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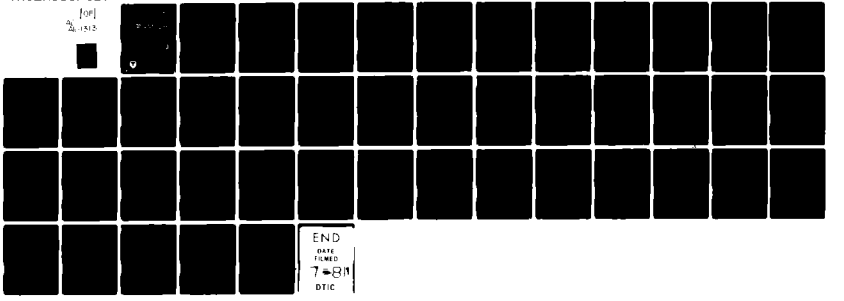

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EXTENDING APPLICATION OF THE ARTILLERY COMPUTER METEOROLOGICAL MESSAGE

MAY 1981

By

ABEL J. BLANCO

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US Army Electronics Research and Development Command
ATMOSPHERIC SCIENCES LABORATORY
White Sands Missile Range, NM 88002

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Preliminary results derived from a mathematical algorithm for calculating impact dispersion due to meteorological factors are presented. The report presents a comparison of three techniques for extending the maximum ordinate of the Artillery Computer Meteorological Message from 20 to 23 km, for application to projectiles traversing higher altitudes. The three techniques, called the default, the extrapolation, and the modified extrapolation (or climatological), are analyzed against data from 69 rocketsonde flights that

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20. ABSTRACT (cont)

were conducted over White Sands Missile Range, New Mexico, during 1979. The measured and estimated data are used to ballistically simulate 552 impact displacements for a trajectory of a proposed rocket system. The findings show that the extrapolated meteorological correction yields a significant improvement over the current default method of using a standard meteorological message. Impact dispersion error analyses illustrate that a software addition to the current meteorological message procedure predicts all impacts within the current one probable error when the meteorological message is extended 3 km in altitude.

SUMMARY

The United States Army Field Artillery School needs to know the expected meteorological impact displacement for new weapons traversing the atmosphere to altitudes where measurements are not available from the meteorological field units. The preliminary status is that simple persistence for extrapolating the wind, extending temperature by adding the standard gradient to the last known temperature value, and using the hydrostatic extrapolation of density and pressure significantly reduces the meteorological impact error. The improvement is summarized as allowing all impacts to locate within the current one probable error dispersion. A software addition to the current meteorological message procedure reduces the error when the message is extended 3 km in altitude.

CONTENTS

INTRODUCTION

With advanced technology in artillery ballistics, projectile delivery at ranges greater than 50 km can be expected. Under certain conditions these projectiles will traverse altitudes higher than 20 km above ground level (AGL). The expected meteorological effects on the target displacement error need to be investigated for projectile traversals beyond 20 km AGL because the current computer meteorological message reports information only to 20 km AGL. This report presents preliminary results from a comparison of three techniques that extend the maximum ordinate of the artillery meteorological message for application to projectiles traversing higher than the 20 km meteorological message limit. The comparison really reduces to the question of how well the actual meteorological profile can be estimated from available information at the lower altitudes.

The techniques investigated include the current default method of using a standard meteorological message, the method of extrapolating available data from lower levels, and the method of using climatological values. The report illustrates the effect of the default method in assuming zero wind and using temperature and density and pressure profiles representative for global applications. The method of extrapolating wind, temperature, and density and pressure provided the smallest expected (meteorological) impact displacement for the sample considered. For extrapolations extended up to 3 km beyond the 20 km current maximum altitude, the extrapolated values proved to be good estimates of the actual ballistic parameter values effecting the projectile impact. The climatological method which required adjusted corrections from available information at the lower altitudes also showed a significant improvement over the default method. The meteorological impact errors are smaller than those allowed from the default method but larger than those allowed from the extrapolated method. Climatological input is also required. The method is included in this study because it may prove advantageous when extrapolated values are needed at ranges which cause the ballistic trajectory to exceed the extended 3 km height.

The development of the extended meteorological message techniques and ballistic simulation programs was tested by using a single rocket configuration. The selected trajectory reaches 65 km range and traverses 23 km AGL in altitude. Data needed to describe this trajectory (for example, ballistic wind and temperature and density coefficients including weighting factors and unit effects) were obtained from the Project Manager of the Multiple Launched Rocket Systems (MLRS).* To attain this altitude, the projectile had to be launched at 3048 m above sea level; consequently, the meteorological extending techniques could be evaluated at the 23 to 26 km level of the lower stratosphere. As is the case for the artillery techniques for aiming a gun[1] on a target, this report uses the launcher surface as the zero level.

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*Personal communication between Mr. Henry Oldham, Missile Command, and Dr. Donald M. Swingle, Atmospheric Sciences Laboratory, January-February 1980

[1]Field Manual 6-40, June 1974, Field Artillery Cannon Gunnery, Department of the Army Field Manual, Headquarters, Department of the Army, Washington DC

EXTENDING METEOROLOGICAL APPLICATION

Available techniques for extending the meteorological data for projectiles reaching higher than 20 km AGL vary from hardware and software or a combination of these. In this report only software techniques will be discussed. The rocketsonde data are assumed to represent the actual atmospheric parameters; then the extending technique comparison reduces to how well the actual meteorological profile can be estimated from available information below the 20 km AGL limit. Also, the implication is that if these measured meteorological data are used for aiming an artillery piece, then the displacement due to meteorology on the target is zero. When the true meteorological data are known, the simulated fire provides a hit every time.

The first technique examined--one which the Artillery currently uses--will be called the default method. Whenever a meteorological message or climatological tables are unavailable, the artillery pieces are aimed by using a meteorological message which contains standard temperature and pressure and density data. The standard wind is a constant zero speed for all (line numbers) layers. In cases where the meteorological messages are unavailable or are not complete to the 20 km AGL limit, the current procedure defaults to the standard meteorological conditions for the missing data.

The second technique is extrapolation. The missing data are defined from the last available layer and are used to estimate the remainder of the meteorological message for application up to the maximum ordinate of the artillery projectiles. A persistent wind is used which is the wind direction and windspeed at the 20 km layer held constant up to the apogee of the trajectory. The extended values for temperature are computed by adding the standard gradient of the temperature default method to the last known temperature value. Finally, for the last parameters, the hydrostatic extrapolation of the density and pressure is computed by using the extrapolated temperature values and available density and pressure value. The detailed extrapolation, assuming the hydrostatic equation and the perfect gas law, yields the following expressions:

Gravity $g_0 = 9.80665 \text{ m s}^{-2}$

Air molecular weight $M = 28.966 \text{ g mol}^{-1}$

Gas constant $R = 8314.32 \text{ J } (^\circ\text{K})^{-1} \text{ mol}^{-1}$

Geopotential layer $$\Delta H(I) = \left(\frac{9.7376}{g_0}\right)(I)(1000)\text{m}$$

where $I = 1, 2, 3$

Extended temperature $$T(I) = T_0 + T_S(I) - T_{S_0}$$

where T_0 = 20 km value
T_S = standard temperature
T_{S_0} = standard temperature at 20 km
$T \rightarrow {}^\circ\text{C}$

Lapse rate

$$L(I) = [T(I) - T_0]/\Delta H(I)$$

$$L \rightarrow (^{\circ}K)\ km^{-1}$$

Extended density

$$\rho(I) = \rho_0 \frac{[T_0 + 273.16]}{[T(I) + 273.16]}^{(1 + \frac{gM}{RL})}$$

where ρ_0 = 20 km value

$$\rho \rightarrow g/m^3$$

The extrapolated values for the layers of 1 km thickness are extended by iterating the above relationships with respect to I until the maximum altitude desired is reached.

The third technique is defined by a modification to the extrapolated technique. This method uses climatological data to estimate values of the unavailable data. The difference between the data at the 20 km AGL layer and the data of the climatological values for the time of year and location of actual meteorological application is used to adjust the climatological estimate. Even though the Field Artillery does not have climatological tables available for these extended heights, this technique was included to develop the concept of translating the meteorological trend from climatological or fallout meteorological messages to continue the extended meteorological message from the 20 km AGL values.

The US Army Field Artillery needs an estimate of the meteorological impact displacement for proposed high trajectory weapons. Therefore, the emphasis of this report is to estimate the ballistic meteorological effects and not the actual value of the missing meteorological data at the extended altitudes. The three methods for extending meteorological data above the altitude actually measured are then transformed into a departure from a selected meteorological standard, and the error in failing to estimate the ballistic atmospheric effect will be illustrated by a displacement about the target. In summary, figure 1 illustrates the percent departures, plotted as (.), from the United States Standard Atmosphere (USSA) 1962[2] for 16 rocketsonde data flights collected during January 1979. This is the standard atmosphere the Ballistic Research Laboratory uses for trajectory computations.[3] The departures for the

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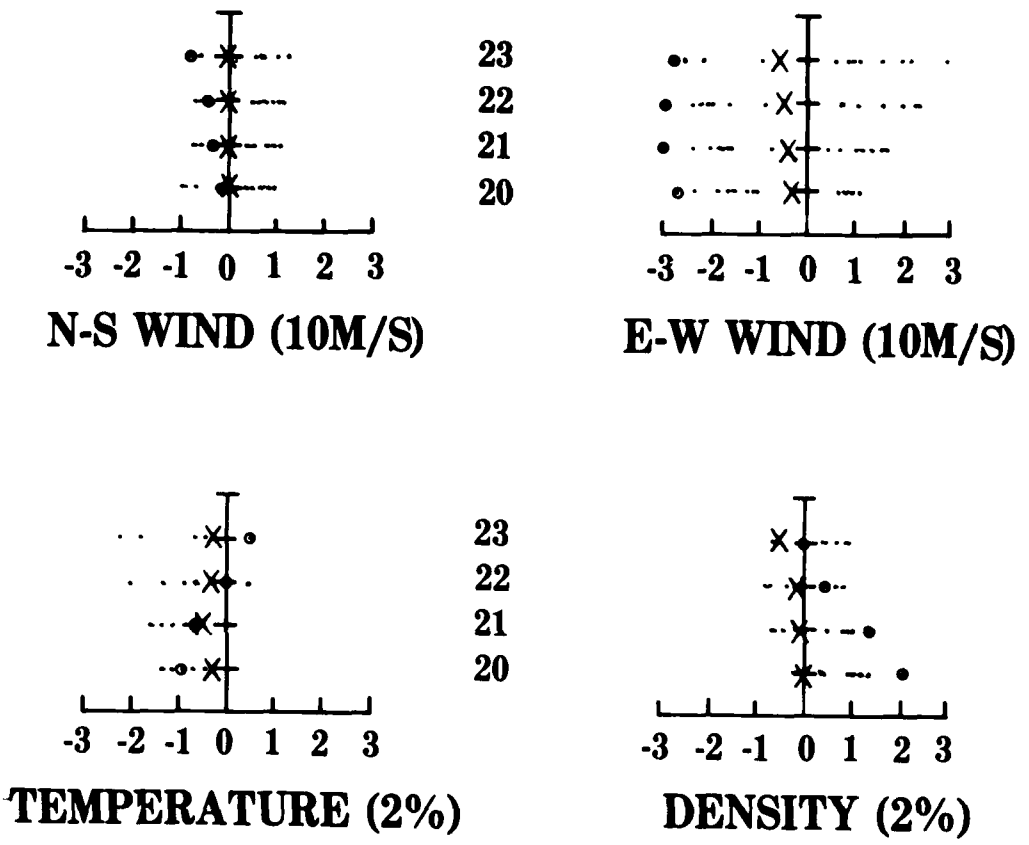
[2] US Standard Atmosphere, 1962, December 1961, National Aeronautics and Space Administration, United States Air Force, United States Weather Bureau

[3] William Barnhart, 1966, "The Standard Atmosphere Used by BRL for Trajectory Computations," BRL MR 1766, US Army Materiel Command, Ballistic Research Laboratory, Aberdeen Proving Ground, MD



(.) January rocketsonde data

(X) January climatological data

(0) January 4, 1979, 1900 hours, data

Figure 1. Percent departures from the 1962 United States Standard Atmosphere 16 rocketsonde data flights.

month's climatological data are also plotted (x). Extending technique 1 uses the default value of the USSA (no departure). Technique 2 uses the wind components measured at the 20 km layer and also uses this value at the 21, 22, and 23 km layers. The extended values for the departure temperatures and density and pressure values are the normalized deviations between the extended values and corresponding values of the USSA. Technique 3 adds the climatological data with respect to the corresponding heights and the difference between the last available data and the climatology at 20 km to compute the data at the missing layers. By superimposing the climatological departure value (x) on a particular value of the 20 km level, one computes the difference that will be arithmetically added to the remaining climatological profile levels.

BALLISTIC SIMULATION

A comparison of the impact dispersions (realized by three techniques) was reviewed to evaluate the extending techniques and to gain some insight on the effect of the extended meteorological message. This report assumes that the actual meteorology is defined as the measured parameters deduced from the rocketsonde data.[4] These data were then represented in the Artillery computer meteorological message format[5] with new layers of 1 km thickness added to complete an extended message to 23 km AGL. The investigated techniques used measured data below 20 km AGL and extrapolated or climatological data for each layer up to the maximum ordinate of 23 km AGL. Using the same data, each extending method yields a dispersion about an assumed target. The meteorological technique that yields the smallest dispersion about the simulated target is selected as the best of those tested.

The corresponding dispersions are defined as the group of displacements calculated by the ballistic weighting technique. Here an algorithm is introduced that utilizes the extended messages and ballistically computes a displacement about a fixed target. This algorithm can be used to compute the deviation between the extended and a standard (USSA) method. This deviation is then normalized with respect to the standard (USSA) condition. The deviation is calculated for the averaged parameter (wind, temperature, density and pressure) $\overline{P}(Z)$ at each layer through 23 km. Finally, in the ballistic technique, the normalized parameter is multiplied by the weighted response function $[\delta w'(Z)]$. This function contains the ballistic characteristics of the high trajectory weapon system. The required information is the weighting factors and the unit effect for each of the meteorological parameters at the identical layer structure of the extended messages under evaluation. The sum of these products through the maximum altitude of the proposed trajectory yields the effective displacement (D) from the standard conditions. In reality, by knowing this displacement, an artilleryman can compensate for the meteorological deviations from the standard by appropriately adjusting his weapon aim and firing for effect. This displacement is formulated as follows:

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[4]Federal Meteorological Handbook No. 10, July 1975, Meteorological Rocket Observations, National Aeronautics and Space Administration, US Department of Commerce, US Department of Defense

[5]Field Manual 6-15, August 1978, Artillery Meteorology, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC

$$D = \int_{z_0}^{z} \delta\omega'(Z)\left[\frac{\overline{P}(Z) - \overline{P}_s(Z)}{\overline{P}_s(Z)}\right] dZ \ , \qquad (1)$$

where δ = unit effect; $\omega'(Z)$ = ballistic weighting; dZ is the increment of height; and the parameter $\overline{P}(Z)$ is temperature, density, or wind. In the case of wind there is no standard, and the $\overline{P}(Z)$ is not normalized.

A sample of rocketsonde flights containing different atmospheric conditions yields a set of impact displacements describing the dispersion of the analyzed weapon system. This dispersion is mathematically represented with a bias and a variance for each component (cross and range) about the target. The conventional artillery practice is to describe the dispersion of a weapon in terms of a circular error probable (CEP).[4] This criterion is defined as the circular radius of the smallest circle about the target that contains one-half of the total impact displacements. This procedure is used even though the actual dispersion of a gun is elliptical. In demonstrating the differences between the evaluated extending techniques, this report uses elliptical probable error rather than the CEP. There are cases when a small dispersion is biased too far from the target, thereby yielding artillery fire ineffective. One is cautioned that when converting to CEP about the target the comparison of results will produce a different interpretation of the evaluated meteorological messages. The bias due to meteorological parameters is a major contributor to the impact displacement. In practice, through observed fire the Fire Direction Center would correct for this bias which is caused from the unavailability of a meteorological message update or lack of a procedure to obtain data above 20 km AGL.

The results show that the dispersion is a function of the atmospheric condition. Wind, temperature, and density and pressure effect the range impact displacement, while only wind effects the cross component.[5] Since the azimuth of fire determines the wind bias, calculation of a mathematical composite of eight single azimuth (θ_j) dispersions was considered to be more appropriate. The weapon system was therefore launched at targets on a circle of radius of 65 km at increments of 45 degrees. Figure 2 illustrates the one-probable-error dispersions produced from 16 rocketsonde flights collected during the same month and at the same location. All impacts were computed without an extended meteorological correction between 20 to 23 km AGL. The effectiveness of fire is different for the particular target. This report groups the 128 impact displacements and defines the composite dispersion plotted in the center of figure 2. Notice that the range and cross bias due to the wind are cancelled in the composite dispersion. This cancellation would also be true for a single azimuth target if the sample rocketsonde data included winds from all directions. The temperature and density and pressure

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[4]Field Manual 6-40, June 1974, Field Artillery Cannon Gunnery, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC

[5]Field Manual 6-15, August 1978, Artillery Meteorology, Department of the Army Field Manual, Headquarters, Department of the Army, Washington, DC

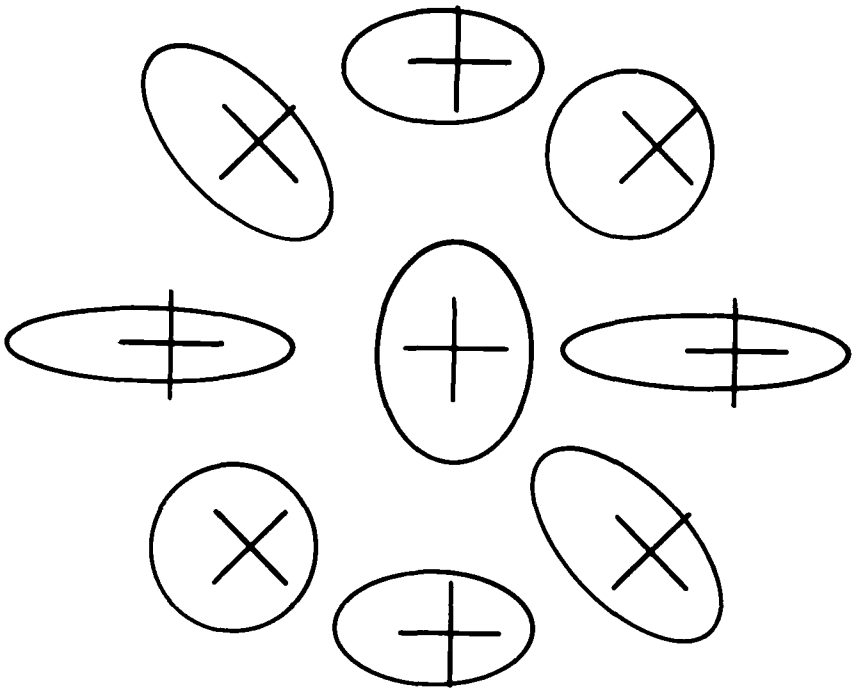

Figure 2. One probable error elliptical dispersions from 16 impact displacements computed without extended meteorological correction between 24 and 26 km above mean sea level. The weapon system is fired at targets on a circle of radius 65 km at 45-degree increments. The center dispersion is the mathematical composite of the 128 displacements.

bias are not cancelled because of the nature of the ballistic computation. If the sample contained data with the temperature and density and pressure above and below the standard, then the bias would be effected in the composite. The next section will present results for the rocketsonde data collected during different months illustrating the variation of temperature and density and pressure effects. The composite results can be interpreted as results of a large sample containing 128 rocketsonde flights collected on the same month. With the inclusion of several months of data collected at one location and following the outlined procedure, the final results can be interpreted for general application.

For each rocketsonde flight, equation (1) is applied to the cross (D_C) and range (D_R) components as follows:

$$D_{C_i}(\theta_j, Z) = \delta_C \sum_{Z_0}^{Z} \omega_C'(Z)\overline{W}_{C_i}(\theta_j, Z) \; ; \tag{2}$$

$$D_{R_i}(\theta_j, Z) = \delta_R \sum_{Z_0}^{Z} \omega_R'(Z)\overline{W}_{R\ i}(\theta_j, Z) + \delta_T \sum_{Z_0}^{Z} \omega_T'(Z)\frac{\Delta T_i}{\overline{T}_S} + \delta_\rho \sum_{Z_0}^{Z} \omega_\rho'(Z)\frac{\Delta \rho_i}{\rho_S}. \tag{3}$$

The cross component does not contain the temperature (T) and density (ρ) effects as illustrated in equation (3). The displacement statistics for the error due to the unextended meteorological message are computed as follows:

$$\text{Bias} = \sum_{i}^{n} \sum_{j}^{8} D_i(\theta_j, Z)/8n \; ; \tag{4}$$

$$\text{Variance} = \frac{8n \sum_{i}^{n} \sum_{j}^{8} D_i(\theta_j, Z)^2 - \left[\sum_{i}^{n} \sum_{j}^{8} D_i(\theta_j, Z)\right]^2}{8n(8n - 1)} \; . \tag{5}$$

Generalizing the results, consider that for each (i) rocketsonde flight there are (j = 8) azimuths providing a total of 8n impact displacements for each month.

TECHNIQUE COMPARISON

Measurements from 69 rocketsonde data flights collected at White Sands Missile Range (WSMR), New Mexico, during January through June 1979 were used to compute the meteorological displacement for the high trajectory projectile at the simulated 65 km range target. Since the evaluation of the three proposed extending techniques is based on the comparison of the dispersion from the

simulated displacements, the formula in equation (1) is computed for heights of 20 through 23 km AGL. These computations represent the meteorological effects which are not compensated for when the selected projectile is fired. However, use of extending meteorological data techniques will provide meteorological compensation for the missing data and should improve the accuracy.

The meteorological effect from surface through 20 km AGL is not computed in this report since the first 20 km of data are the same for each of the three extended meteorological messages. The extended meteorological message that best estimates the rocketsonde data will yield the smallest dispersion about the target at 65 km range. Only the displacement due to meteorology above 20 km is analyzed and illustrated in table A-1 in appendix A. In table A-1, J = 0 indicates the expected miss distance when using the current method which defaults to using standard meteorology when no other meteorological data are available. The largest displacement is 164 m and the smallest is 19 m. Note that this study assumes that there is no time and space difference between the point of measurement and application. For an actual firing, these errors are further increased by a factor determined from the time and space variability.

Table A-1 indicates that the presently used default values for the meteorological message above 20 km AGL yield large displacement variations that the Field Artillery should be correcting.

For J = 1 this table contains a list of the miss distance computed when an extrapolation defined from the last available layer is used to estimate the missing three meteorological data layers. Values in this table for J = 2 represent the displacements expected when persistent meteorology is modified by climatological gradients. The following interpretation can be made from table A-1: If the high trajectory projectile were fired on a cross-road target located 65 km in range on 4 January 1979, 1900 hours, using the current artillery default method, it would miss the target by 164 m. The smallest miss for the month is 50 m (17 January) and this assumes that there are no other time and space associated meteorological contributions. This unacceptable error can be improved significantly by any of the proposed extending techniques. By the simple extrapolated technique, the 164-m miss is reduced to 37 m and the 50-m miss to 17 m. A statistical extrapolation technique may provide further improvement. This improvement is expected from the better estimate of the wind and density effect. The temperature related errors are small because the variations at 23 to 26 km (above mean sea level) were small; and when normalized with the standard (in degrees Kelvin), the ballistic effect is a minimum as shown in table A-1.

Appendix B contains a flowchart illustrating the procedure automated to compute the expected meteorological errors associated with the high trajectory profile. The algorithm compares the statistics from the evaluated techniques. In summary, the no-correction or the default displacement is computed first by setting J = 0. This error is the total effect of the extended layers as computed from the actual rocketsonde data. For each flight, this displacement is saved for comparison with the other evaluated techniques. The difference and square of difference are saved to compute statistics leading to description of the one probable error, elliptical dispersion. In detail the miss distance is defined, using no-correction or default standard, as J0 (C0, R0). E(C1, R1) is the miss distance computed by

using the extrapolated correction. The miss distance provided from the climatology method is labeled as E(C2, R2). The differences J1 and J2, where

$$J1 = E(C1, R1) - JO(CO, RO),$$
$$J2 = E(C2, R2) - JO(CO, RO), \tag{6}$$

provide the comparative values for the evaluated methods. A difference equal to zero indicates that the extended method has fully compensated for the actual extended values. The value of the difference is the error that remains uncompensated. By grouping the corresponding displacements, one can then compare the evaluated technique dispersions.

Table 1 presents statistics based on data from table A-1. The statistics are partitioned into the January, February, March, April, May, and June subsets of 16, 13, 12, 12, 8, and 8 rocketsonde data flights. An analysis of the total sample shows that there is a 64 percent improvement afforded by the extrapolated method over the current default method. Figure 3 presents a graphic demonstration of improved accuracy.

To assure the reader that this sample provides representative results, a test of significance was performed. The chi square distribution test involves the comparison of the computed displacements *versus the* expected displacements. A desired risk is selected, and a test statistic is compared with the chi square table value.[6] This test statistic is defined as follows:

$$\chi^2 = \sum_{i}^{n} \frac{(O_i - E_i)^2}{E_i}, \tag{7}$$

where O_i is the observed frequency of occurrence of the computed displacements, E_i is the expected frequency of displacement for the different technique, and χ^2 is the computed chi square value.

For ease in organizing the results, a contingency table is arranged in table 2. The expected number of less than 30 m displacement is computed as follows: If there were no difference in the effect of the three techniques, the fraction of displacement with better than 30 m would be expected to be the same ratio as the totals in the last column of table 2. The number of the sample displacements is multiplied by this ratio to define the expected results. The computed value of χ^2 is greater than 34. Since the calculated value exceeds the table value (10), the conclusion is that the data indicate a difference from the expected value with a risk less than 0.005.

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[6]Albert D. Rickmers and Hollis N. Todd, 1967, Statistics An Introduction, McGraw-Hill Book Company, New York

TABLE 1. COMPARISON OF RMS MISS FOR THREE EXTRAPOLATED MET MESSAGES USED AS INPUT FOR SIMULATED TRAJECTORY

$$\left(\overline{M^2} + \sigma_M^2\right)^{1/2} \text{ in meters}$$

	Jan	Feb	Mar	Apr	May	Jun	Total
Sample size	16	13	12	12	8	8	69
Rocketsonde	———	———	———	Actual impact	———	———	———
Techniques (20-23 km)							
Default standard	106	55	58	64	74	89	78
Extrapolated	36	25	30	27	12	20	28
Climatology	43	39	46	27	18	27	37

TABLE 2. CONTINGENCY TABLE BASED ON RESULTS OF TEST OF THREE EXTENDING METEOROLOGICAL TECHNIQUES

Technique J =	0	1	2	Total
Total displacement	69	69	69	207
$\leq$ 30 m criteria	5	50	37	92
Expected improvement	30.7	30.7	30.7	

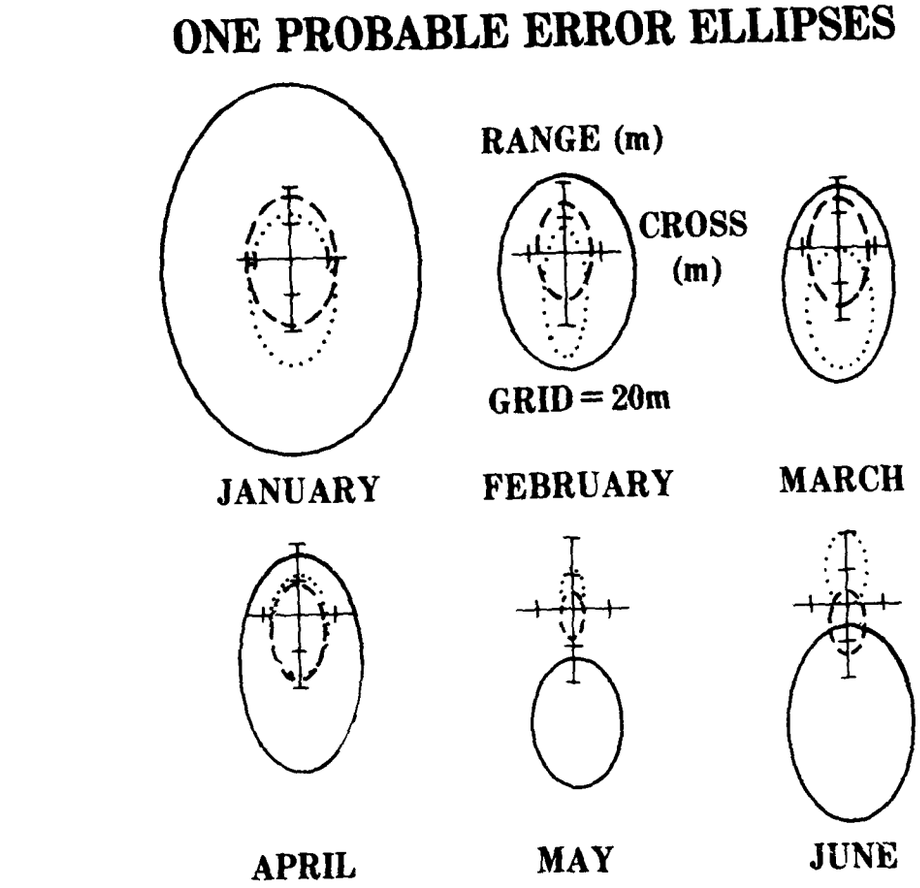

Figure 3. Graphic display of improved one probable error afforded by the extrapolated and climatological messages.

CONCLUSIONS

There is a large variation in the displacement effect due to the measured rocketsonde data collected at 23 through 26 km above mean sea level. For this theoretical study, the largest meteorological displacement in the sample size of 69 is 164 m and the smallest is 19 m. Note that for an actual firing these errors are further increased by a factor determined from the time and space differences between the point of measurement and application of the meteorological data. Under the assumption of no time and space variability, extrapolated meteorological data above 20 km AGL yielded a significant improvement over the current default method of using a standard meteorological message. The total rms 78-m displacement error was reduced to 28 m. The comparison reduces to how well the actual meteorological profile can be estimated from available information. If the estimate is poor, then actual measurements become important. Preliminary results for the high trajectory projectile considered indicate that a software addition to the current message procedure may be sufficient. This indication appears to be true when the meteorological message is extended 3 km in altitude for compensating meteorological effects on a 65 km range trajectory.

The next report to the United States Field Artillery School will present the status on the accuracy and dispersion effects on target impact displacement provided by using statistical extrapolation techniques. The improvement expected originates from bounded physical estimates of density and temperature effects and modified persistent winds with expected wind gradient effects. Instead of climatology, the last available fallout message can be used to provide the trend of the missing data. A more representative case of a high trajectory traversing to the middle stratosphere will be investigated. Under this condition, the default method of using the standard meteorological message is expected to yield increasingly larger errors.

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APPENDIX A

METEOROLOGICAL ERRORS AND ROCKETSONDE DATA

All information catalogued in table A-1 is expressed in meters and is the expected meteorological errors caused by the unavailable information at the extended heights (20 to 23 km) of the artillery computer meteorological message. For general interpretation of results, the statistics for each rocketsonde flight were computed from ballistic simulated firings at targets 65 km range and 45-degree azimuth intervals. The standard deviation and bias are listed, and the total statistics are summarized at the bottom of each month's results. Remember that for an actual application these errors are increased by a factor determined from the time and space difference between the points of measurement and application of meteorological corrections.

The information catalogued in table A-2 presents the rocketsonde data at the extended heights. The height is multiplied by ten to get the distance from mean sea level. In comparison to table A-1, these three 1-km layered data correspond to the 21, 22, and 23 km extension of the artillery meteorological message which is referenced to the launcher level. At the bottom of each month's data the climatology, standard atmosphere, and statistics for each layer are presented. Statistics are expressed in indicated units, the azimuth in degrees and the speed in meters per second, the temperature in degrees centigrade, and the density grams per cubic meter.

TABLE A-1. METEOROLOGICAL ERRORS

Iflight= 16 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	1	4	1900	89.33	137.35	163.84	0	-.00	-29.54	.74	-28.80
79	1	4	1900	14.88	33.49	36.65	1	.00	-31.60	6.83	-24.77
79	1	4	1900	9.59	66.43	67.12	2	0.00	-72.30	7.47	-64.83
79	1	5	1900	76.27	115.55	138.45	0	-.00	-15.97	3.82	-12.15
79	1	5	1900	16.94	25.75	30.83	1	-.00	-2.69	1.82	-.87
79	1	5	1900	10.87	27.36	29.44	2	-.00	-24.25	2.48	-21.76
79	1	8	2030	68.98	104.17	124.94	0	.00	-7.44	5.00	-2.44
79	1	8	2030	18.28	28.51	33.87	1	-.00	-8.38	2.57	-5.81
79	1	8	2030	17.85	40.19	43.98	2	-.00	-32.77	3.21	-29.57
79	1	11	1945	62.20	94.60	113.22	0	-.00	-18.27	7.27	-11.00
79	1	11	1945	23.11	35.20	42.11	1	0.00	-3.55	2.23	-1.32
79	1	11	1945	23.75	47.71	53.30	2	0.00	-33.99	2.84	-31.15
79	1	12	1900	73.05	110.25	132.25	0	.00	-3.24	2.10	-1.14
79	1	12	1900	19.78	31.85	37.49	1	-.00	-16.09	5.47	-10.62
79	1	12	1900	17.06	44.10	47.28	2	-.00	-41.75	6.11	-35.64
79	1	15	2230	58.57	89.34	106.83	0	.00	-14.24	1.73	-12.51
79	1	15	2230	4.50	11.29	12.16	1	0.00	12.59	-3.81	8.77
79	1	15	2230	7.28	14.31	16.06	2	0.00	12.00	-3.05	8.95
79	1	16	2145	65.79	99.32	119.13	0	-.00	1.37	4.82	6.19
79	1	16	2145	14.87	24.81	28.92	1	0.00	11.71	-1.11	10.60
79	1	16	2145	19.38	29.63	35.40	2	0.00	5.26	-.42	4.84
79	1	17	2010	26.82	41.63	49.52	0	0.00	-13.34	3.36	-9.98
79	1	17	2010	6.53	15.11	16.46	1	-.00	15.07	-3.52	11.56
79	1	17	2010	7.62	14.66	16.52	2	-.00	12.02	-2.78	9.24
79	1	18	1720	25.73	45.65	52.40	0	.00	-23.92	.01	-23.91
79	1	18	1720	15.53	25.20	29.60	1	-.00	-10.74	1.77	-8.97
79	1	18	1720	16.28	37.25	40.66	2	-.00	-30.39	2.48	-27.91
79	1	19	1930	47.27	71.62	85.82	0	.00	-3.77	-1.54	-5.31
79	1	19	1930	25.24	38.34	45.90	1	0.00	-3.24	1.38	-1.85
79	1	19	1930	26.50	40.85	48.69	2	0.00	-9.38	2.12	-7.26
79	1	23	1835	36.94	55.68	66.82	0	-.00	-7.40	3.45	-3.95
79	1	23	1835	6.22	11.86	13.39	1	-.00	10.82	-3.60	7.22
79	1	23	1835	8.77	14.38	16.85	2	-.00	8.35	-2.86	5.49
79	1	24	1915	52.27	81.11	96.49	0	0.00	17.05	2.73	19.78
79	1	24	1915	12.96	19.48	23.40	1	0.00	1.01	-.95	.06
79	1	24	1915	15.78	23.73	28.50	2	0.00	.04	-.24	-.19
79	1	25	1800	45.00	71.45	84.44	0	-.00	-34.87	11.98	-22.89
79	1	25	1800	11.93	19.80	23.12	1	0.00	8.94	-.55	8.39
79	1	25	1800	12.15	32.51	34.70	2	.00	-26.94	.04	-26.90
79	1	26	1800	34.36	52.89	63.08	0	.00	-27.69	16.24	-11.45
79	1	26	1800	8.68	19.89	21.70	1	0.00	21.73	-6.74	14.99
79	1	26	1800	7.58	14.57	16.42	2	-.00	-2.97	-6.13	-9.10
79	1	29	1700	67.03	101.72	121.82	0	-.00	5.39	3.46	8.84
79	1	29	1700	41.13	63.11	75.33	1	0.00	-13.68	4.11	-9.57
79	1	29	1700	42.14	70.87	82.45	2	0.00	-35.36	4.75	-30.61
79	1	30	1900	57.92	91.08	107.94	0	-.00	29.33	-3.44	25.89
79	1	30	1900	27.85	43.21	51.41	1	0.00	-14.97	5.22	-9.74
79	1	30	1900	28.24	44.16	52.42	2	0.00	-17.24	5.93	-11.31

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
-.00	58.48	68.85	-5.30	89.35	105.20	0	106.5
-.00	19.15	22.55	-.75	30.82	36.28	1	36.1
-.00	19.35	22.78	-16.73	35.39	41.67	2	43.5

TABLE A-1 (CONT)

Iflight= 13 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	2	1	1900	35.40	56.26	66.47	0	0.00	16.08	1.37	17.45
79	2	1	1900	11.56	19.24	22.44	1	0.00	9.19	-1.52	7.67
79	2	1	1900	8.33	18.15	19.97	2	0.00	14.43	-1.54	12.88
79	2	5	1800	8.36	27.98	29.20	0	0.00	-28.54	3.63	-24.91
79	2	5	1800	6.31	9.73	11.59	1	.00	2.95	-1.86	1.09
79	2	5	1800	4.89	17.13	17.81	2	.00	-13.49	-1.90	-15.39
79	2	6	1901	11.03	24.56	26.93	0	-.00	-22.18	4.09	-18.10
79	2	6	1901	5.82	14.27	15.41	1	-.00	15.51	-4.24	11.27
79	2	6	1901	3.61	7.52	8.34	2	-.00	9.48	-4.26	5.22
79	2	7	1930	23.66	43.56	49.57	0	0.00	-32.16	7.27	-24.89
79	2	7	1930	13.51	21.00	24.97	1	0.00	6.30	-1.63	4.68
79	2	7	1930	12.36	27.08	29.77	2	0.00	-17.83	-1.73	-19.56
79	2	8	1900	28.75	52.99	60.28	0	0.00	-37.98	7.63	-30.35
79	2	8	1900	16.74	25.63	30.62	1	0.00	-5.55	1.87	-3.67
79	2	8	1900	13.71	46.98	48.94	2	0.00	-43.84	1.72	-42.12
79	2	13	1900	23.63	36.42	43.42	0	0.00	-3.65	-3.52	-7.17
79	2	13	1900	5.81	40.86	41.27	1	0.00	-52.91	13.03	-39.88
79	2	13	1900	2.60	83.14	83.18	2	0.00	-95.91	12.88	-83.04
79	2	14	1915	12.32	38.91	40.81	0	0.00	-45.35	11.26	-34.09
79	2	14	1915	12.06	19.17	22.65	1	0.00	7.33	-1.75	5.58
79	2	14	1915	12.50	36.23	38.33	2	0.00	-28.97	-1.90	-30.87
79	2	15	2115	10.04	16.38	19.21	0	0.00	-16.53	10.35	-6.18
79	2	15	2115	11.58	21.59	24.50	1	0.00	17.63	-4.71	12.93
79	2	15	2115	12.91	19.33	23.25	2	0.00	3.15	-4.81	-1.66
79	2	16	2000	14.90	27.01	30.84	0	-.00	-22.53	7.45	-15.09
79	2	16	2000	3.25	4.91	5.88	1	.00	2.37	-1.81	.57
79	2	16	2000	6.17	23.54	24.34	2	.00	-19.73	-1.90	-21.63
79	2	20	1945	18.33	30.06	35.20	0	0.00	5.90	6.45	12.35
79	2	20	1945	8.37	13.27	15.69	1	0.00	-5.17	1.12	-4.04
79	2	20	1945	11.31	28.35	30.52	2	0.00	-23.60	1.00	-22.60
79	2	22	1845	40.62	61.26	73.50	0	.00	-13.99	7.63	-6.36
79	2	22	1845	9.28	25.07	26.73	1	0.00	26.68	-5.85	20.83
79	2	22	1845	9.28	22.78	24.60	2	0.00	23.81	-5.90	17.90
79	2	27	1850	46.01	70.60	84.27	0	00	-25.14	13.16	-11.97
79	2	27	1850	18.96	29.39	34.97	1	0.00	-7.57	2.13	-5.44
79	2	27	1850	15.96	57.47	59.65	2	0.00	-53.96	1.91	-52.05
79	2	28	1846	49.73	75.47	90.38	0	.00	-8.74	14.71	5.97
79	2	28	1846	16.87	26.30	31.24	1	0.00	6.37	-1.34	5.03
79	2	28	1846	13.62	33.70	36.35	2	0.00	-24.88	-1.54	-26.42

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
.00	28.48	33.53	-11.03	45.67	53.77	0	54.7
-.00	11.80	13.90	.28	22.70	26.74	1	25.5
.00	10.68	12.59	-21.19	31.20	36.73	2	39.2

TABLE A-1 (CONT)

Iflight= 12 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	3	1	1937	58.23	88.03	105.54	0	-.00	-19.44	18.16	-1.28
79	3	1	1937	29.09	46.75	55.06	1	-.00	18.16	-2.86	15.30
79	3	1	1937	27.89	46.41	54.15	2	.00	-16.68	-2.35	-19.02
79	3	2	1900	40.87	62.59	74.75	0	.00	-26.12	16.80	-9.32
79	3	2	1900	29.14	48.50	56.59	1	-.00	23.25	-3.43	19.82
79	3	2	1900	28.49	44.67	52.99	2	-.00	-8.18	-2.90	-11.08
79	3	5	2200	4.72	21.60	22.11	0	-.00	-27.60	7.27	-20.33
79	3	5	2200	10.74	16.33	19.54	1	.00	-.26	.30	.04
79	3	5	2200	12.79	34.14	36.46	2	.00	-28.98	.92	-28.06
79	3	7	1945	4.86	30.51	30.89	0	-.00	-43.28	13.71	-29.57
79	3	7	1945	13.87	21.11	25.25	1	.00	-1.38	-.34	-1.72
79	3	7	1945	15.96	53.67	55.99	2	.00	-48.09	.19	-47.90
79	3	8	2130	13.85	59.90	61.48	0	.00	-68.20	12.08	-56.12
79	3	8	2130	9.53	19.23	21.46	1	.00	15.32	-2.58	12.74
79	3	8	2130	8.92	31.38	32.63	2	-.00	-26.36	-1.99	-28.35
79	3	12	1930	16.90	67.33	69.41	0	0.00	-77.01	14.71	-62.30
79	3	12	1930	8.12	12.50	14.90	1	0.00	3.54	-1.34	2.20
79	3	12	1930	6.49	55.39	55.76	2	-.00	-53.70	-.80	-54.51
79	3	14	1915	22.19	33.90	40.51	0	0.00	-12.65	7.46	-5.19
79	3	14	1915	8.37	20.95	22.56	1	0.00	-20.62	3.98	-16.64
79	3	14	1915	9.01	56.31	57.03	2	0.00	-59.17	4.54	-54.63
79	3	16	2150	18.55	28.28	33.82	0	0.00	-10.07	6.46	-3.61
79	3	16	2150	3.68	7.14	8.03	1	0.00	-7.40	3.05	-4.36
79	3	16	2150	1.45	32.72	32.76	2	0.00	-36.28	3.64	-32.64
79	3	19	1900	3.20	21.25	21.49	0	0.00	-23.54	2.82	-20.72
79	3	19	1900	.20	7.77	7.77	1	0.00	-12.51	4.75	-7.76
79	3	19	1900	1.91	38.93	38.98	2	0.00	-44.18	5.37	-38.82
79	3	26	2030	36.74	55.68	66.71	0	.00	7.71	-1.35	6.36
79	3	26	2030	10.34	33.38	34.95	1	0.00	-38.42	8.92	-29.49
79	3	26	2030	9.41	60.33	61.05	2	0.00	-68.16	9.54	-58.62
79	3	28	1925	31.35	47.84	57.19	0	0.00	-2.81	-3.99	-6.80
79	3	28	1925	10.28	18.93	21.54	1	0.00	-14.46	3.84	-10.63
79	3	28	1925	8.28	23.37	24.80	2	0.00	-24.22	4.55	-19.66
79	3	30	1900	17.87	42.01	45.66	0	0.00	-30.21	-1.90	-32.10
79	3	30	1900	8.13	12.54	14.94	1	.00	-2.70	1.75	-.95
79	3	30	1900	6.51	18.48	19.59	2	0.00	-17.96	2.46	-15.50

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
.00	27.66	32.56	-20.08	46.70	54.98	0	57.6
-.00	14.57	17.16	-1.79	25.82	30.40	1	29.6
-.00	14.26	16.80	-34.07	26.92	31.70	2	45.6

TABLE A-1 (CONT)

Iflight= 13 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	4	2	1900	34.35	69.88	77.86	0	0.00	-50.93	3.82	-47.11
79	4	2	1900	4.73	9.08	10.24	1	0.00	7.53	-2.04	5.49
79	4	2	1900	1.43	4.22	4.46	2	0.00	6.59	-2.93	3.66
79	4	4	1915	42.74	64.37	77.27	0	-.00	2.28	-4.17	-1.88
79	4	4	1915	8.54	15.65	17.83	1	0.00	-10.84	2.08	-8.76
79	4	4	1915	14.79	24.32	28.47	2	.00	7.95	1.24	9.20
79	4	6	1940	22.94	38.99	45.24	0	0.00	29.86	-11.52	18.34
79	4	6	1940	23.63	46.30	51.99	1	0.00	-40.74	11.37	-29.37
79	4	6	1940	24.62	40.66	47.53	2	0.00	-26.44	10.50	-15.94
79	4	9	1900	34.52	52.97	63.23	0	0.00	-8.34	-1.54	-9.87
79	4	9	1900	7.72	14.83	16.71	1	0.00	-14.64	5.25	-9.39
79	4	9	1900	6.99	13.17	14.91	2	0.00	-12.12	4.33	-7.79
79	4	11	1945	39.36	59.44	71.29	0	-.00	4.84	-6.07	-1.23
79	4	11	1945	12.59	21.14	24.61	1	0.00	-12.89	3.99	-8.91
79	4	11	1945	14.87	24.35	28.53	2	0.00	6.08	3.15	9.23
79	4	12	1931	37.35	56.73	67.92	0	.00	9.53	-3.80	5.72
79	4	12	1931	20.70	35.95	41.49	1	0.00	-21.08	3.65	-17.43
79	4	12	1931	18.89	28.93	34.55	2	0.00	-7.02	2.79	-4.23
79	4	16	1900	29.61	55.05	62.51	0	0.00	-33.23	1.19	-32.04
79	4	16	1900	18.07	27.67	33.04	1	0.00	5.37	-1.34	4.03
79	4	16	1900	20.96	33.70	39.68	2	0.00	13.68	-2.21	11.48
79	4	18	1920	22.46	45.75	50.96	0	0.00	-24.84	-6.07	-30.91
79	4	18	1920	10.36	16.46	19.45	1	0.00	-10.15	3.99	-6.16
79	4	18	1920	5.53	8.36	10.02	2	0.00	-.63	3.15	2.52
79	4	20	1930	8.33	59.80	60.38	0	0.00	-59.11	.64	-58.46
79	4	20	1930	3.80	6.47	7.50	1	0.00	-2.21	-.80	-3.01
79	4	20	1930	2.64	8.46	8.87	2	0.00	-5.69	-1.66	-7.35
79	4	23	2200	3.40	50.75	50.87	0	.00	-47.42	-3.07	-50.49
79	4	23	2200	3.92	14.59	15.10	1	-.00	-16.26	2.92	-13.34
79	4	23	2200	2.91	19.05	19.27	2	.00	-20.57	2.06	-18.51
79	4	25	2140	2.91	87.04	87.08	0	0.00	-87.48	.55	-86.93
79	4	25	2140	5.16	7.94	9.47	1	-.00	.59	1.22	1.82
79	4	25	2140	2.83	15.99	16.24	2	0.00	-15.75	.34	-15.41
79	4	30	1800	12.95	27.31	30.22	0	.00	-12.87	-6.16	-19.03
79	4	30	1800	9.72	28.43	30.05	1	-.00	-32.21	7.94	-24.27
79	4	30	1800	10.89	31.44	33.27	2	-.00	-33.74	7.05	-26.69

CROSS	C SIG	2D PE
-.00	28.00	32.96
-.00	12.60	14.84
.00	13.19	15.53

RANGE	R SIG	2D PE
-26.16	51.50	60.63
-9.11	21.71	25.56
-4.99	23.31	27.44

J	RMS
0	63.9
1	26.6
2	27.1

TABLE A-1 (CONT)

Iflight= 8 Iazimuth= 2

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	5	2	1947	17.25	70.99	73.06	0	0.00	-62.66	-3.44	-66.10
79	5	2	1947	6.95	16.12	17.56	1	0.00	-17.51	5.22	-12.29
79	5	2	1947	7.50	21.99	23.23	2	0.00	-19.57	.69	-18.88
79	5	7	1800	8.37	57.03	57.64	0	.00	-50.76	-4.90	-55.66
79	5	7	1800	3.86	5.98	7.11	1	.00	-.37	-1.05	-.68
79	5	7	1800	4.06	19.35	19.77	2	.00	23.79	-5.48	18.31
79	5	11	1900	22.40	94.68	97.30	0	0.00	-92.32	3.82	-88.50
79	5	11	1900	1.65	3.06	3.48	1	0.00	1.94	-.11	1.83
79	5	11	1900	1.35	12.46	12.54	2	0.00	-7.64	-4.67	-12.30
79	5	18	1800	20.83	71.93	74.89	0	0.00	-61.82	-2.90	-64.71
79	5	18	1800	2.99	9.09	9.57	1	0.00	-10.60	2.74	-7.86
79	5	18	1800	2.77	8.93	9.35	2	0.00	-6.08	-1.76	-7.85
79	5	21	1800	23.13	78.17	81.54	0	0.00	-68.29	-1.71	-70.00
79	5	21	1800	8.98	13.58	16.28	1	0.00	-.98	-.37	-1.25
79	5	21	1800	8.58	13.45	15.95	2	0.00	8.57	-4.85	3.72
79	5	23	1445	23.30	72.61	76.26	0	0.00	-59.64	-3.99	-63.63
79	5	23	1445	3.64	5.91	6.94	1	0.00	-2.19	-.03	-2.21
79	5	23	1445	4.67	11.51	12.42	2	0.00	13.57	-4.48	9.09
79	5	25	1800	19.03	64.19	66.95	0	.00	-53.63	-3.80	-57.43
79	5	25	1800	8.58	14.06	16.47	1	-.00	-4.38	3.65	-5.72
79	5	25	1800	9.40	14.28	17.10	2	-.00	-1.54	-.86	-2.39
79	5	29	2148	17.28	49.58	52.50	0	0.00	-40.72	-1.54	-42.25
79	5	29	2148	4.14	8.95	9.86	1	.00	-8.90	-2.48	-6.42
79	5	29	2148	3.19	28.59	28.77	2	0.00	35.12	-6.94	28.19

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
.00	19.65	23.14	-63.54	32.07	37.76	0	73.7
.00	5.74	6.76	-2.72	10.24	11.06	1	12.0
.00	5.92	6.97	2.24	17.41	20.50	2	19.4

Iflight= 9 Iazimuth= 8

J=0 IS DEFAULT STD; J=1 EXTRAPOLATED; J=2 CLIMATOLOGY

YR	MO	DY	HOUR	CROSS	RANGE	MISS	J	Cbias	DENS	TEMP	Rbias
79	6	1	2145	24.90	75.32	79.33	0	0.00	-62.45	-2.90	-65.34
79	6	1	2145	14.64	23.57	27.74	1	0.00	-13.19	4.67	-8.51
79	6	1	2145	12.29	26.03	28.78	2	0.00	15.38	3.05	18.44
79	6	4	1800	15.78	52.93	55.23	0	0.00	-43.57	-3.71	-47.28
79	6	4	1800	3.82	20.93	21.28	1	0.00	-27.53	7.42	-20.11
79	6	4	1800	1.09	4.84	4.96	2	0.00	-1.22	5.77	4.56
79	6	6	1815	22.60	46.75	51.92	0	0.00	-29.16	-2.90	-32.06
79	6	6	1815	4.53	15.34	15.99	1	0.00	-18.43	4.67	-13.76
79	6	6	1815	8.29	26.29	27.57	2	0.00	20.08	3.05	23.13
79	6	8	1804	32.34	94.42	99.80	0	0.00	-77.53	-3.44	-80.97
79	6	8	1804	2.44	3.63	4.39	1	0.00	1.20	-.57	.63
79	6	8	1804	1.62	38.89	38.92	2	0.00	40.92	-2.12	38.81
79	6	13	1815	25.22	86.03	89.65	0	0.00	-71.27	-5.89	-77.16
79	6	13	1815	5.20	19.03	19.73	1	0.00	-23.00	5.73	-17.27
79	6	13	1815	3.74	9.06	9.80	2	.00	2.84	4.14	6.97
79	6	25	1750	36.76	90.96	98.11	0	0.00	-72.20	.02	-72.18
79	6	25	1750	6.46	16.91	18.10	1	0.00	-17.51	3.69	-13.82
79	6	25	1750	9.14	14.43	17.09	2	0.00	2.17	2.05	4.22
79	6	27	2005	35.61	90.80	97.53	0	0.00	-62.96	-10.24	-73.20
79	6	27	2005	13.58	21.20	25.18	1	0.00	-9.55	4.30	-5.25
79	6	27	2005	10.68	41.28	42.64	2	0.00	35.23	2.73	38.00
79	6	29	1730	39.43	113.85	120.49	0	0.00	-95.70	-1.35	-97.05
79	6	29	1730	10.99	16.78	20.06	1	0.00	-1.94	1.20	-.75
79	6	29	1730	7.97	25.42	26.64	2	0.00	22.71	-.40	22.31

CROSS	C SIG	2D PE	RANGE	R SIG	2D PE	J	RMS
0.00	30.31	35.69	-68.16	49.50	58.18	0	89.2
0.00	8.94	10.52	-9.95	15.30	18.02	1	20.2
.00	7.96	9.37	19.55	17.77	20.92	2	27.5

TABLE A-2. METEOROLOGIDAL DATA

Rocketsonde Data Ht Missing Layers Heights in

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	1	4	1900	2400	263	30	-56	52.78
79	1	4	1900	2500	259	30	-52	43.99
79	1	4	1900	2600	252	29	-49	37.17
79	1	5	1900	2400	265	24	-56	51.57
79	1	5	1900	2500	257	25	-54	47.80
79	1	5	1900	2600	253	28	-52	37.34
79	1	8	2030	2400	268	19	-57	51.51
79	1	8	2030	2500	262	22	-55	43.66
79	1	8	2030	2600	257	29	-51	36.83
79	1	11	1945	2400	265	16	-58	51.77
79	1	11	1945	2500	265	21	-56	43.88
79	1	11	1945	2600	267	26	-53	37.09
79	1	12	1900	2400	257	21	-56	51.47
79	1	12	1900	2500	252	24	-52	43.53
79	1	12	1900	2600	256	29	-50	36.76
79	1	15	2230	2400	250	16	-54	51.29
79	1	15	2230	2500	248	18	-53	43.84
79	1	15	2230	2600	246	24	-54	37.46
79	1	16	2145	2400	248	20	-56	51.17
79	1	16	2145	2500	251	22	-55	43.51
79	1	16	2145	2600	248	24	-52	36.77
79	1	17	2010	2400	281	3	-54	51.12
79	1	17	2010	2500	271	6	-49	43.93
79	1	17	2010	2600	273	10	-51	37.11
79	1	18	1720	2400	41	6	-54	51.24
79	1	18	1720	2500	51	9	-52	44.01
79	1	18	1720	2600	54	11	-50	37.43
79	1	19	1930	2400	65	12	-52	51.19
79	1	19	1930	2500	72	16	-51	43.53
79	1	19	1930	2600	74	20	-50	37.24
79	1	23	1835	2400	51	17	-44	51.05
79	1	23	1835	2500	56	12	-50	43.64
79	1	23	1835	2600	63	12	-54	37.44
79	1	24	1915	2400	57	16	-54	50.51
79	1	24	1915	2500	60	18	-54	43.21
79	1	24	1915	2600	55	18	-52	36.74
79	1	25	1800	2400	45	15	-59	51.91
79	1	25	1800	2500	42	15	-58	44.22
79	1	25	1800	2600	33	15	-59	37.86
79	1	26	1800	2400	39	11	-60	51.64
79	1	26	1800	2500	34	12	-61	44.12
79	1	26	1800	2600	28	11	-61	37.71
79	1	29	1700	2400	92	16	-56	51.21
79	1	29	1700	2500	97	23	-54	43.32
79	1	29	1700	2600	98	29	-51	36.73
79	1	30	1900	2400	103	16	-52	50.31
79	1	30	1900	2500	103	20	-50	42.92
79	1	30	1900	2600	102	22	-49	36.68

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	289	4	-58.82	59.65
2	285	4	-57.50	50.76
3	284	4	-56.19	43.20
4	283	4	-54.88	36.59

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g m	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
1.03	5.81	-4.03	16.33	-55.56	2.14	51.36	5.1
.16	6.65	-3.75	18.57	-54.19	2.66	43.70	5.7
-.54	7.78	-4.55	20.97	-52.25	3.34	37.14	6.3

TABLE A-2 (CONT)

Rocketsonde Data At Missing Layers Iflight= 13

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	2	1	1900	2400	101	9	-54	50.67
79	2	1	1900	2500	97	12	-53	43.15
79	2	1	1900	2600	89	15	-51	36.76
79	2	5	1800	2400	311	1	-55	51.83
79	2	5	1800	2500	271	3	-54	44.11
79	2	5	1800	2600	262	5	-53	37.54
79	2	6	1901	2400	25	3	-54	51.43
79	2	6	1901	2500	36	4	-55	44.09
79	2	6	1901	2600	43	4	-53	37.48
79	2	7	1930	2400	83	6	-58	52.14
79	2	7	1930	2500	88	8	-56	44.18
79	2	7	1930	2600	84	10	-53	37.31
79	2	8	1900	2400	73	7	-58	52.26
79	2	8	1900	2500	73	10	-56	44.27
79	2	8	1900	2600	76	12	-54	37.56
79	2	13	1900	2400	85	6	-55	51.90
79	2	13	1900	2500	81	8	-49	43.30
79	2	13	1900	2600	89	10	-47	36.78
79	2	14	1915	2400	104	2	-59	52.29
79	2	14	1915	2500	88	4	-58	44.46
79	2	14	1915	2600	91	7	-57	37.83
79	2	15	2115	2400	139	2	-58	51.46
79	2	15	2115	2500	155	4	-58	43.92
79	2	15	2115	2600	198	5	-56	37.24
79	2	16	2000	2400	230	5	-57	51.64
79	2	16	2000	2500	239	5	-56	43.97
79	2	16	2000	2600	252	5	-55	37.52
79	2	20	1945	2400	257	8	-57	51.05
79	2	20	1945	2500	270	6	-55	43.23
79	2	20	1945	2600	273	4	-55	37.15
79	2	22	1845	2400	252	13	-58	51.65
79	2	22	1845	2500	261	15	-56	43.76
79	2	22	1845	2600	276	12	-54	37.10
79	2	27	1850	2400	253	12	-60	51.83
79	2	27	1850	2500	251	15	-59	43.98
79	2	27	1850	2600	253	20	-58	37.51
79	2	28	1846	2400	248	13	-61	51.50
79	2	28	1846	2500	247	16	-60	43.66
79	2	28	1846	2600	243	22	-58	36.99

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	281	5	-59.82	59.65
2	279	6	-57.50	50.76
3	277	6	-55.79	43.20
4	276	6	-53.88	36.59

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-1.11	2.38	-1.25	7.56	-57.23	2.20	51.66	.46
-1.02	2.85	-.89	9.46	-55.77	2.83	43.85	.41
-1.09	3.69	-.74	11.43	-54.15	3.00	37.29	.36

TABLE A-2 (CONT)

Rocketsonde Data At Missing Layers Iflight= 12

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	3	1	1937	2400	240	14	-63	51.81
79	3	1	1937	2500	236	20	-62	43.94
79	3	1	1937	2600	239	25	-59	37.00
79	3	2	1900	2400	251	9	-63	52.03
79	3	2	1900	2500	239	14	-61	44.08
79	3	2	1900	2600	233	19	-56	37.07
79	3	5	2200	2400	22	1	-58	52.01
79	3	5	2200	2500	224	2	-56	44.09
79	3	5	2200	2600	216	4	-53	37.24
79	3	7	1945	2400	75	1	-61	52.44
79	3	7	1945	2500	221	2	-59	44.39
79	3	7	1945	2600	222	4	-58	37.58
79	3	8	2130	2400	233	3	-60	53.10
79	3	8	2130	2500	230	5	-59	45.00
79	3	8	2130	2600	242	6	-55	37.78
79	3	12	1930	2400	255	4	-61	53.25
79	3	12	1930	2500	262	6	-60	45.15
79	3	12	1930	2600	263	7	-58	38.17
79	3	14	1915	2400	276	7	-59	51.92
79	3	14	1915	2500	254	7	-56	43.65
79	3	14	1915	2600	253	9	-52	36.84
79	3	16	2150	2400	272	5	-59	51.77
79	3	16	2150	2500	265	6	-55	43.64
79	3	16	2150	2600	262	8	-52	36.80
79	3	19	1900	2400	82	2	-56	51.95
79	3	19	1900	2500	93	1	-53	43.88
79	3	19	1900	2600	0	0	-52	37.41
79	3	26	2030	2400	256	12	-54	51.09
79	3	26	2030	2500	250	12	-51	43.22
79	3	26	2030	2600	244	13	-49	36.91
79	3	28	1925	2400	246	9	-51	51.04
79	3	28	1925	2500	251	10	-50	43.56
79	3	28	1925	2600	251	13	-49	37.26
79	3	30	1900	2400	258	4	-53	51.99
79	3	30	1900	2500	282	6	-51	44.07
79	3	30	1900	2600	296	9	-49	37.60

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	264	5	-56.82	59.65
2	268	5	-55.50	50.76
3	267	6	-54.19	43.20
4	266	6	-52.82	36.59

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-1.48	2.33	-4.94	4.71	-58.17	3.90	52.03	.66
-2.83	3.43	-6.61	5.05	-56.08	4.17	44.05	.57
-3.66	4.65	-8.54	5.98	-53.67	3.82	37.30	.42

TABLE A-2 (CONT)

Rocketsonde Data At Missing Layers Iflight= 13

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	4	2	1900	2400	257	11	-56	52 53
79	4	2	1900	2500	262	12	-54	44.56
79	4	2	1900	2600	269	11	-52	37.85
79	4	4	1915	2400	254	14	-52	51.16
79	4	4	1915	2500	248	14	-50	43.45
79	4	4	1915	2600	242	15	-47	36.80
79	4	6	1940	2400	259	10	-49	50.43
79	4	6	1940	2500	240	7	-45	42.70
79	4	6	1940	2600	216	7	-45	36.76
79	4	9	1900	2400	284	11	-53	51.34
79	4	9	1900	2500	287	11	-51	43 61
79	4	9	1900	2600	279	13	-50	37.30
79	4	11	1945	2400	244	11	-51	51.09
79	4	11	1945	2500	250	13	-49	43.36
79	4	11	1945	2600	255	16	-46	36.85
79	4	12	1931	2400	241	9	-52	50.83
79	4	12	1931	2500	252	13	-50	43.28
79	4	12	1931	2600	259	16	-48	36.93
79	4	16	1900	2400	250	6	-55	52.14
79	4	16	1900	2500	264	11	-53	44 20
79	4	16	1900	2600	273	13	-49	37.39
79	4	18	1920	2400	289	9	-51	51.78
79	4	18	1920	2500	287	7	-49	44.01
79	4	18	1920	2600	245	9	-46	37.46
79	4	20	1930	2400	339	4	-54	52 69
79	4	20	1930	2500	309	4	-53	44 83
79	4	20	1930	2600	274	4	-49	37.81
79	4	23	2200	2400	265	1	-54	52 62
79	4	23	2200	2500	208	1	-51	44 41
79	4	23	2200	2600	206	2	-47	37.71
79	4	25	2140	2400	146	1	-55	53.56
79	4	25	2140	2500	156	1	-52	45.33
79	4	25	2140	2600	119	1	-50	38.50
79	4	30	1800	2400	275	4	-52	51.67
79	4	30	1800	2500	251	4	-48	43.63
79	4	30	1800	2600	232	6	-47	37.28

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	244	2	-55.72	60.60
2	245	1	-53.75	51.31
3	255	1	-52.19	43.54
4	260	2	-50.82	37.28

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	1	SIG	D	SIG
-.89	2.89	-6.87	4.50	-52.83	2.04	51.81	.80
-1.38	2.63	-7.42	5.04	-50.33	2.50	43.95	.75
-2.20	2.75	-8.44	5.79	-48.00	2.04	37.38	.52

Table A-2 (cont)

Rocketsonde Data At Missing Layers Iflight= 8

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	5	2	1947	2400	254	6	-52	52.60
79	5	2	1947	2500	251	6	-50	44.85
79	5	2	1947	2600	240	5	-49	38.30
79	5	7	1800	2400	175	4	-50	52.13
79	5	7	1800	2500	195	3	-50	44.68
79	5	7	1800	2600	195	1	-48	38.11
79	5	11	1900	2400	64	7	-56	53.55
79	5	11	1900	2500	68	8	-54	45.44
79	5	11	1900	2600	67	7	-52	38.66
79	5	18	1800	2400	96	6	-53	52.78
79	5	18	1800	2500	89	7	-50	44.76
79	5	18	1800	2600	87	8	-49	38.17
79	5	21	1800	2400	97	7	-54	53.04
79	5	21	1800	2500	102	8	-51	44.96
79	5	21	1800	2600	100	8	-48	38.00
79	5	23	1445	2400	83	8	-51	52.30
79	5	23	1445	2500	82	8	-50	44.84
79	5	23	1445	2600	74	7	-49	38.43
79	5	25	1800	2400	63	5	-52	52.50
79	5	25	1800	2500	58	7	-50	44.59
79	5	25	1800	2600	76	7	-48	38.11
79	5	29	2148	2400	87	6	-53	52.08
79	5	29	2148	2500	96	6	-51	44.34
79	5	29	2148	2600	92	5	-50	37.95

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	93	3	-54.72	61.61
2	95	3	-52.76	52.32
3	96	3	-50.79	44.31
4	98	3	-40.82	37.59

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
-51.10	37.17

WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-.06	2.25	4.02	4.57	-52.63	1.85	52.62	.50
.10	2.37	4.45	4.97	-50.75	1.39	44.80	.32
.22	1.81	4.53	4.45	-49.13	1.36	38.21	.24

Table A-2 (cont)

Rocketsonde Data At Missing Layers Iflight= 8

YR	MO	DY	HOUR	HZ	AZ	SP	T	D
79	6	1	2145	2400	62	7	-53	52.79
79	6	1	2145	2500	64	9	-50	44.76
79	6	1	2145	2600	84	9	-49	38.23
79	6	4	1800	2400	104	5	-54	52.72
79	6	4	1800	2500	100	5	-49	44.21
79	6	4	1800	2600	102	6	-48	37.64
79	6	6	1815	2400	122	8	-53	52.06
79	6	6	1815	2500	115	7	-50	44.00
79	6	6	1815	2600	105	8	-49	37.57
79	6	8	1804	2400	102	11	-52	53.13
79	6	8	1804	2500	104	11	-50	45.10
79	6	8	1804	2600	97	10	-49	38.53
79	6	13	1815	2400	109	8	-52	53.13
79	6	13	1815	2500	95	8	-49	44.97
79	6	13	1815	2600	85	10	-45	38.16
79	6	25	1750	2400	97	12	-56	53.43
79	6	25	1750	2500	89	12	-52	44.97
79	6	25	1750	2600	87	13	-47	37.83
79	6	27	2005	2400	90	10	-49	52.66
79	6	27	2005	2500	100	12	-47	44.94
79	6	27	2005	2600	92	14	-43	38.01
79	6	29	1730	2400	89	11	-54	53.73
79	6	29	1730	2500	91	13	-51	45.48
79	6	29	1730	2600	95	16	-49	38.68

CLIMATOLOGY (A S T D) INPUT

LA	AZ	SP	TEMP	DENS
1	93	8	-53.72	62.61
2	94	9	-51.76	53.32
3	94	9	-49.79	45.32
4	93	10	-47.88	35.36

STD ATMOSPHERE

TEMP	DENS
-55.08	59.76
-53.09	50.97
-52.09	43.51
-51.10	37.17

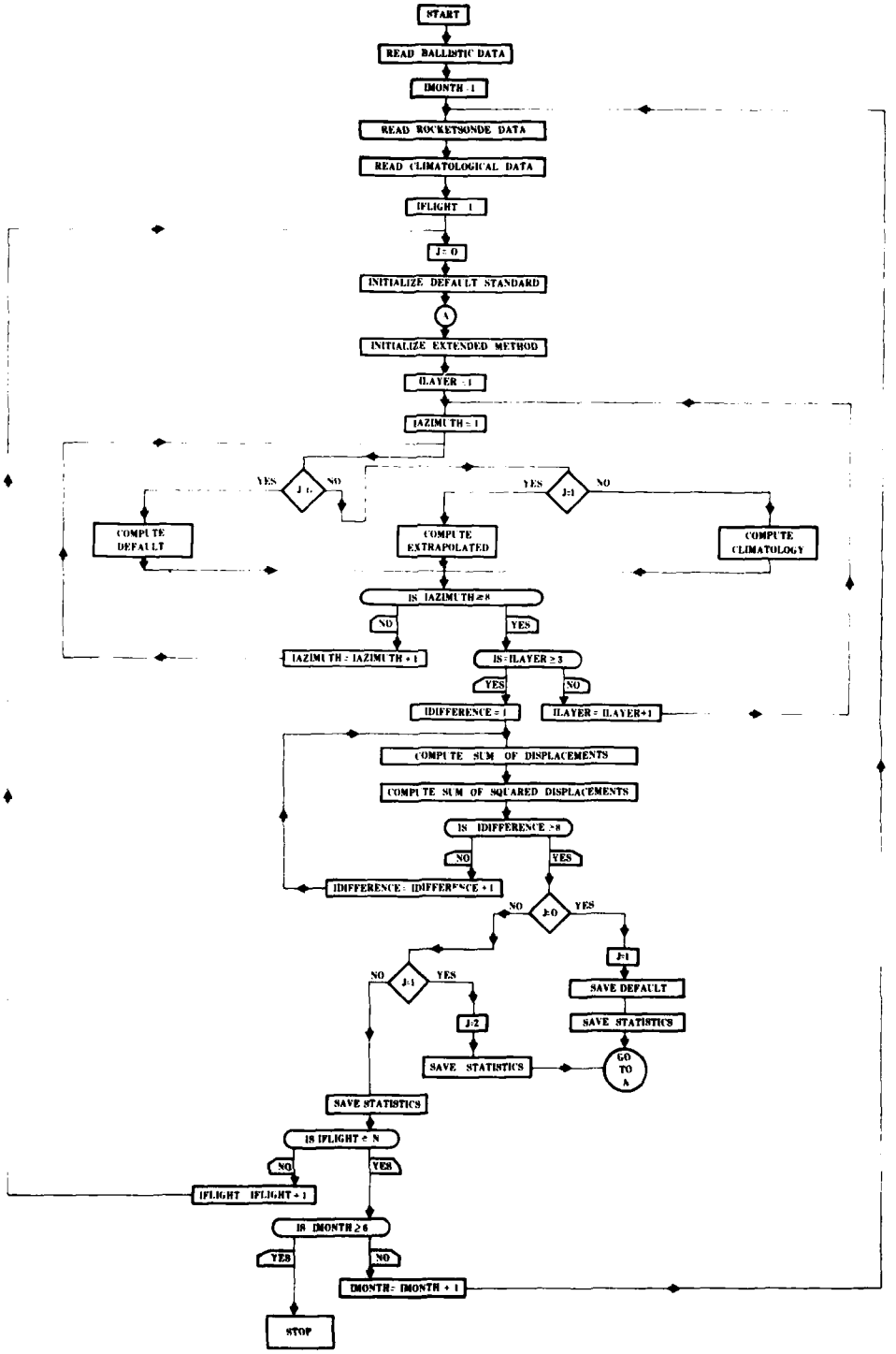
WIND(m/s)				TEMP(oC)		DENS(g/m3)	
N-S	SIG	E-W	SIG	T	SIG	D	SIG
-1.04	2.26	8.63	2.61	-52.88	2.03	52.95	.52
-.67	2.19	9.35	2.93	-49.75	1.49	44.80	.48
-.49	1.18	10.67	3.38	-47.38	2.26	38.08	.40

APPENDIX B

EXTENDED MESSAGE COMPARISON

The logic used to formulate the computation and comparison of the expected meteorological errors associated with methods of extending meteorological information at heights above the artillery computer meteorological message is presented by a flowchart. By examination of the report sections on ballistic simulation and technique comparison, one can define the actual computations presented in this report.

EXTENDED MESSAGE COMPARISON FLOWCHART



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