

# WJBF TV Tower Meteorological Database for the ERAD Code-1993<sup>(U)</sup>

Westinghouse Savannah River Company  
Savannah River Site  
Aiken, SC 29808



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Prepared for the U.S. Department of Energy under Contract No. DE-AC09-89SR18035

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A. H. Weber



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# *Savannah River Site Meteorological Database for the ERAD Code (U)*

## **Executive Summary**

The Explosive Release Atmospheric Dispersion (ERAD) model (Boughton and DeLaurentis 1992) is a three-dimensional numerical model for simulating atmospheric transport and dispersion. The ERAD code is particularly adept at handling explosive releases into the atmosphere and is being used by the Materials and Accountability Department at the Savannah River Site (SRS) to provide risk estimates.

The Environmental Technology Section (ETS) was asked to provide meteorological data to be used for applying ERAD to some site facilities. The ERAD model requires a vertical profile of meteorological measurements. The 1993 data from the WJBF-TV tower has been processed and provided for this purpose. This document describes the steps taken to prepare and format the database.

## **ERAD Description**

The ERAD model is separated into two components: buoyant cloud rise and particle diffusion. Dynamics and thermodynamics of the gas cloud after detonation are insensitive to the presence of particles (i. e., particles are treated as passive tracers flowing freely within the buoyant cloud). The gaseous cloud is treated as a localized region within the atmosphere whose properties are embedded in the ambient flow. Specification of the wind field completes the scheme. Specification of boundary and initial conditions for the ERAD model requires three-dimensional meteorological data as a function of time.

## **Data Description**

Meteorological data from the WJBF-TV Tower for 1993 were selected as being most likely to satisfy the quality and completeness criteria requested by the customer. Data from WJBF-TV and the Central Climatology towers as well as radiosonde observations from the National Weather Service were also used to supplement data collected at the WJBF tower.

Temperature, wind speed, wind direction, relative humidity, pressure, and mixing height are needed to run the

ERAD model. The WJBF-TV tower has instrumentation to provide temperature, wind speed, and wind direction at seven different levels up to 304 m. Relative humidity and atmospheric pressure are available from the Central Climatology 60 m Tower in C Area. Mixing height is obtained from the National Climatic Data Center archives of National Weather Service data. (The National Weather Service deploys sounding balloons, called radiosondes, twice daily. Graphical procedures can be employed to determine mixing heights from these soundings.) The nearest representative radiosonde site around the Savannah River Site is in Athens, Georgia. Athens data for the 1993 mixing heights were obtained for use in the ERAD model.

The temperature, wind speed, and wind direction for seven levels up to 300 m are obtained from instrumentation on the WJBF-TV tower. This tower is located offsite near Beech Island, South Carolina, in a forested and mixed-use agricultural area. The temperature sensor accuracy is  $\pm 0.5^{\circ}\text{C}$ , the wind direction accuracy is  $\pm 3$  degrees, and the wind speed accuracy is  $\pm 10\%$  (Parker and Addis 1993).

The wind speed, direction, relative humidity, pressure, and temperature are obtained at the Central Climatology Site in N Area. The area surrounding the site contains grassy areas, a few trees, and storage yards. The wind data were measured at 2 m above the ground surface until May 1993 (since then collected at 4.5 meters above ground surface) in the center of a grass-covered field 120 meters<sup>2</sup>. The meteorological sensors are calibrated twice per year. The temperature sensor accuracy is  $\pm 0.5^{\circ}\text{C}$ , the dew point accuracy is  $\pm 1.5^{\circ}\text{C}$ , pressure accuracy is  $\pm 0.8$  mb, the wind direction accuracy is  $\pm 3$  degrees, and the wind speed accuracy is  $\pm 10\%$  (Kurzeja 1993). The pressure sensor at the Central Climatology site was out of service for several weeks during 1993. Missing pressure data were replaced by data from Bush Field in Augusta, approximately five miles away. These data were corrected for the difference in elevation.

All meteorological data collected with the WIND System computers (including the WJBF-TV and the Central Climatology towers) are digitized at 1.5 second intervals and averaged over fifteen-minute periods. After applying quality assurance procedures, blocks of two, three, or four 15-

minute data segments are combined to form one-hour averages and archived on permanent storage media. This database is maintained on permanent storage media and then processed and provided according to customer specifications. Wind speed and direction are provided as vector rather than scalar averages. The meteorological sensors are calibrated twice per year.

## Quality Assurance

Data transmitted from the WJBF-TV tower to the VAX-8550 computers in the Environmental Transport Group (ETG) are checked for proper voltage ranges prior to being accepted in the fifteen-minute archives mentioned earlier. Also, after checking the voltage range, each fifteen-minute block was required to have at least 400 data points or 10 minutes (67%) of valid data. Validity checks were performed by deleting data with the following characteristics:

- wind speed  $< 0.01$  m/s
- standard deviation of the wind azimuth angle  $< 0.01^\circ$
- $0.01^\circ\text{C} < \text{temperature} < 0.01^\circ\text{C}$

If both of the first two conditions above occur simultaneously then the wind direction is also set to zero. The third condition above eliminates missing temperature data. (Unfortunately, this check also eliminates a few cases of good data where the temperature is exactly equal to  $0.00^\circ\text{C}$ . No way to avoid this has been found; fortunately, a temperature of  $00.0^\circ\text{C}$  does not occur often at the Savannah River Site.)

Meteorological data collected at SRS is never a completely unbroken time series. Missing data segments are caused by instrument failure from lightning, heavy rain, hail, etc. Thunderstorms, especially during spring and summer, damage sensors so that for any particular time period one or more sensors may indicate missing or inconsistent data. Suspect and missing data periods are particularly likely to occur in WJBF-TV tower data since repair of that tower's sensors can only be carried out with the assistance of an outside contractor. Damaged tv-tower instruments remain in that condition until a subcontractor is authorized to remove the instruments from the tower and deliver them to the Environmental Transport Group for repair. Data were inspected by plotting the several levels simultaneously as a time series. Obviously erroneous data were removed from the database.

Two, three, or four fifteen-minute data blocks must be present in the same hour to qualify for inclusion in the one-hour time average. Otherwise the hour time period is marked as having missing data. One-hour averages of temperature, wind speed, and direction are also plotted and

inspected for outliers. Data values that are judged questionable during the visual inspection are deleted.

Replacement of bad or missing data or deleted data is possible if there are suitable instrumented towers or alternate measurements nearby. This is a time-intensive procedure that was not employed in this project because of budget considerations.

## Function of Code Modules and Their Application

Four computer code modules were constructed and invoked to build the database. These four modules accomplished data extraction, hour-averaging, quality assurance, and formatting functions. These codes were written with a pseudo fourth-generation computer language — SAS. The following section describes these modules and procedures in greater detail.

The extraction module was accomplished with EXTRACT.SAS, a code that uses embedded Structured Query Language (SQL) statements to select data from the appropriate tower, level, and time period from the archived RDB database maintained on ETG's VAX-8550 computer. The data that were extracted from ETG's RDB database, were written in a SAS (binary) data set form, and given the name TV\_93.PERM.SASEB\$DATA. This data set was saved for input into the second module.

Quality assurance criteria are invoked and hour-averages are computed in the second code module—HOUR\_AVE\_TV\_WINDS. This module determines hour-averages for all meteorological variables. The code reads from TV\_93.PERM.SASEB\$DATA, counts observations, fills in missing time periods with a special missing value symbol (a period .), and deletes time periods with less than 10 minutes of data. The second step in this same module uses the quality assurance criteria discussed above to eliminate questionable data before they are included in the one-hour averages.

One-hour averages of temperature are the easiest to produce since they consist of 2-4 fifteen-minute scalar values that can be summed and divided by the number of fifteen-minute time periods for the hour. Computing the mean transport speed is more complicated since a vector average is required. This vector average is found by averaging of the velocity vector components  $u$  and  $v$ . This is not the same quantity that is obtained by computing the scalar average of the wind speeds for the one-hour time period. (A simple example is when the wind blows from the north at 10 m/sec for 15 minutes and then blows from the south at the same speed for the next fifteen-minute time period.

The net movement of the air parcels following such a wind is zero, but the averaged dilution speed appropriate to use in a Gaussian dispersion model would be equal to 10 m/sec. This can be readily seen by imagining air traversing a stack release of smoke in the atmosphere.)

The wind direction must also be found using a vector average. (As a second example, envision a 20 m/s wind from the south followed by a 10 m/s wind from the north in two successive fifteen-minute periods. The scalar averaged direction would be zero, but the vector-averaged wind is from the south.) After following the proper procedures for scalar and vector averages one-hour averages are stored in a second permanent SAS data set TV\_93D(height of measurement)\_93.SASEB\$DATA.

The third computer module MERGE\_TV\_95\_SPEED(DIR,TEMP).SAS merges hour-averaged data for all levels of the TV tower and plots the data as a time series to enable visual quality assurance methods to be employed. This same program runs a second time after questionable data have been removed to ensure that no suspect data remain. The fourth step merges the hour-averaged data for all levels and creates the final SAS data sets (SPD, DIR, TMP)\_ALL.SASEB\$DATA. In the final program module, the data sets SPD, DIR, TMP)\_ALL.SASEB\$DATA are stored in ASCII formats specified by the customer. These formats are shown in the attached Appendix.

## Summary

A 1993 meteorological database required for the ERAD model has been provided as requested by the SRS Consequence Analysis Group. This report describes the data and the steps taken to quality assure the data. These data include temperature, wind speed, wind direction at seven

levels up to 304 m. Also included are relative humidity, pressure from measurements near the surface and mixing height measurements obtained from sounding balloons launched by the National Weather Service in Athens, Georgia.

Quality assurance was a prime consideration in providing the data and was invoked not only in the software but by visually inspecting the data. Unfortunately, substitution of surrogate observations for missing data was not in the scope of this work, and that is the biggest single omission with regard to these data.

A description of each code module and its application is contained here as well. Four computer codes were constructed and applied to construct the database. These four modules accomplish data extraction, hour-averaging, quality assurance, and data formatting functions.

## References

- Boughton, B. A., and J. M. DeLaurentis, 1992: *Description and Validation of ERAD: An Atmospheric Dispersion Model for High Explosive Detonations*, SAND92-2069, Sandia National Laboratories, Albuquerque, NM, 87185, p. 80.
- Kurzeja, R. J., 1993, *The Savannah River Technology Center Research and Development Climatology Center*, WSRC-TR-93-596, WSRC, SRTC, Aiken, SC, p. 36.
- Parker, M. J., and R. P. Addis, 1993, *Meteorological Monitoring Program at the Savannah River Site*, WSRC-TR-93-0106, WSRC, SRTC, Aiken, SC, 29808, p. 87.

## Appendix A

### Data Format For 1993 WJBF-TV Tower Meteorological Data

These computer files are described according to the variable names, formats, and units of measurement. All files were provided as ASCII (text) files for ease of interpretation.

#### Appendix A.1

**File name:**

MIX\_HT\_OUT.DAT

Nine fields per record

Year, Month, Day, Mix\_depa, Ave\_spda, Sf\_spda, Mix\_depp, Ave\_spdp, Sf\_spdp

**Where:**

Mix\_depa: is the mixing depth (m) determined from the morning (7:00 or 8:00 A.M. depending on standard or daylight savings time, respectively) rawinsonde sounding.

Ave\_spda: is the averaged wind speed (m/sec) in the mixed layer determined from the morning rawinsonde sounding. (Surface wind only if the mixing depth is less than 150 m.)

Sf\_spda: is the surface wind speed (m/sec) determined from the morning rawinsonde sounding.

Mix\_depp: is the mixing depth (m) determined from the afternoon (7:00 or 8:00 P.M. depending on standard or daylight savings time, respectively) rawinsonde sounding.

Ave\_spdp: is the averaged wind speed (m/sec) in the mixed layer determined from the afternoon rawinsonde sounding.

Sf\_spdp: is the surface wind speed (m/sec) determined from the afternoon rawinsonde sounding.

#### Appendix A.2

**File name:**

CLIMO\_OUT.DAT

Nine fields per record

Year, Month, Day, Hour, Ave\_spd, Ave\_dir, Ave\_temp, Ave\_rh, Ave\_press

**Where:**

Hour: is the UTC time (Z-time) at the beginning of the hour for which the hour-average was computed.

Ave\_spd: the one-hour-vector-averaged wind speed (m/sec) at 2 meters height or 4.5 m.

Ave\_dir: the one-hour-vector-averaged wind direction (degrees) at 2 meters height or 4.5 m.

Ave\_temp: the one-hour-averaged temperature (°C) at 2 meters height.

Ave\_rh: the one-hour-averaged relative humidity (%) at 2 meters height.

Ave\_press: the one-hour-averaged pressure (mb) at 2 meters height.

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## Appendix A.3

**File name:**

SPD\_OUT.DAT

Eleven fields per record

Year, Month, Day, Hour, Spd\_18, Spd\_36, Spd\_91, Spd\_137, Spd\_182, Spd\_243, Spd\_304

**Where:**

Hour is the UTC time (Z-time) of the beginning of the hour for which the hour-average was computed.

Spd\_18: the one-hour-vector-averaged wind speed (m/sec) at 18 meters height.

Spd\_36: the one-hour-vector-averaged wind speed (m/sec) at 36 meters height.

Spd\_91: the one-hour-vector-averaged wind speed (m/sec) at 91 meters height.

Spd\_137: the one-hour-vector-averaged wind speed (m/sec) at 137 meters height.

Spd\_182: the one-hour-vector-averaged wind speed (m/sec) at 182 meters height.

Spd\_243: the one-hour-vector-averaged wind speed (m/sec) at 243 meters height.

Spd\_304: the one-hour-vector-averaged wind speed (m/sec) at 304 meters height.

## Appendix A.4

**File name:**

DIR\_OUT.DAT

Eleven fields per record

Year, Month, Day, Hour, Dir\_18, Dir\_36, Dir\_91, Dir\_137, Dir\_182, Dir\_243, Dir\_304

**Where:**

Hour is the UTC time (Z-time) of the beginning of the hour for which the hour-average was computed.

Dir\_18: the one-hour-vector-averaged wind direction (degrees) at 18 meters height.

Dir\_36: the one-hour-vector-averaged wind direction (degrees) at 36 meters height.

Dir\_91: the one-hour-vector-averaged wind direction (degrees) at 91 meters height.

Dir\_137: the one-hour-vector-averaged wind direction (degrees) at 137 meters height.

Dir\_182: the one-hour-vector-averaged wind direction (degrees) at 182 meters height.

Dir\_243: the one-hour-vector-averaged wind direction (degrees) at 243 meters height.

Dir\_304: the one-hour-vector-averaged wind direction (degrees) at 304 meters height.

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## Appendix A.5

**File name:**

TEMP\_OUT.DAT

Eleven fields per record

Year, Month, Day, Hour, Tmp\_18, Tmp\_36, Tmp\_91, Tmp\_137, Tmp\_182, Tmp\_243, Tmp\_304

**Where:**

Hour is the UTC time (Z-time) of the beginning of the hour for which the hour-average was computed.

Tmp\_18: the one-hour-scalar-averaged temperature (°C) at 18 meters height.

Tmp\_36: the one-hour-scalar-averaged temperature (°C) at 36 meters height.

Tmp\_91: the one-hour-scalar-averaged temperature (°C) at 91 meters height.

Tmp\_137: the one-hour-scalar-averaged temperature (°C) at 137 meters height.

Tmp\_182: the one-hour-scalar-averaged temperature (°C) at 182 meters height.

Tmp\_243: the one-hour-scalar-averaged temperature (°C) at 243 meters height.

Tmp\_304: the one-hour-scalar-averaged temperature (°C) at 304 meters height.