# AERMOD Modeling System Update

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# Outline

- AERMOD modeling system status
- Update on AERMOD – work completed
- Update on AERMET – work completed
- Update on AERMAP – work completed
- Remaining Issues to Resolve and Planned Updates
- AERMOD Update Process
- Questions

# AERMOD Modeling System Status

- AERMOD promulgation as preferred model in full effect as of December 9, 2006 – end of 1-year grandfather period
- Significant updates to all three components released January 2007 (dated 06341)
- Limited update to AERMOD released January 26, 2007 (dated 07026)

# AERMOD Model Changes: Enhancements

- Updated processing for PM-2.5 NAAQS and removal of “post-1997” processing for PM-10
- Additional options to vary emissions by month, hour-of-day and day-of-week (MHRDOW, MHRDOW7)
- Multiple urban areas in single model run
- User-specified default in-stack NO2/NOx ratio for Plume Volume Molar Ratio Method (PVMRM)

# AERMOD Model Changes: Enhancements (cont.)

- New “BETA” option added to CO MODELOPT card to identify and allow use of new features added to the model that are still in a draft BETA-test status
  - Non-DFAULT option
  - Allows for more efficient evolution of code by reducing need for maintaining multiple versions
- “Beta” options for capped and horizontal releases
  - EPA Model Clearinghouse procedure not applicable for PRIME downwash algorithm

# AERMOD Model Changes: Enhancements (cont.)

- "Beta" option to account for NO2/NOx plume chemistry of combined plumes in the computation of PSD increment consumption with credits for PVMRM
- Maximum number of vertices for AREAPOLY source allocated dynamically
- More memory-efficient process for allocating array storage

# AERMOD Model Changes: Bug Fixes

- Several minor fixes for PRIME (mostly undefined variables)
- Correct variable type error for AREACIRC sources (minor impact), and correct potential error for all AREA source types (impacts may vary)
- Correct error for PVMRM when multi-level on-site wind data are used
- A few additional minor bugs

# AERMOD Model Changes: Miscellaneous Items

- Added range check on VPTGZI in AERMOD to avoid problems with data provided from sources other than AERMET (e.g. gridded met models)
- Tightened range checks on optional urban roughness length on URBANOPT card
  - Default of 1m should be used in most cases; values greater than 5.0m not allowed; warnings issued for values less than 0.8m or greater than 1.5m
  - More details presented later
- Miscellaneous code clean-up items

# AERMOD Model Changes: Urban Roughness Length Issue

- CO URBANOPT card includes option for user-specified urban roughness length; default value of 1.0m used if not specified
- Urban $Z_0$ used to adjust rural $u_*$ based on pseudo-convective urban $w_*$ to "urbanize" sigma-z for surface sources
- Adjustment based on matching convective sigma-w profile with mechanical sigma-w profile at height of $7*Z_{0\text{-urban}}$

# AERMOD Model Changes: Urban Roughness Length Issue

- Considered removing option based on concern that unrealistic values were being used, and possible misinterpretation of how value is used in model:
  - It does **<u>not</u>** adjust for difference in roughness between met site and urban application site
- Performed sensitivity analysis to determine potential impact of removing option
- Results showed sensitivity limited to low-level sources (not surprising), but greater sensitivity than hoped for

# AERMOD Model Changes: Urban Roughness Length Issue

- Sensitivity analysis description:
  - Two met sites – PIT and OKC
  - Nine source types:
    - 3 non-buoyant (0m, 10m, 50m);
    - 3 buoyant (10m, 35m, 100m)
    - 3 downwash (10m-cnr, 35m-cnr, 35m-detached)
  - Four populations – 500K, 1M, 2M and 5M
  - Five urban roughness values – 0.5m, 0.8m, 1.0m, 1.5m and 2.0m

# AERMOD Model Changes: Urban Roughness Length Issue

- Summary of sensitivity analysis results:
  - Only two sources (0m non-buoyant & 10m buoyant) showed significant differences
  - 10m buoyant showed differences for longer averaging periods
  - Differences fairly consistent across range of populations
  - Ground-level source sensitivity to urban roughness greater than sensitivity to population

# AERMOD Model Changes: Urban Roughness Length Issue

Representative results for PIT:

**Ratios of H1H 1-hour Concentrations to Default Z0=1.0m**

| Population | Source | Z0=0.5m | Z0=0.8m | Z0=1.0m | Z0=1.5m | Z0=2.0m |
|---|---|---|---|---|---|---|
| 500,000 | NB000M | 1.514 | 1.140 | 1.000 | 0.794 | 0.678 |
| 1,000,000 | NB000M | 1.512 | 1.139 | 1.000 | 0.795 | 0.722 |
| 2,000,000 | NB000M | 1.510 | 1.139 | 1.000 | 0.796 | 0.796 |
| 5,000,000 | NB000M | 1.507 | 1.138 | 1.000 | 0.905 | 0.905 |
| 500,000 | BY010M | 0.619 | 0.872 | 1.000 | 1.347 | 1.501 |
| 1,000,000 | BY010M | 0.620 | 0.875 | 1.000 | 1.347 | 1.494 |
| 2,000,000 | BY010M | 0.621 | 0.877 | 1.000 | 1.347 | 1.489 |
| 5,000,000 | BY010M | 0.621 | 0.879 | 1.000 | 1.346 | 1.484 |

# AERMOD Model Changes: Urban Roughness Length Issue

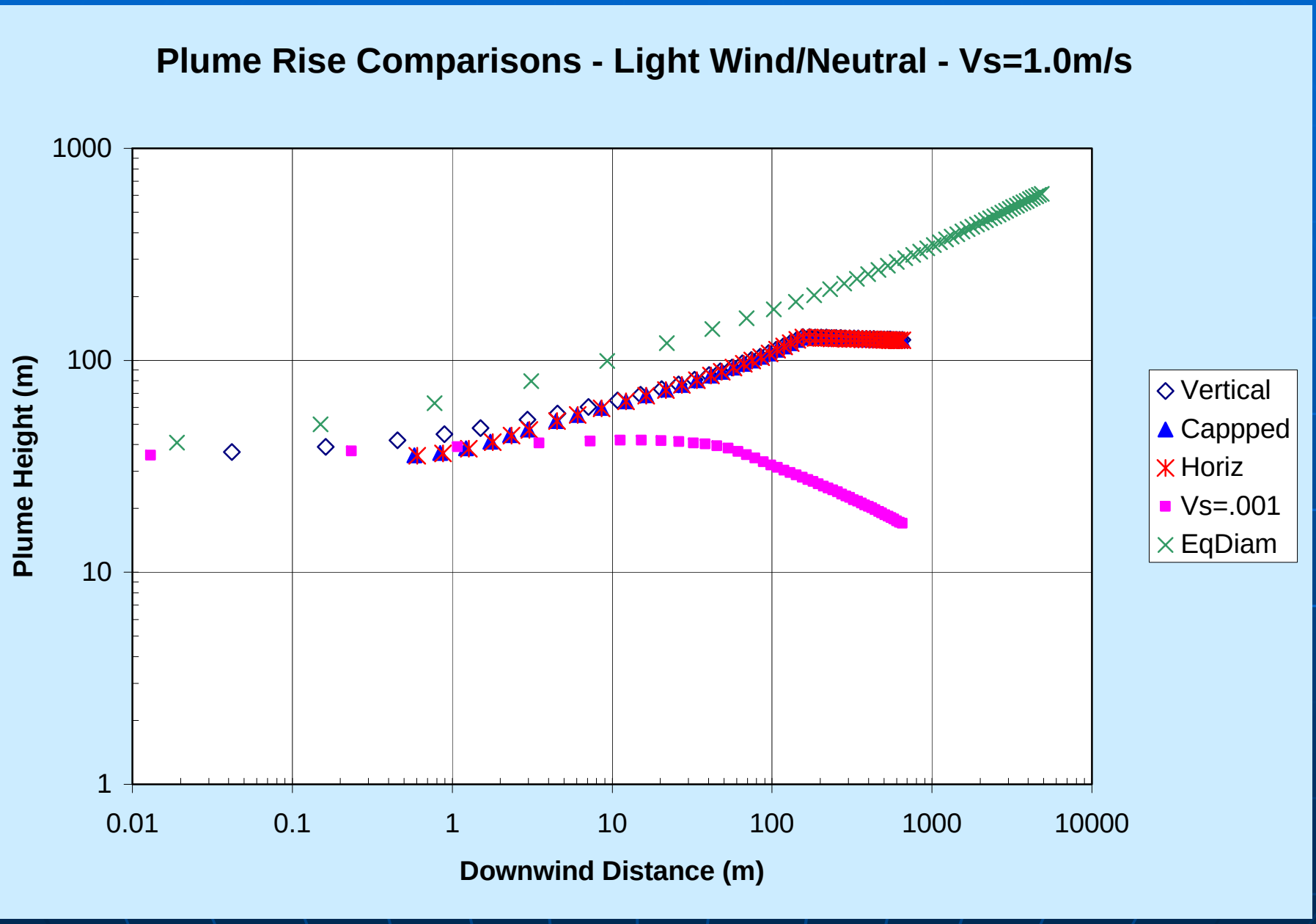
- Decision was to leave option in model, but tighten range checks on user-specified value
  - Model still prohibits values greater than 5.0m
  - Model now issues warnings for values less than 0.8m and greater than 1.5m
- Issue included with other AERMOD urban issues for AIWG consideration

# AERMOD Model Changes: Capped/Horizontal Releases

- Current Model Clearinghouse procedure not applicable to PRIME
  - Clearinghouse procedure involves setting $V_s$ low (0.001m/s) and adjusting $D_s$ to maintain flow rate and buoyancy
  - PRIME numerical plume rise uses input $D_s$ to define radius of plume – use of effective radius will alter results in physically unrealistic ways
  - AERMOD Implementation Guide suggests using $V_s$=0.001m/s with actual $D_s$ as interim solution

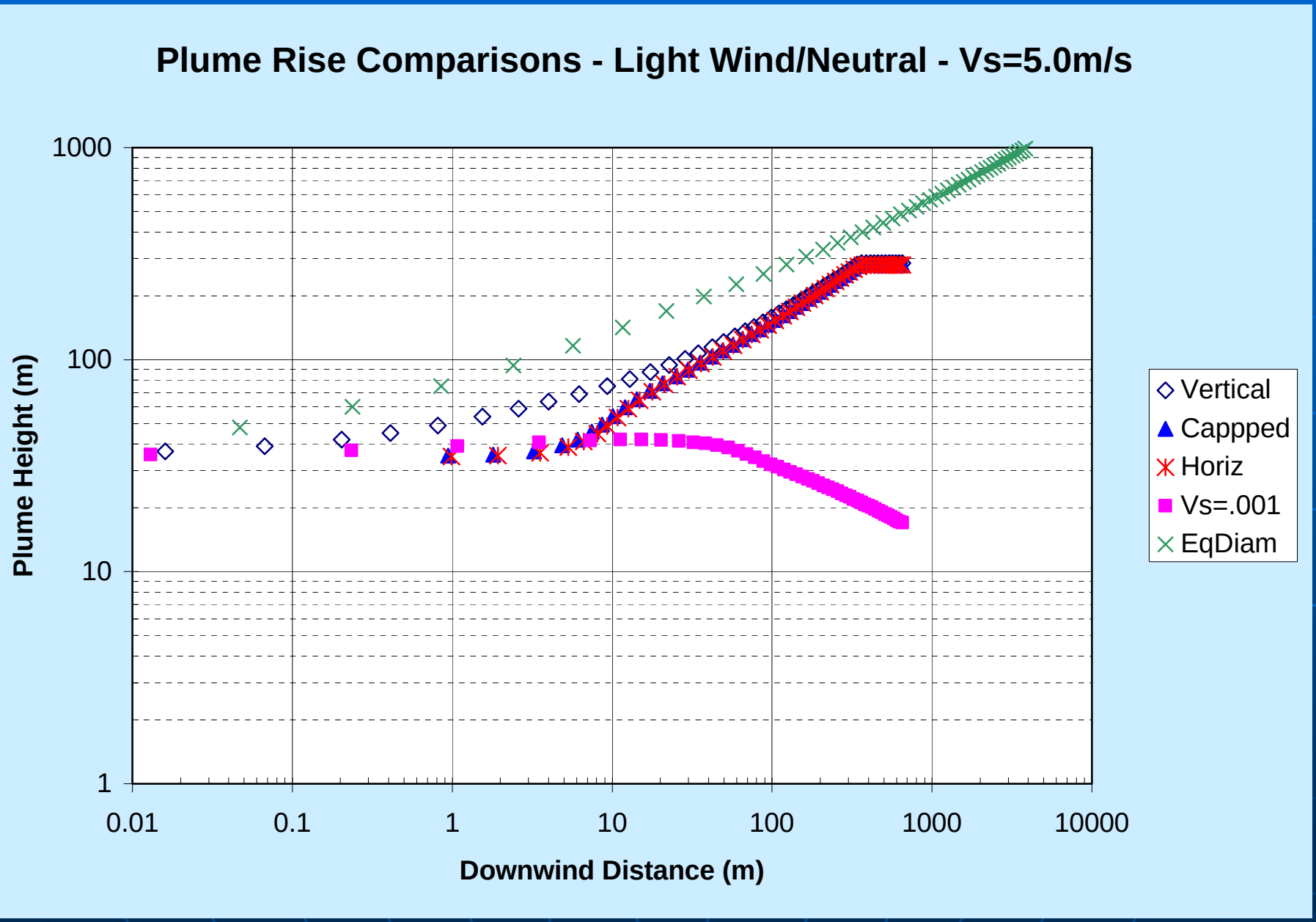
# AERMOD Model Changes: Capped/Horizontal Releases

- Draft/BETA options have been implemented for capped & horizontal
  - User inputs actual stack $V_s$ and $D_s$
  - Source types POINTCAP & POINTHOR used to trigger BETA options
  - Non-downwash sources use existing Clearinghouse procedure
  - PRIME sources adjust plume radius (currently 2X) to account for initial spread from cap
  - Partition vertical and horizontal momentum


Plume Rise Comparisons - Light Wind/Neutral - Vs=1.0m/s
1000
100
10
1
Plume Height (m)
0.01
0.1
1
10
100
1000
10000
Downwind Distance (m)
Vertical
Cappped
Horiz
Vs=.001
EqDiam

*** THE SUMMARY OF HIGHEST 1-HR RESULTS ***

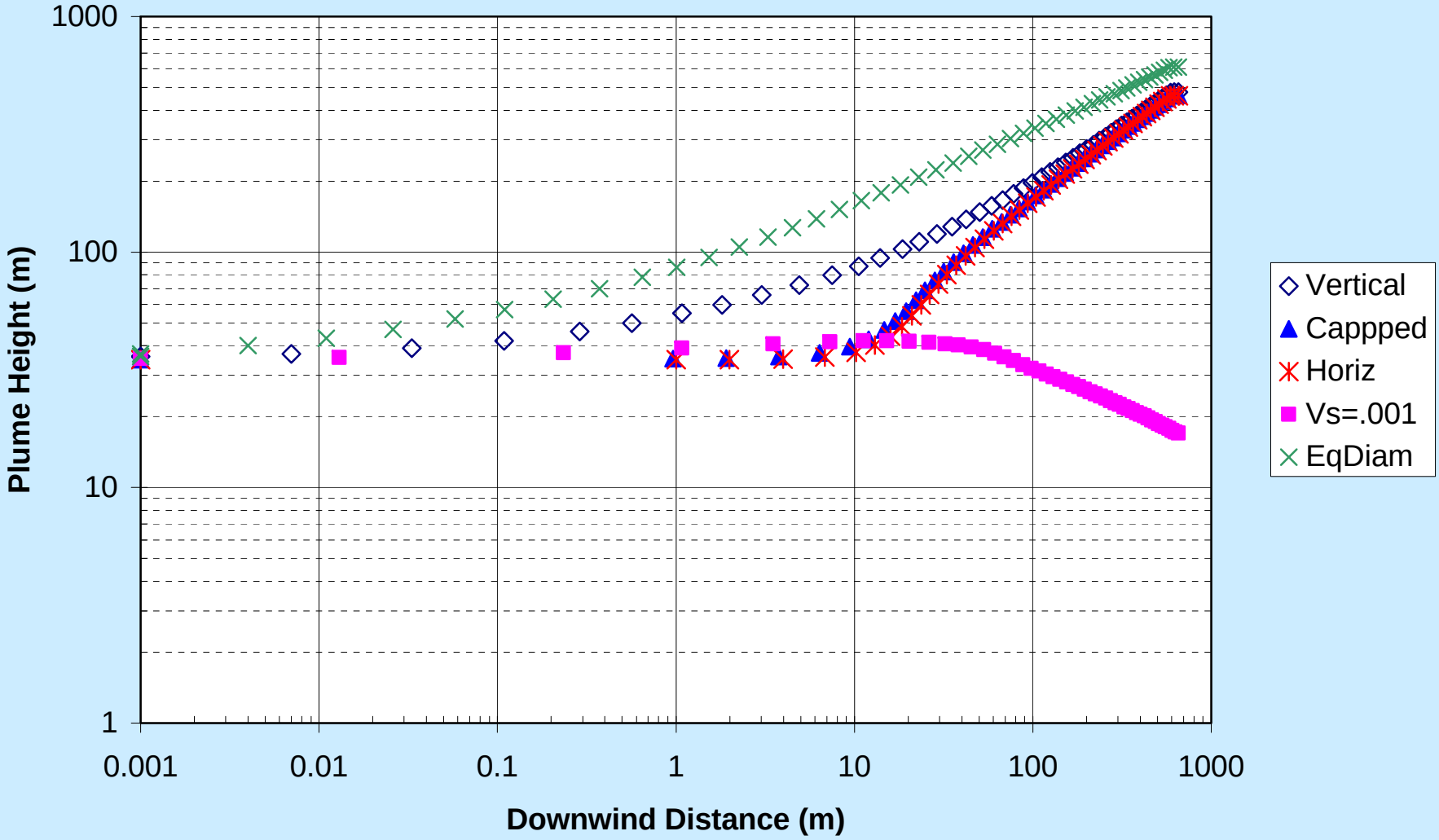
| GROUP ID | | | AVERAGE CONC | DATE (YYMMDDHH) |
|---|---|---|---|---|
| STACK1 | HIGH | 1ST HIGH VALUE IS | 1521.32983 | ON 90010102 |
| STACK1C | HIGH | 1ST HIGH VALUE IS | 1532.27722 | ON 90010102 |
| STACK1H | HIGH | 1ST HIGH VALUE IS | 1534.01941 | ON 90010102 |
| STACK1C0 | HIGH | 1ST HIGH VALUE IS | 19051.35547 | ON 90010102 |
| STACK1CE | HIGH | 1ST HIGH VALUE IS | 181.41460 | ON 90010102 |


Plume Rise Comparisons - Light Wind/Neutral - Vs=5.0m/s
1000
100
10
1
Plume Height (m)
0.01
0.1
1
10
100
1000
10000
Downwind Distance (m)
Vertical
Cappped
Horiz
Vs=.001
EqDiam

*** THE SUMMARY OF HIGHEST 1-HR RESULTS ***

| GROUP ID | | | AVERAGE CONC | DATE (YYMMDDHH) |
|---|---|---|---|---|
| STACK1 | HIGH | 1ST HIGH VALUE IS | 2.97269 | ON 90010102 |
| STACK1C | HIGH | 1ST HIGH VALUE IS | 2.98035 | ON 90010102 |
| STACK1H | HIGH | 1ST HIGH VALUE IS | 72.16824 | ON 90010102 |
| STACK1C0 | HIGH | 1ST HIGH VALUE IS | 19767.68555 | ON 90010102 |
| STACK1CE | HIGH | 1ST HIGH VALUE IS | 2.97411 | ON 90010102 |

# Plume Rise Comparisons - Light Wind/Neutral - Vs = 11.7m/s



*** THE SUMMARY OF HIGHEST 1-HR RESULTS ***

| GROUP ID | | | AVERAGE CONC | DATE (YYMMDDHH) |
|---|---|---|---|---|
| STACK1 | HIGH | 1ST HIGH VALUE IS | 2.29646 | ON 90010102 |
| STACK1C | HIGH | 1ST HIGH VALUE IS | 6.52318 | ON 90010102 |
| STACK1H | HIGH | 1ST HIGH VALUE IS | 6.63034 | ON 90010102 |
| STACK1C0 | HIGH | 1ST HIGH VALUE IS | 19767.68555 | ON 90010102 |
| STACK1CE | HIGH | 1ST HIGH VALUE IS | 2.30701 | ON 90010102 |

# AERMOD Model Changes: PVMRM PSD Credit Option

- Define:
  - A = increment-consuming sources
  - B = existing (non-retired) baseline sources
  - C = increment-expanding (retired baseline) sources
- Increment consumption without credits
  $= (A+B) - B$
- PSD Credit $= (B+C) - B$
- CHITOTAL $= [(A+B) - B] - [(B+C) - B]$
  $= (A+B) - (B+C)$

# AERMET Update: Bug Fixes

- Significant changes to processing of NWS Integrated Surface Hourly Data (ISHD) surface data (TD-3505)
  - Selection of which record to process for hours with multiple records
  - Processing of cloud cover codes
  - Initialization of “additional” character variable – caused data from previous hours to be used
  - Identify “variable” winds as missing WD and non-missing WS rather than calm
  - Corrected problem that allowed observation hour to be incremented prematurely

# AERMET Update: Bug Fixes (cont.)

- Corrected treatment of “variable” winds for TD-3280 format – coded as missing WD with non-missing WS
- Corrected treatment of missing data codes for WS/WD for HUSWO format
- Modified upper and lower bounds for surface pressure for FSL upper air data to avoid skipping valid soundings at high or low elevations
- Corrected bugs in calculation of critical solar angle – affecting transition hours

# AERMET Update: Enhancements

- Single AERMET executable – still needs to be run in 3 stages
- Optional station elevation for ISHD data to substitute for missing elevation in estimating surface pressure

# AERMET Update: Miscellaneous

- Impose lower limit of 0.001 meters for user-specified surface roughness, for consistency with AERMOD model
- User-specified time window for ISHD data removed – default window of 30 minutes preceding the hour used
- Given range of changes affecting results, AERMOD modified to require reprocessing of met data with 06341

# AERMAP Update: Bug Fixes

- Significant changes (overhaul) of datum (NAD) conversion process
  - Previous version did not account for shift due to UTM-Lat/Lon conversion
  - Error typically about 200m in Northing coordinate
  - Incorporated NAD conversion for DOMAIN extent
  - Clarified and simplified treatment of DEM file gaps
- Corrected bug resulting in erroneous elevation for first receptor or source
- Corrected bug with method to optimize hill height scale calculation by skipping adjacent DEM files

# AERMAP Update: Enhancements

- Enhanced debug output file options with additional user control
- Optimized runtime by using limited “check” on DEM file structure – added optional parameter to perform full check
- Additional optimizations for calculating critical hill height scales
- Added “Input Options Summary” page, similar to AERMOD

# Unresolved Issues/Planned Updates

- Updated AERMOD Modeling System package planned ASAP to address:
  - Issues with portability of code to Linux for all three components
  - Problems with AERMAP for Alaska DEM data
  - Cross UTM zone bug in AERMAP
  - Format problem with some ISHD data may cause AERMET to crash
    - *FIXISHD* utility program – interim fix released in April
  - Data (record-period) gap in ISHD data

# Unresolved Issues/Planned Updates

- Inconsistencies between NWS surface data formats
  - TD-3280 sky cover codes
  - Abbreviated ISHD (TD-3505) sky cover
- Allocatable arrays for AERMAP
- Modify AERMAP to support National Elevation Dataset (NED)?
- PRIME/BPIPPRM issues
  - Split building/elongated building issues
  - Discontinuity at GEP stack height
  - Upwind impact of building on plume

# Unresolved Issues/Planned Updates

- Upgrade Fortran compiler
  - Compaq Visual Fortran no longer supported
  - Recent “quirk” with Compaq Visual Fortran
  - Using open-source G95 compiler to debug codes
  - Distribute Windows and Linux executables?
- Eventually updated user’s guides need to be developed

# AERMOD Update Process

- Management of update process
  - Defining scope of changes
  - Efficient bug-tracking system
  - Internal QA of draft changes
  - Documentation and packaging of changes
- Communication regarding pending updates
  - Advance notice to ROs and States? What about general community?
  - Beta test process, perhaps using 3rd-party vendors? – also may fulfill QA function

# AERMOD Update Process

- Scope of model changes
  - Bug fixes, non-technical enhancements, technical enhancements
  - AIWG recommendations
  - AERMIC recommendations
  - Collaboration with other groups (ORD, FAA, etc.)
- Infrastructure development to support process
  - Bug tracking and reporting system
  - QA testing and documentation standards
  - Standardized test beds (consequence analysis and field study data) to document impact of changes

# Questions