November 4, 2011

The following files are available for the EPRI Kincaid Run Data Set:

Informational Files

KincaidDiscussion.pdf: This file [42KB]

Logic Behind Kincaid SF6-Arcs.pdf: This file describes why I was unsuccessful in combining the Developmental and Evaluation data sets and retain the subjective receptor placements used in the original investigations. I developed and used an objective scheme to place receptors along arcs that is nearly the same as that used in the original investigations. I also developed and used an objective scheme for assessing the quality of the SF6 for determination of the maximum concentration along an arc. [56.6MB]

UA5600format.txt: Explains Upper Air 5600 format [1.9KB]

KB50andKB51_SF6Data_Format.txt: Original archive format for SF6 concentration data values. [3KB]

KB52andKB53_SO2Data_Format.txt: Original archive format for SO2 concentration data values. [2KB]

Kincaid-SF6-SamplingSummary.dat: In the original investigations, the data was divided into two (2) data sets; one for model development and one for model evaluation. This file list in a table format the days included in Developmental and Evaluation data sets. [2.98KB]

Kincaid Suspect SF6 Arc-Max Values.pdf: I developed an objective scheme for assessing the quality of the sampling along the SF6 arcs. This file discusses the 13 cases where my assessment scheme determined the maximum SF6 concentration might be suspect. [89.3KB]

Kincaid-KB-47(SO2-Receptor-Coordinates).DAT: This file list the coordinates for the 30 SO2 receptors. [2.5KB]

Meteorological Data Files

KincaidNearSurfaceMetData11022011.dat: Hourly near-surface meteorological observations collected at the Kincaid plant site. [1.54MB]

KincaidTowerMetData09222011.dat: Hourly meteorological observations collected from the 100-m tower located near the Kincaid plant site. [894KB]

Kincaid-KB-89(NWS-UA5600).dat: US National Weather Service Upper Air data in 5600 format. Data begin February 24, 1980 and end June 30, 1981. Upper air balloon was released from Peoria, IL. [600KB]

| | NWS Hourly Surface Weather Data | | | |
|---|---|---|---|---|
| | 1980 | 1981 | Format | |
| Chicago.zip | W94846.h80 | W94846.h81 | W94846.txt | [407KB] |
| Moline.zip | W14923.h80 | W14923.h81 | W14923.txt | [407KB] |
| Peoria.zip | W14842.h80 | W14842.h81 | W14842.txt | [406KB] |
| Rockford.zip | W94822.h80 | W94822.h81 | W94822.txt | [460KB] |
| Springfield.zip | W93822.h80 | W93822.h81 | W93822.txt | [455KB] |
| StLouis.zip | W13994.h80 | W13994.h81 | W13994.txt | [404KB] |
| Evansville.zip | W93817.h80 | W93817.h81 | W93817.txt | [399KB] |
| Indianapolis.zip | W93819.h80 | W93819.h81 | W93819.txt | [408KB] |

SF6 Tracer Data Files

KincadSF611022011.dat: Detailed listing of SF6 concentration values at each receptor along an arc. There were 12 receptor arcs, but not all were active during each hour of sampling. In this file, the data values are listed separately for each receptor arc that was active during each hour. [6.6MB]

KincaidSF6Max.dat: A listing of the maximum SF6 concentration seen along each arc and the objective 'judgment' code of whether the maximum is likely well characterized by the sampling available. I have also included the QC index for the Development Data distributed in the Harmonization Model Validation Kit, but since I used a different scheme for assigning receptors to arcs, these QC index values are only useful for informational purposes. [256KB]

KincaidSF6-Arcs.pdf: This file displays the SF6 concentration values in a fashion similar to that employed by the original investigators. [388KB]

Kincaid-KB-50(SF6-Developmental).DAT: SF6 data for the Developmental data set, in the original format of the Kincaid data archive. [1.26MB]

Kincaid-KB-51(SF6-Evaluation).DAT: SF6 data for the Evaluation data set, in the original format of the Kincaid data archive. [910KB]

KincaidCombinedSF6-50and 51.dat: A spliced together version of the SF6 data for the Developmental and Evaluation data sets, in the original format of the Kincaid data archive. [1.85MB]

SO2 Data Files

KincadHOURLYSO211022011.dat: Listing of SO2 concentration values at each receptor for each hour. There were 30 receptors. [9.69MB]

Kincaid-KB-52(Hrly-SO2-Developmental).DAT: Hourly SO2 data for the Developmental data set, in the original format of the Kincaid data archive. [422KB]

Kincaid-KB-53(Hrly-SO2-Evaluation).DAT: Hourly SO2 data for the Evaluation data set, in the original format of the Kincaid data archive. [390KB]

KincaidCombinedSO2-52and 53.dat: Spliced together version of the hourly SO2 data for the Developmental and Evaluation data sets, in the original format of the Kincaid data archive. [811KB]

Hour convention:
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All hours refer to hour ending, local standard time (LST)

Site description:
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The Kincaid plant is surrounded by generally flat farmlands, and thus we have good reason to believe in horizontal homogeneity in meteorological conditions in the near-vicinity of the plant.

Construction of Data Archive
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One of the original purposes of the Electric Power Research Institute (EPRI) field studies of tall stack transport and diffusion was to establish data sets that could be used for evaluation of atmospheric transport and diffusion model performance.

As part of this effort, the data collected at Kincaid was divided into two independent data sets so that the data used to evaluate an air quality transport and diffusion model would be independent of that used to develop a model. Half of the data set was used for a model development program sponsored by EPRI and was called the Developmental data set. The other half of the data set was used to evaluate the Hybrid Plume Dispersion Model (HPDM), Hanna and Paine (1989), and was called the Evaluation data set.

The Developmental and Evaluation data have been merged together in this data archive.

Stack information:
---
Power Production: 1320 Megawatts

Location:
UTM-E (km):  285.597
UTM-N (km):  4385.088
Lat. (deg):  39.5906 N
Long. (deg):  89.4967 W
UTM Coordinates determined using Clarke 1866 (NAD27)
http://www.rcn.montana.edu/resources/tools/coordinates.aspx?nav=11&c=DMS&md=83&mdt=NAD83/WGS84&latd=36&latm=1&lats=16.1&lath=N&lond=84&lonm=9&lons=23.04&lonh=W

Stack height(m): 187

Stack base elevation:
183.2 m

Stack height:
187 m

Stack inner diameter:
9 m

Source Measurements
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A 10-second polling rate was made of stack gas emissions, plus stack temperature at the 137-meter (450-foot) level of the stack. As a backup procedure, the SO2 emission rate, exit velocity, and temperature were also calculated from plant operating information, daily fuel consumption data, hourly electrical load data, and daily coal analyses. All 10-second data were converted and packaged as 5-minute averages, and these 5-minute averages were then used to construct 1-hour values. Because the stack gas velocity probe was, not operational, one-hour average values of stack velocity were calculated from plant operating data.

SF6 Tracer Monitoring Network
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A network of approximately 1500 potential tracer sampling locations was used at the Kincaid site. The network design consisted of concentric circles at average radial distances of 0.5, 1, 2, 3, 5, 7, 10, 15, 20, 30, 40, and 50 km from the power plant. Using the existing roadway network, the downwind distance of the samplers assigned to an arc varied as much as 20 percent of the mean distance. The monitors on the arcs were spaced at azimuthal intervals ranging from $2^{o}$ to $8^{o}$. Pulsed pump grab samplers, with a 2-second pulse every 20 seconds, were used to produce a 1-hour integrated sample.

Tracer tests generally lasted six to nine hours. During this period, SF6 tracer gas was injected continuously into the ductwork of the 187-m stack. During each test approximately 200 sampling sites located on five to seven of the arcs in a sector ranging from $90^{o}$ to $180^{o}$ of arc, were operating. The sampling array was chosen on the basis of the expected meteorological conditions and remained fixed during any given test period.

SF6 tracer data are available for two collection periods:
April 20 1980 through August 29 1980, and
May 9 1981 through June 1 1981.

SUMMARY OF SF6 SAMPLING

SF6 DEVELOPMENTAL DATA SET
NUMBER OF DAYS: 29 NUMBER OF HOURS: 197

| | Key1.....Key24 | | |
|---|---|---|---|
| | 111111111122222 | | |
| MMDDYY | 123456789012345678901234 | NUM | YYJJJ |
| 42080 | 000000000000011100000000 | 140 | 80111 |
| 42580 | 000000000001111110000000 | 145 | 80116 |
| 43080 | 000000000000000011100000 | 115 | 80121 |
| 50180 | 000000000000000111111000 | 111 | 80122 |
| 50280 | 000000000000000110000000 | 151 | 80123 |
| 50480 | 000000111111000000000000 | 142 | 80125 |
| 50580 | 000001111111000000000000 | 176 | 80126 |
| 50780 | 000000000111111111000000 | 173 | 80128 |
| 50980 | 000000000011111100000000 | 166 | 80130 |
| 71080 | 000000000000111111000000 | 156 | 80192 |
| 71180 | 000000000111111111000000 | 155 | 80193 |
| 71380 | 000000000111111111000000 | 162 | 80195 |
| 72080 | 011111111100000000000000 | 145 | 80202 |
| 72180 | 000000000000111100000000 | 154 | 80203 |
| 72280 | 000000000111111111000000 | 151 | 80204 |
| 72480 | 000000011111111100000000 | 148 | 80206 |
| 72580 | 000000000000001111111000 | 160 | 80207 |
| 72680 | 000000000000111000000000 | 145 | 80208 |
| 50981 | 000000000011100000000000 | 157 | 81129 |
| 51681 | 000011111111100000000000 | 175 | 81136 |
| 51781 | 000000000111000000000000 | 179 | 81137 |
| 52281 | 000000001111111110000000 | 187 | 81142 |
| 52381 | 000000000111111111000000 | 181 | 81143 |
| 52481 | 000000000000001111111110 | 185 | 81144 |
| 52581 | 000000000000011111100000 | 176 | 81145 |
| 52881 | 000000000111111111000000 | 179 | 81148 |
| 52981 | 000000000111111111000000 | 174 | 81149 |
| 53181 | 000011111111100000000000 | 201 | 81151 |
| 60181 | 000011111111100000000000 | 185 | 81152 |

SF6 EVALUATION DATA SET
NUMBER OF DAYS: 21 NUMBER OF HOURS: 175

| | Key1.....Key24 | | |
|---|---|---|---|
| | 111111111122222 | | |
| MMDDYY | 123456789012345678901234 | NUM | YYJJJ |
| 42280 | 000000000001111110000000 | 158 | 80113 |
| 42480 | 000000000011111111100000 | 164 | 80115 |
| 42780 | 000000000011111111100000 | 179 | 80118 |
| 42880 | 000000000000001111111000 | 133 | 80119 |
| 50680 | 000000000111111000000000 | 157 | 80127 |
| 50880 | 000000000111111111000000 | 166 | 80129 |
| 51080 | 000000000011111100000000 | 124 | 80131 |

| | | | |
|---|---|---|---|
| 70980 | 000000000111111111000000 | 165 | 80191 |
| 71280 | 000000000111111111000000 | 156 | 80194 |
| 71480 | 000000011111111100000000 | 180 | 80196 |
| 71580 | 000000000111111111000000 | 167 | 80197 |
| 71780 | 000000000000001111111110 | 148 | 80199 |
| 71980 | 011111111100000000000000 | 152 | 80201 |
| 72380 | 000000001111111110000000 | 144 | 80205 |
| 72780 | 000000000111111111000000 | 159 | 80209 |
| 72880 | 000000000111111111000000 | 162 | 80210 |
| 72980 | 000000000111111000000000 | 155 | 80211 |
| 51281 | 000000000111111111000000 | 163 | 81132 |
| 51381 | 000000000111111111000000 | 179 | 81133 |
| 51581 | 000011111111100000000000 | 189 | 81135 |
| 52781 | 000000000111111111000000 | 171 | 81147 |

MM = MONTH
DD = DAY OF MONTH
YY = YEAR
KEY1..KEY24: 0=NO SAMPLING THIS HOUR
1=SAMPLING OCCURRED THIS HOUR
NUM = NUMBER OF RECEPTORS
JJJ = JULIAN DAY NUMBER

SF6 Quality Codes
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Harmonization QC Index

In 1991, a European initiative was launched for increased cooperation and standardization of atmospheric dispersion models for regulatory purposes. Conferences are held approximately every 18 months. As part of this initiative a Model Validation Kit was developed starting in 1993. Currently, the kit contains four field data sets as well as software for model evaluation.

In developing this kit, it was decided to only report the maximum SF6 concentration value seen along each sampling arc. Subjective Quality Codes (QC) were assigned to each maximum SF6 concentration as to how confident they were that a true maximum was seen.

Since only the Kincaid Developmental data set is included in the Model Validation Kit, we currently only have QC codes for this half of the Kincaid SF6 data archive.

Note: values are only available for Developmental Data set, and my objective placement of receptors along arcs differs in some cases with the subjective placement used in defining arcs by Dr. Steve Hanna and Dr. Joseph Chang for the Developmental Data set, hence, I do not recommend use of these QC index values.

0 This observed maximum concentration should clearly be disregarded.
1 This observed maximum concentration is most probably not the maximum value.
2 An observed maximum concentration is identified, but the true value may be slightly different.
3 A relatively well-defined maximum concentration is observed.

Judgment QC Code

Objective quality (judgment) code John Irwin developed for this listing of the entire set of SF6 concentrations sampled during the EPRI Kincaid field study, where objective criteria were used to place receptors along arcs. For discussion of -2 and -3 Arc-max values,see, 'Logic Behind Kincaid SF6-Arcs.pdf', and 'Kincaid Suspect SF6 Arc-Max Values.pdf'.

0 Number of nonzero concentration values is two (2) or less.
1 Number of nonzero concentration values is three (3) to four (4), deemed too few to use.
2 At least five nonzero concentration values, but observed maximum is not in the middle portion of the sampling array along the arc.
3 At least five nonzero concentration values, and observed maximum is within the middle portion of the sampling array along the arc.
-2 Meets criteria listed for "2", but difference between nearby concentration values and observed maximum looks suspicious.
-3 Meets criteria listed for "3", but difference between nearby concentration values and observed maximum looks suspicious.

Meteorological Measurements:

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The location of the 'Central Station' where most of the meteorological observations were performed, including the 100-m and 10-m meteorological towers, was: Easting 286.30 km Northing 4385.169 km Elevation 183 m. This places the site at 645 m East of the Kincaid stack. Routine weather observations were also obtained at this site. The site was situated in fallow fields away from major obstructions.

A Doppler acoustic sounder was operated at a separate location (Site S) in an area free from extraneous noise.

A 10-second polling rate was used for data acquisition at the air quality monitoring instruments, the stack emissions monitors, and most of the meteorological sensors. All 10-second data were converted and packaged as 5-minute averages, and these 5-minute averages were then used to construct 1-hour values. The acoustic sounder recorded 15-minute averages of mixing depth and wind speed components (uvw every 30 meters up to 600 meters).

| Location | Measurement Height | Frequency | Equipment |
|---|---|---|---|
| 100-m Tower | | | |
| Wind Direction | 10, 30, 50, 100 m | 10-sec | Teledyne Geotech 15658 |
| Wind Speed | 10, 30, 50, 100 m | 10-sec | Teledyne Geotech 15648 |
| Temperature, ΔT | 10-50 m, 50-100 m | 10-sec | Teledyne Geotech T-200 |
| Dewpoint | 100 m | 10-sec | Teledyne Geotech 00-200 |
| 10-m Tower | | | |
| Temperature, ΔT | 2-10 m | 10-sec | Teledyne Geotech T-200 |
| Central Station | | | |
| Atmos. Pressure | 1 m | Hourly | Teledyne Geotech 5P-200 |
| Net Radiation | 1 m | 10-sec | Science Associates 622-1 |
| Solar Radiation | 1 m | 10-sec | Eppley NIP |
| Sky Radiation | 1 m | 10-sec | Eppley 8-48 |
| Acoustic Sounder | | | |
| Mixing Height | 1 m | 15-min | Acoustic Sounder |

NWS METEOROLOGICAL STATIONS

When the Kincaid SF6 data were first analyzed, only the Springfield, IL NWS station observations were used. In constructing this data archive it was decided to provide observations from several other NWS stations that are in the vicinity of the Kincaid site.

The data provided here was obtained from
http://www.epa.gov/ceampubl/tools/metdata/index.html
The data represents a unique blending from four sources.

#1. Solar and Meteorological Surface Observation Network (SAMSON) 1961-1990 data sets, Version 1.0, Sep 1993

#2. National Solar Radiation Data base (NSRDB) version 1.1; NSRDB Hourly Data Files Text files downloaded from http://rredc.nrel.gov/solar/old_data/nsrdb/ -- provided updated radiation parameters.

#3. EarthInfo NCDC Summary of the Day and Surface Airways, 2001 -- provided daily and hourly values for precipitation, and daily evaporation. Missing evaporation was calculated using the Kohler-Nordenson- Fox Class-A Evaporation Pan version of the Penman- Monteith equations.

#4. Evapotranspiration (Et0) formulae based on: Crop Evapotranspiration - Guidelines for Computing Crop water requirements. FAO Irrigation and Drainage Paper 56 by Richard G. Allen, Luis S. Pereira, Dirk Raes, and Martin Smith. Water Resources, Development and Management Service, FAO - Food and Agriculture Organization of the United Nations, Rome, 1998. ISBN 92-5-104219-5. This book may be found online at http://www.fao.org/docrep/X0490E/x0490e00.htm

| NWS Station | Latitude | Longitude | Elevation MSL (m) | Approximate Distance From Stack (km) |
|---|---|---|---|---|
| Chicago, IL | 42.00 N | 87.88 W | 201 | 322 |
| Moline, IL | 41.45 N | 90.50 W | 177 | 113 |
| Peoria, IL | 40.67 N | 89.68 W | 198 | 122 |
| Rockford, IL | 42.20 N | 89.10 W | 221 | 293 |
| Springfield, IL | 39.85 N | 89.68 W | 179 | 35 |
| St. Louis, MO | 38.75 N | 90.37 W | 173 | 135 |
| Evansville, IN | 38.05 N | 87.53 W | 116 | 277 |
| Indianapolis, IN | 39.73 N | 86.27 W | 241 | 359 |

NWS RADIOSONDE
The radiosonde data comes from the station in Peoria
273.20 4505.00 199 m
Thus, the radiosonde station is 119.9 km north of the source.

Site characteristics used in the 1987/88 HPDM project:
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The values of Monin-Obukhov length, friction velocity and mixing height are provided for information purposes. It is suggested that one might do better to compute new values using currently accepted practices.

The procedure used to estimate values for the Monin-Obukhov length, surface friction velocity and mixing height are described in Hanna and Paine (1989). Estimates were made for 'average moisture conditions' and 'dry conditions'. The monthly values for surface roughness length, albedo and Bowen ratio used in these computations are listed below.

Average Moisture Conditions
Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 46 - 60 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.05 | 0.05 |
| 0.33 | 0.29 | 0.24 | 0.12 | 0.10 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.22 | 0.30 |
| 0.55 | 0.55 | 0.30 | 0.40 | 0.40 | 0.30 | 1.10 | 1.10 | 0.50 | 0.55 | 0.55 | 0.55 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 61 - 120 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.09 | 0.09 | 0.09 | 0.09 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.09 | 0.09 |
| 0.56 | 0.50 | 0.40 | 0.17 | 0.14 | 0.16 | 0.21 | 0.21 | 0.21 | 0.21 | 0.36 | 0.50 |
| 0.91 | 0.91 | 0.46 | 0.64 | 0.64 | 0.46 | 1.81 | 1.81 | 0.82 | 0.91 | 0.91 | 0.91 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 121 - 250 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.10 | 0.10 | 0.10 | 0.10 | 0.12 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.10 | 0.10 |
| 0.61 | 0.54 | 0.44 | 0.19 | 0.16 | 0.18 | 0.23 | 0.23 | 0.23 | 0.23 | 0.40 | 0.56 |
| 1.00 | 1.00 | 0.50 | 0.70 | 0.70 | 0.50 | 2.00 | 2.00 | 0.90 | 1.00 | 1.00 | 1.00 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 251 - 45 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.09 | 0.09 | 0.09 | 0.09 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.09 | 0.09 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.56 | 0.50 | 0.40 | 0.17 | 0.14 | 0.16 | 0.21 | 0.21 | 0.21 | 0.21 | 0.36 | 0.50 |
| 0.91 | 0.91 | 0.46 | 0.64 | 0.64 | 0.46 | 1.81 | 1.81 | 0.82 | 0.91 | 0.91 | 0.91 |

Dry Conditions

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 46 - 60 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.05 | 0.05 |
| 0.33 | 0.29 | 0.24 | 0.12 | 0.10 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.22 | 0.30 |
| 0.55 | 0.55 | 0.30 | 1.05 | 1.05 | 1.05 | 2.05 | 2.05 | 0.50 | 0.55 | 0.55 | 0.55 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 61 - 120 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.09 | 0.09 | 0.09 | 0.09 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.09 | 0.09 |
| 0.56 | 0.50 | 0.40 | 0.17 | 0.14 | 0.16 | 0.21 | 0.21 | 0.21 | 0.21 | 0.36 | 0.50 |
| 0.91 | 0.91 | 0.46 | 1.81 | 1.81 | 1.81 | 3.61 | 3.61 | 0.82 | 0.91 | 0.91 | 0.91 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 121 - 250 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.10 | 0.10 | 0.10 | 0.10 | 0.12 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.10 | 0.10 |
| 0.61 | 0.54 | 0.44 | 0.19 | 0.16 | 0.18 | 0.23 | 0.23 | 0.23 | 0.23 | 0.40 | 0.56 |
| 1.00 | 1.00 | 0.50 | 2.00 | 2.00 | 2.00 | 4.00 | 4.00 | 0.90 | 1.00 | 1.00 | 1.00 |

Monthly values of surface roughness (m, line 1), albedo (line 2), and Bowen ratio (line 3) for the 251 - 45 deg wind direction sector:

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.09 | 0.09 | 0.09 | 0.09 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.09 | 0.09 |
| 0.56 | 0.50 | 0.40 | 0.17 | 0.14 | 0.16 | 0.21 | 0.21 | 0.21 | 0.21 | 0.36 | 0.50 |
| 0.91 | 0.91 | 0.46 | 1.81 | 1.81 | 1.81 | 3.61 | 3.61 | 0.82 | 0.91 | 0.91 | 0.91 |

References

Hanna, S.R., and Paine, R.J., (1989): Hybrid plume dispersion model (HPDM) development and evaluation. J. Of Applied Meteorology. (28):206-224.