AERMET 21DRF and MMIF 4.0-Draft release

James Thurman

thurman.james@epa.gov

U.S. EPA/OAQPS/Air Quality Modeling Group

December 9, 2021

Overview

- What is AERMET?
- Motivation for overhaul
- Current configuration of AERMET
- New configuration for AERMET 21DRF
- AERMET 21DRF & MMIF 4.0-draft updates
  - Summary of updates
- Evaluation summary
- Expected differences
- Download links

Current AERMET

New AERMET

Acknowledgements

- AQMG MDT
- Regional testers
  - Rick Gillam and Chris Howard Region 4
  - Melissa Sheffer Region 5
  - Lance Avey Region 7
  - Jay McAlpine Region 10

AERMET

- Regulatory meteorological pre-processor for AERMOD
  - Calculates PBL variables needed by AERMOD
- Inputs
  - Upper air sounding data
  - NWS surface data
    - Hourly and hourly averaged 1-minute ASOS winds (AERMINUTE); introduced in 2011
  - Site-specific meteorological data
  - Prognostic meteorological data processed via Mesoscale Model InterFace (MMIF)
  - Surface characteristics (albedo, Bowen ratio, surface roughness)
    - AERSURFACE or similar methodology
- Outputs
  - AERMOD ready surface file
  - AERMOD ready profile file

Motivation for overhaul

- Runtime or performance is not an issue
- Code update/maintenance primary motivation for overhaul
- AERMET based on older meteorological pre-processor, MPRM
  - Easy to use existing software rather than create new software
- Current AERMET code is convoluted, very “clunky”
  - Each subroutine is its own FORTRAN file, over 180 subroutines
  - Outdated coding practices
    - Intermediate files instead of internal arrays
    - Based on computer technology of 1980’s (small RAM/memory)
  - Difficult/tedious to make substantive changes
    - New data sources
    - New user options
- Not easily portable across operating systems (Windows, Linux)
  - Case sensitivity of filenames on Linux systems

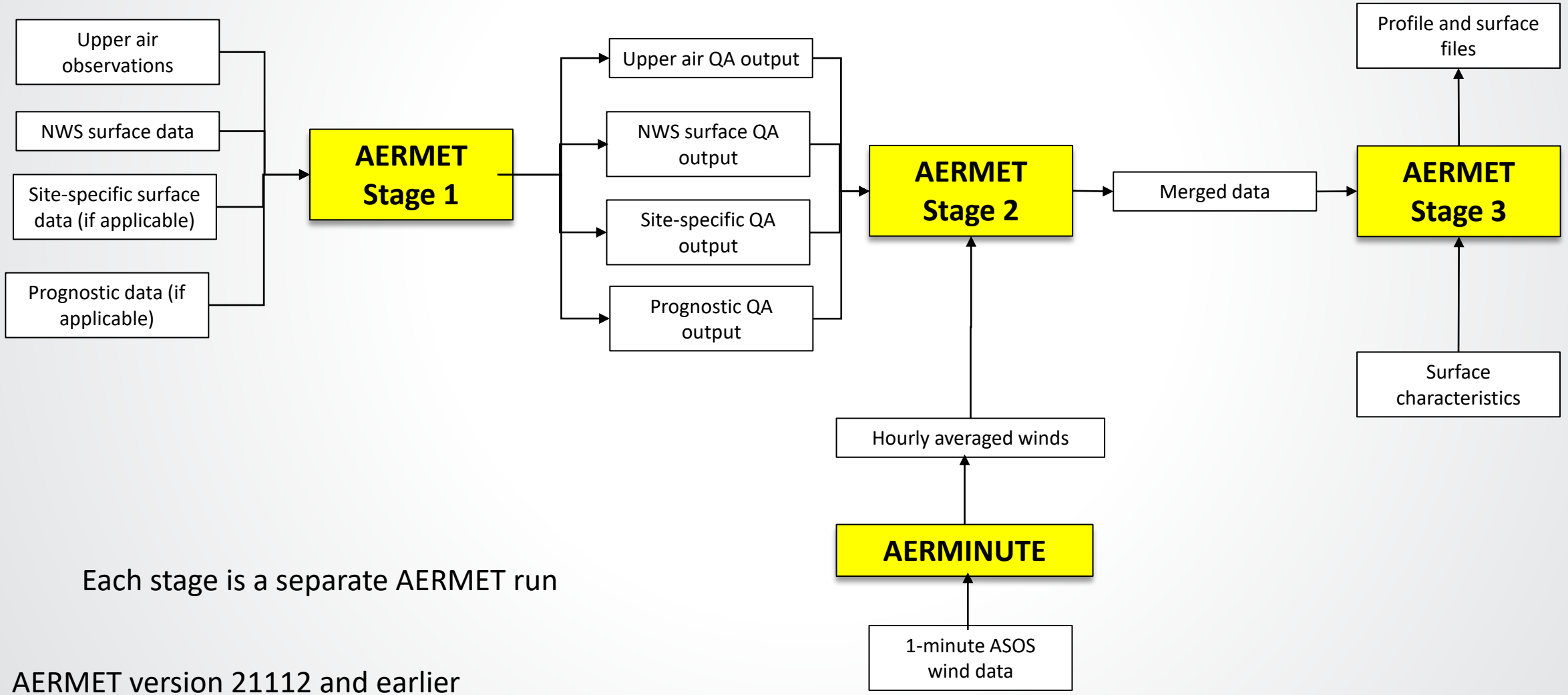
Nature of overhaul

- Recode AERMET to be in line with current best programming practices
  - Modular programming
    - e.g., all subroutines used to process upper air data in one module
  - Arrays instead of writing to intermediate files
    - Take advantage of modern computing power
  - More in-code documentation, variable definitions
    - Easier for others to see what code does
  - Easier to update in future
- Portability across operating systems
  - Case sensitivity of Linux for filenames
- No formulation changes
  - No regulatory action necessary

AERMET 21DRF modules

Module	Description
FILE_UNITS	File units and variables for filenames
MAIN1	Variables, subroutines, and functions used by other modules
UPPERAIR	Variables, subroutines, and functions to control upper air sounding processing (input and QA)
SURFACE	Variables, subroutines, and functions to control NWS surface data processing (input and QA)
ONSITE	Variables, subroutines, and functions to control site-specific or prognostic data processing (input and QA)
PBL	Variables, subroutines, and functions to control boundary layer calculations
READ_INPUT	Variables and subroutines to read the AERMET control file
REPORTS	Variables and subroutines to write AERMET report summary file
MISC	Variables and subroutines for miscellaneous processes
AERMET	Main calling program

Current[1] AERMET Stages



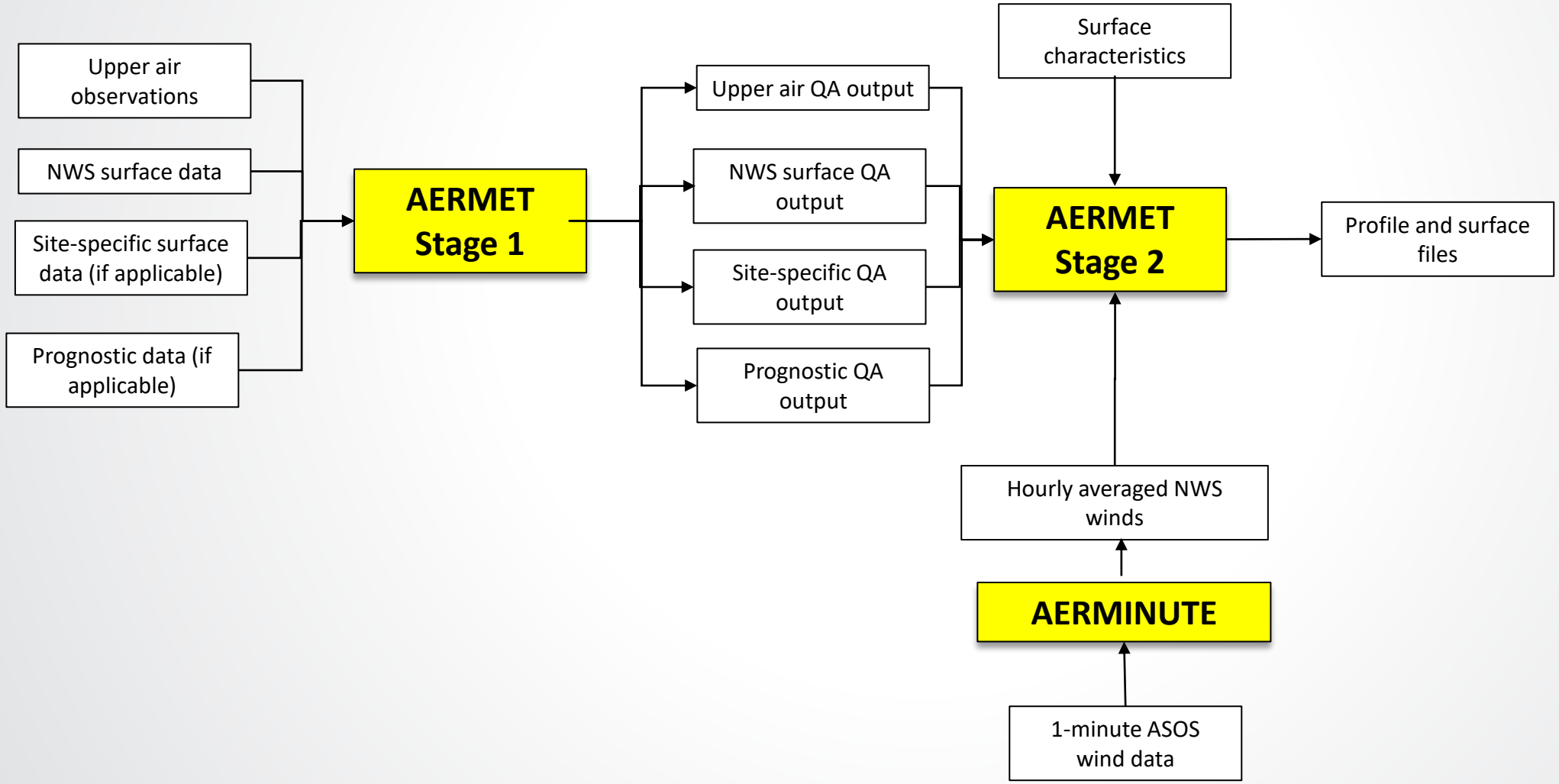
Each stage is a separate AERMET run

1. AERMET version 21112 and earlier

AERMET 21DRF configuration

- Eliminate Stage 2 (merge stage)
  1. Stage 1: raw inputs → QA'd data (current stage 1)
  2. Stage 2: QA'd data → AERMOD ready outputs (modified current stage 3)
- Two options available for running AERMET
  - AERMET modified to allow user to specify either option
  1. Single run: raw inputs → AERMOD ready outputs
     - Stage 1 and 2 in one AERMET run
     - Optional EXTRACT and QAOUT output files
  2. 2 stage run (2 AERMET runs)
     1. Stage 1: raw inputs → QA outputs (current stage 1)
     2. Stage 2: QA outputs → AERMOD ready outputs

AERMET 21DRF Stages



21DRF updates

- Retain original case of input/output filenames in control file(s)
  - AERMET currently coverts lines to uppercase for internal processing
    - Filenames become uppercase
    - Problem for Linux OS due to case sensitivity
- Switch from real to double precision
  - Consistent with AERMAP, AERSURFACE, and AERMOD
  - Will see some differences
- Create PROG pathway (more later)
  - Analogous to ONSITE pathway
  - Allows AERMOD to recognize data is prognostic in nature
  - Add overwater capability with new variables
    - Monin-Obukhov length may be used to determine stabilty of hour (default is solar angle)

21DRF updates (cont)

- New source of upper air data (IGRA format)
- 3280 format for SURFACE data dropped; obsolete
- Reformat of information, report, and intermediate QA outputs
  - Easier review of data (import to spreadsheet)
- More QA of input data files
- For sub-hourly data, a new vector averaging for winds (if vector winds)
- SURFACE dates now checked against XDATES after conversion from GMT to LST and from hour 00-23 to hour 01-24
  - Consistent with UPPERAIR
  - Regains some data

21DRF updates (cont)

- Debug option to see some stage 1 operations and PBL calculations
- NOPRINT option to suppress printing to screen
- Smoothing of mechanical mixing heights every hour, even if site-specific mixing heights; consistent with AERMOD MFED (bug fix)
- Reinitialize output precipitation each day before reading NWS and/or site-specific data (bug fix) for the day
- NWS wind speeds associated with variable wind directions are no longer adjusted to account for ASOS truncation. Does not affect AERMOD since wind direction is missing.
- Elimination of hour 23 and 24 persistence substitution
  - Artifact of using intermediate files
  - Hours 23 and 24 now substituted like other hours
- Elimination of hour 23 swapping for hour 24 for missing NWS data
  - Artifact of intermediate files
- Ability to use multiple sets of surface characteristics for a location for multi-year processing
  - Surface characteristics may vary year to year (year 1 is wet, year 2 is dry, etc.)

21DRF updates (cont)

- For seasonal characteristics only
  - AERMET currently assigns to months based on northern hemisphere seasons/months
    - Winter: January, February, and December (June-August)
    - Spring: March-May (September-November)
    - Summer: June-August (January, February, and December)
    - Autumn: September-November (March-May)
  - AERMET 21DRF uses latitude of ONSITE (or PROG) and SURFACE stations to determine hemisphere of station and assign correct months to season
    - Northern hemisphere winter: January, February, December
    - Southern hemisphere winter: June-August
  - Before 21DRF, southern hemisphere users would have to assign winter characteristics to summer season to ensure characteristics assigned to correct months
  - With 21DRF, applications in southern hemisphere do not have to assign winter characteristics to AERMET summer season to assign to winter characteristics to June-August; assign to winter

Example multi-year surface characteristics for 21DRF

```
XDATES 2013 01 01 2017 12 31
  nws_hgt   wind  10.0
  output    test.sfc
  profile   test.pfl

  AERSURF onsite_2014.txt 2013 2014
  AERSURF2 airport_2014.txt 2013 2014

  AERSURF onsite_2015.txt 2015
  AERSURF2 airport_2015.txt 2015

  AERSURF onsite_2016.txt 2016
  AERSURF2 airport_2016.txt 2016

  AERSURF onsite_2017.txt 2017
  AERSURF2 airport_2017.txt 2017
```

Using AERSURF and AERSURF2 keywords

```
 FREQ_SECT  MONTHLY  4  2013 2014
  SECTOR   1   20.00  120.00
  SECTOR   2  120.00  210.00
  SECTOR   3  210.00  290.00
  SECTOR   4  290.00   20.00

**        Month   Sect   Alb     Bo      Zo
  SITE_CHAR   1     1    0.44    0.47    0.103
.
.
.
 FREQ_SECT  MONTHLY  4  2015
  SECTOR   1   20.00  120.00
  SECTOR   2  120.00  210.00
  SECTOR   3  210.00  290.00
  SECTOR   4  290.00   20.00

**        Month   Sect   Alb     Bo      Zo
  SITE_CHAR   1     1    0.44    0.47    0.103
  SITE_CHAR   1     2    0.44    0.47    0.118
  SITE_CHAR   1     3    0.44    0.47    0.067
  SITE_CHAR   1     4    0.44    0.47    0.340
  SITE_CHAR   2     1    0.44    0.47    0.103
```

Using FREQ_SECT keywords in control file

Seasonal characteristics

```
FREQ_SECT SEASONAL 1
SECTOR 1 0 360

** winter Jan. Feb. Dec.
** (SH summer characteristics)
SITE_CHAR 1 1 0.18 0.8 0.1

** spring March-May
** (SH autumn characteristics)
SITE_CHAR 2 1 0.20 1.0 0.01

** summer June-August
** (SH winter characteristics)
SITE_CHAR 3 1 0.6 1.5 0.001

** autumn Sept.-Nov.
** (SH spring characteristics)
SITE_CHAR 4 1 0.18 0.4 0.05
```

AERMET 21112 AERMET 21DRF

```
FREQ_SECT SEASONAL 1
SECTOR 1 0 360

** SH winter June-August
SITE_CHAR 1 1 0.6 1.5 0.001

** SH spring Sept.-Nov.
SITE_CHAR 2 1 0.18 0.4 0.05

** SH summer Jan. Feb. Dec.
SITE_CHAR 3 1 0.18 0.8 0.1

** SH autumn  March-May
SITE_CHAR 4 1 0.20 1.0 0.01
```

Example UPPERAIR EXTRACT/QAOUT

```
*    AERMET Version  19191
*% UPPERAIR
*    DATA       ..\..\AERMET\DAVENPORT_UA.TXT  FSL
*    EXTRACT    UPPER.IQA
*@   LOCATION   94982 41.60N 90.57W  6
*    XDATES     2013/01/01 2017/12/31
*    QAOUT      UPPER.OQA
*     *** UPPER AIR EXTRACTION
*** EOH: END OF UPPERAIR EXTRACT HEADERS
 13010106   33
   9960      0   -145   -168    345     25
   9930     23   -137   -163    999   9990
   9710    193   -127   -165    999   9990
   9590    288   -113   -151    999   9990
   9360    474   -115   -150    999   9990
   9330    499   -111   -151    999   9990
   9250    565   -107   -207    340     66
   9230    582   -105   -215    999   9990
   9120    674   -101   -221    999   9990
   8500   1216   -101   -241    330    102
   8270   1427   -103   -253    999   9990
```

21112

```
AERMET 19DRF
LOCATION 94982     41.600N     90.570W  6
FILE TYPE: EXTRACT
DATES 2014 01 01 2014 01 01
DATE       SND   HR  LEV    UAPR     UAHT     UATT     UATD     UAWD     UAWS
20140101     1   06   1    996.0      0.0    -12.5    -15.3     65.0      6.2
20140101     1   06   2    985.0     84.0    -13.3    -15.8    999.0   9990.0
20140101     1   06   3    967.0    224.0    -14.7    -16.3    999.0   9990.0
20140101     1   06   4    953.0    334.0    -14.7    -15.5    999.0   9990.0
20140101     1   06   5    925.0    561.0    -10.1    -10.3    110.0     12.3
20140101     1   06   6    924.0    569.0     -9.9    -10.1    999.0   9990.0
20140101     1   06   7    896.0    807.0     -7.5     -8.0    999.0   9990.0
20140101     1   06   8    850.0   1219.0     -6.9     -6.9    265.0      5.7
20140101     1   06   9    843.0   1283.0     -6.9     -6.9    999.0   9990.0
20140101     1   06  10    835.0   1357.0     -4.3     -4.8    999.0   9990.0
20140101     1   06  11    809.0   1605.0     -4.9     -6.3    999.0   9990.0
20140101     1   06  12    799.0   1702.0     -4.7     -8.2    999.0   9990.0
20140101     1   06  13    793.0   1761.0     -4.3     -5.9    999.0   9990.0
20140101     1   06  14    776.0   1931.0     -3.5     -6.4    999.0   9990.0
20140101     1   06  15    742.0   2283.0     -5.1     -9.0    999.0   9990.0
20140101     1   06  16    729.0   2421.0     -6.1     -9.2    999.0   9990.0
```

21DRF

Example SURFACE EXTRACT/QAOUT

```
*    AERMET Version  19191
*% SURFACE
*@   DATA       ..\..\AERMET\MDW.TXT ISHD
*    EXTRACT    MDW.IQA
*    XDATES     2013/01/01 2017/12/31
*@   LOCATION   14819  41.784N  87.756W  6 188.
*    QAOUT      MDW.OQA
*  SURFACE OBSERVATION EXTRACTION
*** EOH: END OF SURFACE EXTRACT HEADERS
 12123119     0 10197  9961     6 01099 09999 00300 00300 00300 00300
        00300 09999 00000 00099 00999   160   -33   999   -78    71    31    31  A
 12123120     0 10200  9965     6 01099 09999 00300 00300 00300 00300
        00300 09999 00000 00099 00999   140   -33   999   -78    71    29    26  A
 12123121     0 10197  9961   999 01099 09999 00300 00300 00300 00300
        00300 09999 00000 00099 00999   110   -28   999   -83    65    36    41  A
 12123122     0 10207  9971     6 01099 09999 00300 00300 00300 00300
        00300 09999 00000 00099 00999   160   -44   999  -100    65    33    57  A
 12123123     0 10212  9975     6 01099 09999 00300 00300 00300 00300
        00300 09999 00000 00099 00999   160   -56   999  -122    59    34    57  A
 12123124     0 10214  9975    30 01099 09999 00300 00300 00300 00300
        00300 09999 00000 00099 00999   160   -56   999  -122    59    33    57  A
```

21112

```
AERMET 19DRF
LOCATION 14819     41.784N     87.756W  6 188.000
FILE TYPE: QAOUT
DATES 2014 01 01 2014 01 01
DATE       HR  ASOS      PRCP      SLVP      PRES      TSKC      PWTH      ASKY      TMPD      DPTP      RHUM      WDIR
20140101   01     Y      0.00    1027.2    1002.5    9999.0       0.0      10.0      -8.9     -11.1      84.0      10.0
20140101   02     Y      0.00    1026.9    1002.1    9999.0       0.0      10.0      -8.3     -10.6      83.0     340.0
20140101   03     Y      0.00    1026.4    1001.8    1099.0       0.0      99.0      -7.8     -10.0      84.0     340.0
20140101   04     Y      0.00    1025.8    1001.1    9999.0       0.0      10.0      -7.2      -9.4      84.0     340.0
20140101   05     Y      0.00    1025.7    1001.5    9999.0       0.0      10.0      -5.0      -7.2      84.0      50.0
20140101   06     Y      0.00    1025.8    1001.5    9999.0       0.0      10.0      -5.6      -7.2      88.0     100.0
20140101   07     Y      0.00    1025.9    1001.5    9999.0       0.0      10.0      -5.6      -7.8      84.0      80.0
20140101   08     Y      0.00    1025.9    1001.5    9999.0       0.0      10.0      -5.6      -8.9      77.0      80.0
20140101   09     Y      0.00    1026.4    1002.1    1099.0       0.0      99.0      -5.6      -8.9      77.0      70.0
20140101   10     Y      0.00    1026.9    1002.5    9999.0       0.0      10.0      -5.6      -8.3      81.0      70.0
20140101   11     Y      0.00    1026.3    1001.8    9999.0       0.0      10.0      -5.6      -7.8      84.0      60.0
20140101   12     Y      0.00    1025.5    1001.1    9999.0       0.0      10.0      -5.6      -7.8      84.0      70.0
20140101   13     Y      0.30    1024.9    1000.5    9999.0       0.0      10.0      -5.6      -7.8      84.0      60.0
20140101   14     Y      0.00    1024.4    1000.1    9999.0       0.0      10.0      -5.6      -7.8      84.0      60.0
20140101   15     Y      0.00    1024.0     999.8    1099.0       0.0      99.0      -5.6      -7.2      88.0      60.0
20140101   16     Y      0.30    1024.3    1000.1    9999.0       0.0      10.0      -5.0      -7.2      84.0      70.0
20140101   17     Y      0.00    1024.0     999.8    9999.0       0.0      10.0      -5.6      -7.2      88.0      70.0
20140101   18     Y      0.00    1023.9     999.8    9999.0       0.0      10.0      -5.6      -7.8      84.0      60.0
20140101   19     Y      0.00    1024.1     999.8    9999.0       0.0      10.0      -5.6      -8.3      81.0      70.0
20140101   20     Y      0.00    1024.0     999.8    9999.0       0.0      10.0      -6.1      -8.3      84.0      60.0
20140101   21     Y      0.00    1023.9     999.8    1099.0       0.0      99.0      -6.1      -8.3      84.0      70.0
20140101   22     Y      0.00    1023.4     999.1    9999.0       0.0      10.0      -6.1      -8.3      84.0      60.0
20140101   23     Y      0.00    1023.2     999.1    9999.0       0.0      10.0      -6.1      -8.3      84.0      50.0
20140101   24     Y      0.00    1022.5     998.5    9999.0       0.0      10.0      -6.1      -8.9      80.0      50.0
```

21DRF

Example ONSITE EXTRACT/QAOUT

```
*    AERMET Version  19191
*% ONSITE
*    DATA ARGONNE_15_MIN.DAT
*    QAOUT ARGONNE.OQA
*    XDATES 2013/01/01 2017/12/31
*@   LOCATION 99999 41.701N 87.995W 0 230.0
*$   READ 1 OSYR OSMO OSDY OSHR OSMN INSO NRAD DT01 PRES
*$   READ 2 HT01 TT01 WS01 WD01 SA01
*$   READ 3 HT02 TT02 WS02 WD02 SA02
*$   FORMAT 1 (5(I2),4(1X,F10.4))
*$   FORMAT 2 (11X,F4.1,4(1X,F10.4))
*$   FORMAT 3 (10X,F5.1,4(1X,F10.4))
*$   DELTA_TEMP 1 10.0 60.0
*$   OSHEIGHTS 10.0 60.0
*$   THRESHOLD 1.0
*    OBS/HOUR 4
*  OS     ON-SITE QUALITY ASSESSMENT
*** EOH: END OF ON-SITE QA HEADERS
13 1 1 1-9     0.0000    -8.8764    -0.4266  9972.5254
          40.0    -7.0316     2.8267   338.4550    20.0218
         240.0    -7.4581     5.2172   351.8875     9.2291
13 1 1 2-9     0.0000   -13.6030    -0.4114  9973.7754
          40.0    -7.3400     2.9517   337.7275    18.4186
         240.0    -7.7514     5.3213   351.0075     8.3045
13 1 1 3-9     0.0000   -24.1175    -0.3585  9975.2500
          40.0    -7.7251     2.3822   337.4700    17.9410
         240.0    -8.0837     4.4032   350.4400     8.6976
13 1 1 4-9     0.0000   -21.3805    -0.3842  9977.7002
          40.0    -8.0849     2.4359   330.7300    17.1271
         240.0    -8.4691     4.3486   345.2575     9.1784
```

21112

```
AERMET VERSION 19DRF
LOCATION 99999     41.701N     87.995W  0 230.000
FILE TYPE: QAOUT
THRESHOLD  0.000
DELTA_TEMP 1   10.000   60.000
DATES 2014 01 01 2014 01 01
DATE       HR     LEV        HTNN        INSO        NRAD        DT01        PRES        SANN        TTNN        WDNN        WSNN
20140101   01       1    10.00000     0.00000     0.49707    -0.39500  1001.05000    14.05437   -11.26800    33.28900     3.03500
20140101   01       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     8.23031   -11.66300    39.60500     4.60217
20140101   02       1    10.00000     0.00000     0.24835    -0.36800  1000.95000    14.24541   -10.98875    24.64050     2.73005
20140101   02       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     7.67013   -11.35675    31.47725     4.32705
20140101   03       1    10.00000     0.00000    -0.21615    -0.28600  1000.85000    13.16328   -10.77375    19.11500     2.31450
20140101   03       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     8.01353   -11.05975    26.37550     3.73682
20140101   04       1    10.00000     0.00000    -1.05878    -0.28025  1000.42500    13.28906   -10.58700    15.71275     2.41682
20140101   04       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     6.27646   -10.86725    24.68675     3.72897
20140101   05       1    10.00000     0.00000    -1.10423    -0.30090  1000.20000    12.68009    -9.88135    17.07475     2.41740
20140101   05       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     6.40961   -10.18225    27.42450     4.13760
20140101   06       1    10.00000     0.00000    -1.70067    -0.26465  1000.12500    16.79956    -8.85697    39.23350     2.61740
20140101   06       2    60.00000  9999.00000   999.00000     9.00000 99999.00000    14.21239    -9.12162    45.92925     4.26520
20140101   07       1    10.00000     0.00000    -2.80525    -0.30968  1000.22500    12.23456    -8.14152    48.68325     2.58803
20140101   07       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     8.23317    -8.45120    66.55050     4.60837
20140101   08       1    10.00000     5.01372    -1.62927    -0.51362  1000.22500    13.05035    -6.88670    65.28800     5.36320
20140101   08       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     8.58509    -7.40032    74.96900     7.71805
20140101   09       1    10.00000    24.51100     8.94332    -0.37235  1000.62500    12.76492    -6.71590    62.16425     5.70950
20140101   09       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     9.48199    -7.08825    71.11625     7.84557
20140101   10       1    10.00000    77.23600    36.43075    -0.32727  1001.15000    13.27201    -6.69533    56.95100     5.55373
20140101   10       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     9.06712    -7.02260    64.68825     7.83988
20140101   11       1    10.00000   181.40250    87.32950    -0.33800  1001.07500    14.02231    -6.44085    57.90775     6.35695
20140101   11       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     9.04043    -6.77885    66.93325     9.06235
20140101   12       1    10.00000   159.70500    75.20525    -0.29383  1000.60000    13.64304    -6.35150    57.98100     6.15785
20140101   12       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     8.18055    -6.64533    65.03875     8.86803
20140101   13       1    10.00000   158.38750    74.10575    -0.27400  1000.17750    15.02612    -6.40345    52.17000     5.92637
20140101   13       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     9.36428    -6.67745    58.72750     8.41387
20140101   14       1    10.00000   140.06750    65.06675    -0.27840   999.62250    14.13351    -6.37058    49.15750     6.09765
20140101   14       2    60.00000  9999.00000   999.00000     9.00000 99999.00000     8.93018    -6.64898    56.53975     9.04335
20140101   15       1    10.00000    68.06625    30.45950    -0.25453   999.42500    14.36972    -6.44093    44.63425     4.33098
```

21DRF

Changes to 21DRF control files

- For both stage 1 and stage 2, XDATES now REQUIRES a 4-digit year
  - XDATES 2020/01/01 2020/12/31
  - XDATES 2020/01/01 TO 2020/12/31
  - XDATES 2020 01 01 2020 12 31
- With exception of XDATES and new options (DEBUG, NOPRINT), current stage 1 control file will work as is
- New stage 2 file is a concatenation of current stage 2 and stage 3 control files
  - Remove old stage 3 JOB pathway/keywords
- New combined stage 1 and 2 control file is a concatenation of current stage 1 and 3 control files with ASOS1MIN from stage 2
  - Remove old stage 2 and stage 3 JOB pathway/keywords
- Overhaul will ignore the MERGE pathway keywords and DATA keyword in METPREP pathway
  - Users are urged however to remove MERGE pathway and keywords and DATA keyword in METPREP pathway

Stage 1 input file

```
job
  messages  test_st1.msg
  report    test_st1.rpt

upperair
  data      ua.txt  fsl
  extract   upper.iqa
  location  99999 35.00N 90.00 W  6
  xdates    2013/01/01  2017/12/31
  qaout     upper.oqa

surface
  data      airport.txt ishd
  extract   nws.iqa
  xdates    2013/01/01  2017/12/31
  location  location  99999 35.00N 90.00 W  6 123.
  qaout     nws.oqa
```

```
onsite
  data onsite_hourly.dat
  qaout onsite_hourly.oqa
  xdates 2013/01/01  2017/12/31
  location dates  99999 35.00N 90.00 W  0 123.

  read 1 osyr osmo osdy oshr inso pres
  read 2 ht01 tt01 ws01 wd01 sa01
  read 3 ht02 tt02 ws02 wd02 sa02

  format 1 (4(i2),2(1x,f10.4))
  format 2 (11x,f4.1,4(1x,f10.4))
  format 3 (11x,f4.1,4(1x,f10.4))

  threshold 0.1

  range sa 0 < 35 99
  range ws 0 <= 50 99
  range wd 0 <= 360 999
  range tt -30 < 40 99
  range rh 0 <= 100 999
  range inso 0 <= 1250 9999
  range nrad -100 < 800 999
  range pres 9000 < 10999 99999
  audit tt01 ws01 wd01 sa01 pres
```

Stage 2 input file

```
job
   messages  test_st2.msg
   report    test_st2.rpt
  debug debug_1.txt
  noprint

upperair
  qaout     upper.oqa

surface
  qaout     nws.oqa
 ASOS1MIN nws.dat

onsite
  qaout    onsite_hourly.oqa

MERGE
  OUTPUT test1.dat
```

New feature

Ignored

```
METPREP

  data test.dat
METHOD     REFLEVEL  SUBNWS
  METHOD     WIND_DIR  RANDOM


  XDATES 2013 01 01 2017 12 31
  nws_hgt   wind  10.0
  output    test.sfc
  profile   test.pfl
 AERSURF onsite_2014.txt 2013 2014
AERSURF2 nws_2014.txt 2013 2014

  AERSURF onsite_2015.txt 2015
  AERSURF2 nws_2015.txt 2015

  AERSURF onsite_2016.txt 2016
  AERSURF2 nws_2016.txt 2016

  AERSURF onsite_2017.txt 2017
  AERSURF2 nws_2017.txt 2017
```

Combined stage 1 and 2 control file

```
job
  messages  test_st1_st2.msg
  report    test_st1_st2.rpt
 debug debug_1.txt
upperair
 data      ua.txt  fsl
 extract   upper.iqa
 location  99999 35.00N 90.00 W  6
 xdates    2013/01/01  2017/12/31
 qaout     upper.oqa

surface
 data      airport.txt ishd
 extract   nws.iqa
 xdates    2013/01/01  2017/12/31
 location  lsh  99999 35.00N 90.00 W  6 123.
 qaout     nws.oqa
 ASOS1MIN nws.dat

onsite
 qaout    onsite.oqa
```

```
onsite
 data onsite_hourly.dat
 qaout onsite_hourly.oqa
 xdates 2013/01/01  2017/12/31
 location onsite. OQA  99999 35.00N 90.00 W  0 123.

 read 1 osyr osmo osdy oshr inso pres
 read 2 ht01 tt01 ws01 wd01 sa01
 read 3 ht02 tt02 ws02 wd02 sa02

 format 1 (4(i2),2(1x,f10.4))
 format 2 (11x,f4.1,4(1x,f10.4))
 format 3 (11x,f4.1,4(1x,f10.4))

 threshold 0.1

 range sa 0 < 35 99
 range ws 0 <= 50 99
 range wd 0 <= 360 999
 range tt -30 < 40 99
 range rh 0 <= 100 999
 range inso 0 <= 1250 9999
 range nrad -100 < 800 999
 range pres 9000 < 10999 99999
 audit tt01 ws01 wd01 sa01 pres
```

```
METPREP

 data test.dat
METHOD     REFLEVEL  SUBNWS
  METHOD     WIND_DIR  RANDOM


  XDATES 2013 01 01 2017 12 31
  nws_hgt   wind  10.0
  output    test.sfc
  profile   test.pfl
 AERSURF onsite_2014.txt 2013 2014
AERSURF2 nws_2014.txt 2013 2014

  AERSURF onsite_2015.txt 2015
  AERSURF2 nws_2015.txt 2015

  AERSURF onsite_2016.txt 2016
  AERSURF2 nws_2016.txt 2016

  AERSURF onsite_2017.txt 2017
  AERSURF2 nws_2017.txt 2017
```

Debug file

- Outputs some stage 1 processes
  - UPPERAIR calculations (speed shear, direction shear, lapse rate, dewpoint deviation)
  - SURFACE ISHD extraction (enhanced messaging about duplicate observations, special observations in MESSAGE file)
  - ONSITE sub-hourly averaging
- Stage 2 processing and PBL calculations
  - Target time for each day's sounding
  - Initial assignments of winds, temperatures, cloud cover, from ONSITE or SURFACE data
  - Stability assignment for each hour based on critical angle or Monin-Obukhov length
  - Inputs and calculations for variables (heat flux, w*, etc.)
  - Iterative processing steps for u* calculations and Bulk-Richardson calculations
  - Mechanical mixing height calculation
  - Iterative processing for convective mixing height calculations
- Use with care, could be large file and slows down AERMET processing

Debug file

```
STAGE 2 DEBUG PROCESSING START

     UPPER AIR SOUNDING WINDOW INFORMATION
     UPPER LON   MY_ZONE  MY_SOUNDING   WINDOW BEGIN     TARGET HOUR       WINDOW END
      -90.570     -6       12          11 ( -1)          12              13 (  1)

 ********************************************************************************
 DATE: 20130316


   LOCAL SUNRISE/SUNSET:  06:08:40 17:53:37
   UPPERAIR SUNRISE/SUNSET:  06:18:56 18:03:57

   SOUNDING WINDOW FOR 20130316
      BEGIN WINDOW DATE/HR    TARGET DATE/HR    ENDING WINDOW DATE/HR
        20130316 05           20130316 06       20130316 07

      READ_SOUND START

         SOUNDING DATE: 20130316 HR 06 SOUNDING #  2
         SOUNDING NOT EXTENDED

         HEIGHT    PRES     TEMP     THETA
          0.000  982.000  273.150  274.571
        330.000  942.000  270.850  275.513
        398.000  934.000  272.250  277.613
        480.000  925.000  272.450  278.587
        619.000  909.000  272.650  280.184
        698.000  900.000  273.550  281.909
       1157.000  850.000  270.850  283.723
       1213.000  844.000  273.150  286.712
       1241.000  841.000  273.550  287.424
       1308.000  834.000  273.750  288.321
       1356.000  829.000  273.950  289.028
       1661.000  798.000  274.150  292.406
       1793.000  785.000  274.950  294.638
       1886.000  776.000  275.150  295.826
       2169.000  749.000  272.850  296.336
       2450.000  723.000  272.450  298.904
       2713.000  700.000  270.850  299.905
       2999.000  675.000  268.650  300.576
       3247.000  654.000  268.050  302.625
       4295.000  571.000  261.050  306.375
       5301.000  500.000  252.250  307.493
```

```
HOUR 01

      WIND SPEED/DIRECTION/HT/SOURCE/Z0:    3.7  30.9  10.0 1   0.14300

      INITIAL ALBEDO/BOWEN RATIO:    0.17   0.45

      TEMPERATURE/HT/SOURCE: 274.5   10.0 1

      INITIAL CLOUD COVER/SOURCE: 10  2
       PRESS: USE ONSITE STATION PRESSURE:  978.3
STABILITY

      SOLAR ANGLE HOUR 24 DATE 20130316: -50.407
      SOLAR ANGLE HOUR 01 DATE 20130316: -48.257
      ANGLE: -49.332

      ANGLE < 0, ALBEDO SET TO 1.0

      ANGLE     CRIT ANGLE   STABILITY
     -49.332  <   94.000     STABLE
```

Overwater or land applications

- MMIF 4.0-Draft updated to output new hourly variables
  - Sensible heat and latent heat fluxes, u*, w*, θ lapse rate, Monin-Obukhov length, hourly varying zo, sky cover
    - Set AER_USE_NEW keyword to true in MMIF 4.0-draft control file
  - Standard variables still output as previous versions of MMIF
    - Winds, temperature, RH, insolation, precipitation, station pressure, delta-T between 2 m and next lowest level
  - These variables (new and existing) output for either land or water cells
    - New variables NOT compatible with AERMET 21112 and earlier
- MMIF outputs control file for PROG and METPREP (combined stage 1 and 2 run)
- New flag in AERMET associated with DATA keyword for PROG data
  - If blank or OL = overland
  - OW= overwater
  - OW cannot be used with ONSITE pathway; OL can
  - MMIF knows if overland or overwater

```
PROG
    DATA INPUT.DAT  OL
```

```
ONSITE
    DATA INPUT.DAT  OL
```

```
PROG
    DATA INPUT.DAT
```

```
ONSITE
    DATA INPUT.DAT
```

```
PROG
    DATA INPUT.DAT OW
```

```
ONSIT
    DA   INP   AT OW
```

Overwater or land applications

- If AERMET detects application is overwater
  - New PROG variables used instead of being calculated by AERMET
  - Monin-Obukhov length used to determine stability of the hour
    - L < 0: convective
    - L > 0: stable
    - Differs from standard AERMET approach of solar angle and critical angle
      - Angle < critical angle: stable (nighttime)
      - Angle > critical angle: convective (daytime)
    - This switch is needed so that AERMET calculates other variables correctly that depend on stability and use the new variables
    - Can have convective hours at night overwater

Overwater or land applications

- If AERMET detects application is overland
  - New PROG variables (except u* and sky cover) **are not used** and are calculated by AERMET
    - u* and sky cover have always been ONSITE variables
    - AERMET alerts user in both stage 1 and 2 that variables won't be used
  - Standard solar angle approach used to determine stability
    - Angle < critical angle: stable (nighttime)
    - Angle > critical angle: convective (daytime)

AERMET overwater option vs. AERCOARE

- AERCOARE with AERMOD is considered alternative model approach
  - AERMET is bypassed
  - AERMET is regulatory pre-processor for AERMOD but is geared toward overland applications
- MMIF 4.0-Draft output of new variables allows AERMET to use those variables and pass through to AERMOD
  - AERMET is not bypassed; not alternative model
  - New variables treated as other site-specific variables
    - W* and θ lapse rate calculated same as in AERMET
    - L uses virtual temperature and virtual flux; AERMET uses temperature and sensible heat flux
      - MMIF L may be more representative than AERMET L over water due to moisture effects
      - Typical NWS land observations may not have information need to calculate virtual temperature and heat flux
    - U* and sky cover already ONSITE variables
    - Hourly surface roughness more representative of varying conditions over the ocean

Evaluations

- Used AERMOD databases that are used for AERMOD update evaluations
- Ran AERMET 21112 and 21DRF and compared meteorological variables for non-adjusted u* and adjusted u* scenarios
- Ran AERMOD 21112 with both AERMET versions
- Ran Cox-Tikvart for selected databases
  - Martins Creek, Lovett, Westvaco, Kincaid, Bowline, Baldwin, and Clifty Creek
- Compared Robust Highest Concentration (RHC) for others
  - Tracy, DAEC, EOCR, Alaska, Indianapolis, AGA, Millston, Prairie Grass

Meteorological comparison summary

- Most variables and hours were within tolerances
- Most differences were precipitation code missing values or turbulence missing values
  - Both AERMET versions had missing values, just different
- Some hour 24 differences due to the hour 23-24 swap for NWS data
- Some differences in Monin-Obukhov length due to slight differences in solar angle leading to differences in θ* and L
- Mixing heights differ for Prairie Grass due to site-specific mixing heights not being smoothed in AERMET 21112 but smoothed in 21DRF
- See AERMET User's Guide Appendix F, Section F.1 for more details

AERMOD evaluations

- No statistically significant differences or differences were 0
- Even though meteorology varied, those hours may not have been hours of interest in RHC calculations
- See details in AERMET User's Guide Appendix F, Section F.2

Expected differences

- Expected differences between AERMET 21112 and AERMET 21DRF
  - Differences due to switch from real to double precision
    - Mostly Monin-Obukhov length, mixing heights
    - Sometimes an hour near sunrise or sunset may switch from convective to stable or vice-versa
  - Differences for missing value codes for precipitation code and turbulence (σ_θ and σ_w)
    - Both versions produce missing values, just different codes (AERMOD unaffected)
  - Differences in precipitation with site-specific data
    - AERMET 21112 does not reinitialize precipitation to 0 when reading a new day
    - Previous day's precipitation can carry over
    - Affects hours that have no data
    - Only affects AERMOD simulations using deposition

Expected differences (cont)

- Expected differences between AERMET 21112 and AERMET 21DRF
  - Difference in wind speeds for NWS ASOS variable wind observations
    - AERMET 21112 accounts for truncation; AERMET 21DRF does not
    - Does not affect AERMOD since wind direction is missing and hour is considered missing by AERMOD
  - Differences between hour 23-24, and possibly 01-02.
    - Removal of hour 23 to hour 24 swapping for missing NWS hour 24 observations in AERMET 21DRF
    - Removal of persistence substitution for hour 23 and 24 in AERMET 21DRF

Release

- Both AERMET 21DRF and MMIF 4.0 released for testing and evaluation purposes
  - Both versions are considered draft and are not to be used for regulatory applications
- 60-day comment period (February 7, 2022)
  - Testing and evaluation; check for bugs
  - Review user's guides and provide feedback
- Once comment period over, user feedback will be used to update both programs
- AERMET 21DRF will become regulatory version of AERMET in spring of 2022
- MMIF will become MMIF version to use for regulatory applications in spring of 2022
  - Update MMIF guidance for AERMOD applications

Links

- Main page: https://www.epa.gov/scram/draft-aermet
- AERMET 64-bit executable
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/draft_aermet/aermet_exe.zip
- AERMET 32-bit executable
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/draft_aermet/aermet_exe-32.zip
- AERMET transmittal memo
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/draft_aermet/AERMET_draft_trans_memo.pdf
- AERMET user's guide
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/draft_aermet/aermet_ug_21DRF.pdf
- AERMET Model Change Bulletin
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/draft_aermet/AERMET_MCB11_v21DRF.pdf
- AERMET test cases
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/met/draft_aermet/aermet_test_cases_21DRF.zip
- MMIF 4.0-draft code and executable
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/mmif/MMIF_4.0_Draft.zip
- MMIF 4.0-draft user's guide
  - https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/mmif/MMIF_4.0_Users_Guide.pdf

Important message

- If you downloaded the AERMET executables or AERMET source code before 5:00 PM EST Thursday December 9, 2021, please download again
- There was an issue with the links pointing to AERMET 21112
- You may need to refresh the page before downloading
- Other AERMET links (user's guide, transmittal memo, etc.) and MMIF 4.0-draft not affected

Contact

- AERMET
  - James Thurman thurman.james@epa.gov
- MMIF
  - Chris Misenis misenis.chris@epa.gov

Cape Hatteras, NC
10/22/21