AERMET

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The Planetary Boundary Layer (PBL)

- Surface Layer
  - 0 to 0.1 Z_i (mixing height)
  - Dominated by friction
  - M-O Similarity applies
- Mixed Layer
  - Capped by a stable layer aloft
  - Develops due to heating from below
  - Wind speed is constant with height

AERMET Science

- The Planetary Boundary Layer (PBL)
  - Convective Boundary Layer (CBL)
    - Driven by surface heating
    - Develops during the day
    - Moderate to strong vertical mixing
  - Stable Boundary Layer (SBL)
    - Driven by surface cooling
    - Develops at night
    - Little to no vertical mixing

AERMET Science

- Properties of the PBL affecting dispersion
  - vertical profiles of
    - Wind speed
    - Temperature
    - Vertical turbulence
    - Lateral turbulence
  - Depth of mixing

AERMET Science

- Surface Layer

- Similarity Theory
  - Applies in the surface layer
  - Important scaling parameters
    - Friction velocity fn (wind shear, z_0)
    - Convective velocity scale fn (H, Z_i, θ)
    - Monin-Obukhov length fn (H, u_*, θ)
    - Temperature Scale fn (H, u_*)
    - Mixing height

CBL Regimes

- Surface Layer
  - Depth 0 to 50 m
  - Dominated by friction
  - M-O similarity theory applies
  - Turbulence depends on roughness and M-O length
- Mixed Layer
  - Depth up to 3000 m
  - Wind speed is constant with height
  - Turbulence depends on convective velocity scale

CBL Characteristics

- Monin-Obukhov length < 0
- Depth increases during the day due to surface heating
- Shear and buoyancy contribute to turbulence
- Capped by a stable layer

Modeling the CBL

- Estimate the sensible heat flux using an energy balance approach
- Given the heat flux, calculate the friction velocity and M-O length using an iterative approach
- Determine the growth of the mixed layer by integrating heat flux over time

SBL Characteristics

- Monin-Obukhov length > 0
- Develops when surface begins to cool
- Turbulence is shear driven
- Turbulence decays with height
- Mixing is weak
- Problematic
  - Not as well understood as the CBL

Modeling the SBL

- Extension of CBL method for estimating friction velocity and M-O length problematic due to small negative heat flux.

- Alternative method uses the Bulk Richardson Number

Bulk Richardson Number

- Advantages
  - Does not require cloud cover
- Required measurements
  - Wind speed at one level in surface layer
  - Vertical Temperature gradient in the surface layer

Evaluation of Bulk Richardson Approach

- Problems were found with the approach used in AERMET 02222
- An evaluation was funded to resolve the problem
- Several alternative implementations were considered
- These were tested using the Kansas, Prairie Grass, and Cinder Cone Butte data bases

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Evaluation of Bulk Richardson Approach

8.1 IMPLEMENTATION AND EVALUATION OF BULK RICHARDSON NUMBER SCHEME IN AERMOD

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1. INTRODUCTION

The AERMOD dispersion model was designed to accept a wide range of site-specific meteorological measurements, including profiles of wind, temperature and turbulence data. However, the algorithm for estimating the heat flux under stable conditions requires a cloud cover measurement, which is not typically available from site-specific monitoring programs. For applications of AERMOD in remote settings, the non-representativeness of cloud cover measurements from the nearest airport may present an obstacle to the application of AERMOD. Concerns have also been raised regarding the representativeness of cloud cover measurements from Automated Surface Observing System (ASOS) installations due to limitations in the vertical range of the ceilometer (EPA, 1997).

An effort was made to resolve the issues associated with the current implementation of the Scheme in AERMET, and a revised version of the code was developed, referred to hereafter as version 02222R. However, once the initial issues with the current implementation were resolved, additional issues with the performance of the Scheme were encountered during tests with the Prairie Grass tracer field study data (Barad, 1958; Haugan, 1959). In particular, cases were encountered where the wind speed was initially above the critical wind speed, but fell below the critical wind speed during the iteration as the critical wind speed was adjusted. The current implementation in version 02222 assigns such cases as missing. In preliminary tests of the revised version (02222R), using the Prairie Grass data, the top three observed and predicted concentrations (based on cloud cover data) fell into this

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Evaluation of Bulk Richardson Approach

6. CONCLUSIONS

The modifications to the implementation of the Bulk Richardson Number Scheme in AERMET appear to have improved the performance of the AERMOD modeling system in relation to the current version of AERMET (dated 02222) based on comparisons of observed to predicted concentrations for the Prairie Grass and CCB tracer field studies. The revised BulkRi implementation produces results that are comparable to results based on the use of cloud cover data for both the Prairie Grass and CCB databases. The revised implementation also shows improved results relative to version 02222 when comparing observed to predicted wind speed and ΔT data. The modified Scheme based on the Prof_UNL method appears to provide a robust method for estimating boundary layer parameters under stable conditions when representative cloud cover data are not available, using a single wind speed measurement and a low-level ΔT.

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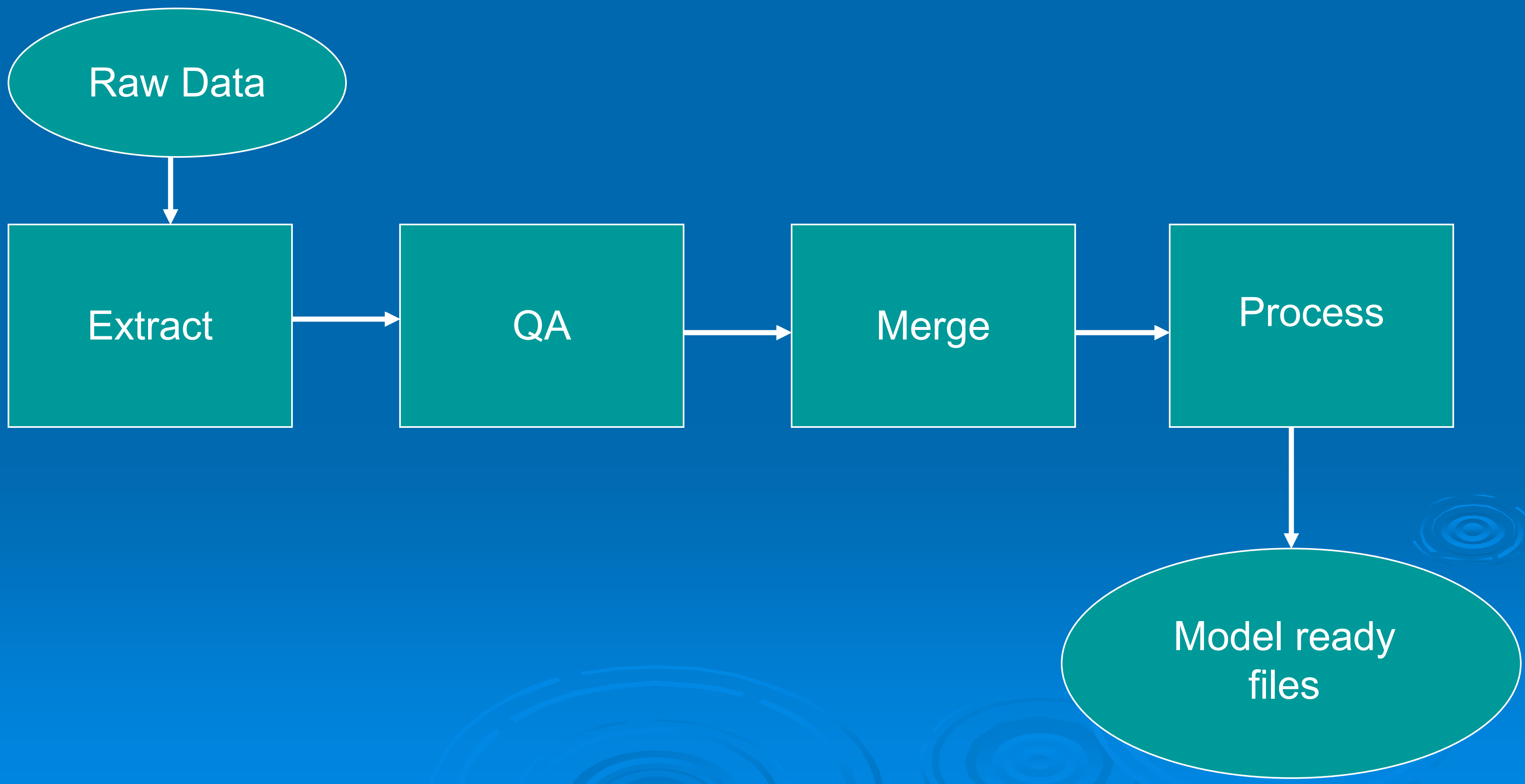
Process meteorological data for use in AERMOD



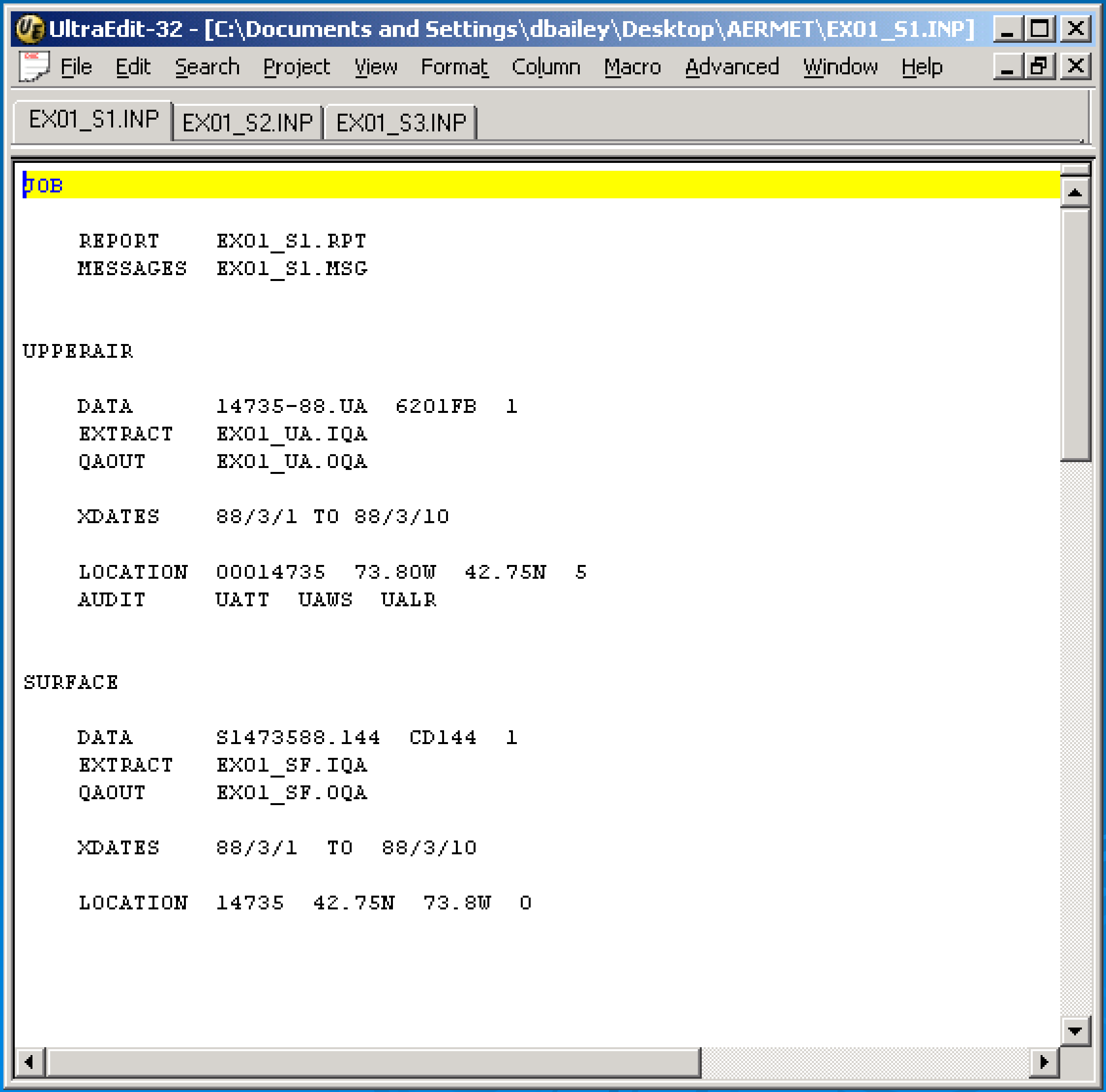
Surface Data

- Supported Formats
  - ***SAMSON***
  - CD 144
  - TD 3280
  - HUSWO
  - *TD 3505 (ISHD)*
  - *SCRAM*

Upper-Air Data

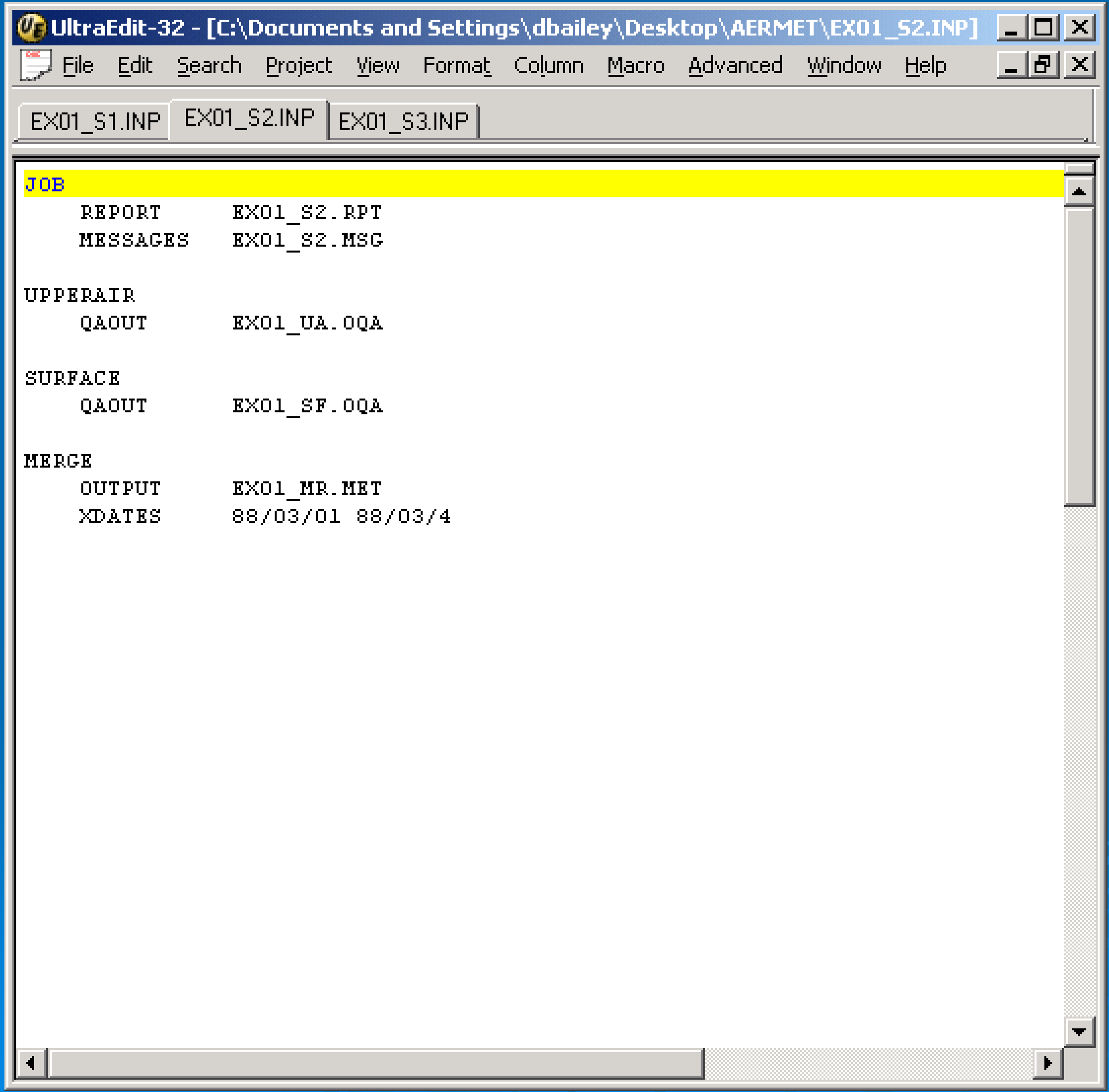
- Supported Formats
  - ***FSL***
  - TD 6201

Stage 1 Extract




```
JOB

    REPORT     EX01_S1.RPT
    MESSAGES   EX01_S1.MSG


UPPERAIR

    DATA       14735-88.UA   6201FB   1
    EXTRACT    EX01_UA.IQA
    QAOUT      EX01_UA.OQA

    XDATES     88/3/1 TO 88/3/10

    LOCATION   00014735   73.80W   42.75N   5
    AUDIT      UATT   UAWS   UALR


SURFACE

    DATA       S1473588.144   CD144   1
    EXTRACT    EX01_SF.IQA
    QAOUT      EX01_SF.OQA

    XDATES     88/3/1  TO  88/3/10

    LOCATION   14735  42.75N  73.8W  0
```

Stage 2 Merge




```
JOB
     REPORT       EX01_S2.RPT
     MESSAGES     EX01_S2.MSG

UPPERAIR
     QAOUT        EX01_UA.OQA

SURFACE
     QAOUT        EX01_SF.OQA

MERGE
     OUTPUT       EX01_MR.MET
     XDATES       88/03/01 88/03/4
```

Stage 3 Process for AERMOD

```
JOB
    REPORT     EX01_S3.RPT
    MESSAGES   EX01_S3.MSG

METPREP
    DATA       EX01_MR.MET

    OUTPUT     EX01_MP.SFC
    PROFILE    EX01_MP.PFL

    LOCATION   MYSITE 74.00W 41.3N 5

    METHOD     REFLEVEL  SUBNWS
    METHOD     WIND_DIR  RANDOM
    NWS_HGT    WIND      6.1
    FREQ_SECT  ANNUAL 1
    SECTOR     1    0      360
    SITE_CHAR  1 1  0.15  2.0  0.12
```

Audit Report Surface Data

UltraEdit-32 - [C:\Documents and Settings\dbailey\Desktop\AERMET\EX01_S1.RPT]

File Edit Search Project View Format Column Macro Advanced Window Help

```
SURFACE DATA         |------VIOLATION SUMMARY------|   |-----TEST VALUES-----|
              TOTAL     #      LOWER  UPPER     %       MISSING   LOWER   UPPER
              # OBS  MISSING   BOUND  BOUND  ACCEPTED    FLAG     BOUND   BOUND
      TMPD     240      0        0      0     100.00     999.0, -300.0,  360.0
      WDIR     240      0        0      0     100.00     999.0,    0.0,   36.0
      WSPD     240      0        0      0     100.00     999.0,    0.0,  500.0

NOTE: Test values were also multiplied by the same factors applied to the data
      (see Appendix B of the AERMET User's Guide)


       In addition, for the   240 hourly obs, AERMET reports that there are:

            20 CALM WIND CONDITIONS (WS=0, WD=0)
             0 ZERO WIND SPEEDS WITH NONZERO WIND DIRECTIONS
             0 DEW-POINT GREATER THAN DRY BULB TEMPERATURES

       The date & time of these occurrences can be found in
       the message file  EX01_S1.MSG
       with the qualifiers CLM, WDS, TDT (resp.)


    THIS CONCLUDES THE AUDIT TRAIL
```

Stage 2 Merge Report

UltraEdit-32 - [C:\Documents and Settings\dbailey\Desktop\AERMET\EX01_S2.RPT]

File Edit Search Project View Format Column Macro Advanced Window Help

```
5.   Merged Data
          Merge Output   -     OPEN:  EX01_MR.MET
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                  Version  04245

                      Data Processed on  9-SEP-04 at 10:52:59

                         Merging the Meteorological Data

                      Merged Data Begin (Yr/Mo/Da) 88/ 3/ 1
                                    End            88/ 3/ 4

                    ***** Daily Output Statistics *****
              MO/DA  3/ 1  3/ 2  3/ 3  3/ 4
NWS  Upper Air  Sdgs   2     2     2     2
NWS Sfc Observations  24    24    24    24
On-site Observations   0     0     0     0

     Upper Air Obs. Read:     9
     Surface Obs. Read:      98
     On-site Obs. Read:       0
```