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Building Downwash Changes, Use of NO_2 Tiered Methods, and $PM_{2.5}$ Modeling Issues

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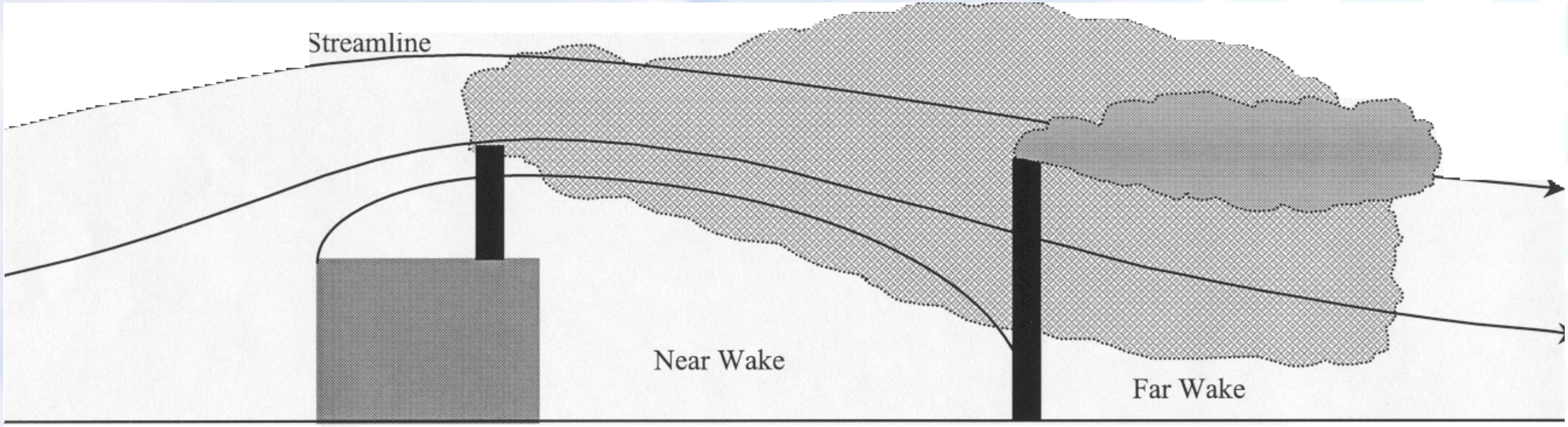
Introduction

- AERMOD design criteria per *Model Formulation Document*
  - Provide reasonable concentration estimates with minimal discontinuities
  - Be user friendly with reasonable input data and computer resources
  - Capture essential physical processes while remaining fundamentally simple
  - Accommodate modifications with ease as the science evolves
- Several recent updates to AERMOD and modeling guidance reflect these criteria

Building Downwash Changes

What is Building Downwash?



(Schulman et al, 2000)

When is Building Downwash Considered?

- "EPA formula height"

$$H_{GEP} = H_b + 1.5L$$

where:

H_b = building height above stack base

L = lesser of building height and projected building width

- Good Engineering Practice (GEP) height
  - Greater of EPA formula height or 65 meters
- Generally cannot take credit for stack height above GEP in dispersion modeling

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Original AERMOD Implementation

- Building downwash effects were turned off if stack height was greater than or equal to EPA formula height
- This changed with version 11059 and later AERMOD versions
  - February 28, 2011 release
- Update classified under “Miscellaneous” changes in Model Change Bulletin #4

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Downwash Change

- Subroutine WAKFLG was modified to no longer ignore potential downwash effects for stack heights that equal or exceed the EPA formula height
- The determination of whether building downwash effects apply is based on the criterion implemented within the PRIME downwash algorithm

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Downwash Change

- Intent is to remove discontinuity in AERMOD building downwash treatment
  - Discussed in recent EPA presentation at 10th Modeling Conference
- Discontinuity did not exist prior to use of PRIME
- What are the implications?

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Downwash Example

- Setup:
  - One building – height 24.38 m
  - Building dimensions 56 m x 104 m
- $H_{GEP} = H_b + 1.5L$

  $H_{GEP} = 24.38\ m + 1.5(24.38\ m) = 61\ m$

Downwash Example (cont'd)

- Experiment varying stack height slightly below and above H_{GEP} (H_{GEP} = 61 m)
- Modeled identical emission rate

Modeled Stack Height (m)	Version 09292 1-hour Result (µg/m³)	Version 11103 1-hour Result (µg/m³)
60	178	178
62	88	160

- Considerable increase in results due to simply changing from old to new executable – no physical (or meteorological data) changes!!

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What is Next?

- EPA intends to issue a Clarification Memo to provide further justification for the change
  - Preview provided at 10th Modeling Conference
- EPA may also make change to lateral zone of influence of buildings in future AERMOD update
  - Currently uses 5L distance limit on structure influence zone

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Use of NO_2 Tiered Methods

NO_X vs. NO_2

- 1-hour and annual NAAQS are for NO_2
- Regulated pollutant for PSD is NO_X
  - NO_X emissions consist of NO and NO_2
- Chemical reactions occur in the atmosphere through which some NO is converted to NO_2
  - NO interacts with ambient ozone to form NO_2 and oxygen

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NO_X vs. NO_2

- *Guideline on Air Quality Models* (November 2005) allows three tiered method to estimate NO to NO_2 conversion
  - Section 5.2.4
- Modeled compliance with annual standard was generally "easy"
  - Assumption that 100% of NO_X is NO_2 was most commonly made
- 1-hour NO_2 NAAQS has resulted in closer look at three tiered methods

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Three Tiers

- Tier 1: Full NO to NO_2 conversion
- Tier 2: Ambient ratio applied to Tier 1 result
  - Sometimes called Ambient Ratio Method (ARM)
  - Annual default ratio is 0.75 per *GAQM*
  - 1-hour default ratio is 0.80 per March 1, 2011 Clarification Memo
- Tier 3: “Detailed Screening Methods”
  - PVMRM (plume volume molar ratio method)
  - OLM (ozone limiting method)

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Tier 2 Considerations

- Default ratios can by used by applicants "without additional justification"
- Easy to implement
- Still conservative in most cases
- ARM 2 suggested at 10th Modeling Conference
- Vary ratios by NO_2 concentration and distance

Tier 3 Considerations

- Case by case assessment until clearer guidance from EPA
  - Need approval from EPA Regional Office to use
- Three variables to input
  - In-stack NO_2/NO_X ratio for each stack
  - Equilibrium ratio downwind
  - Background ozone

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Tier 3 Considerations

- Default in-stack ratio: 0.5
  - March 1, 2011 Clarification Memo
  - Likely very high for most boilers
  - Use unit specific information if possible
- Default equilibrium ratio: 0.9
- Background ozone
  - Constant value
  - Time varying
    - Not all ozone monitors operate for entire year

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Tier 3 Considerations

- Get most benefit with:
  - High NO_X emission rates
  - Low in-stack ratios
  - Low ambient ozone concentrations
- EPA states neither PVMRM nor OLM is inherently superior
  - PVMRM represents more refined treatment for isolated, elevated point sources
  - Algorithm for determining which plumes “complete” for ozone is not thoroughly validated

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$PM_{2.5}$ Modeling Issues

"Order of Magnitude" Dilemma

- Previous controlling PM standard was 24-hour PM_{10}
  - NAAQS = 150 $\mu g/m^3$
  - Typical Background ~50 $\mu g/m^3$ suggests 100 $\mu g/m^3$ available
- $PM_{2.5}$ 24-hour standard substantially more stringent
  - NAAQS = 35 $\mu g/m^3$
  - Typical Background ~25 $\mu g/m^3$ suggests 10 $\mu g/m^3$ available (including condensables)

$PM_{2.5}$ NAAQS Permitting Implications

- Need to know $PM_{2.5}$ emissions better
  - Filterable and condensable
  - Most states have already required inclusion of condensables in modeling for several years
  - No current requirement by states to account for chemical transformations; a minority may consider for very large projects
- 24-hour NAAQS background concentrations very high – modeling demonstrations become very complex
- Revised annual NAAQS will likely create additional nonattainment areas
- Using PM_{10}=$PM_{2.5}$ emissions is a strategy that is being phased out on multiple levels

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Draft $PM_{2.5}$ Modeling Guidance

- Draft guidance originally expected to be released by EPA in fall 2011
- Delay in release contributed to delay to 10th Modeling Conference to March 2012
- Guidance discussed at that meeting, but still not officially released
- Latest estimate of anticipated release data is late 2012
  - Taking comments, suggestions, and feedback into account

Draft $PM_{2.5}$ Modeling Guidance

- One issue addressed is consideration of secondary formation of $PM_{2.5}$
- Considering 4-tiered modeling approach for addressing compliance with PSD increment and NAAQS

Model Requirement	Tier	Approach
Single-source screening analysis to compare with SILs	Tier I	**Primary & Secondary:** AERMOD with region- (or state-) specific offset ratios
Cumulative-source analysis to compare with NAAQS and PSD increments	Tier II	**Primary & Secondary:** AERMOD with region- (or state-) specific offset ratios
	Tier III	**Primary:** AERMOD **Secondary:** Use of a chemistry plume model (e.g., SCICHEM)
	Tier IV	**Primary**: AERMOD **Secondary**: CAMx (or CMAQ) with fine grid and PiG for new source

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Secondary $PM_{2.5}$ Assessment Methods

- Completely qualitative
  - Primary and secondary concentration not co-located
  - Use recent SIP related photochemical modeling for support
- Hybrid qualitative/quantitative approach
  - Add analysis of region specific offset ratios for precursor emissions
- Quantitative approach
  - Chemistry Plume Model (e.g., SCICHEM)
  - Photochemical Model (e.g., CAMx or CMAQ)
  - Only expected to be needed in handful of cases
- EPA recommends consultation with Regional Office including approval of modeling protocol

Scenarios for $PM_{2.5}$ Modeling

- Case 1: No $PM_{2.5}$ compliance demonstration is required
  - If $PM_{2.5}$ emissions < 10 tpy and NO_X and SO_2 emissions < 40 tpy
  - Would not trigger PSD for $PM_{2.5}$
- Case 2: Direct $PM_{2.5}$ modeling only
  - If $PM_{2.5}$ emissions > 10 tpy and NO_X and SO_2 emissions < 40 tpy

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Scenarios for $PM_{2.5}$ Modeling

- Case 3: Direct $PM_{2.5}$ modeling AND account for impact of precursor emissions from the project source
  - If $PM_{2.5}$ emissions > 10 tpy and NO_X and/or SO_2 emissions > 40 tpy
- Case 4: No direct $PM_{2.5}$ modeling AND DO NOT need to account for impact of precursor emissions from the project source
  - If $PM_{2.5}$ emissions < 10 tpy and NO_X and/or SO_2 emissions > 40 tpy

Questions for $PM_{2.5}$ Modeling

- Can photochemical models be used to model single sources?
  - Some techniques are being considered by EPA
- Do states have resources to review expected photochemical modeling studies?
  - How will timing of PSD review be affected if analyses for secondary $PM_{2.5}$ need to go to region or headquarters?

Questions

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