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Volume II

# by

Steven R. Hanna, David G. Strimaitis Joseph C. Chang and Sharon M. McCarthy

> Sigma Research Corporation 234 Littleton Road, Suite 2E Westford, Massachusetts 01886

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# REPRESENTATIVENESS OF WIND MEASUREMENTS ON A MESOSCALE GRID WITH STATION SEPARATIONS OF 312m TO 10000m

To Appear in Boundary Layer Meteorology

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Representativeness of Wind Measurements on a Mesoscale Grid with Station Separations of 312m to 10000m

by

Steven R. Hanna and Joseph C. Chang Sigma Research Corp., 234 Littleton Road, Suite 2E, Westford, MA 01886

#### Abstract

A field experiment was carried out in which wind speed and direction were measured over flat terrain at a height of 10 m using 13 identical instruments spaced logarithmically along two perpendicular 10 km lines. Station separations ranged from 312 m to 1000 m. One-minute data from 11 sampling periods of duration 6 to 10 hours were studied.

The statistics showed little dependence on whether the line of instruments was oriented along the wind or across the wind, or whether wind speeds or wind directions were being analyzed. The integral time scale derived from the variation of the single station variances with averaging time was found to equal several minutes. The correlation coefficients between two stations separated by distance  $\Delta x$  were found to vary exponentially with  $\Delta x$ , with an integral distance scale on the order of 1 km. At a station separation of 10 km, the correlation coefficient equals 0.24, 0.37, and 0.47 for averaging times of 1, 10, and 60 minutes respectively. These correlation coefficients correspond to root-mean-square differences in wind speed at the two stations of about 1.2, 1.1, and 1.0 m/s respectively.

Empirical equations based on dimensional analysis are suggested for fitting these observations. It is found that the observations are best fit if two independent integral time scales are used - a boundary-layer time scale about 300s that best applies to small averaging times or small separations and a mesoscale time scale of about 1800s that applies to larger averaging times or large separations.

#### 1. Objectives

In order to solve most atmospheric transport and dispersion problems, it is necessary to assume that the wind measurements at one site represent the wind flow at a nearby site. The separation between these two sites can range from 10 m to 100 km. This assumption is sometimes quite good, but situations often occur where wind direction observations differ by 180° between two towers in the same mesoscale network. There are a few limited studies of wind variability over mesoscale distances (e.g. Perry et al. (1978), Lockhart and Irwin (1980), Hanna (1982), and Panofsky and Dutton (1984)), but there is much more theoretical and observational work needed.

This study is part of a comprehensive research program in which the contributions of meteorological uncertainties to errors in air quality modeling and source emission estimation are being investigated. A cooperative two week field experiment was conducted in which 13 wind instruments were set up along an "L-shaped" pattern with maximum station separation of 10 km. Variances and spatial correlations of wind speeds and directions are calculated, with the objective being the development of simplified empirical/theoretical formulas. The accuracy of these simplified formulas is calculated and suggestions made for using these formulas in more generalized mesoscale settings. Finally, the formulas were tested with independent data from a wind study at Dugway Proving Ground.

#### 2. Previous Studies of Mesoscale Wind Variability

The literature contains two types of studies of mesoscale wind variability. Both employ near-surface wind observations made by two or more wind monitors with separations of 10 m to 100 km. In the first type of study, the variances for a variety of wind monitor separations are calculated and presented, and a very simple empirical formula is suggested (e.g., Lockhart and Irwin (1980) and Hanna (1982)). In the second type of study, theoretical formulas based on spectral analyses are applied to the problem (e.g., Pielke and Panofsky (1970), Perry et al. (1978) and Panofsky and Dutton (1984)). Reviews of these two types of studies are given below.

Empirical Studies of St. Louis Data. During the St. Louis Regional Air Pollution Study (RAPS), hourly-averaged wind observations were recorded for one year from a network of twenty-five wind monitors. The separation of the wind monitors ranged from 3 km to 80 km. Lockhart and Irwin (1980) and Hanna (1982) report calculations of the standard deviation,  $\sigma$ , of the difference in wind speed, u, and wind direction,  $\theta$ , for concurrent measurements between each pair of stations. For example, the following procedure is used to calculate  $\sigma_{(u_a-u_b)}$  for any pair of stations, a and b, over the entire sampling period:

$$\sigma^{2}(u_{a} - u_{b}) = \frac{\sum_{i=1}^{N} (u_{a}' - u_{b}')^{2}}{N}$$
(A-1)

where the primes indicate deviations from the average speed at each station and N is the total number of time periods being analyzed. As the separation distance between the stations decreases, this standard deviation should asymptotically approach the standard deviation due to instrument errors for two co-located wind monitors. Lockhart and Irwin (1980) suggested the

regression formulas:

$$\sigma_{(\theta_{a}-\theta_{b})} = 15 + 5.7 \ln x$$
(A-2)  
$$\sigma_{(u_{a}-u_{b})} = 0.47 + 0.24 \ln x$$
(A-3)

where x is in km,  $\theta$  is in degrees, and u is in m/s. The median value of  $\sigma_{\left(\theta_{a}-\theta_{b}\right)}$  is about 33° and  $\sigma_{\left(u_{a}-u_{b}\right)}$  is about 1.2 m/s, at a median separation distance of about 20 km. The standard deviations of the points scattered about equations (A-2) and (A-3) are 0.16 m/s and 4°, respectively.

Hanna (1982) reported an analysis by Nappo of the same set of RAPS wind data, emphasizing the dependence of the standard deviations of the wind differences upon wind speed. Nappo defined the spatial standard deviations,  $\sigma_{\Delta u}$  and  $\sigma_{\Delta \theta}$  using the set of concurrent measurements at the 25 monitoring stations. For example, the following procedure is used to calculate  $\sigma_{\Delta u}^2$  for any given hour:

$$\sigma_{\Delta u}^{2} = \frac{\sum_{i=1}^{24} \sum_{n=i+1}^{25} (u'_{i} - u'_{n})^{2}}{24!}$$

where the prime indicates a deviation from the overall average speed for the 25 stations. The magnitude of the spatial standard deviation,  $\sigma_{\Delta u}$  is expected to be somewhat larger than that calculated from equation (A-2), since the differences in the means among the stations are included in equation (A-4). It was found that the differences in wind speed and direction among the stations increase by a factor of three or four as wind speed decreases from 5.0 m/s to about 1.5 m/s. At higher wind speeds (~10 m/s), asymptotic limits of about 5° for  $\sigma_{\theta}$  and about 0.15 for  $\sigma_{u}$ /u are evident. The following empirical formulas fit these data:

$$\sigma_{AA} = (5^{\circ})^{2} + (60^{\circ}/u)^{2}$$
 (A-5)

$$(\sigma_{\Delta u}/u)^2 = (0.15)^2 + (0.6/u)^2$$

where u is in m/s and  $\sigma_{\alpha}$  is in degrees.

#### Theoretical Analyses of Spatial Structure

Panofsky and Dutton (1984, Chapter 9) discuss the technical issues related to the differences in wind velocities measured at two points. They look at the problem from the point of view of the spectrum of sizes of turbulent eddies. They make a distinction between vertical separations,  $\Delta z$ , lateral (cross-wind) separations,  $\Delta y$ , and longitudinal (along-wind) separations,  $\Delta x$ , between the locations of the measurements. Because turbulent eddies tend to maintain their identities as they travel with the wind, at a given separation the along-wind correlations in wind velocities between the measurement stations should be larger than the vertical or cross-wind correlations.

(A-4)

(A-6)

These authors ilso point out that most of the correlation between wind velocities at two points is due to larger turbulent eddies, with dimensions approximately equal to or larger than the separation between the points. By the same argument, the wind fluctuations in small eddies at one point are uncorrelated with the wind fluctuations ir the same size of eddies at a distant point.

Because of the fact that the larger eddies move with the wind flow and slowly change with time, the maximum correlation between two time series of wind velocities at two points separated by an along-wind distance,  $\Delta x$ , may occur at a time lag of about  $\Delta x/\bar{u}$ , where  $\bar{u}$  is the mean wind speed. This is the approximate time required for an air parcel to travel from the first point to the second point.

The issues raised in the previous three paragraphs have led Panofsky and Dutton (1984) and others to the hypothesis that the spatial correlations are functions of the eddy size, the wind speed, and the separation between the wind observation points. They use a mathematical expression known as the coherence, which "is a measure of the square of the correlation between the Fourier component of two time series with their phases adjusted to obtain maximum correlation." The coherence is a function of eddy frequency, n, and is given by:

$$\operatorname{coh}(n) = \frac{\left[\operatorname{Co}^{2}(n) + Q^{2}(n)\right]}{\operatorname{S}_{1}(n) \operatorname{S}_{2}(n)}$$
 (A-7)

where  $S_1(n)$  and  $S_2(n)$  are estimates of the spectral density of the two time series at points 1 and 2, Co(n) is the cospectrum, and Q(n) the quadrature spectrum. The frequency, n, can have units of cycles per second or radians per second. The cospectrum refers to the correlation due to in-phase fluctuations and the quadrature spectrum refers to the correlation due to fluctuations that are 90° out of phase. The coherence ranges from zero, for no correlation, to one for perfect correlation. In order to calculate coh(n)for two long time series, specialized computer software for carrying out time series analysis is needed.

Pielke and Panofsky (1970) generalized an empirical expression for the coherence, coh(n), based on a suggestion by Davenport (1961):

$$coh(n) = exp(-a_n\Delta x_i/u)$$
 (A-8)

where the subscript i refers to the direction component and the dimensionless "constant",  $a_i$ , is called the "decay parameter." Observations show that " $a_i$ " is typically in the range from 1 to 10. The dimensionless variable,  $n\Delta x_i/u$ , is often referred to as the reduced frequency. It is found that the "constant,"  $a_i$ , is in fact a function of station separation,  $\Delta x$ . Other investigators have found  $a_i$  to be a function of the ambient stability, the turbulence intensity, and the integral time or distance scale of the turbulence. For example, Perry et al (1978) propose the following formula for horizontal station separations,  $\Delta x$ :

$$a = (65\sigma_{u}/u) + (6.3\sigma_{v}\Delta x/uL_{v})$$
 (A-9)

where  $\sigma_{W}$  and  $\sigma_{V}$  are the standard deviations of turbulent velocity fluctuations in the vertical and cross-wind directions, and L is the lateral integral distance scale of the lateral turbulence.

#### 3. Proposed Formula

The relation between wind speed, u, or wind direction,  $\theta$ , observed at two stations at positions 1 and 2 can be expressed in terms of a variance or a correlation. The relationship between the two quantities can be derived by beginning with the identity:

$$\sigma_{\Delta u}^{2} = (\overline{u_{2}' - u_{1}'})^{2} = \overline{u_{2}'}^{2} + \overline{u_{1}'}^{2} - 2 \overline{u_{1}' u_{2}'}$$
(A-10)

where the primes refer to fluctuations (i.e., the means have been already subtracted) and the overbar refers to a time average. If the two variances  $\overline{u_2'}^2$  and  $\overline{u_1'}^2$  are equal, then equation (A-10) can be written in the form:

$$\sigma_{\Delta u}^2 / 2\sigma_u^2 = 1 - R_{12}$$
 (A-11)

where  $\sigma_u^2 = \overline{u'}^2$  and the correlation coefficient  $R_{12} = \overline{u_1' u_2'} / \sigma_u^2$ . Thus if the correlation equals 1, 0, or -1, the ratio  $\sigma_{\Delta u}^2 / 2\sigma_u^2$  will equal 0, 1, or 2, respectively. For two stations that are separated by such a large distance that the correlation equals zero, then Equation (A-11) states that  $\sigma_{\Delta u}^2 = 2\sigma_u^2$ .

After investigating the semi-theoretical formulas (A-8) and (A-9), it was decided that there was so much adjustment of "constants" taking place that it was best to begin with a simpler formula based on dimensional analysis. This simpler formula does not explicitly include the frequency, n, but does account for frequency effects through the implicit assumption that wind speed autocorrelograms are exponential (i.e.,  $R = \exp(-\Delta t/T_I)$ , implying that a so-called Markov-energy spectrum is valid) and are completely determined once an integral time scale,  $T_I$ , or space scale,  $\Lambda_I$ , is specified. The following dimensionless relationship can then be postulated:

$$\sigma_{\Delta u}^{2}/2\sigma_{u}^{2} = f(\Delta x, T_{I}, \Lambda_{I}, T_{a})$$
 (A-12)

where f is a universal dimensionless function, and variables and parameters are defined in the following way:

 $\sigma_{\Delta u}^2 = \overline{(u_2' - u_1')^2}$ , where  $u_1'$  and  $u_2'$  are wind speed fluctuations at positions 1 and 2.

 $\sigma_u^2 = (\sigma_u^2 + \sigma_u^2)/2$  is the average turbulent energy at positions 1 and 2.

 $\Delta x$  is the horizontal separation between positions 1 and 2.

- $T_{I}$  is the integral time scale of the time series of wind speed fluctuations measured at position 1 or position 2.
- $\Lambda_{I}$  is the integral space scale of the correlogram of wind fluctuation differences ( $u_{i}' - u_{i}'$ ) measured between positions 1 and i for several positions.

T<sub>1</sub> is the averaging time.

The averaging time,  $T_a$ , is very important because it is typically of the same order of magnitude as the integral time scale (i.e., within the range from 1 min to 1 hr). As  $T_a$  approaches zero, the ratio  $\sigma_{\Delta u}^2/2\sigma_u^2$  reaches a maximum at any given station separation, since there are poor correlations between wind fluctuations in smaller eddies at two positions.

Exponential shapes are proposed for all correlation functions:

$$R(\Delta x/\Lambda_{I}) = \exp(-\Delta x/\Lambda_{I})$$

$$R(\Delta t/T_{I}) = \exp(-\Delta t/T_{I})$$
(A-13b)

The following approximation to Taylor's equation is used to account for the effects of averaging time on variances:

$$\sigma^{2}(T_{a})/\sigma^{2}(0) = (1 + T_{a}/2T_{I})^{-1}$$
 (A-14)

For a given separation,  $\Delta x$ , the spatial correlation  $R(\Delta x/\Lambda_I)$  is also going to depend on averaging time,  $T_a$ , since the effects of the fluctuations due to small eddies will drop to zero at large averaging times. Consequently,  $R(\Delta x/\Lambda_I)$  should approach unity as  $T_a$  increases, and the second term in the following empirical formula is proposed to account for this effect:

$$R(T_{a}, \Delta x) = [\overline{u_{2}' u_{1}'} / \sigma_{u_{1}} \sigma_{u_{2}}](T_{a}, \Delta x)$$
$$= \exp(-\Delta x / \Lambda_{I}) + (1 - \exp(-\Delta x / \Lambda_{I}))g(T_{a} u / \Lambda_{I})$$
(A-15)

where the dimensionless function  $g(T_a u / \Lambda_1)$  approaches zero as  $T_a$  approaches zero and approaches unity as  $T_a$  becomes very large.

#### 4. Field Experiment at Hereford, Colorado

The research programs summarized in Section 2 all took advantage of wind observations made at two or more locations. However, none of these wind observations satisfied all of the following desired characteristics of a study in which differences in wind observations are being calculated.

- Flat terrain with few obstructions.
- All wind instruments alike, with relatively fast response and
   adequate calibration procedures.
- Five or more wind stations along a line with spacings ranging from a few hundred meters to 10000 meters.
- Two perpendicular lines of wind stations.
- Several days or more of one-minute averaged wind observations.

A field experiment was designed to satisfy these characteristics, using instruments and technicians from the National Center for Atmospheric Research (NCAR). Thirteen identical wind stations from NCAR's Portable Automated Mesonetwork (PAM) were set up in flat, open farmland (mostly covered by short, winter-weathered grass) near Hereford, Colorado, and operated for the two week period between 30 March 1990 and 14 April 1990. The instruments were installed, maintained and calibrated by experienced NCAR technicians. The anemometers were located at an elevation of 10 m above the ground. A schematic diagrams of the relative instrument locations is given in Figure A-1. The slope of the terrain is less than about 1% over the entire network. It is seen that logarithmic spacings (312.5m, 625m, 1250m, 2500m, 5000m, 10000m) are used for the instruments along each leg of the "L"-shaped network. The perpendicular axes were used in order to determine if there was a significant difference between the along-wind and cross-wind statistics.

The resulting "Hereford" dataset contained values of N-S and E-W components of the wind velocity at one minute resolution. First, these wind components were converted to wind speed, u, and wind direction,  $\theta$ , for each minute. Because the threshold of these instruments was about 0.5m/s, periods with reported wind speeds less than 0.5m/s were flagged and not used in the analysis. 5-minute averages of u and  $\theta$  were made and the resulting time series for each station plotted for the entire 16 day duration of the study (see Figure A-2 for an example of the time series plots for 31 March 1990 Station 6). Visual inspection of the 15 days of time series in the figure revealed that, most of the time, the wind speed and direction are quite variable and unsteady in time. For example, during the afternoon on 1 April and 10 April, the wind speed went through a cycle in which it increased from



Figure A-1. Schematic diagram of wind station locations at the Hereford site. Terrain sloped slightly downward from west to east with an average slope of 1%. North is towards the top of the figure and there is 10 km spacing between stations 1 and 7 or stations 7 and 13.

nearly zero to about 10 m/s and decreases back down to zero again. This large half-sine-wave would totally dominate any statistical analysis of these wind data.

Because it became clear that any time series analysis of the 16 days would be overly influenced by diurnal changes and synoptic effects, it was decided to confine the analysis to time periods on the order of 6 to 10 hours, when the wind speed and direction appeared to be relatively steady. The eleven steady-state periods that were chosen are listed in Table A-1. Two of these periods are indicated by thick lines in Figure A-2. Median values of wind speed, u, wind direction,  $\theta$ , standard deviation of wind speed,  $\sigma_{u}$ , and standard deviation of wind direction,  $\sigma_{\theta}$ , are also listed on the table. These eleven periods are seen to cover a wide range of wind speeds (2.5 to 10.5 m/s), wind directions(170° to 330°) and times of the day.

5. Analysis of Hereford Data

This section presents the results of the analysis of the Hereford data and the next section presents some empirical formulas that fit this dataset. As a first step, variances and time and space correlations were calculated for. averaging times of 1, 10, and 60 minutes. A linear trend (estimated from the data from all 13 stations) was removed from the data from each run. Because steady-state periods have been selected and linear trends have been removed, much of the influence of larger mesoscale and regional eddies has been removed there statistics. As will be shown, mesoscale eddies with time scales less than the sampling time are still strongly reflected in the statistics.

5.1 Single Station Variances as a Function of Averaging Time

The variances in the wind speed and wind direction time series were calculated for each of the eleven "steady-state" runs, for each of the thirteen stations, for averaging times of 1, 10, and 60 min. The data are presented in a Table A-2, in the form of ratios of the variance for 10 or 60 minute time periods to the variance for the one minute time period. The medians over the thirteen stations are listed. The overall medians at the

`A-11

Table A-1

Wind Direction  $\theta(\circ)$ Wind Speed σ<sub>θ</sub>(°) Date/Run Time 👘 u(m/s) œ<sub>u</sub>(m∕s) 0330 00-10 2.5 130 0.7 17 0330 14-24 3.0 215 0.8 17 0331 00-08 3.5 200 0.45 10 0331 16-24 7.5 325 1.2 13 0404 06-12 5.5 90 1.2 13

135

215

10

170

140

330

1.2

0.9

1.3

0.9

1.1

1.1

10

14

8

13

11

10

0404

0406

0409

0411

0412

0413

12-20

18-24

14-24

06-16

80-00

14-20

7.5

4.0

10.5

3.0

5.5

7.5

.

Steady-State Periods from the Hereford Dataset Selected for Analysis. Meteorological Parameters Represent Medians over 13 Stations



Figure A-2. Time series of five-minute averaged wind speed (u) and wind direction (θ) for Station 3 for 31 March 1990 at the Hereford site. Thick lines indicate steady-state periods selected for analysis.

bottom of the table suggest that there is little difference between the statistics for wind speed and wind direction, with medians of the variance ratios of about 0.68 for  $\sigma^2(10 \text{ min})/\sigma^2(1 \text{ min})$  and about 0.39 for  $\sigma^2(60 \text{ min})/\sigma^2(1 \text{ min})$ . The run-to-run variability in the median variance ratios is about  $\pm$  0.20, with no dependence on wind speed, wind direction.  $\sigma_{\rm u}$ ,  $\sigma_{\theta}$ , or time of day. For a given day, the station-to-station variability in the variance ratios is typically about  $\pm$  0.05 to 0.10.

Table A-2 suggests that observed median values of  $\sigma^2(10 \text{ min})/\sigma^2(1 \text{ min})$ and  $\sigma^2(60 \text{ min})/\sigma^2(1 \text{ min})$  are 0.68 and 0.37, respectively. Solving Equation (14) for the integral time scale  $T_I$ , we obtain  $T_I \approx 9 \text{ min}$  for  $T_a = 10 \text{ min}$ and  $T_I \approx 15 \text{ min}$ . for  $T_a = 60 \text{ min}$ . This trend is duplicated in all types of calculations in this analysis, i.e., the derived time and distance integral scales increase as the averaging time,  $T_a$ , or station separation,  $\Delta x$ , increase. Persistent mesoscale eddies are associated with turbulence at time scales of several hours and distance scales of several tens of kilometers. Superimposed on these "baseline mesoscale eddies" are the smaller turbulent eddies normally thought to be associated with the atmospheric boundary layer. Consequently it is assumed that the turbulent velocity field is described by two times scales, one  $(T_{I1})$  associated with boundary layer turbulence, and another  $(T_{I2})$  associated with mesoscale eddies. These two time scales are assumed to contribute equally to  $\sigma^2(T_a)$ , leading to the following modification to Equation (A-14):

$$\frac{\sigma^{-}(T_{a})}{\sigma^{2}(0)} = \frac{0.5}{1 + T_{a}/2T_{I1}} + \frac{0.5}{1 + T_{a}/2T_{I2}}$$
(A-16)

The Hereford dataset is best-fit by  $T_{I1} \cong 300s$  and  $T_{I2} \cong 1800s$ , which yield  $\sigma^2(10)/\sigma^2(1) = 0.71$  (slightly above the median observation of 0.68) and  $\sigma^2(60)/\sigma^2(1) = 0.35$  (slightly below the median observation of 0.37).

#### 5.2 Statistics for Pairs of Observing Stations

2

The spatial statistics to be presented are all keyed to wind station (7) at the corner of the "L" of the network shown in Figure A-1. The results in this section are given for the spatial correlation coefficient, Ratios of Variances  $\sigma^2(T_a)/\sigma^2(1 \text{ min})$  for Averaging Times,  $T_a$ , of 10 and 60 min., for Wind Speed and Wind Direction at the Hereford Site. Results are Given for Each of Eleven Runs. The Median of the Ratios for the Thirteen Stations is Given. The Scatter of the Ratios for the Thirteen Stations about any Median has a Standard Deviation of about 0.05 to 0.10. Medians over all Dates are Given at the Bottom.

σ_2 <sup>(T</sup> _a)∕σ	$u^2(1 \text{ min})$
-------------------------	----------------------

 $\sigma_{\theta}^{2}(T_{a})/\sigma_{\theta}^{2}(1 \text{ min})$ 

	Wind Speed		. Wind Direction	
Run Date/Time	10 Minute	60 Minute	10 Minute	60 Minute
0330/00-10	. 88	. 61	. 93	. 58
0330/14-24	.71	. 58	. 69	. 50
0331/00-08	. 74	. 39	. 77	. 36
0331/16-24	. 41	. 21	. 64	. 25
0404/06-12	. 55	. 19	. 81	. 50
0404/12-20	. 51	. 37	. 42	. 17
0406/18-24	. 31	. 13	. 40	. 10
0409/14-24	. 68	. 58	. 63	. 34
0411/06-16	. 81	. 51	. 76	. 38
0412/00-08	. 80	. 56	. 92	. 52
0413/14-20	. 38	. 15	. 50	. 20
Overall Median	0.68	0.39	0.69	0.36

 $R(\Delta x, T_a) = \overline{u_1' u_7'} / \sigma_{u_1'} \sigma_{u_7'}$ , which are functions of the separation,  $\Delta x$ , of stations i and 7, the averaging time,  $T_a$  and the integral scale of the turbulence. Averaging times of 1, 10 and 60 min are used. Results are presented separately for the E-W and N-S legs of the "L". Rather than showing the correlation for all eleven time periods or runs, we present the median of the 11 periods. These correlations, are plotted in Figure A-3. There does not appear to be a strong dependence on E-W or N-S leg, or on whether wind speed or wind direction is being plotted.

As expected, the calculated correlations are lowest for the shorter averaging times and the largest station separations, due to the fact that the dominant turbulent eddies are characterized by space scales of a few hundred meters and time scales on the order of a few minutes.

At the 10 km separation distance, the correlations average about 0.5. Because of the relation between spatial correlation,  $R_{12}$ , spatial variance,  $\sigma_{\Delta u}^2$ and variance,  $\sigma_u^2$ , indicated by Equation (A-11), it follows that, at 10 km separation,  $\sigma_{\Delta u}^2 = \sigma_u^2$ . Knowing that  $\sigma_u^2(T_a = 1 \text{ min}) \approx 1.2 \text{m}^2/\text{s}^2$ , and using the median values of  $\sigma_u^2(T_a)/\sigma_u^2(1 \text{ min})$  in Table A-2, it can be concluded that  $\sigma_{\Delta u}^2 \sim 1.1 \text{m}^2/\text{s}^2$  for  $T_a = 1 \text{ min}$ ,  $\sigma_{\Delta u}^2 \sim 0.8 \text{m}^2/\text{s}^2$  for  $T_a = 10 \text{ min.}$ , and  $\sigma_{\Delta u}^2 \sim 0.4 \text{m}^2/\text{s}^2$  for  $T_a = 60 \text{ min}$  at the 10 km separation distance. This value of  $\sigma_{\Delta u} \sim 0.7 \text{m/s}$  for one-hour averages is close to that found with the St. Louis RAPS data, as discussed in Section 2.

At small averaging times,  $T_a$ , Equation (A-15) suggests that the correlation coefficient for wind speed fluctuations at two points separated by a distance,  $\Delta x$ , should be an exponential function of  $\Delta x$ . Therefore, if ln R is plotted against  $\Delta x$ , a straight line should be seen. Observations of R from this wind network are plotted in Figure A-4, for the six  $\Delta x$  values (312.5, 625, 1250, 2500, 5000, and 10000 m) and three averaging times (1, 10, and 60 min) of interest. Because the correlations in Figure A-3 did not indicate much dependence on E-W or N-S direction, and were similar for wind speed and wind direction, all runs, legs, and variables are combined in this table and figure.

- A-16



Figure A-3. Spatial correlation coefficient, R, as a function of station separation for E-W and N-S legs of Hereford monitoring network. Wind speed (u) correlations are on the left, and wind direction (0) correlations are on the right. Medians over all eleven runs are shown for averaging times of 1 min. (Long Dashes), 10 min. (Short Dashes), and 60 Min. (Solid Line). The standard deviation of the scatter of the 11 points about each line is about 0.2.





Figure A-4. Spatial correlation coefficients, R, for various spatial separations,  $\Delta x$ , and averaging times,  $T_a$  ( $\Box$  1 min; \* 10 min; + 60 min), from Hereford site. Plotted are the medians over eleven runs. E-W and N-S legs, and wind speed and wind direction observations. Typical scatter of all the data about each line is about 0.2 at a correlation of 0.5. Empirical curves from Equation (A-17) are drawn (dotted, Ta = 1 min.; dashed, Ta = 10 min.; solid, Ta = 60 min.).

The points in the figure follow a straight line only for the largest averaging time (60 min). For the smallest averaging time (1 min), there is a much more rapid drop-off in correlation at small separation distances. This behavior can be explained by the same two-scale phenomenon discussed under Section 5.1 in the analysis of the effects of averaging time; i.e., the results are influenced by a smaller eddy scale,  $\Lambda_1$ , representative of boundary layer processes, and a larger eddy scale,  $\Lambda_2$ , representative of mesoscale fluctuations. However, the effects of the smaller scales tend to disappear at large averaging times,  $T_a$ , when the condition  $T_a > \Lambda_1/u$  is satisfied. Thus, equation (A-15) appears to be satisfied, with the limits:

$$R(\Delta x, T_a \rightarrow 60 \text{ min}) = e^{-\Delta x/\Lambda} 2$$

$$R(\Delta x, T_a \rightarrow 1 \text{ min}) = 0.5e^{-\Delta x/\Lambda}1 + 0.5e^{-\Delta x/\Lambda}2$$

The following empirical equation fits these data and has the proper asymptotic behavior:

$$R(\Delta x, T_{a}) = e^{-\Delta x/\Lambda} 2 - 0.5 \left( e^{-\Delta x/\Lambda} 2 - e^{-\Delta x/\Lambda} 1 \right) / \left( 1 + (T_{a} / A_{1})^{2} \right)$$
(A-17)

where  $\Lambda_1 = 300$  m,  $\Lambda_2 = 12000$  m, and a = 5 when u  $\approx$  5 m/s. The predicted curves are drawn on Figure A-4. The value of a = 5 is consistent with "Pasquill's Beta" = 4, which is the known proportionality factor between Lagrangian and Eulerian scales. Because the actual eddy diameters are equal to about five times the integral scales  $\Lambda$ , the smaller eddy diameters would be about 1500 m and the larger eddy diameters would be about 60 km. Of course the confidence limits on the data (± about 0.2) are so broad that a much wider range of scales,  $\Lambda_1$  and  $\Lambda_2$ , is possible. Furthermore, these results are limited to this particular site and time of year, and to the ranges of  $\Delta x$ ,  $T_a$ , and meteorological conditions that we have considered. The sampling time (a maximum of 10 hours) also imposes a maximum limit on integral scales.

#### 6. Recommended Empirical Formula for Variances

Our analysis of the Hereford data has suggested that the variances and correlations for wind speed and wind direction are similar. In addition, we

have found that, despite the theoretical prediction that along-wind correlations will be larger than cross-wind correlations, there is no clear dependency of the correlations on wind direction (or any other meteorological variable). This apparent lack of dependency may be due to the fact that this effect is overwhelmed by the natural variability in the observations.

The similarity relations in Equation (A-8) have been shown to be valid, resulting in Equation (A-16) for the effects of averaging time and Equation (A-17) for the effects of station separation. These equations can be combined into the following general equation:

$$\frac{\sigma_{\Delta u}^{2}(\Delta x, T_{a})}{2\sigma_{u}^{2}(T_{a} = 0)} = \left[\frac{0.5}{1 + T_{a}^{2}/2T_{11}} + \frac{0.5}{1 + T_{a}^{2}/2T_{12}}\right].$$

$$\left[1 - e^{-\Delta x/\Lambda_{2}} + 0.5 \frac{(e^{-\Delta x/\Lambda_{2}} - e^{-\Delta x/\Lambda_{1}})}{(1 + (T_{a}u/a\Lambda_{1})^{2})}\right] \qquad (A-18)$$

where  $T_{I1} \sim 300$  s  $T_{I2} \sim 1800$  s  $\Lambda_1 \sim 300$  m  $\Lambda_2 \sim 1200$  m a (Lagrangian-Eulerian scale) ~ 5

This equation should be tested with independent data from a different site. Slightly different values of the time and distance scales may be appropriate at a different site. For any given time and place, the confidence limits on the results would be expected to be in the same range (about 20% to 30%) has been found here.

7. Test of General Equation with Independent Data

A set of independent wind data from the so-called XM21 field study at Dugway Proving Ground, Utah, were provided by C. Biltoft. Data were available from two towers, separated by 500m, on a relatively flat test range. Instruments were located at heights of 2, 4, 8, 16, and 32m, and measurements were made at a frequency of one per second. Because the towers were constructed of scaffolding, it was necessary to disregard periods when the wind blew through one of the towers. Two periods of valid data were analyzed--from 1110 to 1651 on 11 April 1989, and from 0937 to 2059 on 2 May 1989. Both periods were marked by wind speeds of about 3.5 m/s and relatively strong turbulence intensities ( $\sigma_u/\bar{u} \sim 0.3$  and  $\sigma_{\mu} \sim 30^\circ$ ).

Because the integral scales of the horizontal components of turbulence are not strongly dependent on height, the results from all five levels are combined in our analysis. This assumption will cause a slight error, since the various ratios  $\sigma^2(T_a)/\sigma^2(1 \text{sec})$  and correlations are observed to increase by about 10% to 20% between heights of 2m and 32m. In addition, the wind speed and direction results appear similar and are combined in our analysis. The combined data results (two variables, two days, five levels) are presented in Table A-3.

The predictions of  $\sigma^2(T_a)/\sigma^2(1 \sec)$  in the table have been made using Equation (A-16), with the same time scales derived from the NCAR wind network ( $T_1 = 300s$  and  $T_2 = 1800s$ ). There is a  $\pm 10\%$  agreement between the predictions and the observed medians, and the predictions are within the  $\pm$ standard deviation error bounds of the observations. It can be concluded that the variances  $\sigma^2(T_a)$  show similar behavior at the two sites, and that Equation (A-16) can adequately simulate this behavior.

Equation (A-17) (for spatial correlations) does not transfer as well to the new site. Its predictions are shown under column (2), assuming the parameters ( $\Lambda_1 = 300m$ ,  $\Lambda_2 = 12000m$ , and a = 5) derived from the NCAR wind network. Clearly the predictions of  $R_{\Delta u}(T_a)$  are too low by about 10 to 30%. If the  $\Lambda_1$ ,  $\Lambda_2$ , and "a" parameters are "tuned" with these new data, the predictions under column (3) are all within  $\pm 4\%$  of the observations. However, the smaller of the length scales,  $\Lambda_1$ , has to be increased from 300m to 1000m, and the Lagrangian-Eulerian parameter "a" has to be reduced from 5 to 0.2. It appears that the weakest part of Equation (A-17) is the correction term.  $(1 + (uT_a/a\Lambda_1)^2)^{-1}$ , for averaging time,  $T_a$ . This term is intended to cause an increase in the spatial correlation as averaging time increases. However, the functional form for this correction term is not obvious and more thought is clearly needed.

### Table A-3

Observations and Model Predictions for Dugway Proving Ground Wind Data, with Tower Separation of 500m, for All Levels Combined, and Wind Speed and Direction Combined. Medians are Listed for the Observed Values. Model Parameters are given in the Footnotes.

Av	veraging Time Ta	$\frac{\sigma^2(T_a)}{\sigma^2(1 \sec)}$ Observed	$\frac{\sigma^{2}(T_{a})}{\sigma^{2}(1 \text{ sec})}$ Predicted (1)	$R_{\Delta u}(T_a)$ Observed	R <sub>Δu</sub> (T Predi	a) .cted (3)
1	sec			0.78	0.57	0.77
60	sec	0.87	0.95	0.83	0.58	0.86
600	sec	0.68	0.65	0.94	0.83	0.95
	· .					

Footnotes: (1) Equation (A-16) is used, with the same values for the parameters as derived from the NCAR data ( $T_1 = 300s$  and  $T_2 = 1800s$ )

- (2) Equation (A-17) is used, with the same values for the parameters as derived from the NCAR data ( $\Lambda_1 = 300m$ ,  $\Lambda_2 = 12000m$ , and a = 5)
- (3) Equation (A-17) is used, with  $\Lambda_1 = 1000m$ ,  $\Lambda_2 = 12000m$ , and a = 0.2.

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# APPENDIX B-1

# UNCERTAINTY ASSOCIATED WITH EMISSION RATE ESTIMATION

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# Appendix B-1

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A, B, C, D	coefficients which are determined by fitting the observed wind tunnel experiments to a curve
<sup>COV</sup> xy	covariance of xy
cv <sup>2</sup> <sub>x</sub>	squared coefficient of variation of x, $\frac{\sigma_x^2}{\overline{x}^2}$
cv <sup>2</sup> y	squared coefficient of variation of y, $\frac{\sigma_y^2}{\overline{y}^2}$
h	relative humidity
Mo	initial mass
M	mass of zinc or phosphorus aerosolized, as measured in the
A	wind tunnel experiments
MYF	munition yield factor, the ratio $\frac{M_{x}}{M_{o}}$
Q <sub>t</sub>	mass emission rate
đ	Q <sub>t</sub> M <sub>o</sub>
x	mean of x
ÿ	mean of y
YF	yield factor, theoretical adjustment to mass of aerosol based on the ability of the active ingredient to absorb water vapor
ΔΜ	mass lost during burn, initial mass less final mass, as measured by the load cell
°xy	variance of the product xy
σ <sup>2</sup> x	variance of x
σ <sup>2</sup> y	variance of y

#### Appendix B-1

#### UNCERTAINTY ASSOCIATED WITH EMISSION RATE ESTIMATION

#### 1. Introduction

To estimate the uncertainty of an entire model it is necessary to evaluate the uncertainty of its components. The input data for atmospheric dispersion models consists of emission rate data and meteorological data. In this discussion we address the issue of uncertainty associated with the estimation of emission rates of aerosols from smoke munitions. Emission rates are generally expressed in terms of weight per unit time; in this case they are expressed as grams of active ingredient, (e.g., phosphorus) per second.

The issue of estimating the emission rate of obscurant munitions is complex, aside from the issue of estimating the associated uncertainty. There are several reasons for this. First, the critical property which provides the obscurant effect is not directly emitted by the munition; it results from an interaction of the active ingredient, e.g., red phosphorus, and moisture in the ambient atmosphere to form a dense smoke cloud. Second, munitions contain other materials which burn simultaneously but do not contribute directly to the obscurant effect; thus measuring total weight loss over burn time only indirectly measures the amount of active ingredient which has been released. Third, to experimentally determine the amount of active ingredient released, the mass of the active ingredient in the entire smoke cloud must be determined and this measurement can only be carried out in a wind tunnel. Thus, data from the wind tunnel experiments are extrapolated to the field setting. These issues affect emission rate estimation as well as contribute to the associated uncertainty.

This discussion covers the following topics: how emissions are measured in both wind tunnel and field experiments, the model used for estimating emission rates, a technique for estimating uncertainty (using existing data as an example), and conclusions and recommendations for the collection of additional data which would enhance the uncertainty analysis. Several reports were reviewed for this analysis, but the information on the method of measuring and modeling emission rates is based on two reports: *Basic* 

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Smoke Characterization Test (DPG-FR-77-311) (DPG,1978) and Methodology Investigation Final Report Validation of a Transport and Dispersion Model for Smoke (DPG-FR-702) (Carter et al., 1979). These reports contain data on three different types of smoke obscurant munitions: white phosphorus, red phosphorus, and zinc oxide-hexachloroethane-aluminum. Because only limited amounts of appropriate data are available for the uncertainty analysis, the conclusions drawn from this analysis must be considered tentative.

#### 2. Measurement of Smoke Munition Emissions

#### 2.1 Wind Tunnel Experiments

The most detailed measurement of emission rates of submunitions were conducted in wind tunnel experiments. Although field measurements have been collected, these data are not adequate for developing a model. Thus, the model used to predict emission rates is based on the wind tunnel experiments. The experiments and the data described in this section are summarized from DPG (1978).

The wind tunnel experiments were conducted at the Dugway wind tunnel. In the experiments, single submunitions (e.g., an individual component which contains the smoke producing compound) of zinc and white phosphorus were burned. In actual field use of smoke munitions, multiple submunitions are loaded into a canister and burn simultaneously. For red phosphorus, three submunitions (wedges) were burned simultaneously. The wind tunnel tests were conducted at a wind speed of 2 m/s and the ambient temperature, relative humidity, (%RH), and barometric pressures were recorded. Pre-weighed submunitions were placed on a load cell in the center line of the tunnel and fired remotely. The load cell recorded the elapsed time and weight loss of the submunition as it burned. The end of the tunnel had a barrier that contained a grid of holes through which the air in the tunnel passed. The air passed into sampling lines and through collection devices, impingers. (See Figure B-1.) The impingers were then analyzed for zinc or phosphorus, the appropriate active ingredient. The concentrations in all impingers were summed to determine the total amount of active ingredient which had been aerosolized during the burn. Data collected on each test included: weight loss with burn time, total zinc or phosphorus, tunnel wind speed, temperature, and relative humidity.

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		CROS Samp	SS SE	TION Grid		
A.				_		Chemical Impingers
	0	02	3	04	05	6 in. 1 T. 1 ft.
	а. б	<b>o</b> 7	0 8	0 9	0 10	×
	<b>o</b> 11	0 12	0 13	0 14	15	<b>.</b>
	0 16	0 17	0 18	0 19	0 20	ع
	0 21	22	° 23	24	0 25	
	26	27	28	29	30	
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ļ	←	<b>~</b>	5 ft	, ' 	و <sup>ت</sup> –	





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Transmittance, which is routinely measured in the field, cannot be measured in the wind tunnel because the concentrations are too high. The types of submunitions tested (as reported in DPG (1978)) were:

155mm HC M1 Canister (zinc) 155mm HC M2 Canister (zinc) 105mm HC M1 Canister (zinc) 6 inch WP Wick (white phosphorus) 2.75 inch Rocket WP Wick (white phosphorus) 81mm Navy RP Wedge (red phosphorus) 155mm Navy RP Wedge (red phosphorus) 81mm German RP Wedge (red phosphorus).

For each type of submunition, two burns were conducted.

2.2 Field Experiments

The field experiments were conducted at the Horizontal Grid, Dugway Proving Ground, Utah. The experiments described in this section are summarized from DPG (1978). The data were collected by means of photography, aerosol sampling with aerosol photometers, particle size analyzers, and impingers. Samplers were located 1.22 meters above the ground. Motion pictures recorded the size and shape of the smoke cloud; aerosol photometers recorded total particle concentration; particle size analyzers recorded size distributions; and impingers measured zinc or phosphorus concentrations. The mass of zinc or phosphorus from these impingers cannot be summed to calculate total zinc or phosphorus aerosolized as was done in the wind tunnel experiments because the total smoke cloud is not collected by the impingers.

Figure B-2 (DPG, 1978) shows the layout of the instruments for these experiments. The sampling line was always oriented perpendicular  $(\pm 45^{\circ})$  to the prevailing wind direction. The impingers were located halfway between the aerosol photometers. As in the wind tunnel experiments, the munitions were placed in a load cell so that data on weight loss with burn time were recorded. The types of submunitions tested were the same as those used in the wind tunnel experiments. For each type of submunition, two burns were conducted.

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The meteorological data recorded in these experiments included: wind speed and direction, temperature, and relative humidity.

#### 3. The Emission Rate Expression

The critical parameter to be derived from these experiments is the amount of smoke generated per second of burn time. In its simplest form, this would be calculated by dividing the mass lost by the burn time to derive a value in units of grams per second. However, the amount of smoke generated is more than a function of the mass burned; it is also a function of the interaction of the zinc or phosphorus with water vapor to create the smoke. Zinc and phosphorus are hydroscopic, absorbing upwards of four times their mass in water vapor. Thus, the actual emission rate of interest is total amount of <u>hydrated</u> smoke generated per second. To add one further complexity to the equation, the burn rate of the munitions is not constant with time. There is an initial growth period, followed by a plateau of relatively constant rate of emissions, followed by a rapid decline. In field tests, there are data which indicate munitions can burn unevenly; this is characterized as "flashing" toward the end of the burn time by the observers.

The following discussion covers two topics. The first topic presents the parameters in the emission rate expression and the second discusses the uncertainty associated with those parameters and presents a technique for computing the uncertainty in the overall emission rate value.

3.1 Input Parameters

The emission rate of hydrated smoke is a function of the initial mass of the munition, the fraction of this mass which is the aerosolized zinc or phosphorus, the increase in mass of the aerosol due to hydration, and burn time. The expression which was developed from the wind tunnel experiments to estimate the emission rate is as follows (DPG, 1978):

$$Q_{t} = M_{o} MYF YF(A/t_{b} + 2Bt/t_{b}^{2} + 3Ct^{2}/t_{b}^{3} + 4Dt^{3}/t_{b}^{4})$$
 (B-1)

where: Q<sub>+</sub> = mass emission rate

M = initial mass

MYF = munition yield factor

- YF = yield factor
- A, B, C, D = coefficients which are determined by fitting the observed data in the wind tunnel experiments to a curve. They are constrained to sum to unity.

The munition yield factor, MYF, is the ratio of the mass of zinc or phosphorus burned,  $M_{\mu}$ , to the initial mass of the munition,  $M_{\mu}$ .  $M_{\mu}$  is determined from the wind tunnel experiments and is calculated by summing the mass of zinc or phosphorus collected by all the impingers. These wind tunnel values of  $M_y$  are used to predict the emission rate,  $Q_t$ , for field experiments, as  $M_x$  cannot be measured in the field setting.

The yield factor takes into account the hydroscopic growth of the aerosolized zinc or phosphorus and is a function of ambient relative humidity. For the three different types of smoke munitions, yield factors are based on theoretical calculations or experimental data. The conceptual definition of the yield factor is:

# $YF = \frac{mass of smoke (including aerosol)}{mass of starting material}$

In the case of phosphorus, the final material is primarily hydrated orthophosphoric acid,  $(H_3PO_4 + nH_2O)$ . According to DPG (1977), it is assumed that the hydration of the droplets of  $\mathrm{H_3PO}_{A}$  proceeds until their aqueous vapor pressure equals the partial pressure of  $H_2O$  in the atmosphere. The mass of hydrated  $H_3PO_4$  is then constant (assuming no other environmental changes occur) and the yield factor can be expressed as:

$$YF = \frac{\text{mass H}_3PO_4 + nH_2O}{\text{mass P}}$$

DPG (1977) contains the following example of how a yield factor is calculated. Yield factors for phosphorus can be readily computed from tables correlating aqueous vapor pressures with the composition of various mixtures

of  $H_3PO_4$ , when the concentration of  $H_3PO_4$  in the solution is expressed as weight %, (i.e., mass  $(H_3PO_4) \times 100/mass (H_3PO_4 + nH_2O)$ ). For a specified aqueous vapor pressure, the ratio of the molecular weight of  $H_3PO_4$  to the atomic weight of P is 3.16:

$$YF = \frac{100 \times 3.16}{H_3 PO_4 (wt \%)} = \frac{316}{H_3 PO_4 (wt \%)}$$

Taking, as an example, the burning of 1 gram of P in the air at 25°C and containing moisture at a partial pressure of 22.39 mmHg, the oxidation to phosphoric oxide and hydrolysis of phosphoric oxide will result in 1 x 98/31 gram or 3.16 gram  $H_3PO_4$ .  $H_3PO_4$  will then hydrate until the aqueous vapor pressure of the diluted  $H_3PO_4$  ( $H_3PO_4$  + nH\_2O) equals the ambient vapor pressure. At 22.39 mmHg and 25°C, the equilibrium composition of the mixture is found to be 20.07 weight %  $H_3PO_4$ . The YF is then 316/20.07 = 15.7, (i.e., under these conditions, the mass of smoke is 15.7 gram for every gram of P burned). An additional correction will be necessary if the munition efficiency is not 100%.

DPG (1978) notes that the theoretical curve for phosphorus assumes that orthophosphoric acid is produced immediately during combustion. If this assumption does not hold, the yield factor may overestimate the effective dosage. DPG (1977) also presents a derivation which proves that YF's are insensitive to temperature up to  $100^{\circ}$ C.

Figure B-3 (DPG, 1978) presents yield factor curves based on theoretical calculations for P as well as empirical data for red phosphorus and theoretical calculations for zinc oxide-hexachloroethane-aluminum (HC). It can be seen from these figures that the slope of the lines for all three materials, white phosphorus, red phosphorus, and the zinc based munition, is relatively shallow over the range of relative humidity from approximately 20% to 65%. For example, over the range of 20% to 65% RH, the yield factor for red phosphorus increases by a factor of 1.4. However, the theoretical curves rise sharply at humidities greater than 65%. Between humidity levels of 65% to 80% red and white phosphorus increase by a factor of approximately 1.3 and hydrated zinc chloride by a factor of 1.7. For field tests conducted on one day, the relative humidity would not be expected to vary over this wide a range, so that





Figure B-3. Yield factors as a function of relative humidity for various smoke producing agents. Source: DPG, 1978.

the yield factor between burns should not vary substantially. For example, an increase from 40% to 50% RH only produces a difference in the yield factor of 1.04 for red phosphorus. During the field experiments, which took place on several different days, the relative humidity varied from 40% to 80%, but within a given day the RH only varied by 2%-4%.

3.2 Approach to Estimating Uncertainty in the Emission Rate

A direct method for determining uncertainty values would be to compare modeled emission rates with actual emission rates; however, emission rate measurements from the field experiments are not available. In the absence of actual data, uncertainty values can be modeled based on estimated uncertainty values for the input parameters and on the uncertainty inherent in the emissions rate model. To estimate uncertainty values for the variables, there should be sufficient data available to calculate the probability density functions (i.e., measures of variability) of the input variables. To model the uncertainty in the emission rate model, an assumption must be made regarding the independence or dependence of the variables in the model, as there are different approaches for each case.

The following discussion presents both a qualitative and quantitative assessment of the emission rate uncertainty of the various smoke munitions. The qualitative assessment highlights the sources of uncertainty of the input parameters to the emission rate model and the limitations imposed by the amount of data (for each type of munition) available for the analysis. The quantitative assessment presents a model for estimating the emission rate uncertainty and an example application for several munitions.

Two factors limit the uncertainty analysis of the smoke munitions data. First, to few experiments were conducted for each type of munition to determine robust probability density functions for the various parameters. For both wind tunnel and field experiments only two burns were conducted for each type of submunition, thus means or variances will not be stable or robust. Confidence intervals are large when n = 2. Therefore the quantitative uncertainty analysis presented subsequently is neither a precise nor an accurate measure of uncertainty, but the method is valid with sufficient data.

Second, the data from the wind tunnel experiment are suspect. For five of the nine munitions tested in the wind tunnel, the mass of aerosolized active ingredient,  $M_{_{\rm X}}$ , as measured by the bubblers exceeded the mass burned,  $\Delta M_{\star}$  as measured by the load cell on which the munition was placed. This clearly violates the law of conservation of mass. There are two plausible hypotheses for these results. First, the design of the wind tunnel is suspect. It has been observed that there may have been insufficient downwind distance from the load cell to establish laminar flow at the sampling point (Carter, (1991), personal communication). Second, the wind speed was measured at only one location and the assumption of constant velocity may not be correct (Bowers, (1991), personal communication). Either or both of these situations could have led to an overestimation of air velocity at the point of sampling. Although this condition most likely existed for all tests, it was not evident in the data from the three types of zinc oxide-hexachloroethane-aluminum (HC) smoke munitions (155mm M1 and M2 and the 105mm canisters) and one red phosphorus (RP) munition (81mm Navy wedge). (This observation is based on data reported in DPG, 1978.) The reason for the differences between munitions is not readily evident, and it is not possible to ascertain given the age of the data. The error associated with the inaccuracy of the bubbler data will affect all field experiment data because of the fundamental assumption in the emission rate model. Namely, the MYF relationship (the ratio of the mass of active ingredient aerosolized,  $M_{y}$ , to the initial mass of the munition,  $M_{y}$ ), as measured in the wind tunnel experiments, is assumed to apply to the field experiments. As the wind tunnel tests overestimated the MYF, the emission rate, Q,, would also be overestimated.

A simple analysis was performed to (1) determine if there was a consistent bias in the data which could be used to adjust the mass aerosolized,  $M_{\chi}$ , and the MYF for those munitions where  $M_{\chi}$  was greater than the mass burned,  $\Delta M$ , and (2) evaluate the within munition variability for  $M_{\chi}$  and  $\Delta M$ . The computation performed was:

bias = 
$$1 - M_{o}/\Delta M$$

where a negative value indicates the mass of Zn or P aerosolized is greater than the mass burned and a positive value indicates this relationship is reversed. The data were taken from DPG (1978) and the results are shown in Table B-1. The first five entries in the table are for the munitions where  $M_{\chi}$ , the mass of Zn or P aerosolized, exceeds  $\Delta M$  mass burned; the next four entries are for munitions where  $M_{\chi}$  is less than  $\Delta M$ . For one munition, the 155mm RP Navy Wedge, in one test result  $M_{\chi}$  was less than  $\Delta M$  and for the second test  $M_{\chi}$  was greater than  $\Delta M$ . The reason for this anomaly within a munition type is not clearly evident. It can be observed from this table that for munitions where the mass of Zn or P is less than the mass burned, the within munition variability is relatively small, less than 20%. However, for the munitions where the mass of Zn or P is greater than the mass burned, the within variability was much larger, ranging from approximately 45%-88%. Because the within munition variability is so large for those cases when  $M_{\chi}$  is greater than  $\Delta M$ , it is not appropriate to adjust  $M_{\chi}$  or MYF for these munitions.

Three conclusions can be made based on this analysis. First, those munitions for which the mass of Zn or P aerosolized exceeds the mass burned will be dropped from further analysis because the data violate the law of conservation of mass and the large within munition variability precludes adjusting the original data. Second, the results indicate that there may be another source of error affecting the data in addition to the wind tunnel design. One would anticipate that the design error would affect all munitions equally, however, this is clearly not the case. There could appear to be other sources of variation related to the type of munition (e.g., mass aerosolized is less than mass burned is for all of the zinc canister munitions). Or there may have been some other source of experimental error associated with the operation of the wind tunnel or in the analyses of the bubblers. These additional sources of error cannot be evaluated further due to the age of the data. Third, if one assumes that the affect of the wind tunnel design on the munitions is constant across all experiments, then it must be concluded that  $M_{\rm o}$ , the mass of Zn or P aerosolized, is overestimated for all munitions even if M is less than  $\Delta M$ , the mass burned. It follows then that the MYF, which is the ratio of mass aerosolized to mass burned, is overestimated for all munitions.

To estimate the uncertainty in the emission rate model the issue of independence or dependence of the variables must be considered. The

Table B-1 Evaluating Wind Tunnel Bias

		Initial Mass (M <sub>o</sub> )	Mass burned (ΔΜ)	Mass <sup>1</sup> Aerosolized (M <sub>x</sub> )	Bias <sup>2</sup>
2.75" WP Wedge	A9	217	125	150	20
	A10	203	116	129	11
6" WP Wick	A5	102	59	64	- 09
	A6	101	51	77	51
3" WP Wick	A7	63	40	45	13
	<b>A8</b>	52	36	Void	
155mm RP	A15	114	78	72	+. 08
Navy Wedge	A16	117	69	79	15
81mm RP	A11	30	15	24	- 60
German Wedge	A14	35	14	15	07
155mm HC M1	A1	3450	2330	425	+. 82
Canister	A2	3572	2412	382	+. 84
155mm HC M2	A12	2055	1162	369	+. 68
Canister	A13	1987	1182	391	+. 67
105mm HC	A3	1178	646	154	+. 76
Canister	A4	1177	633	234	+. 63
81mm Navy RP	A17	117	. 73	64	+ 12
Wedge	A18	116	68	61	+. 10

<sup>1</sup> Zn or P

.

 $\frac{2}{\text{Bias} = 1 - \frac{M}{\Delta M}}$ 

assumption of independence allows one to use a relatively simple expression to calculate overall model uncertainty as the covariance terms can be neglected. However, if this assumption is incorrect and the variables are dependent, the estimated uncertainty will be unrealistically low.

In the case where the variables can be assumed to be independent, Goodman (1960) presents the expression:

$$\sigma_{xy}^{2} = \bar{x}^{2} \sigma_{y}^{2} + \bar{y}^{2} \sigma_{x}^{2} = (\bar{xy})^{2} \left[ C V_{x}^{2} + C V_{y}^{2} \right]$$
(B-2)

where  $\sigma_{xy}^2$  = variance of the product xy  $\overline{x}$  = mean of x  $\sigma_x^2$  = variance of X =  $\frac{\sum(x - \overline{x})^2}{n - 1}$   $\overline{y}$  = mean of Y  $\sigma_y^2$  = variance of Y  $CV_x^2$  = squared coefficient of variation of x,  $\frac{\sigma_x^2}{\overline{x}}$  $CV_y^2$  = squared coefficient of variation of y,  $\frac{\sigma_y^2}{\overline{y}}$ 

The variables in the emission rate model (see equation B-1) are not independent, both the munition yield fraction, MYF, and the yield fraction, YF, depend on the type of active ingredient. The variance of the product of two or more variables, which are not independent, is given as (Goodman, 1960):

$$\sigma_{xy}^2 = \overline{x} \, \sigma_y^2 + \overline{y} \, \sigma_x^2 + 2\overline{x} \, \overline{y}(\text{cov}_{xy})$$

where the variables are defined as above and  $\text{COV}_{xy}$ , the covariance of xy, is expressed as:

$$COV_{xy} = \sigma_x \sigma_y = \frac{1}{N} \sum_{i=1}^{N} (x_i - \bar{x})(y_i - \bar{y}) = \frac{1}{N} \sum_{i=1}^{N} (x_i - y_i) - \bar{x} \bar{y}$$
(B-3)

To apply Equation (B-2) to the model for  $Q_t$ , the emission rate, integrating over the total burn time, it is written as:

$$Q = \int_{0}^{b} dt Q_{t} = M_{0} \cdot MYF \cdot YF$$
(B-4)

Let E = MYF and Y = YF. Assuming the uncertainty associated with the initial mass,  $M_0$ , is small (i.e., the load cell is accurate),  $Q_t$  can be divided by  $M_0$  and expressed as q

$$q = \frac{Q_t}{M_o} = E \cdot Y$$
 (B-5)

The variance of  $q(\sigma_q^2)$  is

$$\sigma_{q}^{2} = \overline{Y} \sigma_{E}^{2} + \overline{E} \sigma_{Y}^{2} + 2\overline{E} \overline{Y} COV_{EY}$$
(B-6)

where  $\text{COV}_{\text{EY}}$  is the covariance of the munition yield fraction, now expressed as E, with the yield factor, now expressed as Y. Since the yield factor is a function of the relative humidity (Y = Y(h) where h is fractional relative humidity), this value can be incorporated into the expression for  $\sigma_q^2$  as follows:

$$\sigma_{q}^{2} = \overline{Y} \sigma_{E}^{2} + \overline{E} Y \sigma_{h}^{2} + 2\overline{E} \overline{Y} Y COV_{Eh}$$
(B-7)

The fractional relative humidity, h, is = 0 at zero humidity and 1 at 100% humidity and Y' is defined as:

$$Y' = \frac{\Delta y}{\Delta h} \bigg|_{h} = \bar{h}$$
(B-8)

As there are only two values for each munition, Y' is simply the slope of the straight line between the two points. The term  $COV_{Eh}$  is the covariance of the munition yield fraction (E) with relative humidity (h).

#### 3.3 Results of Uncertainty Analysis

Table B-2 presents a sample set of data taken from DPG (1978) and used to calculate the variance of the quantity  $Q_t/M_o$ , expressed as  $\sigma_q^2$ . The munitions included in this analysis were only those where the mass of Zn or P aerosolized,  $M_x$ , was less than mass burned,  $\Delta M$ , as discussed previously. An example of how the variance of  $Q_t/M_o$  (or  $\sigma_q^2$ ) is calculated is given below for the zinc munition 155mm HC M1 canister.

Step 1. Calculate the covariance of the munition yield fraction (E) and relative humidity (h) for trials B1R1 and B2R1. The values for E and h are given in Table B-2. Equation B-3 is the definitional formula for covariance; the computation formula is:

$$COV_{E, h} = \frac{N(\Sigma E \cdot h) - (\Sigma E)(\Sigma h)}{N^2}$$

$$COV_{E,h} = \frac{2([0.12 \times 0.76] + [0.11 \times 0.72]) - ([0.12 + 0.11][0.76 + 0.72])}{2^2}$$
$$= \frac{0.3408 - 0.3404}{4}$$
$$= 1 \times 10^{-4}$$

Step 2. Calculate Y' according to Equation B-8 where y, the yield factors (YF), are 5.2 and 5.0, and h, the fractional relative humidity, is 0.76 and 0.72.

$$Y' = \frac{\Delta y}{\Delta h}$$
$$= \frac{5.2 - 5.0}{0.76 - 0.72}$$

# Table B-2<sup>a</sup>

variance	of	the	Ratio	of	the	Emission	Rate	to	the	Initial
	M	ass,	(Q <sub>t</sub> /M	)	for	Selected	Munit	ion	S	

Munition	Trial	Munition <sup>b</sup> Yield Fraction	Relative n Humidity	Yield <sup>C</sup> Factor	Variance of <u>Qt</u> M <sub>o</sub>
155mm HC M1	B1R1	. 12	76	5 2	
Canister	B2R1	. 11	72	5.0	2.15 x $10^{-3}$
155mm HC M2	B3R1	. 18	75	52	
Canister	B4R1	. 20	75	5.2	5.41 x $10^{-3}$
105mm HC	B15	. 13	73	5 1	
Canister	B16	. 19	73	5.1	4.68 x $10^{-2}$
81mm Navy RP	B11	. 55	70	6.6	
Wedge	B12	. 52	80	7.8	0.160

a. Data taken from Tables III and IV in DPG (1978) for the field experiments conducted at the horizontal grid.

b. MYF values are from the wind tunnel data for the particular munitions.

c. Estimated values from Figure B-3 for ZnCl<sub>2</sub> (Curve C) and for the theoretical curve for white phosphorus and red phosphorus (Curve A).

Step 3. Calculate  $\sigma_q^2$  according to Equation B-7. The variance of E, the munition yield fraction, is

$$\sigma_{\rm E}^2 = 2 \times 10^{-4}.$$
 Equation B-7 is as follows:  
$$\sigma_{\rm g}^2 = \overline{Y} \sigma_{\rm E}^2 + \overline{E} Y' \sigma_{\rm h}^2 + 2\overline{E} \overline{Y} Y' \text{COV}_{\rm Eh}$$

and by making the following substitutions:

$$r_q^2 = (5.1)^2 (5 \times 10^{-5}) + (0.115)^2 (5)^2 (8 \times 10^{-4}) + 2(0.115) (5.1)$$
  
(5)(1 × 10^{-4})  
= 2.15 × 10^{-3}

Interpretation of the variance estimates is limited by the potential error in the munition yield fraction (MYF) values and the limited amount of data (n = 2) for each type of munition. However, some summary comments can be made about these data and this approach to calculating variance. The variance of the 81mm Navy red phosphorus wedge is larger than the three zinc based munitions (zinc oxide-hexachloroethane-aluminum). The cause of this difference could be due to the type of munition. For example, the red phosphorus MYF is larger than the MYF for zinc munitions. Further, for phosphorus munitions the relative humidity on the two days of red phosphorus tests differed by 10% where as for two of the zinc munition tests it was constant. If there is no variation in relative humidity the variance of q is the product of the mean of the yield factor and the variance of the MYF (see Equation B-7).

Bevington (1969) defines the standard deviation,  $\sigma$ , as the estimated error or uncertainty of a parameter. When a parameter, e.g., x, is a function of two or more other variables (x = ab) the standard deviations of a and b, when combined, give the uncertainty of x. To put the standard deviation values for each munition in perspective, Table B-3 presents the mean emission rates integrated over time, the standard deviation,  $\sigma$ , (as calculated according to Equation B-7), and the standard deviation expressed as a percentage of the mean. This table shows that the emission rates of the two 155mm HC (zinc) canisters (M1 and M2) have the least uncertainty and the 105mm HC (zinc) wedge has the greatest uncertainty. The uncertainty of the Simm Navy RP wedge is only slightly greater than the 155mm HC canisters.

## Table B-3

Comparison of the Mean and Standard Deviation

# of the Ratio of the Emission Rate to the Initial Mass $\begin{pmatrix} Q_t \\ \overline{M}_o \end{pmatrix}$

Munition	Mean $\frac{Q_t}{M_o}$	Standard Deviation of $\frac{Q_t}{M_o}$	Standard Deviation as a % of the mean
155mm HC M1 Canister	0.587	0.046	7.8
155mm HC M2 Canister	0. 962	0.074	7.7
105mm HC Canister	0.817	0.216	26.6
81mm Navy RP Wedge	3.844	0.40	10.4

•  $Q_t$  is integrated over the burn time, thus the quantity  $\frac{Q_t}{M_o}$  is actually Q<sub>t</sub>. M<sub>b</sub>.t<sub>b</sub>.

An approach to evaluating emission test results from future experiments would be to compute the 95% confidence interval (95% CI =  $\overline{x} \pm 1.96\sigma$ ) of the quantity  $\frac{Q_t}{M_o}$  for each munition. If a subsequent experiment produced a  $\frac{Q_t}{M_o}$  value outside of the confidence interval, than it could be concluded that the munition was significantly different from the original sample of munitions. Ideally, a larger dataset than that currently available would be necessary to assure that the standard deviations were stable.

An interesting comparison can be made between these results and the findings presented in Methodology Investigation Final Report, Validation of Transport and Dispersion Model for Smoke (DPG, 1979). In DPG, (197<sup>°</sup>), modeled concentrations along the line of sight (CL) were compared to field measurements as well as comparisons between measured and modeled concentration line integrated dosage (CLID). DPG (1979) reports that the CLID were consistently underpredicted for the zinc based munitions (HC) by a factor of 1.4-1.5 and overpredicted by a factor of 2 for the red and white phosphorus munitions. A comparison of these air dispersion modeling results to standard deviations of the source term (presented in Table B-3) shows a similar relationship among munitions. The zinc based munitions exhibited less variability than the red phosphorus munition. One hypothesis which could partially explain the discrepancies in the modeled versus measured comparisons in DPG (1979) is uncertainty in source terms. The red phosphorus has the largest uncertainty (as measured by the standard deviation) and it also shows the greatest difference between measured and modeled values. The large uncertainty in the red phosphorus source term may account for a portion of the uncertainty in the modeled red phosphorus concentrations.

#### 4. Conclusions and Recommendations

The smoke munitions data from DPG (1978) have been reviewed and a method for estimating uncertainty, as expressed as the standard deviation, in the emission rates has been presented. Available data for the present analysis is limited, but the approach to variance estimation is applicable to larger data sets. The quality of the smoke munitions data is suspect due to design problems with the wind tunnel. The number of tests conducted on each munition, n = 2, means the variance computations are not stable. The uncertainty

analysis of the source terms indicated that the 105mm HC munition has the largest uncertainty, being slightly more than 3 times the uncertainty of the 155mm HC munitions and 2.6 times the 81mm Navy RP wedge. For the two 155mm HC canisters, the relative humidity was constant for the M2 test runs and varied for the M1 test runs. However, when uncertainty is expressed by the standard deviation as a percent of the mean, the two munitions have almost the same uncertainty.

Two recommendations can be made based on the preceding analysis. First, the munition yield factor should be determined in an accurate and precise manner. This variable is critical, as it is applied to all the field test data. Second, to assess meaningfully the uncertainty in the emission rate values, more than two sets of data must be available for the results to be more stable, and thus reliable.

To use this technique of computing variance to evaluate munition variability, the following plan is suggested. Assuming the wind tunnel design issue has been resolved and accurate MYF's determined, field data from numerous test burns should be collected. This should be done at the horizontal grid, but without simultaneous aerosol and meteorological monitoring. This is because to compute uncertainty for the emission rate value, the only parameters needed are initial weight, M, munition yield fraction, and yield factor (as computed based on relative humidity); thus only M and % RH would need to be recorded. Numerous burns for each type of munition should be conducted, e.g., N = 30. Tests should be conducted under as wide a range of humidities as possible. Such a database could then be used to compute robust variance and 95% confidence intervals. Subsequent test results would be compared to this confidence interval to determine if the emission rate is statistically different. Further, with sufficient data to compute stable variances, these values could be incorporated into an expression with meteorological variances to compute overall model uncertainty.

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# APPENDIX B-2

# ANALYSIS OF FOG-OIL SMOKE EMISSIONS

# Appendix B-2

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# Analysis of Fog-Oil Smoke Emissions

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### Appendix B-2

Analysis of Fog-Oil Smoke Emissions

#### 1. Introduction

This analysis focuses on the fog-oil smoke generator emission rates as tested at the Dugway Proving Ground in March and April, 1985 (Liljegren et al., 1988). Liljegren et al. (1988) reported the details of how the experiment was conducted. Only the method of computing the emission rate will be addressed here. The objectives of this analysis are threefold: (1) to assess the variability in the emission rate from the fog-oil smoke generator, (2) to compare two methods of computing the emission rate, and (3) to evaluate the influence of averaging time on emission rate variability.

#### 2. Method

The fog-oil smoke emission data were taken from Liljegren et al. (1988). The configuration of the smoke test provided for the "instantaneous" measurement of the emission rate based on the weight loss of the oil drum and the exit velocity of the generator. Due to mechanical difficulties, the weight loss values are actually 1-minute averages, as opposed to "instantaneous" values. Plots of these data (and exit temperature) versus time for seven experiments were reported in Figures 3.2 through 3.8 in Liljegren et al. (1988). (For reference, copies of those figures are included, with the original figure numbers.) These data were digitized and the means,  $\bar{x}$ , and standard deviations,  $\sigma$ , were computed for each experiment. These values and the coefficient of variation  $(\sigma/\bar{x})$  for each test are presented in Table B-1. Some experiments were screened to remove values which were approximately zero at the end of the test. Otherwise, the data reflect the actual emissions for the duration of the experiment.

Liljegren et al. (1988) computed a time integrated emission rate based on the total mass of oil burned divided by the duration of operation of the smoke generator. These values, taken from Table 3.1, are shown in Table B-2.

To evaluate the influence of averaging time on the variability in the emission rate, the emission rates were re-calculated based on averaging times up to 510 seconds. To do this the data were processed through a program which





















Figure 3.6. Exit Temperature (°C) and Release Rate (g/s) as a function of time for test T0007 (5 April 1985). "Taken from Liljegren et al., (1988)".

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# Table B-1

# Variation in Instantaneous (i.e., one-minute averaged) Fog-Oil Smoke Emission Rates

Figure No.	Test No.	Average Instantaneous Emission Rate (g/s)	Standard Deviation	Coefficient of Variation
3.2	T0003	21.7	10.9	0.5
3.3	T0004	33.8	8.9	0.3
3.4	T0005	21.5	5.9	0.3
3.5	T0006	31.1	4.2	0.1
3.6	T0007	30.9	7.5	0.2
3.7	T0008	37.9	7.5	0.2
3.8	T0009	37.9	16.8	0.4

# Table B-2

# Comparison of Integrated and Averaged Instantaneous Methods of Calculating Emission Rates

Figure No.	Test No.	Integrated . Emission Rate (g/s)	Average Instantaneous Emission Rate (g/s)	Percent Difference
3.2	T0003	24. 3	21.7	-12
3.3	10004	22.5	33.8	+33
3.4	T0005	22.4	21.5	-4
3.5	T0006	28.7	31.1	+8
3.6	T00C7	30.7	30.9	-0.1
3.7	T0008	36.3	37.9	+6
3.8	T0C09	43.2	37.9	-12

Taken from Liljegren et al., (1988), Table 3.1

interpolated the emission rate at 30 second intervals from the existing data which are at approximately one minute intervals. From this processed data, means and standard deviations were computed by grouping the data at 30 sec, 60 sec, 90 sec, etc. increments up to 510 seconds (8.5 minutes). To evaluate how the variability changed with averaging time, the following equation was used

$$R' = \left(\frac{\sigma_{i \text{ sec}}}{\sigma_{30 \text{ sec}}}\right) \tag{B-1}$$

where  $\sigma_{isec}$  is the standard deviation for the i-th averaging time (i = 60 sec, 90 sec, 120 sec, 510 sec) and  $\sigma_{30sec}$  is the standard deviation from the 30 second averaging time.

3. Results

The first objective of this analysis is to evaluate the variance in the fog-oil generator emissions. Table B-1 shows that the variation in the emission rate, expressed as the standard deviation, can be large. The coefficient of variation (CV) normalizes the standard deviation by the mean. Test T0006 has the smallest CV - 0.1. Tests T0003 and T0009 have the largest CV's, 0.5 and 0.4 respectively. During these tests the smoke generator malfunctioned and the emissions were particularly erratic (see Figures 3.2 and 3.8).

The second objective of this analysis is to compare the methods for calculating the average emission rate. Table B-2 shows a comparison of the two methods of computing the mean emission rate. Liljegren et al. (1988) calculated the time integrated average by dividing the mass of oil burned by the duration of operation of the smoke generator. Our approach averaged the "instantaneous" 1 minute emission rates, as digitized from plots. The percent difference between the two methods ranges from -12% to +33%. The largest difference in the computed emission rates is for experiment TO004. A review of Figure 3.3 and the digitizing indicates that there were no errors in that step and that the mean rate of 33.8 g/sec accurately reflects the data in the plot. It is hypothesized that there may be an error in the field data relating to oil burned or duration of operation of the smoke generator, which may have caused Liljergren et al. to compute a lower emission rate. (In addition, Liljergren et al. note that the data for this experiment were divided into two groups based on a shift in wind direction. It is not clear

how this was done of if this would affect the emission rate calculation. The smallest difference was for TOOO7, an experiment when the smoke generator functioned in a very consistent mode (see Figure 3.6). There does not appear to be a bias in the Liljegren et al. method, with their approach producing a higher mean rate four times and a lower rate three times. The  $r^2$  for the two methods of computing the emission rate is 0.56. This means the time integrated method of computing emissions can only account for 56% of the variance in the method based on averaging the "instantaneous" values.

The third objective of this analysis is to evaluate how the variablity in the emission rate changes with averaging time. The data from five experiments, T0005 (Figure 3.4) through T0009 (Figure 3.8), were analyzed using equation (B-1). Two experiments, T0003 and T0004 (Figures 3.2 and 3.3, respectively), were excluded from this analysis due to insufficient data. Table B-3 presents the squared standard deviation ratios by averaging time for the five experiments as well as the median ratio for each averaging interval. These data are plotted in Figure B-1, with the solid line representing the median value and the minimum and maximums represented by the boxes.

A theoretical curve is also plotted in Figure B-1, representing the equation:

$$\frac{\sigma^2(T_a)}{\sigma^2(30s)} = \frac{1 + 30 s^2 T_I}{1 + T_a^2 T_I}$$
(B-2)

where  $T_I$  is the integral time scale of the physical process. This equation is based on work by G.I. Taylor in the 1920's and is further discussed in Section VIII of the main text. This theory assumes that the time scales of the fluctuations cover a wide range of values, and the time series data in the figures verify that this is the case. An integral scale,  $T_I$ , of 150 seconds provides the best fit to the data in Table B-1.

#### 4. Conclusions

This analysis shows that the variation in the one-minute averaged emission rate from the fog-oil smoke generator can vary from 10% to 50% of the mean rate, based on the coefficient of variation. From the comparison of the two methods of computing the emission rate, it appears that when the smoke

Table P-2	Ta	ble	B-3
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Variations in Emission Rate with Averaging Time

		Squared	i Standard	Deviation	Ratios	
Averaging Times (s)	T0005	T0006	10007	T0008	T0009	Median Ratio
30.	1.000	1.000	1.000	1.000	1.000	1.000
60.	0.879	0.848	0.934	0.922	0.950	0.9220
90.	0.858	0.746	0.837	0.806	0.932	0.8370
120.	0.738	0.605	0.745	0.774	0.872	0.7450
150.	0.639	0.465	0.695	0.823	0.823	0.6950
180.	0.649	0.473	0.696	0.697	0.818	0.6960
210.	0.609	0.415	0.574	0.716	0.804	0.6090
240.	0.652	0.388	0.537	0.551	0.752	0.5510
270.	0.627	0.460	0.574	0.560	0.747	0.5740
300.	0.554	0.356	0.534	0.524	0.636	0.5340
330.	0.544	0. 319	0.506	0.483	0.666	0.5060
360.	0. 523	0.267	0.518	0.670	0.742	0.5230
390.	0.529	0.300	0.484	0.426	0.498	0.4840
420.	0.557	0.334	0.537	0.680	0.391	0.5370
450.	0.481	0.303	0.484	0.411	0.384	0.4110
480.	0.510	0.278	0.436	0.469	0.573	0.4690
510.	0.492	0.318	0.444	0.700	0.650	0.4920

$$R' = \left(\frac{\sigma_{i \text{ sec}}}{\sigma_{30 \text{ sec}}}\right)^2$$



Figure B-1. Variation of emission rate fluctuation variance with averaging time. The solid line represents the median of the five experiments and the stars represent the range at that averaging time. The dashed line represents the theoretical curve given by Equation (B-2).
generator is operating in a consistent manner, both computational methods produce the same result (e.g., T0007, Figure 3.6). However, when the smoke generator malfunctions (e.g., T0003 and T0009, Figures 3.2 and 3.8, respectively), emissions can be highly variable, and the method of Liljegren et al. will over estimate emissions relative to our method of averaging "instantaneous" emissions. An analysis of the emission rate variability with different averaging time showed that a time interval of 150 seconds best represented the experimental data.

5. References

Liljegren, J.C., W.E. Dunn, G.E. DeVaull, A.J. Policastro, <u>Field Study of</u> <u>Fog-Oil Smokes</u>, Supported by U.S. Army Medical Research and Development Command, Fort Detrick, MD, January, 1988.

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# APPENDIX C

# UNCERTAINTIES IN SOURCE EMISSION RATE ESTIMATES USING DISPERSION MODELS

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## UNCERTAINTIES IN SOURCE EMISSION RATE ESTIMATES USING DISPERSION MODELS

## STEVEN R. HANNA, JOSEPH S. CHANG and DAVID G. STRIMAITIS Sigma Research Corp., 234 Littleton Rd., Suite 2E, Westford, MA 01886, U.S.A.

### (First received 7 April 1990 and in final form 5 June 1990)

Abstract—The source emission rates during the Prairie Grass dispersion experiments were carefully observed and were adjusted by the experimentalists so that they were about twice as high during unstable conditions as during stable conditions. The question was asked whether observed concentrations and meteorological conditions could be used in dispersion models in order to predict source emission rates and verify this factor of two difference. Three types of simple dispersion models were applied to this problem, with the result that for the model based on Monin–Obukhov similarity theory, the uncertainties in predictions of source emission rates for individual runs were at best about  $\pm 10-20\%$  when observed cross-wind integrated concentrations from the 50 m arc were used. Consequently this model could discern the factor of two difference in average source emission rates for the two sets of field trials which consisted of about  $\pm 70\%$  to a factor of two in predictions for individual runs, and hence could not discern the difference in average source emission rates and hence could not discern the difference in average source emission rates for individual runs, and hence could not discern the difference in average source emission rates when concentration observations at downwind distances of 100-300 m are used. It is found that the use of observed cross-wind integrated concentrations of source emission rates when concentrations, for the uncertainties in predictions of source emission rates are about a factor of two larger when the observed point concentrations are used.

Key word index: Dispersion models, uncertainties in models, source emission estimates.

#### **OBJECTIVE AND METHODS**

As source emission rates for air pollutants are seldom well-known, air pollution control decisions must often be made based on observations of air pollution concentrations on monitoring networks. Observed concentrations can be combined with meteorological observations (e.g. wind speed and direction, stability, and mixing depth) and used in so-called hybrid source-receptor models in order to estimate source emission rates (Watson, 1989). These models are based on the concept that atmospheric transport and dispersion models are a mathematical link between observed concentrations and predicted source emission rates.

The specific objective of this research, funded by the U.S. Army, is to develop methods for estimating whether there is a significant difference in the source emission rate of similar types of sources from one experiment to another. For example, a typical source might be a fog oil generator (used for smoke obscuration purposes), and the question may be whether the source characteristics of the log oil generator have significantly changed between 1980 and 1990. It is assumed that the source emission rate is not directly measured, but that several field trials are carried out at the same site in 1980 and in 1990. In each field trial, cross-wind integrated concentrations are observed at a distance 100 m downwind of the source, and wind velocities, turbulence, and vertical temperature gradients are observed on a tower near the source. The source position and orientation is not varied. Some

data of this type exist, and the procedures will eventually be tested with these data: however, first we have chosen to apply the source emission rate estimation methods to a simpler data set.

The Prairie Grass dispersion experiments produced a high-quality database (Barad, 1958) that has been used extensively in the development and testing of dispersion models. The experiments were simple, with near-ground-level continuous point sources, and extensive concentration and meteorological observations were made over the flat, homogeneous terrain. Source emission rates were also reported, and were deliberately varied so that they were twice as high during the day as during the night. Because of the care with which the Prairie Grass experiments were conducted, this database serves as an excellent test bed for study of the uncertainty in source emission rate estimation procedures. If the procedures cannot discern the known factor of two difference in average source emission rates in this highly controlled set of experiments, it would be of little use at more complicated sites, where the terrain may be more complex and the observations are likely to contain more errors.

Three representative dispersion models are used to relate observed concentrations and meteorological conditions to source emission rates. The three models include a statistical regression model, a Monin– Obukhov similarity model, and a Gaussian plume model. The Student-t test is used to determine whether the models can discern a factor of two difference, at the 95% confidence level, between average night and day

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source emission rates. Another output of this procedure is an estimate of the typical error or uncertainty the source emission rate estimate.

#### DESCRIPTION OF PRAIRIE GRASS DATABASE

Barad (1958) discusses the Prairie Grass database in great detail. SO<sub>2</sub> tracer gas was released over periods of about 10 min from a point source located at an elevation of 0.45 m. Ten minute averaged tracer concentrations were obtained from measurements observed at an elevation of 1.5 m along arcs at distances of 50, 100, 200, 400 and 300 m from the source. Supporting meteorological observations were made from a nearby tower, located in a flat area, representative of the site, where the average surface roughness,  $z_0$ , was determined to be 0.6 cm. Data from 44 experiments were used in our analysis, covering a wide range of meteorological conditions. The data are approximately equally divided into unstable and stable periods.

The Prairie Grass data are listed in Table 1, based on information in the report by Barad (1958) and in papers by van Ulden (1978), Nieuwstadt (1980), and Briggs (1982). The 2 m wind speed, u, the 2 m standard deviation of wind direction fluctuations  $\sigma_4$ , and the 16 m to 2 m temperature difference. DT, were given in Barad's (1958) report, and the friction velocity,  $u_{\pm}$ , and the Monin-Obukhov length, L, were estimated by van Ulden (1978). The mixing depth and convective scaling velocity,  $w_{a}$ , were calculated for most unstable experiments by Nieuwstadt (1980). The stability class, SC, is estimated using observations of surface roughness, z<sub>o</sub>, Monin-Obukhov length, L, and Golder's (1972) nomogram. Briggs (1982) carefully reviewed all of the data and suggested that certain arcs for some experiments be removed from the data set because of problems with those particular data. At each downwind distance, the table lists observations of  $C_iQ_i$  $C^{\gamma}/Q$ , and  $\sigma_{\gamma}$ , where C is the maximum concentration on that arc,  $C^{\gamma}$  is the cross-wind integrated concentration and  $\sigma_{y}$  is the standard deviation of the lateral concentration distribution. The C' and  $\sigma_{y}$  data were given by Nieuwstadt (1980) for most of the unstable periods. The standard deviation of vertical wind direction fluctuations,  $\sigma_{\phi}$ , has been estimated using boundary layer similarity theory.

#### DISPERSION MODELS

Data from the Prairie Grass experiments (Barad, 1958) were used extensively by Pasquill (1961) and others in the development and testing of a Gaussian diffusion model now known as the Pasquill-Gifford-Turner model (Gifford, 1962, 1968, 1976; Turner, 1967), which is the basis for most decisions regarding air pollution control in the U.S. The data were also part of the database used by Nou (1963) in the development of the empirical OB, DG model, which is the basis of the U.S. Air Force procedures for calculating toxic gas impacts. Because the early data analyses did not make use of Monin-Obukhov similarity modeling or convective scaling concepts, there was a flurry of activity with reanalyses of the Prairie Grass data from this new point of view in the late 1970s (e.g. van Ulden, 1973; Horst, 1979; Nieuwstadt, 1980; Venkatram, 1981; Briggs, 1982). In several of these papers, the new scaling parameters (e.g. the mixing depth, h, the friction velocity,  $u_{e,r}$  and the Monin-Obukhov length, L) were derived by reanalyzing the original field data.

The variety of dispersion models in the references listed above can be grouped into three classes.

- Class 1. Empirical or statistical regression models (e.g. Nou, 1963).
- Class 2. Similarity models (e.g. Briggs, 1982).
- Class 3. Gaussian plume models (e.g. Gifford, 1976).

Because Nou's (1963) empirical or statistical regression formula was based on several other databases besides the Prairie Grass database, and he did not suggest a formula for the cross-wind integrated concentration, we decided not to use his formula directly, but instead we applied a multivariate linear regression procedure to the data in Table 1 in order to derive the foilowing best-fit power-law formulas:

$$C/Q = 0.000137 x^{-1.31} (DT - 10^{\circ} \text{F})^{4.72}$$
(1)

$$C^{\gamma}/Q = 0.00666x^{-1.03}(DT + 10^{\circ}\text{F})^{2.34}$$
 (2)

where C/Q and  $C^{\gamma}/Q$  are in units of s m<sup>-3</sup> and s m<sup>-2</sup>, respectively, x is in units of m and DT is in units of °F. This is the same statistical procedure applied by Nou (1963), and the units for all variables are consistent with those that he used. Nou (1963) also used the 10°F additive factor, which is necessary to prevent negative values of the temperature term. These formulas explain 91 and 84%, respectively, of the variance in the C/Q and  $C^{\gamma}/Q$  observations, where most of the variance is explained by the x term. Note that these formulas are not based at all on physical insights, but are based on least-square fits of linear relationships to the data.

The group of similarity models proposed by van Ulden (1978), Horst (1979), Nieuwstadt (1980), Venkatram (1981) and Briggs (1982) is based on applications of Monin-Obukhov similarity theory and convective scaling similarity theory. According to Monin-Obukhov similarity theory, the following functional relations can be postulated for dispersion from continuous ground-level point sources in the surface boundary layer (Briggs, 1982):

$$Cu_{+}x^{2}/Q = f_{1}(x/L)$$
(3)

$$C^{\gamma}u_{\bullet}x/Q = f_2(x/L) \tag{4}$$

where  $f_1$  and  $f_2$  are non-dimensional universal functions. The friction velocity,  $u_{a_1}$  and the MoninTable 1. Prairie Grass database for 44 experiments, including observations of wind speed, u, and standard deviation, o, at 2 m, temperature difference DT= T(16 m) – T(2 m), and mixing depth, A. Derived values of friction velocity, u, convective scaling velocity, u, Monin-Obukhov kngth, L, and stability class, SC, are listed. Observations on five monitoring ares (x = 50, 100, 200, 400 and BD m) of ocak mortalized concentration. C(0, cross wind intertated concentration. C/0, cross wind intertated concentration. C(0) end lateral standard deviation. o. are also eiven. If a blank appears, then that roise of data is

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(5)

Obukhov length. L, are the fundamental scaling velocity and scaling length in the surface boundary layer, according to Monin-Obukhov similarity theory. The Prairie Grass data are plotted in Fig. 1 in the dimensionless forms suggested by Equations (2) and (3), illustrating that the data are ordered quite well by these similarity relations.

Because the data in the four parts of Fig. 1 appear to approach a constant as x/L approaches zero, the following functional relation is proposed:

$$f(x/L) = a(1 + bx/L)^{\epsilon}.$$

A least-squares algorithm was applied to each figure, with the following results:

$$f_1(x/L) = 3.37(1 - 0.019x/L)^{-1.36} \qquad x/L < 0 \qquad (6)$$
  
$$f_1(x/L) = 3.01(1 - 2.20x/L)^{0.57} \qquad x/L > 0 \qquad (7)$$

$$f_1(x/L) = 3.01(1 + 2.20x/L)^{0.57} x/L > 0 (7)$$

$$f_2(x/L) = 1.06(1 - 0.021x/L)^{-1.74} x/L < 0 (8)$$

$$f_2(x/L) = 1.07(1 + 0.10x/L)^{0.68} \qquad x/L > 0.$$
(9)

provide a good fit at all values of x/L. However, they have been derived with no requirements that certain physically-based asymptotic functional relationships be satisfied. For example, Briggs (1982) points out that  $f_2(x/L)$  should be proportional to  $(-x/L)^{1/2}$  in the limit of free convection  $(-x/L \rightarrow \infty)$ . Consequently, Briggs' (1982) suggests a third term in Equation (5), which he claims to better account for "convective sweep-out" of the plume at large |x/L|. The similarity model is represented by Equations (6)-(9) in our analysis rather than the equations proposed in any of the above references because the other equations are based on a slightly different subset of the Prairie Grass database.

The Gaussian plume models comprise the third class of models in our analysis. The Gaussian model is based on the formulas (Gifford, 1976)

$$C/Q = (\pi u \sigma_y \sigma_z)^{-1} \exp(-(z_y - z_z)^2/2\sigma_z^2)$$
(10)

$$C^{\gamma}/Q = (2/\pi)^{1/2} (u\sigma_z)^{-1} \exp(-(z_s - z_r)^2/2\sigma_z^2). \quad (11)$$

These curves are drawn on the figures and appear to The source height, z, and receptor height, z, equal





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0.45 m and 1.5 m, respectively, in the Praine Grass experiments. The wind speed, *a*, is assumed to be that measured at a height of 2 m (see Table 1). The values for lateral and vertical dispersion coefficients,  $\sigma_y$  and  $\sigma_z$ , that are substituted into Equations (10) and (11) are based on suggestions by Briggs (1973), who used the Prairie Grass experiments, along with many other field experiments, in their derivation. These  $\sigma_y$  and  $\sigma_z$ formulas are given in Table 2. The required stability class is found in Table 1 for each Prairie Grass test.

Note that the empirical and similarity classes of dispersion models have been best-fit to the exact same data (Table 1) that will be used for further testing. The Gaussian plume model has not been subjected to these same best-fit procedures, but has been based on data from many experiments. Because of these differences in databases used to derive the models, it is expected that the Gaussian plume model will have the least success in any comparisons with field data from the Prairie Grass database.

The dispersion models in Equations (3) and (4) and (6-(10) are inverted in order to predict source emission rates:

$$Q_p = C_{\alpha'}(C,Q)_p \tag{12}$$

$$Q_{p} = C_{p,i}^{r} (C^{r}/Q)_{p},$$
 (13)

where subscripts o and p represent observed and predicted variables, respectively. Because of the characteristics of the multiple linear regression or least-squares statistical procedures, an equation that produces a best-fit for C/Q or C'/Q may not necessarily product a best-fit for Q. These statistical procedures attempt to minimize the mean-square error and to force the mean of the observed variable to equal the mean of the predicted variable. We should therefore not be surprised if an equation which produces zero mean bias in C/Q is discovered to produce a mean bias of 20-30% or more in Q.

#### STATISTICAL PROCEDURES

A primary objective of this research is the development of methods for estimating whether there is a significant difference in the source emission rate of similar types of sources from one experiment to another, as determined by observations of meteorological conditions and of point concentrations or cross-wind integrated concentrations. Dispersion models, such as the three presented above, can be used to remove the effects on the concentration observations of variations in meteorological parameters and downwind position of the concentration monitor.

A listing of the observed source emissions. Q, during the Prairie Grass experiment is given in Table 1, and the data are plotted in Fig. 2 as a function of the stability parameter 1/L (the point for run 46 has been excluded, since it was an evening transition period when Q was still high although 1/L had just become positive). During the Prairie Grass experiment the night-time emissions. Q, of tracer gas were controlled so that Q averaged 45.2 g s<sup>-1</sup> with a range from about 38 to 58 gs<sup>-1</sup> and a standard deviation of 5.91 gs<sup>-1</sup>. and the daytime emissions were controlled so that Qaveraged 98.25 gs<sup>-1</sup> with a range from about 90 to 105 gs<sup>-1</sup> and a standard deviation of 4.48 gs<sup>-1</sup>. The experimentalists deliberately maintained this fact( of 2 difference in day-night Qs so that the magnituc ŕ concentrations at the monitors would not vary much from day to night. With 19 stable (night) runs and 20 unstable (day) runs, the Student-t parameter (Panofsky and Brier, 1968, p. 63) can be calculated in order to determine if the daytime  $\overline{O}$  is significantly

$$t = (\vec{Q}_4 - \vec{Q}_n) : \left(\frac{N_4 \sigma_4^2 - N_5 \sigma_{21}}{N_4 - N_5 - 2} \left(\frac{1}{N_4} - \frac{1}{N_5}\right)\right)^{1/2} \quad (14)$$

different from the night-time  $\vec{Q}$ :

where subscripts d and n indicate day and night. If it is less than 2.04, then the difference  $(\bar{Q}_d - \bar{Q}_n)$  is not significantly different from zero, at the 95% confidence level. In fact, using the observed  $\bar{Q}$  and  $\sigma_{Q}$ 



Fig. 2. Observed tracer gas source emission rates,  $Q_1$  as a function of inverse Monin-Obukhov length, 1/L for the Prairie Grass data (run 46 excluded).

Table 2. Formulas recommended by Briggs (1973) for  $\sigma_1$ , and  $\sigma_2$ , for rural conditions

Stability class	σ,(m)	$\sigma_z(m)$
	$0.22x(1-0.0001x)^{-1/2}$	0.20x
в	$0.16x(1+0.0001x)^{-1/2}$	0.12x
С	$0.11x(1+0.0001x)^{-1/2}$	$0.08x(1+0.0002x)^{-1/2}$
D	$0.08x(1+0.0001x)^{-1/2}$	$0.06x(1-0.0015x)^{-1/2}$
ε	$0.06x(1-0.0001x)^{-1/2}$	$0.03xt1 + 0.0003xt^{-1}$
F	$0.04x(1-0.0001x)^{-1/2}$	$0.016x(1-0.0003x)^{-1}$

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figures quoted above, the calculated Student-t parameter is 30.86 for the difference between the mean night-time and daytime emission rates, which implies that the difference is significant at far greater than the 95% confidence level.

Because there is such a clear difference in the observed day and night tracer gas source emission rates. Q, at the Prairie Grass site, it is interesting to ask whether the dispersion models would be able to predict this significant difference in the mean emission rates, based on observed concentrations and meteorological variables. The three types of models described earlier were used to prepare predictions of source emission rate,  $Q_p$  (one set of predictions using  $C_a$  and another set using  $C_{2}^{*}$ ). This calculation of  $Q_{2}$  was made individually using data from each of five monitoring arcs (50, 100, 200, 400 and 300 m) for  $C_{0}$ , and each of three monitoring arcs (50, 200 and 800 m) for C<sup>\*</sup><sub>2</sub>. For each set of predictions, values of night-time and daytime  $\bar{Q}_{o}$  and  $\sigma_{Q_{o}}$  were calculated. Then Equation (14) was used to calculate the Student-t parameter. If the resulting t value exceeds 2.04, it is concluded that the model successfully simulated the difference in source emission rates. If t is less than 2.04, then it is concluded that the model has failed to simulate the difference.

Besides investigating the day-night difference in mean source emission rate predictions, it is also of interest to investigate the ability of the models to predict emission rates for all Prairie Grass runs taken as a group. For this purpose, the following performance measures are calculated (where an overbar represents an average over all the database).

Relative bias: 
$$(\bar{Q}_{o} - \bar{Q}_{o})/\bar{Q}_{o}$$
.

Correlation: 
$$r = (\overline{Q_p} - \overline{Q_p})(Q_s - \overline{Q_s})/\sigma_{Q_p}\sigma_{Q_p}$$

Fractions of predictions,  $Q_{p_1}$ , within a factor of two of observations,  $Q_{q_2}$ .

Normalized mean square error: 
$$(Q_p - Q_s)^2 / \bar{Q}_p \bar{Q}_s$$

These performance measures are tabulated for each model and for  $C_o$  and  $C_o^r$  on each monitoring are. In addition, the individual residuals  $(Q_p - Q_o)$  are plotted as a function of downwind distance for each model.

### **RESULTS AND CONCLUSIONS**

Predictions of average daytime and night-time source emission rates

The procedures for estimating the daytime and night-time average source emission rates reviewed above were applied to the Prairie Grass database, with the results given in Tables 3 and 4, for  $C_0$  and  $C_0^*$ , respectively. By comparing the numbers in the two tables, it is evident that use of the observed cross-wind integrated concentration,  $C_0^*$ , produced better results than use of the observed point concentration,  $C_0$ . The standard deviations,  $\sigma_{2P}$ , of the predicted source emission rates are about 50% larger during the night, and a factor of 2 or 3 larger during the day, for  $C_0^*$ , than for  $C_0^*$ . Consequently the calculated Student-c parameters are about twice as large for  $C_0^*$  than for  $C_0^*$ , implying that there is more confidence in the concursions for  $C_0^*$ . We expected that there would be a difference, because

Table 3. Predictions of source emission rate, $Q_{g}(gs^{-1})$ , for night-time and daytime Prairie Grass						
ins, using observed maximum concentrations, $C_{22}$ on monitoring arcs at distances of 50, 100.						
200, 400 and 800 m. Three different models are used to calculate $Q_a = C_{\pi}(C,Q)_a$ . The average, $\bar{Q}_a$ ,						
and standard deviation, $\sigma_{20}$ , for night-time and daytime conditions is listed. Student-t is						
calculated using Equation (14)						

	Monitoring		Night (	N = 19)	Day (a	V = 20)
Model	distance (m)	Student	Ø, (g s <sup>−1</sup> )	σ <sub>29</sub> (gs <sup>-1</sup> )	Q, (g s <sup>- '</sup> )	<i>a</i> <sub>Qp</sub> (gs <sup>−1</sup> )
Observed Q		30.86	45.2	5.9	98.2	4.5
Regression	50 100 200 400 800	7.40 5.47 4.27 2.20 - 1.19	30.1 43.8 52.0 61.2 84.2	12.0 19.4 23.0 27.3 51.6	144.6 139.1 128.3 93.4 64.5	64.7 71.6 72.5 56.2 48.9
Similarity	50 100 200 400 300	5.68 4.62 5.51 5.52 4.80	39.9 49.2 48.7 45.8 46.3	14.1 16.2 16.2 15.6 14.6	70.8 84.0 -101.1 105.4 116.2	1 <b>8.5</b> 37.1 37.1 43.2 60.1
Gaussian	50 100 200 400 300	2.40 1.07 0.05 -0.88 -1.67	55.2 76.3 98.1 118.8 150.1	45.5 94.9 150.9 196.3 264.1	15.5 109.2 100.2 76.8 48.0	96.9 92.2 70.1 62.7 30.1

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#### Source emission rate estimates

Table 4. Predictions of source emission rate,  $Q_p(g s^{-1})$ , for night-time and daytime Prairie Grass runs, using observed cross-wind integrated concentrations,  $C_{u}^*$  on monitoring area at distances of 50, 200 and 300 m. Three different models are used to calculate  $Q_p = C_w^*(C^*Q)_p$ . The average,  $\bar{Q}_p$ , and standard deviation,  $\sigma_{Qp}$ , for night-time and daytime conditions listed. Student-*c* is calculated using Equation (14)

	Monitoring		Night (	N = (9)	$Day\left(N=20\right)$		
	distance	Student	<i>Q</i> ,	σ <sub>Qp</sub>	Q.	σ <sub>Qp</sub>	
Model	(m)	(	(g s ¯ ')	(g s <sup>-1</sup> )	(gs <sup>-</sup> ')	(gs <sup>-1</sup> )	
Observed Q		27.27	45.2	5.9	97.8	4.7	
Regression	50	17.19	29.7	9.8	140.1	24.8	
	200	7.43	46.9	16.9	124.8	40.1	
	800	0.58	69.4	34.3	62.1	36.4	
Similarity	50	16.24	39.7	8.3	<b>89.6</b>	9.0	
	- 200	9.54	49.0	9.0	100.1	20.3	
	300	4.38	45.2	13.8	99.6	50.2	
Gaussian	50	6.18	61.7	30.9	161.0	58.4	
	200	2.83	65.5	60.3	116.6	34.9	
	300	-0.99	85.5	145.1	-46.9	20.3	

 $\sigma_{\rm v}$  is another complicating factor included in  $C_{\rm o}$  that would act to increase the uncertainty, but did not expect that the difference would be this large.

The ability of the models to arrive at the proper answer (i.e. that the daytime  $\overline{Q}$  is significantly larger than the night-time  $\overline{Q}$ , with at least 95% confidence) can be seen by identifying cases where  $t \ge 2.04$  in Tables 3 and 4. It is seen that most models are able to reproduce this conclusion at most are distances. However, false conclusions (t < 2.04) are reached for the following arca and models.

<i>C</i> .:	100 m arc:	Gaussian
	200 m arc:	Gaussian
	400 m агс	Gaussian
	800 m ar⊂	Regression and Gaussian.
C?:	800 m arc:	Regression and Gaussian.

It is seen that the use of  $C_0$  and  $C_0^*$  from the closest arc (50 m) leads to the correct conclusion for all three models, with a value for Student-r ranging from 2.4 to 7.4 for  $C_{a}$  and 5.2 to 17.2 for  $C_{a}^{*}$ . The regression and similarity models are seen to be better able to simulate the difference in observed Q (i.e. they yield a higher t) than the Gaussian model. However, the number of false conclusions increases as downwind distance increases. At the 300 m arc in both tables, only the similarity model yields the proper conclusion. Figs 3 and 4 contain extreme examples of plots of predicted source emission rates,  $Q_{p}$ , as a function of 1/L, in the same format as the observations in Fig. 2. The similarity model predictions in Fig. 3, using observations of C' on the 50 m arc. produce patter is similar to the observed data, but with slightly more scatter. However, the Gaussian plume model predictions in Fig. 4, using observations of  $C_2$  on the 800 m arc, obviously miss the overall trend of the observations of Q, as well as containing much more scatter.

The failure of the regression model and the Gaussian model to estimate Q using  $C_0$  and  $C_0^*$  observations



Fig. 3. Tracer gas source emission rates,  $Q_{s}$ , predicted by the similarity model as a function of inverse Monin-Obukhov length, 1/L, for the Prairie Grass data (run 46 excluded). Observed cross-wind integrated concentrations on the 50 m arc are used.



Fig. 4. Gas source emissions rate predicted by the Gaussian plume model.  $Q_{\rm eff}$  as a function of inverse Monin-Obukhov length.  $1/L_{\rm eff}$  for the Prairie Grass data trun 46 exclusion. Observed concentrations on the 300 m arc are used.

at the <sup>1</sup> rest distances may been seen by investigating the variation of the ratio  $C_{\mu}C_{\sigma}$  with distance for the three models for stable and unstable conditions (Figs 5 and 6). The  $C_{\mu}C_{\sigma}$  values for the similarity model have very little trend with distance and are always centered 2978

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198.95





18.28 C<sub>0</sub>/C<sub>0</sub> 1.28 9, 19 ə. J1 18 31 3152 315 x (m) C/Q, Similarity 129.29 19.98 0,0Co 1.28 8, 19 8.91 19 31 1999 3152 122 315 x (m) C/Q, Gaussian 199.99 19.29  $c_{\rm u}/c_{\rm 0}$ 1.28 8.18 8.81 18 31 1222 316Z 122 318

C/Q, Regression

Fig. 6. Ratios of predicted to observed concentrations (C/Q) for the Prairie Grass dataset, as a function of downwind distance, for three models (regression, similarity, and Gaussian) for unstable conditions. N is the number of data points at each distance. The midline of each box plot is the median, and the other lines represent  $\pm$  one and two standard deviations.

x (11)

on 1.0. In contrast, at large distances, the regression and Gaussian models tend to underpredict  $(C_{y}, C_{s} < 1)$ during stable conditions (Fig. 3) and overpredict  $(C_{a}/C_{a} > 1)$  during unstable conditions. It is important to note that a model which overpredicts t tration, C, will underpredict the source em Q. Consequently, at large distances, the regi Gaussian models can be expected to over source emission rate, Q, during stable conditions, and underpredict it during unstable conditions. But since the observed stable  $\vec{Q}$  is about 45 gs<sup>-1</sup> and the unstable  $\vec{Q}$  is about 98 g s<sup>-1</sup>, the  $\vec{Q}$ s predicted by these two models will tend to be either nearly the same, or their relative magnitudes may even be switched. This problem is seen to occur for the Gaussian model on the 800 m arc, using the  $C_{o}$  data, where the following discrepancy is found in Table 3 and can be seen in Figs 2 and 4

Thus the Gaussian model leads to the opposite conclusion regarding daytime and night-time  $\vec{Q}$  differences if the 300 m  $C_o$  data are used. Note that if the experimentalists had controlled the emissions in the that the night-time O exceeded the hese trends in the errors in the issian models would have led to a regarding the differences in Q.

	Night	Day
Observed $\bar{Q}_{a}$	45.2	98.2
Gaussian predicted $\bar{Q}_{a}$	150.1	48.0

Consider the best-performing model in Table 6. where  $C_{c}^{*}$  data from the 50 m are are used in the similarity model to predict the average source emission rate,  $\bar{Q}$  (see Fig. 3). The calculated Student-t value

C - 8

Distance to C.	Model	Q,(gs <sup>-1</sup> )	<u>QQ.</u>	Correlation	Fraction within factor of 2	$\frac{Q_{\bullet}-Q_{\bullet}^2}{\bar{Q}_{\bullet}\bar{Q}_{\bullet}}$
	Observed	72.4				
50 m	Regression	88.8	0.23	0.77	0.82	0.53
	Similarity	55.7	-0.23	0.74	0.90	0.15
	Gaussian	86.1	0.19	0.36	0.80	0.97
200 m	Regression	91.2	0.26	0.59	0.85	0.51
	Simularity	75.6	0.04	0.71	0.92	0.14
	Gaussian	99.2	0.37	0.02	0.74	2.08
300 m	Regression	74.1	0.02	-0.15	0.54	0.70
	Similarity	32.1	0.13	0.65	0.90	0.34
	Gaussian	97.6	0.35	-0.25	0.49	5.75

Table 5. Evaluations of predictions of source emission rate,  $Q_p(gs^{-1})$ , for all Praine Grass runs, using observed maximum point concentrations,  $C_p$ , on monitoring arcs at distances of 50, 200 and 800 m. Three different models are used to calculate  $Q_p = C_{\infty}(C^{-}Q)_p$ 

Table 6. Evaluation of predictions of source emission rate,  $Q_{g}(gs^{-1})$ , for all Prairie Grass runs, using observed cross-wind integrated concentrations,  $C_{s}^{*}$ , on monitoring arcs at distances of 50, 200 and 300 m. Three different models are used to calculate  $Q_{g} = C_{s}^{*}/(C^{2}/Q)_{g}$ 

Distance to $C_{\bullet}$ observation	Model	$\bar{Q}_{p}(gs^{-1})$	<u>QQ.</u> Q.	Correlation	Fraction within factor of 2	$\frac{\overline{2_{\bullet}-2_{\bullet}^{2}}}{\overline{\tilde{2}_{\bullet}\tilde{2}_{\bullet}}}$
	Observed	68.4				
50 m	Regression	78.4	0.14	0.94	0.91	0.23
	Similarity	61.7	-0.10	0.98	1.00	0.02
	Gaussian	106.0	0.55	0.74	0.88	0.55
200 ш	Regression	81.2	0.19	0.80	0.94	0.21
	Similarity	71.6	0.05	0.89	1.00	0.04
	Gaussian.	88.1	0.29	0.46	0.88	0.48
800 m	Regression	66.1	-0.03	-0.07	0.74	0.46
	Similarity	69.2	0.01	0.60	0.88	0.26
	Gaussian	68.4	0.00	-0.15	0.65	2.98

in this case is 16.2. Since  $\bar{Q}_o(day)-\bar{Q}_o(night) \cong 53 \text{ g s}^{-1}$ , it is concluded that a significant difference in  $\bar{Q}$  values could be discerned by this model if  $\Delta \bar{Q}_o = \bar{Q}_o(day)-\bar{Q}_o(night)$  drops as low as  $53 \times (2.04/16.2) = 6.7 \text{ g s}^{-1}$ ; that is. if  $\Delta \bar{Q}_o$  is about 15% of  $\bar{Q}_o$ , Therefore, in these best of research-grade experiments, where there are about 20 daytime and 20 night-time tests, and where a dispersion model is fit to these same data, a day-night difference in  $\bar{Q}$  of less than 15% of the mean would not be estimated to be significant by this procedure.

#### Predictions of source emission rates for all cases

Putting aside the question of differences in daytime and night-time averages in  $Q_i$ , it is possible to use the complete database to estimate the overall ability of the models to estimate the 39 individual source emission rates. The relative bias, the correlation, the fraction of predictions within a factor of two of observations, and the normalized mean square error for the three models are listed in Table 5 and 6, for maximum point concentrations and cross-wind integrated concentrations, respectively. These performance measures are calculated using data from the 50 m, 200 m and 800 m arcs.

In most cases, the similarity model shows the most accuracy and the Gaussian model shows the least accuracy. Also, the use of observed cross-wind integrated concentrations,  $C'_{a}$ , leads to better results than the use of observed point maximum concentrations. The deterioration of model performance as distance increases can also be seen. Focusing on Table 6, for cross-wind integrated concentrations, it is seen that the most accurate model, the similarity model, produces a mean relative bias with a magnitude of 0.10 or less on all three distance arcs. The correlation drops from 0.98 to 0.60 as distance increases from 50 to 300 m, and the fraction within a factor of two drops from 1.00 to 0.88 over the same distance. The normalized mean-square-error increases from 0.02 to 0.26 over those distances, implying that the root-meansquare-error (rmse) increases from about 15% to 50% of the mean. In contrast, the Gaussian model yields a

much larger rmse that increases from about 70% to 300% of the mean.

The factor of 5 or 6 difference in rmse between the similarity and Gaussian models implies that the similarity model can discern differences in source emission rates that are a factor of 5 or 6 less than the minimum differences in source emission rates discerned by the Gaussian model. By comparing these numbers between Tables 5 and 6, it is seen that the relative rmses using  $C_0$  observations are about 50% to 100% larger than the relative rmses using  $C_0^*$ observations. Consequently the use of  $C_0^*$  data permits one to discern differences in source emission rate that are 50% to 100% smaller than the minimum differences in source emission rates discerned by  $C_0$  data.

#### IMPLICATIONS FOR FUTURE RESEARCH

The uncertainties in estimating source emission rates were first investigated using the Prairie Grass database, since the source conditions were simplified (a single continuous non-buoyant point source near the ground), the source emission rate was closely monitored, the site was flat and uniform, comprehensive meteorological data were taken, and observations of ground-level concentrations were taken at many points along monitoring arcs at five downwind distances. This experiment represents the optimum database of its type, and has been used in numerous research programs on atmospheric turbulence and dispersion. For this reason, the uncertainties in any analysis procedure should be minimized at this site. Conversely, if these procedures were to be applied to other experiments at other sites, where conditions are not so steady, smooth, or carefully-observed, the uncertainties would be expected to be larger.

In the future, we will test these procedures using less ideal observations from other field experiments. These will include U.S. Army field tests of fog oil generators, which are used for smoke obscuration purposes. The plumes from log oil generators are more complicated than those in the Prairie Grass experiments, since the fog oil plumes are characterized by significant momentum and buoyancy fluxes. Furthermore, the supporting meteorological data are not as complete as at Prairie Grass. Future tests will also include experimental data obtained for plumes from tall power plant stacks, where plume rise and mixing depth are complicating factors. From each set of experiments, the relative uncertainty of the procedures for estimating source emission rate will be assessed. It is expected that the uncertainty will increase as source conditions become more complex or as input data are less complete.

This study has demonstrated that models that do well (in a least squares sense) in estimating point concentrations do not necessarily do well when they are 'turned around' to estimate source emission rate. The reason for this difference is the strong variation with distance of the plume centerline concentration. Consequently it is possible that a model which has zero mean bias in its concentration estimates, will have a 50% mean bias in its source emission rate estimates. For the same reason, if a variable is first made non-dimensional and the model is 'tuned' with the data (e.g. the similarity model described above), the predictions of the non-dimensional variable (e.g.  $Cu_{\pm}x^2/Q$ ) may have zero bias, while the predictions of the concentration, C, may have significant bias. For optimum results, any tuning or regression analysis should be done with the variable that is of ultimate interest.

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## APPENDIX D

# DISPLAY OF RELATIONS AMONG DATA USING BOX PLOTS

### APPENDIX D

### DISPLAY OF RELATIONS AMONG DATA USING BOX PLOTS

One way of displaying large numbers of data is through the use of box plots, where the cumulative distribution function (cdf) of the dependent variables within a group of data is represented by a set of significant percentile values. For example, the 2th, 16th, 50th, 84th, and 98th percentiles are used in our analyses. These five significant points in the cdf are plotted by the SIGPLOT program using a "box" pattern as seen in the examples below. Variations of one type of data with another can be seen by breaking up the first type of data into groups defined by ranges of the second type of data.

The SIGPLOT plotting package (see Appendix E) is used to generate the box plots. The ANADISTR program, described below, is used to generate the special input file required by SIGPLOT from a file containing multiple columns of data, representing concurrent values of variables such as observations of concentrations, wind speed, or stability. In the ANADISTR program, the user defines certain ranges of the primary variables in the input file to be used for grouping the dependent variables and plotting them by means of box plots. The ANADISTR program requires one input file and generates one output file. The output file then serves as the input file to the SIGPLOT plotting package. There are no default names associated with these files, and the user is prompted for the file names during the execution of the program. The ANADISTR program is written in FORTRAN 77.

The input data file of the ANADISTR program could contain multiple columns of dependent variables (such as concurrent values of concentration observation) and other primary variables such as wind speed and stability. The ranges of the primary variables are also defined in the input file, to be used for grouping the data prior to generating the box plots. Table D-1 describes the format of the input file. Figure D-1 shows an example of an input file. Note that the ANADISTR program makes no corrections or substitutions for missing data: it is the responsibility of the user to provide valid data at each position.

The output file of the ANADISTR program contains distributions (the 2th, 16th, 50th, 84th, and 98th percentiles of the cdf) of the first variable as a function of the second variable. The information stored in this output file can then be plotted using the SIGPLOT plotting package (see Figure D-2 for an example).

During the execution of the ANADISTR program, the following questions will be asked:

• Name of the input file:

The user must specify the name of the input data file here. There is no default answer.

Name of the output file:

The user must specify the name of the output file. There is no default answer.

An input file typically contains several columns of dependent and independent data. The ANADISTR program handles one such column or the ratio of any two columns of dependent data, specified by the user, at a time. This is accomplished by asking the user to select any two columns between 0 and MM, (see Table D-2). The distribution of the ratio of the numbers in these columns will be analyzed. Note that column "0" is simply all 1's, and is not part of the input data file. Therefore, if the user wants to investigate the distribution of the dependent data in column 2, then two integers, 2 and 0 should be entered. If the user wants to investigate the distribution of the dependent data in column 2 to the data in column 1, then 2 and 1 should be entered.

Implement a lower threshold for the dependent variable? (y/n):

The user has the option of specifying a lower threshold for the one dependent variable or the ratio of the two dependent variables chosen above. This is sometimes necessary if the logarithmic scale is to be used and there are zero or minute values in the data whose distribution is to be analyzed. The default (i.e., hitting the RETURN key) answer is "y".

TABLE D-1. FORMAT OF THE MANDATORY INPUT DATA FILE OF THE ANADISTR PROGRAM. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL.

LINE NO.	FORMAT	DESCRIPTION
1	FF/I	There are four integer constants in this line,
		representing the total number of observations (NN, $<$
		501), the total number of dependent variable (MM, <
		16), the total number of blocks (KK), and the total
		number of primary variables (NVAR, < 11). Note that
		KK is not used by ANADISTR since the blocking of data
		is performed internally according to the defined
		ranges of the primary variables. The limits on NN,
		MM, and NVAR are assigned in the program using the
		PARAMETER statements, and can be easily changed.

- 2 FF/I There are KK integer constants in this line, representing the number of pieces in each block. The sum of all these integers should equal NN. Note that the information in this line is currently not used by the ANADISTR program.
- 3 FF/I There are MM character constants in this line; each one can be at most eight characters long, containing the name of each of the dependent variables. All character constants must be enclosed in apostrophes.
- 4 FF/I There should be KK character constants in this line. Each one can be at most 20 characters long, containing the name of each of the blocks. All character constants must be enclosed in apostrophes. Note that the information in this line is not used by the ANADISTR program.

LINE NO. FORMAT

Next NN lines:

FF/R

There are MM+NVAR real numbers in each line, with the first MM numbers representing the dependent variables, and the following NVAR numbers representing of the primary variables.

DESCRIPTION

Next NVAR lines:

FF/

Each line describes the way each of the NVAR primary variables is to be blocked. The first parameter is an integer (IXR, < 21), representing the number of ranges for the primary variable. The second parameter is a character constant, at most 40 characters long, enclosed in apostrophes, representing the name of the primary variable. The next IXR+1 real numbers, in numerical ascending order, define the boundaries of the ranges. For example, the following line:

4 'u (m/s)' 0. 2. 5. 10. 20. means that wind speeds should be divided into four groups where the distribution of the dependent variables within each group is to be calculated. The first group is for those data when wind speeds are between 0. and 2. m/s, the second group is for wind speeds between 2. and 5. m/s, etc.

The limits on IXR are assigned in the program using the PARAMETER statement, and can be easily changed. Note that the sequence of the NVAR lines must be consistent with that of the last NVAR columns described in the previous section. As an example, if the MM+1th column in the previous section contains information for wind speeds, then the first line in this section should also contain grouping information for wind speeds.

79 4 2	4							
39 40	9V19_3/		~ ~ ~					
SUBSET1' SUB	SET2'	JEZVAR	-Cr r Di	EPVAR-(				
616.0 708.7	594.7	516.5	11	3.0	800.	2		
504.1 689.2 868 0 674 9	585.9	496.7	12	3.4	1000.	2		
498.6 668.8	652.1	548.3	14	3.3	1200	2		
393.1 560.2	704.7	581.9	15	4.7	1300.	2		
409.0 740.9	570.1	621.4	16	5.2	1000.	3		
265.3 259.6	463.4	446.0	18	3.4	1100.	3		
192.7 91.6	131.0	485.0	19	4.2	1100	5		
1149.1 1217.5	1116.1	520.6	10	2.6	1600.	2		
1137.5 1225.7	1081.7	536.9	12	3.2	1900.	2		
669.5 1052.8	905.1	637.3	13	4.5	1600	2		
595.5 862.0	862.0	664.1	14	5.0	1500.	2		
612.6 602.4	728.2	672 4	15	5.1	1500.	2		
312.0 398.9	657.5	659.5	17	5.2	1500	3		
400.2 340.2	412.3	586.0	18	5.1	1500.	4		
204.7 012.1	757 9	705.9 708 8	15	5.7	1400.	3		
459.5 355.0	512.3	602.4	18	5.1	2000	4		
444.0 216.0	441.4	681.1	19	4.4	2000.	5		
175.1 216.6	456.1	925.4	20	4.6	2000.	5		
128.8 16.5	233.0	834.9	21	4,9	2000.	6		
200.2 301.9	208.9	728.0	23	5.4	ō.	5		
358.3 481.8	354.0	742.4	24	5.4	٥.	6		
499.3 752.5	921.6	725.7	14	4.4	1500.	2		
537.8 724.0	826.8	675.9	16	4.7	1500	3		
220.0 523.3	908.2	640.8	17	3.9	1800.	3		
4/9.2 35/.3	748.6	344.7 738 5	18	4.2	2000.	4		
98.2 167.3	213.5	1064.9	20	3.2	1500	5		
92.5 104.6	142.2	741.2	21	3.1	1200.	6		
21.0 127.4	176.3	805.2 576 a	22	3.3	1200.	6		
358.0 280.9	188.4	225.3	21	2.3	2000	3		
233.3 355.3	234.9	719.1	22	2.4	2000.	5		
198.3 12.7	184.0	745.2	23	3.6	2000.	5		
313.7 0.0		567.1	24	3.3	2000.	ů á		
165.1 0.0	5.5	703.9	2	3.6	s.	6		
295.6 329.9	454.6	695.3	4	5.2	٥.	6		
454.1 301.0	1.0	995.6	5	2.4	a. 0	6		
240.3 417.5	361.1	933.8	7	3.4	0.	6		
590.8 579.3	144.2	666.5	8	3.1	1500.	5		
949.8 1004.2	805.4	400.1	10	3.4	1500.	4		
886.8 855.6	706.2	517.4	11	3.0	1300.	2		
635.5 761.0	670.9	596.6	12	4.5	1200.	2		
484.7 360.7	226.8	979.0	2	2.3.	1200.	5		
529.7 332.0	202.5	980.0	3	2.4	1200	5		
585.8 291.4	186.1	1100.1	4	2.1	1200.	5		
324.7 270-9	72.7	1058.6	2	2.1	1200.	6 6		
489.0 274.6	208.5	942.2	7	2.6	1200.	6		
570.8 337.1	218.0	646.5	8	2.8	1200.	5		
532.8 414.2	197.9	344.0 477 0	9	4.3	1200.	4		
425.2 365.7	198.7	469.5	10	7.1	1700	4		
467.5 411.5	228.5	455.3	11	7.5	2000.	4		
429.2 287.4	139 2	405.2	12	5.1	2000.	4		
446.0 338.1	169.5	461.2	14	5.7	2000.	4		
192.9 253.8	145.6	460.7	15	5.8	2400.	4		
364.9 326.7	257.2	400.5	15	7.3	2700.	4		
111.4 196.4	248.5	0.0	23	1.9	250.	4		
89.8 146.5	254.9	0.0	24	1.9	250.	4		
52.3 248.0 296_5 251.2	193 7	0.0	1	2.9	250.	4		
215.4 299.7	165.0	0.0	3	2.9	250	4		
454.5 274.2	154.0	0.0	4	3.5	250.	4		
384./ 324.6 253.2 488 1	175 4	0.0	5	3.5	250.	4		
289.5 304.1	193.1	0.0	7	3.1	250.	4		
6 'hour of day'	-0.01.	4., 8.,	12., 1	6., 20	., 24.0	1		
⊥ບ່≀ບູ(na/s)/ 0.5 ຣິ/ກໍ(ກາ)/ ⊷ວ_∩1	2, 1.3, . 200	2.5, 3.5	4.5,	5.5.	6.5, 7.	5, 8.5,	9.5,	10.5
3 'pg class' 0.	5 3.5 4	.5 6.5			1000.,			

Figure D-1. An example of the input data file for the ANADISTR program.



DEMONSTRATION OF THE RESULTS GENERATED BY THE ANADISTR PROGRAM.

Figure D-2. An example of the results generated by the ANADISTR program and plotted using SIGPLOT. Significant points on each box represent the 2nd, 16th, 50th, 84th, and 98th percentiles. The dashed lines represent the factor of two lines.

The next question will be asked only if the user answers "y" to the above question.

Enter the lower threshold (e.g. 0.01):

There is no default answer, but 0.01 has proven to be a good choice for the ratio of two dependent variables in our tests.

Implement an upper threshold for the dependent variable? (y/n):

This is sometimes necessary if the logarithmic scale is to be used and there are very large values in the data whose distribution is to be analyzed. The default (i.e., hitting the RETURN key) answer is "y".

The following question will be asked only if the user answers "y" to the above question.

Enter the upper threshold of the ratio (e.g. 100.):

There is no default answer, but 100 has proven to be a good choice for the ratio of two dependent variables in our tests.

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## APPENDIX E

# USER'S GUIDE FOR THE SIGPLOT PLOTTING PACKAGE

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## APPENDIX E

A. USER'S GUIDE FOR THE SIGPLOT PLOTTING PACKAGE

The SIGPLOT plotting package developed at Sigma Research Corporation is a versatile tool for producing different kinds of two-dimensional plots, such as scatter plots, graphs, box plots (sometimes called residual or whisker plots), or error bar plots. The user can specify many parameters including the number of frames per page, the aspect ratio of the frame, and the mapping of the coordinates. The graphics library routines used by SIGPLOT, together with the screen and printer drivers (described later) were originally developed by Dr. Arlindo daSilva of the University of Wisconsin at Milwaukee.

SIGPLOT requires two input files: 1) the template file that contains the control parameters which influence the appearance of the plots, and 2) the input data file that contains the data to be plotted. Tables E-1 and E-2 describe the formats of the template file and the input data file, respectively. Examples of the template file are shown in Figures E-1 and E-2 Examples of the input data file are shown in Figures E-3 and E-4.

SIGPLOT creates a Tektronix picture file that can be viewed directly on any kind of the PC raphics environments (e.g., Hercules, CGA, EGA, and VGA) using the screen driver, TEKPC. Hard copy output can also be generated from the Tektronix picture file with a printer driver. There are three printer drives, TEKEPS, TEKELQ, and PS, that are currently available. The first two drivers are used to drive an EPSON-compatible dot matrix printer, with TEKEPS for low resolution and TEKELQ for high resolution. The PS program is used to drive a PostScript printer, such as Apple LaserWriter, NEC LC-890, or TI MicroLaser PS35. It is recommended that the user have access to a PostScript printer to obtain the best results in the shortest time.

SIGPLOT requires about 200KB of memory. The other screen and printer drivers require less than 100KB of memory, except for TEKELQ, where 450KB of memory is required due to the high resolution and the use of the bitmap approach in the driver program. The SIGPLOT plotting package and the graphics library routines were written in FORTRAN. The screen and printer drivers were written in C.

# TABLE E-1. THE FORMAT OF THE TEMPLATE FILE OF SIGPLOT. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL.

The global control parameters are specified in the first section of the template file, lines 1 through 16.

LINE NO.	FORMAT	DESCRIPTION
1-3		Reserved for comments
4	FF/C	Name of the input data file, currently not used
5	FF/C	Name of the output Tektronix picture file, currently not used
6	FF/I	Flag for the frame aspect ratio, 1-5, 1: x:y = 1:1 2: x:y = 1:2 3: x:y = 2:1 4: x:y = 1:3 5: x:y = 3:1
7	FF/I	Number of frames per page, 1-4
8-9	A80 <sup>-</sup>	Title for the page (no title will be drawn if "O" appears as the first character of the line)
10	FF/C	Flag (PAXIS) for the axis along which the first column, representing the independent variable, of the data in the input data file (see Table E-2) will be plotted (x or y). PAXIS must = x if IPATTN (described below) = 4, and PAXIS must = y if IPATTN = 6
11	FF/I	Flag for mapping, 1-4, 1: linear in x, linear in y 2: linear in x, logarithmic in y 3: logarithmic in x, linear in y 4: logarithmic in x, logarithmic in y E-2

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TABLE E-1. THE FORMAT OF THE TEMPLATE FILE OF SIGPLOT. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL. Continued.

LINE NO. FORMAT DESCRIPTION 12 FF/I Flag (IPATTN) for plot pattern, 1-6, scatter plot 1: 2: line graph 3: scatter plot except line graph for the last variable box plot 4: 5: error bar plot same as 5 but with extra labelling 6: 13 Flag for background, 0 or 2, FF/I 0: no background 2: gridded background 14 FF/C Flag for system time, y or n, if y: system time will be printed out on the upper right corner of each page 15 5A1 Five point patterns for the 'scatter plot 16 FF/I Flag (IEXTRA) for the plotting of extra lines, 1: . x=0 will be plotted y=0 will be plotted 2: 3: x=0 and y=0 will be plotted 4: x=1 will be plotted 5: y=1 will be plotted x=1 and y=1 will be plotted 6: 7: diagonal line will be plotted y=0.5 and y=2 (factor of two) will be 8: plotted x=-0.667, 0, and 0.667, and 9:  $y=4x^2/(4-x^2)$ . (see text) will be plotted, else: no extra lines will be plotted. Note that IEXTRA = 9 is effective only if IPATTN = 6

TABLE E-1. THE FORMAT OF THE TEMPLATE FILE OF SIGPLOT. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL. Continued.

The next section of the template file (lines 17 through 29) contains the parameters that are applicable to a frame. This section can be repeated if there are multiple frames to be plotted in a print job. However, the user can prepare just one such section if the same information is to be used repeatedly by all frames.

LINE NO.	FORMAT	DESCRIPTION				
17-19		Reserved for comments				
20	FF/R	Constants, a and b, for the linear transformation of the independent variable, where $x_{new} = a*x_{old} + b$ , a=1 and b=0 means no transformation is needed				
21	FF/R	Constants, a and b, for the linear transformation of the first dependent variable, where $y_{1,new} = a*y_{1,old} + b$ , a=1 and b=0 means no transformation is needed				
22	FF/R	Same as above, but for the second dependent variable				
23	FF/R	Same as above, but for the third dependent variable				
24	FF/R	Same as above, but for the fourth dependent variable				

TABLE E-1. THE FORMAT OF THE TEMPLATE FILE OF SIGPLOT. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL. Concluded.

LINE NO.	FORMAT	DESCRIPTION				
25	FF/R	Same as above, but for the fifth dependent variable. Note that lines 22 through 25 cannot be omitted even if only one group of data were to be plotted				
26	FF/R	xmin, xmax, and dx of the x-axis				
27	FF/R	ymin, ymax, and dy of the y-axis				
28	FF/C	Format specifier for the numerical labels of the x-axis. If "!" appears as the first character of the line, the appropriate format will be determined internally by the program; otherwise, the user should supply a simple FORTRAN I-, F-, or E-format specifier, enclosed in parentheses, e.g., (I5), (F6.3), and (E8.1) are accepted, but (3I5), (I5,f6.3), (1P,E8.1), and (G9.1) are not accepted				
29	FF/C	Format specifier for the numerical labels of the y-axis				

TABLE E-2. THE FORMAT OF THE INPUT DATA FILE OF SIGPLOT. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL.

LINE NO.	FORMAT	DESCRIPTION		
1	A40	Title for the frame (no title will be drawn if "O" appears as the first character of the line)		
2	A40	Label for the x-axis (no label will be drawn if "O" appears as the first character of the line)		
3	A40	Label for the y-axis (no label will be drawn if "O" appears as the first character of the line)		
4	FF/I	Two integers specifying the number of points (NPTS) and the number of groups of data (MANY) to be plotted. MANY cannot be > 5 for IPATTN = 1, 2, 3, and 5, and MANY must be = 1 for IPATTN = 4 and 6. NPTS cannot be > 700 for IPATTN = 1, 2, and 3. NPTS cannot be > 50 for IPATTN = 4 5 and 6 (see text).		

Next NPTS lines:

For IPATTN = 1, 2, and 3,

FF/R There are 1+MANY real numbers in each line. The first number represents the independent variable, which can be plotted either along the x- or the y-axis depending the value of PAXIS (see Table E-1). The next MANY numbers represent the dependent variables. For example, if three curves (MANY=3),  $f_1(x)$ ,  $f_2(x)$ , and  $f_3(x)$  were to be plotted, then each line here should contain four real numbers,  $x_i$ ,  $f_{1,i}$ ,  $f_{2,i}$ , and  $f_{3,i}$ , where i=1, NPTS. If PAXIS = "x", the x will be plotted along the abscissa, and  $f_1$ ,  $f_2$ , and  $f_3$  will be plotted along the ordinate; vice versa PAXIS = "y". TABLE E-2. THE FORMAT OF THE INPUT DATA FILE OF SIGPLOT. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL. Continued.

LINE NO. FORMAT

## DESCRIPTION

For IPATTN = 4,

FF/R.I There are six real numbers and one integer in each line. The first real number represents the independent variable. The next five real numbers represent the values of the dependent variable at the 2th, 16th, Juth, 84th, and 98th percentiles, respectively. Note that the value of the independent variable listed here frequently represents a range of the independent variable; for example, a wind speed of 7 m/s actually represents wind speeds in the range of 6 to 8 m/s. The integer represents the number of data points based on which the distribution of the dependent variable is derived. No box will be plotted if the number of data points is less than five since not enough information is available to define a distribution.

For IPATTN = 5,

FF/R

There are 1+3=MANY real numbers in each line. The first number represents the independent variable. The remaining numbers for the dependent variables are in MANY groups of three numbers. The three numbers, which must be in order, represent the distribution of a dependent variable. This distribution can be 1)  $\mu$ - $\sigma$ ,  $\mu$ , and  $\mu$ + $\sigma$ , where  $\mu$  is the mean, and  $\sigma$  is the standard deviation, or 2) lower c.l., nominal value, and upper c.l., where c.l. is the confidence limit. TABLE E-2. THE FORMAT OF THE INPUT DATA FILE OF SIGPLOT. THE FOLLOWING KEY LETTERS ARE USED IN THE FORMAT COLUMN - FF: FREE FORMAT, C: CHARACTER, I: INTEGER, AND R: REAL. Concluded

LINE NO. FORMAT DESCRIPTION

For IPATTN = 6,

FF/R,C There are four real numbers and one character constant (no more than 17 characters long) in each line. The definition of the first four real numbers is identical to that when IPATTN = 5, except now MANY must = 1. The character constant, enclosed in apostrophes, is used to label each data point.

The above 4+NPTS lines provide enough information to plot a frame. Additional data, similar in structure, can be appended here if the plotting of more than one frames in a print job is desired.

```
Main switches for plotting.
Ł
        1.
                                   urrs.1
         Name of input data file.
tekl.pic Name of output tektronix file.
         Aspect ratio (integer, 1 - 5).
1
         Number of plots per page (integer, 1 - 4).
1
demo of ipattn=2
۵
         Which axis serves as independent variable (x or y).
x
         Flag indicating log or linear mapping (1 - 4).
1
2
         Pattern.
         Background specification.
۵
         Print out system time on the upper right hand corner (y or n).
Y
         Patterns of scatter plots (5al)
.+0#$
0 Extra line,1:x=0,2:y=0,3:x,y=0,4:x=1,5:y=1,6:x,y=1,7:diag,8:y=fac. 2.,9:fb-nmse, else:nothing.
1----
             _____
1
      Parameters for plot 1.
1-
         ascale, bscale for the independent variable axis.
1. 0.
1. 0.
         ascale, bacale for curve 1.
1. 0.
         ascale, becale for curve 2.
1. 0.
         ascale, becale for curve 3.
1. 0.
         ascale, bscale for curve 4.
1. 0.
         ascale, bscale for curve 5.
-6.28319 6.28319 3.141595 xmin, xmax, and dx for the x axis.
-1.2 1.2 0.3 ymin, ymax, and dy for the y axis.
(15.2)
              format for x label
(f4.1)
             format for y label
```

Figure E-1. An example of the template file of SIGPLOT. Refer to Figure E-6 for the results.

```
Main switches for plotting.
ŧ
       1---
                                     -0-
         Name of input data file.
urrs.1
texl.pic Name of output textronix file.
1
         Aspect ratio (integer, 1 - 5).
1
         Number of plots per page (integer, 1 - 4).
demo of ipattn=5
0
x
         Which axis serves as independent variable (x or y).
3
          Flag indicating log or linear mapping (1 - 4).
S
         Pattern.
         Background specification. (0 or 2)
۵
         Print out system time on the upper right hand corner (y or n).
n
+0.#5
         Patterns of scatter plots (5al)
0 Extra line,1:x=0,2:y=0,3:x,y=0,4:x=1,5:y=1,6:x,y=1,7:diag,8:y=fac. 2.,9:fb-nmse, else:nothing.
1-
      Parameters for plot 1.
1
1.
1. 0.
          ascale, becale for the independent variable axis.
1. 0.
         ascale, bscale for curve 1.
1. 0.
         ascale, bacale for curve 2.
1. J.
         ascale, becale for curve 3.
1. 0.
         ascale, bscale for curve 4.
1. 0.
         ascale, bscale for curve S.
200. 20000. 10. xmin; xmax, and dx for the x axis.
-1.5 1.5 0.5 ymin, ymax, and dy for the y axis.
(15)
(£4.1)
```

Figure E-2. An example of the template file of SIGPLOT. Refer to Figure E-9 for the results.

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50 5	5				
-6.03186	0.248690	-0.368124	-0.844328	-0.998027	-0 770514
-5.78053	0.481754	-0.125333	-0.684547	-0.982287	-0 304827
-5.52920	0.684547	0.125333	-0.481753	-0.904827	-0.982787
-5.27788	0.844328	0.368125	-0.248690	-0.770513	-0.902207
-5.02635	0.951057	0.587786	0.3973598-06	-0.587785	-0.950027
-4.77522	0.998027	0.770513	0.248690	-0.368125	-0.931030
-4.52389	0.982287	0.904827	0.481754	-0.125333	-0.694547
-4.27257	0.904827	0.982287	0.684547	0.125333	-0.481753
-4.02124	0.770513	0.998027	0.844328	0.368125	-0.401733
-3.76991	0.587785	0.951056	0.951057	0.587785	0 2543085-06
-3.51858	0.368125	0.844328	0.998027	0.770513	3.248690
-3.26726	0.125333	0.684547	0.382287	0.904827	0 481754
-3.01593	-0.125333	0.481753	0.904827	0.982287	0 684547
-2.76460	-0.368125	0.248690	0.770513	0.998027	0.844328
-2.51327	-0.587785	0.397391E-07	0.587785	0.951056	0.951057
-2.26195	-0.770513	-0.248690	0.368124	0.844328	0.998027
-2.01062	-0.904827	-0.481754	0.125333	0.684547	0 987797
-1.75929	-0.982287	-0.684547	-0.125334	0.481753	0 304827
-1.50796	-0.998027	-0.844328	-0.368124	0.248690	0.770513
-1.25664	-0.951057	-0.951057	-0.587785	-0.556284F-07	0 587785
-1.00531	-0.844328	-0.998027	-0.770513	-0.248690	0.368174
-0.753983	-0.684547	-0.382287	-0.904827	-0.481753	3 : 753:3
-0.502655	-0.481754	-0.304827	-0.982287	-0.684547	-0 175333
-0.251328	-0.248690	-0.770513	-3.998027	-0.344379	-0.369105
0.000000	0.300000	-0.587785	-0.351056	-0.951057	-1 587725
0.251328	0.248690	-0.368124	-0.844328	-0.998027	-0.270513
0.502655	0.481753	-0.125333	-0.684547	-0.982287	-0.904827
0.753982	0.684547	0.125333	-0.481754	-0.904827	-0.982287
1.00531	0.844328	0.368125	-0.248690	-0.770513	-0.998027
1.25664	0.951056	0.587785	-0.381470E-06	-0.587786	-0.951057
1.50796	0.998027	0.770513	0.248690	-0.368125	-0.844328
1.75929	0.982287	0.904827	0.481754	-0.125333	-0.684547
2.01062	0.904827	0.982287	0.684547	0.125333	-0.481754
2.26195	0.770513	0.998027	0.844328	0.368125	-0.248690
2.51327	0.587785	0.951056	0.951057	0.587785	0.190735E-06
2.76460	0.368124	0.844328	0.998027	0.770513	0.248690
3.01593	0.125334	0.684548	0.982287	0.904827	0.481753
3.26726	-0.125333	0.481754	0.904827	0.982287	0.684547
3.51858	-0.368124	0.248690	0.770514	0.998027	0.844328
3.76991	-0.587785	0.341731E-06	0.587785	0.951057	0.951056
4.02124	-0.770513	-0.248690	0.368125	0.844328	3.998027
4.27257	-0.904827	-0.481754	0.125333	0.684547	0.982297
4.52389	-0.982287	-0.684547	-0.125333	0.481754	0.904827
4.77522	-0.998027	-0.844327	-0.368124	0.248691	0.770514
5.02655	-0.951057	-0.951056	-0.587785	0.723200E-06	0.587786
5.27787	-0.844328	-0.998027	-0.770513	-0.248689	0.368125
5.52920	-0.684548	-0.982287	-0.904827	-0.481753	0.125334
5.78053	-0.481754	-0.904827	-0.982287	-0.684547	-0.125333
6.03186	-0.248690	-0.770513	-0.998027	-0.844328	-0.368124
6.28319	-0.301992E-06	-0.587785	-0.951057	-0.951056	-0.587785

Figure E-3. An example of the input data file of SIGPLOT. Refer to Figure E-6 for the results.

all periods n-s distance (m) var(dws) / median 1-min var(ws) /2 6 3 312.5 -0.029 0.002 0.034 -0.027 0.043 0.112 0.166 0.275 0.383 625.0 -0.009 0.005 0.019 0.011 0.048 0.085 0.209 0.361 0.513 1250.0 -0.035 0.012 0.059 -0.007 0.070 0.148 0.330 0.480 0.630 2500.0 -0.155 0.015 0.185 -0.126 0.100 0.325 0.359 0.565 0.771 5000.0 -0.033 0.170 0.373 0.013 0.323 0.633 0.440 0.751 1.062 10000.0 -0.417 0.061 0.539 -0.137 0.369 0.876 0.406 0.873 1.339

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Figure E-4. An example of the input data file of SIGPLOT. Refer to Figure E-9 for the results.

As one can see from Table E-1, SIGPLOT is capable of creating the following kinds of plots:

IPATTN = 1: scatter plot (e.g., Fig. E-5)
IPATTN = 2: line graph (e.g., Fig. E-6)
IPATTN = 3: scatter plot except line graph for the last variable
 (e.g., Fig. E-7)
IPATTN = 4: box plot (e.g., Fig. E-8)
IPATTN = 5: error bar plot (e.g., Fig. E-9)
IPATTN = 6: same as IPATTN = 5 but with extra labelling (e.g., Fig. E-10)

The usage of each option is described below.

For IPATTN = 1, groups of data are represented by different dot patterns that are defined in the template file (see Table E-1). At most, five groups of data (MANY = 5) can be plotted, with a maximum of 700 points for each group.

IPATTN = 2 is similar to IPATTN = 1 except that points are now connected. The following line patterns are used to represent different curves: solid, short-dashed, long-dashed, dot-dashed, and dotted. At most, five curves (MANY = 5) can be plotted, with a maximum of 700 points for each group. No user customization of the line patterns is allowed. It is important that the data points in the input file are sorted according to the independent variable.

IPATTN = 3, a combination of IPATTN = 1 and 2, is useful when the user wants to see how well a theoretical curve fits the observed data. Although the order of the data points does not matter for a scatter plot, in this case it is important that the data points in the input file are sorted according to the independent variable. At most, five groups of data (MANY = 5) can be plotted, with a maximum of 700 points for each group.

The IPATTN = 4 option is an alternative to the scatter plot when the number of data points is large. In preparing the input data file for SIGPLOT.
the user first defines certain ranges of the independent variable to be used for grouping the dependent variable. The distribution of the dependent variables within each group is then determined and represented by five significant points in the cumulative distribution function (cdf). These five values could be the 2th, 16th, 50th, 84th, and 98th percentiles of the cdf. or the mean and mean ± one and two standard deviations. SIGPLOT then uses a box pattern to represent the distribution of the dependent variable within each grouping or range of the independent variable. Only one set of data (i.e., MANY = 1, even though five points are needed to define a box) is accepted for this option, with a maximum of 50 boxes.

**IPATTN = 5** is similar to **IPATTN = 4** except that three values (vs. five) are needed to define an error bar (vs. a box). These three values can be the mean and mean ± one standard deviation of a dependent variable, or the nominal value of a dependent variable and its 95% confidence limits. At most, five groups (MANY = 5) of data can be plotted, with a maximum of 50 error bars for each group. The following error bar patterns are used: filled square, empty square, filled triangle, empty triangle, and cross.

IPATTN = 6 is similar to IPATTN = 5 except that the user can label each data point. Because of the additional information to be plotted, only one group of data (MANY = 1) is accepted, with a maximum of 50 error bars. This option is designed primarily to plot the FB (fractional bias), together with its confidence limits, against the NMSE (normalized mean square error), where

 $FB = \frac{(\overline{C}_{o} - \overline{C}_{p})}{(0.5(\overline{C}_{o} + \overline{C}_{p}))}$ (E-1)NMSE =  $\frac{\overline{(C_o - C_p)^2}}{\overline{C - C_p}}$ 

(E-2)

If IEXTRA = 9 (see Table E-1), SIGPLOT will plot the additional x = -0.667, 0, and 0.667 lines, representing the factor of two and zero FB lines, together with the  $y = 4x^2/(4-x^2)$  line, representing the "minimum" NMSE (due only to the mean bias) as a function of FB.

The information concerning the usage of the driver programs, TEKPC, TEKELQ, TEKEPS, and PS, can be obtained by simply executing the programs without providing any arguments, and will not be repeated here.

Finally, an example is given below of the procedures followed to use the graphics package.

- Step 1: The user prepares the template file (DEMO. INQ) and the input data file (DEMO. DAT) according to the formats described in Tables E-1 and E-2. The user can create his own template file by editing the sample template file. The input data file is usually generated by some other programs.
- Step 2: After the execution of SIGPLOT, a Tektronix picture file (DEMO.PIC) is generated.
- Step 3: The user can view the results on screen by typing: TEKPC DEMO.PIC if a Hercules graphics card is installed, or TEKPC DEMO.PIC 16 if an EGA (with a resolution of 640x350 pixels) graphics card is installed.
- Step 4: A high resolution hard copy output can be generated on an EPSON-compatible dot matrix printer by typing: TEKELQ DEMO.PIC.
- Step 5: Or if the user has access to a PostScript printer, a PostScript file
   (DEMO.PS) will be created by typing:
   PS DEMO.PIC,
   and this file can be printed out by typing:
   PRINT DEMO.PS

E-15



DEMO OF IPATTN=1

Figure E-5. A sample scatter plot (IPATTN = 1) generated by SIGPLOT.

E-16

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Figure E-6. A sample line graph (IPATTN = 2) generated by SIGPLOT. Refer to Figures E-1 and E-3 for the template and data files used for this figure.





Figure E-7. A sample scatter plot and line graph (IPATTN = 3) generated by SIGPLOT.

DEMO OF IPATTN=4



Figure E-8. A sample box plot (IPATTN = 4) generated by SIGPLOT.

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ALL PERIODS

Figure E-9.

A sample error bar plot (IPATTN = 5) generated by SIGPLOT. Refer to Figures E-2 and E-4 for the template and data files used for this figure.

DEMO OF IPATTN=8



Figure E-10. A sample error bar plot with labelling (IPATTN = 6) generated by SIGPLOT.

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## APPENDIX F-1

## LISTINGS OF THE DUGWAY DATA ARCHIVES - HISTORICAL DATASETS

.

	i trial ID	z munta z day	: Year	z mout z minute	i ho. of sources	: r-coord, of source (m)	: source elevation (m)	: emission rate (g/s)	: cmission duration (s) · rotal//// ////	: cours made waited (ny) : slowD at the source (m)	: sigy0 at the source (m)	: sigro at the source (m)	: amblent pressure (atm)	: Felative bubloity (v)	a temperature at rever st (N) a sessification befolt for tessariature 41 (m)	: temperature at level 12 (K)	: measuring height for temperature 42 (m)	I wind speed (m/s) at a tower	: measuring height for wind data (m)	: domain-averaged wind speed (m/s)	: domain-averaged wind direction (deg) : domain-averaged airma-v (m/a)	: domain-averaged signa-there (dec)	: domain-averaged sigma-phi (deg)	: measuring ht for domain-avg wind speed (s	: averaging time for domain-avg data (s) . wind anaad count is account	: surface roughness (m)	: friction velocity (m)	<pre>% Inverse Monta-Obukhov length (1/m) * Thedo</pre>	: molature availability	: Bowen raio	: mixing beight (m)	; CJONG COVER [%] ; P-G erability class	i averaging time for concentration (a)	: suggested receptor height (m)	: no. of distances downwind • distance downwind (=)	i concentration (md/m**)	<pre>s cross-wind integrated conc. (mg/m^*2)</pre>	: sigmary (m) : distances downwind (m)	: concentration (mg/m**3)	: cross-wind integrated conc. (mg/m**2) : sigma-v (m)	i no. of lines-of-sight
	21165	•~	1961	:5	- 0		2.50	1.333	0.0081	000.0	0.000	0.000	6 66-	2000	1.00	288.75	16.50	9.9	3.70	00. <b>1</b>	0.616	19.90	-99.90	3.70	2820.0	0.2000	-99.900	0006.86-	0.20	5.00	5.5F-		2820.0	4.57	2 101 0	1.0906-03	-9.990E.01	5665.0	1.0706-03	-95,990E101	0
	נוחפה	- 10	1961	30			2.50	1.417	1 800.0	000.0	0.000	0.000	9.99-9	2000	1.80	286.95	16.50	7.00	3.70	00.7	0.025	15.00	-99,90	3.70	2820.0	0.2000	-99.900	0006.66-	0.20	5.00	5.56- -	0.01	2820.0	4.57	2 101.0	1.5206-03	-9.990E+01	5665.0	1.0006-03	10'3066-6-	0
·	01dgb	Š	1961	4	~ • •		2.50	0.122	0.0001	0.000	0.000	0.000	6.66-	285 15		265.05	16.50	0.40	3.70	0. <b>1</b> 0	0.055	26.70	-99.90	3.70	1800.0	0.2000	-99.900	0006.86-	0.20	5.00			1800.0	4.57	2 1012	1.190E-03	-9.990E+01	5665.0	4.190E-04	-9.990E+01	0
	4Jpb 2	28	1961	20	-0		2.50	0.667	0.0001 6.0001	0.000	0.000	0.000	6 66 -	284 15	1.80	284.05	16.50	2.50	9.20	00.1	06.66-	15.50	-99.90	3.70	2820.0	0.2000	-99,900	0006.66-	0.20	5.00		56-	2820.0	4.57	2301.0	5.210E-03	1013066.6-	5665.0	1.600E-03	-99,900-01	•
	() dhp	<b>5</b>	1961		~ 0		2.50	0.978		0.000	0.000	000.0	5. d d d	20015	1.80	288.15	16.50	5.10	3.70	01.50 01.50	06 65-	16.00	-99.90	3.70	2820.0	0.2000	006.66-	0006.66-	0.20	2.00			2420.0	4.57	2301.0	7.3108-04	-9.990E+01	5665.0	5.650E-04	10+306- 6- 06-66-	•
	(dph	56	1961		~ 0		2.50	0.661	1600.0	0.000	0.000	0.000		285 15	1.80	284.05	16.50	2.70	3.70		06.66-	14.50	06.66-	3.70	-99 900	0.2000	006.66-	0006-66-	0.20	2,00		56 -	2820.0	4.57	2301.0	5.480E-04	-9.9902.01	5665.0	9.2806-05	10+3046-6-	• •
	ցվիր	56	1961	19	~ ~		2.50	0.967		0.000	0.000	0.000		2000	1.80	287.45	16.50	2.90	9.10	06.2	06.66-	21.00	-99.90	3.70	2820.0	0.2000	-99.900	0006.88-	0.20	2.00		66-	2820.0	4.57	2301 0	7.680E-04	-9.9906.01	5665.0	3.4708-04	10+306- K-	•
YQ	çdpb	5	1961	2	~ ~ ~		2.50	0.667		0,000	0.000	0.000	5.65 5.6 1	202		264.75	16.50	1.60	3.70	1.60	06.66-	14.00	06.66-	3.70	1800.0	0.2000	006.66-	0005.66-	0.20	5.00		66-	1800.0	4.57	2301.0	1.050E-03	-9.9906.6-	5665.0	9.3705-04	10+306- 6- 06- 60	•
cluded in D on	9 dgb	53	1961		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		2.50	1.278		0000	0.000	0.00		2041.5		288.15	16.50	3.00	3.70	00.F	06.66-	19.30	-99.90	3.70	- 2820.0	0.2000	-99.900	0006.66-	0.20	5.00			2820.0	1.57	2301 0	2.210E-03	-9.990E.01	5665.0	· 8.700E-04	10+306 00-00	•
r trials in a designati (deg)	ie (neg) dyb3	21	1961	15			2.50	0.661		000 0	0.000	0.00	5.661			284.15	16.50	0.80	3.70	0.80	0.955	18.60	-99.90	3.70	- 2820.0	0.2000	-99.900	0006.66-	0.20	5.00	- 10 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	1651	2820.0	4.51	0 1010	2.190E-03	-9.990E.01	5665.0	4.0606-05	10,3054.8-	
Course B : number o : time con	dob dob2		1961				2.50	0.889			0.000	0.000	6.66-			28.95	16.50	2.10	3.70	2.10	1.292.0	21.00	06.66-	3.70	2820.0	0.2000	-99.900	0006-66-	0.20	5.00	5°66-		2820.0	4.57	0 101 0	1.9802-03	10.3066.6-	5665.0	4.440E-04	-9.990E.01	0
Dry Gulch, 12 34.50	ideb Ideb	12	1961				2.50	0.656	1800.0	0000	0.000	0.000.0	6.66-		CT.687	208.05	16.50	5.00	3.70	2.00	328.0	15.40	06.66-	3.70	2820.0	0002 0	-99.900	1 -99.9000	. 0.20	5.00	5°66		2820.0	4.57	2 101 0	5.8606-04	-9.990E.01	5665.0	2.900E-04	-9,990E,01	0

	trial 10	. month	t year	: minute : no of sources	: x-coord, of source (m)	r y-coord, of source (m)	: source glevation (m) : emission rate (g/s)	: emission duration (a)	: total mass cmitted (kg)	: sigku at the source (m) : sigvû at the source (m)	: sigz0 at the source (m)	: ambient pressure (atm)	s relative humidity (9)	: competature at loval () (K) · monumics buicks for former at 1	: masturing maigat dur tamperature Fi (m) 2 tamperatura at laval 42 (K)	i messuring height for temperature #2 (m)	t wind speed (m/s) at a tower	i measuring height for wind data (m)	I domain-averaged wind speed (m/s)	i domain-averaged wind direction (ueg) i domain-averaged signary (m/s)	: domain-averaged signa-theta (deg)	: domain-averaged sigma-phi (deg)	: measuring ht for domain-avg wind speed (m	: everaging time for domain-avg data (s) : wind speed power law exponent	: surface roughness (m)	i friction velocity (m)	i inverse monin-Uduknov jengin (1/m) i albedo	: moisture availability	: Bowen raio	: mixing height (m)	r P-G stability rises	a veraging time for concentration (s)	: suggested receptor height (m)	; no. of distances downwind	: UISLENCES UNWAVING [M] : COSCENTIAL[OR [md/m44]]	<pre>s cross-wind integrated conc. (mg/m**2)</pre>	t elgenery (m.) t distantes dourning (m)	: concentration (mg/m**3)	<pre>s cross-wind integrated conc. (mg/m**2)</pre>	: no. of lines-of-sight
	49124		61	25	0.0	0.0	0.683	1000.0	6 66 - C	000.0	0.000	6.99-	6.66- 		284.65	16.50	2.80	9. 90		06.66-	14.10	06.66-	9. J	-99.900	0.2000	-99.900	00.00	0.20	2.00	6.99-		2820.0	4.57	2 1055	1.7306-03	-9.990E.01	5665 0	2.0706-04	-9.990E.01	0
	dgb23	10,1	115	35	0.0		1.467	1800.0	6.66-	0000	0.000	6.66-			207.15	16.50	3.60	3.70		06.66-	15.70	-99.90	3.70	006.96-	0.2000	006.66-	00.00	0.20	5.00	5.56-		2820.0	4.57	2 1050	5.8202-04	-9.990E+01	5665.0	4.910E-04	-9,990E+01	0
	dgb22	29	61	30	0.0	0.0 ,	0.756	1800.0	5.50- 000 0	0.000	0.000	6.66-	5.66-		285.75	16.50	2.00	97.E		06.99-	15.60	-99,90	0/.6	006.66-	0.2000	-99.900 -49 6000	00.00	0.20	5.00	- 66 -	66-	2820.0	4.57	2 105 0	9.940E-04	-9.990E+01	5665.0	1.410E-04	-9.9902+01 -99 40	
	124hb	87	51		0,0		004.1	1800.0	5.55-		0.000	6.66-	- 66 - 6		286.85	16.50	3.10	3.20		06.66-	18.20	06.66-	0	006.66-	0.2000	006.66-	0.30	0.20	2.00	2.22 2.22	66 -	2820.0	4.57	7 101 6	9.3602-04	-9.990E+01	5665.0	1.3406-03	-9.9905.01	0
	dgb20	5					0.122	1800.0			0.000				285.55	16.50	2.70			06.66-	10.60	06.66-	0/ .e	006-66-	0.2000		05.0	0.20	2.00	1001	66-	1800.0	4.57	7 1010	2.570E-03	-9.990E+01	5665.0	4.430E-04	10-3066-6-	0
	ildpb	2					1.46	1800.0			0.00	-66-			247.5	16.50				-99.96	17.40	-99.90	5	006.66- (	0.2000	006.99.900	0.30	0.20	2.00			0.2820.0	1. S.		0.330E-04	10+3066.6-	5665.0	9.380E-04	-9.990E+01	
	duble 1	52			0.0		0.150	1800.0		000.0	0.000	6.66-			286.95	16.50	1.90	3.70	24.0	06.66-	17.10	06-66-	0 Cor	006.66-	0.2000	005-66-	0.30	0.20	2.00	- 44-	66 -	2820.0	<b>•</b> .51	1010	5. 630E-01	-9.990E+01	5665.0	3.870E-04	10.3090.0-	0
ş	[ tabb	5		96	0.0		0.150	1000.0			0.000	6-66-			286.75	16.50	1.20		1.40	06.66-	11.00	06.66-	0 E	006.66-	0.2000		0.10	0.20	2.00	- <b>56</b> -		2820.0	4.57		1.340E-03	-9.990E+01	5665.0	7.860E-04	-9.990E+01	0
icluded in D on	) [qbp-	21		-	0.0		1.356	1900.0			0.000	-99.4			269.15	16.50	4.00	0. °		06.66-	21.10	06.66-	0 E	006.66-	0.2000	-99.900 	0.30	0.20	2.00			2820.0	4.57	0 101 6	9.420E-04	-9.990E+01	5665.0	5.490E-04	10+3066-6-	9
st trials in a designati (deg)	u (Geg) dyb15	51			0.0		1.133	1800.0		0000	0.000	5.66-	5.66- Car		246.55	16.50	2.00	36		06.66-	22.60	D6.90-	3.10	-99.900	0.2000		0,30	0.20	5.00			2820.0	• • •	<b>V</b> 101 C	2.640E-03	10-3066-6-	5665.0	5.210E-04	10+3066.6-	0
Course B : number o : time zon : tettude	tongrend		1951	9-	0.0	0.0	1.644	1000.0	6.96-		0.000	6.66-	6.6		292.45	16.50	2.60	0		06.66-	25.70	06-66-	3.70	2020.000	0.2000	006.66-	0.30	0.20	2.00	6.99-		2820.0	4.57	2 105 5	2.030E-03	-9.9905+01	5665	5.8106-04	10+3066-6-	0
Dry Gulch, 12 14.50	dgbl	01	98	45	0.0	0.0	010.1	1000.0	6.66-	000.0	0.000	- 66 -	- 99.9	283.13	26.195	16.50	2.40	9. JO	2.40	06-66-	17.70	06.66-	3.70	0.0282	0.2000	-99.900	0.30	0.20	5.00	6 · 66 -		2820.0	4.57	2 1020	E0-3041.C	10-3066.6-	- 99.90 5645 0	1. 1106-04	-9.990E+01	0

·					rce (m)	rce (B)	(m) a	g/s) 60 (s)	ted (kg)	urce (m)	uce (a)	• (atm)	ty (1)	leval J1 (K) F for temperature A) (m)	level 12 (K)	t for temperature 12 (m)	P BC B COWER	vind speed (m/s)	wind direction (dey)	algmaru (m/s) elomartheta (dec)	algenarphi (deg)	r domain-avy wind speed (m)	tor domain-avg data (s) r law excenent	as (m)	ty (m) buther   read b () /=)		bility				tor concentration (3) tor belaht (a)	a downwind	1nd (m)	grated conc. (my/m**2)		mg/m**])	grated conc. (mg/m <sup></sup> 2) -sight	
	i trial JD	: day	: Year	i minute	: NO. OF BONKCOS : X-COORD, OF BON	: y-coord. of sou	: source alevatio	: emission rate ( : emission duract	i total mass emit	alged at the so	i siggo at the so	: ambient pressur	s relative humid!	: comperature at : measuring buigh	: temperature at	s measuring heigh	a who apead (m/s	: domain-averaged	: domain-averaged	: domain-averaged	: domain-averaged	: measuring ht fo	: averaging time	i surface roughne	friction velocity	: Albedo	a molature availa	: mixing helght (	: cloud cover (N)	I V-G SLADIIILY C	: suggested recept	: no. of distance	: distances down	: Cross-wind inte	: sigma-y (m) · distances denom	concentration (	: algma-y (m) : no. of linea-of	
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	trial ID	Month	. Year	t hour minute	no. of sources	<pre>x = Coold. of source (m) v = coold. of source (m)</pre>	scurce elevation (m)	emission rate (g/s)	i cultation duration (s) Fotal mass emitted (ka)	sign0 at the source (m)	sloyd at the source (m)	sigtu at the source (m)	relative bumidity (1)	temperature at level #1 (K)	measuring height for temperature (1 (m)	remperature at rever st (M) measuring height for temperature (2 (m)	wind speed (m/s) at a tower	measuring height for wind data (m)	domain-everaged wind appead (m/s)	domain-averaged sigma-u (m/s)	domain-averaged sigma-theta (deg) domain-susreed sigma-chi (dec)	measuring ht for domain-ave wind succed	averaging thue for domain-avg data (s)	Hund speed power law exponent surface rouchness (m)	friction velocity (m)	. Inverse Monin-Obukhov length (1/m) albado	motsture availability	Bowen raio Livien beicht (m)	cloud cover (%)	P-G stability class	averaging time for concentration (a) suggested receptor height (m)	no. of distances downwind	GISTANCES GOWNWING (m) Concentration (mg/m**3)	cross-wind integrated conc. (mg/m**2)	sigmary (m) distances downwind (m)	concentration (mg/w <sup>4</sup> .3) rrosa-wind in sorstand conc. (mg/m <sup>42</sup> )	aiguary (m) aiguary (m) no. of lines-of-sicht	
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auring baight for camperature #1 (m) auring baight for camperature #1 (m) perature at lavel 12 (K) tamped d apped (m) at a touer a uning haight for uind data (m) auring haight for uind data (m) ann-averaged wind speed (m/a) aln-averaged aigma-theta (deg) allowerged aigma-theta (deg) are deged pourt law exponent ction velocity (m) are wonin-Obuhhov length (1/m) ed (m) concentration (mg/m\*\*3) cross-wind integrated conc. (mg/m\*\*2) ences downwind (m) centration (mg/m\*\*3) se-wind integrated conc. (mg/m\*\*2) downwind (m) (clon (mg/m\*\*3) (d integrated conc. (mg/m\*\*2) (\*) uo] sture availability -of-sight BOUFCE BOUFCE ag height (m) Î Included in DOA ŝ 10. 01 1-0001 trial 9000 0.30 5.00 99.9 0000 291.15 2.69 2820 3.520 06. e ö ad **n** 8.99 8.79 0.5000 -99.9000 -99.9000 3 34.5 120.5 dgd4 00 5**8**2 25 Dry Gulc 204

	13 : trial 10	e : monte 6 : day	9 i Year 9 i hour	0 : minute 1 : no. of sources	.0 : x-coord, of source (m) 0 : u-roord, of source (m)	50 i source elevation (m)	78 : emission rate (g/s)	.0 : emission duration (s) 9 : rotal mass amirrad (tr)	00 : aigrd at the source (m)	00 : algy0 at the source (m)	UU : sigzO at the source (m) .9 : amblent pressure (stm)	.9 : relative humidity (A)	35 : temperature at level #1 (K)	80 : measuring height for temperature () (m) 16 : trococtory - )) (2 /2)	2) ; temperature at icver 12 (0) 50 : measuring haight for temperature 42 /m)	90 ; wind speed (m/s) at a tower	70 : measuring height for wind data (m)	90 : domain-averaged wind speed (m/s)	.u i domain-averaged wind direction (deg) 90 : domain-averaged signa-n (m/s)	60 i domaîn-averaged aloma-theta (deg)	90 : domain-averaged sigma-phi (deg)	/U : measuring ht for domain-avg wind speed (w	the second structure of the second se	00 : surface roughness (m)	00 : friction velocity (m) 10 : (overse Monte-Obuthou Landth ()/m)	18 : albedo	50 : moisture availability	.9 z mikina helaht (m)	5 : cloud cover (N)	99 : P-G stability class	.U ; averaging time for concentration (s) 57 : augestad recentor halohn (m)	3 : no. of distances downwind	.0 : distances downwind (m) 01 : concentration (m) / dis2)	01 : cross-wind integrated conc. (mu/m**2)	90 : aigma-y (m)	.U : distances downwind (m) Di sossestation /sol/sol	us concentanton (my/m==3) 1] : cross-uind integrated room (mu/m43)	90 : sigma-y (m)	.0 : distances downwind (m)	01 : concentration (mg/m <sup></sup> J) 01 : cross-wind integrated conc. (mg/m <sup>-+</sup> 2)	90 : sigma-y (n) D : no of lines-of-sicht
	ob		7		00	~	1.0		0.0	0.0	D.D 0	66-	295.		16.		m		66-	. 12.	.66-	2020	6.66-	0.10				.66-	37	10000	1707		1200	-9.9906.	-99.	nntz (	-9090E	99.	4800	-9.99061	- 66-
	0012	8 vi -	1761	07	00	2.50	1.183	0.0081	0.000	0.000	0.00.0	6.66-	294.25	1.80	16.50	2.40	3.70	2.40	06.66-	13.70	06.66-	0. /C 0.	-99.900	0.1000	006.66-	0.18	0.50	6.66-	31.5	56- 0 0000	4 57		1200.0	-9.990E+01	-99.90	2400.0	10-3060-6-	06.66-	4800.0	-9.990E+01	06-66-
	oldo	29	202	22	00	2.50	0.617	0.0081	0.000	0.000	000.0	6.66-	294.45	1.80	16.50	1.90	3.70	1.50	- 99.90	9.50	-99.90	2020.0	006.66-	0.1000	0000 66-	0.18	0.50	6.66-	31.5	65- 00000	12.4		1200.0	9.990E+01	-99.90	2400.0	9.990F.01	-99.90	4800.0	10+3066.6-	06.99- 0
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	9qo	24	50	•~	0.0	2.50	0.339		0.000	0.000	000°0	6.66-	297.05	1.80	16.50	2.90	3.70	2.30	06.66-	12.80	-99.90	2420.0	-99.900	0.1000	006.86-	0.18	0.50	6.66-	87.5	20-00-0C	4.57		0.0021 F	- 10+3066.6	-99.90	0.00420 1	9.990E+01	06-66-	4800.0	1013066 6	-99.90 0
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uded in DOA	49		191	°.	0.0	2.50	0.989		0.000	0.000	0.00-0	6.66-	299.75	1.80	16.50	3.10	3.70	3.10	06.96-	10.60	-99.90	3.70	-99.900	0.1000	-99,9000	0.18	0,50	-99.9	37.5	66-	4.57		1 0405-02	9.9906+01 -	-99.90	0.0012	9.9906+01	-99.90	4800.0	9.9906+01	-99.90 0
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	: trial ID	: month : dav	: year	: hour : minute	: no. of sources	: x-coord, of source (m) - v-coord of source (m)	: source slevation (m)	: emission rate (g/s)	: emission duration (s) • rotal mass amitrad (ko)	: sigr0 at the source (a)	r sigyO at the source (m)	: sigzO at the source (m)	: ambient pressure (atm)	: IGIALIYO NUMMULLY (4) : fambaratura at javal 4) (4)	: measuring beight for temoerature	: temperature at level 12 (K)	: measuring huight for temperature	: wind speed (m/s) at a tower	: measuring height for wind data (a	t domain-averaged wind speed (m/s)	: domain-everaged wind direction ( : domain-averaged sigma-u (m/s)	i domain-averaged sloma-theta (deu)	: domain-averaged sigma-phi (deg)	a measuring ht for domain-avg wind	: averaging time for domain-ave dat : wind aread count is evolveer	: surface roughness (m)	: friction velocity (m)	: inverse Monin-Obukhov length (1/s : albado	: moisture availability	: Bowen raio	: mixing height (m) • cloud cover (1)	: P-G stability class	: averaging time for concentration	: suggested receptor height (m)	: distances downwind (m)	: concentration (mg/m**3)	<pre>: cross-wind integrated conc. (mg/m</pre>	: algeary (#) · distarts douveled (=)	: concentration (mo/m**3)	: cross-wind integrated conc. (mg/a	: sigma-y (m)	: distances downwind (m) : concentration (mo/m4+3)	: cross-wind integrated conc. (mg/s	: aigma-y (m) : no. of linea-of-aight
	0027		1962	14			2.50	1.611		0.000	0.000	0.000	5.55 · ·	295.35	1.80	295.15	16.50	07.7 7	3.70		06.66-	10.00	06.66-	3.70	2820.0	0.1000	-99.900	0006.66-	0.50	0.50	6.66- 2.CC	66-	2820.0	1.5.4	1200.0	5.470E-02	10.3066.0-	0.0400.00	1.850E-02	-9.9906.01	06.66-	3 1106-01	10.3066.0-	0.0
	ob2(		1962	21			2.50	1.217		0.000	0000.0	0.00		288.85	1.60	5 288.85	16.50	5.10	0.70		06.66- (	10.80	06.99-0	02.E	2820.0	0.1000	006.66- 0	0006-66- 0	0.50	0.50	5,65- 2,05	66	0 2820,0		1200.0	2 1.710E-02	10-3066-6- 1	2400 0	1 3.490E-03	-9.990E+01	06.66- 0	1 1.060E-03	10+3066-6- 1	
	j ob2		1961	37			2.50	1.14		0.00	0.00	0.00		208.8	1.60	5 268.55	0 16.50	2.90	3.2		06.66-		06.64- 0	0	2820.0	0,1000	006.66- 0	0006-66- 0	0.50	0.50		6 <b>6</b> -	0 2820.0		1200.0	3 2.480E-01	1 -9.990E+01	2400-0	4.200E-03	1 -9.990E.01	-99.90	1 1.6405-03	10+3066 - 1	
	2 db 2		1961				2.5	1.45	- 66- 0	0.00	0.00	0.00		296.9	1.8	5 295.8	16.50	1.2			6-66- 0	12.20	6-66- 0	3.7	02820.000	0.1000	)06.99.90	0.1.0	0.50	0.50		61	2820.1		1200.0	7.490E-0		2400.0	7.320E-0	0-3066-6-1	6.99.90	0-3066-6- 1	0-3066.6- 1	, <sup>2</sup>
	1 ob2		196	~~~ ~~~			2.5	1.56		0.00	0.00			302.9	1.0	5 302.2	16.5				6.66- 0	12.0	6-6-0	0.e	0 2820.0	0,100	06.96- 0		0.5	0.5		6-	2620.		1200.0	3 7.060E-0	-9.990E+0	2400.0	3 1.2206-0	0+3066-6- 1	6.66 0	0-306-0	0-3066.6- 1	
	0 ub2	•	1961 1	~ 0			2.5	B 1.55	- 0081 - 6	0.00	0.00			5 302.9	1.8	5 301.8	0 16.5				96-66- 0	0 14.90	6-66- 0	0.10	0.0282 0	0.1000	06.99.90		0,50	0.50	2001	6-	0 2820.	-	0 1200.0	3 5.460E-0	1 -9.990E+01	2400.1	3 1.180E-0	1 -9.990E+01	06.66- 0	0 -9.990E+01	10-3066.6 1	
	9 oh2	••	1 196	<b>8</b> 5			0 2.5	0 1.57		0.00	0.00	0.0		5 297.5	0 1.8	5 296.6	0 16.5				6.66- 0	0 20.7	6.66- 0	0.1.1.1	0 2160-00-00-00-00-00-00-00-00-00-00-00-00-0	0.100	06.69- 0	005.66- 0	0,50	0.5	5 - 74.	6-	0 2160	c. <b>-</b>	0 1200.	3 1.930E-0	1 -9.990E+0	2400.	4 1.020E-0	1 -9.990610	6.66- 0		1 -9.990E+0	
VOD	(do	-	1 196	12			2.5	3 1.45		0.00	0.00	0.00		5 299.1	0 1.8	5 298.3	0 16.5	0.1.0	00		6.66- 0	0 18.3	6.99.9	0 3.7	0 -99.90	0.100	06.66- 0	006.44- 0	0.5	0.5	- 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5	6-	0 2820.	c.+	<b>0</b> 1200.	3 3.520E-0	1 -9.990E.0	2400	3 9.420E-0	1 -9.9906.0	6.66- 0	1 -9.990E+0	1 -9.990E+0	0
ncluded in ion	100		1 196	~ 6			0 2.5	7 1.48		0.00	0.00	0.00		299.4	1.6	5 297.7	0 16.5		- E 0 0		6.66-	0 10.2	6-66- 0	0 	0 2580.	0.100	06.66- 0	0	0.5	0.5 0.5		6-	0 2580.		0 1200.	3 6.240E-0	0-306-0-1	0 2400	3 4.230E-0	1 -9.990E+0	6.66- 0	1 -9.990E+0	013066.6- 1	0
of trials l ne designat e (deg)	de (deg) S (deg)	•	1 196	• •		00	2.5.	15.1	0 1800.	0,00	0.00	0.00		2000	0.1.0	5 298.9	0 16.5	0 2.4	0		6.66- 0	0.01	6.66- 0	0 3.1	0 2820.	0.100	06.66- 0	006-66- 0	0.0	0.5	5 - 99.	6-	0 2820.		0 1200.	3 8.020E-0	1 -9.990E+0	2400	4 2.360E-0	1 -9.9902+0	6.66- 0	0 4800.0	0-3066-0-1	N ' N N - N - N - N - N - N - N - N - N
24 2 : number 5 : time zo 0 : latitud	0 i longitu 4 obl		1 196	~~				2 1.51	1800.	0.00	0.00	0.0	.66- 6			2 295.5	0 16.5	0	0			15.3	6.66- 0	0.1.	2820.	0.100	06.66- 0	006.66- 0	0.5	0.5	- 66- - 70-		0 2820.	•••	0 1200.4	3 7.060E-0.	1 -9.990E+0	- 56- 0 - 0070	1 5.000E-0	1 -9.9905+0	6.66- 0	0 4800 - 1	0+3066-6- 1	× * * * *
Ocean Bree	obl. 7	~	1961		. ~	00	2.51	1.42	1.0081	0,000	0.000	0.00	- 66 -		1.00	297.9	16.54	Г.	2.0		1.70 66-	12.80	36.66-	1.1	2820.1	0.1000	-99.90	1006-66- 1	0.50	0.5	- 66-		2820.(	• •	1200.0	6.5808-0.	-9.990E+0	- 44.90	1.370E-03	-9.9905+01	-99.90	4800.0	-9.990E 101	17. 77- 0

	) ; trial ID	t smeanth 5 day	2 : Year 5 : Dour	: minute	) : X-coord, of source (m)	) : y-coord, of source (m)	) : Source elevation (m) ) : emiation rata (c/a)	) : emission duration (s)	i : total mass emitted (kg)	) : sigku at the source (m)	) ; alged at the source (m)	i ambient pressure (aim)	1 : relative humidity (1) • famoarative at laist al 200	) : measuring height for temperature 11 (m)	i temperature at level 12 (K)	] : measuring beight for temperature #2 (m)	) : wind apeed (m/s) at a touer	) i domate-meracad vind scent (m) ) i domate-meracad vind scent (m/s)	) : domain-averaged wind direction (deg)	) : domain-averaged sigma-u (m/s)	] : domain-averaged sigma-theta (dey) ) : domain-austaced sigma-ch( /loc)	) : measuring ht for domain-avg wind speed (m	) : averaging time for domain-avg data (a)	) ; surface roughness (m)	) : friction velocity (m)	) : Inverse Monin-Obukhov Jenyth (1/m) ) : Albedo	1 : molsture availability	) : Bowen raio	) : cloud cover (8)	1 : P-G stability class	J : Averaging Lime for concentration (a) ) : surrested recentor batcht (m)	1 : no. of distances duwnwind	) : distances downwind (m)	· · · · · · · · · · · · · · · · · · ·	) : sigma-y (a)	) : distances downwind (m)	s concentration (mg/m==J) : cross-wind integrated conc. (mu/m⁴*2)	(m) Y-empts : (	) : distançes downwind (m) · concepting (m, ////////	: cross-wind integrated conc. (aug/m+*2)	) : sigma-y (m) ) : no. of lines-of-siyht
	14 do	2	2 196 8	~ ~ ~	0	0,00		0 1.600.1	-66- 6		0.00	66- 6		1.6	5 292.1	0 16.5		2.61	0 142.4	6.66- 0	16 66- C	9.76	2820.	0.1000	106 66 - 0	006.66- 0	0.50			6- 6			1200.1	013066 6- 1	6.66- 0	2400.0	1 -9.990E.0	16.66- 0	0 4800.0	0.3066.6- 1	x. x8- 0
	Edo				0	•		1600.0	- 66 - 0		0.00	-66-			5 290.7	16.5			36.	6.66- 0		2.E	2820.0	0.100	06.99.90(				100.				0 1200.0	990610-1	6.66- 0		013060.6-1	-66- 0	1 710-00	0+3066-6-1	- 44. A
	i obj	~~~		m ·			1.60(	1800.0	- 66 - C		0.00	- 66-	0.000	1.8(	298.1	16.50			159.0	6.66-	14.41	3.70	2820.0	0.1000	00	0.10	0.50			6-000			1 1200.0	0.3099.0- 1	96.66-	2400.0	-9.9906.01	96.66- 0	1 - 4800.0	-9.990E+01	56.85- 0
	(th)	~	1 1967	=	0.0		1.626	1800.0	66-1 (		0.000	66-		1.80	5 241.75	16.50		2.00	129.0	06.66- 0	91-91 0	3.10	2820.0	0.1000		0.10	0.50	19.01	100.0	6	4.5		1200.0	-9.990E 0	-66.60	1 000E-00	-9.990E.01	-99.90	1 4800.0	-9.990E.01	
	č do j	~	1	¥.	0.0		1.626	1800.0	5.66-		0.00	- 66-	51°166	1.90	296.95	16.50			133.0	06.66-	06.66- (	3.70	2820.0	0.1000		0.16	0.50		100.	56- 6			1200.0	[0+3066 6- ]	-99.90	2400.0	-9.990E+01	- 66- 0	1 -4 4400.0	-9.990E+01	
	Edo 1		1961	~	0			1800.0	5.66-		0.00	-66-		1.80	293.15	16.50		0.50	100.0	99.90	06.66-	3.70	2820.0	0.1000	-99.900	10.0	0.50		3		12.4	_	1200.0	-9.990E+01	99.96-		-9.990E+01	-99.90	- 4800.0	-9.9906.01	JR . MA
	(tdo	52	1961	4	0	0.0	0C.2	1800.0	5.66 -		0.000	6.66-	5 P P 6 C	1.80	294.35	16.50	2.10	2.10	102.0	06.66-	-99.40 -99.40	3.70	2820.0	0.1000	-99.900	0.18	0.50		100.0	56- 000	0.0202 0.57		1200.0 6 50F-03	-9.9905.01	06.69-	0.0012	-9.9906.01	06.66-	4800.0 4805.01	10+3066.6-	
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	t trial ID Henth	: day : year	: hour : minute	: no. of sources : x-coord. of source (m)	r y-coord. of source (m)	sector areas of a sector and a sector	total mass emitted (ig)	: sigrO at the source (m) : sigrO at the source (m)	: sigio at the source (m) : ambient pressure (atm)	relative humidity (8)	i temperature at rever #1 (N) : measuring height for temperatu	: temperature at level \$2 (K) e measuring buick for remover	wind speed (m/s) at a touer	: measuring height for wind data : domain-averaged vind sprevé (m/	domain-averaged wind direction	domain-averaged algma-u (m/a)	domain-averaged algma-thera (deg	measuring ht for domain-avy wi	: averaging time for domain-avg : wind speed Dower law exponent	surface roughness (m)	: Eriction velocity (m) : inverse Monin-Obukhov jength (	t albedo 	. Bowen raio	: mixing beight (m) - cloud court (m)	: P-G atability class	: averaging time for concentrati - automated recentor batch: (a)	no. of distances downlind	: concentration (mg/m <sup>4 a</sup> )	: cross-wind integrated conc. (# : signary (m)	distances downwind (m)	: concentration (mg/m"=J) : cross-wind integrated conc. (w	s algmary (m) s distances doubled (m)	concentration (mg/m**3)	: cross-wind integrated conc. (w s sigmawy (m)	distances downwind (m)	: concentration {mg/m**3} : cross-wind integrated conc. {m	algmary (m)	concentration (mg/m**3)	: cross-wind integrated conc. (m : sigma-y (m)	distances downwind (m)	concentration (my/m)	: sigmary (m) : no. of lines-of-sight
	. 8 . 750	1 459	25	10.0	0.0	1.956		000.0	: 000°0	6.66- 	06.0	292.25	2.80	00.5	0.115	06.66-	- 96.66-	3.00	6.86- 006.86-	0.1000	0006.66-	0.30	2.00.2	6.66-	- 66 -	6.66-	9 000	3.160E-01	-9.990E.01 :	0.000	-9.9906.01	- 06.96-	1.590E-03	: 10:3066.4-	3200.0	2.620E-03 :	- 06.99-	3.9806-04	-9.990E.01 :	25600.0	1013066.6-	-99.90 -
	9326 8	28 1959	17	0.0	0.0	1, 983	5.66	0000.0	0.000.0 9.66-	-99.9 1 1 1 0 C	06.0	291.45	4.70	00.1	325.0	06.66-	06.66-	3.00	6.48-	0.1000	0006.98-	0.30	5.00	0.001	66-	9-99- 05-1	9000	4.9006-01	10+3066-6-	000.0	-9.9906.01	-99.90	1.6502-02	10.3046.6-	3200.0	-9.990E.01	-99,90 12800 0	5.4306-04	1013056-6-	25600.0	10.3066.6-	06 - 66 - 0
	9925 8	1959		10.0	0.0	1.983	6.66-	0.000	0.000.0	-99.9 205.15	06.0	296.35	5.20	5.20	316.0	05.66-	06.66-	3.00	6006.66-	0.1000	0006 66-	0.30	2.00	- 88 - 100 0	66-	6-66- 05-1	9 000	5.200E-01	10,3099.9-	0.009	10.3066.6-	06.66-	1.070E-02	10,3044.4.	3200.0	10+3066.6	06.66-	3.060E-04	9.990E.01	25600-0	9.9906.01	-99,90
	4754	525 r	⇒~ 	10.0 0	0.0	1,900	6.66-	0.000	0.00.0	-99.9 289.15	06.0	292.95	1.60	1.60	293.0	06.66-	06.66-	3.00	006.46-	0.1000	0006.66-	0.10	2.00	6.66-	66-	9-66- 1.50	3000	1.9705100	-9.990E.01	800.0	-9.990E.01	06.99.90	3.010E-02	-95,990 00	3200.0	1013066.6-	06.99.90	-9.990E.01	1013066.6- 0	25600.0	-9.990E.01	06-66- 0
	9923		22	-0-		2.050		0.000	0.000	1 99. 1	06.0	292.25		1.00 1.00	315.0		06.66-		006.66- 0	0.1000	0006.66- 0	0.30	2.00	-99.9	6		000	10-3060.9	-9.9906+01   -9.9906+01	0.00.0	10-3066-6-		1.5106-02	10+306	3200.0			3.4506-04	-9.9906+01 9.9906+01	25600.0	-9.990E+01	0 - 99. % 0
	1 9922	19541	202	-0		1.96.1 1.90.0001	5.50		0.000	9.66- 0 201 100	0.00	291.43	5.10	5,10	11.0	06.66- 0	06.66-	0.0		0.1000	0006.66- 0	0.30		- 66- 0			000	1 6.390E-01	010-30906-01 0-306-01 00-305-01	900.0		06.99- 00 0 0091 0	1.500E-02		3200.0		06.99-00	1 -9.990E+01	9.990E.01	25600.0	10-3066 .6- 1	- 46 - 0
	9 4421	1951	- 2	-0		3 2.000		0.00	0.00 90.00	96		5 298.8	4.10		316.0	5.56- 0 	06.66- 0	0.0	005.65- 0	00100	0006.66- 0	0.7	20.0	6-66- 02-50-	5		2010	1 8,4508-01	1 -9,990E+0) 0 -99,9(	800.0	0-306-0-1	0 - 99.90	0 1.960E-02	0,3066- 0	3200.0	0-3066-6-1	0 12800 0	3.1106-04	0+3065-6-10)6-66-0	0 25600.0	10-3066-6-1	17.66- 0
<b>N</b> UU	100 <b>8</b>	6 1 2 5 1 2 1 2	•••	-0-	00	1.98		0.00	0 0.00 9 - 99.	9 - 99.		5 295.2 0 15.2	0	0.0	600	6.66 <sup>1</sup>	6.66- 0	0.00	06.66- 0	0.100	006.66- 0		2.0	99- 1001		-66- 6-1 0	900	1 3.140E-0	0.3060-0-1 0-306-0-0	008 0	1 -9.990E.0	6 - 66 - 0 0 1 6 0 0	0-3096.5	0.3088.8- 1 0.3088.8- 0	0 3200.	1 ~9.990E+0	0 -99.90 0 12800	4 3.210E-0	0.3056.6- 10.90.90	0 25600.	0.306.0-1	۰. ۲. ۵
ncluded in ion	1 001	195		0.	, , ,	2.01	-66 6	0.00	00.00 99.	9 - 99. K		288.2	2.0	20.0	0 322	5.66- 0	6.66- 0	0.00	06.66- 0	0.100	006.66- 0	0.0	20.0	96 - 99. 0 100	5	9 - 99. 0 1.5	900	0-3061.5 I	0-3066-6- 1. 0-3066- 0	0 800.	013066.6- 1	6-66- 0 1500	2 8.2205-0	0 -96- 00-90	0 3200.	0+3066-6-1	0 -99,9 0 12800	0-3009 6 1	0 -9.990610	25600	0-3066.6- 1	e 89. 9
of trials l ne designat e (deg)	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	195	~~	0. 0.	°.	1.15	- 66- ·	0.00	00.0 00.00	66- 66	6.0	15 JUD 5	5.5		0 119.	6.66- 01	6.66- 0	0 3.0	.99- 99.90	0 0.100	006.66- 0	0.0	2.0	96- 60.		-98- - 66- 0	900	1 6.510E-0	0+306-6- 10 6-66- 0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-	000	1 -9.990E+0	6 - 66 - 0	2 1. 1006-0	013066-6- 10 6-66- 0	0 3200	0-3051-1 1-0-00-10	6.99- 0 0 12800	1 3.7606-0	1 -9.190E10 0 -99.9	0 25600.	0.3066.6- 1	0 -99.9
2 : number 6 : time zo 0 : laticud	d i tongicu 4 991 7	9 195	~	0.	, e	9 1,16	- 66 - 6	0.00	0.00	66- 6	6.0	5 300.8	0	0.0	0 300.	6.66- 0	6,66- 0	0.0	96-66-00	0 0.100	006.66- 0		20.2	- 66-	- 6	96 - 96. 0		0 7.7206-0	0-3066-0	.000	2 3.4205-0 1 -9,990E+0	6.66- 0	2 2.290E-0	013066.6- 0	3200.	0-3010-1 E	6.66- 0 00001 0	9.4706-0	1 -9.990E+0 0 -99.9	25600	0-3066-6-1	6.66- 0
Green Glou 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	166	195			0	1.28	.99-	0.00	00.0		1.482	292.3		9.0 7	279.	66	5.56- .66-	0.0	- 66	0,100	06.66-		າດັ 	.66- 	. đi	.66-		1.2506+00	-9.990E+0	008	- 1 90E-0	6.66-	1.4406-0	0-3066-6- 76 66-	3200.1	-9.990E-0	6 66 -	1.6406-0	0.3066.6~	25600	0-3066.6-	6.66-

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		i trial ID scott	: day : year	i hour I miaute	: no. of sources : x-coord. of source (m)	: y-coord, of source (m)	: source elevation (m) : emission rate (g/s)	: emission duration (s)	: Lucal meas emilted (kg) : sigx0 at the source (a)	: algy0 at the source (m)	: 31920 At the source (m) : amblent pressure (atm)	: relative humidity (1)	: temperature at level g1 (K) • meanwing holder for same view of for	: measuring mergin. Lot temperature #1 (#) : temperature at level #2 (K)	: measuring height for temperature 12 (m)	: Wind speed (m/s) at a tower : measuring height for uind data (m)	: domain-averaged wind speed (m/s)	: domain-averaged wind direction (deg)	: domain-averaged algma-u (m/s) : domain-averaged algma-thara (444)	: domain-averaged sigma-phi (deg)	a measuring ht for domain-avg wind speed (a	: Averaging time for domain-avg data (s) : wind speed dower )aw exconent	: surface roughness (m)	: friction velocity (m)	: INVELSE MONIN-JOUKNOV LEAGER (1/m) : albedo	: molsture availability	: Bowen rajo : mixing height (m)	: cloud cover (4)	: P-G stability class : averacing time for concentration is)	: suggested receptor height (m)	: no. or distances downwind : distances downwind fmi	: concentration (mg/m <sup>4+3</sup> )	i cross-wind integrated conc. {my/m**2} : signa-v (m)	: distances downwind (m)	: concentration (mg/m <sup>ss</sup> ])	: cross-wind intrugrated conc. ind/m <sup></sup> 2) : signa-y (m)	: distances downwind (m)	: concentration (mg/m <sup>ad</sup> ) : cross-wind interation from (main)	: sigma-y (m)	: distances downwind (m) · concentral (co / co/real)	: cross-wind integrated conc. (mg/m**2)	: sigma-y (m) : distances downing (m)	concentration (mg/m**3)	: CIUSS-WING INLAGIATAG CONC. (mg/m="2] : sigma-y (m)	: no. of lines-of-sight
		96 pq 8	1956	n 0	0.0	0.0	45.400	600.0	0.000	0.000	6-86-	6.66-	294.15	294.35	16.00	2.00	4.10	170.0	5.00	06.64-	2.00	006.66-	0.0060	0.280	0.20	0.50	6.66-	80.0	0009	1.50	0.04	3.528E+02	101314c.r	100.0	1.316E4U2	06.66-	200.0	10.396.0.C	-99.90	101.001	-9.9906.01	06.064	6.311E+00	-99.90	0
		1 6 8 9 9 1 1 9 9 9 1 9 9 9 9 9 9 9 9 9 9 9	1956	-	0.0	0.0	40.300	600.0	0.000	0.000	-99.9	6.66-	294.15	294.55	16.00	2.00	4.60	187.0	- 22.90	-99.90	2.00	006.66-	0.0060	0.290	0.20	0.50	0. 5 - 99. 9	30.0	600.0	1.50	50.0	2.216E+02	-99.90	100.0	7./38E+U1	06.99.90	200.0	2.221E+01 8.463E+02	-99.90	1 254F100	-9.990E+01	06.99-	2.0396+00	06.99.90	a
		9036 9	11 1956	20	0.0	0.0	40.000	600.0	0.000	0.000	6.66-	6.66-	293.15	294.95	16.00	2.00	1.90	160.0	06.66-	-99.90	2.00	006.66-	0.0060	0.100	0.20	0.50	6.66-	0.0	600.0	1.50	20.02	7.9608+02	-99.90	100.0	2.200E102	-99.90	200.0	1.928E+02	06.66-	400.0 400.0	-9.990E+01	800.00	3.704E+01	-99.90	0
		14 14	19561	5 O	0.0	0.0	9.1.400	600.0	0.000	000.0	6.66-	6.66-	304.15	303.05	16.00	2.00	00.6	146.0	06.66-	-99.90	2.00	006.96-	0.0060	0.600	0.20	0.50	6.66-	20.0	600.0	1.50	0.05	1.8706.02	-99.90	100.0		-99.90	200.0	1./82E101 8.766E102	-99.90	400.0	-9.990E.01	0.008	1.1796.00	-99.90	0
		1003	1956	20	0.0	0.0	001.16	600.0	0.000	0.000	6.66-	6.66-	302.15	301.15	16.00	2.00	8.50	101.0	10.50	06.66-	2.00	006.66-	0.0060	0.500	0.20	0.50	6.66-	0.0	6.00.	1.50	50.05	1.941E+02	-99:90	100.0	-9 440E+01	-99.90	200.0	1./BUE+U1 6.523E+02	-99.90	400.0	10+3066.6-	0.008	6.885E-01	06.66-	0
		pg 32 8	1956	20	0.0	0.0	001.11	600.0	0.000	0.000	6,66-	6.661	295.15	299.45	16.00	2.00	2.20	172.0	06.46-	06.99-	2.00	006.66-	0.0060	0.130	0.20	0.50	6.66-	10.0	600°0	1.50	20.02	-9.990E+01	10+3046-6-	100.0	-9.950E101	06.66-	200.0	2.650E102 4.761E103	-99.90	1 1145.02	-9.990E+01	800.00	5.465E+01	06.66-	0
		626d	1956	~0	0.0		11.500	600.0	0.000	0.000	6.66-	6.66-	298.15	299.05	16.00	2.00	3.50	220.0	96.00 9.00	06-66-	2.00	006.66-	0.0060	0.230	0.20	0.50	6.99-	0.0	600.0	1.50	50.05	2.270E+02	- 1036103 -	100.0	4.030E(UL -	06.66-	200.0	2.677E+01	06.66-	400.0 H 4225+00	- 10+3066 . 6-	0.008	2.5236+00	-99.90	•
	4	pg28 8	1956	20	0.0	0.0	11.100	600.0 1 8 8 9	0.000	0.000	000-0 6-66-	6.66-	297.15	298.15	16.00	2,000	2.60	174.0	- 79.30	-99.90	2.00	006.66-	0.0060	0.160	0.20	0.50	6.66-	0.0	600,00	1.50	50.05	1.837£+02	-99.90	100.0	1.918E+U2	06.66-	200.0	2.1276.03	-99.90	100.0	1013066 6-	800.00	8.382E+00	-99.90	0
	luded la DD	pg25	1956	20	0.0	0.0	101.400	600,009	0.000	000.0	6,66-	6.66-	298.15	297.45	16.00	2.00	2.80	177.0	24.80	-99,90	2.00	006.86-	0.0060	0.200	0.20	0.50	763.0	100.0	600,0	1.50	50.02	2.8706+02	1.0356:03	100.0	IDIJECH C	36.00	200.0	0.011E+00 7.504E+02	72.00	0.001 0.001	3.001E+02	114.00 800.0	2.160E-01	214.00	•
	ttials ind designatio (deg)	1054 1924	1956	ຕິ	0.0	0.0	41.200	600.0	0.000	0,000	000.0 6.66-	6.66-	295.15	295.35	16.00	00.6	6.20	141.0	01.0	-99.90	2,00	006.66-	0,0060	0.380	0.20	0.50	00.2 6.66-	0.0	\$00° 0	1.50	50.02	1.58JE+02	1.9366-03	100.0	4.820E+01	06.66-	200.0	1.599E+U1 6.180E+02	-99.90	400.0	9.9906.01	06,006	1.805E+00	06.66-	0
	time zone time zone	1 100011000 0023	1956	2°	0.0	0.0	40.900	00.009	0.000	0000.0	000.0	6.66-	296.15	296.35	16.00	2.0	5.90	128.0	06.66-	-99.90	2.00	006.66-	0,0060	0,390	0.20	0.50	00'Z	0.0	0.002	1.50	50.05	1.6738+02	1.9226.13	100.0	5.8086+01	06.66-	200.0	1.812E+01 6 953E+02	06.96-	400.0	1013066.6-	-99.90 000.0	1.9636+00	06.99.40	•
'talile Gras.	12 42.30 60.30	P922	1956	20	10.0	0.0	46.400	600.0	000.0	0.000	0.000	6.66-	300.15	300.45	16.00		. 40	176.0	-99.90 5 AD	06.96-	2,00	0.004	0.0060	0.460	0.20	0.50	2.00.2	60.09	<b>9</b> 009	1.50	0 05	2.21/15.02	2.2756+09	100.0	8.0346+01	06.99-	200.0	2.6336+01	-99.90	0.004	- 10:3066.6-	06.99-	2. 357E+00	1.9165.02	0
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albedo molature availability Bouen relo maixiny height (m) cloud cover (%) F-G atability class averaging time for concentration (s) averaging time for concentration (s) auggested for concentration (m) no. of distances downing (m) concentration (mg/m\*3) cross-wind integrated conc. (mg/m\* distances downing (m) concentration (mg/m\*3) cross-wind integrated conc. (mg/m\* signmary (m) (mg/m...2] (mg/m\*\*2) {mg/m^^2] (mg/m\*\*2) (mg/m--2) 3 sigma-y (a) distances downwind (a) concentration (ag/a<sup>\*\*3</sup>) cross-vind integrated conc. ( sigma-y (a) distances downwing (a) conc. conc. wstances downwind (m)
concentration (mc/m\*\*3)
rcoss-wind integrated con
igna-r() gma-y (m) stances downwind (m) ncentration (mg/m<sup>4+3</sup>) oss-wind integrated co lines-of-sight 9 trial month day year hour miaure 4269 19561 10.00 10 1956 1956 59 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.0000 0.0000 0.00000 0.00000 0.00000 21 1956 24 1956 1956 17 number of trials included in DD time zone designation latitude (deg) t longitude (deg) po12 (deg) po13 (deg) po14 (d 5.3676-01 1.400E+02 126,00 21.00 21.00 20.00 40.00 40.00 2.2482.00 3.5982.00 3.6982.00 4.6932.00 1.2032.00 0.00 -99.90 400.0 7.5582+00 0.00 10+3I 3.023 42.30 98.30 99.10 14 1956

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Ĵ 3 Juer nd data (m) Jeed (m/a) Irection (deg) (mg/m++2) (mg/m..2) (mg/m...2) (my/m++2) (mg/m\*\*2) ature #1 peraturu \$2 Ξ erse Monin-Obukhov length (1/m) (ded) UO eraging time for concentrati ggested receptor height (m) . of distances downwind stances downwind (m) ncentration (mg/m\*\*3) oss-wind integrated conc. istances downwind (m)
ncentration (mg/m\*\*3)
coss=wind integrated conc.
gma-y (m) litances downwind (m) ncentration (mg/m<sup>4+</sup>3) coss-wind integrated conc. gma-y (m) lstancus downwind (m) mcentration (mg/m\*3) ross-wind integrated conc. gmary (m) us downwind (m) ration (mg/m\*\*3) ind integrated conc. t level 1 ght for tem ght for tem //) at a tem ght for tem ght for wim ed wind dir ed wind dir ed sigma-th ed sigma-th 11 disture availability wen talo xing height (m) lnes-of-sight minute bo. of sources k-coord. of source ( y-coord. of source ( c Lass : ient pressure 00 ad cover (N) stability o ission rate ission durat cal mays emi gx0 at the s gy0 at the s gz0 at the s ource elevati Ē ction ve ACE LO 3 Jmā−γ trial month Year 50.0 -9.9902+01 -9.9902+01 2966 1956 3.8086:00 7.1 196d 19561 5.1251 2.1031 p960 5 1950 3 1.39061 1066.6-4.042 P956 1956 266 1956 22 3 -9.990 -9.990 3.256 trials included in DDA designation (deg) 1.3006+02 9359 -9.990 066.6-66.6-66.6-600.0 2.5682+02 4.263E+03 9906:01 i çhd 8580 g latitude (deg) longitude (deg) pg56 zone 50.0 3.0486+02 3.2598+0 1956 X and 1.0796 4000 400 4000 4 \$00.4 1.50 0.001 8.1546+01 9.990E+01 -99.90 7.4296+00 -9.990E+01 2.718E+00 2.265E+02 -99.90 42.30 98.30 P955 E+02 E+03 9,90 . 6096+01 . 1546+02 -99.90 Gra 1950 .... Š. 4016 Prairie

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APPENDIX F-2

LISTINGS OF THE DUGWAY DATA ARCHIVES - SMOKE/OBSCURANT DATASETS

															-	1							ä												7	11	11	ì	1	17	7	7		T	11	î	
						ource (m)	ton (m)	(d/s)	tted (ka)	Bource (m)	source (m)	source (m)	dity (A)	E Level 11 (K)	pht for temperature #1 (m	t level 12 (K) abt for tenourations 41 (-	det at a round to the	pht for wind data (m)	ad wind speed (m/s)	ad wind direction (deg)	ad algaaru (a/a) Madararya (ara)	ad sigma-chela (dag) ad sigma-chi (dag)	for domain-avy wind apeed	· for domain-avg data (a)	der lau exponent	dess (m) citv (m)	-Obukhov length (1/m)	lability.		(m)	4) 21 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	• for concentration (a)	aptor height (m) tee dououisd	of-sight	it and-point for 1.051 (m)	It and point for LOSI (m)	ad end-point for LOSI (m)	1 conc. (ng/m+2)	i domage (my-s/m°.2) r and-motor for 1051 (-)	of end-point for LOSI (m)	d end-point for LOSI (m)	ia ena-point for 1.051 (m) 1 conc. (ma/m**?)	[ dosage [my-s/m^*2]	it and-point for LOSI (m)	d and-point for LOSI (m)	id end-point for LOSI (■)   conc /ma/w**?)	dosage (mg-s/m*2)
	: trial JD : month	: day	: year : hour	: minute	: no. of source	: Y-coord. of e	: source elevet	: emission rate	: total man an	: sigro at the	: sigy0 at the	: sigzu at the	: relative humi	temperature A	: measuring hel	. Temperature A	a vind analy :	measuring heit	: domain-average	: domain-averag	: domain-average	: domain-averad	: measuring ht	: averaging tim	od pesde pute :	: friction velo	: Inverse Monin	: albedo : moisture avai	: Bowen raio	: mixing height	: Cloud cover (	: averaging time	: suggested red	: no. of lines-	: x-coord, of Ju	: Y-coord, of J.	: V-coord, of 21	: LOS integrated	: LOS Integrated	: y-coord. of li	t x-coord. of 21	: Y-coord, of 21 : LOS integrated	: Los integrated	: w-coord. of 1	: x-coord. of 21	: y-coord. of 21 : 105 integrated	: LOS Integrated
	10 10	20	20	00			0.00	-99.9 155.0	10.904	0.170	0.170		6.66-	300.00	2.00		2.64	2.00	2.64	175.8	04.44-	06.66-	2.00	60.0		006.66-	0006.66-	0.18	0.50	6,66-	5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5	60.09	1.50	) ~	240.2	180.4	-155.1	6.66-	1.25/E+06	230.9	-291.3	6.66-	3.4968+05	112.0	-325.4	0.42-	1.0032+05
(INVHC)	125 10	20	11	00	1 20-	126.3	0.00	-99.9	3.527	0.350	0.350	0.5.0	6.66-	300.00	2.00		11.5	2.00	3.14	344.4	06.66- 6 6	06.66	2,00	60.0		-99.900	0006-66-	0.18	0.50	6.66-	7.77. 7.77.	60.09	05.1	'n	240.2	- 257 3	-155.1	6.66-	CU+3154.1	230.9	-291.3	6.66-	1.6348405	172.0	-325.4	0.42-	4.9945+05
IC Grenades Sluded in DV DA	19	50	11	00	- 98 - 2 3 1	126.3	0.00	- 86 -	23,681	0.170	0.170			300.00	2.00		1.93	2.00	3,93	352.7	06.66-	-99.90	2.00	60.0		-99,900	0006.66-	0.18	0.50	6.66-		60.0	1.30		240.2	- 253 -	-155.1	-99.9 5 . 5 . 5 . 5 . 5	CU1300C.C	230.9	-291.3	6.66-	8.2406+05	172.0	-325.4		2.7728+06
Tests of 1 trials luc designation (deg) (deg)	10	20	22	ÖC		0.0	0.00	-99.9	9.940	0.170	0.170	0.10	6.66-	100.00t	2.00	04 40	50.4	2.00	E0.4	139.6	-99.90	06.66-	2.00	60.0	0,107	006-66-	0006.66-	0.18	0.50	6.66-	5.55 - 5.51	60.09	00.1		240.2	180.4	-155.1	6.69-	CO13191.6	230.9	-291.3	6.66-	3.619E+05	112.0	-325.4	-54.0	1.7056+05
atory Smoki : aumber of : time zoni : latitude : longitude	12	20	52	2		000	00.00	- 99.9	1.765	0.110	0.170			300.00	2.00			2.00	7.60	156.1	06.66-	-99.90	2.00	60.0	0,180	006.99-	0006.66-	0.18	0.50	6.66-	5.55-1 5.55-1	60.09	0.1	<b>m</b>	240.2	180.4	-155.1	- 66 -	CD+3916.1	230.9	-291.3	6.66-	1.4206+05	172.0	-325.4		1.3742.05
The Inve 6 40.20 113.00	12	20	22	2	•	000	00.0	6.66-		0.110	0.170	0.130		300.00	.2.00	06.66-		2.00	5.28	181.1	06.66-	06.66-	2.00	60.0	0.124	-99,900	-99.9000	0.18	0.50	6.66-	5.55- 55.	6.04	1,50		240.2	180.4	-155.1	6.99.9	7.9202404	230.9	-291.3		2.4106+04	172.0	-325.4	-54.0	-9.9902101

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The Development Teat I of Mild (MC), 19803 (MP) and 20033 (MP) Gronados (MIIG MC only, DTIMC) 13 1 audios of Estala Instituded In 2004 6 1 time some designation

																			uce 21 (m)		ure 82 (m)		3	(1)	r (teg		Ī	5	(a) have his				(1/=)							1			ton tot			1081		(
trial 10	work b	4r.	1	hour	ai put o	no. of sources	s-coord. of severa (m)	y-morth. of searce (s)	source elevation (m)	mission rate (g/s)	emission duration (a)	total mana smitted (hg)	eiged at the source (n)	sigyd at the source thi	sigs0 at the source (s)	ablest pressure (ets)	relative humidity (1)	Leapersture at level 41 (11)	securing height for temperati	temperature at level #2 (B)	seconding buight for temperatu	wind speed (a/s) at a tomst	security height for viad dat.	deals-sveraged wind apped in	domain-averaged wind direction	deala-averaged algua-u fa/al	domata-averaged signa-thets (	den averaged signa-phi (de	measuring M for donate-avy w	averaging time for demain-ave	utas speed pourt law angesent	friction valuetty int	Inverse Monin-Chukhev lessth	. ibeto	molature availability	Bours Talo	mising height (m)	cloud cover (1)	-G stability class	averaging time for concentrat	augusten teaspiot merger in	mut of threads for the	and a first and make for	v-coord of lot and mint for	h-mostd. of 2nd end-moint for	y-word, of 2nd and-point for	Lot integrated coae. (mg/m**2)	108 Integrated dosage ing-s/a
Glace .	-				:		-166.9 -	94.1 .	1 00.0	-99-9 -	-98-9	5.011 1	12.551	1.443 4	0.120		- 8.6	100.001	2.00 4	- 99.90	- 99.90	. 16.5	2.00 .	1,16.6	10.00	- 39.90	20.10	- 89.90 1	2.00.1			- 000-00-	- 88. 9000 1		0.50	0.50	- 8.6-						- 199	-110.0	1039.2	609.0 ·	- 99-9 -	3.7505+04 +
61664	•	1	2	2	8		1.112	-111-	1	- 29.5	-9.9	4.362	6.940	13.060	0.120	- 88 -	- 19.9	399.98		-99.8		1.5	8	1.5	0.661	-99.90		8 · 8				- 11. 900	-99.9090		9.1 9	9	<b>6.6</b> -	•••••				• -	-239.0		1019.2	6.603	8,881	7.2602+04
61501	•	~	2	2	•	- :	-16.9	41.1	9.9	6-66-	-91.9	3.925	42.966	10.650	0.128	-11.9	- 19.0	300.00	9. C	- 39.90	- 99.90	9	2.00	1.01	360.6	8.8-	9. IZ	96.46-	2.00			- 19.50	- 35. 9000	0.10	0.50	0.30	<b></b>					• -	-224.4	-150.4	1019.2	609.0	- 23. 9	2.0156+05
G14C1	•	~	*		10	- 1	1.41	14.2	0.0	6.66-	- 89 - 9	1.034	43.444	9.361	0.120	- 88 -	- 39.9	300.00	2.8		96 66 -		2.8	4.56	344.0	-99,90			2.00			- 19. 100	-93.9000	0.10	0.50	0.50			66- 007		2	• •	-239.6	-150.0	1039.2	6.003	-99.9	1.5622:05
61301	•	-	*	3	•		1.66-		4.4	-98-	-99.9	4.007	24.109	20.714	0.120		-88-	300.00				2.2	8.2	2.71		8.88-		96-66-				-11.50	-99-9000										-255.4	-150.4	1019.2	6.003		3.3406+05
61303	•	-	*	-		-	-42.3	7.8	1	-99.9		4.007	20.202	33.64	0.120			360.00	8	<b>96-98-</b>	2.6			3.46	596.9		11.00		<b>8</b> .2			198. et -	-99.9000	<b>1.4</b>									-245.0	- 16	1039.2	1 600.0		1.4785.05
10110	-	-		-	7	-		7	0.0		-9	1.41	. 42.83	1.151	• • · 134			1 306.00	3.99	<b>6. 86</b> - 1			5.6	2.2	1 355.0	9.8- -			00.2			11.900	- 55. 5000	1. e. l	0.30	5 0 5 0							-255.	-150.4	1019.1	1.003	-93.	9.3405.01
0 6903	-	2	-	-	-				ā.			a 4.751	MH.	9.36	• • · 121			90,000,00	×.	¥.6-	8 	1 1 1 1 1	×.			8-98-9		×				- 19.404	15. 5000										-255.	- 24	1019.	1 600.		0'32EE'8
4 690	-	-	~	-	~	-	200.	-152.	ð. •	ļ		5 F. D	12.12		• • 12	-		9 308.0		×	÷.6-	3.6			160.0	-19.9							99.900		Ň	3.0							-225-		1029.	. 660.	-19	5 1.962E+0
1 ,610	-	-	~	-	-					-		30.8	14-11 A			-		1	<b>.</b>					3.6									- 98. 960										- 254		1029.			1.7116.0
39	-		Ē	-	•				•	-		1.5	14.70	÷.	ē. 12		-	4.47			- <b>8</b>		ě.		192.	4.6- 0										ä.							- 11		1019.	3	-	5.223610
1 630				-	-	_	3	-111.4	*			10.4	1 23.04	21.40				9.995	2.6	1. 1. 1.	H. (3). H	#. *	ð	8.8 9	136.0	N	11.5	2.8 2.4	2				-15.200	9.1	0.34	3.4					-					. 600 .		6 4.425E+#
1000						_		1.4	ă. e		-	1.4.1	39.69	1 31.52	. I2			10.000	2.9			1. T	3.8		391.0	1.99.9	1.1	¥.8.					- 20. 200			2. <b>e</b>			Ŧ							9	-	1.3656+01
000			7		4	-		1.4		1.00- 0	1-00-1	1.401	1 41.425	100.41	0.136	1.66- 1		8-997 L	2.6	N-10- 1	EB. M	<b>X</b>	2.W	N	1.022 0		N 11 A		2.2					0.M	2.0	×	1.68- 6											1.1316.01
610					2	-	19.1	1.1	<b>9</b> .9	-98.1	-99.1	4.521	42.711	7.921	0.124	- 39.1	-99.5	306.06	2.94	- 54.94	- 99. 96	3.4	2.04	31.45	1.410	- 33. 34	9.8	- 25. 91	2.66	1.00			10.00		<b>9</b> .5	9.5			Ŧ	100						, ee	- 99-1	1. 4256101

The Development Test I of Mills (MC), 2003 (MP) and 20025 (MP) Geometer (20063 MP only, Origh)

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		6191 645	3	2 .	1409	1	1969	611 <b>9</b>	C 82 19	51342		1415	1915	6115		
	• •	• 9		_	• :	• 1	• -	• •	• -	• •	•	•	• 1	• 1		
		: 2	: =		: =	: 2	: =	. =	* *	. 2	2	• z	: =	: #	2	1
		2	-			•	1	:	3	:	15	3	:	2	2	1
	2	2	•		Ŧ	\$	2	3	÷.	2	2	3	2	g ·	<b>3</b> ·	l sinute
															-	the of sources
			1			3				<b>9</b> 0.0			.0	8		terrer eleveties (m)
	- 10. 0 - 10.0		- 89 - 9		- 39. 8	- 99.9	- 99. 9	- 29- 1	-19.9	- 33.5	-99.5		- 39.9	6.46-	-99.9	i amiasios tato (s/s)
-99.9 -99.9 -99.9 -99.9		-99.9 -99.9	-89.9		- 99.0	- 99.9	- 19.3	-99-9	- 89. 8	- 11.5	- 33. 3	1-86-	- 33. 3	- 94.9	-11.1	a mission duration (s)
16.11 14.24 16.34 16.31 14.21	162.61 485.24 516.21	16.23 17.235	11.235		11.11	10.130	17.235	16.412	16.233	16.150	16.158	16.150	16.012	11.114	11.71	i total more emitted (hg)
13.613 35.616 45.45 27.461 1	1 131.112 111.451 311.461 1	101-11 111-111 1	11.461 1		1.344	20.124	11.141	44.461	56.136	11.525	49.538	10.13	81C.18	81.15	14.532	s signt at the source (a)
1. 969.8 467.85 88.609 35.66 11	1 918.6 25.723 25.86	10.111 5.970 10	4.876	ž	1.256	0.125	5.405	29.413	EC) . LT	12.675	15.212	11.433	4.760	7.150	24.642	i sigyt at the source (m)
0.120 0.120 0.120 0.120 0	6.120 0.120 6.120 0	0.120 0.120 0	6.120	•	. 126	0.120	0.120	0.120	0.120	0.120	0.126	0.120	0.120	0.120	. 120	s signt at the source (s)
- 81,898,8 -98,8 -98,8 -	- 83.8 - 99.8 - 99.8	- 87.8 - 88.8 -		'	83.8	- 39. \$	-99.9	6,61-	-93.9	- 23.9	-99.9		- 99.9	- 99.9		s ambient preserve (a.s.)
		- 8.8 - 88.8		7		- 24.9	- 23.9	- 88- 9		6.66-		- 59 - 5	• • • •			1 solative hunidity (5)
306.00 300.00 304.00 300.00 300	300.00 300.00 300.00 300	364.66 366.66 308	366.66 300	20	Ę	300.00	100.00	200.10	300.00	100.00	300.88	240.66	300.00	308.00		t temperature at lovel \$1 (K)
2.40 2.60 3.66 2.66 2	2.06 2.66 2.60 2	3.66 3.66 2	2.80	~	\$	8	2.90	8.7	3.90	5.68	2.00		2.00	8	8	a manufied beight for temperature 21 (m)
- 45, 56 - 35, 56 - 45, 56 - 95, 56 - 39,	-39, 30 -39, 36 -59, 36 -39			<b>1</b>	2		- 29.90	- 29. 10		- 99, 90		-19.8	- 56	- 39. 90		tanporature at loval #2 (#)
					2 :	- 22. 20			- 35. 50	- 33. 50		9. S	00 · 60 -	8.6		measuring height for temperature 12 (s)
			5.5 5.5 5.5													Hund Speed (5/2) at a (over
									1.15		1.22					a montaine mangan tat una anta (a) a dimenta-surrand sist sured (s)s)
			102.0 219.0			100.0	191.0	320.0	114.0	0.~	112.0	0.960	170.0	163.0		therefore a section of the section (due)
	-15.36 -15.36 -31.30	-85-96 - 99-96 -	-99.90 -99.9	6.66-		-99.90	- 33. 30	-99.10	- 09.90	- 39.90	- 59 . 56		- 99.94	-99.90	- 39.96	i densla-averaged algua-u (n/a)
15.68 21.66 10.46 12.66 15.5	21.60 30.40 33.66 15.5	10.40 13.60 15.0	13.66 15.5	15.1	3	12.50		21.20	00°TI	7.10	26.70	30.00	3,00	e. 70	31.04	i domain-averaged signa-theta (dog)
-99,9095,90 -99,90 -99,90 -39,10		-98-96 -99-90 -99-1	-88- 96-88-	-	:	-99,90	- 59 . 99	-99. 10	- 35. 50	- 99.30	- 39.96		- 89.30	- 53. 90	- 39- 90	i domain-averaged aigne-phi (dog)
2.66 2.66 2.06 2.06 2.	3.00 3.00 2.00 2.	3.66 2.06 2.	2.00 2.	<b>~</b>	:	8	2.09	1	2.00	2.00	2.0	2.8	2,00	8		I masuring ht for domain-avg wind append (a)
444.8 400.8 484.8 640.0 100	400.0 408.0 600.0 100	609.0 600.0 000	600.0 0	ğ	•	6.001	400.0			600 · 0	8.044	1. 005	6.003	1.943		averaging time for demokanty data (a)
6.446 8.116 8.946 9.130 6.	6.110 0.900 0.130 C.	0.000 0.130 0.		•		011.0	0.120	9.119	0.120	0.1.0	0.010	6.490	0.130	0.030		I used speed power has exposent
			0.0100 0.0 22 22 22			9.0300	0.0100			9.0100	9010.9	0.0100	0000.0	9.6100		I Sufface soughasse (a)
165- 801.86- 801.46- 001.46- 80-46- 801.46-						- 20. 200	- 19, 100			006-46-			- 40 - 40 -			I Effection Volgelity (m)
					1 =	0.15			• •	0.10			9.16			, sites
0.50 0.30 0.50 0.50	0.30 0.30 0.50	0.30 0.30	•.5e	-		0.50	0.50	6.30	8.50	0.50	0.30	0.50	0.30	9.79	0.50	a soluture availability
0.50 0.50 0.50 0.50 0	8,36 8.58 8.54 B	0.50 0.50 0	9.36	•	ş.	0.50	0.50		0.10	0.50	<b>8</b> .50	0.50	0.30	0.30	9.50	i bowa raie
	- 8,84- *8,48- 8,48-		F	7	8.8	- 99.9	-99.9	- 89-9	- 99.9	- 55.8	-99.8	-99.9	-99.9	6.66-	- 99.9	i mining bolght (m)
-93.9 -93.6 -94.8 -94.9	- 6'66- 8'66- 5'66-	- 6.66- 6.66-	- 88.9	ĩ		- 39.3	- 25. 5	- 23.9	-11.1		- 33. 5		6.66-	- 23.3		s aloud cover (1)
			: ;		:	<b>9</b>	<b>F</b>	ŗ		<b>R</b> ,	6	-	Ŗ	<b>F</b>		: P-9 stability siess
608.0 600.0 408.0 600.0 60	600.0 400.0 600.0 60	408.8 600.8 60	(so . e	3	•	<b>6.0.</b>	408. <b>8</b>	6.04 J	6.001	0.004	609. <b>6</b>	600.0	\$00.\$	Q. 909		i averaging time for anomakration (a)
1.50 1.58 1.50 1.59	1.50 1.50 1.50	1.50 1.50	1.50	-	1.50	1.50	1.54	1.34	1.50	1.50	1.50	1.50	1.50	1.30	9.1	suggested sempter height in)
•	•	•	•		•	•	•	•	•	•	•	•	a	•	•	o mo. al distances durauind
		-	-		-	-	-	-	-	-	-	-	-	-	-	1 m. af lines-of-sight
-259.0 -259.0 -259.0 -259.0	-259.0 -259.0 -259.4	-259.6 -259.4	-339.4		-259.0	-259.8	-259.6	-259.0	- 250. 8	-259.0	-259.0	-259.0	-259.8	-259.8	-239.0	i s-sward. of lat and-point for 1061 (m)
-156.0 -156.6 -156.6 -156.0	-158.6 -158.6 -158.8	-150.0 -150.0	-150.0		-150.0	-150.0	-150.0	-186-	-130.0	-150.0	-150.0	-150.0	-150.0	-150.0	-150.0	1 y-mord. of lat and-point for 1081 (a)
1025.2 1025.2 1025.2 1025.2	1019.2 1019.2 1019.2	1019.2 1019.2	1019.2		1019.2	1039.2	1039.2	1019.2	1019.2	1019.2	1019.2	1039.2	1019.2	1039.2	1019.2	1 2-000rd. of 2nd on -point for 1081 (n)
600.6 600.0 601.0 600.8	6.00.0 648.0 600.0	64.0 600.8	6.00£		600.0	6.002	600.0	6.063	609.9	6.00.A	500°.0	6.003	6.003	9, 903	6.00	I T-mord. of 2nd and-point for 1081 (n)
-99, 8 - 93, 8 - 94, 8 - 94, 9 	6.86- 8.68- 8.68-	6-66- B-68-			-19.9	- 23.9	-99.9	-99.9	-13.1	- 99.9	- 39. 9	- 99.9	- 33. 3		- 89- 8	i 108 integrated conc. (sg/s**1)
3.6466405 1.3146405 3.3058405 1.7326405 0.1	1.3146405 3.3058405 1.7328405 0.1	1.3656:05 1.7326:05 0.1	1.7326:05 0.1	3	80E+04 1	1.4112145	. 0122.05	. 3962+05	1.7446.05 2		A 2013ELE.	. 1012(01.	. 4978105 4	\$ 126105 \$	. 9942454	ı 108 istagrated dosage (ag-s/s**2)

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and 20025 [32] Greendes (20025 20 caly, 07142] ŝ ŝ

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- 24.4	<b>9</b> .9	- 39.9		6.900	0.120 0.120	1.04.1	• 74. • 0. 00	- 39.9	904.0 9.490	6.940	6.900 0.120	101.7	-161.3		904.0	0.161		0.120		0.00	0.408	0.130	6.380 6.380	4.120	1.61	0,00	1.11.1	901.0 1.144	6.960	6.940 6.120	146.4	-119.6 0.00		904.0 1.614	6.960	0.120	212.6	00.0	- 99 - 9	2.451	6.900	0.120	230.5	0,00	- 81.9	6.163	6.900 6.900	0.130	-175.0	0.00	0.406	0.940		0.120	140.4	0.00	904.0
- 89.1	0.00			6.940	6. 300 0. 120	4.10	-04.6 0.00	- 99 - 9	1.461 1.461	6.340	6.940 0.120	1.04	- 70.0	6.66-	904.0	1.23	. <b>4</b> 0	0.120		0.00	- 19. 104.0	0.122	6. 310 6. 310	0.120	- 26.4	0,00	- 39. 3	9.106	6.910	6. 900 0.120	-0.1	-154.4 0.00		0.104 0.183	6. 300	6. 120 0. 120	26.1	0.00		0.914	6.940	0.120	52.5	0.0	6.66-	119 0	6. 380 6. 380	0.120	-110.4	0.00	9.4.6	0.056		0.120		0.0	0.108
1.851-	<b>9</b> .9	6.06- -	1.454	6.96	e	30.6	-116.6 0.00	- 89.9	9-1-1 991-1	946.9	6.900 120	104.0	C.34-	8.61-	9.4.9	.6.		•.12 <b>•</b>	- 191-	8.		0.124	6.9 6.9	0.130	11.1		6.68-	904.0 6.494	6.940	6.900 0.120	40.6	-166.1	-	904.0 902.1		0.120	3	-131.6	- 8- 9	1.11	6.96.9	0.120	1.14	9.9	6.64-	0.112	6.900 6.900		-122.5	0.00	9.196	0.147		• • •	-206.9	9 ° 9	0,108
-100.7			e. 136	98.9	6. No 0. 120		-166.1	-19.9	1. 040 1. 040		6.300 A 130	3	-151.6	- 99.9	904.0	1.020		0.120	-111.4	4a. 4	- 11. 1 10(. 1	1.040		0.120	119.4	00.0	- 99.9	904.0 0.130	6.900	4.120		- 206. 9	÷.	904.0 6.116			\$1.2	-191.4 0.00			83	0.120			- 99. 6		<b>!</b> ;;	0.120	-161.1	0.00		1.300		0.120	-109.5	0 · 0	0.104
-100.4	<b>0</b> . 0		6.509	4.344	6.980 6.120	200.9	-145.8 A 00	1.11	904.0 2.01]		6.900	110.5	C.0[1-	0.00 - 99.9	904.0	0.302		6.120	1.011	0.00	- 99 - 9 90 - 90	1.400	6 . 9 0 0	0.120	0.611	2.102-	- 11.9	904.0 A.616	6.900	6.910 6.1.6	1.1.1	-106.7	-9.1	901.0	6.900	6.380	111.1	-174-1 0.00		1.762	6.910	0.120	0.015	00.0		1.655	6. 300 6. 300	0.120		0.0	- 104	- 95, 900		0.120		0 . 0	0.106
154.4				4.444	6.900 0.120	14.4	169.0	- 29.9	804.8 1.176	6.340	6.960	52.6	101.5	80.8 - 98.8	9.4.6	1.949	6. 300	0.120	1.61	8.00	- 99.9 904.0	0.110	6.940 6.940	0.120		0.00		901.0	6. 300	6-160 1120	3	128.2	-9.9	0.106	6.940	6.980 6.120	<b>6</b> . 9	142.7 8.00	- 19-9	0.700	6.910	0.120	7.9	9.9	- 19.9	1.040	6.940 6.940	0.120		<b>9</b> .0	9.44-	012.0	6. 500 6. 300	0.120	102.0	9.00	0.104
- 114	8	- <b>89.9</b>	1.221	6.84	6.900	104.4	-		9.104 101 1		<b>1</b> 11		-166.1	8.9		161.0	6. 900 6. 900		-151-	8.9	- 99. 9	1.712	6. 300 6 1 1 0		1.14	• • • •	-	0.100		4.900	119.4	1.41-	ļ	904.4		6.900	145.4	- 101 -	-	119.9	6.944	0.120	1.1	0.0	6-64-		9 9 9 9 9 9 9 9 9	0.120	0.01	90,0	- 90 . B	101-1	6.980 6.980			0°.0	0.106 0.106
	90.0	- B1.B	1. 145 145	6.944	6.360		1.01		904.0	1 10	6.80	0.120 - 61.2	C.181-	9.9		0.240	6. 90 9 10	0.120	6.01-	0.00	6 · 6 ·	1.040	6. M0	9.130	-14.7	124.2	6-64	9.406	6. 900	6.900	11.5			904.9		6.940		-169.0 a ao		904-0 6-910	9.90	6.549	-	8.961-	- 19.8	904.0	6.340 1 1 1 0	• 170		90, 9	0.10	1.110	6. 360 4 960	071-0		00.0	6.46- 0.104

1.481 ; total area molified (hg)	6.946 1 algeb at the source (a)	0.128 t oign at the source (a)	48.6 1 h-mostd. af source (a)	-166.1 1 y-coerd. ef source (s) A AB 4 source electrice (s)	-35.8 1 emission sate (g/s)	904.0 1 emission duration (s) 0.201 1 total most antition (ha)	6.960 t sign at the source [a]	6.940 I sigy0 at the source (m) 0.120 I sist0 at the source (m)	46.3 5 R-mord. of source (n)	-151.5 1 y-moord. of anyrus (m)	-19.9 1 materio elevation (g/s) -19.9 1 materios tata (g/s)	904-0 : emission duracion [a]	U. TVE I VALAI MARA BALLIAJ (AG) 6.948 I SIGNA SE Lha source (s)	6.940 1 signa at the source (s)	0.120 : signi at the source (s) -99.5 : s-coord: of source (s)	-33.3 1 Presetd. of source (a)	0.00 i source elevation (a)	201.0 1 mission duration [s]	-19.900 i total anos entreed (hy)	6.348 1 sign at the source [s]	0.138 1 signs at the source (a)	-33,5 1 2-00014. 05 source (a) -33.9 1 y-00014. 25 source (a)	0.00 1 source elevation (a)	-99.9 i emission rate (g/s) 901.0 i emission Aurar(en (r)	-15.508 1 total sees estited [hg]	6.948 ( signif at the source (s)	0.120 1 signs at the source [s]	-11.3 1 H-motd. of source (m)	-95.9 1 proceed. of source (s) 6 00 1 source elevation (s)	-93.9 1 mission fate (g/s)	104.0 1 emission duration (s) 	6.900 1 algad at the source (a)	6.980 1 algys at the source (s)	0.126 : sign at the source [a] -99.9 : s-coord. of source [a]	-35.5 1 y-mostd. of sources (s)	9.00   BOUEGA BIOVALIGA (m) -39.9   Salasica Eato (4/s)	204.4 : mission duration (s)	-13.900   Cotal mass emitted (hg) 6.940   signab at the source (s)	6.968 : sigy6 at the source [s]	0.120 : sigst at the source (a) -19.0 : a-coard, at source (a)	-33.3 1 Y-month. at source (a)	0.00 1 mource elevation (a) -19.0 1 metadom rate (a/a)	901.0 1 mission duration (s)	6.300 1 signed and section (by)	6.900 i sigyb at the source [s]	-120 1 signs at the source (s) -19.9 1 stored. at source (s)	-11.1 1 y-coord. ef source (s)	-19.3 : miseion zate (g/s)	201.8 1 emission duracion (a)	-79.240 7 LOCAL BARE WEILEN THU 6.240 1 signt at the source (s)	6.900 : algre at the source (a)	0.120 ; sigst at the source (a) -99.0 ; a-coord, of source (a)	-39.8 1 y-coord. of suurce [a]	8.00 1 source elevation (m) -19 2 2 setestic rate (m/s)	901.0 1 mission duration (s)	-99.000 total ass saitted (hy) 4 440 s stard at the surger (s)	1.300 1 sigy0 at the source [a]	0.120 : elgeb at the source (a)
0.145	4.940	0.120	11.2	-132.4	- 95.4	0.104 1.415	6.900	6.900 0.120		-111-		904.0	6. 940	6.340	0.120	-111.2	00.0	0.100	0.230		0.120		0.00	9.44	- 19 . 500	6.900	0.120	• • • •	8.66- 00.0	- 8-	904.9	6.980	6.940	- 999	- 11.1	6.00 -	904.0	6. 910	6.940	0.120 - 99.9	- 89 - 9	0 0 1 1	904.0	6, 980	6.50		- 89 . 8	- 99 - 9	904.9	946.4	4.500		- 19.9	0.00	0 106	- 89.900 643.40		0.120
- 89 - 900	9.940	e. 120	4.46-	6.66- 00.6		- 33. 300		6, 960 0, 120		- 98 - 9	-9.9	904.0	6.940	6. 340	6.130 - 59.9	- 99.9	0.00	9.10	- 99. 900		<b>6</b> .120		00.0	0.106	- 88, 500	6.940	0.120	6.64- -	6.66- 0.00		9.4.0	6.940	6.940	- 99. 9		- 99.9	904.0	- 39. 900	940	6,120 - 99.9	- 19.9	0.00 - 99.9	9.1.0	- 11. Jun	6.940		- 99. 9		904.0		6.900	0,120 - 99. 9	- 11.5	00.0	9 1 0	- 39, 300 6, 340	6.980	0.120
0.440			1.101	-101-		1.144	6.300	6.98 9.120	6.m.			9.106		6.340	0.120	-114.2		9.196			•-120 	••••	3	8. 46 - 9. 796	- 11.900			<b>6.86</b> -			6, 198 404 - 84 -		9.9 9.9	0.120 - 99.9	1.8-		1.146	6.900	6.00		- 11. 9	8.4	904.0	6. Jeo	6.900		- 22 -	- 19.9	964.8		6.310	- 99.9	- 11.1	- 29.4	504.0	- 53. 300 6. 340	6.980	0.128
1.310	6 . M 0	0.120	1.4	0.111		9.996	6.940	6. 34 0 0. 120	- 22.9	- 99.8	-	904.0	6.300	6.960	0.120 - 99.9	- 99.9	0 . 00 -	9.4.6	- 35. 500		0.120		0.00	9.406	- 99. 900	6.340	0.120		0.00		901.0 - 199. 909 -	6. 36 0	6.900	- 99.9	- 99. 9	- 99. Đ	304.0	6.980	6.980	0.120 - 99.9	- 39. 9	9.90 - <b>19</b> .9	904.0	4.940	6.900 0110		- 99. 9 0.00	-99.9	904.0	6.960	6.980	- 99.9	- 39. 8	99°9	904.0	004 Y	4.940	0.120
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The Development Test II of 155994 SMOKE GREMADES (XM825, 2 projectiles, DT2M2) 9 : mumber of trials included in DDA 6 : time some designation

	WV19 : trial ID 0 : morth	25 : day	B] : Year	17 : minute	<pre>31 : no. of sources -72.9 : x-coord. of source (m)</pre>	-23.2 : y-coord. of source (m) 0.00 : source algorithm (m)	-99.9 : emission rate ( $4/s$ )	904.0 : emission duration (s) 0.135 : total mass emitted (ku)	6.980 : sigx0 at the source (m) 6.980 : slov0 at the source (m)	0.120 : sigz0 at the source (m)	-8.7 ; y-coord, of source (m)	0.00 : source elevation (m) -99.9 : emission rate (c/a)	904.0 : emission duration (s)	U.406 : total mana emitted (kg) 6.980 : slox0 at the source (m)	6.980 : sigy0 at the source (m)	U.12U : algzU at the source (m) -32.1 : x-coord, of source (m)	-34.9 : y-coord. of source (m)	0.00 : source elevation (m)	904.0 : emission duration (a)	0.406 : total mass emitted (kg) 6.480 : signo at the source (s)	6.980 : signo at the source (m)	0.120 : sigz0 at the source (m)	-5.8 : x-coord. of source (m) -20.4 : v-coord. of source (m)	0.00 : source elevation (m)	-99.9 : emission rate (g/s) 904.0 : emission duration (s)	0.135 : total man emitted (kg)	6.980 : sigku at the source (m) 6.980 : sigy0 at the source (m)	0.120 : sigz0 at the source [m]	-104.8 : y-coord. of source (m)	0.00 : source elevation (m) -99 9 : emission rate (2/4)	904.0 : emission duration (s)	0.133 : FOCAL MARS CHIFTED (Kg) 6.980 : sigxO at the source (m)	6.980 : sigy0 at the source (m)	-43.8 : x-coord. of source (m)	-75.7 : y-coord, of source (m) 0.00 : source alevation (m)	-99.9 : emission rate (g/s)	0.135 : total mass cmitted (kg)	6.980 : sigx0 at the source (m) 6.980 : sigy0 at the source (m)	0.120 : sigs0 at the source (m)	-11.2 Freedu. of source (m) -61.2 Fy-coord. of source (m)	0.00 : source elevation (m) -99.9 : emission rate (c/s)	904.0 : emission duration (s)	U.406 : total mass emitted (ky) 6.980 : sigx0 at the source (m)	6.980 : sigy0 at the source (m) 0 120 : sign0 at the source (m)	B.7 : x-cord of source (m)	-10.0 : y-coord, of source (m) 0.00 : source shevation (m)	-99.9 : emission rate (g/s) 904 0 : emission duration (s)	1.218 : total mana control (ky)	6.980 : sigru at the source (m) 6.980 : sigr0 at the source (m)	0.120 : sigzO at the source (m) 34.9 : x-coord, of source (m)
	MP 1 8	21	1	222	56,32 -58,3	-49.5	6.66-	0.135	6.980 6.980	0.120	94.96-	00.00	0.406	6.980 6.980	6.980	0.120 8.69-	-15.1	0.00	0.106	0.135	6.980	0,120	-11.2	0.00	0,406	1.353	6.980	0.120	-116.5	00.0	0.106	6.980	6.980	-29.2	-102.0	6.66-	1.488	6.980 6.980	0.120	- 61.4	00.00 6.66-	904.0	1.671	6.980	23.2	00.00	6.99- 0.406	1.082	6.980	0.120 49.5
	ue 17	24	19	123	28-58.3	-49.5	6.66-	0.281	6.980	0.120	94.96-	00.0	904.0	0.421	6.980	-43.8	-15.1	0.00	0.100	0.140	6.980	0.120	-11.2	00.00	0.406	0.421	6.980	0.120	-46.6	0.00	0.106	6.980	6.980	-29.2	-102.0	6.66-	0.201	6.980 6.980	0.120	-81.4	00.0	0.106	1.960 6.980	6.980	23.2	0.00	6.99. 0.106	1.403	6.980	0.120
	MP16	24	18	6	15 - 43.8	-15.7	6.66-	0.145	6.980	0.120	-61.2	00.00	904.0	6,140 6,980	6.980	0.120	146.6	0.00	904.0	0.290 6 980	6.980	0.120	-116.5	0.00	0.106	0.145	086.9	0.120	-102.0	0.00	0.106	6.980	6.980	0.0	- 87.4	6.99-9	0.435	096.9	0.120	-72.9	0.00-00-00-0	0.106	1.880 6.980	6.980	6.01-	0.00	6.99.9 904.0	0.145	6.980	0.120
	MP15	24	19		-10.0	-90.3	6.66-	0.151	6,980 980	0.120	-46.6	00.00	0.106	0.301	6.980	-55.5	-116.5	0.00	904.0	0.151	6.980	0.120	-102.0	0.00	0.106	0.452	6.980	0.120	-72.9	0.00	0.106	6.980	6.980	5.64	0,00	-99.9	0.603	6.980	0.120	-142.7	0.00	904.0	0.151 6,980	6.980	-14.7	00.0	-99.9 904.0	1.959	6.980	0.120
	41 AM	<b>50</b>	1	17	-29.2	-102.0	6.66-	0.106	6,980	0.120	-87.4	0.00	904.0	0.000	6.980	-67.2	-151.3	0.00	901.0	0.153	6.980	0.120	-142.7	0.00	0.406	1.224	6.980	0.120	-128.2	0.00	0.106	6.980	6.980	11.5	0.00	6.99-	2.601	6.980	0.120	1.66-	0.00	901.0	6.980	6.980	0.13	0.00	6.66-	1.224	, 980 9	0.120 -52.6
deg) (deo)	ELIM	50 20		17	24 - 43.8	-15.7	6.66	904.0	6.980	0.120	-116.5	0,00	0.106	0.156	990	0.120	-102.0	0.00	904.0	1.401	6,980	0.120		00 0	0.406	2.491	086.9	0.120	-12.9	0.00	901.0	6.980	980	5.6	-58.3	6.66-	0.156	6,980	0.120	-142.7	00.0	901.0	1.246	6.980	-14.7	0.00	6.99.9	1.401	080.9	0.120
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The Development Test II of 155pm SMOKE GRENADES (MII6A), 1 projectile, DT2M1) 11 : number of crials included in DOA 6 : time zone designation

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	HC20 : 1	18 : 0	1.1	70.9	0.00	138.9	1.248 : 0 0.350 : 1	0.350	60.5	-114.3 : 1		138.0 :	0.350	0.350 0	131.6 : 1		6.66-	1.248 : 0	0.350 : 1	0.350 : 1	105.7 : 1	0,00	5.66	1.138 : 0	0.290 : .	0.290		300.00	1 : 06 . 66 -	- 99.90 -	2.00	212.0 : 6	-99-90 : 0 13.00 : 0	06-66-	270.0	0.0300	2 006,88-	0.10	0.50	5 · · · · · · · · · · · · · · · · · · ·	270.05	1.50		-158.2	280.9 : 1	3 8006.04	-238.0 2 2
	NC19	17	<b>4</b> 27		0.00	138.0	1.144	0.350	9.96	-63.7	6.66-	138.0	0.350	055.0	78.2	0.00	6.66-	1.144	0.350	0.130	12.1	0.00	6.66	1.043	0.290	0.290	6.66 -	300.00	-99.90	-99.90	2.00	321.0	-99.90	06-66-	150.0	0.0300	0006.66-	0.18	0.50	6.66- -	66- 0,041	1.50		-156.2	587.9 280.1	- 99.9 - 94005101	-238.0
	NC1 /	12 81	50	12.1	0.00	-99.9	1.414	0.350	52.6	-101.2	6.66-	138.0	0.350	051 0	60.5	00.00	6.66-	1.414	0.350	0.350	43.3	- 202 -	6.66-	1.289	0.290	0.290	5.461 5.66-	300.00	06.64-	06.99-	2.00	150.0	-99.90	06.66-	210.0	0.0300	-99,9000 -99,9000	0.18	0.50	6.66-	210.0	1.50		-156.2	587.9 280.1	-9-99-9 -9-940Fi01	-238.0
	NC16	51 81 81	16 42	1. F	0.00	-99.9	1.426	0.350	. 129.5	-87.2	6.66-	0.851	0.350	0.150	83.6	00.00	6.66-	1.426	0.350	0.350	100.1	0.00	6.66-	1.300	0.290	0.250	6.66-	300.00	06.66-	06-66-	2.00	158.0	99.90	06.96-	240.0	0.0300	-99.9000 -99.9000	0.10	0.50	6.66 l	240.0	1.50	990	-156.2	280.1	9 66	-238.0
	IIC15	12 61	215 25	103.6	00.0	-99.9 138.0	1.567	0.350	145.1	-107.1	6.66-	138.0	0.350	0.350	157.9	0.00	6.66-	1.567	0.350	0.350	98.96	0.00	6.66-	1.428	0.290	0.290	5.55   	300.00	06.66-	06-66-	2.00	126.0	-99.90	06-66-	210.0	0.0300	-99.9000	0.18	0.50	6.66-	210.0	1.50		-156.2	587.9 280.1	- 10+3056 6- 6 66-	-238.0
	NC13	<b>6</b> 19	28.	-29.5	0.00	-99.9	1.045	0.350	-45.3	-145.2	6.66-	138.0	0.350	0.350		00.00	6-66-	1.045	0.350	0.350	0.6	-171-	6.65-	0.952	0.290	0.290	5.55- 5.65-	300.00	06.66-	-99,90 4.30	2.00	185.0	13.80	-99.90	240.0	0.0100	-99.9000 -99.9000	0.18	0.50	6.66- 6.66-	240.0	1.50		-139.3	287.9	6.99- 1.0305405	-238.0
	NC12	6 19	20	24.0	0.00	-99.9	1.045	0.350	13.1	-150.4	6.99-9	138.0	0.350	0.25.0	115.4	0,00	6.99-	1.045	0.350	0.350	56.2	-132.3	6 6 6 F	0.952	0.290	0.290		300.00	06.66-	06.66- 01.4	2.00	184.0	-99.90	-99.90 2 00	164.0	0.0300	0006.66-	0.18	0.50	6.66 - 66 - 1	164.0	1.50		-156.2	280.1	-99.9 6.500£+04	-238.0 -86.2
	HC11	619	119	19-	0.0	-99.9	1.107	0.350	-21.1	0.16-	6.66-	138.0	0.350	0.350	10.1	00.0	6.66-	1,107	0.350	0.350	5.6	1.611-	6.661	1.009	0.290	0.290	5.66-	300.00	06.66-	06.96-	2.00	159.0	-99.90	06.96-	240.0	0.0300	0006.66-	0.18	0.50	5 6 6 6 6 1	240.0	1.50		-155.2	587.9 280.1	-99.9 1 1208.05	-238.0
(deg)	HC10	6	22	- 76.6	00.0	-99.9	1.107	0.350	-20.1	-133,6	6.66-	138.0	0.350	0.350	43.5	-107.4	6.66-	1107	0.350	0.350	- 34.4	1.101-	6.66-	1.009	0.290	0.290	6 65 - 6 65 -	00.005	06.64-	06.99- 08.6	5.00	182.0	-99.90 28.80	06.99-	180.0	0.0300	0006.66-	0.18	0.50	-99.9	0.081	1.50		-159.3	587.9 280.1	6.06- 1 2705405	-238.0
: latitude	NC3	29 81	53	-116.0	0,00	-99.9 138.0	1.016	0.350	1.18-	- 66- 200	6.66-	130.0	0.350	0.350	-11.0	-12/-1	6.66-	1.016	0.350	0.350	- 61.2	-92.8	6.66-	0.926	0.290	0.290	6.66- 6.66-	300.00	06.66-	06.99- 08.4	2.00	176.0	-99.90	06.66-	220.0	0.0300	006.66-	0.16	0.50	- <del>9</del> 9 . 9 - 99 . 9	-99 - 220.0	1.50		-156.2	587.9 280.1	-99.9 -4 4405101	-238.0
40.20	5 <u>7</u>	29 81	17 55	-14.1	0.00	-99.9 138.0	1.090	0.350	0.50 2.81-	-143.0	0.00 6.99-	138.0	0.350	0.350	4.6	-119.8	6.66-	138.0	0.350	0.350	- 7.6	-126.6	6-66-	18.0	0.290	0.290	6.66- 6.66-	300.00	06.99-	06-66-	2.00	193.0	06.66-	06.66-	195.0	00000.0	006.96-	0.19	0.50	6'66- 6'66-	-99 	1.50	3 <b>19 6</b>	-199.3 -156.2	587.9 280.1	6.66- 	-238.0

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199.9	276.9	-16.2	120.1	10.30	180.4	0.643	8.00 8.00	5.66-	10+30	110.5	281.8	125.9 125.9	505.4	6.99	0.104	10.5	120.6	<b>395.8</b>	166.6	e.99.9	E+04
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The Duvelopment Test 1 of Blam Smoke Cartidges (XH019, 3 projectiles, DT1X3) 7 : number of trials included in DDA

				-	uta Of sources	oord, of source (m)	oord. Of source (m) rrs staustion (m)	asion rate (g/s)	selon duration (s)	at mass smilled (xy) x0 at the source (m)	yO at the source (m)	20 al the source (m) Dord of source (m)	oord, of source (m)	rce elevation (m)	stion rate (g/s) meion duration (s)	al mass emitted (kg)	x0 at the source (m)	yu at the source (m) 20 at the source (m)	oord. of source (m)	cord, of source (m)	ECO CLEVACION (M) Asion rate (n/4)	selon duration (s)	al mass emitted (kg)	AU AT THE SOURCE (M) VO AT THE SOURCE (M)	20 at the source (m)	lent pressure (aim)	ative humidity (%) Derature at level 4) (k)	putanuka at tever ri (m) suring height for temperatura () (m)	perature at level 12 (K)	suring height for temperature (2 (m) d seemed (m/s) at a rower	suring height for wind data (m)	afa-averaged wind speed (m/s) starstood wind direction (see)	ain-averaged sigma-u (m/s)	ain-averaged sigma-theta (deg)	ain-averaged sigma-pui (deg) suring ht for domain-avg wind speed (m)	raging time for domain-avg data (s)	d speed power luw exponent face roughness (m)	ction velocity (m)	atsa monin-Ubuknov jengen (1/m) Sao	sture availability	ing height (m)	ud cover (V) arability class	raging time for concentration (a)	gested receptor height (m) of distances downwind	of lines-of-sight	oord. of 1st end-point for LOSI (m) oord. of 1st end-point for LOSI (m)	oord. of 2nd end-point for LOSI (m)	oord. of 2nd end-point for LOSI (m) integrated cone. (mg/m**2)	Integrated douage (mg-a/man2)	uord, of 1st end-point for 1.051 (m) cord, of 1st end-point for 1.051 (m)	oord. of 2nd end-point for LOSI (m)	uru. ur zna enarpunc rot Lusi (m) integrated conc. (mg/m**2)	Integrated dusage (mg-s/ma*2)	oord, of lat and point for LOSI (m)	oord, of 2nd end point for LOSS (m) cord of 2nd and noist for LOSS (m)	Integrated conc. (mg/m*2)
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	11024 -		. <b>.</b>	1 61	40 I	-61.6 2	- 00 0	E 6.66-	120.0 :	14.200 :	14.200 :	-1.40	69.9	0.00	120.0	4,590 :	9.400	9.400 :	1 6.66-	- 66- 66-		120.0	1 006.96-	- 006 00-	0.120	- 6.66-	- 00 00t	2.00 1	- 06-66-	- 06.66-	2.00	2.80 :	1 06.66-	17.20 1	2.00 1	516.0 3	1 1 20.0	1 006.99-	0.16 2	0.50	<b>6</b> .66-	* * * * * * * * * * * * * * * * * * *	120.0 :	: 0C.1		-241.7 2 -68.7 2	1064.2 1	1 6.86- - 99.99	1013066.6-	-173.7	1122.4 :		1.1106+05 :	69.69	421.8 :	1 6.66-
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	802A	m.	<b>•</b> 19	12	02 02	86.1		6.66-	120.0	6.000	B.000	54.4	E 69-	0.00	120.0	6.161	9.700	0.120	10.6	-81.0	00.0	120.0	5.519	12.600	0.120	6.66-	6.66- 00.001	2.00	-99.90	06.96-	2.00	4.40	06.66-	9.60	2.00	585.0	0.0300	006.66-	0.18	0.50	6.66-	3.9 5 5 1	120.0	00.1	5	-241.1	1064.2	6.86-	1.8406+05	-113.7	1122.4	6.66-	10.3069.0	69.69	421.8	6.66-
	801A		• 1	01		-2.7		6.66-	120.0	22.400	22.400		6.66	0.00	120.0	-99.900	-99.900	-99.500	6.66-	6.66-		120.0	006.66-	000 000-	0.120	6.66-	6.66- 00 005	2,00	-99.90	06.96-	2.00	4.70	06.66-	8.10	2.00	614.0	0.0300	006.99-	0.16	0.50	6.66-		120.0	00.1	5	-241.1	1064.2	6.86-	1.5802.05	-113.1	1122.4	6,66-	-9.990E+01 -	9.69	421.8	6.66-
designatio	(deg)	7	12	1		61.4	-22.0	6.66-	120.0	21.600	21.600	0.120	-65.0	0.00	120.0	0.961	24.500	24.500	6.66-	6.66-	0.00	120.0	-99.900	000 00-	0.120	6.66-	6.66- 00 002	2,00	06.66-	06.66	2.00	1.90	06.66-	27.60	2.00	502.0	0.0300	-99,900	0.18	0.50	6.66-	6.66-	120.0	00.1	5	-241.7	1064.2	6.86- 9.99	8.900E+04	-112.6	1122.4	6.66.	-9.990E+01	9.69	421.8	6.66-
time zone	longltude	2	12	121	27	16.5	-62.9	-99.9	120.0	17.800	17.800	0.120	4 . 66 I	0.00	4-66- 0 001	-99.900	-99.900	-99.900	6.66-	6.66-	0.00	120.0	006.66-	006.66-	0.120	6.99.9	6.96- 00 005	2,00	-99.90	06.66-	2.00	1.90	06.66-	16.80	2,000	0.96.9	0.060	-99,900	91.0	0.50	6.66-	5.55- 55:	120.0	1.50		-247.7	1064.2	628.2	9. 900E.04	-189.6	1122.4	6.66	- 101306.01 -	69.69	421.8	6.66-
40.20	113.00	12	22 80	21	0-		24.4	6°66-	120.0	13.600	13.600	0.120	6.66-	0.00	99.96-	006.66-	006.66-	-99.900	6.66-	6 66 -	0.00	120.0	006 66-	006.99-	0.120	6.66-	- 99° -	00.00r	06.99	06.99-	2.00	1.50	06.66-	12.70	00.5	690.0	0.068	006.66-	0006.88-	0.50	6.66-	9.99- 90-	120.0	1.50		-247.7	1064.2	628.5	-9.990£101	-189.6	1122.4	6,66 -	2.1606.05 -	69.69	421.8	6.66-

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ated durage (mg-1/m*2) f lat end-point for LOSI ( f lat end-point for LOSI ( f 2nd end-point for LOSI (	k kna eka-point tor LOSI ( ated conc. (mg/m**2) ated dosage (mg-s/m**2)	f lat end-point for LOSI	f 2nd end point for LOSI ( ated Lonc. (mg/m*2) ated dotage (mg/m*2)
04 : LOS lategu -7 : x-coord, c -3 : y-coord, c	.9 i Los integr 01 i Los integr	.6 : x-coord. c .8 : y-coord. c .5 : h-coord. c	.5 : y-coord. o .9 : LOS lategr 01 : LOS lategr
9.000£	-9.990E+	110	-775 
1.020£.05 -21.7 142.3 408.7 -368.2	6.66- 1013066.6-	110.8	-175.5 -99.9 -9.990E+01
-9.9906.01 -21.7 142.3 408.7 -768.2	10+3066.6-	110.0 395.5	-175.5 -99.9 -9.990E+01
-9.9902+01 -21.7 142.3 408.7 -768.2	6.66- 10+3066.6-	110.0	-775.5 -99.9 -9.9908.01
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-9.990£401 -21.7 142.3 40£.7 -768.2	6.99- 10+3066.6-	110.8	- 10-3066-6- 10-3066-6-
-9.990£+01 -21.7 142.3 408.7 -768.2	6.66- 10+3064.6-	110.8	-175.5 -99.99.9 -9.9906-91

The Grouplement Test 1 of Gimm Smale Cattridges (M1)142, 1 projectile, 071M1) 16 : number of trials included in DOA 6 : time som designation 40 : 1 : include (May)

							source (s)	eourde (m) Atlas (m)	- (1/1)	racion (s) 	esii(cod (kg) > eeurge (a)	(=) ******	1 martes (1)	saura (sta) Jaira (st	at level () (K)	ight for temperature () (m)	at level #2 (K)	olghi for temperature (2 (m) (m/m) at a tours	light for view date to)	igod uind spood (m/s)	aged wind direction (deg)	iged signa-u (n/s)	ugad sigma-thats (day) 	. for doorle-ove wind sumed for	the fur domain-ave data [a]	www.law asponant	(=)	jocity (m) 10-Chuthou   crath 11/ct			1		y state	ine for concentration (s)	septer beight (m) acts docaries		lst and-point for LOGI (m)	lat and-point for LOBI (n) 2nd and-point for line (n)	2nd end-point for LOGI (b)	(1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	ied dosege (mg-s/m''2) ist and-molet for 1091 (-)	ist and point for Loss (a)	2nd and-point for LOSI (a)	Ind and point for LOBI (a)		lat and pulat for 1031 (a)	lat and point for LOH (n) and and point for that (n)	2md and point for LORI (a)	ad cons. (mg/m**2)	.es essige (ag-s/s**7) let end-pulat for LOGI (s)	lat and point for LOBI (a)	Ind and polat for LOBI (a)	2md emd-point for LOSi (m) ad some fastation	(2	lat and-putat fur LO61 (m)	lat end-point for LUSI (n) 2nd end-point for LUSI (n)	2nd and point for LOSI (=)	.ed coma. (my/m**2) ad dosayo (my a/m**2)
	trial 10	BORTH	414	Ĭ	a lauta	no. of nour	1-coord. of	y-coord. ef	ententos ra	enteston du	stand at the	eigyê at th	algaD at th	and last pro-	( mpristure	assauring he	tempstature	d Bellunees	To south the second	denain-aver	dumán-num	dimala-aver	duesis-aver-	Peesurian A	13 Buigesove	wind speed ,	has every ine	fridt Jon we	albedo	actecute av	Bowen sale states hateb	sloud cover	P-G stabilit	13 BelBereve	augented to to, of dista	to. of line	1-coord. of	y-coord. of	Y-COOLD. of	Los Integrat	ton integrat trecord. of	r-coord. of	• . coord . of	Y-COSE4. DE	LOS INCOMENT	-cuerd, of	V-coord, of	r-cuord. of	Los Jacopras De Jacopras	tre sategrat	receid. of	a cord. of	y cuord, of	los Integrat	a coord. of	r coord. of	r cuerd. of	liut Integrat liut Bategrat
	1 4104	-	-	= :		-	a. 8.	.00	- 89.9	120.01	1.610	0.910	1.400 -		100.00	1.00 1	- 35.30		1 00 1	3.00 .	* 0 *	- 98.98-	00.01	2.00	10.401	.040	0.0100	- 55. 5000	0.10	e . 50 -	0.50	0.00-	- 88 -	120.0			-10.1	1064.2	1 2 . 9 2 9	- 9.9	- 109.601-		1112.4		1.1006101	-152.9		- 760.9 1	- 99.9 -	- 21. 1	142.3 4 1	10.00		. 10+3465.1		1.1.1	115.201-	1 8.86-
	8296	-	• ;		2 =	-	-17.4	00.0	-	120.0	1.620	0.910	1.400		300.00	2.00	- 99.90	94.14- 94.1	2.00	1.50	305.0			2.00	170.0	0.040	0.0300	- 15, 2000	0.10	0.50	0.50		ŗ	120.0	9 9 9	~	-20.7	1064.2	650.5			-111-	1122.4		1.0002.04	-152.9		- 760. 9	-99.9 • •••••••		142.3	40 <b>9</b> .7	- 10.2	2.2001-04 -1	9 91 -	5.16	-115.5	
	9196	-	• ;	::	: \$	-	-76.9			9.916.8	1.610	0.910	1.400		309.00	3.00	-99.90	2 2	8.8	2.7	149.0			2.00	147.0	0.004	0.0300 - 40 200	-11. 1000		0.50	0.50	-	ę	120.0	-			1064.2	651.5	6.00- 10.1000 1	- 189.4	-111.7	1.22.1		3.1002.04	-152.9	421.0	6.031-	- 99.9 4 4002404 -	- 21.1	142.3	(		9.9906101	9.97		-115.5	4.86- 10:3064.6
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(161D1) M	BB40 ; trial ID	6 : month 17 : day	81 : year	12 ; hour 29 : minute	1 : no. of sources	-ZU.Y ; X-COOID. OI SOUICE (M) 91.] : V-COOID. OI SOUICE (M)	0.00 : source elevation (m)	-99.9 : emission rate (g/s)	0.859 : total mays emitted (kg)	3.737 : sigx0 at the source (m)	12.9// : sigyU at the source (m) A 120 : sigro at the source (m)	-99.9 : amblent pressure (atm)	-99.9 : relative humidity (A)	JUU.UU : [emperature at ]evel #1 (%) 7 AA : maaaurion huloh for remonsture #1 /m)	-99,90 ; temperature at level (2 (K)	-99.90 : measuring height for temperature (2 (m)	6.50 ; wind speed (m/s) at a tower 2 00 :	6.50 : domain-averaged wind speed (m/s)	25.0 : domain-averaged wind direction (deg)	-99.90 ; domain-averaged sigma-u (m/s) e fo : domain-averaged eisma-thare (dom)	9,00 ; domain-averaged aigma-theta (deg) -99.90 ; domain-averaged aigma-phi (deg)	2.00 : measuring ht for domain-avg wind speed (m)	187.0 ; averaging time for domain-avg data (s) 0.042 ; wind speed power law exponent	0.0300 ; surface roughness (m)	-39.9000 ; inverse Monin-Obukhov langth (1/m)	0.18 : albedo	0.50 : Bowen raio 0.50 : Bowen raio	-99.9 ; mixing height (m)	-99.9 ; cloud cover (%) -99 : P-G stability class	115.0 : averaging time for concentration (a)	1.00 ; suggested receptor height (m)	2 : no. of lines-of-sight	-24).7 : x-coord, of lat and-point for LOSI (m)	-68.7 ; y~coord. of lat and-point for LUSI (m) 149 K · *-roord of 2nd and-roint for LOSI (m)	113.7 ; y-coord. of 2nd and-point for LOSI (m)	-99.9 : LOS Integrated conc. {mg/m <sup>±±</sup> 2} 1 1005.04 - 105 (ntegrated docord docord (accedented)	1./IUETUT ; LUD INCEGIACED GOURGE (MY-2/M-7) 	-173.7 : y-coord. of lat and-point for Losi (m)	241.1 : x-coord, of 2nd and-point for LOSI (m) 68.7 : y-coord, of 2nd and-point for LOSI (m)	-99.9 : 105 Integrated conc. (mg/m**2)	-9.99UE+UI : LUD INTEGIATED GOBAGE (85-3/10-14)
a Grenades luded in Du n		99	18	015		-94.0	0.00	6.66-	0.782	0.456	13.497	6.66-	6.66-	00.001	06.66-	-99.90	.6.80	6.80	167.0	05.56-	06.66-	2.00	161.0	0.0300	0006.66-	0.18	0.50	6.66-	6.66   67	0.211	1.00	~ C	-247.7	-68.7	173.7	6.66		-113.7	241.1	6.66-	1.5105105
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	trial ID	day	year	minute	No. OF SOURCES K-CUORD, OF SOURCE	y-coord. of source	enlasion rate (g/s)	emission duration (1	sigx0 at the source	sigy0 at the source sigz0 at the source	x-coord. of source	y-coord. of source in source	emission rate (g/s)	contation duration () total mass emitted	algx0 at the source	aigro at the source	x-coord. of source	averse elevation (m)	emission rate (g/a)	total mass emitted	sigx0 at the source	sigro at the source	K-coord, of source	source elevation (m)	emission rate (g/s) emission duration (s	total mass emitted	sigyO at the source sigyO at the source	sigr0 at the source	y-coord, of source	source elevation (m) emission rate (n/e)	entaston duration (s	sigx0 at the source	sigyO at the source sigzO at the source	k-coord, of source	source elevation (m)	emission rate (g/a) emission duration (a	total maws emitted (	sigy0 at the source	sigzu at the source ( x-coord, of source (	y-coord, or source ( source elevation (m)	emission rate (g/a) emission duration (s	total mass emitted	sigy0 at the source	algz0 at the source / x-coord of source /	y-coord. of source	source elevation (m) emission rate (g/s)	emission duration (a total mass emitted i	sigx0 at the source	sigru at the source	N-COOLD. OF SOURCE
	8648			• <u>9</u> ;	62.4 :	-120.9 :	6.66-	115.0 :	5.906	0,120	15.3	-136.8	6.66-	19.011	1.397 :	0.120	92.9	00.00	- 6.66-	0.781	3.282	0.120 :	68.2	0.00	115.0	0.761	3.708 : 12.586 :	0.120 :	-150.2 :	- 00'00 - 00'0	115.0	5.507	12.331 : 0.120 :	83.7 : -142 6 :	0.00	115.0 :	0.781 :	11.471	62.4	0.00	115.0 :	0.781	12.145	0.120 :	-101.5	: 6.66-	115.0 :	9.704	0,120	: 1.90
L8112	8845 2	16	(9) 0	2	62.4	-120.9	6.66-	126.0	7.979	0.120	15.3	-136.8	6.66-	0.813	3.420	0.120	92.9	0.00	-99.9	0.013	1.551	0.120	68.2	0,00	-99.9	0.013	5.787	0.120	-150.2	00.0	126.0	4.004	13.775 0.120	<b>0</b> 3.7	0.00	126.0	0.613	14.314	62.4	0.00	-99.9	0.813	11.922	0.120	-101.5	0.00-	126.0	11.575	0,120	1.40
Grenadea ( uded in DUA	8844 2	12		223	70.2	-116.6	6.66-	199.0 0.001	10.096	0.120	56.0	1.66-	6.66-	0.601	3.468	0.120	36.7	0.00	-99.9	0.001	3.579	0.120	63.9	0.00	-99.9 199.0	0.801	6,887	0,120		0.00	199.0	6.993	19.047	46.9	8	199.0	0.801	20.290	10.2	0.00	0.661	0.801	17.600	0,120	-137.9	6.66-	199.0 0.801	15.507	0.120	1.1
e Le Series triais incl designation degi	bb4]			• ?? :	51.5	-123.7	6.66-	199.0	10.096	17.600	211.5	-141-	6.66.	0.820	3.468	0.120	80.06 6.05	00.00	6.99.	0.820	3.579	0.120	63.6	00.00	0.991	0.620	6.887	0.120	-156.0	0.00	199.0	6.993	19.047 0.120	80.6	0.00	5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5	0.820	20.290	51.3	0.00	6.99- 0.991	0.820	17.600	0.120	-102.4	0.00 9.99-9	199.0	15.507	0.120	r.0c
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The Eval	119.00	• •	3	•	112	-116.0	0.00-0	251.0	10.995	12.511	80.4	-133.6	6.66-	251.0	6.053	0.120	9.16	0.00	6.66-	0.820	0.301	0.120		0.00	6.66-	0.820	8.656 14.231	0.120	-146.8	0.00	251.0	2.517	16.465	6.6.5	0.00	251.0	0.820	16.333	6.120	0.00	-99.9 0.15c	0.820	112.511	0.120	6.86-	00.0 6.66-	251.0 0 820	14.612	0.120	6.19

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	trial ID	month	day			neuro no. of sources	x-coord, of source (m)	y-coord, of source (m)	source elevation (m)	emission rate (g/s)	emission duration (s)	total mass emitted (kg)	signO at the source (m)	sigy0 at the source (m)	sigz0 at the source (m)	x-coord, of source (m)	y-coord. of source (m)	source elevation (m)	enission rate (g/s)	emission duration (2) 	LOCAL MANA COLOCOL (NG)	signo at the source (m)	algy at the source (m)	sugar at the source (m) success of source (m)	strong of source (m)	ground of active two	active statetics (m) Aminatics rate (s/s)	destation targ (y/a) ambaeton duration (a)	Guildeich duistach an Pòraí mean amírtad (Ér)	stord at the source (a)		algreet the source (m)	r-coord. of source (m)	v-coord, of source (m)	source elevation (m)	emission rate (g/s)	emission duration (a)	total mass emitted (kg)	sigxU at the source (m)		sigzu ar fre source (m) s-soord of source (m)	wroning of source (m)	y-court of source (m) source sisterion (m)	source state to a second and second s	emission duration (s)	total mass emitted (kg)	sign() at the source (m)	aloy0 at the source (m)	algau at the source (m)	K-COOLD, OF SOURCE (B)	y-coold. Of source (m) source sleartion (m)	emission rate (q/s)	emission duration (a)	total mass emitted (kg)	signum the source (m)	stord at the source (m)	amblent pressure (acm)	relative humidity (N)	temperature at level #1 (K)	measuring height for temperature 11 (m)	temporature at level 42 (A)	measuring height for temperature 14 (m)	wind speed (m/s) at a count measuring height for wind data (m)	domato-accreted wind monoid (m/s)	domain-averaged wind direction (deg)	domain-averaged sigma-u (m/s)	domain-averaged sigma-theta (dey)	domain-averaged sigma-phi (deg)	measuring ht for domain-avg wind speed (m)	averaging time for domain-avg data (2)	wind spead power law exponent	surface roughness (m)	friction velocity (B) terrest Monte-Obstitate Jacath /1/m)	INTEL POLITICATION AUNTRACTATION DEJOAUL
	1 : q98					• • •	- 15.7	100.8 :	0.00	- 39.9 :	101.0 : 4	0.801 :	2.872 :	16.719 :	0.120 :	-51.4 :	117.5 :	0.00	5.55-	101.0												120	-28.0	15.5	0.00	: 6.66-	101.0	0.801 :	10.962 :	116.21					101.0	0.601 :	3.020 :	16.693 1	0.120 :	-25.6 :		: 6.66-	101.0	0.801		. 001 0	6.66-	-99.9 :	300.00	2.00:	. 05.551	- 32.46-			10.0	-99.90 :	15.70 :	2.60 :	2.00 :	100.01	: 100.0	0.0300	- 99. 400 -	- 27.3444
	85b		-		•	- <b>-</b>	1.25-	100.0	0.00	- 69 - 6	101.0	0.859	1.848	16.863	0.120	-51.4	117.5	0.00	6.66-	101.0	508.0	1011									001.11	12.23		15.5	0.00	-99,9	101.0	0.859	14.106	121-6	071.0	- 47- - 47-			101.0	0.859	7.504	15.214	0.120	-25.6		6-66-	101.0	0.859		11100	6.66-	6.66-	300.00	2.00	-99.90	06.48		00.7	0.95E	-99.90	12.70	3.80	2.00	300.0	0.102	0.0300	-99,300	- 23. 3444
esignation eg) deol	84b			79		2.4	- 35 -	100.8	00.00	6-66-	0.101	0.954	1.554	16.893	0.120	-51.4	117.5	0.00	6.66-	101.0	0.934		10.400	0.120				A . AA .	1.101		716.11	017.U58			00 0	6.66-	101.0	0.954	13.939	9,668	0.120	8.97-		0.00	0 101	0.954	7.237	15.343	0.120	-25.6		6 66-	101.0	0.954	12.048	216.11	0.41.0	6.66-	00.000	2.00	-99.90	06.66-		00.7	155.0	06.66-	11.40	2.50	2.00	300.0	0.059	0.0300	-99.900	- 59. 3000
time zone d time zone d latitude (d longitude (d	d[0			67	23	7	•	100.8	00 0		0.101	0.992	5.032	16.201	0.120	-51.4	111.5	00 0	6.66-	101.0	0.992	0.813	16.945	0.120	- 45. 1	130.3	0.00	- 99.9	101.0	266.0	9.176	14.268	0.120	- ve. c		- 6 - 66 -	101.0	0.992	15.645	6.559	0.120	-26.8	1.61	0.00		0.992	10.269	13.503	0.120	-25.6			101.0	0.992	14.268		0.140	6.66-	300.00	2.00	06.66-	-99.90	4.40	00.7		06.66-	10.50	3.00	2.00	300.0	0.074	0.0300	006.96-	- 99. 9000
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The Evaluation of the LB Series Gremades (LBA), 8 grenades, LB1E8) 6 : number of trials included in DOA

	trial ID	month	day vear	hour	minute no. of sources	x-coord. of source (m)	source elevation (m)	emission rate (g/s) emission duration (s)	total mass emitted (kg)	sigx0 at the source (m) sigv0 at the source (m)	sigzo at the source (m)	<pre>x-coord. of source (m) v-coord. of source (m)</pre>	source elevation (m)	emission rate (g/s) emission duration (s)	total mass emitted (kg)	sigk0 at the source (a)	sigro at the source (m)	K-coord. of source (m)	y-coord. of source (m)	emission rate (g/a)	emission duration (s)	total mass emitted (kg)	sign at the source (m)	sigzo at the source (m)	x-coord. of source (m) w-coord of source (m)	source elevation (m)	emission rate (g/s)	total mass emitted (kg)	sign0 at the source (m)	sigyu at the source (m) sigz0 at the source (m)	x-coord of source (m)	y-coord. of source (m) source elevation (m)	emission rate (g/s)	cmission duration (s) rotal mass sainted (ho)	sigx0 at the source (m)	sigy0 at the source (m)	x-coord. of source (m)	y-coord. of source (m)	emission rate (g/s)	emission duration (2) total mass emitted (kg)	sigx0 at the source (m)	sigyu at the source (m) sigz0 at the source (m)	K-COORD. OF SOURCE (B)	y-coord. Or source (m) source elevation (m)	emission rate (g/s)	emission duration (4) total mass amitrad (kg)	aigx0 at the source (m)	sigyU at the source (m) sigzO at the source (m)	x-coord. of source (m)	y-coord. of source (m) source elevation (m)	cmission rate (g/s)	emission duration (2)	sigx0 at the source (m)	sigy0 at the source (m)	ambient pressure (atm)	
	: 9128			21		62.6	0.00	- 6.66-	0.763	1.048 : 16 863 :	0.120		0.00		0.763	2.579 :	0.120	37.2 :	- 20.0	: 6.66-	101.0 :	0.763 :	15.528 :	0.120	20.9	0.00	- 66-6-	0.763	10.617 :	0.120 :	68.0 :	-83.6 1	- 66- 6	101.0:	4.748 :	16.286 :	72.6	-100.2 :	6.66-	101.0	8.802 :	0.120 :	12.7	. 00.0	- 66- - 66-		12.255 :	0.120 :	60.4 :	0.00	- 6.66-	101.01	14.873	8.158 :	- 6.66-	
	वाष	-	6	50	10	62.6	0.00	6-66- 0 101	0.763	4.603	0.120	+ · IC	0.00	2.55- 0.101	0.763	8.672	0.120	37.2	9.00 -	6.66-	0.101	0.763	868.11	0.120	20.9	0.00	0.00	0.763	14,800	0.120	68.0	-83.6	6.66-	0.101	1.698	16.879	12.6	-100.2	6.66-	0,101,0	2.728	0,120	12.1	0.00	6.66-	0.763	6.969	0.120	68.4	-134.1	6.66-	101.0	10.734	13.136	6.66-	
	9106	-		12		62.6 -11.6	0.00	6.66-	0.763	160.9	0.120	- 109-	0.00	0 101	6.763	8.158 14 633	0.120	37.2	-20.4	6.66-	0.101	0.763	12.255	0.120	20.9	0.00	6.661	0.763	14.502	0.120	68.0	0.00	6.66-	101.0	1.108	16.928	12.6	-100.2	6.66-	0.763	110.6	0.120	12.1	00.0	6.66-	0.763	7.504	0.120	68.4	-134.1	6.66-	101.0	11.166	12.753	6.66-	
designation deg)	(deg) A9b		- 6	-	6 <b>6</b> 7	-35.7	0.00	6.66-	0.782	7.769	0.120	-46.9	0.00	6-66- 0 101	0.782	3.601	0.120	-61.1	123.6	-99.9	101.0	0.782	16.945	0.120	-11.4	0.00	6.66-	0.782	5.170	0,120	- 30. 3	90.6	6.66-	101.0	10.269	13.503	-25.7	0. <b>1</b> .0	6.66	0.782	13.414	0,120	-25.6	0.00	6.66-	0.101	15.645	0.120	-29.9	0,00	-99.9	101.0	16.809	2.286	6,66-	-
time zone	long i tude Bab		~ 6	4 1	40 Q	65. <u>6</u>	00.0	6.66-	0.001	7.369	0.120	51.4	0.00	6.66-	0.801	11.072	0.120	37.2	-50.6	- 99.9	101.0	0.001	9.54B	0.120	20.9	0.00	6.66-	0.801	16.015	9.594	68.0	-83,6	6.66-	101.0	1.603	16.327	72.6	-100.2	6.66-	101.0	0.221	0 120	12.7	0,00	6.99.	0.101	4.177	0.120	68.4	1.411-	6.66-	101.0	B.290	14.800	- 99.9	
40.20	113.00 :		~;	16	21	3.5	0.00	6.66-	0.897	11.624	0.120	51.4	0.00	- 99.9 101	0.097	<b>8</b> ,031	0.120	5.76	-50.6	00°0 6°66-	101.0	0.897	16 512	0.120	20.9	00.00	6.66-	0.897	0.517	0.120	69.0	-83.6	6.66-	101.0	13.593	10.149	12.7	-117.5	6.66-	101.0	16.847	1.995 001 0	68.4	1.4.1-	6.66-	101.0	16.788	2.435	6, 66-	6,99- 0,00	6.99-9	101.0	006.96-	006.66-	0.14U	•

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The Evaluation of the 18 Suches Grenades (L&A), 12 grenades, L01E2) 6 : number of trials included in DUA

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The Evaluation of the LB Series Grenades (LBA), medium condition temp., LB12M) 6 : number of tilals included In DDA -

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8.5 : y-coord. of 2nd end-point for 1051 (m 9.9 : LOS integrated conc. (mu/m**2)	+05 : LOS integrated domage (mg-s/m**2) 7.7 : x-coord: of lat and-point for 1051 /m	9.1 : y-coord. of lat and-point for 1.051 (m	2.1 : x-coord. of 2nd end-point for LOSI (m	2.6 : y-coord. of 2nd and-point for LOSI (m	<pre>9.9 : LUS Integrated conc. (mg/m<sup>*</sup><sup>*</sup>2)</pre>	+05 : LOS integrated dosage (mg-s/m**2)
18.5 208 19.9 -99	2+01 2.8906+	9.1 -29	2.1 2.62	252 97.20	<u> </u>	:+01 1.530E+
9.9	+05 -9.990E	9.1	2.1 26	5. •		+01 -9.990E
20	1 1.5508					-9.990E
200	-9.990610	-29.	262.	.262		0+3066.6-
208.5	-9.9906.01	-29.1	262.1	252.6	- 39. 3	-9.990E+01
208.5	1013064.6-	-29.1	262.1	252.6	6.99.9	- 4. 940E • 01

The Evaluation of the LB Series Grenades (LBA), high condicion temp., L01EH) 6 : number of tilals included in DDA 6 : time zone designation

202	: latitude : iongitude Béa	(deg) a (deg) Bila	8124	B17a	Bl8a :	trial ID	
	4 0		- 0	40	49 68	month day	
32	21	85 20 20	212	19	16.2	Year	
:a •	33	15	S.	16	22	minuce no of a	ources
•	1.35-	63. F	62.5	-35.7	-35.7	x-coord.	of source (m)
	100.8	0,00	c.6/-	0,00	0,00	y-coord.	or source (m) levation (m)
	6.66-	6.66-	6.66-	6.66-	6.66-	enission	rate (g/s)
	0.801	0.763	0.763	0.840	0.840	total ma	duration (s) as emitted (kg
<b>9</b> 0	2.872	4.60]	1.848 14 843	0.075	9.053	sigx0 at	the source (a
22	0.120	0.120	0.120	0.120	0.120	31920 At	the source (n
÷.	-51.4	51.4	51.4	1-51.4	-51.4	K-coord.	of source (m)
ng.	0,00	00.00	00.0	00.00	0.00	Pource &	ot source (m) levation (m)
-	6.66-	6.66-	6.66-	6.69-	6.66-	enission	rate (g/s)
٩,ç	101.0 0 A01	101.0	101.0	0.640	0.840	cmission total ma	duration (s) as <b>emitte</b> d (ko
1	8.417	8.672	2.579	5.731	3.601	sigx0 at	the source (n
22	14.729	14.580	16.767	15.967	: //C.91	algy0 at	the source (s
2 –	-83.1	31.2	37.2	-71.8	- 11.8	x-coord.	of source (m)
: <b>m</b> .:	130.3	-50.6	-50.6	127.9	127.9	y-coord.	of source (m)
8.	0.00	0.00	0,00	0.00	0.00	source e	levation (m) rate (c/a)
20	0.101	101.0	101.0	0.101	101.0	emission	duration (s)
5	0.601	0.763	0.763	0.840	0.840	total ma	as emitted (kg
3%	14.035 712 8	001.21	15 528	110.041	- 608 91		the source (n
ເລ	0.120	9.120	0.120	0.120	0.120	sigzo At	the source (s
o, v	-28.0	20.9	20.9	-42.8	-42.8	K-COOLD.	of source (m)
ng.	00.0	00.00	00.0	00.00	0.00	source e	or source (m) levation (m)
5	6.66-	6.66-	6.661	6.66-	6.661	enission	rate (9/3)
0.9		0.101	101.0	101.0	101.0	enission	duration (s) amitrad (ko
10	10.962	14.800	10.617	2.812	6.425	sigx0 at	the source (n
	12.947	8.290	13.231	16.719	15.700 :	sigy0 at	the source (s
, e	-26.8	68.0	0.84	-63.1	-63.1	k-coord.	of source (m)
<b>.</b>	19.1	-63.6	-83.6	130.3	130.3	y-coord.	of source (m)
g •	0.00	0.00	0.00			aource e	LOVALION (M) Tata (g/s)
2	101.0	101.0	101.0	101.0	101.0	enission	duration (s)
55	0.001	0.763	0.763	0.840	0.040	total ma	as emitted (ky
57	120.5	16 879	16 285	10.962	16 157 :	algku ar	the source in the source in
12	0.120	0.120	0.120	0.120	0.120	sigz0 at	the source (n
•	-25.6	72.6	12.6	-61.1	-61.1 :	K-coord.	of source (m)
.8	00.00	0.00	0.00	0.00	00.00	POUTCE .	levation (m)
٥.	6.66-	6.66-	6.66-	6-66-	- 6-66-	enission	rate (g/s)
	0.001	0.763	0.763	0.840	0.840	total mai	duration (8) sa emitted (ku
5	B.547	2.128	8.602	8.417	0.667	sigx0 at	the source (m
22	14.653	16./13	14.502	0 120	106.91	sigy0 at	the source (m
3	6.66-	12.7	12.7	-30.3	-30.3	x-coord.	of source (n)
5	6.66-	-117.5	-117.5	90.6	90.6	y-coord.	of source (m)
3 -	00'00 -	6.66-	6°-66-	6°66-	- 6.66	source e.	LOVACION (M) Fata (d/a)
<u>.</u>	0.101	101.0	101.0	101.0	101.0	enission	duration (a)
5	0.801	697.0 5 959 3	0.763	0.840	0.840 :	total man	an emitted (kg
88	006.66-	15.467	11.730	16.693	12.556	algy0 at	the source (s
ູ	0.120	0.120	0.120	0.120	0.120 :	algz0 at	the source (s
n 0	5 55 - 5 55 -	-134.1	1.461-	6.63-	: 7.67- : 89	v-coord.	of source (m)
28	0.00	0.00	0.00	0.00	0,00	SOUFCe 6	levation (m)
9	6.66-	6.66-	6.66-	6,66-	- 66- 66-	enission	rate (g/s)
5.0	0.801	0.763	0.763	0.840	0.840	total ma:	auracion (s) se emitted (ky
2	-99,900	10.134	14.073	8.547	15.014	sigx0 at	the source (n
20	-99.900	0,120	0,120	0.120	0.120 :	sigyU at	the source (s the source (s
5 00	6.66-	6.69-	6.66-	-20.0	-28.0	x-coord.	of source (m)

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y-coord. of 2nd end-point for LOSI	LOS Integrated conc. /mg/u4+21	LOS integrated domage (mo//m**2)	x-coord of lat and-owing for their	v-coord, of lat and-point for tost	k-coord, of 2nd and-point for 10st	v-coord, of 2nd end-point for 10st	LUS integrated conc. (mu/m**2)	LOS integrated dosage (mg-s/m**2)
		•••	-	•••	•	•••		••
208.5	-99.9	-9.9906.01	-267.7	-29.1	262.1	252.6	6.99.9	-9.990E+01
208.5	-99.9	-9.9906+01	-267.7	-29.1	262.1	252.6	-99.9	-9.9906.01
208.5	6.66-	1.2202+05	-261.7	-29.1	262.1	252.6	6.69-	5.9006+04
208.5	6.66-	1.180E+05	-267.7	-29.1	262.1	252.6	-99.9	-9.990E+01
208.5	- 39.9	-9.990E+01	-267.7	-29.1	262.1	252.6	- 6.6-	-9.9906.01
208.5	6.66-	-9.9906.01	267.7	-29.1	262.1	252.6	6.66-	9.9906+01

The Evaluation of the LB Series Grenades (Reworked LBA), 6 grenades, LB1K6) 6 : number of trials included in DOA

																																										(m) (j m)		e 12 (B)	(m)	(deg)	(1)		u speed (m)		/m)
		onth	lay 		ilnute 10. of sources	r-cuord. of source (m) 	iource elevation (m)	mission rate (g/a) mission duration (s)	otal mass emitted (kg) lov() at the source (s)	igyo at the source (m)	ligz0 at the source (m) record, of source (m)	-coord, of source (m)	cource elevation (m) mission rate (d/a)	mission duration (s)	otal mass emitted (kg) lar0 at the source (m)	19y0 at the source (m)	igz0 at the source (m) -coord of source (m)	-coord. of source (m)	ource elevation (m) mission rate (s/s)	mission duration (s)	otal mass emitted (kg) lox0 at the source (m)	igy0 at the source (m)	lgz0 at the source (m) -coord of source (m)	-coord. of source (m)	ource elevation (m) mission rate (n/a)	mission duration (a)	otal mass emitted (kg) lox0 at the source (m)	igy0 at the source (m)	igzu at the source (m) -coord. of source (m)	-coord. of source (m)	curce elevation (m) mission rate (g/s)	mission duration (s) oral mass smitted (kg)	igx0 at the source (m)	lgyO at the source (m) lozO at the source (m)	-coord. of source (m)	-coord. of source (m) .ource elevation (m)	mission`rate (g/s) mission durar (on (s)	otal mass emitted (kg)	igku at the source (m) igyO at the source (m)	igzo at the source (m) mbiant pressure (atm)	elative humidity (1)	emperature at level #1 (K) leasuring height for temperatur	emperature at level 12 (K)	casuring height for temperatur ind speed (m/s) at a tower	easuring height for wind duta	onain-averaged wind direction	omain-averaged aigma-u (m/s) omain-averaged aigma-theta (d	omain-averaged algmarph1 (deg)	veraging time for domain-avy wi	ind speed power law exponent urface roughness (m)	riction velocity (m) nverse Monin-Obukhov length (1
	1 . 4828			50		-37.4 : 1	00.0	-99.9 : e 118.0 : e	0.820 : t	17.526 : -	0.120 : 4	128.3 : 1	0.00	118.0 : 6	0.820 : 0	7.103 .	0.120 : 1	46.1 : 7	0.00	118.0 : 6	0.820 : 0	15.349 : 4	0.120 : 1	79.2	0.00	118.0	0.820 2 0.986 2 3	18.292 : -	-27.6 2 4	57.0 2	-99.9	118.0 : 6	7.103	16.852 : 1 0.120 : 1	6.66-	0.00	-99.9 2 6	0.820	- 906-66-	0.120 : 3	7 : 6.66-	300.00 : t	- 99.90	- 74.40 = E	2.00	11.0.4	-99.90 : d	3.30	300.00	0.0300 : 4	-99.900 1 1 0006.66-
	df CH	9	80.4	16	29	-37.4	0.00	-99.9	0.859	17.414	0.120	115.9	00.0	116.0	0.859	18.309	0.120	126.3	0.00	118.0	0.859	15.550	0.120	46,1	0.00	118.0	0.859	6.837	0.120 -28.7	79.2	6.66-	118.0 0 849	11.300	14.419	-27.6	0.00	-99.9	0.859	9.685	0.120	6.66-	300.00 2.00	06.66-	- 59.90	2.00	342.0	09.90-	2.60	0.006	0.0300	0006.66- 0006.66-
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The Evaluation of the LB Series Grenades (Neworked LSA), 8 grenades, LB1NB) 5 : number of trials included in DDA

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The Evaluation of the LB Series Grenades (Reworked LBA1, 12 grenades, LB1R2) 6 : number of trials included in DOA

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36b ; trial ID	6 : month	8 day	of a year 17 : hour	29 : minute	12 1 no. of sources	7.4 : K-CUORD. OF SOURCE (m)	19.7 ; yrcostu, ut poutee (m) 1.00 : source elevation (m)	9.9 : emission rate (g/s)	8.0 ; emission duration (s)	905 : stord at the mource (mg)	009 : sigy0 at the source (m)	120 : sigz0 at the source (m)	2.6 : X-COOLD. OF SOURCE (M) 5.9 : U-COORD OF SOURCE (M)	.00 : source elevation (m)	9.9 : emission rate (g/s)	8.0 ; emission duration (s) acceleration (s)	833 : slovů mása Gertred (Ay) 893 : slovů at the source (m)	089 : sigy0 at the source (m)	120 : sigz0 at the source (m)	2.4 : X-COORD. OF SOURCE (M) 6 D : V-COORD. OF SOURCE (M)	.00 : source eleverion (m)	9.9 : emission rate (g/s)	8.0 : emission duration (a) 860 : Forth more cuitted (to)	469 : slovû at the source (m)	988 : sigy0 at the source (m)	120 : sigzO at the source (m)	<pre>4.1 I X-coord. of source (m) 8.5 : v-coord. of source (m)</pre>	00 : source elevation (m)	9.9 ; emission rate (g/s)	u.u : emission duration (a) 859 : total mass emitted (kg)	990 : sigx0 at the source (m)	Jič : sigyU at the source (m) 120 : sigzO at the source (m)	3.3 : x-coord. of source (m)	<pre>8.3 : y-coord. of source (m) 00 : source slaution (m)</pre>	9.9 : emission rate (g/s)	8.0 : emission duration (s)	540 : sigx0 at the source (m)	112 : sigy0 at the source (m)	120 : BIG2U AT THE BOUTCE (M) 2.0 : x-coord, of source (m)	1.8 : y-coord. of source (m)	.00 : source elevation (m) 0 0 : control or control of control	8.0 ; emission duration (s)	859 : total maas emitted (kg) 202 :	317 : sigy0 at the source (m)	120 : sigz0 at the source (m)	5.2 : X-COOFG. OF SOURCE (M) 9.8 : V-COOFd. OF SOURCE (M)	.00 : source elevation (m)	9.9 : emission rate (g/s) 8.0 : emission duration (s)	859 : total mass emitted (kg)	550 : sigx0 at the source (m) 214 : sign0 at the source (m)	120 : alg20 at the source (m)	7.2 : x-coord. of source (m)	8.2 : y-coord. of source (m) .00 : source elevation (m)	9.9 ; emission rate (g/s)	8.0 : emission duration (s)	859 : total mass emitted (kg) 716 : elovo et the elovor (m)	412 : sigvo at the source (m)	120 : sigio at the source (m)	9.9 I X-COOLG, UL BUULCO (M)	
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208.5	-9.990E+01	-261.7	-29.1	262.1	252.6	6.99.9	-9.9902+01
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	B32a	οų.	82	F		6 U9	-74.6	0.00	6.66-	0.840	7.767	16.591	0.120	-56.3	0.00	6.66-	0.840	1.624	18.247	25.9	48.2	0.00	7 . 7	0.840	4.715	11.102	54.0	-65.8	0.00	118.0	0.840	17.688	0.120	-15.0	0.0	6-66-	0.840	112.1	0.120	36.3	0.00	6.66-	0.840	1.570	0.120	1.17	0.00	-99.9	0.810	15.022	0.120	-128.1	0.00	118.0	0.840	4.715	0.120
	b 31 a	νų	62	2	23	- 11 <b>1</b>	5.96	0.00	6.66-	116.0	12.278	13.596	0.120	115.9	0.00	6.66-	0.840	6.888	16.975	-12 4	126.0	0.00	- 44 - 4	0.840	0.666	18.307	-44.3	108.5	0.00	118.0	0.840	15.521	0.120	-83.3	0.00	6.66-	0.840	2.523	0.120	-62.0	0.00	6.66-	0.840	3.835	0.120	-32.2	0.00	6.66-	0.840	14.452	0.120	-27.2	0.00	-99.9	0.840	5,635	0.120
	B264	•	8. 8.	61	ື	6 U 9	-74.6	0.00	6.66-	110.0	0.027	10.319	0.120	-52.4	0.00	6 6 6 1 7	0.763	9.136	15.878	20.5	-46.8	0.00		0.763	12.934	12.973	66.1	-84.4	. 0.00	118.0	0.763	3.208	0.120	100.6	0.00	6.99-	0.763	7.767	0.120		0.00	6.99-	0.763	11.796	0.120	66.6	0.00	-99.9	0.763	15.022	0.120	6.66-	0.00	-99.9	0.763	-99,900	0.120
designation deg)	625a	•	92	10	<b>56</b>		-14.6	0.00	6.66-	118.0	6.837	16.995	0.120	-61.9	0.00	6-66-	0.801	11.003	14.647	121.0	-52.4	0.00	- 49	0.601	14.419	11.300	20.5	-46.8	0.00	118.0	0.901	16.552 1.183	0.120	66.] -84 4	0.00	6.66-	0.001	3.782	0.120	20.6	00.00	6.69-	0.801	0.986	0.120	20-2	0.00	6.66-	0.801	5.687	0.120	-133.4	0,00	-99.9 118.0	0.801	15.349	0.120
time zone latitude (	620à	n n	62	16	27		1.66	0.00	6.66-		5.015	17.602	0.120	115.9	0.00	6.66-	118.0	1.251	10.276	1.120	128.3	0.00	6.86- 0 011	0.859	10.221	15.202	-29.9	1.91	0.00	118.0	0.059	16./46	0.120	-28.7	00.00	6.66-	0.859	10.790	0.120	-27.6	0.00	6.66-	0.859	15.202	0.120	6.66-	0.00	6.66-	0,859	006,99-	0,120	6 - 66	0.00	-99.9 118.0	0.859	006 66-	0.120
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: y-coord, of 2nd end-point for LOS1	: LOS integrated conc. (mg/w <sup>++</sup> 2)	LOS integrated dosage (mu-s/m**2)	x-coord. of lat and puint for LOSI	y-coord, of lat and-point for LOSI	x-coord, of 2nd end-point for LOSI	y-coord. of 2nd end-point for LOSI	Los integrated conc. (mu/u**2)	Los integrated dosage (my-s/m**2)
208.5 :	- 6.66-	1.5306+05 :	-267.7 :	-29.1 :	262.1 :	252.6 :	: 6.66-	1.0506.05
208.5	6.66-	-9.9902+01	-267.7	-29.1	262.1	252.6	6.66-	-9.9906+01
200.5	6.66-	8. 600E+04	-261.7	-29.1	262.1	252.6	6.66-	4.500E+04
208.5	6.66-	-9.9906+01	-261.7	1.9.1	262.1	252.6	6.66 -	-9.9966.01
208.5	-99.9	-9.9906+01	-261.7	-29.1	262.1	252.6	-99.9	-9.9906.01
208.5	6.66-	10.3000.9-	-261.7	-29.1	262.1	252.6	6.99.9	-9.9906+01

The Evaluation of the LB Series Grenades (Reworked LBA), medium condicton temp., LB1RM) 6. combur of visio included to Dux

	4	2	=			te of sources	ord. of source (m)	ord, of source (m) calcution (m)	alon rate (g/s)	sion duration (s)	0 at the source (m)	0 at the source (m)	ord, of source (m)	ord. of source (m)	ce elevation (m)	sion take (y/s) sion duration (s)	I mass emitted (kg)	0 at the source (m)	0 at the source (m)	ord. of source (m)	ord. of source (m)	ce elevation (m) sion rate (g/s)	alon duration (a)	l mass emitted (kg)	0 at the source (m)	0 at the source (m)	ord. of source (m) ord: of source (m)	ce elevation (m)	sion rate (g/s)	aton duration (a) 1 maas emitted (kg)	0 at the source (m)	0 at the source (m)	ord. of source (m)	ce elevation (m)	sion rate (g/s)	sion duration (s) 1 mass emitted (kg)	0 at the source (m)	D At the source (m)	ord. of source (m)	ce alevation (m)	sion rate (g/s)	I mass cmitted (ky)	0 at the source (m) 0 at the source (m)	D at the source (m)	ord. of source (m)	ce elevation (m)	sion rate (g/s) sion duration (s)	I mass emitted (kg)	) at the source (m) ) at the source (m)	0 at the source (m)	ord. of source (m) ord. of source (m)	ce elevation (m)	alon rate (g/a) alon duration (4)	mass emitted (kg)	) at the source (m) ) at the source (m)	at the source (m)	old. OL SOULCE IM/
			day.	year	hour		K-CO	Y-00	emla	eals	slgx	1914	201-1	Y-co	TUOR		tota	a19 x	2018		V-C0	a ma	enia	tota	1014	2614	00-3	BOUL	ents	t ot a	algx	2014	00 - X	N-CO	ella	enis tora	s 19 x	2012 2192	x-00	300E	e les	tota	algx	s192	00-3			tota	194	a 1 g 2	- CO		emis	tota	algx	2010	5 5 1
			• •	82		12 :	-11-1	- 00 0	- 6.66-	118.0 :	0.986	18.292 :	-52.6 1	115.9 :	00.00	118.0 :	0.820 1	5.330 2	0.120	-12.4	126.0 :	: 6,66-	118.0 :	0.820 :	14.647	0.120	-44.3 :	0.00	- 6,66-	0.820 :	2.206 :	0.120 :	-63.3	00.0	6.66-	114.0 : 0.820 :	13.379	0.120 :	-62.0 :	0.00	- 66- 6	0.820	8.292 : 16.335 :	0.120 :	- 32.2 2	0.00	- 66- - 0.911	0.820	17.843	0.120 :	-21.2 :	0,00	- 6-66- 118 0 -	0.820	10.000 :	0.120	
		6250 7	9	82	61	28	-37.4		-99.9	118.0	0.932	16.295	-52.6	115.9	0.00	118.0	0.897	7.133	0.120	-72.4	126.0	6.66-	118.0	0.897	13.416	0.120	108.5	0.00	6.66-	0.897	100.1	0.120	-63.3	00.00	-99°.9	0.897	14.614	0.120	-62.0	0.00	-99.9	0.897	15.378	0.120	-32.2 89.8	0.00	0.914	0.897	2.229	0.120	-21.2	0.00	0.99-9	0.897	8.341 16.310	0.120	E' E 3 L
ded 1a DUA		y 7879	•~	62	22	n <b>4</b>	60.9		6.66-	119.0	1.094	17.856	50.02	-61.9-	0.00	118.0	0.763	8.576 	0.120	36.3	-52.4	6.66-	110.0	0.763	13.416	0.120	20.5	00.00	6.66-	0.763	15.521	0.120	1.99	0,00	6.66-	0.763	0.932	0.120	20.6	00.00	-99.9	0.763	518.1 518.11	0.120	-11-	0.00	0.811	0.763	16.310	0,120	-133.4	0.00	0.911	0.763	12.278	0.120	
triais laciv designation	(deg)	4/ 78 Y	• ~	62	e (		60.9	9.11.	6.99-	118.0	7.426	16.746	50.0	-61.9	0.00	118.0	0.763	11.507	0.120	16.36	-52.4	00.00-	116.0	0.763	061 01	0.120	20.5	0.00	6.66-	0.763	11.093	0.120	66.1	00.00	6.66-	118.0	4.405	0.120	20.6	0.00	- 66- 0 0 1 1	0.763	0.347	0.120	00	0.00	0.911	0.763	5.0/5	0.120	66.6 -133.4	0,00	0.96-	0.763	9.458 15.688	0.120	
time zone	longitude	B228	•	62	91	<b>N 1</b> 7	1.16-	99.J	6.66-	118.0	0.932	10.295	-52 6	115.9	0.00	110.0	0.954	7.133	0.120	-63.3	128.3	00.00	118.0	0.954	11 046	0.120	-29.9	0.00	6.66-	0.954	13.416	0.120	-28.7	0,00	6.66-	0.911	5.382	0.120	6.66-	0.00	6.66-	0.954	006.66-	0.120	99. 9	0.00	-99.9	0.954	006-66-	0.120	6.66-	0.00	6 66 -	0.954	006.99-	0.120	F. F.F
	113.00	<b>B</b> 21,		82	5	5	1. LE-	99.1	00.0 6.66-	118.0	1.416	16.724	0.120	115.9	0.00	0.011	619.0	1,305	0.120	-83.3	120.3	0.00	118.0	0.973	8.00 16 477	0.120	-29.9	0.00	6.66-	0.911	17.617	021.0	-28.7	0.00	6.66-	0.911	12.745	0.120	-27.6	0.00	6.99-9	0.913	16.477 A 006	0.120	6.66-	0.0	0.99.6	0.973	- 99.900	0.120	6.99-	0.00	0.99.9	6.6.0	006.96-	0.120	F. 17

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46.1 : Y-CCOOF -99.9 : emission 116.0 : sources 14.647 : saigno 14.647 : saigno 16.852 : saigno 17.852	118.0 : entiant 16.130 : cotal 16.132 : alged 16.120 : alged 12.27.6 : w-coor 57.0 : w-coor 57.0 : w-coor 18.0 : w-coor 18.0 : w-coor 18.0 : w-coor 19.9 : alged 11.2 : 511 : alged 12.5 : 0 : alged 13.5 : alged	-99.90 c domain 16.20 c domain 2.00 c domain 2.00 c measur 2.00 c measur 0.050 c surfac -99.90 c invict -99.9 c cloud -99.9 c cloud 2.00 c sugges 2.00 c sugges 2.00 c sugges	-173.8 ************************************
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208.5 208.5 208.5 ; Y-coord. of 2ad and-point for LOSI (m) -99.9 -99.9 ; LOS integrated conc. [mg/m<sup>1+2</sup>) 1.2902+05 -9.9902+01 -9.9902+01 ; LOS integrated domage (mg-3/m<sup>1+2</sup>) 208.5 -99.9 1.340£+05 208.5 208.5 -95.9 -55.9 -9.9902+01 -9.9902+01 v

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The Evaluation of the LB Series Grenades (Reworked LBAI, high condition tamp., LBIRH) s i number of trials included in DOA

	a trial ID	t month Aau	year	r hour	no. of sources	: x-coord, of source (m) : v-coord, of source (m)	: source elevation (m)	: emission rate (g/s) : emission duration (s)	total mass emitted (kg)	: sigx0 at the source (m) : slov0 at the source (m)	sigro at the source (m)	: x-coord, of source (m)	: source elevation (m)	: emission rate (g/s)	: emission duration (s) · roral maas emitted (kn)	i sigk0 at the source (m)	: sigy0 at the source (m)	: sigz0 at the source (m)	: v-coord, of source (m)	s source elevation (m)	: emission rate (g/s)	s emission duration (#)	s sigk0 at the source (m)	: sigy0 at the source (m)	s sigso at the source (m)	: x-coord, of source (m)	source elevation (m)	; emission rafe (g/s) • emission duration (s)	: total mass emitted (ky)	; sigk0 at the source (m)	; sigzo at the source (m)	<pre>x + coord. of source (m) </pre>	; y-coord, of source (m) ; source elevation (m)	: emission rate (g/s)	: emission duration (#) : total mass emitted (ku)	: sigx0 at the source (m)	; sigy() at the source (m) • sign() at the source (m)	r x-coord. of source (m)	: Y-coord, of source (m) . source alwarton (m)	: emission rate (g/s)	: emission duration (2) • tota) mass emitted (kg)	: sigx0 at the source (m)	: sigyu at the source (m) : sigzû at the source (m)	: x-coord. of source (m)	: Y-COOR <b>d. Of SOURCE (m)</b> : Source elevation (m)	: emission rate (g/s)	: emission duration (s) • roral mana amitted (kg)	: sigr0 at the source (m)	: sigyu at the source (m) • siggu at the source (m)	: x-coord. of source (m)	: Y-coord. of source (m)	; emission rate (g/s)	r emission duration (2)	: signo at the source (m)	sigy0 at the source (m)	: algzu at the source two ; x-coord, of source (m)
	B36a		6	15	12	1.66	0.00	118.0	0.859	506.81 600.91	0.120	-52.6	0.00	6.66-		2.693	18.089	0.120	126.0	0.00	6.66-	118.0	994.6	17.988	0.120	108.5	0.00	6.66-	0.659	5.990	0.120	- 83.3	00.00	6.66-	0.859	6.540	17.112	-62.0	121.8	6.6	0 859	0.293	0.120	-32.2	89.69	6.66-	118.0	11.550	01120	-27.2	68.2	6.66-	118.0	15.716	9.412	-29.9
	<b>1</b> 1354	4	82	<b>6</b> 4	12	1.66	0.00	-99.9	0.620	1.476	0.120	-52.6	0.00	-99.9	118.0	1.305	18.272	0.120	126.0	0.00	-99.9	118.0	5.023	17.617	0.120	108.5	0.00	-99.9	0.820	4.458	0.120	-83.3	0.00	6.66-	0.820	B.006	16.477	-62.0	121.8	6.66-	118.0	1.888	0.120	-32.2	8.68	6.66-	118.0	10.266	2/1.51	-27.2	68.2	-99.9	118.0	14.836	10.746	-29.9
	<b>6</b> 30 <u>a</u>		<b>8</b> 2	2		-14.6	00.00	-99.9	0.744	7.426	0.120	50.0	00.00	6.66-	118.0	11.507	14.254	0.120	- 22 -	0.00	6.66-	110.0	14.804	10.790	0.120	- 70. - 46. B	00.00	-99.9	0.744	17.093	0.120	66.1	00.0	6.66-	116.0	1.405	17.781	10.7	-117.2	6.66-	110.0	5.075	0 120		1.133.4	6-66-	118.0	9.458	15.688	6.66-		-99.9	110.0	006.66-	-99.900	0.12U
designation (deg)	(deg) 829a	<b>w</b> r	62	20		60.9 - 11 6	0,00	-99.9	0.763	1.251	0.120	20.0	00.00	6.66-	118.0	5.918	000.01	0.120		00.00	6.99-	119.0	10.221	15.202	0.120	20.5	0.00	6.66-	0.763	13.008	0.120	66.1	00.00	6.66-	118.0	1.942	18.216	10.6	-100.5	6.66-	118.0	6.590	660'LI	10.1	-117.2	6.66-	118.0	10. 790	14,804	66.6	-133.4	0.00-0 0.99-	118.0	14.254	11.507	0,12U - 99,9
time zone	: 100911004		65 67	20	<b>n</b> vo	4.00-	0.00	6.66-	0.620	5.330	0.120	- 63.3	0.00	6.66-	118.0	0.020	7.183	0.120	67-	00.00	6.66-	118.0	0.820	15.349	0.120	-28.1	00.00	6.66-	0.820	0.986	0.120	-27.6	0.76	6.66-	118.0	7.183	16.852	6.66-	6.66- 0.00	6.66-	116.0	-99.900	006.66-	6.66-	-96.9 0000	6.66-	118.0	-99.900	-99.900	6.66-	6.66- 0.00	00.0 6.66-	118.0	078.0	006.66-	0.120 -99.9
40.20	B23A	<b>.</b>	65 C	23		4.16-	0.00	6.66-	0.859	5.687	0.120	-52.6	0.00	6.66-	118.0	0.619	10.309	0.120	-85.1	00.00	6.66-	118.0	0.859	15.550	0.120	-29.9	0.00	6.66-	0.859	16.995	0.120	-28.7	19.2	6.66-	118.0	11.300	14.419	-27.6	51.0	6.66-	118.0	15.550	9.685	6.66-	6.66-	6.66-	118.0	-99,900	006.66-	-99.9	6.66-	00.0 6.66-	118.0	006 66-	99.900	0.120 -99.9

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<pre>i end-putet for LOS1 conc. (maxme+2)</pre>	doaagu (mg-u/ma-2)	and-point for LOSI	l end-point for 1051	conc. (my/m++2) dosege (my-s/m+2)
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208-2	-9.9902+01	-29.1	262.6	-9.9902+01
208.5	1.0/06+05	-29.1	262.1	-99.9 5.400£+04
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y-coord, of 2nd end-point for LUSI	LOS integrated conc. (mg/m*2)	LOS Integrated dosage (mq-s/m*2)	w-coord. of lat and-point for LOSI	y-coord, of lat and-point for LOSI	x-coord, of 2nd and-point for 1.051	y-coord. of 2nd end-point for 1.051	LOS integrated conc. (mu/14+2)	Los integrated dosage (my-s/m+2)
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208.	.66-	1.9406+0	-261.	-29.	262.	252.	-99.	9.400E+0
208.5	-99.9	-9.9906+01	-261.1	-29.1	262.1	252.6	- 6.6-	-9.9906.01
208.5		1.2006+05	-261.7	-29.1	262.1	252.6	6.69.	7.4002+04
208.5	-99.9	1.3606.05	-267.7	-29.1	262.1	252.6	- 99.9	-9.990E+01
208.5	6.66-	-9.9906+01	-267.7	-29.1	262.1	252.6	6.66-	-9.9906.01
208.5	-93.9	-9.9906+01	-261.7	-29.1	262.1	252.6	-99.9	-9.9906+01

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	di tetat	month	day vear	hour	minute no. of sources	K-coord, of source	y-could. of source source (m)	celssion rate (g/s)	total mass emitted	sigkU at the source sign of the source	sigz0 at the source	y-coord. of source	Bource elevation (m)	emission fate (9/4) emission duration (1	total mass emitted	aigy0 at the source	<pre>alg20 at the source x-coord. of source</pre>	y-coord. of source	source sievation (m) emission rate (g/s)	emission duration (a	alga0 at the source	algy0 at the source	x-coord. of source (	y-coord. of source (	emission rate (g/s)	total mass emitted	algx0 at the source algv0 at the source	sigz0 at the source	y-coord, of source	source elevation (m) emission rate (g/s)	emission duration (s	bigx0 at the source	algyu at the source algz0 at the source	y-coord. of source (	acurce elevation (m) emission rate (g/a).	emission duration (a	sign0 at the source	sigru at the source sigz0 at the source	w-coord, of source v-coord, of source	source elevation (m)	emission duration (s	total mass emitted ( signo at the source	sigy() at the source	r-coold. of source	y-coord. of source (m)	emission rate (g/s) emission duration (s	total mass emitted	algy0 at the source	algzu at the source ( a-coord, of source (
	S POR		83 C		• = • =	- 46.6	0.00	- 6-66-	0.840	12.636	0.120	101.1	0.00	105.0	0.840 :	13.938	-15.6	115.5	- 99.9	105.0 :	3.497	13.560 :	-52.3	101.0	6.66-	0.840	3.751 :	0.120	117.4	-99.9 -	105.0	5.799	0.120	-67.0 :	: 00'0 : 6'66-	105.0	1.090	0.120 :	-42.3 : 85.5 :	0.00	105.0	0.840 :	11.395	- 19.2	0.00	105.0	0 840	7.924	-40.4
uded in DUA	. 853a		828		• 11	- 46.6	0.00	-99.9	0.640	2.061	0.120	101.1	0,00	105.0	0.840	112.311	-15.6	115.5	6.66-	105.0	10.482	9.286	-52.3	101.0	6.66-		4.435	0.120	117.4	0.00	105.0	11.935	0.120	-67.0	0.00 9.96-	105.0	0.710	0.120	-42.3	00.0	105.0	0.840	13.999	- 30.2	00.00	-99.9	0.040	13.026	-39.5
trials included dealgoation	(069) M484			12	77 8	51.7	0.00	6.66-	0.744	4.435	0.120	-10.0	0.00	105.0	0.744	11.683	0.120	-62.2	6.66-	105.0	10.402	9.286	19.2	-57.6	6.66-	0.744	12.520	0.120	- 66.7	00.00 6.66-	105.0	2.061	0.120	-102.0	00°0 6°66-	105.0	1.594	0.120	59.8 -115.9	0.00	105.0	0.744	13.026	56.4	0.00	-99.9 105.0	0.744	11.252	6.99-9
ation of the number of time zone jatitude (	1 100015000			12	-	9.97-	0.00	6.96-	0.782	1.333	0.120	101.1	0.00	105.0	0.782	12.644	0.120	117.4	-99.9	105.0	11.536	1.939	40.4	49.J	6.66-	0.782	9.822	0.120	1.91	00.0	105.0	3.515	0.120	- 38.5	00.00	105.0	616.1	0.120	6.66- 6.66-	00.0	105.0	0.782	006.66-	6.66-	00.00	9.99.9	0.782	006.66-	-99.9
40.20	113.00		• ;	9	<b>4</b> .4	- 16.6	0.00	6.66-	0.859	3.278	0,120	1.001	00.00	105.0	0.859	11.915	0.120	117.4	- 99.9	105.0	6.322	11.263	-40.4	<b>6</b> 10.00	6.65	0.659.0	12.537	0,120		0.00	105.0	131	0.120	- 38.5	0.00	105.0	11.263	0.120	6.66- 1.66-	0.00	105.0	0.859	-99.900	6.66-	0.00	- 99.9 105 0	0.859	-99,900	0.120 -99. <b>9</b>
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300.00		300.00	200.00	300.00	100.00	100.00	200.00	200.00	100 00	00.001	200.00	200.001		De Ad : terreriture et level et (m)
8.7		1.60	1	2.00	2.80	2.00	8	2.00	8	2.00	8	0.4		1.00 i manutime bish for imministry in the
- 35. 80		18.86-	- 53, 30	- 39.30	- 35.90	- 11.30	-33, 56	-99.90	143 90	- 35.90	- 85. 90	- 39.30	- 33. 90	-91.96 I temperature at level 12 (E)
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5.10		<b>9</b> .9	4.30	5.30	2.2	5.00	8.8	3.70	2.50	4.60	3.20	9E.E	1.50	4.86 i wind speed (s/s) at a tower
2.6			8	2.00	8	2.00	8.8	2.00	2 00	2.00	1	2.00	2.00	2.00 s measuring height for viad date (a)
				8 · 8			3	9. TO	2 20	<b>9</b> -	9.20	92.2	2.5	4.80 i domain-averaged wind apood (n/s)
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5.00		4.00	4.20	5.20	5.30	4.80	5.20	6.90	01.5	94.7		96. 6	9.20	4.10 1 dealerantized almost data (444)
3.06		1.4	2. B	2.00	2.00	2.00	3.90	2.60	2 00	2.00	1	00.2	2.00	2.00 t meanting by for domain and wind avoid
•. • ICI		1361.2	1111.0	1296.2	5.11.1	1221.0	1.11.11	2356.2	2 104 5	5.1641	6.1111	1441.2	1.11.1	1106.2 1 averaging time for demain any data (a)
0.110		•.112	.14	6.133	9.191	0.111		0.112	0.114	8.504	6.123	0.144	0.121	6.136 : wind aprod power haw asychent
0.0100		0.4100	. 0100	0.0300	0.0300	0100	9.0100	0.0300	0010.0	0010.0	0.0100	0.000	0.0100	8.8300 h surface foughness (m)
- 55 . 300				- 80 - 900	000 . 65 -		- 88 - 8 <del>0</del> 0	- 33. 300	006 66	- 99. 908	- 99 . 990	- 39. 900	- 99 . 900	-19.900 ; friction velocity (a)
- 99. 9000						0000 - 44 -			0004.66-	- 33. 3008	- 79. 1000	- 99. 5000	- 99. 0000	-59.9000 i laverae Nunia Chukhov jenyih (1/m) A ta14
		9.9		0.10	0.10	95.9								
0.50		0.30	. 8. 50	0.20	0.50	0 50	0.20	0.30	0.50	92.9	3			1.50 . Bound rate
- 99 - 9		- 99. 8	- 19.9	- 39.3	- 89.8	- 53.5	6.66-	- 99.9	- 35 - 5	- 39.9	- 11.1		- 99 - 9	-93.9 i alaine helaht (al
		- 89- 9	1.11.	- 39.3	- 99.9	- 93. 9	4-88-	- 99. 9	1.41	-99.9	- 99.9	- 39. 3	- 99 - 9	-99.0 i sloud cover (1)
		<b>6</b>	<b>86</b> -	•	<b>8</b> 1-	-11	ŗ	•	8.	<b>66</b> -	66 -	- 11		-99 1 2-G stability since
1116.0		1541.2	1911.0	1394.2	1.11.61	1521.0	5.1601	2356.2	2501.0	1.11.1	1111.2	1441.2	1. II U	1486.2 i averaging time for concentration (a)
2.00		3.00	3.00	2.00	2.00	2.00	2.08	3.00	2.00	2.00	2.00	3.00	2.00	2.00 i suggested receptor height (n)
•		•	•	•	<b>a</b> .	a .	•	<b>a</b>	•	•	•	•	•	B 1 mo. of distances downwind
-		••		-			-	-	-	-	-	-	-	1 i mo. of lines-of-sight
-316.7		- 319. 3	- 116 -	-210.7	C. 11 C-	- 510 - 3	-210.7	- 519-7	5.012-	-218.7	-216.7	-210.7	-214.7	-218.7 : s-ouord. of lot and putat for LOSI int
5.121-		-121-2	-121-2	- 121 - 3	-121-2	-121.2	-121.2	-121.2	121.2	-121.2	-121.2	-121.2	1.121-	-121.2 1 y-word. of lat ant-point for 1031 [a]
1.91		260.5	4. B.	366.5	5.69.5	549.5	564.5	540.5	5.69.5	5.035	360.5	560.5	5.69.5	568.5 : a-mourd. of 2nd and pulmt for LOSI (m)
1.510		1.516	1.61	1.516	1.416	1.616	115.1	1.216	1.416	1.210	1.210	115.1	315.1	215.1 : y-coord. of 2nd and point for LOBI (u)
• •									<b>1</b> .66	- 39. 8	8. S.		- 99 -	-99.9 : 506 integrated conc. (ny/m**2)
		. Peus aud		. Jaug.us	47. Jane . 4	1. 31UL UL		COVINCO'S				. 4356.06	SC+3042.	1,350E(85 I LOS Latagratad dosaga (my`e/m°*2)

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The Tests of Foreign Smoke Pots/Generators (Japanese 3-00, iNUJA) 7: number of trials included in DDA

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	trial ID	2 Moosta 7 day	1 VQBF	a hour	i minute	: no. of sources	: K-COOTd. Of SOUTCE (m)	t y-coord, of source (m)	t mource elevation (m)	t emission rate (g/s)	t emission duration (s)	: total mass emitted (kg)	z algy0 at the source (m)	: algy0 at the source (m)	: sigr0 at the source (m)	t amblent pressure (aim)	relative humidity (1)	i temperature at level #1 (K)	a measuring height for temperature (1 (m)	t temperature at level 12 (K)	a measuring height for temperature \$2 (m)	t wind speed (m/s) at a tower	t measuring height for wind data (m)	t domain-averaged wind speed (m/a)	: domain-averaged wind direction (deg)	<pre>t domain-averaged sigma-u (m/s)</pre>	<pre>the state of the state of the state (deg)</pre>	i domain-averaged signa-phi (deg)	t measuring ht for domain-avg wind apred (m)	t averaging time for domain-avg data (3)	a minu apagu power law sapungan t surface rouchsels (m)	i friction velocity (m)	: Inverse Monin-Obukhov length (1/m)	1 albado	: molsture availability	s Bowen tato tatas bataba (-)	: cloud coust (s)	· P_C stability rises	: Averaging time for concentration (a)	z suggested recentor helaht (s)	i no. of distances downwind	a no. of lines-of-sight	a m-coord. of lat end-puint for LOSI (m)	<pre># y-coord. of lst end-point for LOSI (m) </pre>	: M-COOLD. DE 2nd end-point for LOSI (m)	<pre># T-could. Ut fild clumpoint tot coal (m) # [OS integrated conc. imp(mis))</pre>	I LOS integrated dowage (mg-s/m**2)
	1622	12	81	20	¥	-	19.4	-35.0	0.25	6.99-	1330.8	15.146	0.230	0.230	0.230	6.66-	6.66-	300.00	2.00	06.66-	-99.90	3.60	2.00	3.60	146.0	-99.90	8.20	02.4	00.2 00.2		0 0100	-99.900	-99.9000	0.18	00				1330.8	2.00	0	-	-218.7	-121-2		- 66 -	7.080E+05
	1620	12	61	15	22	-	19.4	-35.0	0.25	6.66-	1381.2	20.368	0.230	0.230	0.230	6.69-	6 66 -	300.00E	2.00	-99.90	06.99-	3.20	2.00	3.20	134.0	-99.90	13.60	00.4	2.00.2	11811	0 0100	006.66-	-99.9000	0.18	0.0		999-		2.1381.2	2.00	0		-218.7	-121-2	1.500	6.66-	1.1566.06
2	1610	10	91	18	•	-	19.4	-35.0	0.25	6.99-	1111.2	14.326	0.230	0.230	0.230	6.66-	6.66-	300.00	2.00	06.66-	-99.90	4.80	2.00	4.80	140.0	-99.90	9.60	2.4	2.111	21117	01000	006.96-	-99.9000	0.18	0.0			66-	1111.2	2.00	0	-	-218.7	-121.2	0.940	6.66-	5.780E+05
	1609	::		16	9	-	19.4	- 35.0	0.25	6.66-	1266.0	14.715	0.230	0.230	0.230	6.66-	6.66-	300.00	2.00	-99.90	06.99-	4.50	2.00	4.50	160.0	06.88-	<b>Q</b>	3.80	00.2		0010.0	006.66-	0006.66-	0.18	<b>P</b>	0.00			1266.0	2.00	0		-218.7	2.121-		6.66-	8.340£+05
designation (dug) (deo)	1608	17	61	53	•	-	19.4	- 35.0	0.25	6.66-	1426.2	15.146	0.230	0.230	0.230	6.66-	6.66-	00.000	2.00	-99.90	-99,90	01.E	2.00	3.10	136.0	06.66-	00.7	80. <b>.</b>	2.00	1478.2	00100	006 66-	-99.9000	0.18	0.50	00.00			1426.2	2.00	0	-	-218.7	-121-	0.940		9.6106+05
time zone latitude	1604	5 Y		5	7		-29.1	52.5	0.25	-99.9	1307.2	14.413	0.230	0.230	0.230	6.66-	6.96-	300.00	2.00	-99,90	-99.90	2.60	2.00	2.60	346.0	-99.90	26.00	-99.90	2.00	138/.2		006 66-	-99.9000	0.18	0.50	0.00		20-	CALL	2.00	0	-	-218.7	-121-2	0.940		3.5906.05
40.20	3602			20	1	-	-29.1	52.5	0.25	e-99-9	1345.0	14.326	0.230	0.230	0.230	6.66-	6.66-	300.000	2.00	- 99.90	-99.90	3.50	2.00	3.50	346.0	06.66-	1.60	06.66-	2.00	B.CP.1	0,0100	- 49 400	- 99, 9000	0.18	0,50	0,50				2.00	9	-	-210.7	-121-2	0.990		8.500E+05

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The Toule of Earenge Amule Pure/Learning Flandlen SC19, IMTCA) 1) : number of stalls insituated in BOA 6 : Lien some designation

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	i trial to					1 alante	t de. el entres	t E-coord. of pource (a)	t y-coord. of source (a)	i source sievetion (s)	i mission sate (a/s)	t emission duration ist	t total mass spitted (hg)	I signd at the source (s)	I signa at the source (s)	I sign at the source (s)	i mbioat prosence (ata)	: solative humidity (1)	I temperature at level 11 (K)	I measuring height for temperature 11 to	I Competature at level 12 (K)	4 14 answering height for temperature 12 4	I wind append (s/s) at a tower	i measuring buight for vind date (n)	I domale-everaged wind speed (n/s)	) domain-averaged wind direction (deg)	1 domain-averaged eigne-u (n/s)	i domain-averaged eigne-thete (day)	i domain-averaged algua-ghi (deg)	t measuring he for domain-any wind apont	i averaging time for domain-avy data (a)	I wind opened power law exponent	1 surface compasse (s)	filicitos velocity (a)	s severes roass-unusady tength (1/4) 1 albado	1 mototure availability	I Bouna cala	t mining beight int	t sloud cares (1)	1 2-8 stability class	1 averaging time for concentration (a)	i auguated receptor helyht (a)	1 mo. of distances duraulad	t me. of lines-of-sight	1 s-coord. of tat and-putat for LOBI (a)	i presend. of lat and-point for LOBI (n)	1 2- coord. of 2nd ond-point for 1031 (a)	1 T-seerd. of 2nd and-point for 1031 (n)	i 102 lategrated cone. (mg/a*12)	i 106 lategrated dosege (ng-s/a <sup>++2</sup> )
	C 633	THE SECOND				-	-	19.4	-35.6	14.0	- 88- 8	1106.0	13.230	0.230	0.230	0.230	6.66-	- 89.8	100.001	2.60	- 99.96 -	- 19.14	3.1	2.00	. 4.40	154.0	- 99.96 -	5.50		2.00	1100.0		0.010			0.50	0.50	- 87.6	-99.9	ę,	1100.0	2.99.4	•	-	- 2110.7	-121.2	560.5 4	115.1	-89.9	
	C + 20	H	: :	: -	1	; \$	-	13.4	- 35 -	16.9	- 35.8	1016.2	10.450	0.230	011.0	012.0	6.66-	<b>6 - 86 -</b>	208.00	2.00	- 39.90	-35.90	3.7	2.00	3.6	144.0	-99,90	2.40	4.20	2.80	1014.2		6.0100 - 20 200			0.30	8.50	- 53.5	6,66-	<b>4</b> -	1016.2	<b>8</b> .8	•	-	- 218.7	-121.2	5.66.5	1.216	- 23.5	. 2306.05
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	C610	H	1		2	3	-	1.41	<b>9.86</b> -	16.0	6.66-	790.0	14.407	0.230	4.234	012.0	-19.9	6.66-	300.00	8.2	- 39. 36	- 99, 90	2.00			177.0	-83. 86	16.00	9.6	7.8			6.0100 - 45 800			8.5			4.44-	-	290.4	2.8	•	-	-316.7	2.121-	5.4.5	1.416	- 22 -	
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Duvelopment Test i of the Man-Postable Smoke Generators (XM49, ik unly and IR part of dieselvik, POXI) 6 : aumbar of tribis included in DDA

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		2	_	_ •			2007C41	of source (m)	. of source (m)	elevation (m)	a rate (g/s)	a duration (s)	ass emitted (kg)	t the source (m)	t the source (m)		pressure (acm) - bunkatu (a)	tire of lovel 41 (K)	a helebt for temperature ()	ture at level \$2 (K)	ag height for temperature \$2	eed (m/s) at a tower	ng height for wind data (m)	averaged wind speed (n/s)	averaged wind direction (deg)	averaged sugmand (2/3)	averaged sigma-there (ded) averaged sigma-the (ded)	no ht for domain-avy wind appe	ng time for domain-avg data (	and power law exponent	roughness (m)	n velocity (m) Mostacobuttou (numi b /) /m)	HONIN-VOUKNOV LENGLA (1/M)	a availability	alo	height (m)	bility class	and the for concentration (a)	ed receptor height (m)	distances downwind	lines-of-sight	. OF 1st and point for 1051 to	. of 2nd end-point for LOSI (	l. of 2nd end-point for LOSI (	egrated conc. (mg/m*2)	egrated dosage (mg-s/m"2)	, of lat and-point for 1051 (	l. of 2nd end-point for 1.051 (	l. of 2nd end-point for LOSI (	egrated conc. (mg/m**2)	i of lat end-point for 1.051 (	. of lst end-point for 1.051 (	I. of 2nd end-point for LOSI (	arated conc. (mg/m**2)	eğrated dosage (ég-s/a^2)
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	196.30	uc set		<b>'</b> a	; <del>4</del>	::	3-	-248.5	-52.0	0.38	6.99.9	240.0	13.015	0.230	0.230	0.2.0		00 000	2.00	06.66-	-99,90	5.50	5.00 5.00	9. S		06.66-		2.00	390.0	0.012	0.0300	006.44-	0,000,000	0.50	0.50	6.66-	20 - 20 - 20 - 20 - 20 - 20 - 20 - 20 -	240.0	2.44	0		0.116-	-80.2	-61.6	6.66-	2.4902402	- 156 5	-51.1	-114.1	6.66- 20.3003 1	-459.3	-409.0	-22.0	6.66-	6.200E+04
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	96.43						-	-294.1	-11.4	0.38	-99.9	240.0	1.510	0.230	0.230	0.230			8.0	-99.90	-99.90	2.80	2.00	2.5	297.0			2.00	360.0	0.084	0,0300	- 99, 900		0.50	0.50	6.66-		240.0	2.44	0	-	C./1C-	-80.2	-61.6	6.66-	3.200E+04	- 196 -	-51.1	-114.1	6.00-	-459.3	-409.0	-22.0	6.66-	1.1006+04
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Development Test i of the Man-Portable Smoke Generators (MX49, fuguil part of fogoil/IN, FUXFU) 10 : number of trials included in DDA

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