  - Next bin is 120 g/s, 10% bin width
- The remaining (lower emission bins) have emission rates below the critical value, and need not be included in the permit.
- For this case, the permit language would be as follows:
  - The hourly emission rate will never exceed 200 g/s
  - The hourly emission rate will be at or below 150 g/s for at least 95% of the hours in the long-term period
  - The hourly emission rate will be at or below 120 g/s for at least 85% of the hours in the long-term period

Overall Conclusions

- EMVAP is a useful tool for applications involving new or modified sources
- SO_2 and NO_2 1-hour NAAQS are probabilistic, so EMVAP is consistent with this approach
- EMVAP can be used with an emissions distribution with a rigorous modeling approach to demonstrate that a coupled short-term limit would be protective of a 1-hour NAAQS standard
- EMVAP is available for download at http://sourceforge.net/projects/epri-dispersion/

Questions? / Contact Information

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